Director, Operational Test and Evaluation

FY 2015 Annual Report

January 2016

This report satisfies the provisions of Title 10, United States Code, Section 139. The report summarizes the operational test and evaluation activities (including live fire testing activities) of the Department of Defense during the preceding fiscal year.

J. Michael Gilmore
Director

FY 2015 Annual Report

Introduction

American national security is based on preparedness. By ensuring our armed forces' ability to deal with any extant challenge, we disincentivize threats to our interests and mitigate the effects of any attacks when perpetrated. To truly be prepared for the diverse body of threats facing the U.S., from aggressive nation-states to terrorists groups, in cyber and kinetic domains, and across land, sea, and air, weapons must be tested realistically in the environments in which they are to be used. This is the purpose of operational test and evaluation (OT&E). It is essential to assuring the men and women we send into combat can win.

In my tenure as the DOD's Director of Operational Test and Evaluation, I have made it my top priority to ensure that operational tests are adequate, particularly regarding the realism of the conditions under which the testing is conducted. In doing this, I consider all Service-defined operational conditions, including the system operational envelope, the intended mission(s), and the range of operationally realistic kinetic and cybersecurity threats. Conducting a rigorous and operationally realistic test capturing these key parameters is the only way to inform our forces what weapons systems actually can and cannot do.

I have also prioritized the objectivity and scientific rigor of operational tests. By leveraging scientific methodologies including Design of Experiments (DOE), survey design, and statistical analyses, DOT&E ensures defensible and efficient tests are conducted providing the critical information decision makers and warfighters require. Rigorous, scientifically-defensible analyses of the data ensure my reports tell the unvarnished truth. This introduction summarizes my office's continuing efforts to institutionalize these methods in the DOD test and evaluation (T&E) community.

Early stage testing can miss significant operationally relevant problems that are revealed during operational testing in realistic environments. In FY15, as in previous years, OT&E discovered problems missed during development and in previous testing. Finding and addressing these problems before production and deployment is critical, as the only other option is to discover them in combat, when the issues would endanger warfighter lives. In addition, identifying and fixing these problems once full-rate production is underway would be a far more expensive way to address deficiencies, as retrofits are rarely, if ever, cheaper than fixing the problems before full-rate production. Further details on problem discovery during OT&E are provided in a separate section (page 13). OT&E also highlights and exposes previously known problems, as many programs unfortunately choose to progress to operational testing with operationally significant unresolved problems identified in prior testing.

Also included in this introduction, I describe in more detail several focus areas of my office, including the following:

- My continued emphasis on the need to improve reliability of all weapon systems and my recent initiatives to include all relevant information in operational reliability assessments.
- The recently released updated DOT&E Test and Evaluation Master Plan (TEMP) Guidebook, which provides new guidance in my primary focus areas on what substance and level of detail, should be included in TEMPs.
- Recent improvements made in the area of cybersecurity and the need to continue to emphasize cybersecurity as a focus area for all DOD systems.
- Other topics of interest.

RIGOROUS, DEFENSIBLE TESTING

In order to provide rigorous quantitative evaluations of combat performance, and to ensure that we fully utilize scarce test resources, I have advocated the use of scientific test design and statistical analysis techniques for several years. Since 2009, there have been substantial improvements in the use of these techniques within the Services, specifically at each of the Service Operational Test Agencies (OTAs). This improved capability has provided the Department with scientifically rigorous test results that identify what the systems the Services are acquiring can and cannot do in combat. These techniques have helped ensure adequate operational testing; providing sufficient information to characterize combat performance across the set of operational scenarios in which the Services themselves state the weapon systems will be used.

Both DOT&E and the Undersecretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)) updated OSD policy and guidance to promote the use of scientific approaches to test planning; in particular, the DOD Instruction 5000.02 now calls for universal employment of scientific approaches T&E. Specifically, the new instruction emphasizes that the test program should be designed to characterize combat mission capability across the operational environment using an appropriately selected set of factors and conditions.

Warfighters need to know under what conditions the system is effective and when it is not. This characterization is a key element of my guidance for OT&E. In OT&E, characterization ensures adequate information to determine how combat mission capability changes across the operational envelope. Under this concept, testers examine performance as a function of relevant operational conditions and threat types. This is in contrast to the historical approach where test results frequently have been averaged across the operational envelope. For example, a metric such as detection range was averaged across all conditions and compared to a single threshold requirement (or average historical performance). A simple average is not the best way to evaluate performance because it fails to identify differences in performance across the operational envelope, and consequently, it is not informative to the warfighter. Average performance across all conditions masks variances in performance across the operational envelope. An extreme example of this I have seen blended a 100 percent rating in one set of parameters with a 0 percent rating in another, saying the system was 50 percent effective across conditions. This statement is meaningless, and the conditions under which the system under test is ineffective need to be known by the users and developers of the system so that fixes or workarounds can be developed.

I have advocated for the use of scientific methods, including DOE, to ensure that this characterization is conducted as efficiently as possible. The methods that I advocate not only provide a rigorous and defensible coverage of the operational space, they also allow us to quantify the trade-space between the amount of testing and the precision needed to answer complex questions about system performance. They allow us to know, before conducting the test, which analyses we will be able to conduct with the data and therefore, what questions about system performance we will be able to answer. Finally, these methods equip decision makers with the analytical tools to decide how much testing is enough in the context of uncertainty and cost constraints.

The Deputy Assistant Secretary of Defense Developmental Test and Evaluation (DASD(DT&E)) has advocated the use of these methods through his Scientific Test and Analysis Techniques (STAT) T&E Center of Excellence (COE), which employs qualified statistics experts to aid acquisition program managers in applying advanced statistical techniques in developmental testing. The STAT T&E COE helps program managers plan and execute more efficient and effective tests beginning with early developmental testing. Initially 20 Acquisition Category I programs were partnered with the COE. To date, 36 programs have had dedicated COE support for development of test strategies, mentoring, or training. The COE is envisioned to eventually be funded by the Services' in order to expand in size and also provide support to program managers in smaller acquisition programs. I encourage all program offices to ensure that they have access to such a knowledge source.

As a community, we should always strive to improve our test methods. While I have seen improvements in several areas, continued improvement is possible. Important future focus areas include: statistical analytic techniques to examine test results, improving surveys in testing, validation of models and simulations, and using all the appropriate information to maximize the information available to decision makers and operators.

Statistical Analytic Techniques

It is not sufficient to employ statistical methods only in the test design process; corresponding analysis methods should be employed in the evaluation of system performance, otherwise we risk missing important conclusions. Using statistical analysis methods instead of conventional approaches to data analysis, we have been able to learn more from tests without necessarily increasing their size and cost. In all of my reports, my staff uses rigorous statistical analysis methods to provide more information from operational tests than ever before. In the past few years, my staff has used these analysis techniques to identify areas of performance shortfalls. For example, in the operational test and of the Multi-Spectral Targeting System, which is intended to enable helicopters to target small-fast boats and employ HELLFIRE missiles, a logistic regression of the test results revealed a significant interaction between two factors that resulted in performance falling well below the required value in one of the scenarios, suggesting the need for a potential system algorithm improvement. In another example, the operational testing of the AN/TPQ-53 Counterfire radar, showed how performance degraded as a function of range and projectile elevation. This analysis was especially useful because in this case testers did not control all factors likely to affect performance in order to maintain operational realism. Regression techniques enabled DOT&E to determine causes of performance degradations across multiple operating modes, even with highly unbalanced data. Finally, we are using statistical analysis techniques to show statistically significant improvements between incrementally improved versions of systems. In the operational testing of the Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) sonar system an in-lab portion of testing was added to the traditional at-sea testing to evaluate operator detection capabilities across a range of environments and targets. Statistical analysis techniques (coupled with a robust experimental design) showed a statistically

significant improvement in the software build over the legacy build and allowed us to definitively claim that the improvement was universal across all operating conditions. It is important to note that if DOT&E had not pushed for these more rigorous analyses, all of these results would have been missed.

Rigorous methods should also be used for suitability analyses. In the past year, I have put a larger emphasis on the rigorous analysis of survey and reliability data. One notable example of this is the reliability assessment conducted for the Littoral Combat Ship (LCS). The LCS reliability requirement as stated would have been nearly impossible to test, requiring a core mission reliability of 0.80 for a 720-hour mission. Instead, my office focused on critical sub-systems that contributed to the core mission. Using Bayesian methodologies and series system models we were able to assess the core mission reliability defensibly, providing reasonable interval estimates of the reliability even in cases where the critical sub-systems had different usage rates and zero failures. This type of analysis also lays the groundwork for how different sources of information discussed below can be used to evaluate system reliability and performance.

Unfortunately, the implementation of rigorous statistical techniques is still far from widespread across all DOD T&E communities. Overall, statistical analysis methods such as logistic regression and analysis of variance, which supported the above discoveries, are underused. Until they are routinely employed in the analysis of T&E data, the OT&E community will miss opportunities to identify important performance results and truly understand system capability. Furthermore, we are not currently leveraging these methods in a sequential fashion to improve knowledge as we move from developmental testing to operational testing. Knowledge about the most important factors from developmental testing will improve our ability to clearly define an adequate operational test that avoids the unnecessary expenditure of resources.

Survey Design and Analysis

In 2015, I issued additional guidance on the design and use of surveys in OT&E. Surveys provide valuable quantitative and qualitative information about the opinions of operators and maintainers as they employ and maintain weapon systems in an operationally realistic test environment. An objective measurement of these opinions is an essential element of my evaluation of operational effectiveness and suitability. However, I have noted that many of the surveys used in OT&E are of such poor quality they can actually hinder my ability to objectively evaluate the system. My office has worked closely with the Service OTAs to improve the quality of surveys used in operational testing.

Custom surveys, established surveys (e.g., NASA workload questionnaire), interviews, and focus groups all have important roles in OT&E. For example, focus groups are often essential venues to elicit operator opinions; however, focus groups should not be the sole source of operator opinion data. Focus groups can be affected by group dynamics and therefore should be used to obtain diagnostic information rather than quantitative information. To maximize the usefulness of focus groups, the test team should examine the survey responses immediately after administering them to look for trends. These initial results can then be used to help guide the focus group questioning which should occur after the written surveys but as soon as possible to ensure impressions are still fresh in the user's minds.

All of the OTAs are currently working on improving their own guidance on the use of surveys in OT&E. Once the scientific best practices I have advocated for are incorporated, I expect future evaluations to include better quality and usable survey results.

Validation of Modeling and Simulations

Modeling and simulation (M&S) can and often does provide complementary information that is useful in my evaluations of operational effectiveness, suitability, and survivability. For example, there are cases in which not all of the important aspects of weapon system effectiveness or system survivability can be evaluated in an operationally realistic environment due to safety, cost, or other constraints. In these cases, M&S provides valuable information to my assessment. However, for M&S to be useful it must be rigorously validated to ensure that the simulations adequately represent the real-world performance under the conditions of its intended use (at a specific level of accuracy). A model that is validated under one set of operational conditions may not be valid under other sets of operational conditions.

Since my assessment of operational effectiveness includes the characterization of combat mission capability across the operational envelope, validation methods must ensure that M&S is valid across that operational envelope. We need to explore new scientific methods for validation that allow me to characterize where the M&S provides useful information to my assessments and where models do not represent the real-world conditions to a high enough level of accuracy. Historical methods of rolling up accuracy of the M&S across a variety of conditions do not provide this level of fidelity and must be improved upon using state-of-the-art scientific methods.

In my recent review of TEMPs that propose M&S as a key aspect of operational testing, I reviewed the selection of M&S points and the validation methods with the same scrutiny as the proposed live operational test points in order to ensure adequacy.

Using All Information in Operational Evaluations

Operational testing occurs under realistic combat conditions, including operational scenarios typical of a system's employment in combat, realistic threat forces, and employment of the systems under test by typical users rather than by hand-picked or contractor crews. History has shown us that emphasizing operational realism is essential in identifying critical system performance problems, many of which are only discoverable in an operationally realistic environment. However, operational testing is limited in that it typically spans a short period of time compared to the rest of the testing continuum. In many cases, it is beneficial to consider other test data in an operational evaluation. In doing so, we must account for the fact that these additional data were collected under less operationally realistic conditions.

In cases where other test data, especially that from operationally realistic developmental testing, operational assessments, and M&S, provide additional information we should use state-of-the-art analysis methods to include that information in our analyses. However, it is also essential that we avoid biasing the operationally realistic results in such analyses. Thoughtful application of statistical models, especially Bayesian models, has proven useful in this regard.

IMPROVING SYSTEM RELIABILITY

Many defense systems continue to demonstrate poor reliability in operational testing. As shown in Figure 1, only 9 of 24 (38 percent) systems that had an Initial Operational Test and Evaluation (IOT&E) or Follow-on Operational Test and Evaluation (FOT&E) in FY15 met their reliability requirements. The remaining 15 systems either failed to meet their requirements (29 percent), met their requirements on some (but not all) platforms on which they were integrated (8 percent), or could not be assessed because of limited test data or the absence of a reliability requirement. In four instances where the system failed to meet its reliability requirement or did not have a reliability requirement, DOT&E assessed that the reliability demonstrated in testing was sufficient to support operational missions resulting in 13 of 24 (54 percent) programs being assessed as operationally reliable.

Various policies have been established to improve reliability performance. Most recently, the January 2015 update to the DOD 5000.02 codified the need for programs to employ best practices in reliability growth planning. The instruction requires program managers to formulate a comprehensive reliability and maintainability program that is part of the systems engineering process, assess the reliability growth required for the system to achieve its reliability threshold during IOT&E, and report the results of that assessment to the Milestone Decision Authority at Milestone C.

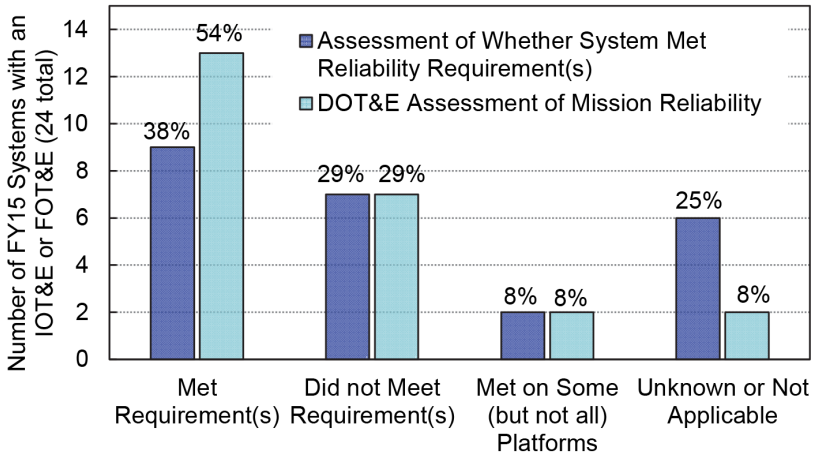


FIGURE 1. RELIABILITY ASSESSMENT FOR 24 SYSTEMS THAT HAD AN IOT&E OR FOT&E IN FY15

Since my office began monitoring reliability in 2005, programs have increasingly complied with these policies, but this has not yet translated to improved reliability performance. Common reasons why programs fail reliability requirements include lack of a design for reliability effort during the design phase; unrealistic requirements that are too large relative to comparable systems; lack of contractual and systems engineering support; insufficient developmental test time to identify and correct failure modes; absence of, or disagreement on, reliability scoring procedures; or failure to correct significant reliability problems discovered in developmental testing prior to operational testing.

Despite these shortfalls, there is some evidence that programs with a reliability Key Performance Parameter (KPP) are more likely to meet their reliability requirements. A 2014 National Academy of Sciences report commissioned by myself and Mr. Frank Kendall (USD(AT&L) recommended programs develop a reliability KPP and ensure that all proposals explicitly designate funds for reliability improvement activities. [1] To follow-up on this recommendation, my office reviewed the requirements documents for programs that conducted an operational test in 2014. Of the 34 programs that had an IOT&E or FOT&E in FY14 and had a reliability requirement in their Capability Development Document (CDD), 8 had a reliability KPP and 26 did not. Seven of the eight programs (88 percent) with reliability KPPs achieved their reliability requirements while

1. National Academy of Sciences, *Reliability Growth: Enhancing Defense System Reliability*, 2014.

only 11 of the 26 (42 percent) programs without reliability KPPs achieved their requirement. This initial result provides limited evidence that requiring reliability KPPs may be a good policy change for ensuring programs take the need for reliable systems seriously.

In the same annual review on reliability, my office noted that over a quarter (27 percent) of programs had operational test lengths that were shorter in duration than their reliability requirement. As part of my ongoing effort to ensure that testing is done as efficiently as possible, I have continually encouraged programs to intelligently use information from all phases of test, particularly when assessing reliability. Similar to the assessment of other system capabilities, it is important to understand the risks to both the government and the contractor when determining the appropriate length of a test. Overly simple rules of thumb such as testing for duration equal to three times the reliability requirement often lead to inconclusive assessments. In other cases, system reliability requirements can be so high that a test adequate for assessing effectiveness would only permit a limited assessment of reliability. This situation, in particular, benefits from the intelligent incorporation of developmental and early operational test data in the final reliability assessments. It is crucial to note that this does not mean simply adding developmental test data to operational test data. A rigorous statistical approach that accounts for the differences in test environments is necessary.

When a program intends to use developmental test data to support an operational assessment, it is crucial to involve the operational test community early in the data scoring process. Scoring conferences, used extensively by both the Air Force and the Army, provide a forum for stakeholders to discuss reliability, and I recommend that all programs use them. Even if a program does not intend to use developmental test data to supplement the operational assessment, including operational testers in scoring conferences for developmental tests provides the Program Office a better understanding of how issues observed in developmental testing are likely to effect the system's reliability assessment in subsequent operational testing. This helps program offices identify priority corrective actions. I have updated my guidance on reliability test planning in the recently updated DOT&E TEMP Guidebook to address my desire to incorporate all relevant information into operational reliability assessments.

TEMP GUIDEBOOK 3.0

Throughout my tenure, I have always strived to provide clear guidance on my expectations. This year my office updated the DOT&E TEMP Guidebook to complement the January 2015 version of DOD Instruction 5000.02. While the updates also included formatting updates, strict or immediate adherence to the new TEMP format is not required as my evaluation of TEMP adequacy is based on the TEMP's content, not the format. The TEMP Guidebook 3.0 follows the updated DOD 5000.02 TEMP organization; there are bold blue font callouts with links to DOT&E guidance and examples. The callouts have been placed throughout TEMP Guidebook 3.0 at locations where DOT&E and other applicable policies apply. The combination of guidance and examples is intended to highlight areas of emphasis to me, and provide clear examples how my guidance should be interpreted.

There are several key content areas that my office revised in this third iteration of the TEMP Guidebook based on lessons learned over the past several years. The primary areas where substantive updates were made were the creation of an operational evaluation framework, methods for combining information from multiple phases of testing, reliability test planning, and cybersecurity.

I have also expanded my guidance on the use of developmental test data for operational test evaluation. In the current fiscal climate, it is important we test enough to provide the warfighter with valuable information on system capability without testing too much. I have taken every opportunity to use all information available to me to ensure we provide valuable information as efficiently as possible. The Integrated Testing section and the Bayesian guidance section capture best practices for leveraging all available information while still ensuring operational assessments reflect performance in the operational environment.

There is a new section on reliability test planning, which is distinctly different from the reliability growth section. This new section provides clear guidance on my expectations for planning reliability tests as well as what information I expect to be in a reliability growth program.

Additionally, TEMP Guidebook 3.0 contains expanded guidance and examples for implementation of the DOT&E memorandum, "Procedures for Operational Test and Evaluation of Cybersecurity in Acquisition Programs" dated August 1, 2014. These examples are based on lessons learned from cybersecurity test successes and challenges in the past year of implementing the 2014 DOT&E cybersecurity procedures memorandum.

CYBERSECURITY

DOT&E observed improvements in several cybersecurity areas within the DOD this past year; however, operational missions and systems remain vulnerable to cyber-attack. Observed improvements during training exercises include enhanced protection of network elements, greater challenges for cyber opposing forces attempting to access networks, and growing awareness by DOD leadership that cyber-attacks can degrade key systems and critical missions. In some networks, vulnerabilities routinely available elsewhere were mitigated by timely upgrades and software patches. Operational tests of isolated systems experienced much less success in preventing and detecting cyber intrusions highlighting the importance of cyber defense-in-depth. A layered approach to stop primary attack vectors, such as phishing, proved effective at defending some networks. Application whitelisting, where network defenders allow only "known good" applications to operate on a network, also hindered the cyber opposing force from expanding its foothold in the network. However, these improvements were insufficient to ensure that networks and systems can continue to support DOD missions in the presence of a cyber adversary.

In FY15 operational tests and exercise assessments, cyber opposing forces frequently attained a position to deliver cyber effects that could degrade operational missions, often significantly. Unfortunately, exercise and test control authorities seldom permitted aggressive cyber-attacks to affect systems and networks, or allowed non-cyber forces to exploit compromised information in their operations. These restrictions limit insights on both the scope and duration of associated mission effects and preclude the opportunity for training in representative cyber-contested conditions. Acquisition programs, Combatant Commands, Services, and cyber defenders need realistic operational tests and training events that include cyber-attacks and mission effects representative of those expected from advanced capability cyber adversaries.

The demand on DOD-certified Red Teams, which are the core of the cyber opposing forces teams, has more than doubled in the past three years. In the same timeframe, the Cyber Mission Force and private sector have hired away members of Red Teams, resulting in staffing shortfalls during a time with increasing demand. To reduce administrative overhead and increase the realism in portraying cyber threats, DOT&E worked with U.S. Pacific Command, U.S. Northern Command, U.S. Strategic Command, and U.S. Cyber Command to establish permissions for continuous Red Team operations on selected DOD networks and systems. DOT&E also helped Red Teams access advanced cyber capabilities so that they can better emulate advanced capability cyber threats. However, these efforts alone will not offset the Red Team staffing and capability shortfalls, which the DOD must address to retain the ability to assess DOD systems and train Service members against realistic cyber threats.

ADDITIONAL TOPICS OF INTEREST

In this section, I provide details on specific test resources and test venues that have had significant action on my part this year. For more details on the Multi-Stage Supersonic Target (MSST), self-defense test ship (SDTS), Radar Signal Emitters (RSE), Warrior Injury Assessment Manikin (WIAMan), and Fifth-Generation Aerial Target (5GAT), see the Resources section of this Annual Report (page 397).

DOT&E Staffing

The FY08 National Defense Authorization Act (NDAA) expressed concern about the adequacy of DOT&E staffing and directed a manpower study be conducted. As a result of that study, the Secretary of Defense authorized 22 additional government billets for DOT&E, increasing civilian authorizations from 54 to 76. Subsequently, in FY10, the DOD evaluated contractor support Department-wide and authorized in-sourcing of inherently government functions while directing a reduction in the levels of contractor support for headquarters organizations. As a result, DOT&E in-sourced 17 inherently government positions and reduced contractor support by a total of 47 (from 72 in 2008 to 25 in 2015 and beyond). Multiple OSD efficiency reviews further reduced DOT&E civilian authorizations from 93 to 67 by FY20.

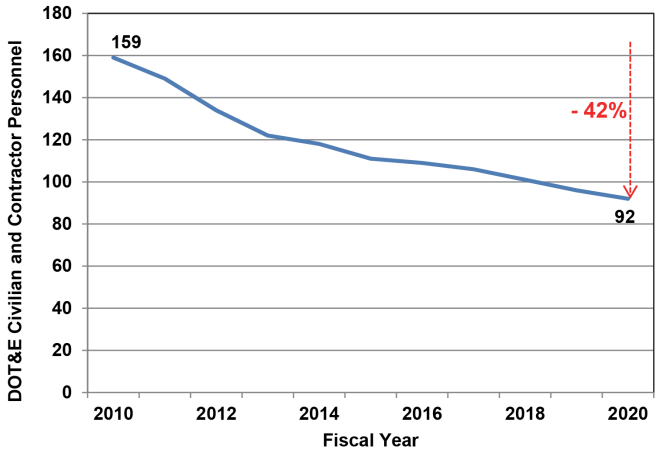


FIGURE 2. DOT&E CIVILIAN AND CONTRACTOR STAFF PROJECTION BETWEEN 2010 – 2020

Between 2010 and 2020, DOT&E civilian and contractor personnel will shrink by 42 percent, and DOT&E anticipates further reductions in budgets and/or manpower authorizations. It is noteworthy that DOT&E, unlike other headquarters staffs, did

not receive any additional manpower or funding to support the missions of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). Because headquarters staff reductions Department-wide are intended to reduce those staffs that grew larger to support OEF and OIF, the impact to DOT&E staffing is especially significant. To preserve its Title 10 responsibilities, it is likely that DOT&E will have to terminate some non-core, non-Title 10 activities.

Multi-Stage Supersonic Target (MSST)

The Navy's MSST program was intended to provide a threat representative surrogate for a specific class of Anti-Ship Cruise Missiles (ASCMs). Unfortunately, the MSST program, originally intended to cost $297 Million, ballooned to $962 Million and was nearly five years behind schedule. Moreover, recent analysis by the Navy's intelligence community indicated the target, if completed, would likely have been a poor surrogate for the threats it was intended to emulate. For these reasons, the Navy directed that the program be terminated.

I agree with the Navy's decision to terminate the MSST program. I also strongly recommended to the Navy that it not pursue a segmented, highly artificial test approach as a substitute for the MSST that the Navy estimated would have cost more than $700 Million to implement. The artificialities of the alternative proposed by the Navy would have hopelessly confounded the interpretation of any results obtained from its use, making it unwise, unwarranted, and a waste of resources. Nevertheless, without a threat representative surrogate for the threats the MSST was intended to emulate, I will not be able to assess the ability of Navy surface combatants to defend against such threats.

Aegis Self-Defense Test Ship (SDTS)

The Navy's Aegis cruisers and destroyers are charged with defending our Carrier Strike and Amphibious Ready Groups against ASCM attacks. Without such a defense, the self-defense systems on our carriers and amphibious ships may be overwhelmed. It is thus critical that our Aegis ships be able to defend themselves against ASCM attacks so they can survive and complete their air-defense missions. These facts are reflected in the self-defense requirements for all new ship classes and combat system elements to include the Navy's new flight of DDG 51 destroyers (DDG 51 Flight III), the Air and Missile Defense Radar (AMDR) that is to be installed on DDG 51 Flight III, the upgraded Aegis Weapon System planned for DDG 51 Flight III, and the Block 2 upgrade to the Evolved SeaSparrow Missile (ESSM Block 2).

Operationally realistic testing of DDG 51 Flight III, AMDR, the Aegis Weapons System, and ESSM Block 2 requires demonstrating the ship's combat system's ability to defeat raids of ASCMs including a particularly menacing and proliferating set of threats--supersonic ASCMs flying directly at the ship (stream raids). Navy sea-range safety restrictions do not permit ASCM surrogates to be flown directly at crewed ships; even with a cross-range aim-point, the surrogate threats cannot fly within the ranges necessary to test the ship's self-defense combat system. Amphibious ship classes and aircraft carriers have used a crewless SDTS in combination with live firings and M&S to evaluate their self-defense systems. However, the Aegis combat system has never been installed on a test ship. For nearly three years, my office has engaged the Navy regarding the need for an AMDR- and Aegis-equipped SDTS. In doing so, my office has detailed numerous problems found on other Navy surface combatants only as a direct result of testing on a SDTS. Without those tests, critical failure modes would not have been found and could not have been corrected.

In 2015, OSD Cost Analysis Performance Assessment (CAPE) studied various options for acquiring an Aegis- and AMDR-equipped SDTS. The CAPE study, which was based on Navy cost data, showed that an appropriately-equipped SDTS could be acquired for $320 Million. DOT&E has raised this issue to the Secretary and Deputy Secretary for resolution in the FY17 program and budget review. Meanwhile, DOT&E continues to work with the Navy to develop an integrated test plan for live firings using crewed ships, the SDTS (if available), and M&S.

Radar Signal Emitters (RSE)

In order to improve realism of electronic warfare threats at open air ranges, DOT&E is collaborating with the Test Resource Management Center (TRMC) and Army Threat Systems Management Office (TSMO), to procure a fleet of mobile, programmable radar signal emulators (RSEs) designed to replicate a wide variety of modern, ground-based threat air defense radars. These test assets are essential for creating operationally realistic, multi-layered air defense scenarios for open-air testing of many new systems that are required to operate in an Anti-Access Air Denial (A2AD) environment. These systems include the Joint Strike Fighter (JSF), F-22, B-2, Long-Range Strike Bomber, and the Next Generation Jammer for the EA-18G, as well as others. The first two RSEs are schedule to be delivered to the Nevada Test and Training Range (NTTR) for testing and integration in FY16. A total of 16 systems are under contract and scheduled to be delivered and integrated at Air Force and Navy open-air test ranges.

Now that the JSF Program Office has decided to discontinue the Lockheed Martin Verification Simulation, a high-fidelity manned simulation that had been central to JSF's operational test plans, the ability of open-air testing to replicate more

realistic and stressing operational environments is paramount. Having the RSEs integrated on the test ranges and available for the JSF IOT&E is essential.

Significant progress was made this year on the development, production, and planning for testing and range integration of the first two RSEs. Each RSE is capable of high-fidelity emulation of the output power, signal parameters, and performance of long-range surface-to-air missile radars, and is mounted on its own highway-certified and range-road-capable trailer with integral cooling for all weather operability. Once delivered to NTTR, these systems will each be paired with a tow vehicle that incorporates a generator for powering the RSE, communications equipment for connecting to range networks, and an operator control cabin. The RSEs are rapidly reprogrammable and capable of emulating the signals of a wide variety of radars found in modern air defense environments. They employ active electronically-steered array radar technology with high-powered, high-efficiency transmit and receive modules.

With close cooperation of the Air Force NTTR range personnel, the integration and implementation of the RSEs for the JSF IOT&E was defined. Several test events are currently being planned for initial check out. Operational testing of the RSEs is expected to begin by the end of 2016.

Additionally, we are now working closely with the Navy range personnel (Point Mugu Sea Test Range) to implement enhancements at that range necessary to incorporate the RSEs. The Navy will eventually take ownership of 5 RSEs and the Air Force the other 11 for the purposes of operations and maintenance. However, the mobility of the systems is such that any or all of the RSEs would be available for any test program that requires them, and they are readily transportable by air (C-17 or C-130) or over the road to a variety of test ranges.

Warrior Injury Assessment Manikin (WIAMan)

There have been over 23,000 casualties from underbody blast (UBB) events due to improvised explosive devices (IEDs) in the Iraq and Afghanistan conflicts; furthermore, the UBB threat has been an effective enemy tactic over the past decade and a half, and it is likely to remain so. The need to protect our Service members from this threat in the future is clearly reflected in the force protection requirements developed by the Services for their ongoing combat and tactical wheeled vehicle programs. The Army has spent over $2 Billion to retrofit existing vehicles with UBB protection. New vehicles such as the Joint Light Tactical Vehicle, the Amphibious Combat Vehicle, and the Mobile Protected Firepower Light Tank are being procured with requirements to protect occupants against UBB threats. However, the Department remains without an adequate test device and scientifically-defensible injury criteria to effectively evaluate the protection provided by our combat and tactical wheeled vehicles.

The Department's inability to assess injuries due to UBB events was made clear during the early (2007 – 2009) LFT&E of the Mine-Resistant Ambush Protected (MRAP) vehicles, when the Army could not evaluate differences in the degree of force protection provided to occupants by the different MRAP variants due to non-biofidelic instrumentation and poor injury assessment capability. The DOT&E MRAP assessment, published in 2010, highlighted these test resource deficiencies. Despite these shortcomings, the same ineffective instrumentation and injury criteria used in those tests remain in use today. As part of a retrospective review of MRAP procurement and performance, the DOD directed a status review of UBB M&S to determine if an enhanced UBB M&S capability could have identified the MRAP performance differences prior to the publication of the DOT&E report. The review identified 10 major gaps in the Department's capability to accurately model the effects of UBB; the top three gaps were all associated with the shortcomings in test instrumentation and criteria to assess human injury in the UBB environment. This study highlighted that the current T&E techniques used to address occupant injuries in UBB LFT&E (using automotive crash test dummies and injury criteria designed and developed for forces and accelerations in the horizontal plane to address frontal impact-induced injuries) are not appropriate to assess the effects of the vertical forces and accelerations imparted from a combat UBB event. To address these gaps, I submitted an issue paper in 2010 that ultimately provided $88 Million for five years of funding for an Army-led research and development program to increase the Department's understanding of the cause and nature of injuries incurred in UBB combat events, and to develop appropriate instrumentation to assess such injuries in testing. This project is known as the Warrior Injury Assessment Manikin, or WIAMan.

In 2013, the Army created a dedicated office (the WIAMan Engineering Office (WEO)) under the Army Research, Development, and Engineering Command (RDECOM) to lead its execution of the program. However, in early 2015 the office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology determined the WIAMan project would become an Acquisition Category II program of record under the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI). Army PEO STRI and RDECOM are developing a Test Capabilities Requirements Document based on the previous five years of research by the WEO, which I intend to approve upon its completion. Finally, PEO STRI worked with the WEO to develop and validate a formal Program Office Estimate for full funding of the program.

Unfortunately, the Army elected not to program any funding for the WIAMan project after its initial five years of funding was to end in FY16, despite knowing the project would not be completed by then. This delay was, in part, due to the Army's early mismanagement of the biomechanics testing, which necessitated restructuring the project in its third year. This restructuring resulted in cost overruns and schedule delays that the Department has not accounted for in its allocation of resources to WIAMan. The Assistant Secretary of Defense (Health Affairs) has committed Science and Technology funding to the program post-Milestone B to ensure critical injury biomechanics research is completed, but this commitment has not been matched by a similar commitment from the Army to program for the anthropomorphic test device (ATD) production and procurement.

Some within the Army question whether the DOD still needs a combat-specific injury assessment capability for UBB test events; however, it is entirely appropriate for the DOD, and in particular for the Army, to accord the same high priority to testing and verifying the protection provided to Soldiers by their combat vehicles that the commercial automotive industry accords to testing and verifying the protection provided to the U.S. public by their automobiles. For example, the U.S. automotive industry has developed ATDs tailored to the multiple axes of impact that occur in civilian car crashes. This includes, but is not limited to, ATDs to assess injuries from frontal impacts, rear impacts, and side impacts. There is no single ATD that is acceptable for all automotive impact conditions, even for the relatively slow impacts of a car crash and none of these automotive ATDs are acceptable for impact conditions observed in combat. The Army's lack of a commitment to completing this project required me to submit an issue paper this year for additional funding of $98 Million through FY21 that would enable the continuation of development of defensible injury criteria, predictive modeling and simulations, and two generations of prototype ATDs.

Fifth-Generation Aerial Target (5GAT)

DOT&E investigated the need for an aerial target to adequately represent the characteristics of Fifth Generation threat aircraft in light of the emergence of threat aircraft like Russia's PAK-FA and China's J-20. The Fifth-Generation Target study effort began in 2006 and examined the design and fabrication of a dedicated 5GAT that would be used in the evaluation of U.S. weapon systems effectiveness. The study team, comprised of Air Force and Navy experts, retired Skunk Works engineers, and industry, completed a preliminary design review for a government-owned design. DOT&E and the TRMC have invested over $11 Million to mature the 5GAT government-owned design. Further investment is required to complete the prototype. DOT&E submitted an issue paper this year for $27 Million to complete final design, tooling, and prototyping efforts. The prototyping effort will provide cost-informed, alternative design and manufacturing approaches for future air vehicle acquisition programs. These data can also be used to assist with future weapon system development decisions, T&E infrastructure planning/investment, and could support future analysis of alternative activities.

Network Integration Evaluation (NIE)

In FY15, the Army executed two Network Integration Evaluations (NIEs) at Fort Bliss, Texas, and White Sands Missile Range, New Mexico. NIE 15.1 was conducted in October and November 2014, and NIE 15.2 was conducted in April and May 2015. The purpose of the NIEs is to provide a venue for operational testing of Army acquisition programs, with a particular focus on the integrated testing of tactical mission command networks. During NIE 15.1, the Army executed an FOT&E for Warfighter Information Network – Tactical (WIN-T) Increment 2. During NIE 15.2, the Army conducted an FOT&E for the Distributed Common Ground System – Army (DCGS-A) and a Limited User Test for the Mid-Tier Networking Radio (MNVR). Individual articles on these programs are provided elsewhere in this Annual Report. Beginning in FY16, the Army will devote one NIE a year to operational testing and another annual event to experimentation and force development. The latter event is to be called an Army Warfighting Assessment; the first of these was conducted in October 2015.

The Army Test and Evaluation Command's Operational Test Command and the Brigade Modernization Command, continue to develop realistic, well-designed operational scenarios for use during NIEs. The Army should continue to improve its instrumentation and data collection procedures to support operational testing, including refining its method for the conduct of interviews, focus groups, and surveys with the units employing the systems under test. The Army continues to improve threat operations during NIEs, particularly with respect to threat information operations, such as electronic warfare and computer network operations. NIEs should incorporate a large, challenging regular force threat that includes a sizeable armored force and significant indirect fire capabilities.

Network components, both mission command systems and elements of the transport layer, remain excessively complex to use. The current capability of an integrated network to enhance mission command is diminished due to pervasive task complexity. It is challenging to achieve and maintain user proficiency. While networked communications at lower tactical levels may create enhanced operational capability, the use of these networking waveforms brings negative attributes, which need to be fully evaluated and understood. The challenge of integrating network components into tracked combat vehicles

remains unresolved. Due to vehicle space and power constraints, the Army has yet to successfully integrate desired network capabilities into Abrams tanks and Bradley infantry fighting vehicles. It is not clear how the desired tactical network will be incorporated into heavy brigades. The WIN-T FOT&E conducted during NIE 15.1 revealed significant problems with the integration of WIN-T into Stryker vehicles. Integration of the tactical network into an Infantry Brigade Combat Team has not been evaluated at NIEs due to the lack of a light infantry unit assigned to the NIE test unit. Integration of the network into the light forces will be challenging given the limited number of vehicles in the Infantry Brigade Combat Team. The intended tactical network places a greater demand upon the available electromagnetic spectrum than has been the case with non-networked communications. An integrated tactical network introduces new vulnerabilities to threat countermeasures, such as threat computer network attacks, and the ability of a threat to covertly track friendly operations. The Army has yet to integrate radios into its rotary-winged aircraft, which are capable of operating in the same network as ground forces at the company level and below. Units remain overly dependent upon civilian Field Service Representatives to establish and maintain the integrated network. This dependency corresponds directly to the excessive complexity of use of network components.

Ballistic Missile Defense

The Ballistic Missile Defense System (BMDS) is a system of sensors and weapons that have not yet demonstrated an integrated functionality for efficient and effective defense. Currently, the BMDS relies on man-in-the-loop processes to integrate across the blue force instantiations for mission execution coordination within each Combatant Command because the Command and Control, Battle Management, and Communications (C2BMC) element does not provide engagement management capability to the BMDS. The Missile Defense Agency (MDA) should continue C2BMC development efforts to provide an engagement management capability to the BMDS.

In its ongoing efforts to demonstrate BMD theater defense, the MDA conducted several system- and weapon-level flight and ground tests in FY/CY15 using Aegis Ballistic Missile Defense (Aegis BMD), Terminal High-Altitude Area Defense (THAAD), and Patriot. However, the MDA still needs to prioritize development and funding for a BMDS simulation-based performance assessment capability including M&S validation, verification, and accreditation and the ability to produce high-fidelity and statistically-significant BMDS-level performance assessments. Aegis BMD has demonstrated the capability to intercept short- and medium-range ballistic missiles with Standard Missile-3 (SM-3) Block IB interceptors, but the reliability of that interceptor needs to be improved. A key component of the MDA's efforts to improve SM-3 Block IB reliability is the redesign of that interceptor's third-stage rocket motor aft nozzle system, which must be sufficiently ground and flight tested to prove its efficacy. DOT&E recommends that a flight test of the THAAD system against an intermediate-range target should occur as soon as possible. The first THAAD flight test against an intermediate-range ballistic missile (the expected threat class for defense of Guam where THAAD is currently deployed) was scheduled for 2015, but was delayed because of problems with other BMDS test events.

At the BMD strategic defense level, the MDA did not conduct a Ground-based Midcourse Defense (GMD) interceptor flight test in FY/CY15. To improve and demonstrate the capability of the GMD and the reliability and availability of the operational Ground-Based Interceptors (GBIs), the MDA should continue diligently extending the principles and recommendations contained in the Independent Expert Panel assessment report on the GBI fleet to all components of the BMDS instantiation for Homeland Defense and should continue with their plans to retest the Capability Enhancement-I Exo-atmospheric Kill Vehicle in 4QFY17 to accomplish the test objectives from the failed Flight Test GBI-07 (FTG-07) mission. In addition, DOT&E recommends that the MDA should also determine additional sensor capability requirements for a robust Defense of Hawaii capability.

Combat Data

Combat operations over the past 14 years have resulted in a large number of rotary-wing aircraft hit by enemy fire resulting in aircraft losses and personnel casualties (fatalities and injuries). In 2009, Congress directed the DOD to conduct a study on rotorcraft survivability with the specific intent of identifying key technologies that could help reduce rotary-wing losses and fatalities. However, since non-hostile and non-combat mishaps accounted for more than 80 percent of the losses and 70 percent of the fatalities, conclusions from the 2009 study were concentrated towards preventing mishaps rather than surviving direct combat engagements. Since then, DOT&E has continued to analyze combat damage to rotary-wing, fixed-wing, and unmanned aircraft to provide insight on the threats (including small arms, Man-Portable Air Defense Systems, and rocket-propelled grenades), aircraft components and systems, and operational conditions that led to the loss or damage of aircraft and personnel casualties. Additionally, analyses of combat-damaged aircraft have been compared to live fire testing to determine if any changes need to be made in how live fire test programs are conducted.

This year, analyses of combat data have been conducted for aircrew currently engaged in combat operations. Forward deployed aircrews have found the data extremely valuable and have modified their tactics, techniques, and procedures based on these data. Because combat data are perishable if not collected immediately, I made a recommendation to institutionalize an Air Combat Damage Reporting (ACDR) process across the Department. Institutionalizing the ACDR will improve the Department's ability to understand and rapidly respond to changes in enemy tactics and weapons resulting in fewer losses of personnel and aircraft through mitigation actions. The value of the data provided by ACDR is lessened due to a lack of structured and enforced combat damage data collection in theater. Integrating ACDR into operational scenario planning and subsequent manning to deploy combat damage assessment teams as an integrated element of the aviation fighting force will fill the capability gap. It will enable the timely collection of perishable combat damage data to support the Department's rapid and long-term response to current and evolving threats.

Full Ship Shock Trial (FSST)

In combat, even momentary interruptions of critical systems can be catastrophic when those systems are crucial to defending against incoming threats. This is why the Navy has historically required mission-essential systems to remain functional before, during, and after shock. The Navy's shock qualification specification states that a momentary malfunction is acceptable only if it is automatically self-correcting and only if no consequent derangement, mal-operation, or compromise of mission essential capability is caused by the momentary malfunction. The FSST will provide critical information regarding a ship's ability to survive and continue to conduct combat operations after absorbing hits from enemy weapons. Understanding these vulnerabilities is essential. Discoveries made by conducting the FSST on the first-of-class ships will enable timely modification of future ships of the class to assure their survivability.

At the direction of the Deputy Secretary of Defense, the Navy is planning to conduct an FSST on CVN 78 before her first deployment—to do otherwise would have put CVN 78 at risk in combat operations. Historically, FSSTs for each ship class have identified previously unknown mission-critical failures that the Navy had to address to ensure ships would be survivable in combat. We can expect that CVN 78's FSST results will have significant and substantial implications on future carriers in the *Gerald R. Ford* class and any subsequent new class of carriers.

Shock trials are routinely conducted on first-of-class ships, recently including PGH 1, LCC 19, DD 963, CV 59, LHA 1, FFG 7, DDG 993, LSD 41, MCM 1, LHD 1, and MHC 1. However, on occasion, various circumstances have caused some shock trials not to be conducted on the first-of-class, with the primary reason being to ensure testing is conducted on the most representative ship of the class. For example, FSSTs will not be conducted on the first-of-class LCSs because numerous significant design changes are being incorporated in later ships. Nonetheless, the preference is to perform the FSST on the first-of-class, so as to identify and mitigate mission-critical failures as soon as possible.

Some have argued component-level testing and M&S are sufficient to identify and correct shock-related problems on fully-integrated ships. However, the mission-critical failures occurring during every FSST, which are conducted at less than the design-level of shock, discredit this theory. For CVN 78, the FSST is particularly important given the large number of critical systems that have undemonstrated shock survivability. These systems include the Advanced Arresting Gear (AAG), Electromagnetic Aircraft Launching System (EMALS), Dual Band Radar (DBR), the 13.8 kilovolt Electrical Generation and Distribution Systems, the Advanced Weapons Elevator (AWE), a new reactor plant design, and a new island design and location with a unique shock environment.

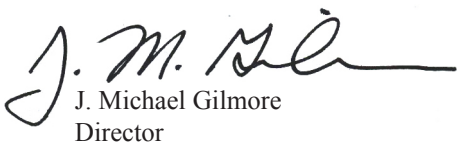
It is noteworthy that the conduct of an FSST on CVN 78 prior to her first deployment had been a part of the program of record since 2004; therefore, the Navy has had ample time to plan for this event. Nonetheless, a number of claims have been and are being made regarding the potential delay in CVN 78's deployment caused by conducting the FSST prior to the ship's first deployment. These claims span months to years; however, only the former is consistent with the Navy's conduct of the FSST on CVN 71, USS *Theodore Roosevelt*. Commissioned in October 1986, CVN 71 was underway most of January and February 1987 conducting crew and flight operations as part of shakedown. From March to July 1987, CVN 71 underwent a post-shakedown availability. The month of August was used to prepare for the FSST, which was conducted during the period spanning August 31, 1987, to September 21, 1987. Upon completing the FSST, CVN 71 returned to Norfolk Naval Station for a two-week period to remove specialized trial equipment and to complete repairs to systems essential to flight operations. After completing those mission-critical repairs, CVN 71 returned to sea to conduct fleet carrier qualifications. From November 1987 to January 1988, the ship underwent a restricted availability to complete all post-FSST and other repairs. CVN 71 was then underway for most of the remainder of 1988, conducting independent steaming exercises and other activities, departing on its first deployment on December 30, 1988. The effect of conducting the FSST on CVN 71's

availability for operations following the shock trial was two weeks to conduct mission-critical repairs, and the total time required to prepare for, conduct, and recover fully from the FSST was about five months, including the restricted availability.

Currently, FSSTs for LCS 5 and 6 are planned for 2016. The inevitable lessons we will learn from these tests will have significant implications for LCS combat operations, as well as for the construction of the future frigate, which may be based on one of the LCS designs.

Despite the benefits of expedited FSST, the Navy intends to delay FSST from DDG 1000 to DDG 1002—a decision that I do not support. Conducting FSST on DDG 1000 is critical to finding and correcting failures in mission critical capabilities prior to her first deployment. I submitted an issue paper this year to restore the funding for this test.

I submit this report, as required by law, summarizing the operational and live fire test and evaluation activities of the Department of Defense during Fiscal Year 2015.



J. Michael Gilmore
Director

FY15 TABLE OF CONTENTS

DOT&E Activity & Oversight

FY15 Activity Summary 1
Program Oversight 7
Problem Discovery Affecting OT&E 13

DOD Programs

Defense Agencies Initiative (DAI) 25
Defense Medical Information Exchange (DMIX) 27
Defense Readiness Reporting System – Strategic (DRRS-S) 31
Department of Defense (DOD) Teleport 33
F-35 Joint Strike Fighter (JSF) 35
Global Command and Control System – Joint (GCCS-J) 83
Joint Information Environment (JIE) 87
Joint Warning and Reporting Network (JWARN) 91
Key Management Infrastructure (KMI) Increment 2 93
Public Key Infrastructure (PKI) Increment 2 97
Theater Medical Information Program – Joint (TMIP-J) 101

Army Programs

Network Integration Evaluation (NIE) 103
Abrams M1A2 System Enhancement Program Version 3 (SEPv3) Main Battle Tank (MBT) 105
Distributed Common Ground System – Army (DCGS-A) 107
Global Combat Support System – Army (GCSS-Army) 109
Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) M30E1 113
HELLFIRE Romeo 115
Integrated Personnel and Pay System – Army (IPPS-A) Increment I 117
Javelin Close Combat Missile System – Medium 121
Joint Battle Command – Platform (JBC-P) 123
Joint Light Tactical Vehicle (JLTV) Family of Vehicles (FoV) 125
M109 Family of Vehicles (FoV) Paladin Integrated Management (PIM) 129
M270A1 Multiple Launch Rocket System (MLRS) Improved Armored Cab (IAC) 131
M829A4 (formerly M829E4) Armor Piercing, Fin Stabilized, Discarding Sabot – Tracer (APFSDS-T) 133
Mid-Tier Networking Vehicle Radio (MNVR) 135
Mine Resistant Ambush Protected (MRAP) MaxxPro Long Wheel Base (LWB) Ambulance 137
MQ-1C Gray Eagle Unmanned Aircraft System (UAS) 139
Nett Warrior 143
One System Remote Video Terminal (OSRVT) Increment II 145
Patriot Advanced Capability-3 (PAC-3) 147
Precision Guidance Kit (PGK) 149
Q-53 Counterfire Target Acquisition Radar System 151
Rifleman Radio 153
Warfighter Information Network – Tactical (WIN-T) 155

Navy Programs

Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) for AN/BQQ-10(V) Sonar 159
Aegis Modernization Program 163
AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program 167
AIM-9X Air-to-Air Missile Upgrade 169
AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite 171
CH-53K – Heavy Lift Replacement Program 173

Common Aviation Command and Control System (CAC2S) 175
Consolidated Afloat Networks and Enterprise Services (CANES) 179
Cooperative Engagement Capability (CEC) 181
CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier 183
DDG 1000 *Zumwalt* Class Destroyer 189
DDG 51 Flight III Destroyer/Air and Missile Defense Radar (AMDR)/Aegis Combat System 193
Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM) 197
E-2D Advanced Hawkeye 199
F/A-18E/F Super Hornet and EA-18G Growler 201
Global Combat Support System – Marine Corps (GCSS- MC) 203
H-1 Upgrades – U.S. Marine Corps Upgrade to AH-1Z Attack Helicopter and UH-1Y Utility Helicopter 205
Infrared Search and Track (IRST) 207
Integrated Defensive Electronic Countermeasures (IDECM) 209
Joint High Speed Vessel (JHSV) (Expeditionary Fast Transport) 213
Joint Standoff Weapon (JSOW) 217
LHA 6 New Amphibious Assault Ship (formerly LHA(R)) 219
Light Armored Vehicle – Anti-Tank Modernization (LAV- ATM) 223
Littoral Combat Ship (LCS) and Associated Mission Modules 225
MH-60R Multi-Mission Helicopter 247
MH-60S Multi-Mission Combat Support Helicopter 249
Mine Resistant Ambush Protected (MRAP) Family of Vehicles (FoV) – Marine Corps 253
Mobile Landing Platform (MLP) Core Capability Set (CCS) (Expeditionary Transfer Dock) and Afloat Forward Staging Base (AFSB) (Expeditionary Mobile Base) 255
Mobile User Objective System (MUOS) 259
MQ-4C Triton Unmanned Aircraft System (UAS) 261
Multi-Static Active Coherent (MAC) System 263
MV-22 Osprey 267
P-8A Poseidon Multi-Mission Maritime Aircraft (MMA) 269
Remote Minehunting System (RMS) 273
Rolling Airframe Missile (RAM) Block 2 281
RQ-21A Blackjack Unmanned Aircraft System (UAS) 283
Ship Self Defense for LHA(R) 287
Ship-to-Shore Connector (SSC) 291
Small Surface Combatant (SSC) Modification to the Littoral Combat Ship (LCS) 293
SSN 774 *Virginia* Class Submarine 295
Standard Missile-6 (SM-6) 299
Surface Electronic Warfare Improvement Program (SEWIP) Block 2 301
Surface Ship Torpedo Defense (SSTD) System: Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT) 303
Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar 307

Air Force Programs

AC-130J Ghostrider 309
Advanced Extremely High Frequency (AEHF) Satellite Communications System 313
AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) 315
Air Force Distributed Common Ground System (AF DCGS) 317
Air Operations Center – Weapon System (AOC-WS) 321
CV-22 Osprey 325
Defense Enterprise Accounting and Management System (DEAMS) 327
F-22A Advanced Tactical Fighter 331
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) 335

KC-46A 337
Massive Ordnance Penetrator (MOP) 341
Miniature Air-Launched Decoy (MALD) and MALD- Jammer (MALD-J) 343
MQ-9 Reaper Armed Unmanned Aircraft System (UAS) 345
QF-16 Full-Scale Aerial Target (FSAT) 349
RQ-4B Global Hawk High-Altitude Long-Endurance Unmanned Aerial System (UAS) 351
Small Diameter Bomb (SDB) II 355

Ballistic Missile Defense Programs

Ballistic Missile Defense System (BMDS) 357
Aegis Ballistic Missile Defense (Aegis BMD) 361
Command and Control, Battle Management, and Communications (C2BMC) System 367
Ground-Based Midcourse Defense (GMD) 371
Terminal High-Altitude Area Defense (THAAD) and AN/TPY-2 Radar (Forward-Based Mode) 373

Live Fire Test and Evaluation (LFT&E) 377

Cybersecurity 389

Test and Evaluation Resources 397

Joint Test and Evaluation (JT&E) 411

Center for Countermeasures (CCM) 419

Index 425

DOT&E Activity and Oversight

DOT&E Activity and Oversight

FY15 Activity Summary

DOT&E activity for FY15 involved oversight of 312 programs, including 27 Major Automated Information Systems. Oversight activity begins with the early acquisition milestones, continues through approval for full-rate production, and, in some instances, during full production until removed from the DOT&E oversight list.

Our review of test planning activities for FY15 included approval of 35 Test and Evaluation Master Plans (TEMPs); 84 Operational Test Plans; 4 Live Fire Test and Evaluation (LFT&E) Strategies and Management Plans (not included in a TEMP); and disapproval of the following 1 TEMP and 1 Test Plan:

- CVN 78 Class Program Number 1610, Revision C TEMP
- Littoral Combat Ship (LCS) 2 with Mine Countermeasure (MCM) Mission Package (MP) Technical Evaluation (TECHEVAL) Data Management and Analysis Plan (DMAP)

In FY15, DOT&E prepared for the Secretary of Defense and Congress: 9 IOT&E reports, 5 Early Fielding Reports, 4 FOT&E reports, 3 LFT&E reports, 1 Operational Assessment (OA) report, 2 OT&E reports, 1 special report, and the Ballistic Missile Defense program's FY14 Annual Report. DOT&E also prepared and submitted numerous reports to the Defense Acquisition Board (DAB) principals for consideration in DAB deliberations. Additional FY15 DOT&E reports that did not go to Congress included: 9 Cybersecurity reports, 3 FOT&E reports, 3 IOT&E reports, 4 LFT&E reports, 6 OA reports, and 3 OT&E reports.

During FY15, DOT&E met with Service operational test agencies, program officials, private sector organizations, and academia; monitored test activities; and provided information to the DAB committees as well as the DAB principals, the Secretary and Deputy Secretary of Defense, USD(AT&L), the Service Secretaries, and Congress. Active on-site participation in, and observation of, tests and test-related activities are a primary source of information for DOT&E evaluations. In addition to on-site participation and local travel within the National Capital Region, approximately 790 trips supported the DOT&E mission.

Security considerations preclude identifying classified programs in this report. The objective, however, is to ensure operational effectiveness and suitability do not suffer due to extraordinary security constraints imposed on those programs.

TEST AND EVALUATION MASTER PLANS / STRATEGIES APPROVED (*INCLUDES LIVE FIRE STRATEGY)

Abrams M1A2 System Enhancement Package Version 3 Engineering Change Proposal 1a (SEPv3 ECP 1a) TEMP*

Multifunctional Information Distribution System (MIDS) Joint Tactical Radio System (JTRS) with Concurrent Multinetting/Concurrent Contention Receive (CMN/CCR) Capability on F/A-18 and EA-18G Aircraft Annex K (Revision A) TEMP

Armored Multi-Purpose Vehicle (AMPV) TEMP Update, Change 1

Army Logistics Modernization Program (LMP) Increment 2 for the Milestone C Decision TEMP

Bradley Family of Vehicles (BFoV) ECP Program TEMP*

Combat Rescue Helicopter (CRH) TEMP*

Common Analytical Laboratory System (CALS) TEMP

Common Aviation Command and Control System (CAC2S) TEMP

Common Infrared Countermeasure (CIRCM) Milestone B TEMP

Defense Healthcare Management Systems Modernization TEMP

Distributed Common Ground System – Army (DCGS-A) TEMP

Dry Combat Submersible (DCS) TEMP

Enhanced Polar System (EPS) TEMP, Version 3.0

F/A-18E/F and EA-18G TEMP

F-15 Eagle Passive/Active Warning Survivability System (EPAWSS) Milestone A TEMP

Family of Advanced Beyond Line of Sight – Terminal (FAB-T) TEMP

Infrared Search and Track (IRST) System ACAT III TEMP, Revision A

Integrated Defensive Electronic Countermeasures (IDECM) AN/ALQ-214 (V) Software Improvement Program TEMP

Integrated Personnel and Pay System – Army (IPPS-A) Increment 2 Milestone B TEMP, Version 1.2

Integrated Strategic Planning and Analysis Network (ISPAN), Increment 4 TEMP

Integrated XM25 Counter Defilade Target Engagement (CDTE) Weapon System TEMP

Joint Air-to-Ground Missile (JAGM) TEMP*

Joint Biological Tactical Detection System (JBTDS), ACAT III, TEMP Supporting Milestone B

Long Range Strike Bomber (LRS-B) TEMP

Miniature Air Launched Decoy – Jammer (MALD-J) FOT&E TEMP

Mobile Landing Platform (MLP) TEMP Revision 1.0*

Next Generation Diagnostic System (NGDS) Increment 1 TEMP

Precision Guidance Kit (PGK) TEMP

Presidential Helicopter Replacement Program (VH-92A) Revision A TEMP*

Small Diameter Bomb Increment II (SDB II) TEMP*

Space-Based Infrared System (SBIRS) Enterprise TEMP

Spider M7E1, Dispensing Set, Munition, Network Command, Increment 1A TEMP

Stryker Family of Vehicles (FoV) ECP TEMP*

Theater Medical Information Program – Joint (TMIP-J) Increment 2, Release 3 TEMP

Warfighter Information Network – Tactical (WIN-T) Increment 3 TEMP

OPERATIONAL TEST PLANS APPROVED

Aegis Weapon System (AWS) Baseline 9C Integrated Testing on Integrated Air and Missile Defense (IAMD) Destroyer DMAP

Air Forces Central Command (AFCENT) Information Assurance Assessment Plan

Aegis Weapon System (AWS) Baseline 9A Air Defense Cruiser IOT&E Plan

AGM-154C-1 Joint Stand-off Weapon (JSOW) FOT&E Test Plan

AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) FOT&E Test Plan

Air Defense Cruiser Aegis Baseline 9A Cybersecurity IOT&E Test Plan

Air Force Distributed Common Ground System (AF DCGS) Geospatial Intelligence Baseline (GB) 4.X Upgrade Force Development Evaluation (FDE) Plan

Air Force Distributed Common Ground System (AF DCGS) System Release 3.0 Operational Utility Evaluation (OUE) Plan

Air Force Distributed Common Ground System (AF DCGS) System Release 3.0 Operational Utility Evaluation (OUE) Plan Deviation

Air Operations Center (AOC) Weapons System (WS) Increment 10.1 Recurring Event 13 FDE Plan

Air Operations Center (AOC) Weapon System (WS) Increment 10.2 OA Plan

Air Warfare/Ship Self Defense (AW/SSD) Enterprise (ET05 Phase 2) Ship Self Defense System (SSDS) Mk2 (OT-IIIH Phase 2) and Rolling Airframe Missile (RAM) Block 2 (OT-C2 Phase 2) Combined Operational Test Plan

Air Warfare/Ship Self Defense (AW/SSD) Enterprise (ET06), Ship Self Defense System (SSDS) Mk 2 (OT-IIIH) FOT&E and Rolling Airframe Missile (RAM) Block 2 (OT-C3) IOT&E Combined Operational Test Plan

Amphibious Assault Ship Replacement (LHA (R) FLT 0) IOT&E Test Plan

AN/AAQ-24B(V)25 Department of the Navy Large Aircraft Infrared Countermeasures Advanced Threat Warning System (DoN LAIRCM) FOT&E Test Plan

AN/SQQ-89A(V)15 Surface Ship Undersea Warfare (USW) Combat System Program IOT&E Test Plan, Change 2

AN/TPQ-53 Target Acquisition Radar System Initial Operational Test 2 (IOT 2) Operational Test Agency (OTA) Test Plan

Assembled Chemical Weapons Alternatives (ACWA) Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP) Test Concept Plan Revision 4 Test and Evaluation Plan

Automated Biometric Identification System (ABIS) 1.2 IOT&E, Phase 2 Test Plan

Ballistic Missile Defense System (BMDS) Flight Test, Operational-02 (FTO-02) Test Plan

Ballistic Missile Defense System (BMDS) Integrated Master Test Plan (IMTP) v15.1

Battle Control System – Fixed (BCS-F) Increment 3 Release 3.2.3 FDE Plan

CNO Project Number 1610, CVN-78 Gerald R. Ford Class Nuclear Aircraft Carrier OT-B4 OA Test Plan

Coastal Battlefield Reconnaissance and Analysis (COBRA) OA Test Plan

Common Aviation Command and Control System (CAC2S) Data Fusion Developmental Test Observation Plan

Common Aviation Command and Control System (CAC2S) use of DT-C2 Developmental Test and Evaluation Data for IOT&E

Consolidated Afloat Networks and Enterprise Services (CANES) FOT&E Test Plan and Cybersecurity Plan

Cooperative Engagement Capability (CEC) Cybersecurity FOT&E Test Plan

Cooperative Engagement Capability (CEC) FOT&E OT-D1A Test Plan

CVN-75 (USS *Truman*) Command and Control Exercise (C2X) Assessment Plan

Defense Agencies Initiative (DAI) Increment 2, Release 1 OA Plan

Defense Enterprise Accounting and Management System (DEAMS) IOT&E Plan Deviation

Defense Medical information Exchange (DMIX) Release 2 OA Plan

Defense Readiness Reporting System – Strategic (DRRS-S) Version 4.6 IOT&E Plan

Department of Defense Teleport Generation 3, Phase 3 (G3P3) OA Plan

Distributed Common Ground System – Army (DCGS-A) Increment 1, Release 2 FOT&E Plan

Distributed Common Ground System – Navy (DCGS-N) Increment 1, Block 2 FOT&E Test Plan with the Cybersecurity Annex

EA-18G FOT&E Test Plan

F/A-18e/F System Configuration Set H10 FOT&E Test Plan

F-22 Update 5 Operational Flight Program FDE Plan Approval

F-22A Increment 3.2A FOT&E Plan

Global Command and Control System – Joint (GCCS-J) Version 5 OT&E Plan

Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW) Implementing the Tactics, Techniques, and Procedures (TTP) Demonstration Test Plan

Integrated Defensive Electronic Counter Measures (IDECM) Suite Block IV FOT&E Test Plan Deviation

Joint Warning and Reporting Network (JWARN) Increment 1 FOT&E 3 Plan

KC-46A OA-2 Plan

KC-46A OA-2 Plan Deviation

Key Management Infrastructure (KMI) Capability Increment 2 Spiral 2 Spin 1 Limited User Test (LUT) Plan

Light Armored Vehicle Anti-Tank Modernization (LAV-ATM) OA Test Plan

Littoral Combat Ship (LCS) 2 Surface Warfare (SUW) (DT-A6) Integrated Testing DMAP

Littoral Combat Ship (LCS) 2 with Mine Countermeasure (MCM) Mission Package Cybersecurity OT&E Test Plan

Littoral Combat Ship (LCS) 4 with Surface Warfare (SUW) Mission Package Increment 2 IOT&E Plan

Littoral Combat Ship (LCS) 4 with Surface Warfare (SUW) Mission Package Increment 2 DT/IT-B4 Phase 2 and DT/IT-C4 DMAP

Logistics Modernization Program (LMP) IOT&E Plan

M109 Family of Vehicles (FoV) Self Propelled Howitzer (SPH) 5A Ballistic Test OTA Test Plan

Marine Corps H-1 Upgrades Program AH-1Z/UH-1Y FOT&E Test Plan

Marine MV-22B OT-IIIK FOT&E Test Plan

MaxxPro Long Wheel Base (LWB) LUT in support of the Mine Resistant Ambush Protected (MRAP) OTA Test Plan

Mid-Tier Networking Vehicular Radio (MNVR) LUT OTA Test Plan

Miniature Air Launched Decoy – Jammer (MALD-J) Test Plan

MQ-1C Gray Eagle Unmanned Aircraft System (UAS) Follow-on Operational Test (FOT) and the One System Remote Video Terminal (OSRVT) Increment II Initial Operational Test (IOT) OTA Test Plan

MQ-4C Triton Unmanned Aircraft System (UAS) OA Test Plan, (1731-OT-B1)

Nett Warrior (NW) IOT&E (Phase 2) OTA Test Plan

Next Generation Jammer (NGJ) Early OA Test Plan

P-8A Increment 2, ECP-1 Multi-static Active Coherent (MAC) OT&E Test Plan

P-8A Poseidon Multi-Mission Maritime Aircraft (MMA) Verification of Correction of Deficiencies (VCD) Test Plan

Pueblo Chemical Agent Destruction Pilot Plant (PCAPP) Explosive Destruction System (EDS) Test and Evaluation Plan

Remote Minehunting System (RMS) Integrated Testing DMAP

RQ-4 Global Hawk Block 40 IOT&E Test Plan

Surface Electronic Warfare Improvement Program (SEWIP) Block 2 IOT&E Cybersecurity Test Plan

Surveillance Towed Array Sonar System (SURTASS)/Compact Low Frequency Active (CLFA) IOT&E Test Plan Addendum

Theater Medical Information Program – Joint (TMIP-J) Increment 2 Release 3 Multi-Service OT&E Plan

Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo Torpedo (CAT) Quick Reaction Assessment (QRA) DMAP

TRIDENT II (D5) Strategic Weapons Systems Test and Evaluation Plan and Strategy

U.S. Africa Command Judicious Response 2015 Assessment Plan

U.S. Army Warfighter 2015-4 Assessment Plan and Addendum

U.S. European Command Austere Challenge 2015 Final Assessment Plan

U.S. Northern Command Vigilant Shield 2015 Cybersecurity and Interoperability Final Assessment Plan

U.S. Pacific Command Pacific Sentry 2015-3 Assessment Plan

U.S. Southern Command Integrated Advance 2015 Assessment Plan

U.S. Special Operations Command Tempest Wind 2015 Assessment Plan

U.S. Transportation Command Turbo Challenge 2015 Final Assessment Plan

Warfighter Information Network – Tactical (WIN-T) Increment 2 FOT&E 2 OTA Test Plan

XM1156 Precision Guidance Kit (PGK) OTA Test Plan

LIVE FIRE TEST AND EVALUATION STRATEGIES/MANAGEMENT PLANS APPROVED

Combat Rescue Helicopter (CRH) LFT&E Strategy

Heavy Equipment Transporter (HET) Urban Survivability Kit (HUSK) LFT&E Strategy

Javelin Spiral 2 Missile LFT&E Strategy

VH-92A Presidential Helicopter Replacement Program LFT&E Strategy

FY15 REPORTS TO CONGRESS	
PROGRAM	**DATE**
Initial Operational Test and Evaluation Reports	
Aegis Ballistic Missile Defense (BMD) 4.0 and Standard Missile-3 Block IB	December 2014
Miniature Air-Launched Decoy with Jammer (MALD-J)	March 2015
Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW)	March 2015
Nett Warrior	May 2015
DOD Automated Biometric Identification System (ABIS) Version 1.2	May 2015
RQ-21A Blackjack Small Tactical Unmanned Aircraft System (STUAS)	June 2015
Mobile Landing Platform with Core Capability Set (MLP w/CCS)	July 2015
Air Intercept Missile – 9X (AIM-9X) Block II	July 2015
Defense Enterprise Accounting and Management System (DEAMS) Increment 1 Release 3	August 2015
Early Fielding Reports	
Air Intercept Missile – 9X (AIM-9X) Block II	December 2014
Defense Enterprise Accounting and Management System (DEAMS) Increment 1 Release 3	March 2015
Massive Ordnance Penetrator (MOP) Enhanced Threat Reduction Phase 2	April 2015
Aegis Baseline 9A Cruiser	July 2015
Virginia Class SSN Block III	September 2015
Follow-on Operational Test and Evaluation Reports	
Handheld, Manpack, Small Form Fit (HMS) AN/PRC-155 Manpack Radio and Joint Enterprise Network Manager (JENM)	December 2015
Lot 4 AH-64E Apache Attack Helicopter	December 2015
Warfighter Information Network – Tactical (WIN-T) Increment 2	May 2015
Joint High Speed Vessel (JHSV)	September 2015
Live Fire Test and Evaluation Reports	
Stryker Reactive Armor Tiles (SRAT) II	November 2014
Cartridge 7.62 Ball M80A1	February 2015
HELLFIRE Romeo Final Lethality Report	August 2015
Operational Test and Evaluation Reports	
Joint Battle Command – Platform (JBC-P)	January 2015
Advanced Extremely High Frequency (AEHF)	May 2015
Operational Assessment Reports	
F/A-18E/F Infrared Search and Track (IRST) Block I	December 2014
Special Reports	
Report on the Littoral Combat Ship (LCS) required by Section 123 of H.R. 3979, National Defense Authorization Act (NDAA)	April 2015
Ballistic Missile Defense Reports	
FY14 Assessment of the Ballistic Missile Defense System (includes Classified Appendices A, B, C, and D)	March 2015

OTHER FY15 REPORTS (NOT SENT TO CONGRESS)	
PROGRAM	**DATE**
Cybersecurity Reports	
U.S. Army Warfighter Exercise 2014-4	December 2014
U.S. Central Command Special Operations Command Central Headquarters (HQ) and Forward HQ	February 2015
Integrated Electronic Health Record (iEHR) Increment 1	April 2015
U.S. Air Forces Central Command 2015	May 2015
U.S. Special Operations Command-Pacific Tempest Wind 2014	May 2015
North American Aerospace Defense Command and U.S. Northern Command Vigilant Shield 2015	July 2015
U.S. Pacific Fleet Valiant Shield 2014	July 2015
U.S. Africa Command Judicious Response 2015	August 2015
U.S. Southern Command Integrated Advance 2015	September 2015
Follow-on Operational Test and Evaluation Reports	
RQ-7BV2 Shadow Tactical Unmanned Aircraft System	December 2014
Global Combat Support System – Marine Corps (GCSS-MC) Increment 1	February 2015
Integrated Personnel and Pay System – Army (IPPS-A) Increment 1	March 2015
Initial Operational Test and Evaluation Reports	
Global Command and Control System – Maritime (GCCS-M) Increment 2 Version 4.1 Group Level	January 2015
QF-16 Full-Scale Aerial Target (FSAT)	January 2015
Consolidated Afloat Network and Enterprise Services (CANES) Program, Unit Level Ship	July 2015
Live Fire Test and Evaluation Reports	
HELLFIRE Romeo Missile Variant (AGM-114R-9E)	November 2014
MaxxPro DASH with Independent Suspension System (ISS) and MaxxPro Survivability Upgrade (MSU)	April 2015
Littoral Combat Ship (LCS) 3 Total Ship Survivability Trial (TSST)	August 2015
Joint Light Tactical Vehicle (JLTV)	August 2015
Operational Assessment Reports	
Key Management Infrastructure (KMI) Spiral 2, Spin 1	November 2014
Common Aviation Command and Control System (CAC2S) Phase 2	February 2015
GBU-53/B Small Diameter Bomb, Increment 2 (SDB II)	May 2015
Family of Advanced Beyond-Line-of-Sight Terminals (FAB-T)	July 2015
Defense Medical Information Exchange (DMIX) Release 2	August 2015
Joint Light Tactical Vehicle (JLTV)	August 2015
Operational Test and Evaluation Reports	
DOD Teleport Generation 3, Phases 1 and 2	November 2014
Global Command and Control System – Joint (GCCS-J) Global Release 4.3 Update 1	December 2014
Integrated Electronic Health Record (iEHR) Increment 1	February 2015

Program Oversight

DOT&E is responsible for approving the adequacy of plans for operational test and evaluation and for reporting the operational test results for all Major Defense Acquisition Programs to the Secretary of Defense, USD(AT&L), Service Secretaries, and Congress. For DOT&E oversight purposes, Major Defense Acquisition Programs were defined in the law to mean those programs meeting the criteria for reporting under Section 2430, Title 10, United States Code (USC) (Selected Acquisition Reports (SARs)). The law (sec.139(a)(2)(B)) also stipulates that DOT&E may designate any other programs for the purpose of oversight, review, and reporting. With the addition of such "non-major" programs, DOT&E was responsible for oversight of a total of 312 acquisition programs during FY15.

Non-major programs are selected for DOT&E oversight after careful consideration of the relative importance of the individual program. In determining non-SAR systems for oversight, consideration is given to one or more of the following essential elements:

- Congress or OSD agencies have expressed a high-level of interest in the program.
- Congress has directed that DOT&E assess or report on the program as a condition for progress or production.
- The program requires joint or multi-Service testing (the law (sec. 139(b)(4)) requires DOT&E to coordinate "testing conducted jointly by more than one military department or defense agency").
- The program exceeds or has the potential to exceed the dollar threshold definition of a major program according to DOD 5000.1, but does not appear on the current SAR list (e.g., highly-classified systems).
- The program has a close relationship to or is a key component of a major program.
- The program is an existing system undergoing major modification.
- The program was previously a SAR program and operational testing is not yet complete.

This office is also responsible for the oversight of LFT&E programs, in accordance with 10 USC 139. DOD regulation uses the term "covered system" to include all categories of systems or programs identified in 10 USC 2366 as requiring LFT&E. In addition, systems or programs that do not have acquisition points referenced in 10 USC 2366, but otherwise meet the statutory criteria, are considered "covered systems" for the purpose of DOT&E oversight.

A covered system, for the purpose of oversight for LFT&E, has been determined by DOT&E to meet one or more of the following criteria:

- A major system, within the meaning of that term in 10 USC 2302(5), that is:
  - User-occupied and designed to provide some degree of protection to the system or its occupants in combat
  - A conventional munitions program or missile program
- A conventional munitions program for which more than 1,000,000 rounds are planned to be acquired.
- A modification to a covered system that is likely to affect significantly the survivability or lethality of such a system.

DOT&E was responsible for the oversight of 122 LFT&E acquisition programs during FY15.

Programs Under DOT&E Oversight
Fiscal Year 2015
(As taken from the September 2015 DOT&E Oversight List)

DOD PROGRAMS

AC-130J

BMDS – Ballistic Missile Defense System Program

CHEM DEMIL-ACWA – Chemical Demilitarization Program – Assembled Chemical Weapons Alternatives

CHEM DEMIL-CMA – Chemical Demilitarization (Chem Demil) – Chemical Materials Agency (Army Executing Agent)

Common Analytical Laboratory System

Defense Agency Initiative (DAI)

Defense Enterprise Accounting and Management System – Increment 1 (DEAMS-Inc. 1)

Defense Medical Information Exchange (DMIX)

Defense Readiness Reporting System – Strategic

Defense Security Assistance Management System (DSAMS) – Block 3

DoD Healthcare Management System Modernization (DHMSM)

EDS – Explosive Destruction System

Enterprise Business Accountability System – Defense

DOD PROGRAMS (continued)

EProcurement

Global Combat Support System – Joint (GCSS-J)

Global Command & Control System – Joint (GCCS-J)

Joint Biological Tactical Detection System

Joint Chemical Agent Detector (JCAD)

Joint Command and Control Capabilities (JC2C) [Encompasses GCCS-FoS (GCCS-J, GCCS-A, GCCS-M, TBMCS-FL, DCAPES, GCCS-AF, USMC JTCW, USMC TCO]

Joint Information Environment

Joint Light Tactical Vehicle (JLTV)

Joint Warning and Reporting Network (JWARN)

Key Management Infrastructure (KMI) Increment 2

Mid-Tier Networking Vehicle Radio

milCloud

Modernized Intelligence Database (MIDB)

Modernized Intelligence Database (MIDB)

Multi-Functional Information Distribution System (includes integration into USAF & USN aircraft)

Next Generation Chemical Detector

Next Generation Diagnostic System Increment 1 (NGDS Inc 1)

Public Key Infrastructure (PKI) Increment 2

SOCOM Dry Combat Submersible Medium (DCSM)

Teleport, Generation III

Theater Medical Information Program – Joint (TMIP-J) Block 2

ARMY PROGRAMS

3rd Generation Improved Forward Looking Infrared (3rd Gen FLIR)

ABRAMS TANK MODERNIZATION – Abrams Tank Modernization (M1E3)

Abrams Tank Upgrade (M1A1 SA/M1A2 SEP)

Advanced Field Artillery Tactical Data System

Advanced Field Artillery Tactical Data System (AFATDS) Version 7

Advanced Multi-Purpose (AMP) 120 mm Tank Round

AH-64E Apache

Airborne and Maritime/Fixed Site Joint Tactical Radio System (AMF JTRS) Small Airborne Link 16 Terminal (SALT)

Airborne and Maritime/Fixed Site Joint Tactical Radio System (AMF JTRS) Small Airborne Networking Radio (SANR)

AMF Airborne & Maritime/Fixed Station

AN/PRC-117G Radio

AN/TPQ-53 Radar System (Q-53)

Armed Aerial Scout (previously named ARH Armed Recon Helicopter)

Armored Multipurpose Vehicle (AMPV)

Armored Truck – Heavy Dump Truck (HDT)

Armored Truck – Heavy Equipment Transporter (HET)

Armored Truck – Heavy Expanded Mobility Tactical Truck (HEMTT)

Armored Truck – M915A5 Line Hauler

Armored Truck – M939 General Purpose Truck

Armored Truck – Palletized Loading System (PLS)

Army Vertical Unmanned Aircraft System

Assured Precision, Navigation & Timing (Assured PNT)

Biometrics Enabling Capability (BEC) Increment 1

Biometrics Enabling Capability Increment 0

Black HAWK (UH-60M) – Utility Helicopter Program

Bradley Engineering Change Proposal (ECP) and Modernization

C-17 Increase Gross Weight (IGW) and reduced Formation Spacing Requirements (FSR) with T-11 parachute

CH-47F – Cargo Helicopter

Common Infrared Countermeasures (CIRCM)

Common Operating Environment

Common Remotely Operated Weapons System III

Department of Defense Automated Biometric Information System

Distributed Common Ground System – Army (DCGS-A)

EXCALIBUR – Family of Precision, 155 mm Projectiles

FBCB2 – Force XXI Battle Command Brigade and Below Program

FBCB2 – Joint Capability Release (FBCB2 - JCR)

Fixed-Wing Utility Aircraft

FMTV – Family of Medium Tactical Vehicles

Gator Landmine Replacement Program (GLRP)

General Fund Enterprise Business System (GFEBS)

Global Combat Support System – Army (GCSS-A)

Guided Multiple Launch Rocket System – Unitary (GMLRS Unitary)

Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS AW)

HELLFIRE Romeo

High Mobility Multipurpose Wheeled Vehicle (HMMWV)

HIMARS – High Mobility Artillery Rocket System

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Improved Turbine Engine Program

Indirect Fire Protection Capability Increment 2 – Intercept

Integrated Air and Missile Defense (IAMD)

Integrated Personnel and Pay System – Army (Army IPPS) Increment 1

Integrated Personnel and Pay System – Army (IPPS-A) Increment 2

Interceptor Body Armor

Javelin Antitank Missile System – Medium

Joint Air-to-Ground Missile

ARMY PROGRAMS (continued)

Joint Assault Bridge
Joint Battle Command Platform (JBC-P)
Joint Future Theater Lift Concept (JFTLC)
Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
Joint Tactical Networks (JTN)
Logistics Modernization Program (LMP)
Long Range Precision Fires (LRPF)
M270A1 Multiple Launch Rocket System (MLRS)
M829E4
Modernized Expanded Capacity Vehicle (MECV) – Survivability Project
Modular Handgun System (MHS)
MQ-1C Unmanned Aircraft System Gray Eagle
Near Real Time Identity Operations
Nett Warrior
One System Remote Video Terminal
Paladin/FASSV Integrated Management (PIM)
PATRIOT PAC-3 – Patriot Advanced Capability 3 (Missile only)
PATRIOT/MEADS – Patriot/Medium Extended Air Defense System
RQ-11B Raven – Small Unmanned Aircraft System
RQ-7B SHADOW – Tactical Unmanned Aircraft System
Soldier Protection System
Spider XM7 Network Command Munition
STRYKER ECP – STRYKER Engineering Change Proposal
Stryker M1126 Infantry Carrier Vehicle including Double V-Hull variant
Stryker M1127 Reconnaissance Vehicle
Stryker M1128 Mobile Gun System
Stryker M1129 Mortar Carrier including the Double V-Hull variant
Stryker M1130 Commander's Vehicle including the Double V-Hull Variant
Stryker M1131 Fire Support Vehicle Including the Double V-Hull Variant
Stryker M1132 Engineer Squad Vehicle Including the Double V-Hull Variant
Stryker M1133 Medical Evacuation Vehicle Including the Double V-Hull Variant
Stryker M1134 ATGM Vehicle Including the Double V-Hull Variant
Stryker M1135 NBC Reconnaissance Vehicle (NBCRV)
Tactical Mission Command
Tactical Radio System Manpack
Tactical Radio System Rifleman Radio
UH-60V Black HAWK
UH-72A Lakota Light Utility Helicopter
WIN-T INCREMENT 1 – Warfighter Information Network – Tactical Increment 1
WIN-T INCREMENT 2 – Warfighter Information Network – Tactical Increment 2
WIN-T INCREMENT 3 – Warfighter Information Network – Tactical Increment 3
WIN-T INCREMENT 4 – Warfighter Information Network – Tactical Increment 4
XM1156 Precision Guidance Kit (PGK)
XM1158 7.72 mm Cartridge
XM25, Counter Defilade Target Engagement (CDTE) System
XM395 Accelerated Precision Mortar Initiative (APMI)

NAVY PROGRAMS

Acoustic Rapid COTS Insertion for SONAR
Advanced Airborne Sensor
Advanced Extremely High Frequency Navy Multiband Terminal Satellite Program (NMT)
AEGIS Modernization (Baseline Upgrades)
AGM-88E Advanced Anti-Radiation Guided Missile
AH-1Z
AIM-9X – Air-to-Air Missile Upgrade Block II
Air and Missile Defense Radar (AMDR)
Air Warfare Ship Self Defense Enterprise
Airborne Laser Mine Detection System (AN/AES-1) (ALMDS)
Airborne Mine Neutralization System (AN/ASW-235) (AMNS)
Airborne Resupply/Logistics for Seabasing
Amphibious Assault Vehicle Upgrade
Amphibious Combat Vehicle (ACV)
AN/APR-39 Radar Warning Receiver
AN/AQS-20 Minehunting Sonar (all variants)
An/BLQ-10 Submarine Electronics Support Measures
AN/SQQ-89A(V) Integrated USW Combat Systems Suite
Assault Breaching System Coastal Battlefield Reconnaissance and Analysis System Block I
Assault Breaching System Coastal Battlefield Reconnaissance and Analysis System Block II
CANES – Consolidated Afloat Networks and Enterprise Services
CH-53K – Heavy Lift Replacement Program
Close-In Weapon System (CIWS) including SEARAM
COBRA JUDY REPLACEMENT – Ship-based radar system
Common Aviation Command and Control System (CAC2S)
Cooperative Engagement Capability (CEC)
Countermeasure Anti-Torpedo
CVN-78 – *GERALD R. FORD* CLASS Nuclear Aircraft Carrier

NAVY PROGRAMS (continued)

DDG 1000 – *ZUMWALT* CLASS Destroyer – includes all supporting PARMs and the lethality of the LRLAP and 30 mm ammunition

DDG 51 – *ARLEIGH BURKE* CLASS Guided Missile Destroyer – includes all supporting PARMs

DDG 51 Flight III – *ARLEIGH BURKE* CLASS Guided Missile Destroyer– includes all supporting PARMs

Department of Navy Large Aircraft Infrared Countermeasures Program

Distributed Common Ground System – Navy (DCGS-N)

Distributed Common Ground System – Marine Corps (DCGS-MC)

E-2D Advanced Hawkeye

EA-18G – Airborne Electronic Attack

Electro-Magnetic Aircraft Launching System

Enhanced Combat Helmet

Enterprise Air Surveillance Radar (EASR) (replacement for SPS-48 and SPS-49 air surveillance radars)

Evolved Sea Sparrow Missile (ESSM)

Evolved Sea Sparrow Missile Block 2

F/A-18E/F – SUPER HORNET Naval Strike Fighter

Future Pay and Personnel Management Solution (FPPS)

Global Combat Support System – Marine Corps (GCSS-MC)

Ground/Air Task Oriented Radar (G/ATOR)

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Infrared Search and Track System

Integrated Defensive Electronic Countermeasures

Joint and Allied Threat Awareness System

Joint High Speed Vessel (JHSV)

JOINT MRAP – Joint Mine Resistant Ambush Protected Vehicles FOV – including SOCOM vehicles

Joint Precision Approach and Landing System

Joint Stand-Off Weapon C-1 variant (JSOW C-1)

KC-130J

Landing Ship Dock Replacement (LX(R))

Large Displacement Unmanned Undersea Vehicle

LCS Surface Warfare Mission Package Increment 3 – Interim Surface to Surface Missile including Longbow Hellfire Missile (or other candidate missiles and their warheads)

LHA 6 – *AMERICA* CLASS – Amphibious Assault Ship – includes all supporting PARMs

LHA 8 Amphibious Assault Ship (America Class with well deck)

Light Armored Vehicle

Light Weight Tow Torpedo Countermeasure (part of LCS ASW Mission Module)

Littoral Combat Ship (LCS) – includes all supporting PARMs, and 57 mm lethality

Littoral Combat Ship Mission Modules including 30 mm

Littoral Combat Ship Surface-to-Surface Missile (follow on to the interim SSM)

Littoral Combat Ship Variable Depth Sonar (LCS VDS)

Logistics Vehicle System Replacement

LPD 17 – *SAN ANTONIO* CLASS – Amphibious Transport Dock Ship – includes all supporting PARMs and 30 mm lethality

LSD 41/49 Replacement

Marine Personnel Carrier

Medium Tactical Vehicle Replacement Program (USMC) (MTVR)

MH-60R Multi-Mission Helicopter Upgrade

MH-60S Multi-Mission Combat Support Helicopter

MK 54 torpedo/MK – 54 VLA/MK 54 Upgrades Including High Altitude ASW Weapon Capability (HAAWC)

MK-48 CBASS Torpedo including all upgrades

Mobile Landing Platform (MLP) Core Capability Set (CCS) Variant and MLP Afloat Forward Staging Base (AFSB) Variant

Mobile User Objective System (MUOS)

MQ-4C Triton

MQ-8 Fire Scout Unmanned Aircraft System

Multi-static Active Coherent (MAC) System CNO project 1758

Naval Integrated Fire Control – Counter Air (NIFC-CA) From the Air

Naval Integrated Fire Control – Counter Air (NIFC-CA) From the Sea

Navy Enterprise Resource Planning (ERP)

Next Generation Jammer

Offensive Anti-Surface Warfare Increment 1

Offensive Anti-Surface Warfare, Increment 2

OHIO Replacement Program (Sea-based Strategic Deterrence) – including all supporting PARMs

OSPREY MV-22 – Joint Advanced Vertical Lift Aircraft

P-8A Poseidon Program

Remote Minehunting System (RMS)

Replacement Oiler

Rolling Airframe Missile (RAM) including RAM Block 1A Helicopter Aircraft Surface (HAS) and RAM Block 2 Programs

RQ-21A Unmanned Aircraft System (UAS)

Ship Self Defense System (SSDS)

Ship to Shore Connector

Small Surface Combatant (also called the Frigate modification to the Littoral Combat Ship variants) including the Anti-Submarine and Surface Warfare component systems

SSN 774 *VIRGINIA* Class Submarine

SSN 784 *VIRGINIA* Class Block III Submarine

Standard Missile 2 (SM-2) including all mods

Standard Missile-6 (SM-6)

Submarine Torpedo Defense System (Sub TDS) including countermeasures and Next Generation Countermeasure System (NGCM)

Surface Electronic Warfare Improvement Program (SEWIP) Block 2

Surface Electronic Warfare Improvement Program (SEWIP) Block 3

NAVY PROGRAMS (continued)

Surface Mine Countermeasures Unmanned Undersea Vehicle (also called Knifefish UUV) (SMCM UUV)

Surveillance Towed Array Sonar System/Low Frequency Active (SURTASS/LFA) including Compact LFA (CLFA)

Tactical Tomahawk upgrade (includes changes to planning and weapon control system)

Torpedo Warning System (Previously included with Surface Ship Torpedo Defense System) including all sensors and decision tools

TRIDENT II MISSILE – Sea Launched Ballistic Missile

UH-1Y

Unmanned Carrier Launched Airborne Surveillance and Strike System

Unmanned Influence Sweep System (UISS) include Unmanned Surface Vessel (USV) and Unmanned Surface Sweep System (US3)

USMC MRAP-Cougar

VH-92 – Presidential Helicopter Fleet Replacement Program

AIR FORCE PROGRAMS

20 mm PGU-28/B Replacement Combat Round

Advanced Pilot Trainer

AEHF – Advanced Extremely High Frequency (AEHF) Satellite Program

AFNet Modernization capabilities (Bitlocker, Data at Rest (DaR), Situational Awareness Modernization (SAMP))

AFNET Vulnerability Management (AFVM) – Assured Compliance Assessment Solution (ACAS)

AIM-120 Advanced Medium-Range Air-to-Air Missile

Air Force Distributed Common Ground System (AF-DCGS)

Air Force Integrated Personnel and Pay System (AF-IPPS)

Air Force Organic Depot Maintenance, Repair and Overhaul Initiative (MROi)

Air Operations Center – Weapon System (AOC-WS) initiatives including 10.0 and 10.1

Air Operations Center – Weapon System (AOC-WS) initiative 10.2

Airborne Signals Intelligence Payload (ASIP) Family of Sensors

Airborne Warning and Control System Block 40/45 Computer and Display Upgrade

B-2 Defensive Management System Modernization (DMS)

B-2 Extremely High Frequency SATCOM and Computer Increment 1

B-2 Extremely High Frequency SATCOM and Computer Increment 2

B61 Mod 12 Life Extension Program

Battle Control System – Fixed (BCS-F) 3.2

C-130J – HERCULES Cargo Aircraft Program

Cobra Judy Replacement Mission Planning Tool

Combat Rescue Helicopter (CRH)

Command and Control Air Operations Suite (C2AOS)/Command and Control Information Services (C2IS) (Follow-on to Theater Battle Management Core Systems)

ECSS – Expeditionary Combat Support System

Enclave Control Node (ECN)

EPS – Enhanced Polar System

F-15 Eagle Passive Active Warning Survivability System

F-22 – RAPTOR Advanced Tactical Fighter

F-35 – Lightning II Joint Strike Fighter (JSF) Program

FAB-T – Family of beyond Line-of-Sight Terminals

Full Scale Aerial Target

GBS – Global Broadcast Service

Geosynchronous Space Situational Awareness Program

GPS OCX – Global Positioning Satellite Next Generation Control Segment

GPS-IIIA – Global Positioning Satellite III

Hard Target Munition

Identification Friend or Foe Mark XIIA Mode 5 (all development and integration programs)

Integrated Strategic Planning and Analysis Network (ISPAN) Increment 2

Integrated Strategic Planning and Analysis Network (ISPAN) Increment 4

Joint Air-to-Surface Standoff Missile Extended Range

Joint Space Operations Center Mission System (JMS)

JSTARS Recapitalization

KC-46 – Tanker Replacement Program

Long Range Stand Off (LRSO) Weapon

Long Range Strike Bomber

Massive Ordnance Penetrator (MOP)

Military GPS User Equipment (GPS MGUE)

Miniature Air Launched Decoy – Jammer (MALD-J)

MQ-9 REAPER – Unmanned Aircraft System

Multi-Platform Radar Technology Insertion Program

NAVSTAR Global Positioning System (GPS) (Includes Satellites, Control and User Equipment)

OSPREY CV-22 – Joint Advanced Vertical Lift Aircraft

Presidential Aircraft Recapitalization

Presidential National Voice Conferencing

RQ-4B Block 30 – High Altitude Endurance Unmanned Aircraft System

RQ-4B Block 40 Global Hawk – High Altitude Long Endurance Unmanned Aircraft System

SBIRS HIGH – Space-Based Infrared System Program, High Component

SBSS B10 Follow-on – Space-Based Space Surveillance Block 10 Follow-on

SF – Space Fence

SIPRNET Modernization

Small Diameter Bomb, Increment II

Three-Dimensional Expeditionary Long-Range Radar

Weather Satellite Follow-on (WSF)

Wide Area Surveillance (WAS) Program

Problem Discovery Affecting OT&E

Overview

Operational testing of new acquisition programs frequently identifies new and significant problems missed in earlier program development, but it can also find issues known prior to testing that were unaddressed. The latter category is especially problematic, as delays in addressing these problems only exacerbate the cost and time required to fix them. Since 2011, my annual report has documented both categories of problems and the extent to which they exist in programs undergoing operational tests. This year, as in previous years, examples of both were present. Highlighting each of these types of problems is valuable, as the different natures of these categories offer insights into the actions needed to field weapons that work.

Discovering problems during operational testing is crucial for those problems to be corrected prior to the deployment and use of a system in combat. In many cases, an operational environment or user is necessary to uncover the problem, as in the Follow-on Operational Test and Evaluation (FOT&E) of Department of the Navy Large Infrared Countermeasures (DoN LAIRCM) on the CH-53E helicopter, where it was found that cycling the power to reset system faults could put the aircrew at risk during a combat mission for an extended time. Although the system technical manuals contained the times needed for each activity in the power-cycling sequence, it required operationally realistic testing to reveal how the combination of various times could affect a combat mission.

Realistic operational testing can also identify the full implications of problems seen during developmental testing for success in combat. This was true in the case of Ship Self Defense System (SSDS) MK 2, in which problems had been observed in contractor testing prior to the operational test event, but correcting these problems was not considered a high priority until operational test results showed the potential for these problems to result in missed cruise missile engagements.

The discussion below provides an overview of the problems discovered in FY15 during analyses of operational test events. Detailed accounts of the discovered problems can be found in corresponding individual program write-ups in this report. I also list 48 programs that presented significant problems during early testing. If left uncorrected, these deficiencies could affect my evaluation of operational effectiveness, suitability, or survivability. At the conclusion of this section, I report on the progress of the problems reported in my FY14 Annual Report.

The results of problem discovery in FY15 are shown in Figure 1. There were 134 programs on the DOT&E oversight list that planned or conducted operational testing between FY15 – FY17. Of those, 66 programs had a total of 75 operational tests this year (some programs had more than one phase of testing this year). About one-third (27/75) of the operational tests conducted this year had no significant problem discovery, while nearly two-thirds (48/75) revealed problems significant enough to adversely affect my evaluation of the system's operational effectiveness, suitability, or survivability. Almost 40 percent (29/75) of these operational tests discovered significant problems that were unknown prior to operational testing.

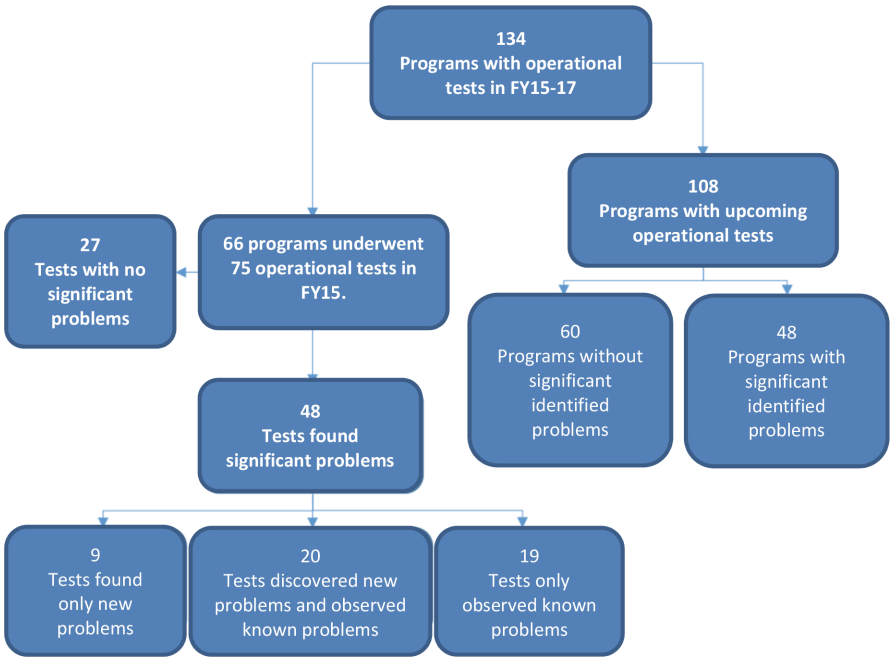


FIGURE 1. PROGRAMS/OPERATIONAL TESTS UNDER OVERSIGHT IN FY15 WITH IDENTIFIED PROBLEMS

(Note: Programs with testing in FY15 and upcoming testing in FY16-17 may be counted more than once if there were multiple test events. All counts exclude some classified and chemical demilitarization programs.)

Figure 2 shows the distribution of the types of significant problems found during operational testing (effectiveness, suitability, survivability) according to whether the problem was known prior to the operational test. The majority of the problems (including 75 percent of effectiveness problems) were known going into operational testing. Many programs proceeded to operational testing with known problems because they planned to address the problems later. An example of this was the P-8A Increment 2 Engineering Change Proposal (ECP) 1, which did not meet its wide-area Anti-Submarine Warfare search requirement in some environments because of known limitations in its Multi-static Active Coherent (MAC) sonobuoy system; the Navy plans to improve P-8A's performance with upgrades fielded as part of Increment 2 ECP 2 in FY17.

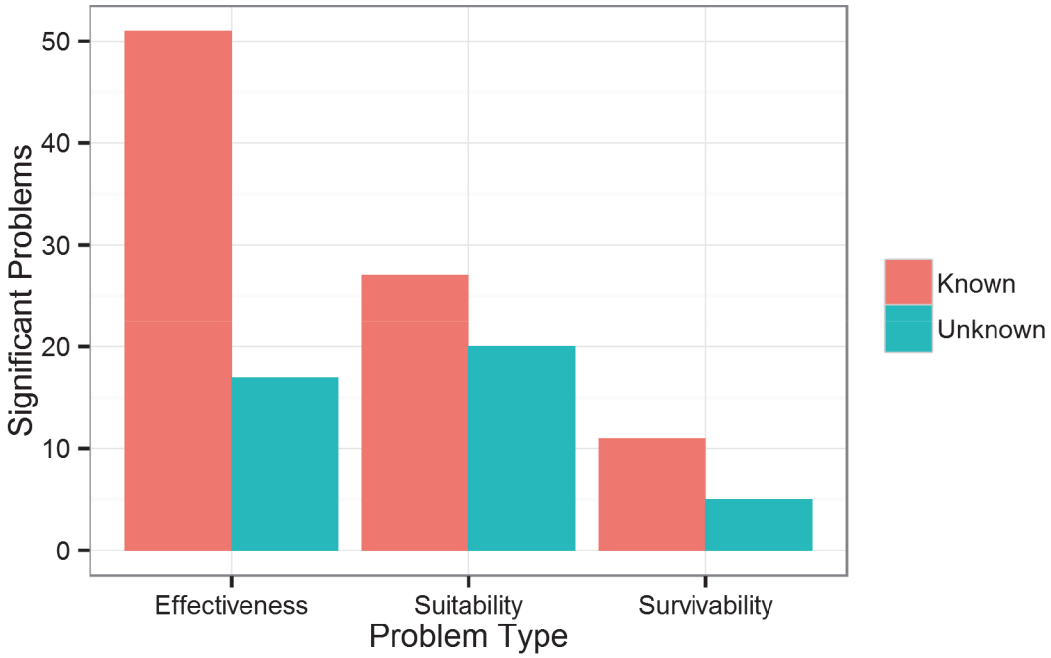


FIGURE 2. BREAKDOWN OF PROBLEMS BY TYPE AND WHETHER THEY WERE KNOWN PRIOR TO OPERATIONAL TESTING

Often, the realistic environment of operational testing provided new insights into problems even if they were known previously. Sometimes the scope of a problem was not understood until the system operated in a realistic operational test environment against realistic threats, as in the SSDS example above. Another example of this case occurred with the electro-optical/infrared (EO/IR) system installed on the *Independence* variant of the Littoral Combat Ship (LCS) for 57 mm gun engagements. Although developmental testing revealed the significant update rate and tracking performance problems, the full impact of these deficiencies was only realized in the operational test environment. In operational testing, these problems, combined with poor bearing accuracy and an unwieldly operator interface, forced the crew to supplement the watch team with a dedicated operator for the sensor. Even with this unsustainable manning arrangement, the ship was only able to achieve modest gun performance, expending excessive amounts of ammunition against a single target.

In other cases, a problem was rediscovered after the program thought it was fixed, either because a technical fix did not perform as expected or because operational testing discovered that workarounds for a known problem were impractical or not effective in an operational environment. As an example, the operational availability of the Twin-Boom Extensible Crane (TBEC) used by the *Independence* variant LCS to launch and recover watercraft is degraded by equipment failures and the crew's limited capability to diagnose problems and repair the system when it fails. Without the TBEC, the LCS is unable to launch and recover boats needed to support Maritime Security Operations or Special Operations Force missions, or the Remote Multi-Mission Vehicle (RMMV) needed to conduct Mine Countermeasures (MCM) missions. Following initial observation of TBEC problems, the Program Office worked with the vendor to improve system operability and refined shipboard operating procedures, which resulted in some improvement in watercraft launch and recovery operations. However, there have been continuing problems with the ability of the ship's crew and Navy repair activities to diagnose problems and effect repairs without the assistance of the original equipment manufacturer.

Finally, in other cases, a problem was thought to be an isolated occurrence until it re-occurred again in operational testing, as in the case of the Integrated Defensive Electronic Countermeasures (IDECM) program. Serious suitability problems (cabin pressure problems and avionics cooling air "degrades" were seen at about 20,000 feet in altitude) for IDECM on the F/A-18C/D platform were discovered during integrated test, but were thought to be isolated problems. Later FOT&E re-observed the problems on three jets, suggesting that the issues were widespread.

New problems discovered in operational testing tended to cluster into several categories. New suitability problems were typically caused by low reliability once placed in an operational environment (7/20), training and documentation issues (7/20), or usability problems that prevented operators from successfully using a system (2/20). Other suitability problems included logistics and software deficiencies. New effectiveness problems primarily resulted from unexpectedly low performance in an operational environment or against a stressing threat. Survivability problems uncovered in FY15 operational tests were all cybersecurity vulnerabilities (5/5), which are harder to uncover in developmental testing. (Cybersecurity testing in operational testing consists of Cooperative Vulnerability Penetration Assessments (CVPAs) and Adversarial Assessments (AAs).)

Figure 3 further breaks down the number of significant problems discovered per operational test by each of the Services. Marine Corps tests are included with Navy; Special Operations Command and the Defense Agencies are grouped into a fourth category. In some cases, outliers have distorted the overall average. For example, in Navy operational tests this year, the LCS and the SSDS experienced many significant problems. These are documented in the individual write-ups for these programs. LCS, in particular, revealed nine significant problems in each of the two operational tests for the *Freedom* and *Independence* variants. Effectiveness problems, such as those described above, include surface warfare capabilities, air defense capabilities, and basic ship functions, such as fuel endurance and boat handling equipment. The 18 problems for LCS also include significant suitability problems with the reliability of such systems as the propulsion and cooling systems, as well as survivability and cybersecurity problems, the latter only being counted once for each ship variant despite the existence of numerous deficiencies in the architecture of the shipboard networks.

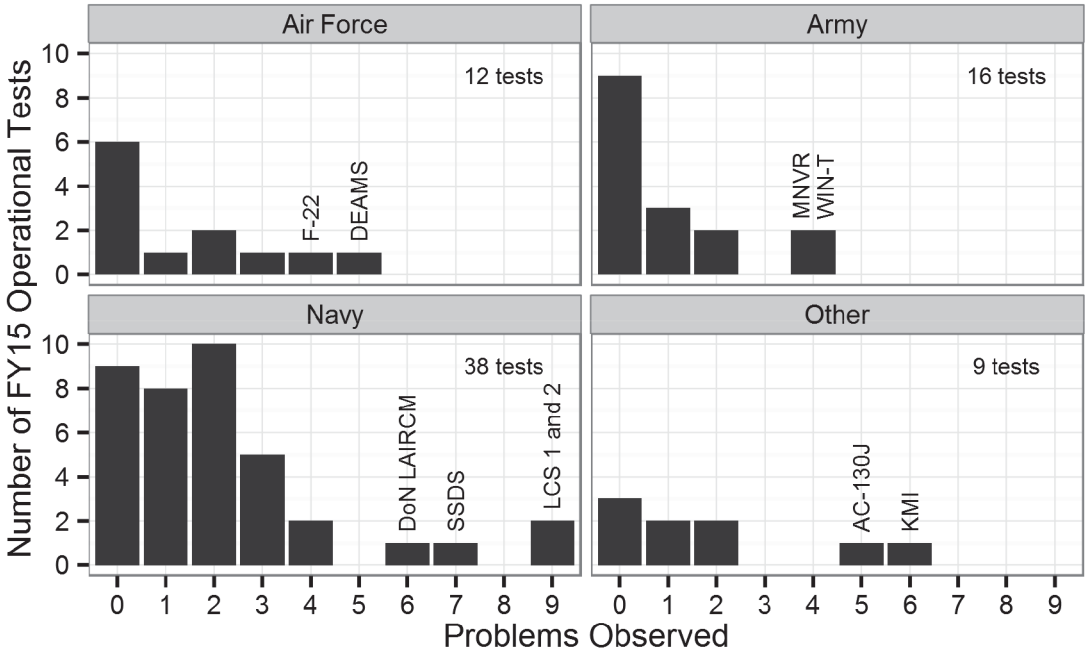


FIGURE 3. HISTOGRAM SHOWING THE NUMBER OF PROBLEMS OBSERVED IN EACH PROGRAM, BY SERVICE. PROGRAMS WITH THE MOST PROBLEMS FROM EACH SERVICE ARE LABELED.
(Note: Navy includes the Marine Corps; Other includes the U.S. Special Operations Command, Missile Defense Agency, Defense Logistics Agency, Defense Information Systems Agency, and National Security Agency.)

With the exception of these outliers, the histograms in Figure 3 show that, in general, the Services experience similar trends in the number of problems observed while conducting operational testing. Fortunately, few programs experienced large numbers of problems in operational testing. It is also noteworthy that each of the Services experienced tests with no problems (Air Force 6/12, Army 9/16, Navy (and Marine Corps) 9/38); even in these cases, the operational testing was essential to confirm that users will be able to employ these systems in realistic conditions and not be plagued by significant problems.

Tables 1 and 2 list the 75 operational tests discussed in this year's annual report. Each row provides the name of the system and operational test, and indicates which categories of problems were observed; for details on the problems observed, see individual system write-ups in this report.

TABLE 1. OPERATIONAL TESTS (OT) IN FY15 WITH NO SIGNIFICANT PROBLEM DISCOVERY	
System Name	**OT Name**
AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) (pg. 315)	AMRAAM Basic Electronic Protection Improvement Program (EPIP) OT
AMRAAM	AMRAAM System Improvement Program (SIP-1) OT
Ballistic Missile Defense System (BMDS) (pg. 357)	BMDS Flight Test-Operational (FTO)-02
Common Aviation Command and Control System (CAC2S) (pg. 175)	CAC2S Increment I OA
Consolidated Afloat Networks and Enterprise Services (CANES) (pg. 179)	CANES Force-Level FOT&E
CANES	CANES Unit-Level IOT&E
Distributed Common Ground System – Army (DCGS-A) (pg. 107)	DCGS-A Increment 1 Release 2 FOT&E
E-2D Advanced Hawkeye (AHE) (pg. 199)	E-2D AHE FOT&E
EA-18G Growler (pg. 201)	H10 Software Configuration Set FOT&E
Global Combat Support System – Army (GCSS-Army) (pg. 109)	LSVT 2015
Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) XM30E1 (pg. 113)	GMLRS-AW FOT&E
Integrated Personnel and Pay System – Army (IPPS-A) (pg. 117)	IPPS-A Increment 1 FOT&E
Joint Light Tactical Vehicle (JLTV) (pg. 125)	JLTV LUT (an operational assessment)
Light Armored Vehicle – Anti-Tank Modernization (LAV-ATM) (pg. 223)	LAV-ATM OA
KC-46A (pg. 337)	KC-46A OA-2
Massive Ordnance Penetrator (MOP) (pg. 341)	Enhanced Threat Reduction Phase 2 OA
Mine Resistant Ambush Protected Vehicles (MRAP) (pg. 137)	Long Wheel Base (LWB) Ambulance LUT (an operational assessment)
Naval Integrated Fire Control – Counter Air (NIFC-CA) From the Sea (FTS) (pg. 163, 181)	AWS 9A/CEC/ NIFC-CA FTS DT/OT
Nett Warrior (pg. 143)	Nett Warrior IOT&E
One System Remote Video Terminal (OSRVT) (pg. 145)	OSRVT IOT&E
Precision Guidance Kit (PGK) (pg. 149)	PGK IOT&E
QF-16 Full-Scale Aerial Target (FSAT) (pg. 349)	QF-16 IOT&E
Standard Missile-6 (SM-6) (pg. 299)	SM-6 Block I FOT&E

DT – Developmental Test
FOT&E – Follow-on Operational Test and Evaluation
IOT&E – Initial Operational Test and Evaluation
LSVT– Lead Site Verification Test
LUT – Limited User Test
OA – Operational Assessment
OT – Operational Test

TABLE 2. OPERATIONAL TESTS IN FY15 WITH DISCOVERY OF SIGNIFICANT PROBLEMS				
System Name	Operational Test	Effectiveness	Suitability	Survivability
AC-130J Ghostrider (pg. 309)	AC-130J Block 10 OA	X	X	X
Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) for AN/BQQ-10(V) Sonar (pg. 159)	A-RCI Advanced Processing Build 2011 (APB-11) Phase 2 FOT&E	X	X	
Aegis Modernization Program (pg. 163)	Aegis Weapon System (AWS) 9A (Cruiser (CG)/Cooperative Engagement Capability (CEC)/Navy Integrated Fire Control – Counter Air (NIFC-CA) DT/OT	X	X	X
Aegis Modernization Program	AWS 9A (CG) OT	X		
Aegis Modernization Program	AWS 9C (Destroyer (DDG) OT	X	X	
AIM-9X Air-to-Air Missile Upgrade (pg. 169)	AIM-9X Block II IOT&E		X	
Air Force Distributed Common Ground System (AF DCGS) (pg. 317)	Geospatial Intelligence (GEOINT) Baseline (GB) 4.1 FDE Phase 1	X	X	
Air Operations Center – Weapon System (AOC-WS) (pg. 321)	AOC-WS 10.1 Recurring Event (RE) 13 OT	X	X	X
Airborne Mine Neutralization System (AMNS; under LCS and MH-60S) (pg. 225, 249)	MH-60S with AMNS Phase B OA and concurrent LCS Mine Countermeasures (MCM) Mission Package (MP) DT	X		
AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite (pg. 171)	Advanced Capability Build (ACB) 11 Pre-IOT&E		X	
Q-53 Counterfire Target Acquisition Radar System (pg. 151)	Q-53 IOT&E(2)	X		
Ballistic Missile Defense System (BMDS) (pg. 357)	Aegis BMD 4.0 IOT&E	X		
Countermeasure Anti-Torpedo (CAT) (under Surface Ship Torpedo Defense (SSTD)) (pg. 303)	SSTD QRA aboard CVN 71	X	X	
CV-22 Osprey (pg. 325)	Suite of Integrated Radio Frequency Countermeasures Block 8 FDE	X		
CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier (pg. 183)	CVN 78 OTB4 OA	X	X	
Defense Agencies Initiative (DAI) (pg. 25)	DAI Increment 2 Release 1 OA			
Defense Enterprise Accounting and Management System (DEAMS) (pg. 327)	DEAMS Release 3 IOT&E	X	X	X
Defense Medical Information Exchange (DMIX) (pg. 27)	DMIX Release 2 OA	X		X
Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM) (pg. 197)	DoN LAIRCM Advanced Threat Warning (ATW) FOT&E on CH-53E	X	X	
F-22A Advanced Tactical Fighter (pg. 331)	F-22A Increment 3.2A FOT&E	X		X
F/A-18E/F Super Hornet (pg. 201)	Super Hornet FOT&E	X	X	
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) (pg. 335)	FAB-T OA-1	X		
Global Combat Support System – Marine Corps (GCSS-MC) (pg. 203)	GCSS-MC Release 1.1.1 FOT&E	X	X	
Global Command and Control System – Joint (GCCS-J) (pg. 83)	GCCS-J Global Release 4.3 Update 1 OT&E			X
Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) M30E1 (pg. 113)	GMLRS-AW IOT&E	X		
H-1 Upgrades – U.S. Marine Corps Upgrade to AH-1Z Attack Helicopter and UH-1Y Utility Helicopter (pg. 205)	H-1 Upgrades OT-IIIC FOT&E	X	X	
Infrared Search and Track (IRST) (pg. 207)	IRST OA 1	X		
Integrated Defensive Electronic Countermeasures (IDECM) (pg. 209)	IDECM Block 4 FOT&E	X	X	
Integrated Personnel and Pay System – Army (IPPS-A) (pg. 117)	IPPS-A Adversarial Assessment			X
Joint High Speed Vessel (JHSV) (Expeditionary Fast Transport) (pg. 213)	JHSV FOT&E	X	X	
Joint Warning and Reporting Network (JWARN) (pg. 91)	Navy FOT&E for JWARN Increment 1	X	X	

TABLE 2. OPERATIONAL TESTS IN FY15 WITH DISCOVERY OF SIGNIFICANT PROBLEMS (CONTINUED)				
System Name	**Operational Test**	**Effectiveness**	**Suitability**	**Survivability**
Key Management Infrastructure (KMI) Increment 2 (pg. 93)	KMI Spiral 2 Spin 1 LUT (an operational assessment)		X	
KMI Increment 2	KMI Spiral 2 Spin 1 LUT Retest (an operational assessment)		X	
KMI Increment 2	KMI Spiral 2 Spin 1 OA		X	
LHA 6 New Amphibious Assault Ship (formerly LHA(R)) (pg. 219)	LHA 6 IOT&E	X	X	
Littoral Combat Ship (LCS) (*Freedom* Class) (pg. 225)	*Freedom* Class LCS with Increment 2 Surface Warfare (SUW) mission package OT	X	X	X
LCS (*Independence* Class) (pg. 225)	*Independence* Class LCS with Increment 2 SUW mission package	X	X	X
MH-60R Multi-Mission Helicopter (pg. 247)	LAU-61G/A Digital Rocket Launcher QRA	X		
Mid-Tier Networking Vehicular Radio (MNVR) (pg. 135)	MNVR and Joint Enterprise Network Manager (JENM) LUT (an operational assessment)	X		X
Miniature Air-Launched Decoy (MALD) and MALD – Jammer (MALD-J) (pg. 343)	MALD-J FDE	X	X	
Mobile Landing Platform (MLP) Core Capability Set (CCS) (Expeditionary Transfer Dock) and Afloat Forward Staging Base (AFSB) (Expeditionary Mobile Base) (pg. 255)	MLP CCS IOT&E	X		
MQ-1C Unmanned Aircraft System Gray Eagle (pg. 145)	Gray Eagle FOT&E	X		X
MV-22 Osprey (pg. 67)	MV-22B OT-IIIK FOT&E	X	X	
P-8A Poseidon Multi-Mission Maritime Aircraft (MMA) (pg. 269)	P-8A Increment 2 Engineering Change Proposal (ECP) 1 FOT&E	X		
Surface Electronic Warfare Improvement Program (SEWIP) Block 2 (pg. 301)	SEWIP Block 2 IOT&E (Phase 1)	X	X	
Ship Self-Defense System (SSDS) (pg. 287)	SSDS FOT&E	X		
Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar (pg. 307)	SURTASS/CLFA IOT&E	X		X
Torpedo Warning System (TWS) (as part of Surface Ship Torpedo Defense (SSTD)) (pg. 303)	SSTD QRA aboard CVN 71		X	
SSN 784 *Virginia* Class Block III Submarine (pg. 295)	*Virginia* Block III Early Fielding Certification Event	X	X	
Warfighter Information Networking – Tactical (WIN-T) (pg. 155)	WIN-T Increment 2 FOT&E 2	X	X	X

DT – Developmental Test
FDE – Force Development Evaluation
FOT&E – Follow-on Operational Test and Evaluation
IOT&E – Initial Operational Test and Evaluation
LUT – Limited User Test
MOT&E – Multi-Service Operational Test and Evaluation
OA – Operational Assessment
OT – Operational Test
OT&E – Operational Test and Evaluation
QRA – Quick Reaction Assessment

There are 108 operational tests scheduled to begin in the next two fiscal years, and I am aware of significant problems, that if not corrected, may adversely affect my evaluation of the system's effectiveness, suitability, or survivability in 48 of these systems. Table 3 lists the upcoming operational tests for systems discussed in this year's annual report (see individual system write-ups in this report for details on the problems). Table 4 lists the upcoming operational tests for systems that do not have entries in this year's report. For these systems, I provide a brief description of the problems below the table.

TABLE 3. PROGRAMS IN THIS ANNUAL REPORT WITH PROBLEMS THAT MAY ADVERSELY AFFECT UPCOMING OPERATIONAL TESTING

System Name	Upcoming Test	Effectiveness	Suitability	Survivability
AC-130J Ghostrider (pg. 309)	AC-130J Block 10 IOT&E	X	X	X
Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) for AN/BQQ-10(V) Sonar (pg. 159)	A-RCI Advanced Processing Build 2013 (APB-13) FOT&E	X	X	
Aegis Modernization Program (pg. 163)	Aegis Weapon System (AWS) 9C OT (DDG)	X	X	
AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) (pg. 167)	AARGM Block 1 Upgrade FOT&E	X		
Air Force Distributed Common Ground System (AF DCGS) (pg. 317)	Geospatial Intelligence (GEOINT) Baseline (GB) 4.1 FDE Phase 2	X	X	
Air Operations Center – Weapon System (AOC-WS) (pg. 321)	AOC-WS 10.2 OA	X		
Airborne Laser Mine Detection System (ALMDS; under LCS and MH-60S) (pg. 225, 249)	Combined MH-60S with ALMDS Block I and LCS Mine Countermeasures (MCM) mission package Increment 1 OT&E	X	X	
Airborne Mine Neutralization System (AMNS; under LCS and MH-60S) (pg. 225, 249)	Combined MH-60S with AMNS Block I and LCS MCM mission package Increment 1 OT&E	X	X	
AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite (pg. 171)	Continued Advanced Capability Build (ACB) 11 IOT&E		X	
Ballistic Missile Defense System (BMDS) (pg. 357)	Aegis BMD 5.0 Capability Upgrade (CU) OT	X		
CH-53K – Heavy Lift Replacement Program (pg. 173)	CH-53K OT-B1 OA		X	
Countermeasure Anti-Torpedo (CAT) (under Surface Ship Torpedo Defense (SSTD)) (pg. 303)	Salvo Capability QRA	X	X	
CV-22 Osprey (pg. 325)	Operational Utility Evaluation (OUE) of the CV-22 Tactical Software Suite 20.2.02/20.2.03	X	X	X
Defense Enterprise Accounting and Management System (DEAMS) (pg. 327)	DEAMS Inc 1 FOT&E	X	X	X
Defense Medical Information Exchange (DMIX) (pg. 27)	DMIX Release 3 IOT&E	X		X
Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM) (pg. 197)	DoN LAIRCM Advanced Threat Warning (ATW) QRA on MV-22	X	X	
F-22A Advanced Tactical Fighter (pg. 331)	F-22A Increment 3.2B IOT&E		X	
F/A-18E/F Super Hornet (pg. 201)	System Configuration Set H12 and APG-79 upgrade OT		X	
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) (pg. 335)	FAB-T IOT&E	X	X	
Global Command and Control System – Joint (GCCS-J) (pg. 83)	GCCS-J 6.0 OT&E			X
Infrared Search and Track (IRST) (pg. 207)	IRSTS Block I OA 2	X		
Integrated Defensive Electronic Countermeasures (IDECM) (pg. 209)	IDECM Software Improvement Program FOT&E	X	X	
Joint Battle Command – Platform (JBC-P) (pg. 123)	JBC-P-Log FOT&E	X	X	X
Key Management Infrastructure (KMI) Increment 2 (pg. 93)	KMI Spiral 2 Spin 2 LUT (an operational assessment)	X	X	
Littoral Combat Ship (LCS) (pg. 225)	*Independence* variant OT with the MCM mission package	X	X	X
Mid-Tier Networking Vehicular Radio (MNVR) (pg. 135)	MNVR IOT&E	X		X
Mobile User Objective System (MUOS) (pg. 259)	MUOS MOT&E 2	X	X	
MQ-4C Triton Unmanned Aircraft System (UAS) (pg. 261)	MQ-4C IOT&E	X		
MQ-9 Reaper Armed UAS (pg. 345)	MQ-9 Block 5 FOT&E		X	X
Nett Warrior (pg. 143)	Nett Warrior FOT&E	X		
P-8A Poseidon Multi-Mission Maritime Aircraft (MMA) (pg. 269)	P-8A Increment 2 Engineering Change Proposal (ECP) 2 FOT&E	X		
Patriot Advanced Capability-3 (PAC-3) (pg. 147)	Patriot Post-Deployment Build-8 (PDB-8) IOT&E	X	X	X
Remote Minehunting System (RMS; also addressed in LCS) (pg. 273)	LCS MCM mission package Increment 1 OT&E and unofficial concurrent RMS OA	X	X	
Surface Electronic Warfare Improvement Program (SEWIP) Block 2 (pg. 301)	SEWIP Block 2 IOT&E (Phase 2)	X	X	
Torpedo Warning System (as part of Surface Ship Torpedo Defense (SSTD)) (pg. 303)	Towed Active Acoustic Source QRA		X	
SSN 784 *Virginia* Class Block III Submarine (pg. 295)	*Virginia* Block III FOT&E	X	X	
Warfighter Information Networking – Tactical (WIN-T) (pg. 155)	WIN-T Increment 2 Network Management and Cybersecurity FOT&E	X		X

FDE – Force Development Evaluation
FOT&E – Follow-on Operational Test and Evaluation
IOT&E – Initial Operational Test and Evaluation
LUT – Limited User Test
MOT&E – Multi-Service Operational Test and Evaluation
OA – Operational Assessment
OT – Operational Test
OT&E – Operational Test and Evaluation
QRA – Quick Reaction Assessment

TABLE 4. PROGRAMS NOT IN THIS ANNUAL REPORT WITH PROBLEMS THAT MAY ADVERSELY AFFECT UPCOMING OPERATIONAL TESTING				
System Name	Upcoming Test	Effectiveness	Suitability	Survivability
AH-64E	AH-64E Lot 6 FOT&E II			X
AN/BLQ-10 Submarine Electronic Support System	Technical Insertion 14 (TI-14) FOT&E	X	X	
Coastal Battlefield Reconnaissance and Analysis (COBRA) System (also addressed in LCS)	COBRA Block I IOT&E	X		
DOD Automated Biometric Identification System (ABIS)	DOD ABIS 1.2 Adversarial Assessment			X
GPS Next Generation Operational Control System (OCX)	OCX Milestone C OA	X	X	
Mark XIIA Mode 5 Identification Friend or Foe (IFF)	Mode 5 Joint Operational Test Approach (JOTA) 3	X		
Integrated Personnel and Pay System – Army (IPPS-A) Increment II	IPPS-A Increment II Release 2.0 LUT (an operational assessment)		X	
Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)	JLENS Combatant Command Integration Assessment (CCIA)	X	X	
Military GPS User Equipment (MGUE) Increment 1	MGUE OUE	X	X	
MK 54 Lightweight Torpedo	MK 54 MOD 1 IOT&E	X	X	
XM25 Counter Defilade Target Engagement System	XM25 LUT (an operational assessment)		X	

FOT&E – Follow-on Operational Test and Evaluation
IOT&E – Initial Operational Test and Evaluation
LUT – Limited User Test
OA – Operational Assessment
OUE – Operational Utility Evaluation

AH-64E. The AH-64E is a four-bladed, twin-engine attack helicopter. The AH-64E Lot 6 FOT&E II is scheduled to begin in late FY17.

Lot 4 AH-64E and its interfacing systems have potentially significant cybersecurity deficiencies. Further testing of the AH-64E embedded systems is necessary to determine the significance of the deficiencies.

AN/BLQ-10. The BLQ-10 is an electronic support system that provides submarines the capability to detect, classify, and localize communications and radar signals. The TI-14 FOT&E is scheduled to begin in FY16.

- Classified effectiveness problems
- TI-08 testing in FY13 found that the Navy's training program and promotion system does not maintain operator proficiency on the communications subsystem (of BLQ-10). Additionally, normal operations do not frequently involve the communications subsystem, so operators do not have a chance to maintain their proficiency.

Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I. The COBRA Block I system is designed to detect and localize surface minelines, minefields, and obstacles in the beach zone in support of a beach landing by offensive forces. The COBRA Block I IOT&E is scheduled to begin in FY16.

- During dynamic conditions, such as roll or pitch maneuvers, the Integrated Gimbal (IG) was unable to maintain the correct step-stare sequence. During flight operations, the IG must continually look at a single spot while several images are taken. In addition, the IG must also adjust its look direction systematically to the next correct spot to optimize its imagery acquisition. This process of adjusting the look angle of the IG is called the step-stare sequence. Failures in the system to maintain the correct step-stare sequence can result in lack of imagery data for portions of the target area needed for Post Mission Analysis (PMA).

DOD Automated Biometric Identification System (ABIS). DOD ABIS consists of information technology components and biometric examiner experts that receive, process, and store biometrics from collection assets across the globe, match new biometrics against previously stored assets, and update stored records with new biometrics and contextual data to positively identify and verify actual or potential adversaries. The DOD ABIS 1.2 Adversarial Assessment is scheduled to begin in FY16.

- There are numerous (classified) deficiencies, as well as the network defenders' lack of knowledge of the network architecture, that could prevent the system from being adequately defended.

Global Positioning System (GPS) Next Generation Operational Control Segment (OCX). GPS OCX will provide command and control of the GPS satellite constellation and functions including monitoring and correction of position and time signals from each satellite, use of modernized GPS signals, and features that support navigation warfare requirements.

- The Air Force has stated that it needs to delay the start of OCX operations from 2018 to 2022 due to severe problems with software development. The Air Force has also stated that delaying OCX until 2022 poses a significant risk of a gap in GPS coverage starting in 2019 because the Air Force requires OCX to operate the GPS III satellites the Air Force is building to sustain the GPS constellation.
- To avoid a worldwide degradation in GPS-based military and civilian positioning, navigation, and timing, the Air Force should prioritize acquisition of a GPS III ground station capability which can be operationally tested and employed prior to the constellation sustainment need date in 2019.
- GPS monitoring stations are inadequate for testing and operations of modernized GPS signals, which will prevent collection of worldwide signal quality data and full evaluation of required navigation warfare capabilities during both developmental and operational testing.

Mark XIIA Mode 5 Identification Friend or Foe (IFF). The Mark XIIA Mode 5 IFF is a cooperative identification system that uses interrogators and transponders on host platforms to send, receive, and process friendly identification information. The Mode 5 Joint Operational Test Approach (JOTA) 3 is scheduled to begin in FY17.

- The system does not meet the criteria for Lethal Interrogation performance. If uncorrected, this could result in fratricide incidents during real world combat operations, especially in dense target environments.
- Identification information from some Mode 5-equipped command and control systems could not be directly passed into the command and control system, limiting the ability of that system to develop an unambiguous picture of the dynamic ongoing air battle.

Integrated Personnel and Pay System – Army (IPPS-A) Increment II. IPPS-A is a human resource system that will become the authoritative database for demographic information, deployment history, pay, and other personnel information for the Army. The IPPS-A Increment II LUT is scheduled to begin in FY17.

- Personnel data in the Army and DOD systems that interface with IPPS-A need to be verified as correct in order for IPPS-A to provide accurate reports

Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS). JLENS consists of separate surveillance and fire control radar systems that are individually mounted on 74-meter tethered aerostat balloons that operate at altitudes up to 10,000 feet above mean sea level. The JLENS Combatant Command Integration Assessment (CCIA) is scheduled to begin in FY16.

- System-level reliability, both software and hardware, is not meeting the program's goals for reliability growth.
- Electronic interference has limited the surveillance radar system to certain frequencies.
- The JLENS surveillance radar, as initially configured, had certain features incorporated into its software system intended to deal with the very high target densities that exist. However, the design approach chosen to deal with this problem resulted in certain target sets being excluded by the software algorithms associated with the surveillance radar. This could result in some high priority radar targets not being processed and tracked.
- Early testing has revealed problems related to the timely passing of unambiguous radar target track information from the JLENS system into the North American Aerospace Defense Command.
- During preparations for the CCIA exercise, one of the aerostats suffered a tether failure and was badly damaged. The accident is under investigation and corrective actions will determine the future direction of the CCIA.

Military GPS User Equipment (MGUE) Increment 1. MGUE consists of GPS receivers, capable of receiving and processing the new military GPS code (M-code), for all DOD platforms except precision guided munitions, handheld devices, and space vehicles. M-code is designed to provide a more secure and electronic warfare resistant signal. The MGUE Operational Utility Evaluation is scheduled to begin in FY17.

- Developmental testing observed emerging power consumption, peak power draw, thermal output, and messaging problems in very early platform integration efforts. These problems might make MGUE incompatible with many DOD platforms, driving host platform and interface redesigns before those platforms can incorporate MGUE and employ M-code. Although MGUE is expected to eventually integrate in nearly all platforms and munitions across the DOD portfolio, the current acquisition strategy does not involve significant integration testing on many platforms until after completion of OT&E on the four lead platforms in 2019. Without wider testing, there is a significant risk of late discovery of compatibility problems that could

delay fielding and result in significant additional costs for either re-designing the MGUE itself or the platforms on which the MGUE is planned to be used.
- Messaging incompatibilities between current MGUE designs, existing platforms, and munitions may prevent some platforms from employing GPS M-code as required.

MK 54. The MK 54 lightweight torpedo is the primary Anti-Submarine Warfare weapon used by U.S. surface ships, fixed-wing aircraft, and helicopters. The MK 54 MOD 1 IOT&E is scheduled to begin in FY17.
- During FOT&E, the MK 54 MOD 0 demonstrated below threshold performance in many scenarios.
- Launch platforms are not always able to launch the MK 54 torpedo in a manner that can support an effective attack.
- The MK 54 torpedo does not always interface properly with the fire control systems on its launch platforms.
- There are several other classified problems.

XM25 Counter Defilade Target Engagement System (CDTE). The XM25 CDTE fires 25 mm programmable high-explosive airburst rounds to defeat defilade and point area targets out to 500 meters. A Limited User Test is scheduled to begin in FY16.
- The Army conducted three Forward Operational Assessments of the XM25 CDTE with prototype weapons in 2011, 2012, and 2013, each of which resulted in a weapon malfunction and minor injuries to the operators. The program conducted a root cause investigation and made design changes to ensure the safety of the weapon. Developmental testing of the modified design is ongoing.

PROGRESS UPDATES ON DISCOVERIES REPORTED IN THE FY14 ANNUAL REPORT

In my annual report last year, I identified 8 systems that discovered new problems, 10 systems that discovered new problems and re-observed known problems, and 15 systems that re-observed known problems during operational testing in FY14. The status of these 33 programs is listed below.

All fixes implemented and verified in OT
- AIM-120D Advanced Medium-Range Air-to-Air Missile (AMRAAM)
- Joint Light Tactical Vehicle (JLTV)
- QF-16 Full-Scale Aerial Target (FSAT)

Some (or all) fixes implemented but new problems discovered or known problems re-observed in OT
- Aegis Ballistic Missile Defense (Aegis BMD)
- Air Force Distributed Common Ground System (AF DCGS)
- Air Operations Center – Weapon System (AOC-WS)
- AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite
- Ballistic Missile Defense System (BMDS)
- CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier
- Defense Enterprise Accounting and Management System (DEAMS)
- Defense Medical Information Exchange (DMIX)
- F/A-18E/F Super Hornet and EA-18G Growler
- Infrared Search and Track (IRST)
- Joint High Speed Vessel (JHSV)
- Joint Warning and Reporting Network (JWARN)
- Littoral Combat Ship (LCS)
- Miniature Air-Launched Decoy (MALD) and MALD – Jammer (MALD-J)
- Multi-Static Active Coherent (MAC) System
- MV-22 Osprey
- P-8A Poseidon Multi-Mission Maritime Aircraft (MMA)
- Q-53 Counterfire Target Acquisition Radar System
- Surface Ship Torpedo Defense (SSTD) System: Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT)
- Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar

Some fixes (potentially) implemented; currently in OT or planning additional OT
- Battle Control System – Fixed (BCS-F)
- DOD Automated Biometric Identification System (ABIS)

- Joint Battle Command – Platform (JBC-P)
- Manpack Radio
- Mark XIIA Mode 5 Identification Friend or Foe (IFF)
- MK 54 Lightweight Torpedo

No fixes planned, or no fixes planned to be tested in the next two years
- AN/PRC-117G
- Distributed Common Ground System – Marine Corps (DCGS-MC)
- F-15E Radar Modernization Program (RMP)
- RQ-21A Blackjack (formerly Small Tactical Unmanned Aerial System (STUAS))

In FY14, I also identified 23 systems that had significant issues in early testing that should be corrected before operational testing. The following provides an update on the progress these systems made in implementing fixes to those problems.

Fixes verified in OT – No other problems observed
- Distributed Common Ground System – Army (DCGS-A)
- Key Management Infrastructure (KMI)
- Precision Guidance Kit (PGK)

Fixes verified in OT – New problems discovered
- AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite

Fixes verified in OT – Known problems re-observed
- Ballistic Missile Defense System (BMDS)
- Infrared Search and Track (IRST)
- LHA 6 New Amphibious Assault Ship (formerly LHA(R))
- Littoral Combat Ship (LCS)
- Mobile Landing Platform (MLP) Core Capability Set (CCS) (Expeditionary Transfer Dock) and Afloat Forward Staging Base (AFSB) (Expeditionary Mobile Base)

Fixes tested in OT – Both new problems discovered and known problems re-observed
- AC-130J Ghostrider
- Air Force Distributed Common Ground System (AF DCGS)
- Defense Enterprise Accounting and Management System (DEAMS)
- Defense Medical Information Exchange (DMIX)
- Warfighter Information Network – Tactical (WIN-T)

Fixes not planned to be tested in the next two years
- F-35 Joint Strike Fighter (JSF)

Fixes currently being tested or planned to be tested in the next two years
- M829E4 Armor Piercing, Fin Stabilized, Discarding Sabot – Tracer (APFSDS-T)
- Public Key Infrastructure (PKI)
- RQ-4B Global Hawk High-Altitude Long-Endurance Unmanned Aerial System (UAS)
- AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)
- MQ-4C Triton Unmanned Aircraft System
- MQ-9 Reaper Armed Unmanned Aircraft System (UAS)
- Patriot Advanced Capability-3 (PAC-3)
- Remote Minehunting System (RMS)

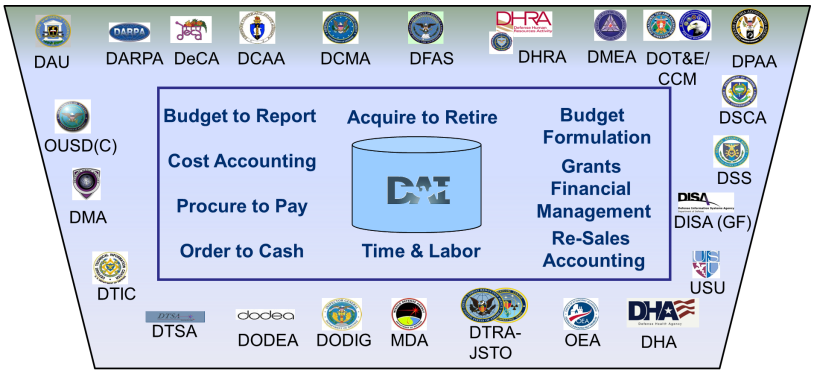
DOD Programs

DOD Programs

Defense Agencies Initiative (DAI)

Executive Summary

- During the operational assessment conducted by the Joint Interoperability Test Command (JITC) from July 20 through August 14, 2015, the Defense Agency Initiative (DAI) Increment 2 Release 1 critical functionality and interfaces worked as designed.
- The DAI system usability requires ongoing improvements for several defense agencies. The conversion to Oracle eBusiness Suite Release 12 as part of DAI Increment 2 Release 1 has been difficult, resulting in slow response times and defects requiring software patches to fix.



Legend

DARPA	Defense Advanced Research Projects Agency	DOT&E	Director, Operational Test and Evaluation
DAU	Defense Acquisition University	DPAA	Defense Prisoner of War/Missing Personnel Accountability Agency
DCAA	Defense Contract Audit Agency		
DCMA	Defense Contract Management Agency	DSCA	Defense Security Cooperation Agency
DeCA	Defense Commissary Agency	DSS	Defense Security Services
DFAS	Defense Finance and Accounting Service	DTRA-JTSO	Defense Threat Reduction Agency-Joint Science and Technology Office
DHA	Defense Health Agency (formerly TMA)		
DHRA	Defense Human Resources Activity	DTSA	Defense Technology Security Administration
DISA (GF)	Defense Information Systems Agency (General Funds)	DTIC	Defense Technical Information Center
DMA	Defense Media Activity	MDA	Missile Defense Agency
DMEA	Defense Microelectronics Activity	OEA	Office of Economic Adjustment
DoDEA	DoD Education Activity	OUSD(C)	Office of the Under Secretary of Defense (Comptroller)
DODIG	DoD Inspector General	USU	Uniform Services University of Health Sciences

System

- DAI is an information technology system with a core functionality that provides a commercially-available Oracle Enterprise Resource Planning system.
- DAI modernizes the financial management processes for many DOD agencies and field activities by streamlining financial management capabilities, addressing financial reporting material weaknesses, and supporting financial statement auditability.
- The Defense Information Systems Agency (DISA) provides facilities for the DAI servers at its Ogden, Utah, and Columbus, Ohio, Defense Enterprise Computing Centers.
- DAI is employed worldwide and across a variety of operational environments via a web portal on the Non-classified Internet Protocol Network using each agency's existing information system infrastructure.
- DAI includes two software increments:
  - Increment 1 was in Operations and Sustainment and was used for financial reporting at 12 defense agencies.
  - Increment 2 has four software releases, each with additional capabilities, with deployments to 11 additional defense agencies continuing through FY17.
- DAI supports financial management requirements in the Federal Financial Management Improvement Act and DOD Business Enterprise Architecture; therefore, it is subject to the 2010 National Defense Authorization Act requirement to be auditable by 2017.

Mission

Defense agencies use DAI for budget, finance, and accounting operations to provide accurate, reliable, and auditable financial information that supports DOD missions.

Major Contractors

- CACI Arlington – Northampton County, Virginia
- International Business Machines – Armonk, New York
- Northrop Grumman – Falls Church, Virginia

Activity

- JITC conducted two developmental tests of DAI Increment 2 Release 1: a System Integration Test from February 9, 2015, through March 25, 2015, followed by a User Acceptance Test conducted from March 30, 2015, through April 17, 2015.
- JITC conducted an operational assessment of DAI Increment 2 Release 1 from July 20 through August 14, 2015, in accordance with a DOT&E-approved test plan.
- A DISA Field Security Operations Red Team conducted a cybersecurity Adversarial Assessment of DAI Increment 1 Release 3 from October 14 through November 25, 2014.
- On September 16, 2015, USD(AT&L) signed an Acquisition Decision Memorandum approving limited fielding of DAI Increment 2 Release 2 to current and additional defense agencies.
- The DAI Program Management Office (PMO) has coordinated for a full cybersecurity test (Cooperative Vulnerability and Penetration Assessment and Adversarial Assessment) for 2QFY16 on Increment 2 Release 2.

Assessment

- During the operational assessment, the system's critical functionality and interfaces worked as designed; however, the testing revealed deficiencies that reduced user satisfaction. Deficiencies included:
  - Workflow and certification problems that affected the approval of some financial documents and forced resubmission.
  - The time to process employee payroll records was a queued, serial process that often took hours to complete for each agency. To mitigate, the DAI PMO has assumed this task until an acceptable software solution is implemented and tested.
  - There were often long system response times and time outs that required users to take extra steps to complete their tasks. The DAI help desk effectively supported the production system during the operational test and worked well with DISA and defense agency customers.
- The conversion to Oracle eBusiness Suite Release 12 was a challenge, but the PMO employed effective patch management to resolve many issues during and after testing.
- System stability issues led to seven critical failures between May 4 and July 7, 2015. To alleviate the failure rate, the program manager rescheduled weekly maintenance to weekends and turned off system logging to reduce the demand on the system. DAI meets operational availability requirements for peak and non-peak periods.

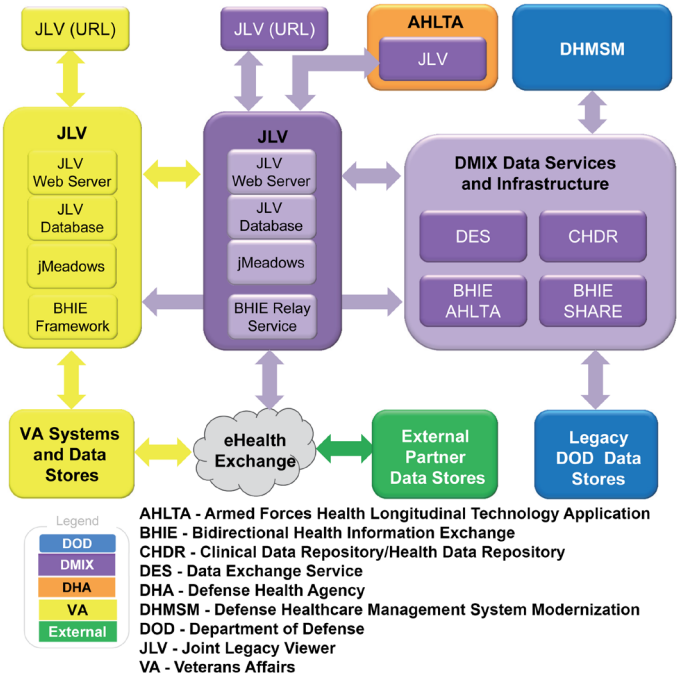
Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The DAI PMO should:
  1. Improve system response times, reduce time outs, and correct other errors requiring users to take extra steps to complete their tasks.
  2. Establish a scheduled maintenance program that supports all agencies' missions that accounts for the defense agencies' worldwide and weekend operations.
  3. Complete cybersecurity testing, to include a Cyber Economic Vulnerability Assessment, at the Program Office, data centers, and customer agencies during FY16.

Defense Medical Information Exchange (DMIX)

Executive Summary

- In December 2014, USD(AT&L) separated the Defense Medical Information System (DMIX) into two components: Interoperability and Viewer. USD(AT&L) declared the Interoperability component to be under sustainment and designated the Viewer component as a tailored Automated Information System Acquisition Category III program.
- The United States Army Medical Department Board (USAMEDDBD) and the Army Test and Evaluation Command (ATEC) performed an operational assessment of DMIX Release 2 from April 20, 2015, through May 1, 2015, to support a Milestone C decision for the Viewer component of the DMIX program. The USAMEDDBD conducted an operational assessment of DMIX Release 2 because the DMIX program manager will implement the Virtual Lifetime Electronic Record (VLER), a major capability of the system, in DMIX Release 3. The USAMEDDBD plans to conduct a Multi-Service Operational Test and Evaluation (MOT&E) of DMIX Release 3 with the VLER capability and operational commercial health care partners.
  - Based on the operational assessment, DOT&E determined that the system was operationally suitable, but not operationally effective because of high-severity defects that included (1) inconsistent query results for which the system did not always display all records available in a date range, (2) medical record notes not displaying due to the format of the original note, and (3) inconsistencies in data displays and navigation buttons between different display schemes within the DMIX viewer.
  - Although the high-severity defects affected data completeness, all data displayed in the Joint Legacy Viewer (JLV) were accurate and patient records downloaded in a timely manner.
- The Program Management Office (PMO) took immediate steps to correct these problems. The PMO scheduled a Verification of Correction of Deficiencies (VCD) in December 2015 to verify DMIX Release 2 fixes.
- After the deployment of Release 3 in September, users discovered two new system defects and an external system data accessibility problem. The DMIX program manager stated that she has developed a plan to resolve the DMIX Release 3 system defects and data accessibility problem.
- Space and Naval Warfare Systems Command (SPAWAR) conducted a cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) of DMIX Release 2 in the developmental test environment that concluded in June 2015. The CVPA identified vulnerabilities that could result in the loss of confidentiality, integrity, or availability of personal health information and personally identifiable information.
- SPAWAR conducted a cybersecurity CVPA of Integrated Electronic Health Record (iEHR) Increment 1 from October 27, 2014, through December 10, 2014, and an adversarial assessment from January 12 – 16, 2015. The CVPA of iEHR Increment 1 identified vulnerabilities that could compromise medical information if not quickly and adequately addressed.



System

- The DMIX program supports integrated sharing of standardized health data among DOD's Defense Healthcare Management System Modernization program, DOD legacy systems, Veterans' Affairs (VA), other Federal agencies, and private-sector healthcare providers.
- Together, the Defense Healthcare Management System Modernization and DMIX are intended to modernize the Military Health System to enhance sustainability, flexibility, and interoperability for improved continuity of care.
- The DOD is developing DMIX incrementally, delivering upgrades to capabilities that have already been fielded:
  - JLV provides an integrated read-only, chronological view of health data from DOD and VA Electronic Health Record (EHR) systems, eliminating the need for VA or DOD clinicians to access separate viewers to obtain real-time patient information. DOD and VA users logon to their respective JLV Web Servers using a Uniform Resource Locator (URL) address in their web browser. Armed Forces Health Longitudinal Technology Application users can connect to the JLV Web Server through their system menu.

  - The Data Exchange Service (DES) receives user queries entered through JLV and queries hundreds of DOD and VA data stores, returning the results to jMeadows. jMeadows maps local VA and DOD clinical terms to standard medical terminology and aggregates the data for presentation by the JLV Web Server.
  - The Bidirectional Health Information Exchange (BHIE) enables the VA to access clinical data from multiple DOD and VA systems using the Data Exchange Service, BHIE Share, and Clinical Data Repository/Health Data Repository. The Clinical Data Repository/Health Data Repository enables bidirectional exchange of outpatient pharmacy and medication allergy data for checking drug-to-drug and drug-to-allergy interactions.
  - The VLER capability provides views of a patient's medical history and outpatient clinical visits within DOD medical facilities. The VLER provides the ability to both retrieve and share medical documentation with external partners, such as the VA and other Federal or commercial health care partners. The DOD and external partners pass VLER data through the eHealth Exchange service. The DMIX program manager implemented VLER viewer functionality into JLV, replacing the legacy VLER viewer.
- iEHR, not shown in the system diagram, is a program deployed to a single site, the James A. Lovell Federal Healthcare Center in North Chicago, Illinois, where it is now in sustainment. iEHR provides single sign-on and context management capabilities to enable a user to logon to all published applications via a Common Access Card. It allows users to enter a patient once and the same patient will automatically populate in other applications. iEHR also provides a roaming capability to allow users to access their information from multiple devices.

Mission

The DOD, VA, Federal agencies, and private-sector health providers will use the DMIX infrastructure and services to:

- Share standardized health data using standard terminology
- Securely and reliably exchange standardized electronic health data with all partners
- Access a patient's medical history from a single platform, eliminating the need to access separate systems to obtain patient information
- Maintain continuity of care
- Exchange outpatient pharmacy and medication allergy data and check for drug-to-drug and drug-to-allergy interaction

Major Contractors

- Data Federation/JLV: Hawaii Resource Group – Honolulu, Hawaii
- Test Support: Deloitte – Falls Church, Virginia
- Program Manager support: Technatomy – Fairfax, Virginia

Activity

- During FY15, the USAMEDDBD and ATEC conducted operational tests of DMIX Release 2 and iEHR Increment 1 in separate events. The USAMEDDBD conducted an operational assessment of DMIX Release 2 because the DMIX program manager will implement VLER, a major capability of the system, in DMIX Release 3. USAMEDDBD plans to conduct an MOT&E of DMIX Release 3 with the VLER capability and operational commercial health care partners.

DMIX Release 2

- From April 20, 2015, through May 1, 2015, the USAMEDDBD and ATEC conducted an operational assessment of DMIX Release 2 in accordance with a DOT&E-approved test plan to support a Milestone C decision for the JLV Viewer component of the DMIX program.
- SPAWAR conducted a cybersecurity CVPA of the system in the developmental test environment. The assessment concluded in June 2015.
- The PMO coordinated with USAMEDDBD and the San Antonio Military Medical Center to schedule a VCD of DMIX in December 2015 to verify corrective actions for Release 2 high-severity defects.

DMIX Release 3

- After successful developmental testing, the Program Executive Office DHMS deployed DMIX Release 3 on September 18, 2015, to implement fixes to system defects discovered during DMIX Release 2 operational testing and to prepare for the Release 3 MOT&E.
- Following deployment, users discovered two problems associated with theater inpatient data and progress notes not displaying properly in JLV. Users also identified an Essentris site that had made local changes, which prevented the site's users from accessing patient data from DMIX. The DMIX program manager stated that she has developed a plan to resolve the DMIX Release 3 system defects and data accessibility problem.

iEHR Increment 1

- SPAWAR conducted a cybersecurity CVPA of iEHR Increment 1 from October 27, 2014, through December 10, 2014, and an Adversarial Assessment from January 12 – 16, 2015.

Terminology Mapping

- Both the DOD and VA had planned to provide health data mapped to a medical terminology standard through the JLV to help users read and analyze patient data more

easily. There are 20 Clinical Domains, which have national standards for terms within the domain. In December 2013, the DOD and VA delivered terminology maps for seven Clinical Domains to support DMIX Release 0. In 2014, the DMIX program manager implemented terminology maps for 14 Clinical Domains; in FY15, completed delivery of the remaining Clinical Domain maps and provided maintenance of active terms for another 11 Clinical Domains. The VA implemented terminology maps for one additional domain in December 2014.

- DOT&E is working with the DMIX PMO, the Interagency Program Office, and the operational test community to develop an operational test methodology to determine the accuracy and completeness of Clinical Domain terminology maps.

Assessment

DMIX Release 2

- DMIX Release 2 was not operationally effective because of high-severity defects that included (1) inconsistent query results for which the system did not always display all records available in a date range, (2) medical record notes not displaying due to the format of the original note, and (3) inconsistencies in data displays and navigation buttons between different schemes within the DMIX viewer. DOT&E sent a memorandum to the Program Executive Office DHMS on May 8, 2015, which detailed the Severity 1 defect causing inconsistent query results in a date range. Although the high-severity defects affected data completeness, all data displayed in JLV were accurate and user queries of patient records were timely. The Program Office took immediate steps to correct the problems and operational testers plan to verify the fixes in December 2015. The VCD results will be included in the 2016 Annual Report.
- The PMO improved DMIX developmental testing to evaluate the system's response to invalid inputs. DOT&E recommended such testing to discover failure modes caused by non-typical use cases, such as those observed in DMIX Release 2 operational testing, earlier in the test cycle.
- DMIX Release 2 is operationally suitable. Users liked the functionality and indicated that it improved their business processes. Additionally, users rated the system highly for usability and liked the data display, record selection and customization capabilities, and supporting documentation.
- The cybersecurity assessment identified significant vulnerabilities that could result in the loss of confidentiality, integrity, or availability of personal health information and personally identifiable information.

DMIX Release 3

- The DOD and VA deployed DMIX Release 3 in September 2015 to all JLV users. The user base has significantly expanded from 3,000 users earlier this year to an estimated 17,000 users. Program risk, and potential risk to patient safety, increased following the deployment of Release 3 when users discovered problems with theater inpatient data, progress notes not displaying properly, and with local data access.
- The DMIX program manager has scheduled an MOT&E of DMIX Release 3 in March 2016, creating a gap of six months between deployment and operational testing. The long gap between deployment and operational testing further increases the risk of DMIX users experiencing system problems prior to the MOT&E.

iEHR Increment 1

- The cybersecurity assessment of iEHR Increment 1 identified vulnerabilities that could compromise medical information if not quickly and adequately addressed.

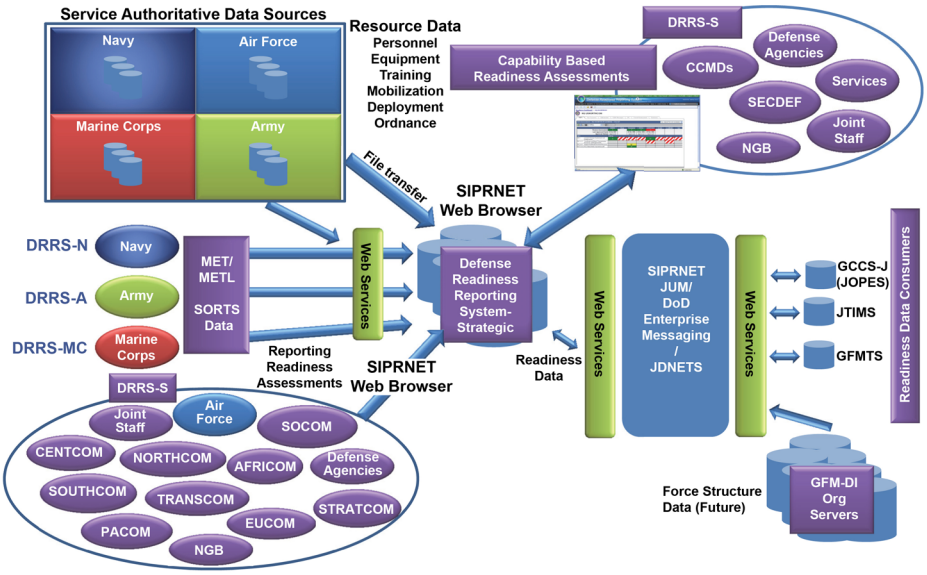
Recommendations

- Status of Previous Recommendations. The DOD and DMIX PMO have addressed the FY14 recommendations; however, the VA was not able to accelerate clinical terminology mapping efforts. The VA implemented terminology maps for one additional domain in December 2014.
- FY15 Recommendation.
  1. The DMIX PMO should conduct further cybersecurity testing on the operational DMIX system to verify fixes and mitigations of the vulnerabilities found during testing of DMIX Release 2.

Defense Readiness Reporting System – Strategic (DRRS-S)

Executive Summary

- The Joint Interoperability Test Command (JITC) conducted the Defense Readiness Reporting System – Strategic (DRRS-S) IOT&E from May 2015 through June 2015. Emerging results identified significant system and end-to-end process deficiencies. The DRRS-S program manager requested an extension of the IOT&E through October 2015 to correct system deficiencies and allow JITC to independently validate the fixes. DOT&E agreed to the extension.
- JITC continued IOT&E in September and October 2015. DOT&E plans to submit a DRRS-S IOT&E report in 2QFY16.



AFRICOM - Africa Command
CCMDs - Combatant Commanders
CENTCOM - Central Command
DRRS-A - Defense Readiness Reporting System - Army
DRRS-MC - Defense Readiness Reporting System - Marine Corps
DRRS-N - Defense Readiness Reporting System - Navy
EUCOM - European Command
GCCS-J - Global Command and Control System – Joint
GFM-DI - Global Force Management Data Initiative
GFMTS - Global Force Management Toolset
JDNETS - JOPES Data Network Services
JSUB - JOPES Subscriptions
JOPES - Joint Operational Planning and Execution System
JTIMS - Joint Training Information Management System
JUM - Joint User Messaging
MET - Mission Essential Task
METL - Mission Essential Task List
NGB - National Guard Bureau
NORTHCOM - Northern Command
PACOM - Pacific Command
SECDEF - Secretary of Defense
SIPRNET - Secret Internet Protocol Router Network
SOCOM - Special Operations Command
SORTS - Status of Resources and Training System
SOUTHCOM - Southern Command
STRATCOM - Strategic Command
TRANSCOM - Transportation Command

System

- DRRS-S is a Secret Internet Protocol Router Network-accessible web application designed to replace the Global Status of Resources and Training System, a Force Readiness component of Global Command and Control System – Joint.
- DRRS-S production and backup systems are hosted at separate Defense Enterprise Computing Centers on commercial off-the-shelf hardware consisting of application and database server enclaves using Microsoft Windows® operating systems.
- DRRS-S receives and processes readiness reports and data from Service-specific increments of the larger DRRS enterprise, including DRRS-Army, DRRS-Marine Corps, and DRRS-Navy. Combatant Commanders, and the subordinates they direct, DOD agencies, and Air Force units report directly within DRRS-S.

Mission

- Combatant Commanders, Military Services, Joint Chiefs of Staff, Combat Support Agencies, and other key DOD users (such as the Secretary of Defense and National Guard) use the DRRS collaborative environment to evaluate the readiness and capability of U.S. Armed Forces to carry out assigned and potential tasks.
- Reporting organizations input both mission readiness and unit readiness data, such as Global Status of Resources and Training System data, into DRRS-S and use it to make mission readiness assessments against standardized missions and tasks.

Major Contractor

InnovaSystems International, LLC – San Diego, California

Activity

- From May 2015 through June 2015, JITC conducted an IOT&E in accordance with the DOT&E-approved test plan. IOT&E revealed a number of significant deficiencies with the system and end-to-end data management processes. Therefore, the DRRS-S program manager requested an extension of the IOT&E through October 2015 to allow for correction of system deficiencies and provide sufficient time for JITC to independently verify the fixes. DOT&E agreed to the extension.

- JITC continued IOT&E in September and October 2015. This test window included two monthly readiness reporting cycles to verify the accuracy, completeness, and timeliness of Service readiness reports.
- JITC and the Army Research Laboratory Survivability and Lethality Assurance Directorate conducted a Cooperative Vulnerability and Penetration cybersecurity assessment from February 2015 through May 2015. The Defense Information Systems Agency Risk Management Executive Red Team conducted a cybersecurity Adversarial Assessment in June 2015.
- DOT&E will submit an IOT&E report on the DRRS-S in 2QFY16.

Assessment

The DRRS-S Data Authentication Group reviewed and authenticated IOT&E data in November 2015. DOT&E began evaluating the IOT&E test data in November 2015. DOT&E plans to submit a DRRS-S IOT&E report in 2QFY16.

Recommendations

- Status of Previous Recommendations. The DRRS-S Program Office addressed all previous recommendations.
- FY15 Recommendations. None.

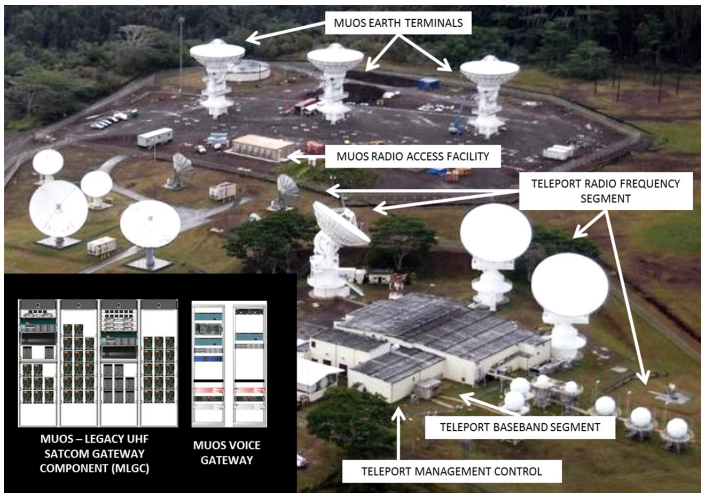
Department of Defense (DOD) Teleport

Executive Summary

- The Defense Information Systems Agency (DISA) is developing the Teleport Generation 3 Phase 3 (G3P3) capability that is intended to provide interconnectivity between legacy Ultra High Frequency (UHF) radios, which provide half duplex, push-to-talk service and the Mobile User Objective System (MUOS) radios, which can provide full duplex service. To achieve the G3P3 capability, the program manager is adding two new components to the Teleport architecture, the MUOS to Legacy Gateway Component (MLGC) and MUOS Voice Gateway (MVG). The program manager is planning to install the MLGC at five of the six primary Teleport sites and the MVG at the Virginia and Hawaii Teleport sites, collocated with two MUOS Radio Access Facilities.
- The Joint Interoperability Test Command (JITC) conducted the G3P3 operational assessment (OA) from June 22, 2015, to August 11, 2015, at the Northwest Virginia Teleport in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan. The OA is intended to inform a Milestone C decision by the DISA Component Acquisition Executive planned for February 2016.
- The MLGC and MVG operated as intended in the limited operational environment afforded during the OA period. Government program personnel and contractors completed data exchanges through the MLGC with completion rates of 98 percent relative to an 88 percent threshold criterion. Government program personnel and contractors completed voice exchanges through MLGC and MVG at completion rates of 94 percent relative to the 88 percent threshold criteria. Additional developmental testing is required prior to operational testing in 1QFY17.

System

- DOD Teleport sites are globally-distributed Satellite Communication (SATCOM) facilities. There are six core Teleport facilities located in Virginia, Germany, Italy, Japan, Hawaii, and California, and three secondary facilities located in Bahrain, Australia (future), and Guam. Teleport sites consist of four segments:
  - The radio frequency segment consists of SATCOM earth terminals that operate in UHF, X, C, Ku, Ka, and Extremely-High Frequency bands. The terminals provide radio frequency links between the Teleport site and the deployed user SATCOM terminal via military or commercial satellites.



  - The baseband segment includes encryption, switching, multiplexing, and routing functions for connecting data streams or packetized data to the terrestrial Defense Information Systems Network (DISN).
  - The network services segment provides connectivity to the DISN long-haul networks and other internet-working functions necessary to meet the user's requirements.
  - The management control segment provides centralized monitoring and control of Teleport baseband hardware, earth terminal hardware, transmission security, and test equipment.
- Teleport provides deployed forces access to standard fixed gateways from anywhere in the world for all six DISN services:
  - Secret Internet Protocol Router Network
  - Non-classified Internet Protocol Router Network
  - Defense Red Switch Network
  - Defense Switched Network
  - Video Teleconference
  - Joint Worldwide Intelligence Communications System

Mission

Combatant Commanders, Services, and deployed operational forces use DOD Teleport systems in all phases of conflict to gain access to worldwide military and commercial SATCOM services.

Major Contractor

Government Integrator: Defense Information Systems Agency (DISA)

Activity

- DISA is developing the Teleport G3P3 capability that is intended to provide interconnectivity between legacy UHF radios, which provide half duplex, push-to-talk service and MUOS radios, which have the capability to provide full duplex service. To achieve the G3P3 capability, the program manager is adding two new components to the Teleport architecture, the MLGC and MVG. The program manager is planning to install the MLGC at five of the six primary Teleport sites and the MVG at the Virginia and Hawaii Teleport sites, collocated with two MUOS Radio Access Facilities.
- In March 2015, DISA installed a MLGC test suite at the DOD Teleport Test Lab within the Army's Joint Satellite Engineering Center, at Aberdeen Proving Ground, Maryland, and at the Northwest Virginia Teleport site for integrated testing.
- JITC conducted the G3P3 OA from June 22, 2015, through August 11, 2015, at the Northwest Virginia Teleport in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan. The OA informs a Milestone C decision by the DISA Component Acquisition Executive planned for February 2016.
  - JITC testers observed set-up, management, and tear-down of services at the DOD Northwest Virginia Teleport, and communication between deployed users at Saint Julien's Creek, Virginia, and the MUOS Radio Integration Laboratory in San Diego, California. Operators using two legacy UHF radios and two MUOS-capable terminals located at Saint Julien's Creek exchanged data and voice with two MUOS-capable terminals located at the MUOS Radio Integration Laboratory. Contractor and government subject matter experts configured the Teleport equipment and operated the deployed radios.
  - Operational testers collected equipment uptime and downtime to support an assessment of reliability and availability.
  - In conjunction with the OA, JITC conducted a cooperative cybersecurity assessment from September 28, 2015, through October 2, 2015, at the Northwest Virginia Teleport site.
- DOT&E submitted the DOD Teleport System, G3P3 Operational Assessment in December 2015.
- JITC plans to conduct an operational test of the G3P3 capability in 1QFY17.

Assessment

- The OA provided a limited operational environment. The MLGC and MVG test suites installed at the Northwest Teleport were configured and operated by contractor personnel. Teleport operators were not contractually allowed to configure the MLGC or MVG prior to government acceptance of the equipment.
- The MLGC and MVG operated as intended in the limited operational environment afforded during this test period. Government program personnel and contractors completed data exchanges through the MLGC with completion rates of 98 percent relative to an 88 percent threshold criterion. Government program personnel and contractors completed voice exchanges through MLGC and MVG at completion rates of 94 percent relative to the 88 percent threshold criteria.
- The JITC cooperative cybersecurity assessment identified potential vulnerabilities that could degrade system security.
- Although the MLGC and MVG performed well, the limited data from this test precludes the MLGC and MVG meeting reliability and availability requirements with confidence. Based upon the scope of the OA testers were not able to evaluate maintainability and documentation.
- The Teleport Test and Evaluation Master Plan needs to be updated to support the G3P3 Milestone C decision planned for February 2016 and support the G3P3 operational test planned for 1QFY17.

Recommendations

- Status of Previous Recommendations. DISA has satisfactorily addressed all previous recommendations.
- FY15 Recommendation.
  1. DISA should update the Teleport Test and Evaluation Master Plan before the G3P3 Milestone C decision planned for 2QFY16 and the G3P3 operational test planned for 1QFY17.

F-35 Joint Strike Fighter (JSF)

Executive Summary

Test Planning, Activity, and Assessment

- The program focused on culminating Block 2B development and testing in order to provide a fleet release enabling the Marine Corps F-35B Joint Strike Fighter (JSF) declaration of Initial Operational Capability (IOC), while transitioning development and flight test resources to Block 3i and Block 3F.
  - The program terminated Block 2B developmental flight testing in May 2015, delivering Block 2B capability with deficiencies and limited combat capability. The Marine Corps declared IOC at the end of July 2015. However, if used in combat, the Block 2B F-35 will need support from command and control elements to avoid threats, assist in target acquisition, and control weapons employment for the limited weapons carriage available (i.e., two bombs, two air-to-air missiles). Block 2B deficiencies in fusion, electronic warfare, and weapons employment result in ambiguous threat displays, limited ability to respond to threats, and a requirement for off-board sources to provide accurate coordinates for precision attack. Since Block 2B F-35 aircraft are limited to two air-to-air missiles, they will require other support if operations are contested by enemy fighter aircraft. The program deferred deficiencies and weapons delivery accuracy (WDA) test events from Block 2B to Block 3i and Block 3F, a necessary move in order to transition the testing enterprise to support Block 3i flight testing and Block 3F development, both of which began later than planned in the program's Integrated Master Schedule (IMS).
  - Block 3i developmental flight testing restarted for the third time in March 2015, after two earlier starts in May and September 2014. Block 3i developmental flight testing completed in October, eight months later than planned by the program after restructuring in 2012, as reflected in the IMS. Block 3i began with re-hosting immature Block 2B software and capabilities into avionics components with new processors. Though the program originally intended that Block 3i would not introduce new capabilities and not inherit technical problems from earlier blocks, this is what occurred. The Air Force insisted on fixes for five of the most severe deficiencies inherited from Block 2B as a prerequisite to use the final Block 3i capability in the Air Force IOC aircraft; Air Force IOC is currently planned for August 2016 (objective) or December 2016 (threshold). However, Block 3i struggled during developmental testing (DT), due to the inherited deficiencies and new avionics stability problems. Based on these Block 3i performance issues, the Air Force briefed that Block 3i mission capability is at risk of not meeting IOC criteria to the Joint Requirements Oversight Council (JROC) in December 2015. The Air Force recently received its first Block 3i operational aircraft and is assessing the extent to which Block 3i will meet Air Force IOC requirements; this assessment will continue into mid-2016.
  - Block 3F developmental flight testing began in March 2015, 11 months later than the date planned by the program after restructuring in 2012, as reflected in the IMS. Progress has been limited (flight testing has accomplished approximately 12 percent of the Block 3F baseline test points as of the end of November) as the program focused on closing out Block 3i testing and providing a software version suitable to support plans for the Air Force to declare IOC in August 2016.

- The current schedule to complete System Development and Demonstration (SDD) and enter IOT&E by August 2017 is unrealistic.
  - Full Block 3F mission systems development and testing cannot be completed by May 2017, the date reflected in the most recent Program Office schedule, which is seven months later than the date planned after the 2012 restructure of the program. Although the program has recently acknowledged some schedule pressure and began referencing July 31, 2017, as the end of SDD flight test, that date is unrealistic as well. Instead, the program will likely not finish Block 3F development and flight testing prior to January 2018, an estimate based on the following assumptions:
    - Continuing a six test point per flight accomplishment rate, which is equal to the calendar year 2015 (CY15) rate observed through the end of November.

  - Continuing a flight rate of 6.8 flights per month, as was achieved through the end of November 2015, exceeding the planned rate of 6 flights per month (note that if the flight rate deteriorates to the planned rate of 6 flights per month, then testing will not complete until May 2018).
  - Completing the full Block 3F test plan (i.e., all 7,230 original baseline and budgeted non-baseline test points in the Block 3F joint test plan).
  - Continuing the CY15 discovery rate of 5 percent, i.e., 5 additional test points are required to address new discoveries per 100 baseline test points accomplished. This assumption is optimistic. In the likely event significant new discoveries continue during developmental testing in 2016, additional Block 3F software releases would be needed to address them, adding more test points and extending development further.
- The program could, as has been the case in testing previous software increments, determine that test points in the plan are no longer required for the Block 3F fleet release. However, the program will need to ensure that deleting and/or deferring Block 3F testing before the end of SDD and start of IOT&E does not result in increasing the likelihood of discovery of deficiencies in IOT&E or degrading F-35 combat capability. Whatever capability the program determines as ready for IOT&E will undergo testing fully consistent with the Department's threat assessments, war plans, and the Services' concepts of operation.

- The program has proposed a "block buy" that commits to and combines procurement of three lots of aircraft to gain savings. Executing the "block buy" would require commitments to procuring as many as 270 U.S. aircraft, as well as commitments by foreign partners to purchasing substantial numbers of aircraft. Depending upon the timing, it is possible a commitment to the "block buy" would be made before operational testing is complete. In that case, entering a "block buy" would raise the following questions:
  - Is it premature to commit to the "block buy" given that significant discoveries requiring correction before F-35's are used in combat are occurring, and will continue to occur, throughout the remaining developmental and operational testing? The program continues to struggle with Block 3F developmental testing, and in December 2015 the Air Force rated its proposed initial operational capability supported by Block 3i as "red" due to the problems ongoing testing has revealed.
  - Is it prudent to further increase substantially the number of aircraft bought that may need modifications to reach full combat capability and service life? As the program manager has noted, essentially every aircraft bought to date requires modifications prior to use in combat.
  - Would committing to a "block buy" prior to the completion of IOT&E provide the needed incentives to the contractor and the Program Office to correct an already substantial list of deficiencies in performance, a list that will only lengthen as Block 3F testing continues and IOT&E is conducted?
  - Would entering a "block buy" contract prior to the completion of IOT&E be consistent with the "fly before you buy" approach to defense acquisition that many in the Administration have supported? Similarly, would such a "block buy" be consistent with the intent of Title 10 U.S. Code, which stipulates that IOT&E must be completed and a report on its results provided to Congress before committing to Full-Rate Production—a commitment that some could argue would be made by executing the "block buy?"

Helmet Mounted Display System (HMDS)

- The program tested the Generation III (Gen III) helmet-mounted display system (HMDS), which is intended to resolve all of the deficiencies discovered in the Gen II system in prior years. The Gen III system is a requirement for Air Force IOC in 2016; it will be the helmet used to complete SDD and IOT&E. After Gen III developmental testing, developmental test pilots reported less jitter, proper alignment, improved ability to set symbology intensity, less latency in imagery projections, and improved performance of the night vision camera. However, operational testing in realistic conditions and mission task levels, including gun employment, is required to determine if further adjustments are needed.

Mission Data Load Development and Testing

- The F-35 relies on mission data loads—which are a compilation of the mission data files needed for operation of the sensors and other mission systems—to work in conjunction with the system software data load to drive sensor search parameters and to identify and correlate sensor detections, such as threat and friendly radar signals. The U.S. Reprogramming Lab (USRL), a U.S. government lab, produces these loads for U.S. operational and training aircraft. Mission data optimization testing, which includes both lab-testing and flight-testing, is conducted by an Air Force operational test unit augmented by Navy personnel. The unit provides the test plans to the DOT&E for approval and independent oversight.
- Significant deficiencies exist in the USRL that preclude efficient development and adequate testing of effective mission data loads for Block 3F. Despite being provided a $45 Million budget in FY13, the program has still not designed, contracted for, and ordered the required equipment—a process that will take at least two years, not counting installation and check-out. In addition, despite the conclusions of a study by the Program Office indicating that substantial upgrades are needed to the laboratory's hardware, the program is currently only pursuing a significantly lesser upgrade due to budgetary constraints. This approach would leave the USRL with less capability than the F-35 Foreign Military Sales Reprogramming Lab. Unless remedied, these deficiencies in the USRL will translate into significant limitations for the F-35 in combat against existing threats.

The program must take immediate action to complete required modifications and upgrades to the lab before the USRL is required to provide the Block 3F mission data load for tactics development and preparations for IOT&E.

- After the program delayed the build-up of the USRL equipment and software tools, which created schedule pressure on Block 2B mission data load development and testing, the Program Office forced the USRL to truncate the planned testing, forgoing important steps in mission data load development in order to provide a limited mission data load in June 2015 for the Marine Corps IOC declaration in July 2015. Fielded operational units must take into consideration the limited extent of lab and flight testing that occurred—which creates uncertainties in F-35 effectiveness—until the USRL is able to complete development and testing of a Block 2B mission data load. This is planned to occur in early 2016.

Weapons Integration

- The program terminated Block 2B developmental testing for weapons integration in December 2015 after completing 12 of the 15 planned WDA events. The program planned to complete all 15 WDA events by the end of October 2014, but delays in implementing software fixes for deficient performance of mission systems sensors and fusion delayed progress. Three events were deferred to Block 3i (one event) and Block 3F (two events) developmental testing.
  - Eleven of the 12 events required intervention by the developmental test control team to overcome system deficiencies and ensure a successful event (i.e., acquire and identify the target and engage it with a weapon). The program altered the event scenario for three of these events, as well as the twelfth event, specifically to work around F-35 system deficiencies (e.g., changing target spacing or restricting target maneuvers and countermeasures).
  - The performance of the Block 2B-configured F-35, if used in combat, will depend in part on the degree to which the enemy's capabilities exceed the constraints of these narrow scenarios and the operational utility of the workarounds necessary for successful weapons employment.
- The Block 3F WDA events plan currently contains events that will test Block 3F capabilities to employ the GBU-12 Paveway II laser-guided bomb, GBU-31/32 Joint Direct Attack Munition (JDAM), Navy Joint Stand-off Weapon (JSOW)-C1, Small Diameter Bomb I (SDB-1), AIM-120C Advanced Medium-Range Air-to-Air Missile (AMRAAM), AIM-9X, and the gun in the full operating environment of each variant.
  - The Block 3F developmental test WDA plan contains 48 events in the approved Test and Evaluation Master Plan (TEMP), plus two WDA events deferred from Block 2B, for a total of 50. These 50 WDA events cannot be accomplished within the remaining time planned by the Program Office to complete Block 3F flight test (by May 2017, per the program's master schedule), nor by July 2017 (the most recent briefed date to complete Block 3F flight test from the Program Office), and support the date in the IMS for the Block 3F fleet release (August 2017). The past WDA event execution rate is approximately one event per month. The test team would need to triple this rate to complete all WDA events in the approved TEMP by May 2017. However, these Block 3F events are more complex than the Block 2B and 3i events.
  - In an attempt to meet the schedule requirements for weapon certification, the Program Office has identified 10 WDA events for the F-35A and 5 events for the F-35B and F-35C that must be accomplished during Block 3F developmental testing. The program still plans to accomplish the remaining 33 events, if schedule margin allows. The overall result of the WDA events must be that the testing yields sufficient data to evaluate Block 3F capabilities. Deleting numerous WDA events puts readiness for operational testing and employment in combat at significant risk.

Verification Simulation (VSim)

- Due to inadequate leadership and management on the part of both the Program Office and the contractor, the program has failed to develop and deliver a Verification Simulation (VSim) for use by either the developmental test team or the JSF Operational Test Team (JOTT), as has been planned for the past eight years and is required in the approved TEMP. Neither the Program Office nor the contractor has accorded priority to VSim development despite early identification of requirements by the JOTT, $250 Million in funding added after the Nunn-McCurdy-driven restructure of the program in 2010, warnings that development and validation planning were not proceeding in a productive and timely manner, and recent (but too late) intense senior management involvement.
- The Program Office's sudden decision in August 2015 to move the VSim to a Naval Air Systems Command (NAVAIR)-proposed, government-led Joint Simulation Environment (JSE), will not result in a simulation with the required capabilities and fidelity in time for F-35 IOT&E. Without a high-fidelity simulation, the F-35 IOT&E will not be able to test the F-35's full capabilities against the full range of required threats and scenarios. Nonetheless, because aircraft continue to be produced in substantial quantities (all of which will require some level of modifications and retrofits before being used in combat), the IOT&E must be conducted without further delay to evaluate F-35 combat effectiveness under the most realistic conditions that can be obtained. Therefore, to partially compensate for the lack of a simulator test venue, the JOTT will now plan to conduct a significant number of additional open-air flights during IOT&E relative to the previous test designs. In the unlikely event a simulator test venue is available, the additional flights would not be flown.

Suitability

- The operational suitability of all variants continues to be less than desired by the Services and relies heavily on contractor support and workarounds that would be difficult to employ in

a combat environment. Almost all measures of performance have improved over the past year, but most continue to be below their interim goals to achieve acceptable suitability by the time the fleet accrues 200,000 flight hours, the benchmark set by the program and defined in the Operational Requirements Document (ORD) for the aircraft to meet reliability and maintainability requirements.

- Aircraft fleet-wide availability continued to be low, averaging 51 percent over 12 months ending in October 2015, compared to a goal of 60 percent.
- Measures of reliability that have ORD requirement thresholds have improved since last year, but eight of nine measures are still below program target values for the current stage of development, although two are within 5 percent of their interim goal; one—F-35B Mean Flight Hours Between Maintenance Event (Unscheduled)—is above its target value.
- F-35 aircraft spent 21 percent more time than intended down for maintenance and waited for parts from supply for 51 percent longer than the program targeted. At any given time, from 1-in-10 to 1-in-5 aircraft were in a depot facility or depot status for major re-work or planned upgrades. Of the fleet that remained in the field, on average, only half were able to fly all missions of even a limited capability set.
- The amount of time required to repair aircraft and return them to flying status remains higher than the requirement for the system when mature, but there has been improvement over the past year.
- The program fielded new software for the Autonomic Logistics Information System (ALIS) during 2015. All fielded units transitioned from version 1.0.3 to 2.0.0 between January and April 2015. Additional increments were tested—2.0.1 and 2.0.1.1—which included software updates to correct deficiencies discovered in 2.0.1. Version 2.0.1.1 software was fielded to operational units between May and October 2015. These versions included new functions, improved interfaces, and fixes for some of the deficiencies in the earlier ALIS versions. However, many critical deficiencies remain which require maintenance personnel to implement workarounds to address the unresolved problems.

Live Fire Test and Evaluation (LFT&E)

- The F-35 LFT&E program completed one major live fire test series using an F-35C variant full-scale structural test article (CG:0001) with an installed Pratt and Whitney F135 engine. Preliminary test data analyses:
  - Demonstrated the tolerance of the F135 initial flight release (IFR) configured engine to threat-induced fuel discharge into the engine inlet
  - Confirmed the expected vulnerabilities of the fuel tank structure
- The program demonstrated performance improvements of the redesigned fuel tank ullage inerting system in the F-35B fuel system simulator (FSS). However, aircraft ground and flight tests, designed to validate the fuel system simulator tests and aircraft system integration, revealed design deficiencies that require further hardware and software modifications.
- The test plan to assess chemical and biological decontamination of pilot protective equipment is not adequate; no plans have been made to test either the Gen II or the Gen III HMDS. The Program Office is on track to evaluate the chemical and biological agent protection and decontamination systems in the full-up system-level decontamination test planned for FY16.
- The Navy completed vulnerability testing of the F-35B electrical and mission systems to the electromagnetic pulse (EMP).
- The F-35 program continues to collect data to support the lethality evaluation of the 25 mm x 137 mm PGU-48 Frangible Armor Piercing (FAP) round, a designated round for the F-35A variant, and the PGU-32/U Semi-Armor Piercing High Explosive Incendiary-Tracer (SAPHEI-T) ammunition currently designated for the F-35B and F-35C variants.

Air-Ship Integration and Ship Suitability

- The Marine Corps conducted a suitability demonstration with six operational F-35B aircraft onboard the USS *Wasp* from May 18 – 29, 2015.
  - As expected, the demonstration was not an operational test and could not demonstrate that the F-35B is operationally effective or suitable for use in combat. This is due to the following:
    - Lack of production-representative support equipment
    - Provision of extensive supply support to ensure replacement parts reached the ship faster than would be expected in deployed combat operations
    - Incompleteness of the available maintenance procedures and technical data, which required extensive use of contractor logistics support
    - Lack of flight clearance to carry and employ combat ordnance
    - Lack of the full complement of electronic mission systems necessary for combat on the embarked aircraft
    - No other aircraft, and their associated equipment, that would normally be employed with an Air Combat Element (ACE) were present, other than three MH-60S rescue helicopters
  - The USS *Wasp* demonstration event did, however, provide useful training for the Marine Corps and amphibious Navy with regards to F-35B operations onboard L-class ships, and also provided findings relevant to the eventual integration of the F-35B into the shipboard environment. However, aircraft reliability and maintainability were poor, so it was difficult for the detachment to keep more than two to three of the six embarked aircraft in a flyable status on any given day, even with significant contractor assistance. Aircraft availability during the deployment was approximately 55 percent. Around 80 percent availability

would be necessary to generate four-ship combat operations consistently with a standard six-ship F-35B detachment.
- The second phase of F-35C ship suitability testing on CVN class carriers, Developmental Test – Two (DT-2), was conducted from October 2 – 10, 2015. Ship availability delayed the start of DT-2 from the planned date in August 2015. The principal goal of DT-2 was to perform launch and recovery of the F-35C with internal stores loaded.
- The Navy continues to work on numerous air-ship integration issues including carrier Jet Blast Deflector (JBD) design limitations, as well as improving support equipment, hearing protection, and firefighting equipment.

Cybersecurity Testing
- In accordance with DOT&E and DOD policy, the JOTT developed and presented a cybersecurity operational test strategy to DOT&E for approval in February 2015. This strategy established a schedule and expectations for cybersecurity testing of the JSF air system through the end of SDD and IOT&E in late 2017. The strategy includes multiple assessments aligned with the blocks of capability as the program delivers them to the field in both the air vehicle and ALIS. The test teams will conduct the assessments on fielded, operational equipment. All testing requires coordination from the JSF Program Executive Officer, via an Interim Authority to Test (IATT). This testing is OT&E where DOT&E approves plans and independently reports results. The test strategy, approved by DOT&E, includes end-to-end testing of all ALIS components and the F-35 air vehicle.
- The JOTT began planning Cooperative Vulnerability and Penetration Assessments (CVPAs) and Adversarial Assessments (AAs) of all ALIS components in the latest configuration to be fielded—ALIS 2.0.1.1—as well as the F-35 air vehicle in the Block 2B configuration. The JOTT planned a CVPA for September 21 through October 2, 2015, and an AA from November 9 – 20, 2015. However, the test teams were not able to complete the CVPA as planned because the Program Office failed to provide an IATT due to insufficient understanding of risks posed to the operational ALIS systems by cybersecurity testing. This testing was postponed and combined with an AA, planned to take place in early November 2015. However, the Program Office approved only a partial IATT, which allowed a CVPA of the ALIS components at Edwards AFB, California, and a CVPA of the Operational Central Point of Entry (CPE)—a major network hub in the overall ALIS architecture—to proceed. Although authorized, the AA for the CPE was not accomplished because the IATT was approved too late for the AA team to make arrangements for the test. The limited testing that was permitted revealed significant deficiencies that must be corrected and highlighted the requirement to complete all planned cybersecurity testing.
- Only ALIS components were planned to be tested in these events in late 2015; inclusion of the air vehicle is planned for future events. An end-to-end enterprise event, which links each component system, including the air vehicle, is required for adequate cybersecurity operational testing.

Pilot Escape System
- The program conducted two sled tests on the pilot escape system in July and August 2015 that resulted in failures of the system to successfully eject a manikin without exceeding load/stress limits on the manikin. These sled tests were needed in order to qualify the new Gen III HMDS for flight release. In July 2015, a sled test on a 103-pound manikin with a Gen III helmet at 160 knots speed demonstrated the system failed to meet neck injury criteria. The program did not consider this failure to be solely caused by the heavier Gen III helmet, primarily due to similarly poor test results observed with the Gen II helmet on a 103-pound manikin in 2010 tests. The program conducted another sled test in August 2015 using a 136-pound manikin with the Gen III helmet at 160 knots. The system also failed to meet neck injury criteria in this test. Similar sled testing with Gen II helmets in 2010 did not result in exceedance of neck loads for 136-pound pilots.
- After the latter failure, the Program Office and Services decided to restrict pilots weighing less than 136 pounds from flying any F-35 variant, regardless of helmet type (Gen II or Gen III). Pilots weighing between 136 and 165 pounds are considered at less risk than lighter weight pilots, but still at an increased risk (compared to heavier pilots). The level of risk was labeled "serious" by the Program Office based on the probability of death being 23 percent, and the probability of neck extension (which will result in some level of injury) being 100 percent. Currently, the Program Office and the Services have decided to accept this level of risk to pilots in this weight range, although the basis for the decision to accept these risks is unknown.
- In coordination with the Program Office, the ejection seat contractor funded a proof-of-concept ejection sled test in October to assess the utility of a head support panel (HSP), a fabric mesh behind the pilot's head and between the parachute risers, to prevent exceeding neck loads during the ejection sequence for lighter weight pilots. Based on the initial results, the Program Office and Services are considering seat modifications that would include the HSP, but they may take at least a year to verify improvement and install them onto aircraft. Additional testing and analyses are also needed to determine the risk to pilots of being harmed by the transparency removal system (which shatters the canopy before, and in order for, the seat and pilot leave the aircraft) during ejections in other than ideal, stable conditions (such as after battle damage or during out-of-control situations).
- The program began delivering F-35 aircraft with a water-activated parachute release system in later deliveries of Lot 6 aircraft in 2015. This system, common in current fighter aircraft for many years, automatically jettisons the parachute when the pilot enters water after ejection; in the case of pilot incapacitation, an automatic jettisoning of the

parachute canopy is essential for aircrew survival. In June 2012, while reviewing preparations to begin training pilots at Eglin AFB, Florida, the Program Office accepted the serious risk of beginning training without the water-activated release system installed in the early production lots of training aircraft. At that time, the Program Office expected the full qualification of the system to be completed by the end of 2012.

System

- The F-35 JSF program is a tri-Service, multi-national, single-seat, single-engine family of strike aircraft consisting of three variants:
  - F-35A Conventional Take-Off and Landing (CTOL)
  - F-35B Short Take-Off/Vertical-Landing (STOVL)
  - F-35C Aircraft Carrier Variant (CV)
- It is designed to survive in an advanced threat (year 2015 and beyond) environment using numerous advanced capabilities. It is also designed to have improved lethality in this environment compared to legacy multi-role aircraft.
- Using an active electronically scanned array radar and other sensors, the F-35 is intended to employ precision-guided bombs such as the GBU-31/32 JDAM, GBU-39 SDB, Navy JSOW-C1, AIM-120C AMRAAM, and AIM-9X infrared-guided short-range air-to-air missile.
- The program provides mission capability in three increments:
  - Block 1 (initial training; two increments were fielded: Blocks 1A and 1B)
  - Block 2 (advanced training in Block 2A and limited combat capability in Block 2B)
  - Block 3 (limited combat in Block 3i and full combat capability in Block 3F)
- The F-35 is under development by a partnership of countries: the United States, Great Britain, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway.

Mission

- The Combatant Commander will employ units equipped with F-35 aircraft to attack targets during day or night, in all weather conditions, and in highly defended areas of joint operations.
- The F-35 will be used to attack fixed and mobile land targets, surface units at sea, and air threats, including advanced aircraft and cruise missiles.

Major Contractor

Lockheed Martin, Aeronautics Division – Fort Worth, Texas

Test Strategy, Planning, and Resourcing

- The Program Office continues to plan for a start of IOT&E in August 2017, three months after the program's planned completion of developmental flight test in May 2017, or one month later than the recently briefed date of July 2017. In the intervening three months, the program must complete all the analyses and certification requirements to allow final preparations for IOT&E to begin. There are clear indications that it is no longer possible to meet the requirements to start an adequate IOT&E at that time. Specifically:
  - The program's joint test plans for Block 3F mission systems testing contain more testing than can be completed by May 2017, which is the planned end of Block 3F flight test, according to the most recent program schedule. Even extending until the end of July 2017 to compete System Development and Demonstration (SDD) flight test is not realistic. Instead, the program will likely not finish Block 3F development and flight testing prior to January 2018, based on the following:
    - Continuing a six test point per flight accomplishment rate, which is equal to the CY15 rate observed through the end of November
    - Continuing a flight rate of 6.8 flights per month with the 6 mission systems developmental test aircraft assigned to Edwards AFB, as was achieved through the end of November 2015, exceeding the planned rate of 6 flights per month (if the flight rate deteriorates to the planned rate of 6 flights per month, then testing will not complete until May 2018)
    - Completing the full Block 3F mission systems test plan (i.e., all original 7,230 baseline and budgeted non-baseline test points in the Block 3F joint test plan)
    - Continuing the CY15 discovery rate of 5 percent
  - Based on these projected completion dates for Block 3F developmental testing, IOT&E would not start earlier than August 2018. The program could, as has been the case in testing previous software increments, determine that test points in the plan are no longer required for the Block 3F fleet release. However, the program will need to ensure that deleting and/or deferring testing from Block 3F before the end of SDD and the start of IOT&E does not result in increasing the likelihood of discovery in IOT&E or affect the assessment of mission capability. Whatever capability the program determines as ready for IOT&E will undergo the same realistic and rigorous combat mission-focused testing as a fully functioning system.
  - The 48 Block 3F developmental test weapons delivery accuracy (WDA) events in the approved Test and Evaluation Master Plan (TEMP), plus two test events deferred from Block 2B, will not be accomplished by the planned date of May 2017, according to the program's official schedule, nor by July 2017, a more recently briefed date for the completion of SDD flight test, unless the program is able to significantly increase their historic WDA completion rate. In order to meet the schedule requirements for weapon certification, the Program Office has identified 10 WDA events for the F-35A and 5 events

for the F-35B and F-35C that must be accomplished during Block 3F developmental testing. The program plans to accomplish the remaining 33 events as schedule margin allows.
  - Modifying the fleet of operational test aircraft to the required production-representative Block 3F configuration, with the TEMP-required instrumentation capability, will not be complete before August 2017.
  - The Program Office did not put the Block 3F Verification Simulation (VSim) development on contract in early 2015, as was needed in order to complete development for IOT&E. The Program Office decided instead to move from VSim to the Joint Simulation Environment (JSE), which will result in a fully verified, validated, and accredited simulator not being ready in time for IOT&E.
- Comparison testing provides insight into the capabilities available from new weapon systems relative to the legacy systems they replace. Since the Department plans to retire a large portion of its tactical aircraft inventory and replace them over time with the F-35, comparison testing will be a part of the Block 3F IOT&E. The JSF Operational Test Team (JOTT), in coordination with DOT&E staff, began to develop test plans for IOT&E, which will include comparisons of the F-35 with the A-10 in the Close Air Support role and with the F-16C (Block 50) in the Suppression of Enemy Air Defense/Destruction of Enemy Air Defenses (SEAD/DEAD) mission area. Comparison testing involving other strike aircraft is under consideration by the JOTT and DOT&E.
- JSF follow-on development will integrate additional capabilities in Block 4, address deferrals from Block 3F to Block 4, and correct deficiencies discovered during Block 3F development and IOT&E.
  - The program plans to complete Block 3F software development in 2016 and flight testing in early 2017. The next planned software delivery will be a Block 4 build in 2020, creating a four year gap between planned software releases. Considering the large number of open deficiencies documented from Blocks 2B and 3i testing, the ongoing discovery of deficiencies during Block 3F testing, and the certainty of more discoveries from IOT&E, the program needs to plan for additional Block 3F software builds and follow-on testing prior to 2020.
  - As has been the case with the F-22, the F-35 program will remain on DOT&E oversight during follow-on development and therefore must plan for and fund an associated formal OT&E of each Block 4 increment prior to release to operational units.
- The program has proposed a "block buy" combining three production lots comprising as many as 270 U.S. aircraft purchases to gain near-term savings. A commitment to the "block buy" could be necessary before IOT&E is complete. In that case, entering a "block buy" would raise the following questions:
  - Is the F-35 program sufficiently mature to commit to the "block buy?" The program continues to discover significant problems during developmental testing that, if not addressed with corrections or, in some cases, labor-intensive workarounds, will adversely affect the operational effectiveness and suitability of all three variants; these deficiencies need to be corrected before the system is used in combat. To date, the rate of deficiency correction has not kept pace with the discovery rate. Examples of well-known significant problems include the immaturity of the Autonomic Logistics Information System (ALIS), Block 3F avionics instability, and several reliability and maintainability problems with the aircraft and engine. Much of the most difficult and time-consuming developmental testing, including approximately 50 complex WDA events, remains to be completed. Hence, new discoveries, some of which could further affect the design or delay the program, are likely to occur throughout the time the Department could commit to the "block buy." Recent discoveries that require design changes, modifications, and regression testing include the ejection seat for safe separation, wing fuel tank over-pressurization, and the life-limitations of the F-35B bulkhead. For these specific reasons and others, further program delays are likely.
  - Is it appropriate to commit to a "block buy" given that essentially all the aircraft procured thus far require modifications to be used in combat? Although still officially characterized as low-rate, F-35 production rates are already high. Despite the problems listed above, F-35 production rates have been allowed to steadily increase to large rates, well prior to the IOT&E and official Full-Rate Production (FRP) decision. Due to this concurrency of development and production, approximately 340 aircraft will be produced by FY17 when developmental testing is currently planned to end, and over 500 aircraft by FY19 when IOT&E will likely end and the FRP milestone decision should occur. These aircraft will require a still-to-be-determined list of modifications in order to provide full Block 3F combat capability. However, these modifications may be unaffordable for the Services as they consider the cost of upgrading these early lots of aircraft while the program continues to increase production rates in a fiscally-constrained environment. This may potentially result in left-behind aircraft with significant limitations for years to come.
  - Would committing to a "block buy" prior to the completion of IOT&E provide the contractor with needed incentives to fix the problems already discovered, as well as those certain to be discovered during IOT&E? Would it be preferred—and would it provide a strong incentive to fix problems and deliver fully combat-capable aircraft—to make the "block buy," as well as any additional increases in the already high annual production rate, contingent upon successful completion of IOT&E? Similarly, would the "block buy" also be consistent with the "fly before you buy" approach to acquisition advocated by the Administration, as well as with the rationale for the

operational testing requirements specified in Title 10 U.S. Code?

- This report includes assessments of the progress of testing to date, including developmental and operational testing intended to verify performance prior to the start of IOT&E.
  - For developmental flight testing, the program creates plans by identifying specific test points (discrete measurements of performance under specific flight test conditions) for accomplishment in order to determine capabilities as being compliant with contract specifications.
    - Baseline test points refer to points in the test plans that must be accomplished in order to evaluate if performance meets contract specifications.
    - Non-baseline test points are accomplished for various reasons. Program plans include a budget for some of these points within the capacity of flight test execution. The following describes non-baseline test points.
      - » Development points are test points required to "build up" to, or prepare for, the conditions needed for specification compliance (included in non-baseline budgeted planning in CY15).
      - » Regression points are test points flown to ensure that new software does not introduce discrepancies as compared to previous software (included in non-baseline budgeted planning in CY15).
      - » Discovery points are test points flown to investigate root causes or characterize deficiencies so that the program can design fixes (not included in planning in CY15).
  - As the program developed plans for allocating test resources against test points in CY15, the program included a larger budget for non-baseline test points (development and regression points) for all test venues (i.e., each variant of flight sciences and mission systems). For CY15 mission systems testing, planners budgeted an additional 45 percent of the number of planned baseline test points for non-baseline test purposes (e.g., development and regression points). In this report, growth in test points refers to points flown in addition to the planned amount of baseline and budgeted non-baseline points (e.g., discovery points and any other added testing not originally included in the formal test plan). The program allocates budgeted non-baseline test points in specific quantities to test categories (i.e., variant flight science, Block 2B, 3i, and 3F mission systems).
  - The need to budget for non-baseline test points in the CY15 plan is a result of the limited maturity of capability in the early versions of mission systems software. In CY15, when the first versions of Block 3F software were planned to be introduced to flight testing, limited baseline test points could be completed and development points would be the majority of the type of points flown. Also, as three versions of Block 3F software were planned to be introduced to flight testing in CY15, the test centers would need to accomplish a large number of regression points.
  - Cumulative SDD test point data in this report refer to the total progress towards completing development at the end of SDD.

TEST FLIGHTS (AS OF NOVEMBER 2015)					
	All Testing	Flight Sciences			Mission Systems
	All Variants	F-35A	F-35B	F-35C	
2015 Actual	1,193	188	283	270	452
2015 Planned	1,281	231	311	256	483
Difference from Planned	7.4%	22.9%	9.9%	-5.2%	6.9%
Cumulative Planned	6,242	1,489	1,844	1,188	1,721
Cumulative Actual	6,416	1,466	1,893	1,193	1,864
Difference from Planned	2.8%	-1.5%	2.7%	0.4%	8.3%
Prior to CY15 Planned	5,049	1,301	1,561	918	1,269
Prior to CY15 Actual	5,135	1,235	1,582	937	1,381

TEST POINTS (AS OF NOVEMBER 2015)												
	All Testing	Flight Sciences[1]						Mission Systems				
	All Variants	F-35A		F-35B		F-35C		Block 2B	Block 3i	Block 3F	Budgeted Non-Baseline[2]	Other[3]
		Block 3F Baseline	Budgeted Non-Baseline[2]	Block 3F Baseline	Budgeted Non-Baseline[2]	Block 3F Baseline	Budgeted Non-Baseline[2]					
2015 Test Points Planned (by type)	8,673	1,221	113	2,181	211	1,819	130	143	514	575	1,097	669
2015 Test Points Accomplished (by type)	8,011	1,196	62	2,003	191	1,910	59	160	469	674	834	453
Difference from Planned	-7.6%	-2.0%	-45.1%	-8.2%	-9.5%	5.0%	-54.6%	11.9%	-8.8%	17.2%	-24.0%	-32.3%
Points Added Beyond Budgeted Non-Baseline (Growth Points)	457	0		0		0		93	364	0	0	0
Test Point Growth Percentage (Growth Points/Test Points Accomplished)	5.7%	0.0%		0.0%		0.0%		58.1%	77.6%	0.0%	0.0%	0.0%
Total Points (by type) Accomplished in 2015[4]	8,468	1,258		2,194		1,969		253	833	674	834	453
Cumulative Data												
Cumulative SDD Planned Baseline[5]	43,611	10,919		13,995		10,650		6,232	699	575	N/A	541
Cumulative SDD Actual Baseline	43,528	10,978		13,835		10,729		5,933	660	674	N/A	719
Difference from Planned	-0.2%	0.5%		-1.1%		0.7%		-4.8%	-5.6%	17.2%	N/A	32.9%
Estimated Test Baseline Points Remaining	12,905	1,597		3,250		2,428		0	0	4,841	N/A	789
Estimated Non-Baseline Test Points Remaining	2,175	139		443		270		0	0	1,323	N/A	0

1. Flight sciences test points for CY15 are shown only for Block 3F. Block 2B Flight Sciences testing was completed in CY14 for F-35A, May 2015 for F-35B, and January 2015 for F-35C. Cumulative numbers include all previous flight science activity.
2. These points account for planned development and regression test points built into the 2015 plan; additional points are considered "growth".
3. Represents mission systems activity not directly associated with Block capability (e.g., radar cross section characterization testing, test points to validate simulator).
4. Total Points Accomplished = 2015 Baseline Accomplished + Added Points
5. SDD – System Design and Development

F-35A Flight Sciences

Flight Test Activity with AF-1, AF-2, and AF-4 Test Aircraft

- F-35A flight sciences testing focused on:
  - Internal gun testing
  - Flight envelope expansion with external weapons required for Block 3F weapons capability
  - Air refueling qualification with Italian and Australian tanker aircraft
  - Testing to mitigate fuel system over-pressurization conditions caused by fuel and On-Board Inert Gas Generation System (OBIGGS) gas pressure stacking within the system

F-35A Flight Sciences Assessment

- Through the end of November, the test team flew 23 percent more flights than planned (231 flown versus 188 planned), but was 2 percent behind the plan for Block 3F baseline test point completion (1,196 test points accomplished versus 1,221 planned). By the end of November 2015, the test team flew an additional 62 test points for regression of new air vehicle software (which were part of the budgeted non-baseline test points allocated for the year) and 238 points for air refueling qualification with partner nation tanker aircraft (these points are not included in the table of test flights and test points above). All F-35A flight sciences

testing accomplished in CY15 was relevant to Block 3F requirements.

- All Block 2B flight sciences test points were completed in CY14 and provided the basis for the F-35A Block 2B fleet release to the training and operational units in August 2015. The Block 2B flight sciences test points also provided the basis for Block 3i initial flight clearances needed for Lot 6 and Lot 7 production aircraft delivered in CY15. There is no additional flight envelope provided by Block 3i compared to Block 2B.
- The following details discoveries in F-35A flight sciences testing:
  - Testing to characterize the thermal environment of the weapons bays demonstrated that temperatures become excessive during ground operations in high ambient temperature conditions and in-flight under conditions of high speed and at altitudes below 25,000 feet. As a result, during ground operations, fleet pilots are restricted from keeping the weapons bay doors closed for more than 10 cumulative minutes prior to take-off when internal stores are loaded and the outside air temperature is above 90 degrees Fahrenheit. In flight, the 10-minute restriction also applies when flying at airspeeds equal to or greater than 500 knots at altitudes below 5,000 feet; 550 knots at altitudes between 5,000 and 15,000 feet; and 600 knots at altitudes between 15,000 and 25,000 feet. Above 25,000 feet, there are no restrictions associated with the weapons bay doors being closed, regardless of temperature. The time limits can be reset by flying 10 minutes outside of the restricted conditions (i.e., slower or at higher altitudes). This will require pilots to develop tactics to work around the restricted envelope; however, threat and/or weather conditions may make completing the mission difficult or impossible using the work around.
  - Testing to characterize the vibrational and acoustic environment of the weapons bays demonstrated that stresses induced by the environment were out of the flight qualification parameters for both the AIM-120 missile and the flight termination system (telemetry unit attached to the missile body required to satisfy range safety requirements for terminating a live missile in a flight test). This resulted in reduced service life of the missile and potential failure of the telemetered missile termination system required for range safety.
  - Deficiencies in the sequencing of release commands for the Small Diameter Bomb (SDB) from the Bomb Rack Unit-61, which provides the interface between the SDB and the aircraft, were discovered in the lab and verified in aircraft ground testing. The program will assess software corrections to address these deficiencies in future flight testing.
  - Mechanical rubbing between the gun motor drive and the wall of the gun bay was discovered during initial ground testing of the gun on the AF-2 test aircraft, requiring structural modifications to the bay and alterations to the flow of cooling air and venting of gun gasses.
  - Under certain flight conditions, air enters the siphon fuel transfer line and causes the pressure in the siphon fuel tank to exceed allowable limits in all variants. As a result, the program imposed an aircraft operating limitation (AOL) on developmental test aircraft limiting maneuvering flight for each variant (e.g. “g” load during maneuvering). F-35A developmental test aircraft with the most recent fuel tank ullage inerting system modifications are limited to 3.8 g’s when the aircraft is fully fueled. The allowable g increases as fuel is consumed and reaches the full Block 2B 7.0 g envelope (a partial envelope compared to full Block 3F) once total fuel remaining is 10,213 pounds or less, or roughly 55 percent of full fuel capacity, for developmental test aircraft with test control team monitoring (through instrumentation) of the fuel system. For developmental test aircraft without fuel system monitoring, the full Block 2B 7.0 g envelope becomes available at 9,243 pounds, or roughly 50 percent of full fuel capacity. Flight testing to clear the F-35A to the full Block 3F 9.0 g envelope, planned to be released in late 2017, is being conducted with developmental test aircraft with fuel system monitoring. Fleet F-35A aircraft are limited to 3.0 g’s when fully fueled and the allowable g is increased as fuel is consumed, reaching the full Block 2B 7.0 g envelope when approximately 55 percent of full fuel capacity is reached. The program modified the AF-4 test aircraft in October and November with the addition of a relief line, controlled by a solenoid valve, to vent the affected siphon tanks, and a check valve on the inert gas line feeding the tanks. The test team completed testing of the modified design in late November 2015; the results are under review. Until relieved of the g restrictions, operational units will have to adhere to a reduced maneuvering (i.e., less “g available”) envelope in operational planning and tactics; for example, managing threat engagements and escape maneuvers when in the restricted envelope where less g is available. This restriction creates an operational challenge when forward operating locations or air refueling locations are close to the threat/target arena, resulting in high fuel weights during engagements.
  - Testing of operational “dog-fighting” maneuvers showed that the F-35A lacked sufficient energy maneuverability to sustain an energy advantage over fourth generation fighter aircraft. Test pilots flew 17 engagements between an F-35A and an F-16D, which was configured with external fuel tanks that limited the F-16D envelope to 7.0 g’s. The F-35A remained at a distinct energy disadvantage on every engagement. Pitch rates were also problematic, where full aft stick maneuvers would result in less than full permissible g loading (i.e., reaching 6.5 g when limit was 9.0 g), and subsequent rapid loss of energy. The slow pitch rates were observed at slower speeds—in a gun engagement, for example—that restricted the ability of an F-35A pilot to track a target for an engagement.

- The program completed the final weight assessment of the F-35A air vehicle for contract specification compliance in April with the weighing of AF-72, a Lot 7 production aircraft. Actual empty aircraft weight was 28,999 pounds, 372 pounds below the planned not-to-exceed weight of 29,371 pounds. The program has managed the weight growth of the F-35A air vehicle with no net weight growth for the 76 months preceding the final weight assessment. Weight management of the F-35A is important for meeting performance requirements and structural life expectations. The program will need to continue disciplined management of the actual aircraft weight beyond the contract specification as further discoveries during the remainder of SDD may add weight and result in performance degradation that would adversely affect operational capability.

F-35B Flight Sciences

Flight Test Activity with BF-1, BF-2, BF-3, BF-4, and BF-5 Test Aircraft

- F-35B flight sciences focused on:
  - Completing Block 2B flight envelope testing by the end of May
  - Flight envelope expansion with external weapons, including Paveway IV bombs, required for Block 3F weapons capability
  - Testing to characterize and mitigate fuel system over-pressurization conditions caused by fuel and OBIGGS gas pressure stacking within the system
  - Air refueling testing, including low altitude air refueling with KC-130 tanker aircraft
  - Testing of control authority during landings in crosswind conditions, both with and without external stores

F-35B Flight Sciences Assessment

- Through the end of November, the test team was able to fly 10 percent more flights than planned (311 flown versus 283 planned), but accomplished 8 percent less than the planned Block 3F baseline test points (2,003 points accomplished versus 2,181 planned). The team flew an additional 191 test points for regression of new air vehicle software, which were part of the budgeted non-baseline points planned for CY15. The team also completed four test points needed to complete the Block 2B flight envelope. The program also declared that 23 planned Block 2B baseline points were no longer required.
- The following details discoveries in F-35B flight sciences testing:
  - Testing to characterize the thermal environment of the weapons bays demonstrated that temperatures become excessive during ground operations in high ambient temperature conditions. As a result, during ground operations, fleet pilots are restricted from keeping the weapons bay doors closed for more than 10 cumulative minutes prior to take-off when internal stores are loaded and the outside air temperature is above 90 degrees Fahrenheit. Time with the weapons bay doors closed in flight is currently not restricted.
  - Under certain flight conditions, air can enter the siphon fuel transfer line and cause the pressure in the siphon fuel tanks to exceed allowable limits in all variants. As a result, the program imposed an aircraft operating limitation (AOL) on developmental test aircraft limiting maneuvering flight for each variant. The program implemented a partial mitigation in software on the F-35B. For F-35B developmental aircraft with the most recent fuel tank ullage inerting system modifications, the AOL limits maneuvers to 5.0 g's when the aircraft is fully fueled, but the allowable g increases as fuel is consumed. The full Block 2B 5.5 g envelope (a partial envelope compared to Block 3F) is available once total fuel remaining is approximately 13,502 pounds, or roughly 96 percent fuel remaining for developmental test aircraft with ground station monitoring of the fuel system, and 7,782 pounds or less, or roughly 56 percent fuel remaining for developmental test aircraft without monitoring. Flight testing to clear the F-35B to the full Block 3F 7.0 g envelope, planned to be released in late 2017, is being conducted with developmental test aircraft with fuel system monitoring. Fleet F-35B aircraft are limited to 3.0 g's when fully fueled and the allowable g is increased as fuel is consumed, reaching the full Block 2B envelope of 5.5 g's at roughly 63 percent of fuel remaining. The program has successfully developed and tested a hardware change on the F-35B to correct the overpressure problem involving the addition of a relief line controlled by a check valve to vent the affected siphon tanks. Once installed in fleet aircraft, the relief line and check valve will prevent the pressure in the siphon tanks from exceeding the allowable limits. Until the F-35B aircraft have the modification that relieves the g restrictions, operational units will have to adhere to a reduced maneuvering (i.e., less "g available") envelope in operational planning and tactics; for example, managing threat engagements and escape maneuvers when in the restricted envelope where less g is available. This restriction creates an operational challenge when forward operating locations or air refueling locations are close to the threat/target arena.
  - Air refueling with strategic tankers (KC-135 and KC-10) was restricted to use of centerline boom-to-drogue adapter (BDA) refueling only. Refueling from tanker wing pods was prohibited due to response anomalies from the hose and reel assemblies and the F-35B aircraft with the air refueling receptacle deployed.
- Weight management of the F-35B aircraft is critical to meeting the Key Performance Parameters (KPPs) in the Operational Requirements Document (ORD), including the vertical lift bring-back requirement, which will be evaluated during IOT&E. This Key Performance Parameter (KPP) requires the F-35B to be able to fly an operationally representative profile and recover to the ship with the necessary fuel and balance of unexpended weapons (two 1,000-pound bombs and two AIM-120 missiles) to safely conduct a vertical landing.

- The program completed the final weight assessment of the F-35B air vehicle for contract specification compliance in May 2015 with the weighing of BF-44, a Lot 7 production aircraft. Actual empty aircraft weight was 32,442 pounds, only 135 pounds below the planned not-to-exceed weight of 32,577 pounds and 307 pounds (less than 1 percent) below the objective vertical lift bring-back not-to-exceed weight of 32,749 pounds.
- The program will need to continue disciplined management of weight growth for the F-35B, especially in light of the small weight margin available and the likelihood of continued discovery through the remaining two years of development in SDD.

F-35C Flight Sciences

Flight Test Activity with CF-1, CF-2, CF-3, and CF-5 Test Aircraft

- F-35C flight sciences focused on:
  - Completing Block 2B testing by the end of January 2015
  - Ship suitability testing in preparation for the next set of ship trials (DT-2), originally planned for August, but slipped to October 2015 due to carrier availability
  - Flight envelope expansion with external weapons, required for Block 3F weapons capability
  - Testing with wing spoilers to reduce the adverse effects of transonic roll off in the portions of the flight envelope where it occurs
  - High angle of attack testing
  - Testing of control authority during landings in crosswind conditions, both with and without external stores
  - Testing of landings on wet runways and the effectiveness of anti-skid braking procedures
  - Air refueling testing
  - Initial testing of the Joint Precision Approach and Landing System

F-35C Flight Sciences Assessment

- Through the end of November, the test team flew 5 percent less than planned flights (256 flown versus 270 planned), but accomplished 5 percent more than the planned Block 3F baseline test points (1,910 points accomplished versus 1,819 planned). The team flew an additional 59 test points for regression of new software, which were part of the budgeted non-baseline points planned for the year. With the exception of three high angle of attack test points in January for the Block 2B envelope, all testing in CY15 supported Block 3F testing requirements.
- The following details discoveries in F-35C flight sciences testing:
  - Under certain flight conditions, air can enter the siphon fuel transfer line and cause the pressure in the siphon fuel tank to exceed allowable limits in all variants. The program imposed an AOL on developmental test aircraft, limiting maneuvering flight for each variant. On F-35C developmental test aircraft with the most recent fuel tank ullage inerting system modifications, the AOL limits maneuvers to 4.0 g's when the aircraft is fully fueled and the allowable g increases as fuel is consumed. The full Block 2B 6.0 g envelope (a partial envelope compared to Block 3F) is available with 18,516 pounds or roughly 93 percent fuel remaining for developmental test aircraft with test control team monitoring (through instrumentation) of the fuel system, and 8,810 pounds or roughly 40 percent fuel remaining for developmental test aircraft without monitoring. Flight testing to clear the F-35C to the full Block 3F 7.5 g envelope, planned to be released in late 2017, is being conducted with developmental test aircraft with fuel system monitoring. The program has developed and tested a correction involving the addition of a relief line controlled by a check valve to vent the affected siphon tanks on the F-35B, which has very similar fuel system siphoning architecture as the F-35C. However, the program has not tested the pressure relief design in flight on an F-35C. Fleet F-35C aircraft are limited to 3.0 g's when fully fueled and the allowable g is increased as fuel is consumed, reaching the full Block 2B envelope of 6.0 g's at roughly 43 percent of total fuel quantity remaining. Until relieved of the g restrictions, operational units will have to adhere to a reduced maneuvering (i.e., less "g available") envelope in operational planning and tactics; for example, managing threat engagements and escape maneuvers when in the restricted envelope where less g is available. This restriction creates an operational challenge when forward operating locations or air refueling locations are close to the threat/target arena.
  - Air refueling with strategic tankers (KC-135 and KC-10) was restricted to use of centerline BDA refueling only. Refueling from tanker wing pods was prohibited due to response anomalies from the hose and reel assemblies and the F-35C aircraft with the air refueling receptacle deployed.
  - The Patuxent River test center (Maryland) conducted an assessment of the effects of transonic roll off (TRO), which is an un-commanded roll at transonic Mach numbers and elevated angles of attack. The test center also assessed buffet, which is the impact of airflow separating from the leading edge of the wing that collides and "buffets" aft areas of the wing and aircraft on basic fighter maneuvering. TRO and buffet occur in areas of the maneuvering envelope that cannot be sustained for long periods of time, as energy depletes quickly and airspeed transitions out of the flight region where these conditions manifest. However fleeting, these areas of the envelope are used for critical maneuvers. The testing determined that TRO, observed to cause up to 8 degrees angle of bank, adversely affected performance in defensive maneuvering where precise control of bank angles and altitude must be maintained while the F-35C is in a defensive position and the pilot is monitoring an offensive aircraft. The test pilots observed less of an effect when the F-35C is conducting offensive maneuvering. However, buffet degrades precise

aircraft control and the readability of heads-up-display symbology in the HMDS during execution of certain critical offensive and defensive tasks, such as defensive maneuvers.

- The program completed two test flights in February with CF-2, an instrumented flight sciences test aircraft modified with spoilers, to investigate the effects on flying qualities when using control laws to deploy spoilers in the flight regions where buffet and TRO manifest (between Mach 0.92 and 1.02 and above 6 degrees angle-of-attack).
  - Testing showed the spoilers reduced buffet at some flight conditions, but also may increase buffet under other flight conditions, and reduced the magnitude of TRO when experienced; an observation predicted by wind tunnel testing.
  - Pilots reported that spoilers made a measurable difference in the buffet-laden region of the flight envelope but, due to the transient nature of buffet, the operational significance may be low.
  - Operational testing of the F-35C will need to assess the effect of TRO and buffet on overall mission effectiveness.

- Weight management is important for meeting air vehicle performance requirements, including the KPP for recovery approach speed to the aircraft carrier, and structural life expectations. These estimates are based on measured weights of components and subassemblies, calculated weights from approved design drawings released for build, and estimated weights of remaining components. These estimates are used to project the weight of the first Lot 8 F-35C aircraft (CF-28) planned for delivery in March 2016, which will be the basis for evaluating contract specification compliance for aircraft weight.
  - The current F-35C estimate of 34,582 pounds is 286 pounds (less than 1 percent) below the planned not-to-exceed weight of 34,868 pounds.
  - The program will need to ensure the actual aircraft weight meets predictions and continue rigorous management of the actual aircraft weight beyond the technical performance measurements of contract specifications in CY16. The program will need to accomplish this through the balance of SDD to avoid performance degradation that would affect operational capability.

Mission Systems

Flight Test Activity with AF-3, AF-6, AF-7, BF-4, BF-5, BF-17, BF-18, CF-3, and CF-8 Flight Test Aircraft and Software Development Progress

- Mission systems are developed, tested, and fielded in incremental blocks of capability.
  - Block 1. The program designated Block 1 for initial training capability in two increments: Block 1A for Lot 2 (12 aircraft) and Block 1B for Lot 3 aircraft (17 aircraft). No combat capability is available in either Block 1 increment. The Services have upgraded a portion of these aircraft to the Block 2B configuration through a series of modifications and retrofits. As of the end of November, 9 F-35A and 12 F-35B aircraft had been modified to the Block 2B configuration and 4 F-35A were undergoing modifications. Two F-35B aircraft, which are on loan to the Edwards AFB test center to support mission systems developmental flight testing, have been modified to the Block 3F configuration, leaving one F-35A and one F-35B in the Block 1B configuration. Additional modifications will be required to configure these aircraft in the Block 3F configuration.
  - Block 2A. The program designated Block 2A for advanced training capability and delivered aircraft in production Lots 4 and 5 in this configuration. No combat capability is available in Block 2A. The U.S. Services accepted 62 aircraft in the Block 2A configuration (32 F-35A aircraft in the Air Force, 19 F-35B aircraft in the Marine Corps, and 11 F-35C aircraft in the Navy). Similar to the Block 1A and Block 1B aircraft, the Services have upgraded these aircraft to the Block 2B configuration with modifications and retrofits, although fewer modifications were required. By the end of September, all 62 Lot 4 and 5 aircraft had been modified to the Block 2B configuration. One F-35C aircraft, which is on loan to the Edwards AFB test center, has been modified to the Block 3F configuration to support mission systems developmental flight testing. Additional modifications will be required to fully configure these aircraft in the Block 3F configuration.
  - Block 2B. The program designated Block 2B for initial, limited combat capability for selected internal weapons (AIM-120C, GBU-31/32 JDAM, and GBU-12). This block is not associated with the delivery of any lot of production aircraft. Block 2B mission systems software began flight testing in February 2013 and finished in April 2015. Block 2B is the software that the Marine Corps accepted for the F-35B Initial Operational Capability (IOC) configuration.
  - Block 3i. The program designated Block 3i for delivery of aircraft in production Lots 6 through 8, as these aircraft include a set of upgraded integrated core processors (referred to as Technical Refresh 2, or TR-2). The program delivered Lot 6 aircraft with a Block 3i version that included capabilities equivalent to Block 2A in Lot 5. Lot 7 aircraft are being delivered with capabilities equivalent to Block 2B, as will Lot 8 aircraft. Block 3i software began flight testing in May 2014 and completed baseline testing in October 2015, eight months later than planned in the Integrated Master Schedule (IMS). The program completed delivery of the U.S. Service's Lot 6 aircraft in 2015 (18 F-35A, 6 F-35B, and 7 F-35C aircraft). The delivery of Lot 7 aircraft began in August 2015, with four F-35A aircraft delivered to the U.S. Air Force. By the end of November, the program had delivered 13 F-35A

Lot 7 aircraft to the U.S. Air Force and two F-35B Lot 7 aircraft to the Marine Corps.
  - Block 3F. The program designated Block 3F as the full SDD capability for production Lot 9 and later. Flight testing with Block 3F software on the F-35 test aircraft began in March 2015. Aircraft from production Lots 2 through 5 will need to be modified, including the installation of TR-2 processors, to have Block 3F capabilities.
- Mission systems testing focused on:
  - Completing Block 2B flight testing
  - Completing Block 3i flight testing
  - Beginning Block 3F flight testing
  - Regression testing of corrections to deficiencies identified in Block 2B and Block 3i flight testing
  - Testing of the Gen III HMDS
- The six mission systems developmental flight test aircraft assigned to the Edwards AFB test center flew an average rate of 6.8 flights per aircraft, per month in CY15 through November, exceeding the planned rate of 6.0 by 13 percent, and flew 107 percent of the planned flights (483 flights accomplished versus 452 planned).
- The program prioritized flight test activity early in the year to complete Block 2B flight testing. The program declared testing complete on Block 2B software at the end of April. The program made the decision, in part, based on schedule, to support the need for moving forward with Block 3i and Block 3F testing, which required modifying the mission systems test aircraft with upgraded TR-2 processors.
- The Edwards AFB test center used production operational test aircraft, assigned to the operational test squadron there, to assist in accomplishing developmental test points of Block 2B capabilities throughout the year, including augmenting testing requiring formation flight operations.

Mission Systems Assessment

- Block 2B Development
  - The program completed Block 2B mission systems testing and provided a fleet release version of the software with deficiencies identified during testing.
  - The program attempted to correct deficiencies in the fusion of information—from the sensors on a single aircraft and between aircraft in formation—identified during flight testing in late CY14 and early CY15 of the planned final Block 2B software version. The test team flew an "engineering test build" (ETB) of the software designated 2BS5.2ETB. on 17 test flights using 3 different mission systems test aircraft in March. Although some improvement in performance was observed, distinguishing ground targets from clutter continued to be problematic. As a result, the program chose to field the final (prior to the ETB) version of Block 2B software and defer corrections to Block 3i and Block 3F.
  - Five mission systems deficiencies were identified by the Air Force as "must fix" for the final Block 3i software release, while the Marine Corps did not require the deficiencies to be fixed in Block 2B. These deficiencies were associated with information displayed to the pilot in the cockpit concerning performance and accuracy of mission systems functions related to weapon targeting, radar tracking, status of fused battlespace awareness data, health of the integrated core processors, and health of the radar. Another deficiency was associated with the time it takes to download files in order to conduct a mission assessment and debriefing.
  - Continuing to work the Block 2B deficiencies would have delayed the necessary conversion of the labs and the developmental test aircraft to the Block 3i and Block 3F configuration, delaying the ability for the program to complete Block 3i testing needed for delivery of aircraft from production Lots 6 and 7, and starting flight testing of Block 3F software.
  - The program deferred two WDA events from Block 2B to Block 3F as a result of the decision to stop Block 2B testing in April. This deferred work will add more pressure to the already demanding schedule of Block 3F WDA events.
  - The program attempted to correct known deficiencies from flight testing of Block 2B software in the Block 3i software product line (i.e., mission systems labs and Block 3i flight test aircraft). The program corrected some of these deficiencies and, as of the end of November 2015, planned to transfer these corrections to a new version of Block 2B software (2BS5.3) for a release in CY16. In order to accomplish this, the program needs to use aircraft from the operational test fleet, which will still be in the Block 2B configuration, to test the 2BS5.3 software. However, this entire process introduces inefficiencies in the program's progress for developing and testing Block 3F software.
- Block 2B Fleet Release
  - The program finished Block 2B developmental testing in May (mission systems testing completed in April, and F-35B flight sciences testing completed in May) and provided the necessary data for the Service airworthiness authorities to release Block 2B capabilities to their respective fleets. The Marine Corps released Block 2B to the F-35B fielded units in June, the Air Force to the F-35A units in August, and the Navy to the F-35C units in October. The fleet release enabled the Services to load Block 2B software on their aircraft, provided they had been modified at least in part to the Block 2B configuration.
  - Because of the limited combat capability provided in Block 2B, if the Block 2B F-35 aircraft will be used in combat, it will need the support of a command and control system that will assist in target acquisition and to control weapons employment for the limited weapons carriage available. If in an opposed combat scenario, the F-35 Block 2B aircraft would need to avoid threat engagement and would require augmentation by other friendly forces. The Block 2B fleet release carries maneuver and envelope restrictions that, although agreed to by the Services during requirements reviews, will also limit effectiveness:

  - For the F-35A, the airspeed at which the weapons bay doors can be open in flight (550 knots or 1.2 Mach) is less than the maximum aircraft speed allowable (700 knots or 1.6 Mach). Such a restriction will limit tactics to employment of weapons at lower speeds and may create advantages for threat aircraft being pursued by the F-35A.
  - For the F-35A, the airspeed at which countermeasures can be used is also less than the maximum speed allowable, again restricting tactical options in scenarios where F-35A pilots are conducting defensive maneuvers
- The program formally vets deficiency reports submitted by test and operational organizations. The formal process assigns deficiency reports to categories correlating to urgency for correction. Category I deficiencies are those which may cause death, severe injury, or severe occupational illness; may cause loss or major damage to a weapon system; critically restrict the combat readiness capabilities of the using organization; or result in a production line stoppage. Category II deficiencies are those that impede or constrain successful mission accomplishment (but do not meet the safety or mission impact criteria of a Category I deficiency). As of the end of October 2015, 91 Category 1 (mission or safety of flight impact, 27) and Category 2 (mission impact, 64) high-severity deficiencies in the full Block 2B configuration (air vehicle, propulsion, mission systems) were not yet resolved by the program. Of these 91, 43 are assigned to mission systems engineering for resolution.
- In addition to the mission systems deficiencies cited above, the Block 2B fleet aircraft are restricted by fuel system deficiencies:
  - All variants of the fleet Block 2B aircraft are restricted from exceeding 3 gs in symmetric maneuvers when fully fueled in order to avoid exceeding the allowable pressure in the siphon fuel tanks. The allowable g increases as fuel is consumed. The program has developed and tested a hardware correction to the problem for the F-35B; corrections for the F-35A and F-35C are still in work. Modification kits for installation on fielded production aircraft are currently in production for the F-35B and aircraft delivered in production Lot 8 will include the correct hardware. This modification will restore the envelope of the F-35B.
  - The program lifted the restriction preventing the F-35B from flying within 25 nautical miles of known lightning prior to the declaration of IOC; however, the program has added a restriction from taxiing or taking off within 25 nautical miles of known lightning because of only a partial software mitigation to the siphon tank overpressure problem. The program plans to field a new software release in 1QCY16, which will enable a hardware correction to the overpressure problem, once fielded F-35B aircraft are retrofitted with the hardware modification.

- Block 3i
  - Block 3i flight testing began in May 2014 with version 3iR1, derived from Block 2A software, six months later than planned in the IMS. The latest version of Block 3i software—3iR6—began flight testing in July 2015 and was derived from the latest version of Block 2B software. Block 3i mission systems flight testing completed in October 2015, eight months later than planned in the IMS.
  - Since the program planned to not introduce new capabilities in Block 3i, the test plan was written to confirm Block 3i had equivalent capabilities to those demonstrated in Block 2A (for 3iR1) and Block 2B (for subsequent versions of Block 3i software). The program's plan required completion of 514 baseline test points by mid-February 2015, with additional development, regression, and discovery points flown as necessary for each increment of software to address deficiencies. The program completed Block 3i mission systems testing by accomplishing 469 of the 514 baseline Block 3i test points, or 91 percent. Of the 45 test points remaining, 6 were transferred for completion in Block 3F and the remaining 39 were designated as "no longer required." The program executed an additional 515 test points. Of those 515 points, 151 were allocated in the budgeted non-baseline points for the year, and the 364 additional points represent growth in Block 3i testing. These 364 additional points, needed to accomplish the 469 baseline test points, represent a growth of 78 percent, which is much higher than the non-baseline budgeted of 30 percent planned by the program to complete Block 3i testing.
  - Results from 3iR6 flight testing demonstrated partial fixes to the five "must fix for Air Force IOC" deficiencies, showing some improved performance. Poor stability in the radar, however, required multiple ground and flight restarts, a condition that will reduce operational effectiveness in combat.
  - Instabilities discovered in the Block 3i configuration slowed progress in testing and forced development of additional software versions to improve performance. Two additional versions of the 3iR5 software were created in an attempt to address stability in start-up of the mission systems and inflight stability of the radar. Overall, radar performance has been less stable in the Block 3i configuration than in Block 2B. The test centers developed a separate "radar stability" series of tests—including both ground startup and inflight testing—to characterize the stability problems. Radar stability is measured in terms of the number of times per flight hour that either of these events occurred: a failure event requiring action by the pilot to reset the system; or, a stability event where the system developed a fault, which affected performance, but self-corrected without pilot intervention. For the last version of Block 2B software—2BS5.2—the test team measured a mean time between stability or failure event of 32.5 hours over nearly 200 hours of flight testing. For

3iR6, the time interval between events was 4.3 hours over 215 hours of flight testing. This poor radar stability will degrade operational mission effectiveness in nearly all mission areas.
- Since no capabilities were added to Block 3i, only limited corrections to deficiencies, the combat capability of the initial operational Block 3i units will not be noticeably different than the Block 2B units. If the Block 3i F-35 aircraft will be used in combat, they will need equivalent support as for the Block 2B F-35 aircraft, as identified previously in this report.
- As of the end of October, a total of nine Category 1 (three mission or safety of flight impact) and Category 2 (six mission impact) high-severity deficiencies in the full Block 3i configuration (air vehicle, propulsion, mission systems) were unresolved. Eight of these nine are assigned to mission systems engineering for resolution.
- Based on these Block 3i performance issues, the Air Force briefed that Block 3i mission capability is at risk of not meeting IOC criteria to the Joint Requirements Oversight Council (JROC) in December 2015. The Air Force recently received its first Block 3i operational aircraft and is assessing the extent to which Block 3i will meet Air Force IOC requirements; this assessment will continue into mid-2016.

• Block 3F
- Block 3F flight testing began in March 2015, six months later than the date planned by the program after restructuring in 2012.
- As of the end of November, a total of 674 Block 3F baseline test points had been completed, compared to 575 planned (17 percent more than planned). An additional 653 development and regression points were flown, all of which were part of the budgeted non-baseline points for the year.
- Since many of the baseline test points—which are used to confirm capability—cannot be tested until later versions of the Block 3F software are delivered in CY16 and CY17, the program allocated a large number of test points (979 for CY15) for development and regression of the software, while expecting to accomplish only 677 baseline test points in CY15. The total planned amount of baseline test points to complete Block 3F are approximately 5,467; combined with the planned non-baseline test points in the approved test plan, there are approximately 7,230 test points for Block 3F.
- Due to the later-than-planned start of Block 3F mission systems testing (6 months late), the large amount of planned baseline test points remaining (88 percent), and the likelihood of the need for additional test points to address discoveries and fixes for deficiencies, the program will not be able to complete Block 3F missions systems flight test by the end of October 2016, as indicated by the IMS. Instead, the program will likely not finish Block 3F development and flight testing prior to January 2018, based on the following:
  - Continuing a six test point per flight accomplishment rate, which is equal to the CY15 rate observed through the end of November
  - Continuing a flight rate of 6.8 flights per month, as was achieved through the end of November 2015, exceeding the planned rate of 6 flights per month (if the flight rate deteriorates to the planned rate of 6 flights per month, then testing will not complete until May 2018).
  - Completing the full Block 3F test plan (i.e., all original 7,230 baseline and budgeted non-baseline test points in the Block 3F joint test plan)
  - Continuing the CY15 discovery rate of 5 percent
- The program currently tracks 337 total Category 1 (42 mission or safety of flight impact) and Category 2 (295 mission impact) high-severity deficiencies in the full Block 3F configuration (air vehicle, propulsion, mission systems), of which 200 are assigned to the mission systems engineering area for resolution. An additional 100 Category 1 and Category 2 high-severity deficiencies are unresolved from Block 2B and Block 3i configurations, of which 51 are assigned to mission systems for resolution. It remains to be determined how many of these the program will be able to correct in later Block 3F versions. If any of these deficiencies are not resolved in the planned Block 3F design, additional efforts to isolate causes, and design and verify fixes will increase the amount of time needed to complete Block 3F development and testing.
- The program could, as has been the case in testing previous software increments, determine test points in the plan are no longer required for the Block 3F fleet release. However, the program will need to ensure that deleting and/or deferring testing from Block 3F before the end of SDD and start of IOT&E does not increase the likelihood of discovery in IOT&E or affect the evaluation of mission capability. Whatever capability the program determines as ready for IOT&E will need to undergo the same rigorous and realistic combat mission-focused testing as a fully functioning system.
- Block 3F mission systems capabilities require more complex test scenarios than prior versions of mission systems. It requires testing involving significantly more complex threat behavior and threat densities on the test ranges than was used in prior versions of mission systems. Additionally, Block 3F capability requires more testing in multi-ship formations.

Helmet Mounted Display System (HMDS)

• The HMDS is pilot flight equipment. It has a display on the visor that provides the primary visual interface between the pilot and the air vehicle and mission systems. The HMDS was envisioned to replace a traditional cockpit-mounted "heads-up display" and night vision goggles. It projects imagery from sensors onto the helmet visor, which is intended to enhance pilot situational awareness and reduce

workload. In 2010, the Program Office identified significant deficiencies and technical risk in the HMDS.

- The program created a "dual-path" approach to recover required capability.
  - One path was to fix the existing Generation II (Gen II) HMDS through redesign of the night vision system/camera and electro-optical/infrared sensor imagery integration on the visor.
  - The second path was to switch to an alternate helmet design incorporating legacy night vision goggles and projecting sensor imagery only on cockpit displays.
  - The program terminated the dual path approach in 2013 and decided to move forward with fixes to the existing Gen II HMDS which created the Gen III HMDS
- The Gen II HMDS was fielded with Block 2 and earlier configurations of aircraft. The program developed and tested improvements to address deficiencies in stability of the display (referred to as "jitter"), latency in the projection of Distributed Aperture System (DAS) imagery, and light leakage onto the display under low-light conditions (referred to as "green glow"). However, adequate improvements to the night vision camera acuity were not completed and pilots were prohibited from using the night vision camera. Pilot use of the DAS imagery was also restricted.
- The Gen III HMDS is intended to resolve all of the above deficiencies. It is a requirement for Air Force IOC in 2016, and will be used to complete SDD and IOT&E in 2018. The following provide Gen III HMDS details:
  - It includes a new higher-resolution night vision camera, software improvements, faster processing, and changes to the imagery projection systems for the visor.
  - It requires aircraft with Block 3i hardware and software.
  - Developmental flight testing began in December 2014 and will continue into 2016 with primary flight reference testing.
  - Operational testing will occur in tests conducted to support the Air Force IOC in 2016 (Block 3i), and in IOT&E (Block 3F).
  - It will be used with all Lot 7 aircraft, which are being delivered now, and later deliveries.
  - Later-than-planned escape system qualification delayed Gen III HMDS deliveries to the field; the program plans full flight clearance to occur in 2016.
- Results of the Gen III HMDS performance during developmental testing thus far indicate the following:
  - Symbology jitter and alignment. Some corrections were made for jitter and alignment in the latest configuration of the fielded Gen II HMDS via modifications to the display management computer. These are carried into the Gen III design. Developmental test pilots report less jitter and proper alignment. However, jitter still occurs in regimes of high buffet (i.e., during high g or high angle of attack maneuvering). Operational testing in heavy maneuvering environments is needed to determine if further attention will be required.
  - Green glow (difficulty setting symbology intensity level without creating a bright green glow around perimeter of display). The Gen III HMDS includes new displays with higher contrast control, which has reduced green glow compared to Gen II; the phenomena still exists, but at a manageable level, according to developmental test pilots. Developmental test pilots were able to air refuel and operate in "no moon" low illumination conditions at night. Simulated carrier approaches were also conducted at San Clemente Island off the coast of California and during carrier trials in October 2015. Operational testing in high mission task loads is also needed to confirm if further adjustments are needed.
  - Latency (projected imagery lagging head movement/placement). The Gen III HMDS includes faster processing to reduce latency in night vision camera imagery and DAS imagery projected onto the visor. The update rate in the Gen III HMDS is twice that of the Gen II. Developmental test pilots reported improvement in this area. Nonetheless, pilots have to "learn" an acceptable head-movement rate; that is, they cannot move their heads too rapidly. However, operational testing in these environments is needed to determine if the problem is resolved and pilot workload is reduced, especially during weapons employment.
  - Night vision camera resolution. The Gen II camera included a single 1280 x 1024 pixel night vision sensor. The Gen III camera includes two 1600 x 1200 sensors and additional image processing software changes, which are intended to provide improved resolution and sensitivity. Developmental test pilots reported better acuity allowing pilots to accomplish mission tasks. Operational testing under high mission task loads will determine if further improvement is needed.

Mission Data Load Development and Testing

- F-35 effectiveness in combat relies on mission data loads—which are a compilation of the mission data files needed for operation of the sensors and other mission systems—working in conjunction with the system software data load to drive sensor search parameters so that the F-35 can identify and correlate sensor detections, such as threat and friendly radar signals. The contractor team produced an initial set of files for developmental testing during SDD, but the operational mission data loads—one for each potential major geographic area of operation—are being developed, tested, and produced by a U.S. government lab, the U.S. Reprogramming Lab (USRL), located at Eglin AFB, Florida, which is operated by government personnel from the Services. The Air Force is the lead Service. These mission data loads will be used for operational testing and fielded aircraft, including the Marine Corps and Air Force IOC aircraft. The testing of the USRL mission data loads is an operational test activity, as was arranged by the Program Office after the restructure that occurred in 2010.

- Significant deficiencies exist in the USRL that preclude efficient development of effective mission data loads. Unless remedied, these deficiencies will cause significant limitations for the F-35 in combat against existing threats. These deficiencies apply to multiple potential theaters of operation and affect all variants and all Services.
  - In February 2012, DOT&E recommended upgrades to the USRL to overcome the significant shortfalls in the ability of the lab to provide a realistic environment for mission data load development and testing. The Department provided a total of $45 Million in resources to overcome these shortfalls, with the funding beginning in 2013. Unfortunately, due to the Program Office leadership's failure to accord the appropriate priority to implementing the required corrections, not until last year did the program move to investigate the deficiencies in the lab and build a plan for corrections, and only recently did it initiate the process of contracting for improvements, which has yet to finalize at the time of this report. The status of the Department's investment is not clear.
  - The program's belated 2014 investigation confirmed the nature and severity of the shortfalls that DOT&E identified in 2012. The analysis also identified many other gaps, some of which are even more urgent and severe than those uncovered by DOT&E three years prior. Failure to aggressively address the deficiencies results in uncertainties in the aircraft's capabilities to deal with existing threats; uncertainties that will persist until the deficiencies have been overcome and which could preclude the aircraft from being operationally effective against the challenging threats it is specifically being fielded to counter. The program planned to complete upgrades to the lab in late 2017, which will be late to need if the lab is to provide a mission data load for Block 3F tactics development and preparation for IOT&E. It is important to note that many of these deficiencies apply equally to the contractor's mission systems development labs because the government lab is essentially a copy of one of the mission system software integration test labs at the contractor facility.
  - The findings of the program's 2014 investigation include:
    - Shortfalls in the ability to replicate signals of advanced threats with adequate fidelity and in adequate numbers
    - Inability to adequately and coherently stimulate all signal receivers in F-35 mission systems
    - Receiver scan scheduling tools do not function correctly when replicating complex threats
    - Mission data file generation tools errantly combine emitter modes
    - Important emitter data are ignored by the tools, which adversely affect the quality of the mission data files
    - Inability to edit existing mission data files, a condition which requires inefficient processes to make changes where the lab technicians must reconstruct the entire mission data file set with new/corrected information
  - The program must make these modifications before the USRL is required to provide the Block 3F mission data load for tactics development and preparations for IOT&E. The program's 2014 study, while agreeing with DOT&E that significant hardware upgrades are needed, has not resulted in a plan to procure those upgrades in time for Block 3F mission data load development and verification. Despite the $45 Million budget, the program has still not designed, contracted for, and ordered the required equipment—a process that will take at least two years, not counting installation and check-out. In addition, despite the conclusions of the 2014 study by the Program Office, the program has sub-optimized the upgrades it will eventually put on contract due to budgetary constraints. Procuring only a limited number of signal generators would leave the USRL with less capability than the F-35 Foreign Military Sales Reprogramming Lab. This decision constitutes a critical error on the part of the program's leadership.
  - An investment greater than the $45 Million recommended by DOT&E in 2012 is needed to address all necessary hardware and software corrections to the lab. Although over three years have already been lost to inaction, the Program Office still does not plan to put Block 3F upgrades to the USRL on contract until late in 2016. The program recently briefed that once the equipment is finally ordered in 2016, it would take at least two years for delivery, installation, and check-out—after IOT&E begins (according to the current schedule of the program of record). This results in a high risk to both a successful IOT&E and readiness for combat. When deficiencies were first identified in 2012, there was time to make early corrections and avoid, or at least significantly reduce, the risk that is now at hand. Instead, due to the failure of leadership, the opposite has occurred.
- The USRL staff submitted a plan in 2013 for the operational testing of the Block 2B mission data loads, which was amended by the test team per DOT&E instructions, and approved by DOT&E. The plan includes multi-phased lab testing followed by a series of flight tests before release to operational aircraft.
- Because the program elected to delay the arrival of the USRL equipment several years, a significant amount of schedule pressure on the development and testing of the Block 2B mission data loads developed in 2015. The USRL staff was required to truncate the planned testing, forgoing important steps in mission data load development, optimization, and verification, and instead, apply its resources and manpower to providing a limited mission data load in June 2015 for the Marine Corps IOC. The limited extent of lab and flight testing that occurred creates uncertainties in F-35 combat effectiveness that must be taken into consideration by fielded operational units until the lab is able to complete optimization and testing of a Block 2B mission data load in

accordance with the plan. This additional work is planned to occur in early 2016.
- A similar sequence of events may occur with the Air Force IOC, planned for August 2016 with Block 3i. Mission data loads must be developed to interface with the system data load, and they are not forwards or backwards compatible. Block 3i mission data load development and testing will occur concurrently with completion of Block 2B mission data loads, creating pressure in the schedule as the lab configuration will have to be changed to accommodate the development and testing of both blocks.

Weapons Integration

Block 2B

- The program terminated Block 2B developmental testing for weapons integration in December 2015 after completing 12 of the 15 planned WDA events. The program had planned to complete all 15 WDA events by the end of October 2014, but delays in implementing software fixes for deficient performance of the Electro-Optical Targeting System (EOTS), radar, fusion, Multi-function Advanced Data Link (MADL), Link 16 datalink, and electronic warfare mission systems slowed progress.
  - All three of the deferred events are AIM-120 missile shot scenarios. The program deferred one of the remaining events to Block 3i, awaiting mission systems updates for radar deficiencies. The program completed that missile shot scenario in September 2015 with Block 3i software. The program deferred the other two events to Block 3F due to mission systems radar, fusion, and electronic warfare system deficiencies. Fixes to Block 3F capability are needed in order to execute these scenarios.
  - Eleven of the 12 completed events required developmental test control team intervention to overcome system deficiencies to ensure a successful event (acquire and identify target, engage with weapon). The program altered the event scenarios to make them less challenging for three of these, as well as the twelfth event, specifically to work around F-35 system deficiencies (e.g., changing target spacing or restricting target maneuvers and countermeasures). The performance of the Block 2B configured F-35 in combat will depend in part on the degree to which the enemy conforms to these narrow scenarios, which is unlikely, and enables the success of the workarounds necessary for successful weapons engagement.
- Mission systems developmental testing of system components required neither operation nor full functionality of subsystems that were not a part of the component under test. The developmental test teams designed the individual component tests only to verify compliance with contract specification requirements rather than to test the complete find-fix-identification (ID)-track-target-engage-assess-kill chain for air-to-air and air-to-ground mission success. The test team originally designed WDA events, however, purposefully to gather weapons integration and fire-control performance using all the mission systems required to engage and kill targets in the full kill chain. WDA events, therefore, became the developmental test venue that highlighted the impact of the backlog of deficiencies created by focusing prior testing only on contract specification compliance, instead of readiness for combat.
- Each WDA event requires scenario dry-runs in preparation for the final end-to-end event to ensure the intended mission systems functionality, as well as engineering and data analysis requirements (to support the test centers and weapon vendors), are available to complete the missile shot or bomb drop. Per the approved TEMP, the preparatory and end-to-end WDA events must be accomplished with full mission systems functionality, including operationally realistic fire control and sensor performance. However, as stated above, the program executed all 12 of the Block 2B WDA events using significant procedural and technical workarounds to compensate for the deficiencies resident in the Block 2B configuration.
  - Deficiencies in the Block 2B mission systems software affecting the WDA events were identified in fusion, radar, passive sensors, identification friend-or-foe, EOTS, and the aircraft navigation model. Deficiencies in the datalink systems also delayed completion of some events. Developmental test team intervention was required from the control room to overcome deficiencies in order to confirm surface target coordinates, confirm actual air targets among false tracks, and monitor/advise regarding track stability (which could not be determined by the pilot). Overall, these deficiencies continued to delay the CY15 WDA event schedule and compromised the requirement to execute the missions with fully functional integrated mission systems. Obviously, none of this test team intervention would be possible in combat.
  - The first table on the next page shows the planned date, completion or scheduled date, and the number of weeks delayed for each of the Block 2B WDA preparatory and end-to-end events. Events completed are shown with dates in bold.
- The accumulated delays in the developmental testing WDA schedule have delayed the initiation of the operation test WDA events. The JSF Operational Test Team (JOTT) had planned on starting their full system integrated WDA event testing in July 2015; however, due to the delays in delivery of operationally representative mission systems software, coupled with delays in modifications of the operational test aircraft to the full Block 2B configuration, this operational test activity will not start until CY16. This is six months after the program and the Services fielded initial Block 2B capability, and three months later than the JOTT had planned to start.

BLOCK 2B WEAPON ACCURACY DELIVERY EVENTS							
Weapon	WDA Number	Preparatory Events			End-to-End Event		
		Planned	Completed/ *Scheduled*	Weeks Delayed	Planned	Completed/ *Scheduled*	Weeks Delayed
AIM-120	102	Sep 13	**Sep 13**	2	Oct 13	**Oct 13**	2
	112	Sep 13	**Sep 13**	3	Oct 13	**Nov 13**	3
GBU-12	113	Sep 13	**Oct 13**	3	Oct 13	**Oct 13**	0
GBU-32	115	Sep 13	**Nov 13**	6	Nov 13	**Dec 13**	3
AIM-120	108	Oct 13	**Dec 13**	7	Dec 13	**Feb 14**	12
	110	Oct 13	**Aug 13**	43	Dec 13	**Nov 14**	50
	111	Dec 13	*Deferred to Block 3F*	--	Jan 14	*Deferred to Block 3F*	--
	106	Dec 13	**Sep 14**	40	Jan 14	**Nov 14**	43
GBU-31	114	Dec 13	**May 14**	45	Feb 14	**Nov 14**	41
			Jun 14				
			Oct 14				
AIM-120	104	Feb 14	**Aug 14**	28	Mar 14	*Deferred to Block 3i*	71
			Sep 14	30			
	107	Mar 14	**Jun 14**	12	May 14	**Feb 15**	30
	101	May 14	**May 14**	17	Jun 14	**Jan 15**	26
			Sep 14				
	103	Jun 14	**Mar 14**	-4	Aug 14	**May 14**	-10
			May 14				
	109	Jul 14	**Jan 14**	-29	Sep 14	**Mar 14**	-27
	105	Sep 14	*Deferred to Block 3F*	-	Oct 14	*Deferred to Block 3F*	-
1. Some WDA events require more than one preparatory event.							

Block 3i

- The program planned that Block 3i would not incorporate any new capability or fixes from the Block 2B development/fleet release. The block 3i WDA events were capability demonstrations to confirm translation of Block 2B performance to the Block 3i TR-2 hardware. The one AIM-120 missile shot scenario deferred from Block 2B was completed in September 2015.
- The table to the right shows the planned date, completion or scheduled date, and weeks delayed for each of the WDA preparatory and end-to-end events.

BLOCK 3I WEAPON ACCURACY DELIVERY EVENTS							
Weapon	WDA Number	Preparatory Events			End-to-End Event		
		Planned	Completed/ *Scheduled*	Weeks Delayed	Planned	Completed/ *Scheduled*	Weeks Delayed
AIM-120	104 (deferred from 2B)	Feb 14	**Sep 15**	82	Mar 14	**Sep 15**	78
	201	May 15	**May 15**	0	Jun 15	**Jul 15**	3
	204	Jul 15	**Jul 15**	0	Aug 15	**Sep 15**	4
GBU-12	202	May 15	**May 15**	0	May 15	**Aug 15**	11
GBU-31	203	May 15	**May 15**	0	Jun 15	**Jun 15**	0
1. Some WDA events require more than one preparatory event.							

Block 3F

- The Block 3F weapons delivery plan currently contains 48 events that will test required Block 3F capabilities. Twenty-nine of these weapon profiles accommodate full Block 3F expanded envelope employment and systems integrated testing of the GBU-12, GBU-31/32 JDAM, Navy JSOW, GBU-39 SDB-1, AIM-120, and AIM-9X. Nineteen of the Block 3F WDA events test air-to-air and air-to-ground gun employment in all three variants (F-35A internal gun; F-35B and F-35C external gun pod). Including the two deferred events from Block 2B creates a total of 50 required weapons delivery accuracy events to be accomplished in approximately 15 months. These Block 3F events are more complex than the Block 2B and 3i events

because of additional capability in mission systems such as advanced geolocation, multiple weapon events, enhanced radar modes, and expanded weapons envelopes and loadouts. As will be needed in combat employment, Block 3F WDA events will require reliable and stable target tracking, full MADL shoot-list sharing, Link 16 capability, and predictable fusion performance in integrated systems operation.

- While the program has instituted several process changes in mission systems software testing, maintaining the necessary WDA event tempo to complete the Block 3F events will be extremely challenging. The current build plans for each Block 3F software version show that the most challenging scenarios will not be possible until the final software version. This increases the likelihood of late discoveries of deficiencies, as occurred during Block 2B WDA testing.
- Completing the full set of Block 3F WDA events by May 2017, the planned end of Block 3F flight test according to the most recent program schedule, will require an accomplishment rate of over 3 events per month, more than 3 times the rate observed in completing the 12 Block 2B WDA events (approximately 0.8 events per month). Extending by two months to the end of July 2017, as has recently been briefed by the Program Office as the end of SDD flight test, is still unrealistic. Unless the accomplishment rate increases over the rate during the Block 2B testing period, completing all Block 3F WDA events will not occur until November 2021. In order to meet the schedule requirements for weapon certification, the Program Office has identified 10 high priority WDA events for the F-35A and 5 events for the F-35B and F-35C that must be accomplished during Block 3F developmental testing. The program plans to accomplish the remaining 35 events as schedule margin allows. The overall result of the WDA events must be that the testing yields sufficient data to evaluate Block 3F capabilities. Deleting numerous WDA events places successful IOT&E and combat capability at significant risk.

Static Structural and Durability Testing

- Structural durability testing of all variants using full-scale test articles is ongoing, with each having completed at least one full lifetime (8,000 equivalent flight hours, or EFH). All variants are scheduled to complete three full lifetimes of testing before the end of SDD; however, complete teardown, analyses, and Damage Assessment and Damage Tolerance reporting is not scheduled to be completed until August 2019. The testing on all variants has led to discoveries requiring repairs and modification to production designs and retrofits to fielded aircraft.
- F-35A durability test article (AJ-1) completed the second lifetime of testing, or 16,000 EFH in October 2015. While nearing completion of the second lifetime, testing was halted on August 13, 2015, when strain gauges on the forward lower flange of FS518, an internal wing structure, indicated deviations from previous trends. Inspections showed cracking through the thickness of the flange, so the program designed an interim repair to allow testing to continue and finish the second lifetime.
- F-35B durability test article (BH-1) completed 11,915 EFH by August 13, 2015, which is 3,915 hours (48.9 percent) into the second lifetime. The program completed the 11,000 hour data review on August 5, 2015.
  - Two main wing carry-through bulkheads, FS496 and FS472, are no longer considered production-representative due to the extensive existing repairs. The program plans to continue durability testing, repairing the bulkheads as necessary, through the second lifetime (i.e., 8,001 through 16,000 EFH) which is projected to be complete in mid-2016.
  - Prior to CY15, testing was halted on September 29, 2013, at 9,056 EFH, when the FS496 bulkhead severed, transferred loads to, and caused cracking in the adjacent three bulkheads (FS518, FS472, and FS450). The repairs and an adequacy review were completed on December 17, 2014, when the program determined that the test article could continue testing. Testing restarted on January 19, 2015, after a 16-month delay.
  - The program determined that several of the cracks discovered from the September 2013 pause at 9,056 EFH were initiated at etch pits. These etch pits are created by the etching process required prior to anodizing the surface of the structural components; anodizing is required for corrosion protection. Since the cracks were not expected, the program determined that the etch pits were more detrimental to fatigue life than the original material design suggested. The program is currently developing an analysis path forward to determine the effect on the overall fatigue life.
  - Discoveries requiring a pause in testing during CY15 include:
    - Cracking in the left- and right-hand side aft boom closeout frames, which are critical structural portions at the very aft of the airframe on each side of the engine nozzle, at 9,080 EFH. The cracks were not predicted by modeling and required a three-week pause in testing for repair, which consisted of a doubler (i.e., additional supporting element) as an interim fix to allow testing to continue. Designs for retrofitting and cut-in for production are under development.
    - Damage to a significant number of Electro-Hydraulic Actuator System (EHAS) fasteners and grommets at 9,333 EFH. The EHAS drives the aircraft control surfaces based on the direction and demand input by the pilot through the control stick.
    - Inspections in April 2015 revealed that cracks at four previously-identified web fastener holes near the trunnion lug of the FS496 bulkhead, a component integral to the bulkhead that supports the attachment of the main landing gear to the airframe, had grown larger. FS496 was previously identified as a life-limited part and will be modified as part of the life-limited modification plans for production aircraft in Lots 1

through 8, and a new production design cut into Lot 9 and later lot aircraft.
  - Failure of the left 3-Bearing Swivel Nozzle door uplock in April 2015; requiring replacement prior to restarting testing in May 2015.
  - Crack indication found at two fastener holes on the left side keel.
  - Crack reoccurrence at the Station 3 pylon at 10,975 EFH.
  - Cracks on the transition duct above the vanebox, a component of the lift fan, discovered in August 2015, requiring the jacks that transmit loads to the duct to be disconnected to allow cycling of the rest of the test article to continue.
  - During the repair activity in September 2015, a crack was discovered in a stiffener on the right-hand side of the mid-fairing longeron.
- Testing has been paused since August 2015 to allow replacement and repair activities; a process estimated to take five months. Testing is planned to restart in January 2016.

- Testing of the F-35C durability test article (CJ-1) was paused at the end of October 2015 when cracks were discovered in both sides (i.e., the right- and left-hand sides) of one of the front wing spars after 13,731 EFH of testing. The Program Office considers this to be a significant finding, since the wing spar is a primary structural component and the cracking was not predicted by finite element modeling. Root cause analysis and options for repairing the test article are under consideration as of the writing of this report. Testing of the second lifetime (16,000 EFH) was scheduled to be completed by February 1, 2016, but discoveries and associated repairs over the last year put this testing behind schedule.
  - Additional discoveries since October 2014 include:
    - Cracking of the BL12 longerons, left and right sides, at 10,806 EFH, required a 10-week pause in testing for repairs. The effect to production and retrofit is still to be determined.
    - Cracks on the FS518 wing carry-through lower bulkhead at 11,770 EFH in May 2015.
    - A crack at butt line 23 on the right hand side of the FS496 bulkhead (initiating at a fastener hole).
    - A crack was discovered during the Level-2 inspection in the FS472 wing carry-through bulkhead after the completion of 12,000 EFH in June 2015. Repair work was completed prior to restarting testing in late August.
- The program plans to use Laser Shock Peening (LSP), a mechanical process designed to add compressive residual stresses in the materials, in an attempt to extend the lifetime of the FS496 and FS472 bulkheads in the F-35B. The first production line cut-in of LSP would start with Lot 11 F-35B aircraft. Earlier Lot F-35B aircraft will undergo LSP processing as part of a depot modification. Testing is proceeding in three phases: first, coupon-level testing to optimize LSP parameters; second, element-level testing to validate LSP parameters and quantify life improvement; and third, testing of production and retrofit representative articles to verify the service life improvements. All three phases are in progress, with full qualification testing scheduled to be completed in October 2017.

Verification Simulation (VSim)

- Due to inadequate leadership and management on the part of both the Program Office and the contractor, the program has failed to develop and deliver an adequate Verification Simulation (VSim) for use by either the developmental test team or the JSF Operational Test Team (JOTT), as has been planned for the past eight years and is required in the approved TEMP. Neither the Program Office nor the contractor has accorded VSim development the necessary priority, despite early identification of requirements by the JOTT, $250 Million in funding added after the Nunn-McCurdy-driven restructure of the program in 2010, warnings that development and validation planning were not proceeding in a productive and timely manner, and recent (but too late) intense senior management involvement. As a result, VSim development is another of several critical paths to readiness for IOT&E.
- The Program Office's subsequent decision in September 2015 to move the VSim to a Naval Air Systems Command (NAVAIR) proposal for a government-led Joint Simulation Environment (JSE) will not result in a simulation with the required capabilities and fidelity in time for F-35 IOT&E. Without a high-fidelity simulation, the F-35 IOT&E will not be able to test the F-35's full capabilities against the full range of required threats and scenarios. Nonetheless, because aircraft continue to be produced in substantial quantities (essentially all of which require modifications and retrofits before being used in combat), the IOT&E must be conducted without further delay to demonstrate F-35 combat effectiveness under the most realistic conditions that can be obtained. Therefore, to partially compensate for the lack of a simulator test venue, the JOTT will now plan to conduct a significant number of additional open-air flights during IOT&E, in addition to those previously planned. In the unlikely event a simulator is available in time for IOT&E, the additional flights would not be flown.
- VSim is a man-in-the-loop, mission systems software-in-the-loop simulation developed to meet the operational test requirements for Block 3F IOT&E. It is also planned by the Program Office to be used as a venue for contract compliance verification prior to IOT&E. It includes an operating system in which the simulation runs, a Battlespace Environment (BSE), models of the F-35 and other supporting aircraft, and models of airborne and ground-based threats. After reviewing a plan for the government to develop VSim, the Program Office made the decision in 2011 to have the contractor develop the simulation instead.
- The Program Office began a series of tests in 2015 to ensure that the simulation was stable and meeting the reduced set of requirements for limited Block 2B operational activities. Though the contractor's BSE and operating system had improved since last year, deficiencies in specific F-35 sensor

models and the lack of certain threat models would have limited the utility of the VSim for Block 2B operational testing, had it occurred. The program elected instead to provide a VSim capability for limited tactics development. The Air Force's Air Combat Command, which is the lead for developing tactics in coordination with the other services, planned two VSim events for 2015.

- Air Combat Command completed the first event in July which included one- and two-ship attack profiles against low numbers of enemy threats. This event was planned to inform the tactics manual that will support IOT&E and the operational units, but validation problems prevented detailed analysis of results (i.e., minimum abort ranges).
- The second event, led by the JOTT with Marine Corps pilots flying, was completed in October 2015 for the limited use of data collection and mission rehearsals to support test preparation for IOT&E. While valuable lessons were learned by the JOTT and the Marine Corps, the lack of accreditation made it impossible for the JOTT to make assessments of F-35 system performance.

• Verification, Validation, and Accreditation (VV&A) activity completely stalled in 2015 and did not come close to making the necessary progress towards even the reduced set of Block 2B requirements.

- Less than 10 percent of the original validation points were collected from flight test results, and a majority of those showed significant deviations from installed system performance. The vehicle systems model, which provides the aircraft performance and flying qualities for the simulation, and certain weapons and threats models, were generally on track. However, mission systems, composed of the sensor models and fusion, had limited validation data and were often unstable or not tuned, as required, to represent the installed mission systems performance, as measured in flight-testing.
- The contractor and program management failed to intervene in time to produce a simulation that met even the reduced set of user requirements for Block 2B and, although they developed plans to increase VV&A productivity, they did not implement those plans in time to make a tangible difference by the time of this report. As the focus changed to Block 3F and IOT&E, the contractor and the Program Office made little progress; no VV&A plans materialized, data that had been collected were still stalled at the test venues awaiting review and release, alternative data sources had not yet been identified for new threats, and contract actions needed to complete VSim for Block 3F IOT&E were not completed.

• In September 2015, the Program Office directed a change in responsibility for VSim implementation, reassigning the responsibility from the contractor, Lockheed Martin, to a government team led primarily by NAVAIR. This was triggered by a large increase in the contractor's prior proposed cost to complete VSim, a cost increase which included work that should already have been completed in Block 2B and mitigations intended to overcome prior low productivity. The path to provide an adequate validation of the simulation for Block 3F IOT&E carries risk, regardless of who is responsible for the implementation of the simulation. That risk was increased by the Program Office's decision to move the simulation into a government controlled (non-proprietary) facility and simulation environment. After analyzing the steps needed to actually implement the Program Office's decision to move the VSim to the JSE, it is clear that the JSE will not be ready, with the required capabilities and fidelity, in time for F-35 IOT&E in 2018. It is also clear that both NAVAIR and the Program Office significantly underestimated the scope of work, the cost, and the time required to replace Lockheed Martin's proprietary BSE with the JSE while integrating and validating the required high-fidelity models for the F-35, threats, friendly forces, and other elements of the combat environment.

- The JSE proposal abandons the BSE that is currently running F-35 Block 2B.
- The JSE proposal does not address longstanding unresolved issues with VSim, including the ability of the program to produce validation data from flight test, to analyze and report comparisons of that data with VSim performance, and to "tune" VSim to match the installed system performance demonstrated in flight-testing.
- While the JSE might eventually reach the required level of fidelity, it will not be ready in time for IOT&E since the government team must re-integrate into the JSE the highly detailed models of the F-35 aircraft and sensors, and additional threat models that the contractor has "hand-built" over several years.
- The current VSim F-35 aircraft and sensor models interact directly with both the BSE and the current contractor's operating system. A transition to the JSE will require a re-architecture of these models before they can be integrated into a different environment. The need to do this, along with the costs of contractor support for the necessary software models and interfaces, will overcome the claims of cost savings in NAVAIR's proposal.
- The highly integrated and realistic manned "red air" simulations in VSim, which were inherited from other government simulations, cannot be replicated in the limited time remaining before IOT&E.
- The large savings estimates claimed by NAVAIR as the basis for their JSE proposal are not credible, and, the government team's most recent estimates for completion of the JSE have grown substantially from its initial estimate. Nearly all the costs associated with completing VSim in its current form would also transfer directly to JSE, with significant additional delays and risk. Any potential savings in the remaining costs from government-led integration are far outweighed by the additional costs associated with upgrading or building new facilities, upgrading or replacing the BSE, re-hosting the F-35 on government infrastructure, and paying Lockheed Martin to build interfaces between their F-35 models and the JSE.

- The JSE proposal adds significant work and schedule risk to the contractor's ability to deliver a functioning and validated Block 3F aircraft model in time for IOT&E. Besides being required to complete integration of Block 3F capabilities, validate the simulation, and tune the sensor models to installed system performance, the contractor must also simultaneously assist the government in designing new interfaces and re-hosting the F-35 and hand-built threat models into the JSE to all run together in real-time so they can be validated and accredited.
- Abandoning VSim also affects the F-22 program, as the various weapons and threat models being developed were planned to be reused between the two programs. The upcoming F-22 Block 3.2B IOT&E depends on the BSE currently in development.

• For the reasons listed above, the Program Office's decision to pursue the NAVAIR-proposed JSE, without the concurrence of the operational test agencies (OTAs) or DOT&E, will clearly not provide an accredited simulation in time for F-35 IOT&E, and the OTAs have clearly expressed their concerns regarding the risks posed to the IOT&E by the lack of VSim. Nonetheless, so as not to delay IOT&E any further while substantial numbers of aircraft are being produced, DOT&E and the OTAs have agreed on the need to now plan for the F-35 IOT&E assuming a simulator will not be available. This will require flying substantial additional open-air flights for tactics development, mission rehearsal, and evaluation of combat effectiveness relative to previous plans for using VSim. Even with these additional flights, some testing previously planned against large-scale, real-world threat scenarios in VSim will no longer be possible.

Live Fire Test and Evaluation (LFT&E)

F-35C Full-Scale Fuel Ingestion Tolerance Vulnerability Assessment

• The F-35 LFT&E Program completed the F-35C full-scale, fuel ingestion tolerance test series. The Navy's Weapons Survivability Laboratory (WSL) in China Lake, California, executed four tests events using the CG:0001 test article. Two of the test events were conducted with a Pratt and Whitney F-135 initial flight release (IFR)-configured engine installed in the aircraft. A preliminary review of the results indicates that:
- The F135 IFR-configured engine is tolerant of fuel ingestion caused by single missile-warhead fragment impacts in the F1 fuel tank. The threat-induced fuel discharge into the engine inlet caused temporary increases in the nominal engine temperature, but did not result in any engine stalls or long-term damage.
- Missile fragment-induced damage is consistent with predictions and the tanks are tolerant of single-fragment impacts. The threat-induced damage to the F1 fuel tank caused fuel leak rates that are consistent with tests conducted in FY07 using flat panels.

PAO Shut-Off Valve

• The program has not provided an official decision to reinstate this vulnerability reduction feature. There has been no activity on the development of the PAO-shut-off valve technical solution to meet criteria developed from 2011 live fire test results. As stated in several previous reports, this aggregate, 2-pound vulnerability reduction feature, if installed, would reduce the probability of pilot incapacitation, decrease overall F-35 vulnerability, and prevent the program from failing one of its vulnerability requirements.

Fuel Tank Ullage Inerting System and Lightning Protection

• The program verified the ullage inerting design changes, including a new pressurization and ventilation control valve, wash lines to the siphon tanks, and an external wash line, and demonstrated improved inerting performance in F-35B fuel system simulator tests. A preliminary data review demonstrated that the system pressurized the fuel tank with nitrogen enriched air (NEA) while maintaining pressure differentials within design specifications during all mission profiles in the simulator, including rapid dives. The Program Office will complete and document a detailed data review and analyses that evaluate NEA distribution and inerting uniformity between different fuel tanks and within partitioned fuel tanks.

• The program developed a computational model to predict inerting performance in the aircraft based on the F-35B simulator test results. Patuxent River Naval Air Station completed the ground inerting test on a developmental test F-35B aircraft to verify the inerting model. Preliminary analyses of the results indicate that there is good correlation between the ground inerting test and the F-35B fuel system simulator. The program will use this model, in conjunction with the completed F-35A and F-35C ground tests, to assess the ullage inerting effectiveness for all three variants. The confidence in the final design's effectiveness will have to be reassessed after the deficiencies uncovered in the aircraft ground and flight tests, including small uninerted fuel tank ullage spaces, have been fully resolved.

• When effective, ullage inerting protects the fuel tanks from not just threat-induced damage but also lightning-induced damage. The ullage inerting system does not protect any other components or systems from lightning-induced damage.

• The program has made progress completing lightning tolerance qualification testing for line-replaceable units needed to protect the remaining aircraft systems from lightning-induced currents. Lightning tolerance tests using electrical current injection tests are ongoing, and the program expects to complete the tests by 2QFY16.

Vulnerability to Unconventional Threats

• The full-up, system-level chemical-biological decontamination test on an SDD aircraft planned for

4QFY16 at Edwards AFB is supported by two risk-reduction events:
  - A System Integration Demonstration of the proposed decontamination equipment and shelter was conducted on an F-16 test article during 1QFY15 at Edwards AFB to simulate both hot air chemical and hot/humid air biological decontamination operations. Extensive undesirable condensation inside the shelter and on the test article during the hot/humid air biological decontamination event indicated the need for process and shelter modifications.
  - A demonstration of an improved shelter is planned for 2QFY16 to demonstrate that a modified system process and better insulated shelter can maintain adequate temperature and humidity control inside the shelter, even in a cold-weather environment.
- The test plan to assess chemical and biological decontamination of pilot protective equipment is not adequate. Compatibility testing of protective ensembles and masks has shown that the materials survive exposure to chemical agents and decontamination materials and processes, but the program has neither tested nor provided plans for testing the Helmet Mounted Display Systems (HMDS) currently being fielded. Generation II HMDS compatibilities were determined by analysis, comparing HMDS materials with those in an extensive DOD aerospace materials database. A similar analysis is planned for the Generation III HMDS design. However, even if material compatibilities were understood, there are no plans to demonstrate a process that could adequately decontaminate either HMDS from chemical and biological agents.
- The Joint Program Executive Office for Chemical and Biological Defense approved initial production of the F-35 variant of the Joint Service Aircrew Mask (JSAM-JSF) during 1QFY16. This office and the F-35 Joint Program Office are integrating the JSAM-JSF with the Helmet-Mounted Display, which is undergoing Safety of Flight testing.
- The Navy evaluated an F-35B aircraft to the EMP threat level defined in MIL-STD-2169B. Follow-on tests on other variants of the aircraft, including a test series to evaluate any Block 3F hardware/software changes, are planned for FY16.

Gun Ammunition Lethality and Vulnerability

- The program completed the terminal ballistic testing of the PGU-47 APEX round against a range of target-representative material plates and plate arrays. Preliminary test observations indicated expected high levels of fragmentation when passing through multiple layer, thin steel or aluminum targets, along with a deep penetration through more than an inch of rolled homogeneous armor steel by the nose of the penetrator. The program will evaluate the effect of these data on the ammunition lethality assessment.
- The 780th Test Squadron at Eglin AFB has completed the ground-based Frangible Armor Piercing (FAP) and initiated the PGU-32 lethality tests. The APEX rounds will be tested in FY16 against a similar range of targets, including armored and technical vehicles, aircraft, and personnel in the open. Ground-based lethality tests for the FAP showed expected high levels of penetration against all targets, with slightly less internal target fragmentation than originally anticipated, and low levels of lethality against personnel in the open (unless impacted directly). The program will determine the effect of these data on the ammunition lethality assessment.
- Per the current mission systems software schedule, the weapons integration characterization of the gun and sight systems will not be ready for the air-to-ground gun strafe lethality tests until 1QFY17. Strafing targets will include a small boat, light armored vehicle and technical vehicle (pickup truck), one each for each round type tested. Because the APEX round is not currently a part of the program of record, funding for developmental or operational air-to-ground flight testing of the APEX round is not planned at this time.

Operational Suitability

- Operational suitability of all variants continues to be less than desired by the Services, and relies heavily on contractor support and workarounds that would be difficult to employ in a combat environment. Almost all measures of performance have improved over the past year, but most continue to be below their interim goals to achieve acceptable suitability by the time the fleet accrues 200,000 flight hours, the benchmark set by the program and defined in the Operational Requirements Document (ORD) for the aircraft to meet reliability and maintainability requirements. This level of maturity is further stipulated as 75,000 flight hours for the F-35A, 75,000 flight hours for the F-35B, and 50,000 flight hours for the F-35C.
  - Aircraft fleet-wide availability averaged 51 percent for 12 months ending October 2015, compared to a goal of 60 percent.
  - Availability had been in mid-30s to low-40s percent for the 2-year period ending September 2014. Monthly availability jumped 12 percent to 51 percent by the end of October 2014, one of the largest month-to-month spikes in program history, and then peaked at 56 percent in December 2014. Since then it has remained relatively flat, centering around 50 percent, although it achieved 56 percent again in September 2015. The significant improvement that occurred around October 2014 was due in roughly equal measure to a reduction in the time aircraft were undergoing maintenance and a reduction in the time aircraft were awaiting spare parts from the supply system. The aircraft systems that showed the greatest decreases (improvement) in maintenance downtime during the month of October 2014 were the engine and the ejection seat.
  - It would be incorrect to attribute the still-low availability the F-35 fleet has exhibited in 2015, specifically the failure to meet the goal of 60 percent availability, solely to issues stemming from the additional engine inspections required since the June 2014 engine failure on AF-27. Availability did drop immediately after the engine failure, partly due to these inspections, but has since recovered to pre-engine failure levels, and improved only slightly from there when

considered as a long-term trend. For the three months ending October 2015, the fleet was down for the 3rd Stage Integrally Bladed Rotor (IBR) inspections—required due to the engine failure—less than 1 percent of the time.

- Measures of reliability that have ORD requirement thresholds have improved since last year, but eight of nine measures are still below program target values for the current stage of development, although two are within 5 percent of their interim goal; one—F-35B Mean Flight Hours Between Maintenance Events (Unscheduled)—is above its target value. In addition to the nine ORD metrics, there are three contract specification metrics, Mean Flight Hour Between Failures scored as "design controllable" (one for each variant). Design controllable failures are equipment failures due to design flaws considered to be the fault of the contractor, such as components not withstanding stresses expected to be found in the normal operational environment. It does not include failures caused by improper maintenance, or caused by circumstances unique to flight test. This metric continues to see the highest rate of growth, and for this metric all three variants are currently above program target values for this stage in development.
- Although reliability, as measured by the reduced occurrence of design controllable failures, has shown strong growth, this has only translated into relatively minor increases in availability for several reasons. These reasons include the influences of a large amount of time spent on scheduled maintenance, downtime to incorporate required modifications, waiting longer for spare parts than planned, and potentially longer-than-expected repair times, especially if units have to submit Action Requests (ARs) for instructions on repairs with no written procedures yet available. Finally, aircraft in the field become unavailable for failures not scored as design controllable as well. All of these factors affect the final availability rate the fleet achieves at any given time, in addition to the effect of improved reliability.
- F-35 aircraft spent 21 percent more time than intended down for maintenance, and waited for parts from supply for 51 percent longer than the program targeted. At any given time, from 1-in-10 to 1-in-5 aircraft were in a depot facility or depot status for major re-work or planned upgrades, and of the fleet that remained in the field, on average, only half were able to fly all missions of even a limited capability set.

• Accurate suitability measures rely on adjudicated data from fielded operating units. A Joint Reliability and Maintainability Evaluation Team (JRMET), composed of representatives from the Program Office, the JOTT, the contractor (Lockheed Martin), and Pratt and Whitney (for engine records), reviews maintenance data to ensure consistency and accuracy for reporting measures; government representatives chair the team. However, the Lockheed Martin database that stores the maintenance data, known as the Failure Reporting and Corrective Action System (FRACAS), is not in compliance with U.S. Cyber Command information assurance policies implemented in August 2015. Because of this non-compliance, government personnel have not been able to access the database via government networks, preventing the JRMET from holding the planned reviews of maintenance records. As a result, the Program Office has not been able to produce Reliability and Maintainability (R&M) metrics from JRMET-adjudicated data since the implementation of the policy. The most current R&M metrics available for this report are from the three-month rolling window ending in May 2015. The Program Office is investigating workarounds to enable the JRMET to resume regular reviews of maintenance records until Lockheed Martin can bring the FRACAS database into compliance.

F-35 Fleet Availability

• Aircraft availability is determined by measuring the percent of time individual aircraft are in an "available" status, aggregated over a reporting period (e.g., monthly). The program assigns aircraft that are not available to one of three categories of status: Not Mission Capable for Maintenance (NMC-M); Not Mission Capable for Supply (NMC-S); and Depot status.
  - Program goals for these "not available" categories have remained unchanged since 2014, at 15 percent for NMC-M, 10 percent for NMC-S, and 15 percent of the fleet in depot status. Depot status is primarily for executing the modification program to bring currently fielded aircraft closer to their expected airframe structural lifespans of 8,000 flight hours and to incorporate additional mission capability. The majority of aircraft in depot status are located at dedicated depot facilities for scheduled modification periods that can last several months, and they are not part of the operational or training fleet during this time. A small portion of depot status can occur in the field when depot field teams conduct a modification at a main operating base, or affect repairs beyond the capability of the local maintenance unit.
  - These three "not available" category goals sum to 40 percent, leaving a targeted fleet-wide goal of 60 percent availability for 2015. At the time of this report, this availability goal extended uniformly to the individual variants, with each variant having a target of 60 percent availability as well. For a period during 2015, however, the program set variant-specific availability goals to account for the fact that the variants were cycling through the depots at different rates. A particularly large portion of the F-35B fleet was in depot in early 2015 to prepare aircraft for Marine Corps IOC declaration, for example. From February to August 2015, the variant-specific availability goals were reported as 65 percent for the F-35A, 45 percent for the F-35B, and 70 percent for the F-35C, while the total fleet availability goal remained 60 percent.

- Aircraft monthly availability averaged 51 percent for the 12-month period ending October 2015 in the training and operational fleets. This is an increase over the 37 percent availability reported in both of the previous two DOT&E Annual Reports from FY13 and FY14.
- However, in no month did the fleet exceed its goal of 60 percent availability. In several months, individual variants beat either the 60 percent goal, or their at-the-time variant-specific goal. The F-35A achieved 63 percent availability in December 2014, but never surpassed 65 percent. The F-35C was above 60 percent availability from November 2014 to June 2015, and again in September and October 2015, and was above 70 percent in four of these months. The F-35B was above 45 percent availability in only one month, October 2015, when it achieved 48 percent. This was after the program returned its variant-specific availability target to 60 percent.
- The table below summarizes aircraft availability rates by operating location for the 12-month period ending October 2015. The first column indicates the average availability achieved for the whole period, while the maximum and minimum columns represent the range of monthly availabilities reported over the period. The number of aircraft assigned at the end of the reporting period is shown as an indicator of potential variance in the rates. Sites are arranged in order of when each site began operation of any variant of the F-35, and then arranged by variant for sites operating more than one variant. In February 2015, the Marine Corps terminated operations of the F-35B at Eglin AFB and transferred the bulk of the aircraft from that site to Marine Corps Air Station (MCAS) Beaufort, South Carolina. As a result, the number of F-35B aircraft assigned to Eglin AFB as of September 2015 was zero.

F-35 AVAILABILITY FOR 12-MONTH PERIOD ENDING OCTOBER 2015[1]

Operational Site	Average	Maximum	Minimum	Aircraft Assigned[2]
Whole Fleet	51%	56%	46%	134
Eglin F-35A	55%	62%	39%	25
Eglin F-35B[3]	43%	48%	26%	0
Eglin F-35C	66%	79%	57%	17
Yuma F-35B	39%	62%	16%	17
Edwards F-35A	32%	66%	17%	8
Edwards F-35B[4]	19%	27%	0%	6
Nellis F-35A	51%	77%	33%	10
Luke F-35A	62%	75%	50%	30
Beaufort F-35B[5]	46%	60%	24%	18
Hill F-35A[6]	80%	81%	79%	3

1. Data do not include SDD aircraft.
2. Aircraft assigned at the end of October 2015.
3. Eglin AFB F-35B ended operations in February 2015.
4. Edwards AFB F-35B operational test operations began in October 2014.
5. Beaufort MCAS F-35B operations began in July 2014.
6. Hill AFB F-35A operations began September 2015.

- Statistical trend analysis of the monthly fleet availability rates from August 2012 through October 2015 showed a weak rate of improvement of approximately 5 percent growth per year over this period, but the growth was not consistent. For example, from August 2012 through September 2014, availability was relatively flat and never greater than 46 percent, but from September 2014 through December 2014, it rose relatively quickly month-on-month to peak at 56 percent in December. Availability then dropped a bit, and remained near 50 percent through October 2015 with no increasing trend toward the goal of 60 percent.
- Due to concurrency, the practice of producing operational aircraft before the program has completed development and finalized the aircraft design, the Services must send the current fleet of F-35 aircraft to depot facilities to receive modifications that have been designed since they were originally manufactured. Some of these modifications are driven by faults in the original design that were not discovered until after production had started, such as major structural components that break due to fatigue before their intended lifespan, and others are driven by the continuing improvement of the design of combat capabilities that were known to be lacking when the aircraft were first built. This "concurrency tax" causes the program to expend resources to send aircraft for major re-work, often multiple times, to keep up with the aircraft design as it progresses. Since System Development and Demonstration (SDD) will continue to 2017, and by then the program will have delivered nearly 200 aircraft to the U.S. Services in other than the 3F configuration, the depot modification program and its associated concurrency burden will be with the Services for years to come.
- Sending aircraft to depot facilities for several months at a time to bring them up to Block 2B capability and life limits, and eventually to 3F configuration, reduces the number of aircraft at field sites and thus decreases fleet availability. For the 12-month period ending in October 2015, the proportion of fleet in depot status averaged 16 percent. The depot percentage generally increased slowly at first, reaching a maximum value of 19 percent for the month of May 2015, and then started to decline around summer 2015. The depot inductions were largely in support of modifying aircraft to the Block 2B configuration for the Marine Corps IOC declaration at the end of July 2015.
- Current program plans indicate the proportion of the fleet in depot will remain between 10 and 15 percent throughout CY16. Projections of depot rates beyond 2016 are difficult, since testing and development are ongoing. The program does not yet know the full suite of modifications that will be necessary to bring currently produced aircraft up to the envisioned final Block 3F configuration.
- To examine the suitability performance of fielded aircraft, regardless of how many are in the depot, the program reports on the Mission Capable and Full Mission Capable (FMC) rates for the F-35 fleet. The Mission Capable rate represents the proportion of the fleet that is not in depot

status and that is ready to fly any type of mission (as opposed to all mission types). This rate includes aircraft that are only capable of flying training flights, however, and not necessarily a combat mission. Aircraft averaged 65 percent for the 12-month window considering all variants.

- The FMC rate calculates only the proportion of aircraft not in depot status that are capable of flying all assigned missions and can give a better view into the potential combat capability available to the field. It averaged 46 percent for the 12-month window considering all variants, but started to drop steadily from a peak of 62 percent achieved in December 2014, reaching a minimum value of 32 percent in October 2015. The rate declined for 8 of the 10 months from January to October 2015.
- The monthly NMC-M rate averaged 18 percent over the period, and exhibited the most variability of the non-available status categories. The NMC-M rate started out at 17 percent in November 2014, was as high as 24 percent in August 2015, and as low as 14 percent in September 2015. The Program Office set a threshold goal of 15 percent for 2015, but the fluctuations in month-to-month rates make it difficult to determine whether the goal for NMC-M can be achieved for a sustained period.
- Modifying aircraft also affects the NMC-M rate. Squadron maintainers, instead of the depot, are tasked to complete a portion of the required modifications by accomplishing Time Compliance Technical Directives (TCTDs). The "time compliance" requirements for these directives vary, normally allowing the aircraft to be operated without the modification in the interim and permit maintenance personnel to work the directive as able. While maintainers accomplish these TCTDs, the aircraft are logged as NMC-M status. Incorporating these TCTDs will drive the NMC-M rate up (worse) until these remaining modifications are completed. Publishing and fielding new TCTDs is expected for a program under development and is needed to see improvement in reliability and maintainability.
- The NMC-S rate averaged 15 percent and showed little trend, either up or down, over the period. The NMC-S rate started at 15 percent in November 2014 and ended at 16 percent in October 2015, ranging from between 12 to 19 percent in the months between. The Program Office set a threshold goal of 10 percent for 2015, but the NMC-S trend is not currently on track to achieve this.
- Modifying aircraft also has an effect on the NMC-S rate. Parts are taken from aircraft in depot status at the dedicated modification facilities in order to provide replacements for failed parts in the field, a process known as depot cannibalization. This usually occurs when replacement parts are not otherwise available from normal supply channels or stocks of spare parts on base. With the large number of aircraft in depot status, the program may have been able to improve the NMC-S rate by using depot cannibalizations, instead of procuring more spare parts, or reducing the failure rate of parts installed in aircraft, or improving how quickly failed parts are repaired and returned to circulation. If the Services endeavor to bring all of the early lot aircraft into the Block 3F configuration, the program will continue to have an extensive modification program for several years. While this will continue to provide opportunities for depot cannibalizations during that time, once the 3F modifications are complete, there will be fewer aircraft in the depot serving as spare parts sources and more in the field requiring parts support. If demand for spare parts remains high, this will put pressure on the supply system to keep up with demand without depot cannibalization as a source.
- Low availability rates are preventing the fleet of fielded operational F-35 aircraft from achieving planned, Service-funded flying hour goals. Original Service bed-down plans were based on F-35 squadrons ramping up to a steady state, fixed number of flight hours per tail per month, allowing for the projection of total fleet flight hours.
- Since poor availability in the field has shown that these original plans were unexecutable, the Program Office has since produced "modeled achievable" projections of total fleet flight hours, basing these projections on demonstrated fleet reliability and maintainability data, as well as expectations for future improvements. The most current modeled achievable projection is from November 2014.
  - Through November 23, 2015, the fleet had flown approximately 82 percent of the modeled achievable hours. This is an improvement since October 2014, the date used in the FY14 DOT&E Annual Report, when the fleet had flown only 72 percent of modeled achievable hours, but it is still below expectation.
  - The F-35B variant has flown approximately 11 percent more hours than its modeled achievable projection, in part due to a ramped up level of flying to produce trained pilots for the Marine Corps IOC declaration.

• The following table shows by variant the planned versus achieved flight hours for both the original plans and the modeled-achievable for the fielded production aircraft through November 23, 2015.

F-35 FLEET PLANNED VS. ACHIEVED FLIGHT HOURS AS OF NOVEMBER 23, 2015

Variant	Original Bed-Down Plan Cumulative Flight Hours			"Modeled Achievable" Cumulative Flight Hours		
	Estimated Planned	Achieved	Percent Planned	Estimated Planned	Achieved	Percent Planned
F-35A	26,000	16,768	65%	22,000	16,768	76%
F-35B	14,000	12,156	87%	11,000	12,156	111%
F-35C	5,500	2,949	54%	6,000	2,949	49%
Total	45,500	31,873	70%	39,000	31,873	82%

F-35 Fleet Reliability

- Aircraft reliability assessments include a variety of metrics, each characterizing a unique aspect of overall weapon system reliability.
  - Mean Flight Hours Between Critical Failure (MFHBCF) includes all failures that render the aircraft not safe to fly, and any equipment failures that would prevent the completion of a defined F-35 mission. It includes failures discovered in the air and on the ground.
  - Mean Flight Hours Between Removal (MFHBR) gives an indication of the degree of necessary logistical support and is frequently used in determining associated costs. It includes any removal of an item from the aircraft for replacement with a new item from the supply chain. Not all removals are failures, and some failures can be fixed on the aircraft without a removal. For example, some removed items are later determined to have not failed when tested at the repair site. Other components can be removed due to excessive signs of wear before a failure, such as worn tires.
  - Mean Flight Hours Between Maintenance Event Unscheduled (MFHBME Unsch) is a useful reliability metric for evaluating maintenance workload due to unplanned maintenance. Maintenance events are either scheduled (e.g., inspections, planned removals for part life) or unscheduled (e.g. maintenance to remedy failures, troubleshooting false alarms from fault reporting or defects reported but within limits, unplanned servicing, removals for worn parts—such as tires). One can also calculate the mean flight hours between scheduled maintenance events, or total events including both scheduled and unscheduled. However, for this report, all MFHBME Unsch metrics refer to the mean flight hours between unscheduled maintenance events only, as it is an indicator of aircraft reliability and the only mean-flight-hour-between-maintenance-event metric with an ORD requirement.
  - Mean Flight Hours Between Failure, Design Controllable (MFHBF_DC) includes failures of components due to design flaws under the purview of the contractor, such as the inability to withstand loads encountered in normal operation. Failures induced by improper maintenance practices are not included.
- The F-35 program developed reliability growth projections for each variant throughout the development period as a function of accumulated flight hours. These projections are shown as growth curves, and were established to compare observed reliability with target numbers to meet the threshold requirement at maturity, defined by 75,000 flight hours for the F-35A and F-35B, and by 50,000 flight hours for the F-35C, and 200,000 cumulative fleet flight hours. In November 2013, the program discontinued reporting against these curves for all ORD reliability metrics, and retained only the curve for MFHBF_DC, which is the only reliability metric included in the JSF Contract Specification (JCS). DOT&E reconstructed the growth curves for the other metrics analytically for this report and shows them in the tables on the following page for comparison to achieved values.
- As of late November 2015, the F-35, including operational and flight test aircraft, had accumulated approximately 43,400 flight hours, or slightly below 22 percent of the total 200,000-hour maturity mark defined in the ORD. Unlike the following table, which accounts only for fielded production aircraft, the flight test aircraft are included in the fleet hours which count toward reliability growth and maturity. By variant, the F-35A had flown approximately 22,300 hours, or 30 percent of its individual 75,000-hour maturity mark; the F-35B had flown approximately 15,800 hours, or 21 percent of its maturity mark; and the F-35C had flown approximately 5,300 hours, or 11 percent of its maturity mark.
- The program reports reliability and maintainability metrics on a three-month rolling window basis. This means for example, the MFHBR rate published for a month accounts only for the removals and flight hours of that month and the two previous months. This rolling three-month window provides enough time to dampen out variability often seen in month-to-month reports, while providing a short enough period to distinguish current trends.
- The first table on the following page compares current observed and projected interim goal MFHBCF values, with associated flight hours. It shows the ORD threshold requirement at maturity and the values in the FY14 DOT&E Annual Report for reference as well.
- The following similar tables compare current observed and projected interim goals for MFHBR, MFHBME Unsch, and MFHBF_DC rates for all three variants. MFHBF_DC is contract specification, and its JCS requirement is shown in lieu of an ORD threshold.
- Note that more current data than May 2015 are not available due to the Lockheed Martin database (FRACAS) not being compliant with all applicable DOD information assurance policies mandated by U.S. Cyber Command.
- Reliability values increased for 11 of 12 metrics between August 2014 and May 2015. The only metric which decreased in value was MFHBCF for the F-35C. A more in-depth trend analysis shows, however, that MFHBCF for the F-35C is likely increasing over time, albeit erratically. The MFHBCF metric shows particularly high month-to-month variability for all variants relative to the other metrics, due to the smaller number of reliability events that are critical failures. For the F-35C in particular, the August 2014 value was well above average, considering the preceding and following months, while the May 2015 value was below average for the past year.
- Despite improvements over the last year, 8 of the 12 reliability metrics are still below interim goals, based on their reliability growth curves, to meet threshold values by maturity. Two of these eight metrics however, are within 5 percent of their goal, F-35B MFHBCF and F-35C MFHBME Unsch. The remaining four are above their growth curve interim values. Of the four metrics above their growth curve interim values, three are the contract specification metric MFHBF_DC for each variant; and for this specific metric, the program is

reporting F-35B and F-35C reliability currently at or above the threshold at maturity. The fourth metric that is above the growth curve interim value is F-35B MFHBME Unsch. This is the only one of nine ORD metrics that is above its interim growth curve value. This pattern indicates that, although reliability is improving, increases in the contract specification reliability metric are not translating into equally large improvements in the other reliability metrics, which are operational requirements that will be evaluated during IOT&E.

- The F-35B is closest to achieving reliability goals, while the F-35A is furthest. For the F-35B, two of four reliability metrics are above their growth curves, one is within 5 percent, and one is below, MFHBR. MFHBR is the only metric where all three variants are less than 95 percent of their interim goal. For the F-35A and F-35C, the only metrics above their growth goals are the contract specification metrics, MFHBF_DC. One of three F-35C ORD metrics is within 5 percent of its growth goal, and all remaining F-35A and F-35C ORD metrics are below their interim targets for this stage of development.
- The effect of lower MFHBCF values is reduced aircraft full mission capability, mission capability, and availability rates. MFHBR values lagging behind their growth targets drive a higher demand for spare parts from the supply system than originally envisioned. When MFHBME Unsch values are below expectation, there is a higher demand for maintenance manpower than anticipated.
- DOT&E updated an in-depth study of reliability growth in MFHBR and MFHBME Unsch provided in the FY14 DOT&E Annual Report. The original study examined the period from July 2012 through October 2013, and modeled reliability growth using the Duane Postulate, which characterizes growth by a single parametric growth rate. Mathematically, the Duane Postulate assesses growth rate as the slope of the best-fit line when the natural logarithm of the cumulative failure rate is plotted against the natural logarithm of cumulative flight hours. A growth rate of zero would indicate no growth, and a growth rate of 1.0 is the theoretical upper limit, indicating instantaneous growth from a system that exhibits some failures to a system that never fails. The closer the growth rate is to 1.0 the faster the growth, but the relationship between assessed growth rates is not linear, due to the logarithmic nature of the plot.

F-35 RELIABILITY: MFHBCF (HOURS)

Variant	ORD Threshold		Values as of May 31, 2015				Values as of August 2014	
	Flight Hours	MFHBCF	Cumulative Flight Hours	Interim Goal to Meet ORD Threshold MFHBCF	Observed MFHBCF (3 Mos. Rolling Window)	Observed Value as Percent of Goal	Cumulative Flight Hours	Observed MFHBCF (3 Mos. Rolling Window)
F-35A	75,000	20	15,845	16.1	10.2	63%	8,834	8.2
F-35B	75,000	12	11,089	9.2	8.7	95%	7,039	7.5
F-35C	50,000	14	3,835	10.0	7.4	74%	2,046	8.3

F-35 RELIABILITY: MFHBR (HOURS)

Variant	ORD Threshold		Values as of May 31, 2015				Values as of August 2014	
	Flight Hours	MFHBR	Cumulative Flight Hours	Interim Goal to Meet ORD Threshold MFHBR	Observed MFHBR (3 Mos. Rolling Window)	Observed Value as Percent of Goal	Cumulative Flight Hours	Observed MFHBR (3 Mos. Rolling Window)
F-35A	75,000	6.5	15,845	5.3	4.7	89%	8,834	3.1
F-35B	75,000	6.0	11,089	4.6	3.9	85%	7,039	2.5
F-35C	50,000	6.0	3,835	4.3	3.4	79%	2,046	2.3

F-35 RELIABILITY: MFHBME Unsch (HOURS)

Variant	ORD Threshold		Values as of May 31, 2015				Values as of August 2014	
	Flight Hours	MFHBME Unsch	Cumulative Flight Hours	Interim Goal to Meet ORD Threshold MFHBME Unsch	Observed MFHBME Unsch (3 Mos. Rolling Window)	Observed Value as Percent of Goal	Cumulative Flight Hours	Observed MFHBME Unsch (3 Mos. Rolling Window)
F-35A	75,000	2.0	15,845	1.60	1.18	74%	8,834	0.85
F-35B	75,000	1.5	11,089	1.15	1.32	115%	7,039	0.96
F-35C	50,000	1.5	3,835	1.02	1.00	98%	2,046	0.84

F-35 RELIABILITY: MFHBF_DC (HOURS)

Variant	JCS Requirement		Values as of May 31, 2015				Values as of August 2014	
	Flight Hours	MFHBF_DC	Cumulative Flight Hours	Interim Goal to Meet JCS Requirement MFHBF_DC	Observed MFHBF_DC (3 Mos. Rolling Window)	Observed Value as Percent of Goal	Cumulative Flight Hours	Observed MFHBF_DC (3 Mos. Rolling Window)
F-35A	75,000	6.0	15,845	4.6	4.8	104%	8,834	4.0
F-35B	75,000	4.0	11,089	2.9	4.3	148%	7,039	3.5
F-35C	50,000	4.0	3,835	2.6	4.0	154%	2,046	3.6

For example, a growth rate of 0.4 would indicate reliability growth much higher than twice as fast as a growth rate of 0.2.

- The updated analysis extended the period examined from July 2012 through May 2015. The analysis investigated only the F-35A and F-35B variants due to the still low number of flight hours on the F-35C. The study evaluated the current growth rate, then, using that rate, projected the reliability metric to the value expected at maturity.
- The study also evaluated the growth rate needed to meet the ORD threshold value at maturity from the current observed value of the reliability metric. The first table below shows the results of this updated study, along with the growth rates determined through October 2013 from the original study for comparison.
- The currently exhibited growth rates for three of the evaluated metrics are faster than the growth rates exhibited through October 2013. The growth rate for F-35A MFHBME Unsch reduced slightly. For both F-35A metrics and for F-35B MFHBR, the growth rate is still too low to meet the ORD threshold by maturity. The analyses project that if the current growth rate holds constant, the F-35A MFHBR metric will achieve within 90 percent of its requirement, while F-35B MFHBME Unsch will significantly exceed its requirement. DOT&E does not expect the F-35B MFHBME Unsch growth to sustain its current rate out through 75,000 flight hours, but there is plenty of margin for the rate to drop and still exceed the requirement by maturity.

Metric	Variant	May 2015 Value	Current Growth Rate from Duane Postulate	Projected Value at 75,000 Flight Hours	ORD Threshold	Projected Value as % ORD Threshold	October 2013 Growth Rate from Duane Postulate	Growth Rate Needed to Meet ORD
MFHBR	F-35A	4.7	0.204	6.0	6.5	93%	0.129	0.228
	F-35B	3.9	0.243	4.8	6.0	81%	0.210	0.297
MFHBME	F-35A	1.18	0.142	1.34	2.0	67%	0.162	0.281
	F-35B	1.32	0.427	2.74	1.5	183%	0.347	0.244

- The above growth rates were calculated with around 16,000 hours for the F-35A, and 11,000 hours for the F-35B. For comparison, observed MFHBME Unsch growth rates for several historical aircraft are shown in the table to the right.

Aircraft	MFHBME Growth Rate
F-15	0.14
F-16	0.14
F-22 (at 35,000 flight hours)	0.22
B-1	0.13
"Early" B-2 (at 5,000 flight hours)	0.24
"Late" B-2	0.13
C-17 (at 15,000 flight hours)	0.35

- These growth rates can still change, either increase or decrease, as the program introduces more reliability improvement initiatives and depending on how well they pan out in the field. Also, the Block 2B release expanded the aircraft's flight envelope and delivered initial combat capabilities. As a result, the fielded units will likely fly their aircraft more aggressively to the expanded envelope, and use mission systems more heavily than in the past. This change in operational use may uncover new failure modes that have an impact on sustaining or increasing reliability growth rates. Note that the above analysis covers a time span preceding Block 2B fleet release.
- The growth rates that the F-35 must achieve and sustain through 75,000 flight hours, in order to comply with ORD performance thresholds by maturity, have been demonstrated in the past, but mostly on bombers and transports. The F-22 achieved a MFHBME Unsch growth rate of 0.22, slightly less than the slowest growth rate the F-35 must sustain, for F-35A MFHBR, and only with an extensive and dedicated reliability improvement program.
- A number of components have demonstrated reliability much lower than predicted by engineering analysis. This drives down the overall system reliability and can lead to long wait-times for re-supply as the field demands more spare parts than the program planned to provide. Aircraft availability is also negatively affected by longer-than-predicted component repair times. The table below, grouped by components common to all variants, shows some of the high-driver components affecting low availability and reliability, followed by components failing more frequently on a particular variant or which are completely unique to it.

HIGH DRIVER COMPONENTS AFFECTING LOW AVAILABILITY AND RELIABILITY		
	Common to All Variants	Additional High Drivers by Variant
F-35A	• Avionics Processors • Nutplate and Engine Heat Blanket Cure Parameters • Low Observable Maintenance • Main Landing Gear Tires • Fuel System Components (Pumps and Valves)	• Exhaust Nozzle Converging-Diverging Link • Data Transfer Cartridge
F-35B		• Upper Lift Fan Door Actuator[1] • Flexible Linear Shaped Charge
F-35C		• Lightning Strike Damage • Nose Landing Gear Launch Bar Bolt[2]

1. Unique to the F-35B.
2. Unique to the F-35C.

Maintainability

- The amount of time needed to repair aircraft to return them to flying status remains higher than the requirement for the system when mature, but has improved over the past year. The program assesses this time with several measures, including Mean Corrective Maintenance Time for Critical Failure (MCMTCF) and Mean Time To Repair (MTTR) for all unscheduled maintenance. MCMTCF measures active

maintenance time to correct only the subset of failures that prevent the F-35 from being able to perform a specific mission, and indicates how long it takes, on average, for maintainers to return an aircraft to Mission Capable status. MTTR measures the average active maintenance time for all unscheduled maintenance actions, and is a general indicator of the ease and timeliness of repair. Both measures include active touch labor time and cure times for coatings, sealants, paints, etc., but do not include logistics delay times such as how long it takes to receive shipment of a replacement part.

- The tables below compare measured MCMTCF and MTTR values for the three-month period ending in May 2015 to the ORD threshold and the percentage of the value to the threshold for all three variants. The tables also show the value reported in the FY14 DOT&E Annual Report for reference. For all variants, the MCMTCF and MTTR times decreased (improved), with particularly strong decreases for the F-35A and F-35B MCMTCF. The F-35A improved to a much larger degree than either the F-35B or F-35C. Nonetheless, both maintainability measures for all variants were well above (worse than) the ORD threshold value required at maturity. Note that more current data than May 2015 are not available due to the Lockheed Martin database (FRACAS) not being compliant with all applicable DOD information assurance policies mandated by U.S. Cyber Command.

F-35 MAINTAINABILITY: MCMTCF (HOURS)				
Variant	ORD Threshold	Values as of May 31, 2015 (3 Mos. Rolling Window)	Observed Value as Percent of Threshold	Values as of August 2014 (3 Mos. Rolling Window)
F-35A	4.0	9.7	243%	15.6
F-35B	4.5	10.2	227%	15.2
F-35C	4.0	9.6	240%	11.2

F-35 MAINTAINABILITY: MTTR (HOURS)				
Variant	ORD Threshold	Values as of May 31, 2015 (3 Mos. Rolling Window)	Observed Value as Percent of Threshold	Values as of August 2014 (3 Mos. Rolling Window)
F-35A	2.5	4.9	196%	8.6
F-35B	3.0	7.1	237%	7.5
F-35C	2.5	5.8	232%	6.6

- More in-depth analysis between May 2014 and May 2015, in order to capture longer-term one-year trends, shows that MCMTCF and MTTR for all three variants are decreasing (improving), but with high month-to-month variability. For MCMTCF, the rate of decrease for the F-35A and F-35B is the highest, while improvements for the F-35C have been slower to manifest. For MTTR, the rate of improvement has been greatest for the F-35A, and slightly slower for the F-35B and F-35C.
- Several factors contribute to lengthy maintenance durations, especially adhesive cure times for structural purposes, such as attaching hardware (e.g., nutplates and installing heat blankets around the engine), as well as long material cure times for low observable repairs. From July 2014 to June 2015, program records show that maintenance on "attaching hardware," such as nutplates and heat blankets, absorbed approximately 20 percent of all unscheduled maintenance time, while low observable repairs accounted for 15 percent; these were the two highest drivers. The increased use of accelerated curing procedures, such as blowing hot air on structural adhesives or low observable repair pastes to force a quicker cure, may account for some of the decrease in repair times over the past year, but much room remains for improvement. The third highest driver of unscheduled maintenance, work on the ejection seat, by contrast, only accounted for 3 percent of all unscheduled maintenance hours.
- The immature state of the maintenance manuals and technical information maintainers use to fix aircraft may also negatively affect long repair times. The program is still in the process of writing and verifying Joint Technical Data (JTD) (see separate section in this report). Whenever maintainers discover a problem with no solution yet in JTD, and this problem prevents the aircraft from flying, the maintainers must submit a "Category I" Action Request (AR) to a joint government/Lockheed Martin team asking for tailored instructions to fix the discrepancy. This team can take anywhere from several days to nearly a month to provide a final response to each AR, depending on the severity and complexity of the issue. The number of final Category I AR responses per aircraft per month has been slowly increasing from December 2014 through August 2015. This trend indicates that, as the fleet matures, maintainers are continuing to face failure modes not adequately addressed by the JTD or that require new repair instructions. However, there are other reasons for submitting an AR, which may also partly account for this increasing trend. For example, depot teams submit ARs for depot-related repair work. More aircraft cycling through the modifications program, therefore, drives some of this increase. In addition, supply occasionally delivers parts with missing, incomplete, or incorrect electronic records, known as Electronic Equipment Logs (EELs), preventing those parts from being incorporated into the aircraft's overall record in Autonomic Logistics Information System (ALIS). In these cases, squadron maintenance personnel cannot electronically certify the aircraft safe for flight until supply delivers correct EELs, and maintenance personnel submit an AR to request these EELs.
- A learning curve effect is also likely improving repair times. As maintainers become more familiar with common failure modes, their ability to repair them more quickly improves over time.
- Maintainers must dedicate a significant portion of F-35 elapsed maintenance time to scheduled maintenance activities as well, which also affects aircraft availability

rates in addition to repair times. Scheduled maintenance accounted for 55 percent of all maintenance time from June 2014 to July 2015. (Scheduled maintenance time does not appear in either the MCMTCF or MTTR metrics.)

- Reducing the burden of scheduled maintenance by increasing the amount of time between planned in-depth and lengthy inspections that are more intrusive than routine daily inspections and servicing, will have a positive effect on how often aircraft are available to fly missions, provided experience from the field warrants such increases. An example is the engine borescope inspection, which were required after the engine failure on AF-27 in June 2014. The interval for these inspections increased after the program determined a fix to the cause of the failure and began implementing it on fielded aircraft. It will take more time and experience with field operations to collect data that show whether the program can increase inspection intervals without affecting aircraft safety for flight though.

Autonomic Logistics Information System (ALIS)

- The program develops and fields the ALIS in increments, similar to the method for fielding mission systems capability in the air vehicle. In 2015, the program fielded new versions of both hardware and software to meet requirements for the Marine Corps IOC. Although the program adjusted both schedule and incremental development build plans for ALIS hardware and software multiple times in 2014, it held the schedule more stable in 2015 by deferring capabilities to later software versions. The Program Office released several new versions of the software used in ALIS in 2015. However, each new version of software, while adding some new capability, failed to resolve all the deficiencies identified in earlier releases. Throughout 2015, formal testing of ALIS software has taken place at the Edwards AFB flight test center on non-operationally representative ALIS hardware, which relies on reach-back capability to the prime contractor at Fort Worth. The program still does not have a dedicated end-to-end developmental testing venue for ALIS, but has begun plans to develop one at Edwards AFB. This test venue, referred to as the Operationally Representative Environment (ORE), will operate in parallel with the ALIS squadron unit assigned to the operational test squadrons. The program plans to have the ORE in place as early as spring 2016. The ORE is planned to be a replicate of a full ALIS system and is needed to complete developmental testing of ALIS hardware and software in a closed environment to manage discoveries and corrections to deficiencies prior to OT&E and fielding to operational units. Meanwhile, formal testing, designated as Logistics Test and Evaluation (LT&E), remains limited and differs from how field units employ ALIS. For example, the flight test center at Edwards AFB does not use Prognostic Health Management (PHM), Squadron Health Management (SHM), Anomaly and Failure Resolution System (AFRS), and the Computerized Maintenance Management System (CMMS), each of which are modules within ALIS that the operational units use routinely.

ALIS Software Testing and Fielding in 2015

- During 2015, the program accomplished the following with ALIS software:
  - The program transitioned all fielded units from ALIS 1.0.3 to 2.0.0 between January and April 2015. This software includes integrated exceedance management, improved interfaces with legacy government systems, an upgrade to Microsoft Windows 7 on laptop and other portable devices, fixes to deficiencies, and reduced screen refresh and download times. Testing of software 2.0.0 identified two Category 1 deficiencies (same categorization as previously explained in this report in "Mission Systems" section), both of which remained uncorrected when the program delivered the software to field units. According to the program's LT&E report on ALIS 2.0.0, the test team identified the following deficiencies:
    - A deficiency in the air vehicle's maintenance vehicle interface (MVI)—the hardware used to upload aircraft data files—corrupted the aircraft software files during the upload process. Technical manuals in ALIS direct the process for loading aircraft files. The contractor addressed this deficiency by creating a fix in the final Block 2B aircraft software, and the program fielded it in 2015.
    - The Mission Capability Override (MCO) feature gives maintenance supervisors the authority and ability to override an erroneous mission capability status in ALIS. The LT&E of ALIS 1.0.3, conducted in September and October 2012, revealed a discrepancy in the mission capability status between two modules of ALIS. The Computerized Maintenance Management System (CMMS), which uses Health Reporting Codes (HRCs) downloaded from the aircraft, can report an aircraft as Mission Capable. Meanwhile, another module within ALIS, the Squadron Health Management (SHM), which makes the mission capable determination based on the Mission Essential Function List, could categorize the aircraft as Non-Mission Capable (NMC). This discrepancy is a result of errors in the interfaces between HRCs and the list of mission essential functions. When this discrepancy occurs, maintenance supervisors should be able to use the MCO feature to override either status within ALIS, which makes the aircraft available for flight. However, the Mission Capability Override is deficient because it does not allow override of the status within SHM (the override functions properly for CMMS). In ALIS 2.0.0, the same deficiency remains. However, ALIS 2.0.0 adds capabilities using the aircraft status in SHM to collect the mission capable status of aircraft across the fleet. Using SHM status to generate fleet availability metrics may be inaccurate because of the MCO deficiency.

- In addition to the Category 1 deficiencies listed above, the LT&E test team also identified 56 Category 2 deficiencies (same categorization as previously explained in this report in "Mission Systems" section) in the ALIS 2.0.0 report. The following list highlights deficiencies, either singly or in related groups, which affect aircraft maintenance and sortie generation rates:
  - » Parts management functionality within CMMS, which alerts ALIS users if maintainers attempt to install an incorrect part on an aircraft after the aircraft has undergone modification (i.e., modifications needed due to concurrency of development with production), is deficient. Once an aircraft has undergone modification, maintainers should install only specific, newer types and models of parts. However, CMMS incorrectly authorizes older/inappropriate replacement parts, changing the aircraft to an unauthorized configuration, which lacks the attributes of the modification. The configuration management function of CMMS is also deficient, as it does not maintain accurate configuration records of aircraft with completed modifications when CMMS has permitted the installation of infidel parts on the aircraft.
  - » Maintainers must use manual workarounds to ensure the aircraft mission capable status is accurate if they determine additional maintenance is required beyond that dictated by the HRCs from the post-mission download. For example, if maintenance personnel find or cause additional problems while performing maintenance, they must create new work orders with appropriate severity codes indicating that an aircraft is no longer mission capable. However, CMMS and SHM will not reflect that new aircraft status, requiring a maintenance supervisor to open each work order to review the actual, current aircraft status.
  - » The heavy maintenance workload, required to enter pertinent maintenance data into ALIS, causes field units to create workarounds, including creating task templates outside of ALIS to get maintenance records into ALIS.
  - » AFRS, designed to provide a library of possible maintenance actions for each HRC does not have the troubleshooting solutions for approximately 45 percent of the HRCs.
  - » Data products that ALIS is dependent on to make mission capable determinations, such as HRCs, the HRC nuisance filter list, AFRS troubleshooting libraries, and the mission essential function list, do not sufficiently manage configuration by including version, release date, applicability, or record of changes. As a result, maintenance personnel spend additional time correlating the data files to the individual aircraft—a process which increases the risks of errors and loss of configuration management of the aircraft assigned to the units.
  - » Long wait times to synchronize the Portable Maintenance Aid to transfer work order data to the ALIS squadron unit.
  - » Long wait times needed to complete data searches, export reports, and apply processes within ALIS.
- The program developed ALIS 2.0.1 to upgrade to Windows Server 12, add new capabilities required to support the Marine Corps' IOC declaration in mid-2015, and address ALIS 2.0.0 deficiencies. The program completed the LT&E of ALIS 2.0.1 in May 2015, but results were poor, so the program did not release the software to the field. As of the writing of this report, the program had not signed out the ALIS 2.0.1 LT&E report. According to their "quick look" briefing, the test team discovered five new Category 1 deficiencies and confirmed that the contractor did not correct in ALIS 2.0.1 the two Category 1 deficiencies identified during ALIS 2.0.0 testing (listed above). According to the briefing, the five new Category 1 deficiencies are:
  - The Integrated Exceedance Management System, designed to assess and report whether the aircraft exceeded limitations during flight, failed to function properly. The Services require proper functioning of this capability to support post-flight maintenance/inspections and safe turnaround for subsequent flights.
  - AFRS, which is critical to troubleshooting and maintenance repairs, demonstrated unstable behavior and frequently failed because of interface problems and a system licensing configuration issue.
  - ALIS randomly prevented user logins.
  - The maintenance action severity code functionality in CMMS—designed to automatically assign severity codes to work orders as maintenance personnel create them—did not work correctly.
  - ALIS failed to process HRCs correctly when maintenance personnel used CD media to input them into ALIS at sites that do not use PMD readers (described below) to download maintenance data.
- The program developed another version of ALIS, version 2.0.1.1, which contained numerous software "patches" designed to correct the five Category 1 deficiencies discovered by the test team during the LT&E of ALIS 2.0.1. The test team conducted an LT&E in May and June 2015 specifically to determine if Lockheed Martin had resolved each deficiency. The test team evaluated the correction for each deficiency as the contractor delivered the software patches. As of the end of November, the program had not signed out the LT&E report on ALIS 2.0.1.1, but according to the test team's "quick look" briefing, they recommended releasing ALIS 2.0.1.1 to the fielded units, which the program completed between July and October 2015. In their "quick look" briefing, the test team also noted failures of redundant systems and workarounds that were required to address other unresolved problems. These included:

  - Frequent failures of the aircraft memory device, which serves as a back up to the PMD, to download into ALIS when the PMD is corrupted.
  - CMMS and SHM exhibited disparities in tracking on-aircraft equipment usage which required maintainers to develop and operate a parallel tracking system independent of ALIS.
  - Managing data loads associated with mission planning required extensive contractor support as the maintenance-vehicle interface did not support direct loading to the aircraft as designed.
  - Air vehicle data transfer between squadron hardware, required for deployments and aircraft induction to and from depots, required extensive contractor support.
  - Air vehicle lockdown capability, needed for impounding an aircraft in the event of an investigation, did not work.
- All versions of ALIS have demonstrated persistent problems with data quality and integrity, particularly in the Electronic Equipment Logbooks (EELs), which allow usage tracking of aircraft parts. Frequently, EELs are not generated correctly or do not transfer accurately, requiring manual workarounds that extend aircraft repair and maintenance times. Without accurate EELs data, ALIS can improperly ground an aircraft or permit an aircraft to fly when it should not.

ALIS Hardware Fielding in 2015

- During CY15, the program demonstrated progress in the development and fielding of ALIS hardware and aligning hardware versions with the software versions noted above.
  - The program delivered the first deployable version of the Squadron Operating Unit (SOU), deemed SOU V2 (Increment 1), aligned with ALIS software 2.0.1, to MCAS Yuma to support Marine Corps IOC. The originally fielded unit-level hardware, SOU V1, failed to meet ORD deployability requirements due to its size and weight. SOU V2 incorporates modular components that meet two-man-carry transportation requirements and decrease set-up time. Additionally, field units can tailor the SOU V2 by adjusting the number of components with which they deploy depending on projected duration. SOU V2 allowed the program to meet requirements for Marine Cops IOC. It will support Block 2B, 3i, and 3F aircraft. The program plans to field one set of SOU V2 hardware for each F-35 unit and an additional set of SOU hardware for each F-35 operating location. During partial squadron deployments, the unit will deploy with their SOU V2 while the remainder of the squadron's aircraft will transfer to the base-level SOU.
  - Because the Edwards AFB flight test center does not have an SOU V2, the program conducted the hardware portion of the LT&E at Fort Worth in May 2015. Testing included demonstrating that PMDs from aircraft at the flight test center downloaded correctly into the SOU V2.
  - The program continued to field PMD readers to operating locations. As designed, maintainers download aircraft PMDs post flight to ALIS through a Ground Data Security Assembly Receptacle (GDR). However, it takes between 1.0 and 1.2 hours to download all data from a 1-hour flight. PMD readers download maintenance data only within 5 minutes, permitting faster servicing of aircraft.
  - The program delivered an SOU V2 to the JOTT at Edwards AFB in November 2015. This SOU V2 will be "on loan" from Hill AFB, Utah, and is planned to be used in an F-35A deployment to Mountain Home AFB, Idaho, in March 2016 with six Air Force F-35A aircraft.
  - Lockheed Martin delivered full SOU V2 kits to MCAS Yuma in May 2015 and to the Pilot Training Center at Luke AFB, Arizona (for Norway) in October. Because Israel did not require an SOU V2 when scheduled for delivery, the Program Office arranged for it to go to MCAS Yuma in November 2015, so the squadron could use it in an assessment of the F-35B's capabilities at an austere location. The program delivered an SOU V2 deployment kit to Nellis AFB and a Central Point of Entry (CPE) kit, which included a CPE and an SOU V1, for United Kingdom lab use, in December 2015. A full SOU kit includes more peripheral equipment than a deployment kit.

Cross Ramp Deployment Demonstration May 2015

- During April and May 2015, the Air Force's Air Combat Command tasked the 31st Test and Evaluation Squadron (TES) at Edwards AFB to conduct a limited deployment of F-35A aircraft as part of the de-scoped Block 2B operational test activity. This deployment, from one hangar on the flight line at Edwards AFB to another hangar, termed the Cross Ramp Deployment Demonstration (CRDD), gave the program and the Air Force an opportunity to learn how to deploy the F-35 air system and ALIS. Originally, the 31st TES planned to use ALIS 2.0.1, but delays in releasing that software resulted in the need to use ALIS 2.0.0 instead. Overall, the CRDD showed that ALIS 2.0.0 deficiencies, plus difficulties encountered during the CRDD in downloading and transferring data files from home station to a deployed location, will negatively affect sortie generation rate if they remain uncorrected. The CRDD also demonstrated that getting ALIS 2.0.0 online with current maintenance information while also conducting flying operations is time consuming, complex, and labor intensive. Working around ALIS 2.0.0 deficiencies in this manner was possible for this demonstration of limited duration; however, it would not be acceptable for deployed combat operations.
  - The 31st TES deployed across the ramp on the flightline by packing and moving an ALIS SOU V1 loaded with ALIS 2.0.0 software, mission planning hardware, maintenance personnel, support equipment, and tools. Three F-35A aircraft "deployed" to the cross ramp location after the ALIS SOU V1 was in place. For supply support, maintenance personnel obtained spare parts from the base warehouse as though they had not deployed (i.e., the 31st TES did not deploy in this demonstration with a

pre-planned set of spares as an operational unit would have for an actual deployment).

- Transfer of aircraft data from the SOU at the main operating location to the SOU at the "deployed" location and getting the SOU online took several days to complete and required extensive support from Lockheed Martin ALIS administrators, a level of effort not planned for the deployment and not operationally suitable. Although not finalized by the Services, deployment concepts of operation will include procedures for transferring aircraft data between SOUs via secure electronic methods. The test team attempted the primary electronic method, but the configuration of the deployed SOU caused it to fail. Ultimately, data transfer occurred using the physical transfer of back-up CDs to the deployed location, but the 31st TES could not load the files until the end of the third of the five days of flight operations, because administrators had to load multiple software patches, and resolve ALIS account problems for every authorized user. After loading the aircraft data on the deployed SOU, administrators also had to enter manually all maintenance performed on the aircraft during this time into the SOU before bringing ALIS online to support operations.
- Flight operations did take place without the support of normal ALIS operations for the three days while the test team worked to get the SOU online. During this period, maintenance personnel prepared and recovered aircraft without a full post-mission download of maintenance data, including health and fault codes normally captured and transmitted to ALIS 2.0.0. The deployed aircraft generally required only routine maintenance such as tire changes, which maintainers could complete without access to all maintenance instructions. One aircraft experienced a radio failure, which did not require an HRC download to diagnose, and did not fly again until maintainers replaced the radio.
- To prepare for the deployment, the 31st TES did not fly the aircraft designated for the deployment during the week prior, allowing maintenance personnel to prepare the aircraft and ensure all inspections were current and maintenance actions complete. This preparation allowed the unit to conduct flight operations for three days during the deployment while the SOU remained offline.
- At the end of the demonstration, the 31st TES successfully transferred data to the Autonomic Logistics Operating Unit at Fort Worth—per one of the electronic methods of transfer expected for deployed operations—but staffing levels at Lockheed Martin were insufficient to complete the transfer all the way back to the home station SOU. Instead, the 31st TES transferred data back to the home station SOU via an alternative, web-based, secure, online file transfer service operated by the Army Missile Research and Development Center, referred to as "AMRDEC."
- The CRDD showed that although cumbersome, field units could relocate the SOU V1 hardware to a deployed operating location and eventually support operations with that hardware. However, difficulties in transferring data between home station and a deployed SOU made the deployment and redeployment processes time consuming and required extensive support from the contractor to complete. Although ALIS 2.0.1.1 added improvements to data transfer capabilities, the program has not yet demonstrated those improvements in a Service-led deployment exercise. Therefore, it is unknown the extent to which ALIS 2.0.1.1 improves data transfer capabilities.

Marine Corps Austere Assessment Deployment Demonstration, December 2015

- The Marine Corps deployed eight production F-35B aircraft—six from VMFA-121 at Marine Corps Air Station (MCAS) Yuma, Arizona, and two from VMX-22 at Edwards AFB, California—to the Strategic Expeditionary Landing Field (SELF) near MCAS Twentynine Palms, California, from December 8 – 15, 2015, to assess deployed operations to an austere, forward-base location. The Marine Corps aligned the deployment with a combined arms live fire exercise, Exercise Steel Knight, to have the F-35 detachment provide close air support for the rest of the exercise participants as the forward deployed air combat element (ACE). The SELF had an airfield constructed of AM2 matting (aluminum paneling engineered for rapid runway construction to support austere operations) and minimal support infrastructure, which required the Marine Corps to deploy the necessary support equipment, spare parts, and personnel; and set up secure facilities on the flightline to conduct F-35B flight operations. Although it was not a formal operational test event, the JOTT and DOT&E staff observed operations and collected data to support the assessment.
  - While deployed, and in support of the exercise, the Marine Corps flew approximately 46 percent of the planned sorties (28 sorties flown versus 61 sorties planned), not including the deployment, redeployment, and local familiarization sorties. Accounting for all sorties (i.e., deploying and redeploying, local training, aircraft diverts and swapping one aircraft at home station) the Marine Corps flew approximately 54 percent of scheduled sorties (82 scheduled versus 44 flown). Weather, particularly high winds, aircraft availability, and problems transferring aircraft data from the home station to the deployed ALIS SOU all contributed to the loss of scheduled sorties.
  - The Marine Corps planned to employ inert GBU-12 and GBU-32 weapons in the CAS role during the exercise. The Marine Corps ordnance loading teams completed multiple GBU-12 and GBU-32 upload and download evolutions at the SELF. However, pilots released fewer weapons than planned due to weather and range limitations.
  - Two aircraft experienced foreign object damage to their engines from debris ingested during operations, grounding them until the end of the deployment. The engine damage on both aircraft was not severe enough to cause an engine

change, but required a Pratt and Whitney technician, certified in blending out damage to engine blades, to repair the engines on both aircraft at Twentynine Palms so they could return to flyable status, allowing the aircraft to return to home station at the end of the deployment. No further action was required for the engine repairs on either aircraft. It was still unknown at the time of this report how these types of engine repairs would be conducted during deployed or combat operations.

- The deployment was the first to use the ALIS Standard Operating Unit Version 2 (SOU V2), which is smaller, lighter weight and more modularized than Version 1. Although Marine Corps ALIS personnel were able to set up the SOU V2 (i.e., place and connect the modules and apply power) within a few hours after arrival, setting up connectivity with the broader Autonomic Logistics Global Support (ALGS) function did not occur for quite some time. The Customer Relations Module (CRM) of ALIS, used to submit action requests to the contractor for resolving maintenance actions, operated only intermittently during the deployment.
- The transfer of data from home station to the deployed ALIS SOU took several days to fully complete, a process that is not affected by the version of SOU being used. Since the SOU V2 lacked connectivity to the Autonomic Logistics Operating Unit, which is required for transferring data via the preferred method of keeping the data entirely within the infrastructure of ALIS, initial data transfers for the six aircraft from MCAS Yuma were AMRDEC. Files were transferred to workstations at the deployed site and then loaded into ALIS via CDs. The downloading of files from AMRDEC was slowed several times when SATCOM connectivity was lost during the process. The aircraft from Edwards AFB, however, brought CD's with them for transfer into ALIS.
- The deployment provided valuable "lessons learned" for the Marine Corps as it develops concepts of operation for forward basing and austere operations. While the SOU V2 proved to be easier and quicker to set up than the SOU V1, transferring aircraft data from home station to the deployed location continued to be problematic. Poor aircraft availability reduced the support the F-35B ACE was able to provide to the large force exercise.

ALIS Software and Hardware Development Planning through the End of SDD

- In CY15, the program continued to struggle with providing the planned increments of capability to support the scheduled releases of ALIS software 2.0.x and 3.0.x. The program approved changes to the content of the ALIS developmental software release plan in April 2015 for ALIS 2.0.1 and 2.0.2. To adhere to the previously approved software release schedule for ALIS 2.0.1, the program deferred several capabilities, including cross-domain solutions for information exchange requirements and firewall protections for low observable and mission planning data, to a later fix release. The Marine Corps, which required ALIS 2.0.1 for IOC, supported the Program Office's plan to defer these capabilities until after IOC.
  - These deferrals are in addition to decisions in 2014 to defer life-limited parts management capabilities to ALIS 2.0.2 and ALIS 3.0.0.
  - Although the re-plan included a two-month delay in the LT&E dates for ALIS 2.0.1 from March to May 2015, the program did not change the initial fielding date of July 2015, the planned date for Marine Corps IOC. The program also approved a fix release of this software to follow almost immediately.
  - The program had previously scheduled fielding of software 2.0.2, beginning in December 2015, but approved a nearly eight-month delay to late July 2016. The Air Force IOC requirement is for ALIS software 2.0.2 to be fielded. Since the Air Force also requires operationally representative hardware and software 90 days before declaring IOC, the delayed schedule does not support the Air Force IOC objective date of August 2016. An additional potential problem is that the program currently does not plan to conduct cybersecurity penetration testing during the development of this ALIS release or any future developmental releases, but will instead rely on previous, albeit limited, cybersecurity test results. This decision increases the risk that the program will not be aware of ALIS vulnerabilities before making fielding decisions. However, the JOTT will complete operational cybersecurity testing of fielded ALIS components.
  - At an April 2015 review, the program projected initial fielding of ALIS 3.0.0 in June 2017 and indicated they would propose combining ALIS 3.0.0 and 3.0.1 (previously planned for December 2017) into a single release in June 2018. Should this occur, ALIS software will not include full life limited parts management, a capability planned for Marine Corps IOC, until nearly three years after Marine Corps IOC. All fielded locations will require high levels of contractor support until the program integrates life limited parts management capability into ALIS. In November 2015, the program proposed changing the content of ALIS 3.0.0 to reflect service and partner priorities and moving the fielding date forward by approximately six months.
  - The program has deferred the PHM downlink originally planned for release in ALIS 2.0.0 indefinitely because of security concerns.
- The program plans the following hardware releases to align with software releases noted above:
  - The program plans SOU V2 (Increment 2) to align with ALIS 2.0.2 and include additional SOU V2 hardware improvements to support Air Force IOC, including dynamic routing to deliver data via alternate network paths and sub-squadron reporting to allow deployed assets to report back to a parent SOU.

- The third increment of SOU V2 hardware will address Service requirements for decentralized maintenance, allowing personnel to manage maintenance tasks whether or not they connect their portable maintenance aid (PMA) to the main SOU (the PMA provides connectivity between maintenance personnel and the aircraft, enabling them to do maintenance tasks on the aircraft by viewing technical data and managing work orders downloaded from the SOU). Increment 3 will also permit units to conduct deployments without SOU hardware, instead relying on PMAs. This increment of SOU V2 will align with ALIS release 3.0.0.

Prognostic Health Management (PHM) within ALIS

- The PHM system collects air system performance data to determine the operational status of the air vehicle and, upon reaching maturity, will use data collected across the F-35 enterprise and stored within PHM to predict maintenance requirements based on trends. The PHM system provides the capability to diagnose and isolate failures, track and trend the health and life of components, and enable autonomic logistics using air vehicle HRCs collected during flight and saved on aircraft PMDs. The F-35 PHM system has three major components: fault and failure management (diagnostic capability), life and usage management (prognostic capability), and data management. PHM diagnostic and data management capabilities remain immature. The program does not plan to integrate prognostic capabilities until ALIS 2.0.2.
  - Diagnostic capability should detect true faults within the air vehicle and accurately isolate those faults to a line-replaceable component. However, to date, F-35 diagnostic capabilities continue to demonstrate poor accuracy, low detection rates, and a high false alarm rate. Although coverage of the fault detection has grown as the program has fielded each block of F-35 capability, all metrics of performance remain well below threshold requirements. The table above compares specific diagnostic measures from the ORD with current values of performance through June 2015.
  - PHM affects nearly every on- and off-board system on the F-35. It must be highly integrated to function as intended and requires continuous improvements for the system to mature.
- Poor diagnostic performance increases maintenance downtime. Maintainers often conduct built-in tests to see if the fault codes detected by the diagnostics are true faults. False failures (diagnostics detecting a failure when one does not exist) require service personnel to conduct unnecessary maintenance actions and often rely on contractor support to diagnose system faults more accurately. These actions increase maintenance man-hours per flight hour, which in turn can reduce aircraft availability rates and sortie generation rates. Poor accuracy of diagnostic tools can also lead to desensitizing maintenance personnel to actual faults.

METRICS OF DIAGNOSTIC CAPABILITY
(6-month rolling window as of June 2015. Data provided by the Program Office are considered "preliminary" as they have not completed the formal adjudication process by the data review board.)

Diagnostic Measure	Threshold Requirement	Demonstrated Performance		
		Block 1	Block 2	Block 3
Developmental Test and Production Aircraft				
Fault Detection Coverage (percent mission critical failures detectable by PHM)	N/A	65	73	84
Fault Detection Rate (percent correct detections for detectable failures)	98	65	73	85
Fault Isolation Rate (percentage): Electronic Fault to One Line Replaceable Component (LRC)	90	68	69	72
Fault Isolation Rate (percentage): Non-Electronic Fault to One LRC	70	76	72	79
Fault Isolate Rate (percentage): None-Electronic Fault to 3 or Fewer LRC	90	82	87	87
Production Aircraft Only				
Mean Flight Hours Between False Alarms	50	0.20	0.60	0.18
Mean Flight Hours Between Flight Safety Critical False Alarms	450	1,360	543	170
Accumulated Flight Hours for Measures	N/A	1,360	4,886	1,360
Ratio of False Alarms to Valid Maintenance Events	N/A	44:1	16:1	1079:1

  - Qualified maintenance supervisors can cancel an HRC without generating a work order for maintenance actions if they know that the HRC corresponds to a false alarm not yet added to the nuisance filter list. In this case, the canceled HRC will not result in the generation of a work order, and it will not count as a false alarm in the metrics in the above table. The program does not score an HRC as a false alarm unless a maintainer signs off a work order indicating that the problem described by the HRC did not occur. Because PHM is immature and this saves time, it occurs regularly at field locations but artificially lowers the true false alarms rate (i.e., actual rate is higher).
  - Comparing the values in the table above with previous reports, Mean Flight Hours Between Flight Safety Critical False Alarms is the only diagnostic metric that has shown significant improvement over the last year. Other metrics have stayed either flat or decreased (worsened) slightly.

- The following lists the systems most likely to result in missed fault detections, incorrect fault isolations, and false alarms as of June 2015:
  - Missed detections. Integrated Core Processor, power and thermal management system, panoramic color display, communications-navigation-identification (CNI) rack modules, and the Helmet Mounted Display System.
  - Incorrect isolation. Integrated Core Processor, power and thermal management system, electronic warfare, fuel system, CNI rack modules, and hydraulic power system.
  - False alarms. CNI system, propulsion, electronic warfare, suspension and release, displays and indicators in general.

Off-board Mission Support (OMS) within ALIS

- OMS provides F-35 ground mission planning, mission debrief, security, and sensor management capabilities. Similar to other components of ALIS, the program does not have a developmental test venue for OMS. Mission planning modules include the baseline Joint Mission Planning System software that pilots and tacticians use to develop files for uploading into the aircraft prior to flight. OMS includes separate hardware such as workstations and encryption/decryption devices and networks with ALIS for data management. In addition to mission planning, OMS provides the following functions:
  - Ground security that allows for secure data management and cryptologic key management at multiple classification levels
  - Sensor management and selection of mission data files to create a mission data load
  - Mission debrief capability for replaying audio and video from completed flights
- Until September 2015, the training center did not provide hands-on training on OMS, requiring the pilots to learn it through trial and error and by asking questions of the contractor. Also, the program has not yet provided OMS user manuals. As a result, field units will likely have difficulty providing the expertise to create tailored, theater-specific mission data loads during contingency operations. Few pilots currently possess the training and experience to build mission data loads from beginning to end.
- OMS deficiencies will have a negative impact on combat mission and training flight operational tempo. Long processing times create bottlenecks in both mission planning and mission debrief, particularly for multi-ship missions.
  - Pilots transfer a mission plan into the PMD using a GDR, which encrypts the information. The PMD loading process is unnecessarily complex, taking 25 to 45 minutes to transfer a mission data load from an OMS workstation to a PMD. If pilots transfer the same mission data load to multiple PMDs for a multi-ship mission, each PMD is encrypted separately with no time savings.
  - OMS requires excessive time for loading of PMDs and decryption of mission data and does not support timely mission debrief, particularly if pilots fly multiple missions in one day. For example, a 1-hour mission typically takes between 1.0 and 1.2 hours to decrypt, and depending on the amount of cockpit video recorded, can take longer.
  - Administrative functions in OMS, such as theater data load updates, user authentication file updates, cryptographic updates, and data transfers are inefficient and require excessive times to complete.
    - Because of cryptographic key expirations, OMS administrators must update the theater data load at least every 28 days. The OMS administrator builds the load on OMS equipment, transfers it to a separate laptop, creates a CD, and then uploads it to the SOU. Again, personnel cannot build cryptographic key loads on one OMS workstation and export it to others in the same unit; they must build them individually.
    - Personnel must install cryptographic keys on the aircraft, OMS workstations, GDRs, and GDR maintenance laptops.
    - Block 2B aircraft have 33 different cryptographic keys with varying expiration periods. When building a key for the entire jet, an error frequently means rebuilding from the beginning, which can take several hours.
    - The cryptographic key management tool is not intuitive, prone to errors, and does not have a validation function so the user can determine if a key load is accurate prior to transferring it to the aircraft.
    - Loading of incorrect keys can result in aircrew not having capabilities such as secure voice transmissions.
    - Local security policies vary, making hardware requirements and information technology processes different at each operating location.
  - Current OMS hardware does not have the necessary video processing and display capabilities to allow pilots to effectively debrief a multi-ship mission. Current debriefing capability via laptops does not provide adequate resolution or a large enough presentation for a four-ship debrief.

Joint Technical Data (JTD)

- Although the verification of Joint Technical Data (JTD) modules has proceeded through 2015, field units continue to face challenges where JTD is either not yet verified, is unclear, or includes errors. To work around these challenges, personnel must frequently submit ARs to the contractor and wait for the engineering disposition, a process that adds to maintenance time.
- The program identifies JTD modules and the primary contractors develop and verify them in the field. Once JTD modules complete verification, the program includes them in the JTD package distributed periodically to all field locations through ALIS. At the field locations, they are downloaded to unit-level SOUs and PMAs. JTD updates currently require

downloading of the entire JTD package (i.e., partial changes to JTD cannot be distributed to fielded units).
- ALIS release 2.0.0 included Trilogi Viewer 4.0, which supports delivery of partial builds and amendments to JTD to reduce the time required to install JTD updates at the unit level. However, the program determined that this version of Trilogi contains a software error, which prevented implementation of this capability until corrected. As of December 2015, the program continues to distribute only complete, bundled JTD packages.
- The total number of identified data modules grows each year as the program matures and low-rate initial production (LRIP) contracts include additional JTD delivery requirements. The air-vehicle JTD includes time compliance technical data, depot-level technical data, air vehicle diagnostics and troubleshooting procedures, complete structural field repair series data, aircraft battle damage assessment and repair, and maintenance training equipment. According to the most recent data from the Program Office, as of September 2015, propulsion JTD development is nearly complete and on schedule. To support Marine Corps IOC, the contractor focused on development of F-35B unit-level and Supportable Low Observable (SLO) JTD and deferred approximately 260 data modules, identified by the Marine Corps as not needed until after IOC, such as JTD modules for loading weapons not yet cleared for use.
- Although the program included development of support equipment JTD in the SDD contract, the program funded additional support equipment via another, separate contract, which requires approximately 1,700 more data modules. The contract began in July 2014 and the modules must be verified before the end of SDD.
- The program estimates that development of all JTD for each variant of the air vehicle and for propulsion will meet Service milestones.

• DOT&E sees risk in the ability of the program to complete air vehicle JTD verifications in time to meet Service needs. The program does not have a formal JTD verification schedule nor dedicated time to complete air vehicle JTD verifications. In addition, it depends on the availability of aircraft, primarily at Edwards and Eglin AFBs, to complete this work. JTD verifications have lower priority than maintaining the flight schedule, so verification teams normally cannot schedule dedicated events.
- The program did focus on completing F-35B unit-level verifications during 2015 with verifications lagging development by fewer than 200 modules out of 5,157 developed.
- The program will not complete highly invasive JTD verifications, such as those for removing fuel cells, until an aircraft requires this level of maintenance.
- The program did not fund SLO JTD verifications until March 2014, so SLO JTD lags other verification efforts. However, most SLO JTD verification will take place using desktop analysis, and the program expects verification for all variants to proceed on schedule.

• As of September 2015, the program had verified approximately 94 percent of the identified air vehicle JTD modules for the F-35A, 93 percent of the F-35B, and 73 percent of the F-35C. The table below shows the number of JTD modules identified, developed, and verified for the air vehicle by variant, pilot flight equipment, support equipment, and SLO. Overall, approximately 77 percent of these modules have been identified, developed, and verified. The program tracks propulsion JTD separately.

F-35 SDD JOINT TECHNICAL DATA (JTD) DEVELOPMENT AND VERIFICATION STATUS REQUIRED BY COMPLETION OF SYSTEM DEVEOLOPMENT AND DEMONSTRATION (SDD) CONTRACT Air Vehicle, Pilot Flight Equipment (PFE), Support Equipment (SE), and Supportable Low Observable (SLO) (as of end of September 2015)

	Module Type	Modules Identified	Modules Developed	Percent Identified Modules Developed	Number of Verification Events[1]	Percent Identified Modules Verified
F-35A[2]	Unit-level	4,603	4,326	94 %	4,328	Not Determined
F-35B[2]	Unit-level	5,335	5,157	97 %	4,966	93 %
F-35C[2]	Unit-level	4,766	4,009	84 %	3,488	73 %
Common (all variants)[3]	Unit-level	84	58	69 %	62	Not Determined
PFE	Common	326	318	98 %	274	84 %
SE	Common	2,345	1,596	68 %	1,351	58 %
SLO	F-35A	745	599	79 %	80	11 %
	F-35B	739	739	100 %	428	58 %
	F-35C	668	97	15 %	79	12 %
	Common	6	6	100 %	4	67 %
TOTAL		19,617	16,905	86 %	15,060	77 %

1. For F-35A and Common modules, multiple verifications are required for some single data modules, hence values represent verifications and exceed the number of modules developed.
2. Includes field- and depot-level JTD for operations and maintenance, on- and off-equipment JTD, and structured field repairs.
3. Includes aircraft JTD for general repairs, sealants, bonding, structured field repairs, and non-destructive investigations.

Air-Ship Integration and Ship Suitability Testing

F-35B

- The Marine Corps conducted a suitability demonstration with six operational (i.e., non-test fleet) F-35B aircraft onboard the USS *Wasp* from May 18 – 29, 2015.
  - Despite bearing the title "OT-1" for "Operational Test – One," as expected, the demonstration was not

an operational test and could not demonstrate that the F-35B is operationally effective or suitable for use in any type of limited combat situation. This was due to many factors concerning how the demonstration was structured including, but not limited to, the following major features that were not operationally representative:

- Other aircraft of a standard Air Combat Element (ACE)—with which the F-35B would normally deploy—were not present, except for the required search and rescue helicopters, granting the F-35B unit practically sole use of the flight deck and hangar bay.
- The embarked F-35B aircraft lacked the full complement of electronic mission systems necessary for combat, and not all the normal maintenance procedures necessary to keep those systems in combat-capable state of readiness were exercised.
- The aircraft did not have the appropriate flight clearances to carry or employ any ordnance. Ordnance evolutions were limited to maintainers uploading and downloading inert bombs and missiles on the flight deck.
- Uniformed maintainers had not yet been equipped with complete maintenance manuals and mature troubleshooting capabilities, necessitating the extensive use of contractor maintenance personnel that would not be present on a combat deployment.
- Production-representative support equipment was not available. Instead, the demonstration used interim support equipment cleared for hangar bay use only and requiring workarounds for conducting maintenance, such as fueling operations, on the flight deck.
- The operational logistics support system, known as the Autonomic Logistics Global Sustainment system, was not available. A potentially non-representative set of spare parts was loaded onboard the ship, and the program and Marine Corps provided extensive supply support to ensure replacement parts reached the ship faster than would be expected in deployed combat operations.

- The USS *Wasp* demonstration event did, however, provide useful training for the Marine Corps and amphibious Navy with regards to F-35B operations onboard L-class ships, and also provided findings relevant to the eventual integration of the F-35B into the shipboard environment.
- The Marine Corps and Lockheed Martin could not transfer data for the aircraft, support equipment, spare parts, and personnel from ashore sites to the SOU onboard the ship entirely within the ALIS network as originally envisioned, due to the immaturity of the Autonomic Logistics Operating Unit. An attempt was made to download the data onto the ship via other government and contractor networks, but the download rate over the ship's network proved too slow to efficiently move the numerous large files. Finally, the data were downloaded off-ship via commercial Wi-Fi access, burned to CDs, and imported directly onto the *Wasp*'s SOU. This method of transferring data would not be acceptable for routine combat deployments.
  - Similarly, once the USS *Wasp* was underway, service personnel noted that getting ALIS-related data to the ship to support flight operations, such as the EEL records for spare parts delivered by supply, was slow over satellite communications channels.
  - In addition to the difficulties moving the data back and forth between the *Wasp* SOU and ashore site SOUs, data discrepancies were introduced during the transfer process, including inconsistencies and lost data. Transfer of aircraft data from the shore-based SOU to the *Wasp* SOU took nearly two days to complete, and maintenance personnel were correcting discrepancies found in the aircraft data in ALIS for four additional days. For example, when the aircraft data files were finally received onboard the USS *Wasp*, all outstanding parts requisitions for the aircraft had been stripped. The transfer of support equipment data took 10 days to complete and maintenance personnel were correcting deficiencies in the data during the majority of the at-sea period.
- Aircraft reliability and maintainability were poor enough that it was difficult for the Marines to keep more than two to three of the six embarked aircraft in a flyable status on any given day, even with significant contractor assistance. Aircraft availability during the deployment was approximately 55 percent. Around 80 percent availability would be necessary to generate four-ship combat operations consistently with a standard six-ship F-35B detachment.
- Aircraft availability varied significantly from aircraft to aircraft, however, with some aircraft requiring no major maintenance, and other aircraft barely contributing to meaningful flight operations. In particular, one aircraft, designation BF-23, was reported "Full Mission Capable (FMC)" for the entire 11-day duration of the deployment. Another aircraft, BF-37, flew less than 5 hours, including diverting to shore and back for a landing gear malfunction, and was not flyable for 8 of the 11 days. BF-37 was notable for being in depot modification from December 8, 2014, to May 8, 2015, right before the start of the demonstration. Fleet units have reported initial reliability difficulties with aircraft after they come back from long stays at the depot, and the experience with BF-37 onboard USS *Wasp* would support these observations.
- Poor fuel system reliability proved particularly challenging, in part due to the nature of the shipboard environment. The detachment experienced two major fuel system failures, a fuel boost pump and a high level float valve. For fuel system maintenance, the aircraft must be drained of fuel and then certified gas-free of combustible fuel vapors before work can proceed. Onboard ship, this lengthy process must be done in the hangar bay and little work on other aircraft in the bay can occur, particularly

electrical work or hot-work, due to the risk of sparks igniting fuel vapors. This is less of an issue on land, where the aircraft can be moved far away from other aircraft while de-fueling. The Marines decided to fly one of these aircraft on a one-time waiver back to shore and swap it with a replacement aircraft in order to keep flying, and not over-burden maintenance. However, this would not be an option when deployed in a combat zone. The program should increase fuel system reliability, especially for the F-35B and F-35C variants.

- The detachment staged all necessary personnel, support equipment, tools, and ship's facilities to conduct engine and lift-fan removals and installations in the hangar bay, but did not actually conduct any, as a basic fit-check. The amount of space required for this heavy propulsion maintenance is substantial and could have a significant operational impact on ACE operations when far more aircraft are present in the hangar bay and on the flight deck.
- During the underway period, the Marines successfully delivered a mock spare F-35 engine power module to the USS *Wasp* via internal carry on an MV-22 tilt-rotor, and returned it back to shore. This concept demonstration opens up a potentially viable re-supply method for the F-35 engine power module, which is too large and heavy to deliver to a ship at sea using current, traditional replenishment methods. Work remains to be done to ensure that this method will not damage spare engine modules but, if successful, will ease logistical support of F-35's while onboard ship.
- Ordnance evolutions included uploading and downloading of inert AIM-120 missiles, and GBU-12 500-pound laser guided and GBU-32 1,000-pound Global Positioning System-guided bombs. In order to load the bombs to their appropriate stations in the internal weapons bay, the station had to be disconnected from the aircraft, lowered and coupled to the bomb, and then re-connected to the aircraft with the bomb attached. This procedure potentially invalidates pre-ordnance loading checks to ensure that the weapons stations are working properly (i.e., that they will provide appropriate targeting information to the weapon and release the weapon when commanded).
- The lack of production-representative support equipment prevented the detachment from providing cooling air on the flight deck, which is necessary to prevent the avionics from overheating while conducting maintenance and servicing while on external electrical power or internal battery power. This limited the ability to troubleshoot on the flight deck and made refueling operations less efficient. The program should demonstrate regular flight deck operations with the intended operational support equipment before an actual combat deployment.
- The program conducted several tests with a Handheld Imaging Tool (HIT) that uses a small radar to scan the aircraft and determine its degree of stealth. The HIT can be used to scan for areas where the Low Observable (LO) material needs to be repaired, as well as to verify repairs to LO materials. It is a replacement for a previous Radar Verification Radar, which was too large for efficient use in the crowded hangar bay of an aircraft carrier. Initial results of the HIT testing looked very promising, although further developmental work remains.
- Several other important findings surfaced from the USS *Wasp* demonstration:
  - When the aircraft is on jacks in the hangar bay, maintainers must securely tie it down to the deck with chains to ensure that the ship's rocking motion in the waves does not cause the aircraft to slip off. However, the tie down pattern used prevented the weapons bay doors from being opened while the aircraft is on jacks. This will prevent maintainers from connecting cooling air, since the intake port is located in the internal weapons bay, and may limit efficient completion of landing gear maintenance.
  - With the current software configuration, when maintainers apply external power to the aircraft, the anti-collision strobe lights come on automatically, flashing for a few seconds until maintainers can manually turn them off. This violates ship light's discipline, and at night, it can briefly blind flight deck personnel as well as potentially reveal the ship's position. The program must change the software to prevent this occurrence onboard ship.
  - The L-class ships currently lack the facilities to analyze any debris found on magnetic chip collectors in the engine oil system. Metal shavings in the engine oil could indicate that engine components such as bearings may be wearing out, which could cause the engine to seize in flight. Currently, if maintainers discover chips, they will have to down the aircraft and mail them out to a shore facility that can analyze the shavings to determine if the engine is up, or requires particular maintenance. This process could take several days.
  - When the aircraft is wet it is extremely slippery. The F-35 sits higher off the deck than legacy aircraft so falls off of it can cause greater injury, or at sea, can lead to a man-overboard. This is exacerbated by the plastic booties maintainers are supposed to wear when working on the aircraft to protect the LO coatings. The detachment decided, for safety reasons, to allow maintainers to work on the aircraft without wearing these booties. The program should investigate alternate footwear to continue to protect aircraft LO coatings while also ensuring the safety of maintainers.
  - When aircraft were landing nearby, the Maintenance Interface Panel door vibrated alarmingly. The maintainers have this door open in order to plug in their portable computers to get information from the aircraft and control it while conducting servicing and maintenance. The Marines resorted to assigning a maintainer to hold the door, while another worked on the computer if flight operations were ongoing nearby.

This was an inefficient use of manpower, and the door hinge should be stiffened to withstand the flight deck environment.

- The Navy made several modifications to the USS *Wasp* in order to support F-35B operations. The deployment demonstration provided the following observations on some of these ship modifications:
  - Naval Sea Systems Command installed a Lithium-Ion battery charging and storage facility. The F-35 relies on 270 Volts-Direct-Current and 28 Volts-Fully-Charged Lithium-Ion batteries, and other assets that will deploy onboard L-class ships are also predicted to make greater use of Lithium-Ion batteries. However, Lithium-Ion batteries can catch fire under certain circumstances, especially during charging and, due to their chemical nature, cannot be extinguished but must burn themselves out. The storage facility consisted of racks of lockers that resembled ovens, each with its own exhaust system that could flue smoke and heat from a battery undergoing "thermal runaway." Battery charging would occur only in these lockers. Despite a flaw relating to the facility's air conditioning system being installed improperly, the general design appeared robust and functional.
  - F-35 pilots must conduct much of their mission planning inside a Special Access Program Facility, a vault-like room that is protected against electronic eavesdropping and is highly secure. The Navy installed a small Special Access Program Facility to house several classified ALIS components and provide an area for pilot briefings and debriefings. This facility was adequate for the demonstration, but was stretched to capacity to support a six F-35B detachment. The Navy and Marine Corps are investigating concepts for equipping L-class ships with JSF "heavy" ACEs consisting of 16 to 20 F-35B's. In these cases, a much larger facility would be required.
  - The Navy applied a high-temperature coating called Thermion to the flight deck spots where F-35B aircraft will land, in lieu of the traditional "non-skid" coating, to withstand the F-35B's exhaust, which is hotter than the AV-8B. One week into flight operations, personnel noted several chips of the first of two layers of Thermion were missing along a weld seam and started monitoring the site after each landing. No further degradation of the Thermion was noted for the rest of the detachment. Naval Sea Systems Command is analyzing the performance of the coating.

F-35C

- The second phase of ship suitability testing—DT-2—was conducted from October 2 – 10, 2015. Ship availability delayed the start of DT-2 from the planned date in August 2015. The principal goal of DT-2 was to perform launch and recovery of the F-35C with internal stores loaded.
  - The F-35C sea trials are a series of developmental tests conducted by the program with the principal goal of supporting development of the aircraft launch and recovery bulletins, and the general goal of characterizing ship suitability for operating and maintaining F-35C on a CVN-class ship. During DT-2, only developmental test aircraft CF-3 and CF-5, transient aircraft needed for logistical support, and search and rescue helicopters deployed to the carrier. No air wing was present. The major contractor was responsible for maintenance. ALIS was not installed on the carrier; it was accessed via satellite link to a location ashore.
  - Testers accomplished 100 percent of threshold and objective test points (280 total test points) over the course of 17 flights totaling 26.5 flight hours. The results of the test are still in analysis. In addition to the principal goal, the test points addressed:
    - Minimum end airspeed for limited afterburner and military power catapult launches. For catapult launches that use afterburner, engine power is initially limited to less than full afterburner power while the aircraft is static in the catapult, but then automatically goes to full afterburner power once released. This power limitation was in place to reduce thermal loads on the Jet Blast Deflectors (JBDs) behind the aircraft.
    - Crosswinds catapults
    - Recovery in high headwinds
    - Initial Joint Precision Approach and Landing System testing
    - Qualities of the Gen III HMDS at night
    - Running the Integrated Power Package (IPP) and engine in the hangar bay
    - Engine and power module logistics in the hangar bay
  - There were 7 bolters (failure to catch an arresting wire) in 66 arrestments during DT-2. During DT-1 (Developmental Test – One), there were no unplanned bolters in 122 arrestments. The higher rate was expected since the carrier arresting gear was not fully operational during DT-2. The third arresting wire (i.e., the wire typically targeted in carrier landings), was removed from service during the test because of a malfunction.
  - Testers ran the aircraft's IPP, a miniature gas turbine engine that can provide ground power, in the hangar bay. They then performed a low-thrust engine run as well. This process simulated maintenance checkout procedures that frequently occur in the hangar bay with legacy aircraft. During these evolutions, crew position the aircraft with its tail pointing out of one of the set of hangar bay doors to the aircraft elevators to direct heat and exhaust away from the inside of the ship. For the F-35C, the unique concern is that the IPP exhaust vents up towards the hangar bay ceiling. The test team monitored the IPP exhaust gas temperature to ensure it would not damage the ceiling of the hangar bay. During both the IPP run and the engine-turn, this temperature remained within safe limits. Testers also collected noise data; analysis is ongoing. The team did not collect data on the potential build-up of IPP exhaust gases within the hangar bay atmosphere, but plans to collect these data during DT-3.

- DT-3, the third and final set of sea trials, will expand the carrier operating envelope further, including external stores, and is scheduled to occur in August 2016.
- The Navy is working on the following air-ship integration issues, primarily for carriers. Some of the following issues also apply to F-35B operations on L-class ships:
  - Flight deck JBDs may require additional side panel cooling in order to withstand regular, cyclic limited afterburner launches from an F-35C. JBDs are retractable panels that re-direct hot engine exhaust up and away from the rest of the flight deck when an aircraft is at high thrust for take-off. Even with this additional cooling, however, JBDs may be restricted in how many consecutive F-35C limited afterburner launches they can withstand before they will require a cool down period, which could affect the launch of large "alpha strikes" that involve every aircraft in the air wing, a combat tactic the Navy has used frequently in past conflicts. F-35C limited-afterburner launches are required when the F-35C is loaded with external weaponry and in a heavy, high-drag configuration. The Navy estimates that an F-35C will have 3,000 catapult launches over a 35 year expected lifespan, but that no more than 10 percent of these launches will be limited-afterburner.
  - The Navy continues to investigate the replacement of a mobile Material Handling Equipment crane for several purposes onboard carriers, including, and perhaps most importantly, facilitating F-35 engine module maintenance. In order to transfer spare F-35 engine modules from their containers onto a transportation trailer, so they can later be installed in an aircraft, or to take broken modules from a trailer and put them into a shipping container to send back to an ashore repair site, a heavy lift capable crane is required. Onboard L-class ships, the Navy will use an overhead bridge crane built into the hangar bay ceiling, but CVNs do not have any similar ship's facility and the Navy intends to use a mobile crane. However, efforts to acquire a suitable crane have gone more slowly than originally expected. Given procurement timelines, the Navy must proceed without any further delays in order to have an appropriate crane onboard ship in time for the projected first deployment of an F-35C.
  - Work continues on developing triple hearing protection for flight deck crews, but with little update since the FY14 DOT&E Annual Report. Both the F-35C and F/A-18E/F produce around 149 decibels of noise where personnel are normally located when at maximum thrust during launch evolutions. The Navy has determined that 53 decibels of attenuation will be required from a triple hearing protection system to allow these personnel to be on deck for 38 minutes, or the equivalent of 60 launch and recovery cycles. Current designs only achieve in the mid-40s decibel range of attenuation, which allows less than 10 minutes of exposure before certain flight deck personnel reach their maximum daily limit of noise.
  - Two methods of shipboard aircraft firefighting for the F-35 with ordnance in the weapons bay are being developed, one for doors open and one for doors closed. Each will consist of an adapter that can fit to the nozzle of a standard hose. The open door adapter will also attach to a 24-foot aircraft tow bar so firefighters can slide it underneath the aircraft and spray cooling water up into the bay.
    - The Navy has produced four articles of the open bay firefighting device. This adapter performed well in preliminary tests conducted in 2014. Three of the production articles have been sent to Naval Air Station China Lake for further evaluation, and the fourth has been sent to a training command at Naval Air Station Norfolk to begin training flight deck personnel in its use and ship's company personnel how to maintain it.
    - Developmental work continues on the closed bay adapter. The Navy is currently pursuing two different designs that would cut through the aircraft skin to flood the weapons bay with water as well as lock into place to allow firefighting crews to back away from the fire after the hose is securely attached to the aircraft. One design will require two sailors to use, and the other design is more aggressive, but would potentially only require a single sailor.

Climatic Lab Testing

- The program conducted climatic testing on an F-35B test aircraft (BF-5) in the McKinley Climatic Laboratory from October 2014 to March 2015. All the planned environments were tested, but logistics tests (low observable repair and weapon loading, for example) were not completed due to delays that occurred in test execution.
- Testing of timelines to meet alert launch requirements showed start-up to employment capabilities (both air-to-air and air-to-ground) exceeded the ORD requirements (i.e., took longer than required), in some cases up to several minutes. Cold alert launches performed better than predicted (and in some cases met requirements), while hot launch times were worse than predicted. The program has no plan to address these requirements during SDD.
- The program did not fully test some necessary functions, such as landing gear operations. Additionally, some major production support equipment was not available for testing. Portable enclosures for low-observable restoration did not meet expectations. The program has an additional test period planned for February 2016 using an operational aircraft.

Cybersecurity Operational Testing

- In accordance with DOT&E and DOD policy, the JOTT developed and presented a cybersecurity operational test strategy to DOT&E for approval in February 2015. This strategy established a schedule and expectations for cybersecurity testing of the JSF air system through the end of SDD and IOT&E in late 2017. The strategy includes multiple assessments aligned with the blocks of capability as

the program delivers them to the field in both the air vehicle and ALIS. The test teams will conduct the assessments on fielded, operational equipment. All testing requires coordination from the JSF Program Executive Officer, via an Interim Authority to Test (IATT). This testing is OT&E; DOT&E approves the plans and independently reports results. The test strategy approved by DOT&E includes end-to-end testing of all ALIS components and the F-35 air vehicle.

- The Navy conducted a Cooperative Vulnerability and Penetration Assessment (CVPA) of the ALIS Squadron Kit 2.0.0.2 aboard the USS *Wasp* from May 26 through June 15, 2015. Findings were mostly administrative in nature and the test team recommended changes to the procedures for updating antivirus signatures, system restoral, and issuing user IDs and passwords prior to systems becoming operational at deployed or ship-based locations.
- Starting in early CY15, the JOTT began planning CVPAs and Adversarial Assessments (AA) of all ALIS components in the latest configuration to be fielded—ALIS 2.0.1.1—as well as the F-35 air vehicle in the Block 2B configuration. Consistent with the strategy, the JOTT planned a CVPA for September 21 through October 2, 2015, and an AA for November 9 – 20, 2015. Only the ALIS components were to be tested in these events, with an air vehicle to be included in a future test event. However, the test teams were not able to complete the CVPA as planned due to the failure of the Program Office to provide an IATT. According to the Program Office, an IATT was not granted due to insufficient understanding of risks posed to the operational ALIS systems by cybersecurity testing. As a result, the Program Office directed a more thorough risk assessment and restoration rehearsals on the ALIS systems undergoing testing to improve confidence in the identified risk mitigations.
- To recover progress on the test strategy, the JOTT coordinated with cybersecurity test teams for the November 2015 AA to be combined with a CVPA. However, the program approved only a partial IATT, which allowed a CVPA of the ALIS components at Edwards AFB and a CVPA of the Operational Central Point of Entry (CPE)—a major network hub in the overall ALIS architecture—to proceed. Although authorized, the AA for the CPE was not accomplished as the IATT was not provided in time for the AA team to make arrangements for the test. Although significantly limited in scope relative to original plans, the testing nonetheless revealed significant cybersecurity deficiencies that must be corrected.
- An end-to-end enterprise event, which links each component system, including the air vehicle, is required for cybersecurity operational testing to be adequate. The test teams are developing the needed expertise to conduct a technical vulnerability and penetration test of the air vehicle avionics and mission systems. Laboratory simulators at the U.S. Reprogramming Lab (USRL) and Lockheed Martin might be suitable environments for risk reduction and training, but will not take the place of testing on the vehicle. The Air Force Research Laboratory recently published an F-35 Blue Book of potential operational vulnerabilities that should help scope future air vehicle operational testing. The Program Office should accelerate the actions needed to enable cybersecurity operational testing of the fielded Block 2B and Block 3i systems that includes both ALIS and the air vehicle.
- The program plans to develop an ALIS test laboratory, referred to as the Operationally Representative Environment, to support developmental testing and risk reduction in preparation for future operational testing. This venue should be made available for cybersecurity testing as well, but will likely not be an adequate venue for cybersecurity testing for IOT&E.

Pilot Escape System

- In 2011, the program and Services elected to begin training and flight operations at fielded units with an immature pilot escape system by accepting risks of injury to pilots during ejection. These risks included pilots flying training missions with ejection seats that had not completed full qualification testing and flying overwater without the planned water-activated parachute release system (a system which automatically releases the parachute from the pilot's harness upon entry into water). Certain risks are greater for lighter weight pilots. Recent testing of the escape system in CY15 showed that the risk of serious injury or death are greater for lighter weight pilots and led to the decision by the Services to restrict pilots weighing less than 136 pounds from flying the F-35.
- Two pilot escape system sled tests occurred in July and August 2015 that resulted in failures of the system to successfully eject a manikin without exceeding neck loads/stresses on the manikin. These sled tests were needed in order to qualify the new Gen III HMDS for flight release.
  - A sled test in July on a 103-pound manikin with a Gen III helmet at 160 knots speed failed for neck injury criteria. The program did not consider this failure to be solely caused by the heavier Gen III helmet, primarily due to similarly poor test results having been observed with Gen II helmet on a 103-pound manikin in tests in 2010.
  - The sled test was repeated in August 2015 using a 136-pound manikin with the Gen III helmet at 160 knots. This test also failed for neck injury criteria. Similar sled testing with Gen II helmets in 2010 did not result in exceedance of neck loads for a 136-pound pilot.
- After the latter failure, the program and Services decided to restrict pilots weighing less than 136 pounds from flying any F-35 variant, regardless of helmet type (Gen II or Gen III). Pilots weighing between 136 and 165 pounds are considered at less risk than lighter weight pilots, but at an increased risk (compared to heavier pilots). The level of risk was

labeled "serious" risk by the Program Office based on the probability of death being 23 percent and the probability of neck extension (which will result in some level of injury) being 100 percent. Currently, the program and the Services have decided to accept the risk to pilots in this weight range, although the basis for the decision to accept these risks is unknown.

- The testing showed that the ejection seat rotates backwards after ejection. This results in the pilot's neck becoming extended, as the head moves behind the shoulders in a "chin up" position. When the parachute inflates and begins to extract the pilot from the seat (with great force), a "whiplash" action occurs. The rotation of the seat and resulting extension of the neck are greater for lighter weight pilots.
- The Gen III helmet weighs 5.1 pounds, approximately 6 ounces more than the Gen II helmet. The increased weight is primarily due to the larger/heavier night vision camera optics. The program has a weight reduction project ongoing to determine if approximately 5 ounces can be eliminated in the Gen III helmet by reducing structure and materials without affecting fit or optics.
- In coordination with the Program Office, the ejection seat contractor funded a proof-of-concept ejection sled test in October to assess the utility of a head support panel (HSP), a fabric mesh behind the pilots head and between the parachute risers, to prevent exceeding neck loads during the ejection sequence for lighter weight pilots. Based on the initial results, the Program Office and Services are considering seat modifications that would include the HSP, but they may take up to a year to verify improvement and install them onto aircraft.
- Additional testing and analysis are also needed to determine the risk of pilots being harmed by the transparency removal system (which shatters the canopy before, and in order for, the seat and pilot to leave the aircraft) during ejections in other than ideal, stable conditions (such as after battle damage or during out-of-control situations).
- The program began delivering F-35 aircraft with a water-activated parachute release system in later deliveries of Lot 6 aircraft in 2015. This system, common in current fighter aircraft, automatically jettisons the parachute when the pilot enters water after ejection and is particularly beneficial if the pilot is incapacitated at this point.

Progress in Modification of LRIP Aircraft

- Modification of early production aircraft is a major endeavor for the program, driven by the large degree of concurrency between development and production. Modifications are dependent on the production, procurement, and installation of modification kits, completed either at the aircraft depot locations or at the field units. If early production aircraft are to be used for IOT&E, as has been planned, the program will need to modify them in order to provide production representative Block 3F operational test aircraft for an adequate IOT&E. Current projections by the Program Office show that, even with accelerated contracting, the operational test fleet will not complete modifications until April 2019. This is 20 months past August 2017, the date currently planned by the Program Office for the start of IOT&E.
- The program maintains a complex modification and retrofit database that tracks modifications required by each aircraft, production break-in of modifications, limitations to the aircraft in performance envelope and service life, requirements for additional inspections until modifications are completed, and operational test requirements and concerns.
  - Major modifications take place at aircraft depots while depot field teams will travel to field unit to complete other modifications. Additional modifications will occur while aircraft undergo unit-level maintenance.
  - Some aircraft, primarily those assigned to operational test, will undergo modification first to a Block 2B and then to a Block 3F configuration, and will require two inductions to an aircraft depot for several months each.
- Upgrading F-35 aircraft to a Block 2B configuration includes modifications based on capability and life limits on hardware. Major modification categories include:
  - Structural life-limited parts, or Group 1 modifications
  - F-35B Mode 4 operations, including a modification to the Three Bearing Swivel Module (3BSM) so F-35B aircraft can conduct unrestricted Mode 4 operations
  - On-Board Inert Gas Generation System (OBIGGS), which provides the upgraded hardware for generating adequate nitrogen-enriched air to support lightning protection requirements and reduce vulnerability to fuel tank explosions from a live fire event; however, the aircraft will need additional modifications to the fuel system for full lightning and vulnerability protection
  - Upgrades to ALIS and training systems
- During the first half of 2015, Marine Corps IOC aircraft received top priority for Block 2B modifications. During the second half of 2015, the program prioritized modification of operational test aircraft.
  - To successfully modify Marine Corps aircraft in time for IOC, and because aircraft modifications frequently took longer than projected, the program, for the first time, sent Marine Corps aircraft to the Air Force depot at Hill AFB.
  - Because of the re-scoping of the Block 2B operational testing, the program delayed modifications to a number of aircraft assigned to operational test squadrons. As of December 2015, 8 of 14 aircraft assigned to operational test squadrons were in the full Block 2B configuration, which includes the OBIGGS modification, with 1 more undergoing depot modifications. One F-35B is not scheduled to complete this modification until June 2017. Twelve of the 14 aircraft have been at least partially modified to the Block 2B configuration, allowing them to fly with the Block 2B software.

- Modifying aircraft to a Block 3F configuration includes completing Block 2B modifications, Technical Refresh 2 (TR-2) upgrades, and Block 3F changes. The table below shows known requirements by production lot of aircraft and the number of those that are authorized and scheduled as of July 2015. Later lots of aircraft require fewer modifications because of changes incorporated into the production line.

KNOWN BLOCK 3 IOT&E MODIFICATION REQUIREMENTS IN LOTS 3 THROUGH 9[1]							
Variant	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
F-35A	124 (69)	100 (44)	83 (32)	38 (15)	15 (2)	10 (1)	2 (1)
F-35B	130 (77)	106 (56)	82 (38)	38 (19)	10 (2)	3 (0)	1 (0)
F-35C	-	96 (43)	80 (30)	38 (15)	14 (2)	8 (1)	2 (0)

1. Numbers in parentheses denote authorized and scheduled modifications.

- Current Program Office plans for modifications show that none of the operational test aircraft will have all Block 3F modifications completed by the Program Office's projected start of IOT&E in August 2017.
  - The program awarded an undefinitized contract action (UCA) for new TR-2 processors in September 2015 to support Block 3F retrofit modifications of the Block 2B operational test aircraft. However, the TR-2 hardware packages have a 26-month lead-time which, along with other required changes that do not yet have approved engineering or hardware solutions, will delay the complete modification of any operational test aircraft until after IOT&E is scheduled to start.
  - The program is analyzing options to reduce this timeline, including seeking authorization outside of normal acquisition practices to purchase hardware early, taking components from the production line before installation occurs for use on operational test aircraft, and installing instrumentation on later LRIP aircraft that will have already received this hardware during production.
  - The majority of aircraft assigned to operational test squadrons are LRIP 3 and 4 aircraft, which require extensive modifications to reach a Block 3F configuration.
- The program has had difficulty maintaining the planned induction schedule at the two F-35 depots located at MCAS Cherry Point, North Carolina, and Hill AFB, Utah, after structural modifications took 20 days longer than planned on early inductees, and Lockheed Martin delivered modification kits late. Transportation issues also resulted in retrograde assets not shipping in a timely manner for repairs and upgrades.
  - At MCAS Cherry Point, early F-35B aircraft inducted took 45 days longer than projected to complete modifications and, as of July 2015, the depot had used nearly 300 more cumulative maintenance days than projected to modify aircraft. To meet Marine Corps IOC requirements, the program sent two aircraft, BF-31 and BF-32, to Hill AFB to complete structural modifications. Prior to this, the program had not scheduled F-35A or F-35B aircraft to complete modifications at the other Service's depot. As of June 2015, the MCAS Cherry Point depot completed modifications on 16 aircraft, 5 of which the program needed for Marine Corps IOC.
  - The Hill AFB depot has stayed closer to projections on completing modifications. Although early inductees exceeded the planned timeline, later aircraft, including the two F-35B aircraft, have completed modifications in less time than projected. Fourteen aircraft have completed modifications at this depot, including two F-35B aircraft needed for Marine Corps IOC. Hill AFB, which began the year with three operational docks, expanded their depot capacity to eight docks in 2015 by accelerating the opening of four of these docks to reduce the risk of maintaining the modification schedule.
  - The program further reduced risk to the modification schedule by employing additional field teams to complete modifications previously planned to occur during aircraft inductions.
  - By July 2015, both depots showed improved tracking with the depot flow plan.

Recommendations

- Status of Previous Recommendations. The program addressed two of the previous recommendations. As discussed in the appropriate sections of this report, the program did not, and still should:
  1. Update program schedules to reflect the start of spin-up training for IOT&E to occur no earlier than the operational test readiness review planned for November 2017, and the associated start of IOT&E six months later, in May 2018.
  2. Complete lab testing of the mission data loads, as is planned in the mission data optimization operational test plan, prior to accomplishing the necessary flight testing to ensure the loads released to the fleet are optimized for performance. If mission data loads are released to operational units prior to the completion of the lab and flight testing required in the operational test plan, the risk to operational units must be clearly documented. Status: Lab testing in Block 2B is still in work; 2B build fielded to operational F-35B units, risk not documented.
  3. Complete the remaining three Block 2B weapon delivery accuracy (WDA) flight test events in a way that ensures full mission systems functionality is enabled in an operationally realistic manner.
  4. Provide adequate resourcing to support the extensive validation and verification requirements for the Block 3 VSim in time for IOT&E, including the data needed from flight test or other test venues.
  5. Extend the full-up system-level (FUSL) decontamination test to demonstrate the decontamination system effectiveness in a range of operationally realistic

environments. Status: The Program Office has elected not to address this recommendation: the FUSL test will be conducted only under ambient conditions at Edwards AFB during 4QFY16 through 1QFY17 preventing the assessment of this system in other, potentially more stressing ambient conditions.

6. Ensure adequate testing of ALIS software upgrades on operationally-representative hardware is complete prior to fielding to operational units.

- FY15 Recommendations. The program should:
  1. Acknowledge schedule pressures that make the start of IOT&E in August 2017 unrealistic and adjust the program schedule to reflect the start of IOT&E no earlier than August 2018.
  2. The Department should carefully consider whether committing to a "block buy," composed of three lots of aircraft, is prudent given the state of maturity of the program, as well as whether the block buy is consistent with a "fly before you buy" approach to defense acquisition and the requirements of Title 10 United States Code.
  3. Plan and program for additional Block 3F software builds and follow-on testing to address deficiencies currently documented from Blocks 2B and 3i, deficiencies discovered during Block 3F developmental testing and during IOT&E, prior to the first Block 4 software release planned for 2020.
  4. Significantly reduce post-mission Ground Data Security Assembly Receptacle (GDR) processing times, in particular, decryption processing time.
  5. Ensure the testing of Block 3F weapons prior to the start of IOT&E leads to a full characterization of fire-control performance using the fully integrated mission systems capability to engage and kill targets.
  6. Complete the planned climatic lab testing.
  7. Provide the funding and accelerate contract actions to procure and install the full set of upgrades recommended by DOT&E in 2012, correct stimulation problems, and fix all of the tools so the U.S. Reprogramming Lab (USRL) can operate efficiently before Block 3F mission data load development begins.
  8. Complete the planned testing detailed in the DOT&E-approved USRL mission data optimization operational test plan and amendment.
  9. Along with the Navy and Marine Corps, conduct an actual operational test of the F-35B onboard an L-class ship before conducting a combat deployment with the F-35B. This test should have the full Air Combat Element (ACE) onboard, include ordnance employment and the full use of mission systems, and should be equipped with the production-representative support equipment.
  10. Develop a solution to address the modification and retrofit schedule delays for production-representative operational test aircraft for IOT&E. These aircraft must be similar to, if not from the Lot 9 production line.
  11. Provide developmental flight test tracking products that clearly show progress on what has been accomplished and test activity remaining.
  12. Develop an end-to-end ALIS test venue that is production representative of all ALIS components.
  13. Ensure the necessary authorizations are provided in time to permit operational cybersecurity testing of the entire F-35 air system, including the air vehicle, as planned by the operational test community.
  14. Provide dedicated time on representative air vehicles to complete Joint Technical Data (JTD) verification.

Global Command and Control System – Joint (GCCS-J)

Executive Summary

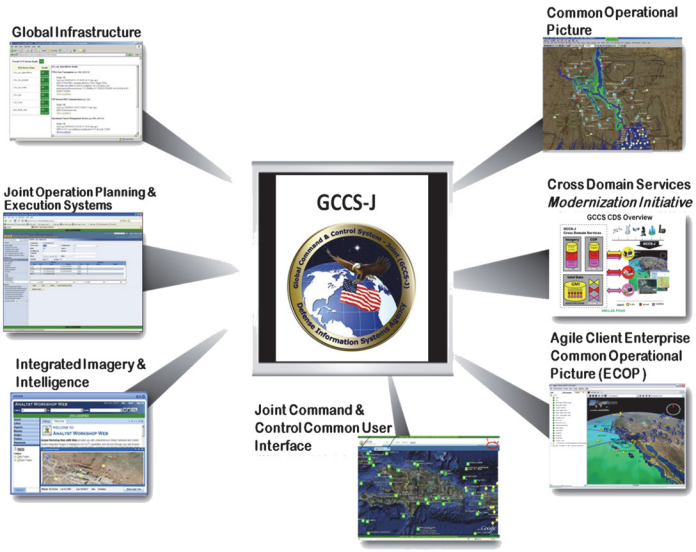
- In FY15, Defense Information Systems Agency (DISA) development of Global Command and Control System – Joint (GCCS-J) focused on fixing cybersecurity vulnerabilities, implementing high-priority capability enhancements, and software defect corrections to both the GCCS-J Global (referred to as Global) and Joint Operation Planning and Execution System (JOPES).

Global

- JITC conducted a Global v5.0 pilot test in January 2015 in preparation for entering operational testing. Global v5.0 failed to satisfy operational test entrance criteria, and DISA, with concurrence of the operational community, subsequently cancelled Global v5.0 in order to reduce risk to Global v4.3 Update 1 sustainment and Global v6.0 development.
- DISA developed Global v4.3 Update 1 Emergency Release 1 to resolve an operational deficiency discovered in the fielded Global v4.3 Update 1 software. This release also included some of the improvements originally planned for the cancelled Global v5.0. The Joint Interoperability Test Command (JITC) and DISA tested Global v4.3 Update 1 Emergency Release 1 in April 2015.
  - GCCS-J Global v4.3 Update 1, with Emergency Release 1, remains effective for use in higher echelons. Testing of Global v4.3 Update 1 for use in lower echelons will occur in FY16 as part of Air Operations Center – Weapons System operational testing.
  - GCCS-J v4.3 is operationally suitable. System installation, help desk, training, and availability are all acceptable.
  - GCCS-J v4.3 Update 1 is not survivable. DISA has not fixed all vulnerabilities identified by the National Security Agency (NSA) cybersecurity testing, and additional vulnerabilities have been identified by cybersecurity testing as part of major Combatant Command exercises.

JOPES

- DISA developed JOPES v4.2.0.3 Emergency Release 4 to implement Global Force Management capabilities and to implement Operational Plan Relevancy codes. JITC conducted an operational test of JOPES v4.2.0.3 Emergency Release 4 in June 2015.
  - JOPES v4.2.0.3 Emergency Release 4 is operationally effective and suitable. Users successfully employed new Global Force Management capabilities and completed all mission tasks.
  - The cyber survivability of JOPES v4.2.0.3 Emergency Release 4 has not yet been tested.



System

- GCCS-J consists of hardware, software (both commercial off-the-shelf and government off-the-shelf), procedures, standards, and interfaces that provide an integrated near real-time picture of the battlespace that is necessary to conduct joint and multi-national operations.
- GCCS-J consists of a client/server architecture using open-systems standards, government-developed military planning software, and, increasingly, use of World Wide Web technology.
- GCCS-J consists of two components, GCCS-J Global and JOPES.

Global (Force Protection, Situational Awareness, and Intelligence applications)

- Global v4.3 Update 1, Emergency Release 1 is the currently fielded version. DISA developed Global v4.3 Update 1 to implement high-priority intelligence mission updates to the Theater Ballistic Missile correlation systems, Joint Targeting Toolbox, and Modernized Integrated Database. The update also resolved 49 defects affecting other parts of the system and implemented security lockdown scripts and Information Assurance Vulnerability Alert updates. Emergency Release 1 resolved an operational deficiency discovered in the fielded Global v4.3 Update 1 software.
- Global v5.0. DISA developed Global v5.0 to introduce updates and new features to the Cross-Functional/ Infrastructure, Situational Awareness, and Integrated Imagery and Intelligence mission areas. DISA also fixed 33 problems, all of which had approved operational workarounds. Poor test results in 2015 induced DISA to

cancel Global v5.0 and instead focus on development of Global v6.0.
- Global v6.0. This version will contain features from v5.0 and implement an Agile Client as the primary GCCS-J user interface to allow removal of the global client from the system baseline. DISA is also modernizing Global interfaces to provide greater flexibility for information sharing with external systems.

JOPES (Force Employment, Projection, Planning, and Deployment/Redeployment applications)
- JOPES v4.2.0.3 Emergency Release 4 is the currently fielded version. DISA developed JOPES v4.2.0.3 Emergency Release 4 to implement Global Force Management capabilities and to implement Operational Plan Relevancy codes. Force Tracking Number and Deployment Order information were added to the system, as well as an ability to identify and query operationally relevant plans. DISA also corrected seven critical deficiencies.

Mission
- Joint Commanders utilize the GCCS-J to accomplish command and control.

Global
- Commanders use Global to:
  - Link the National Command Authority to the Joint Task Force, Component Commanders, and Service unique systems at lower levels of command
  - Process, correlate, and display geographic track information integrated with available intelligence and environmental information to provide the user a fused battlespace picture
  - Provide Integrated Imagery and Intelligence capabilities (e.g. battlespace views and other relevant intelligence) into the common operational picture and allow commanders to manage and produce target data using the Joint Tactical Terminal
  - Provide a missile warning and tracking capability
- Air Operations Centers use Global to:
  - Build the air picture portion of the common operational picture and maintain its accuracy
  - Correlate or merge raw track data from multiple sources
  - Associate raw Electronics Intelligence data with track data
  - Perform targeting operations

JOPES
- Commanders use JOPES to:
  - Translate policy decisions into operations plans that meet U.S. requirements to employ military forces
  - Support force deployment, redeployment, retrograde, and re-posturing
  - Conduct contingency and crisis action planning

Major Contractors
- Government Integrator: Defense Information Systems Agency (DISA)
- Software Developers:
  - Northrop Grumman – Arlington, Virginia
  - Leidos – Arlington, Virginia
  - Pragmatics – Arlington, Virginia

Activity
Global
- In September 2014, DISA approved Global v4.3 Update 1 fielding, based on results from developmental and operational testing conducted in 2014. DISA fixed eight of nine cybersecurity vulnerabilities identified as part of NSA cybersecurity testing shortly after fielding.
- JITC conducted the Global v5.0 pilot test at U.S. Special Operations Command, MacDill AFB, Florida, from January 7 – 9, 2015, to assess the systems readiness to enter operational test. Global v5.0 failed to satisfy operational test entrance criteria, and DISA, with concurrence of the operational community, subsequently cancelled Global v5.0 in order to reduce risk to Global v4.3 Update 1 sustainment and Global v6.0 development.
- DISA developed Global v4.3 Update 1 Emergency Release 1 to resolve an operational deficiency discovered in the fielded Global v4.3 Update 1 software. This release also included some of the improvements originally planned for Global v5.0. In April 2015, JITC and DISA conducted a level 1 operational test of Global v4.3 Update 1 Emergency Release 1 in accordance with a DOT&E-approved policy that did not require a DOT&E-approved test plan.
- On January 7, 2015, the Joint Staff released a memorandum directing a comprehensive review of Global critical and non-critical interface requirements. The Joint Staff directed the review to confirm that Service member data exchange requirements in support of operational missions were being met. This review helped update the correct critical interfaces, and the results of these updates will drive the content, development, and testing of Global v6.0.

JOPES
- In June 2015, JITC conducted a level 1 operational test of JOPES v4.2.0.3 Emergency Release 4 in accordance with a DOT&E-approved policy that did not require a DOT&E-approved test plan. This testing included interface testing with Defense Readiness Reporting System – Strategic.

Assessment
Global
- GCCS-J v4.3 Update 1, with Emergency Release 1, is effective for use in higher echelons.

  - Further operational testing is required to determine the effectiveness for use in lower echelons, such as Air Operations Centers. The interface requirement updates directed by the Joint Staff will assist the Air Operations Center test community in assessing effectiveness at lower echelons.
  - Developmental testing of Global v4.3 Update 1 is planned for the Air Operations Center community in October 2015, with operational testing planned for January 2016.
- GCCS-J Global v4.3 Update 1 is not survivable.
  - DISA has fixed eight of nine significant vulnerabilities identified by NSA cybersecurity testing; however, one significant vulnerability remains. Additional GCCS-J vulnerabilities have been identified by DOT&E-sponsored cybersecurity testing during major Combatant Command exercises.
- GCCS-J v4.3 Update 1 is operationally suitable. System installation, help desk, training, and availability are all acceptable.

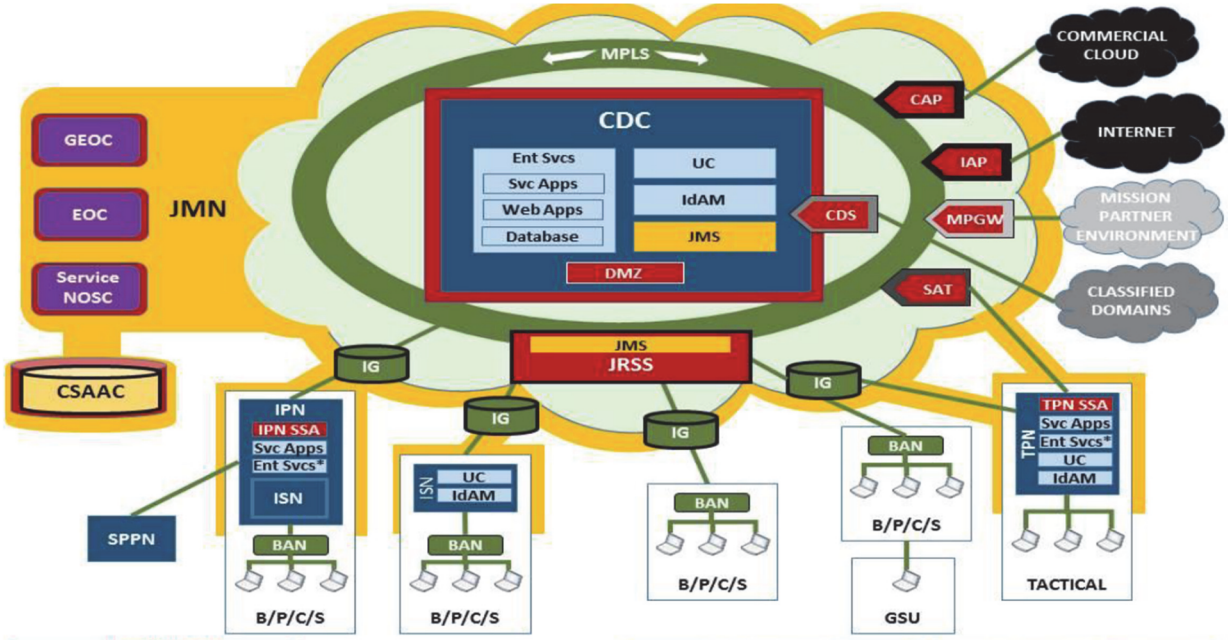
JOPES

- JOPES v4.2.0.3 Emergency Release 4 is operationally effective.
  - Users successfully employed new Global Force Management capabilities and completed all mission tasks.
  - All Combatant Commands experienced data exchange failures linked to either initial subscription or interface maintenance. The Joint Staff, in coordination with the Combatant Commands, updated existing standard operating procedures and identified roles and responsibilities to manage the processes.
  - The JOPES program manager resolved all high-priority problem reports, and JITC did not discover any new problems during operational testing.
  - JOPES demonstrated effective end-to-end data exchanges with the new Joint Capabilities Requirements Manager, as well as with Global Combat Support System – Joint and the Deliberate and Crisis Action Planning and Execution Segments.
- JOPES v4.2.0.3 Emergency Release 4 is operationally suitable.
  - System administrators successfully installed and configured the system. The Combatant Commands validated the updated standard operating procedures to support the new Joint Capabilities Requirements Manager to JOPES interface.
  - The system was available throughout the test period, and users did not notice any degradation of performance or usability.
- The cybersecurity of JOPES v4.2.0.3 Emergency Release 4 has not been tested.

Recommendations

- Status of Previous Recommendations. DISA has addressed one of the two previous FY14 recommendations. However, DISA still needs to conduct cybersecurity testing of GCCS Global v4.3 Update 1 in an operational environment to assess protect, detect, react, and recover capabilities.
- FY15 Recommendations. DISA should:
  1. Correct any remaining major cybersecurity vulnerabilities identified either by the NSA assessment of the GCCS-J v4.3 baseline, or during subsequent Combatant Command exercises.
  2. Conduct cybersecurity testing of both GCCS Global v4.3 Update 1 Emergency Release 1 and the JOPES v4.2.0.3 Emergency Release 4 baselines in operational environments, fix any cybersecurity vulnerabilities identified, and conduct appropriate regression testing.

Joint Information Environment (JIE)



B/P/C/S - Base, Post, Camp, and Station
BAN - Base Area Network
CAP - Cloud Access Point
CDC - Core Data Center
CDS - Cross Domain Solution
CSAAC - Cyber Situational Awareness Analytic Cloud
Data Svcs - Data Services
DMZ - Demilitarized Zone
Ent Svcs - DOD Enterprise Services (*Extended)
EOC - Enterprise Operations Center
GEOC - Global Enterprise Operations Center
GSU - Geographic Separated Unit
IAP - Internet Access Point
IdAM - Identitiy and Access Managment
IG - Installation Gateway
IPN - Installation Processing Nodes
ISN - Installation Service Node
JMN - JIE Management Network
JMS - JIE Management System
JRSS - Joint Regional Security Stacks
MPGW - Mission Partner Gateway
MPLS - Multiprotocol Label Switching
NOSC - Network Operations & Security Center
SAT - Satellite Communications Gateway
SPPN - Special Purpose Processing Node
SSA - Single Security Architecture
Svc Apps - DOD Component Applications
TPN - Tactical Processing Node
UC - Unified Capabilities
Web Apps - Web Applications

Executive Summary

- The Joint Information Environment (JIE) is not a program of record, and to date, the Defense Information Systems Agency (DISA), Joint Interoperability Test Command (JITC), and Services have not conducted any operational testing of the JIE infrastructure or components.
- The JIE effort lacks an overarching systems integration process or program executive organization to manage cost, drive schedule, and monitor performance factors. The European JIE early operational assessment, originally scheduled for March/April 2014, continues to slip due to Joint Regional Security Stack (JRSS) integration complexity, lack of overall schedule discipline, and Service-influenced funding priorities; the DOD Chief Information Officer (CIO) has shifted its near-term focus for JRSS to the Southern Continental United States (CONUS).
- U.S. Cyber Command established the Joint Force Headquarters DOD Information Networks (JDOC) and the JIE Executive Committee (EXCOM) designated the DISA Operation Centers in Europe and the Pacific as Enterprise Operations Centers (EOCs) to support JIE network management, data centers, Internet gateways, JRSS, and cybersecurity. The Joint Operations Steering Group (JOSG) developed EOC continuity of operations plans to better manage networks, and coordinate and communicate with Service operations centers. DISA established EOCs in the European and Pacific theaters that will conduct mission support and information technology operations.
- DOT&E is working with DISA and JITC to plan for an early operational assessment of JIE in late FY16.
- U.S. Cyber Command continues to refine the selection criteria for the CONUS EOCs as well as the JDOC/EOC global and regional situational awareness requirements. In October 2015, the JIE EXCOM endorsed U.S. Cyber Command's proposal that DISA CONUS be the interim EOC to support the implementation of JRSS.

Capability and Attributes

- The DOD CIO has prioritized areas of modernization for the DOD components to implement as the foundational steps to realize the JIE. The DOD CIO's areas of modernization include the following:

  - Network Modernization of optical carrier upgrades and Multi-Protocol Label Switching (MPLS) routers
  - The JRSS, the Joint Management System for the JRSS and Cyber Situational Awareness Capabilities
  - Computing Environment, which includes Commercial Cloud, Cloud Access Points, and milCloud
  - The Mission Partner Environment for coalition/partner information sharing and the Mission Partner Gateways
  - Mobility for the unclassified and classified capabilities
- The JIE is envisioned as a shared information technology construct for DOD to reduce costs, improve and standardize physical infrastructure, increase the use of enterprise services, improve information technology effectiveness, and centralize the management of network security. The Joint Staff specifies the following enabling characteristics for the JIE capability:
  - Transition to centralized data storage
  - Rapid delivery of integrated enterprise services (such as email and collaboration)
  - Real-time cybersecurity awareness
  - Scalability and flexibility to provide new services
  - Use of common standards and operational techniques
  - Transition to a single security architecture
- The DOD plans to achieve these goals via the following interrelated initiatives:
  - Consolidation of applications and data into the cloud or centralized data centers at the regional or global level, which are not segregated by military Service.
  - Establishment of enterprise operation centers to centralize network management and defense.
  - Upgrade of the physical infrastructure to include MPLS, which enables higher bandwidth/throughput, better security, and faster routing capabilities.
  - Implementation of JRSS hardware and other security constructs as part of a single security architecture. These will establish a federated network structure with standardized identity and access management, as well as centralized defensive cyber operations.
- JIE is not a program of record, but is being governed by the DOD CIO, with DISA as the principal integrator for services and testing. An EXCOM, chaired by the DOD CIO, U.S. Cyber Command, and the Joint Staff J6, provides JIE direction, goals and objectives, oversight, and accountability.
- The initial implementation of the JIE is underway in the United States and in the European theater with the establishment of the first JRSS capabilities, JDOC and EOCs, and the European data centers. Installations are ongoing in Europe with tentative implementation and cutover dates in June/July 2016. Additional preparation efforts are ongoing in the Pacific, Southwest Asia, and CONUS.

Activity

- The JIE EXCOM rescheduled an early operational assessment of the European theater capabilities originally planned for March 2014 to 4QFY16 or later to accommodate the engineering, installation, and implementation of the initial JRSS and MPLS capabilities. The DOD CIO has shifted its near-term focus for JRSS to the Southern CONUS.
- JITC developed an evaluation framework that maps testable JIE metrics back to the requirements and high level objectives.
- U.S. Cyber Command established the JDOC and the JIE EXCOM designated the DISA Operation Centers in Europe and the Pacific as EOCs to support JIE network management, data centers, Internet gateways, JRSS, and cybersecurity.
- The JOSG developed EOC continuity of operations plans to better manage networks, and coordinate and communicate with Service operations centers.
- DISA established EOCs in the European and Pacific theaters that will conduct mission support and information technology operations.
- In May and July 2015, the Army, Air Force, DISA, and JITC conducted JRSS lab-based tests at Fort Meade, Maryland, and Joint Base San Antonio, Texas.
- Developmental and laboratory testing continues at initial JRSS sites at Fort Hood and Joint Base San Antonio, Texas, and the DISA Enterprise Services Lab at Fort Meade, Maryland. Current testing focuses on system functionality; however, a Cyber Protection Team (CPT) conducted a hunt mission to find outstanding vulnerabilities in the operational management network and the Joint Base San Antonio JRSS from March to May 2015.
- In October 2015, the JIE EXCOM approved the JIE high-level objectives and initial performance metrics.
- U.S. Cyber Command continues to refine the selection criteria for the CONUS EOCs as well as the JDOC/EOC global and regional situational awareness requirements. In October 2015, the JIE EXCOM endorsed U.S. Cyber Command's proposal that DISA CONUS be the interim EOC to support the implementation of JRSS.
- DOT&E, USD(AT&L), DOD CIO, the Services, DISA, and JITC repurposed the JIE T&E working-level Integrated Product Team into an overarching working group to better synchronize the test preparations and ongoing activities.
- A CPT and the Army's Advanced Research Lab conducted a comprehensive vulnerability and penetration assessment against the JRSS in the Fort Meade labs in 4QFY15.
- JITC conducted the JRSS version 1.0 Initial Operational Assessment with a Red Team to assess Army and Air Force operations in December 2015.

Assessment

- The JIE is not a program of record, and to date, DISA, JITC, and Services have not conducted any operational testing of the JIE infrastructure or components.
- The DOD CIO is the lead for JIE governance; however, the JIE effort lacks an overarching systems integration process or program executive organization to manage cost, drive schedule, and monitor performance factors. The European JIE early operational assessment continues to slip due to JRSS integration complexity, lack of overall schedule discipline, and Service-influenced funding priorities. While the near-term focus for JRSS has shifted to the Southern CONUS, advanced planning for future capability deployment and operational tests has not fully matured.
- No operational test data are available at this point.
- Current testing focuses on system functionality; DISA has yet to schedule full cybersecurity testing or operational testing of the JRSS.
- DOT&E is working with DISA and JITC to plan for an early operational assessment of JIE in late FY16.
- DISA and JITC scheduled a lab-based Computer Network Defense Exercise for mid-October 2015 but it was delayed due to other assessment activities. The National Security Agency plans to conduct a cybersecurity deep-dive assessment in FY16.

Recommendations

- Status of Previous Recommendations. The DOD CIO and Director of DISA continue to address the previous FY14 recommendations to develop adequate test schedules and plans for anticipated future test events in FY16.
- FY15 Recommendations. The DOD CIO, JIE EXCOM, and DISA should:
  1. Establish an overarching JIE program executive to integrate the system efforts and oversee cost, schedule, and performance.
  2. Consider managing the key JIE capabilities/components with program managers.
  3. Continue to develop an overarching test strategy that encompasses not only the upcoming testing of JIE, but also defines the key issues and concepts to be tested in subsequent tests and assessments. Such a plan should address the following areas of interest:
     - Overarching T&E framework and critical test issues
     - The role of both lab and fielded equipment tests in resolving those critical issues
     - Estimated schedules for test events and key issues to be tested
     - Evaluation criteria and any relevant implementation decision points
     - Resources required
     - The role of the Services and Service-sponsored Operational Test Agencies

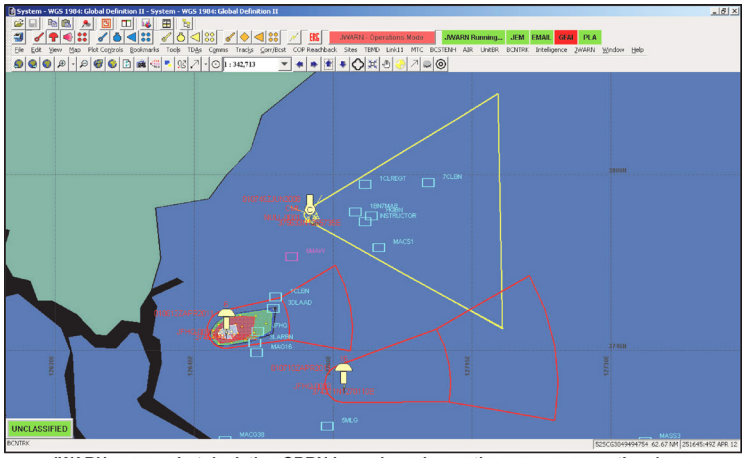
Joint Warning and Reporting Network (JWARN)

Executive Summary

- The Navy's Commander, Operational Test and Evaluation Force (COTF) conducted FOT&E of the Joint Warning and Reporting Network (JWARN) Increment 1 hosted on the Global Command and Control System (GCCS) – Maritime (GCCS-M) Force Level from April to June 2015 onboard the USS *Ronald Reagan* (CVN 76), USS *John C. Stennis* (CVN 74), and JWARN hosted on GCCS – Joint at the Navy Third Fleet Maritime Operations Center (MOC).
- JWARN is an operationally effective tool for the Navy to provide timely hazard warning to Navy ships and other Service units operating 18 kilometers or more away from the initial chemical, biological, radiological, and nuclear (CBRN) release to institute force protective actions before encountering the hazard. Units that are less than 18 kilometers from the release should be warned by other means, such as chat or radio.
- Tactical Action Officers were able to use JWARN information to make operational decisions and recommendations to ship commanders and share CBRN hazard plots within the Combat Direction Center and with other units via the GCCS-M Common Operating Picture Synchronization Tool.
- Testers were unable to exploit JWARN on the Consolidated Afloat Network Enterprise Services (CANES) network or GCCS-M client during remote cyber-attack testing. JWARN demonstrated a 97 percent operational availability and met the requirement for 100 hours Mean Time Between Operational Mission Failure.
- Current plans for sustaining JWARN interoperability in a complex network operating environment are not adequate to sustain the JWARN capability over time.

System

- JWARN is a joint automated CBRN warning, reporting, and analysis software tool that resides on joint and Service command and control systems including the GCCS – Army, GCCS – Joint, GCCS – Maritime, and Command and Control Personal Computer/Joint Tactical Common Workstation.



JWARN screen shot depicting CBRN hazard overlay on the common operational map

- JWARN software automates the NATO CBRN warning and reporting process to increase the speed and accuracy of information.
- JWARN uses the common operating picture of the host command and control system or computing environment to display the location of CBRN events and the predicted or actual location of hazards.
- JWARN is an application on the GCCS-M, and is interoperable with the ship's tactical network, the CANES.

Mission

JWARN operators support the commander's force protection and operational decisions by:

- Providing analysis of potential or actual CBRN hazard areas based on operational scenarios or sensor and observer reports
- Identifying affected units and operating areas
- Transmitting warning reports

Major Contractor

Northrop Grumman Mission Systems – Orlando, Florida

Activity

- COTF conducted FOT&E of the JWARN Increment 1 hosted on the GCCS-M Force Level from April to June 2015, aboard the USS *Ronald Reagan* (CVN 76), USS *John C. Stennis* (CVN 74), and JWARN hosted on GCCS – Joint at the Navy Third Fleet MOC. Testing was conducted in accordance with the DOT&E-approved test plan.
- FOT&E consisted of:
  - Adversarial intelligence collection
  - Local and remote reconnaissance and cyber attacks
  - Initial operator training
  - JWARN installation and configuration at each test location
  - Computer-based refresher training immediately preceding the operational test
  - A logistics and maintenance demonstration
- A three-day operational test in which JWARN operators received reports of CBRN incidents and used JWARN to

analyze the information and generate hazard plots and warning messages sent to units at risk of exposure.
- COTF collected supplemental test data on the time it takes to achieve various levels of mission oriented protective posture in response to a CBRN threat during an operational exercise aboard the USS *Theodore Roosevelt* (CVN 71) in September 2014 and February 2015.

Assessment
- JWARN is an operationally effective tool for the Navy to provide timely hazard warning to Navy ships and other Service units operating 18 kilometers or more away from the initial CBRN release to institute force protective actions before encountering the hazard. Units that are less than 18 kilometers from the release should be warned by other means, such as chat or radio.
- Tactical Action Officers were able to use JWARN information to make operational decisions and recommendations to ship commanders and share CBRN hazard plots within the Combat Direction Center and with other units via the GCCS-M Common Operating Picture Synchronization Tool.
- Twenty-one percent of hazard warnings (10 of 47) were not received in time to support force protection due to CANES network problems or long message transmission times.
- JWARN demonstrated a 97 percent operational availability. Down time resulted from the need to reboot the client computer and network failures. There were no JWARN software failures during 118 hours of operation.
- The local and remote cyber reconnaissance did not expose significant vulnerabilities in the ship's network or the GCCS-M client, which hosts JWARN. Testers were unable to exploit JWARN on the CANES network or GCCS-M client during remote cyber-attack testing.
- Users found the new equipment and online computer-based training to be suitable. Course content is available on computer disks for instances where slow internet connections are a problem.
- Current Joint Program Manager – Information Systems (JPM-IS) plans are not suitable for the installation, configuration, and sustainment of JWARN capability in the complex Navy network operating environment. Prior to operational test, the JWARN software was installed on the ship's and MOC servers. Then, Program Office personnel were required to configure JWARN for operational use and fix problems at each site prior to the test.

Recommendations
- Status of Previous Recommendations. The JWARN Program Office successfully addressed all previous FY14 recommendations.
- FY15 Recommendations.
  1. The JPM-IS, in conjunction with the Program Management Office for host systems, should review plans for the installation and configuration of JWARN and ensure adequate resources and training are provided to install and sustain JWARN in the Navy network operating environments over time. This review should address a process for verifying JWARN operation and interoperability at each location after network updates and software patches and recurring deployment check outs to ensure operational capability.
  2. The Navy should establish recurring training standards for JWARN operators and CVN Tactical Action Officers and consider incorporating JWARN into fleet training exercises.
  3. The Navy should conduct recurring deployment interoperability verification.

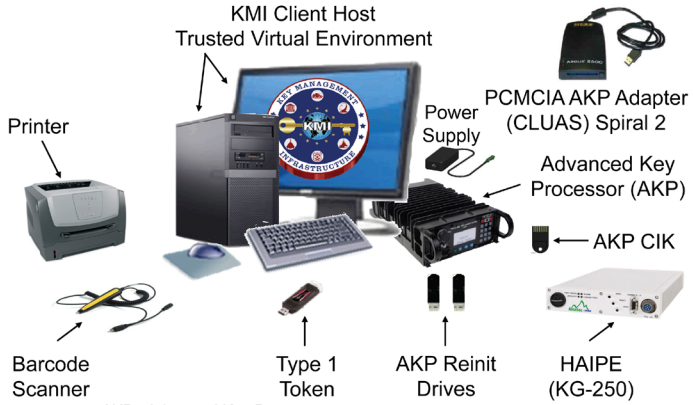
Key Management Infrastructure (KMI) Increment 2

Executive Summary

- In coordination with the Key Management Infrastructure (KMI) Program Management Office (PMO), the Joint Interoperability Test Command (JITC) conducted a Limited User Test (LUT) of Spiral 2, Spin 1 capabilities in April 2015, and a LUT Retest in July 2015 to verify deficiency corrections. Testing was conducted in accordance with a DOT&E-approved test plan.
- Users are satisfied with Spiral 2, Spin 1 capabilities, performance, and system stability. Database management problems during the LUT and LUT Retest affected software downloading. Site failover, Advance Extremely High Frequency keying, card loader, F-22, KMI tokens, benign fill, and existing Spiral 1 functions worked. During the LUT Retest, some problems remained with Mobile User Objective System, Secure Software Provisioning, and the Host-Based Security System (HBSS) and its supporting servers.
- The National Security Agency's (NSA) KMI Help Desk and tiered engineering support personnel lacked specific transition-related knowledge and not enough experienced personnel were available to support extended coverage hours. NSA and Service Help Desks are not prepared for surge transition and sustainment.
- KMI Spiral 2, Spin 2 developmental and operational testing is at least 12 months behind schedule, and the program will probably not be able to meet its Full Deployment Decision in April 2017.
- JITC and Service test participants identified a growing backlog of high-priority deficiencies that remain unresolved. The Service leads requested that the PMO resolve the backlog of deficiencies before continuing new development.

System

- KMI is intended to replace the legacy Electronic Key Management System (EKMS) to provide a means for securely ordering, generating, producing, distributing, managing, and auditing cryptographic products (e.g., encryption keys, cryptographic applications, and account management).
- KMI consists of core nodes that provide web operations at sites operated by the NSA, as well as individual client nodes distributed globally to enable secure key and software provisioning services for the DOD, intelligence community, and agencies.
- KMI combines substantial custom software and hardware development with commercial off-the-shelf computer components. The custom hardware includes an Advanced Key Processor for autonomous cryptographic key generation and a Type 1 user token for role-based user authentication. The commercial off-the-shelf components include a client host computer with monitor and peripherals, High Assurance Internet Protocol Encryptor (KG-250), printer, and barcode scanner.



Mission

- Combatant Commands, Services, DOD agencies, other Federal Government agencies, coalition partners, and allies will use KMI to provide secure and interoperable cryptographic key generation, distribution, and management capabilities to support mission-critical systems, the DOD Information Networks, and initiatives such as Cryptographic Modernization.
- Service members will use KMI cryptographic products and services to enable security services (confidentiality, non-repudiation, authentication, and source authentication) for diverse systems such as Identification Friend or Foe, GPS, Advanced Extremely High Frequency Satellite System, and Warfighter Information Network – Tactical.

Major Contractors

- Leidos – Columbia, Maryland (Spiral 2 Prime)
- General Dynamics Information Assurance Division – Needham, Massachusetts (Spiral 1 Prime)
- L3 Communications – Camden, New Jersey

Activity

- In coordination with the KMI PMO, JITC conducted a LUT of Spiral 2, Spin 1 capabilities in April 2015, and a LUT Retest in July 2015 to verify deficiency corrections, in accordance with a DOT&E-approved test plan.
- Sixty-nine operationally representative Air Force, Army, Marine Corps, Navy, and civil KMI account users participated during the LUT and its retest at geographically dispersed sites.
- DOT&E submitted a classified report detailing results of the LUT and LUT Retest in October 2015.
- NSA and JITC evaluated KMI Spiral 2, Spin 1 cybersecurity in the LUT Retest; the results are classified.
- JITC is developing plans for a Spiral 2, Spin 2 Operational Assessment in 2QFY16 and a LUT to be conducted in 4QFY16.

Assessment

- Users are satisfied with Spiral 2, Spin 1 capabilities, performance, and system stability. Functionality improved for the LUT Retest but suitability problems remained.
- Database management problems during the LUT and LUT Retest affected software downloading. Site failover, Advanced Extremely High Frequency keying, card loader, F-22, KMI tokens, benign fill, and existing Spiral 1 functions worked. During the LUT Retest, some problems remained with Mobile User Objective System, Secure Software Provisioning, and the HBSS and its supporting server.
- The PMO's KMI token reliability growth program continues to identify fault modes and has demonstrated improved reliability.
- KMI Spiral 2, Spin 2 developmental and operational testing is at least 12 months behind schedule, and the program will probably not meet its Full Deployment Decision in April 2017.
- JITC and Service test participants identified a growing backlog of high-priority deficiencies that remain unresolved. The Service leads requested that the PMO resolve the backlog of deficiencies before continuing new development.
- The LUT Retest concluded with only one high-priority product inventory discrepancy.
- The KMI program implemented a re-verification process for account holders, Advanced Key Processor, tokens, and the client that creates unannounced service interruptions when re-verifications are missed. The re-verifications and HBSS-enforced software version controls prevent KMI from operating autonomously for 6-9 months as designed. NSA must address these process-related system-enforced conflicts, to enable the National Guard, Army Reserve, remotely-deployed units, and submarine forces to be able to operate with KMI.
- During the LUT, the Army identified 26 new KMI tokens at the depot that failed at initialization out-of-the box (10.4 percent failure rate), indicating problems with the manufacturing production process. The PMO corrected problems in manufacturing, which helped bring the overall depot failure rate for both the LUT and LUT Retest down to 2.6 percent (52 out of 1,978 tokens).
- The KMI PMO successfully demonstrated continuity of operations planning and execution, by conducting a failover to the backup site during live operations.
- The NSA Help Desk and tiered engineering support personnel lacked specific transition-related knowledge. In addition, not enough experienced KMI engineering, second echelon, system administrators, database management, and Help Desk personnel were available to support extended coverage hours; this problem was previously reported by DOT&E at the 2012 KMI IOT&E, 2013 FOT&E, and again at the 2014 Operational Assessment. The NSA and Service Help Desks are not prepared for surge transition and sustainment, as some new Help Desk technicians lack KMI experience and system knowledge. This was especially noticeable during transition support.
- Problems observed in previous testing, if not corrected during system development, could adversely affect the system's effectiveness, suitability, or survivability during the KMI Spiral 2, Spin 2 LUT, which is scheduled to begin in 4QFY16.
  - There may be latent software flaws that could affect ongoing mission operations.
  - NSA and Service Help Desk manning may not be adequately staffed to support the pace of transition from EKMS to KMI.

Recommendations

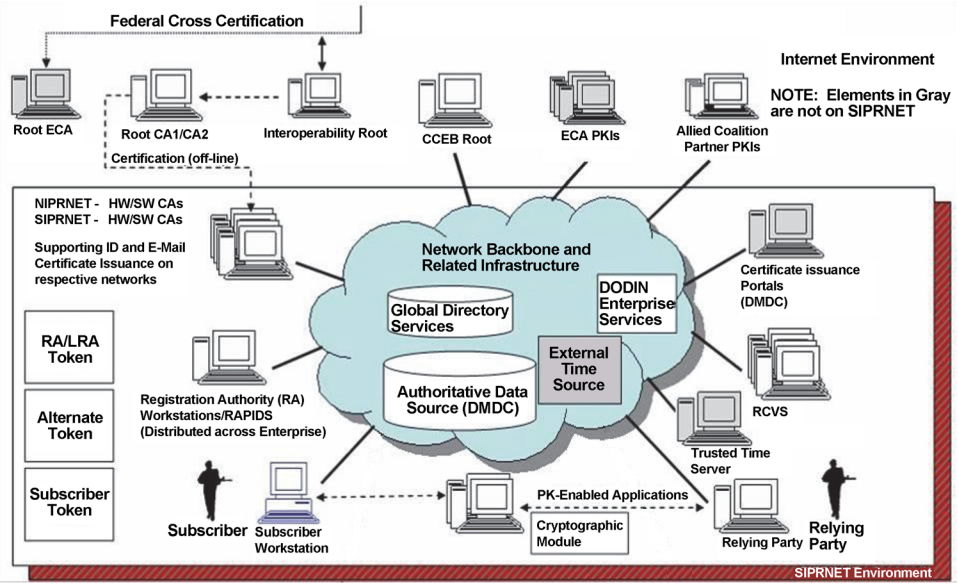
- Status of Previous Recommendations. The KMI PMO satisfactorily addressed two of the five FY14 recommendations. The following remain unresolved:
  1. Continue to improve rigor of the KMI software development and regression process to identify and resolve problems before entering operational test events.
  2. Allot adequate schedule time to support test preparation, regression, post-test data analysis, verification of corrections, and reporting to support future deployment and fielding decisions.
  3. Continue to verify increased KMI token reliability through a combination of laboratory and operational testing with automated data collection from system logs for accurate reliability and usage analysis.
- FY15 Recommendations. The KMI PMO should:
  1. Resolve the mounting backlog of deficiencies and establish a regular maintenance release schedule.
  2. Ensure that appropriate transition and funding plans are in-place to continue development and support fielding efforts beyond FY17 target dates.
  3. Resolve HBSS version management and re-verification process problems that obstruct autonomous operations.

4. Implement improved and rigorous configuration management, Configuration Control Board, Information Assurance Vulnerability Alert update processes and controls to properly sustain KMI.
5. Ensure adequate engineering, second echelon, system administrators, database managers, and NSA and Service Help Desk and transition staff are available to support surge fielding and long-term KMI sustainment.

Public Key Infrastructure (PKI) Increment 2

Executive Summary

- FOT&Es I and II, conducted in January 2013, revealed effectiveness and suitability problems. Although no operational testing has been completed since then, the program manager is addressing the requirements definition and system engineering problems that led to these deficiencies, while also making program personnel and contract management process changes to improve the program's ability to achieve restructured goals.
- In December 2014, the Public Key Infrastructure (PKI) Increment 2 Program Management Office (PMO) and the Joint Interoperability Test Command (JITC) conducted an integrated developmental test/operational test (DT/OT) for Token Management System (TMS) release 3.0 to examine code signing, token Personal Identification Number (PIN) reset, certificate recovery, and additional token issuance capabilities.
- USD(AT&L), guided by the recommendation of the Director of the National Security Agency (NSA), directed the PKI PMO to evaluate the viability of whether a one-token and/or one-infrastructure approach could achieve the DOD PKI mission requirements for both the classified and unclassified networks. This resulted in a program delay of six months.
- USD(AT&L) signed an Acquisition Decision Memorandum (ADM) in April 2015, which concluded that a one token/one-infrastructure approach would cost more money, take longer to develop, and would not improve cybersecurity. The ADM, in conjunction with the Joint Requirements Oversight Council memorandum, directed the NSA to resume development of the PKI Increment 2 program in accordance with plans developed prior to the strategic pause.
- In April and May 2015, JITC verified correction of deficiencies to resolve problems found in the integrated DT/OT for the TMS release 3.0.
- In July 2015, USD(AT&L) approved the revised PKI Acquisition Program Baseline, and approved the updated PKI Acquisition Strategy in September 2015 outlining the PKI PMO's plans to complete Spirals 3 and 4 by 2QFY18. The revised strategy focuses the remaining Increment 2 Spirals (3 and 4) on 15 user-prioritized capabilities. These capabilities are intended to improve the Secret Internet Protocol Router Network (SIPRNET) token management and reporting, improve system availability, and provide new infrastructures for the provisioning and management of the Non-classified Internet Protocol Router Network (NIPRNET) Enterprise Alternate Token System and Non-Person Entity certificates (e.g., workstations, web servers, and mobile devices).



CA – Certificate Authority
CCEB – Combined Communications Electronic Board
DMDC – Defense Manpower Data Center
DODIN – Department of Defense Information Networks
ECA – External Certification Authority
LRA – Local Registration Authority
NIPRNET – Non-secure Internet Protocol Router Network
RA – Registration Authority
RAPIDS – Real-Time Automated Personnel Identification System
RCVS – Robust Certificate Validation Service
SIPRNET – SECRET Internet Protocol Router Network

System

- DOD PKI provides for the generation, production, distribution, control, revocation, recovery, and tracking of public key certificates and their corresponding private keys. The private keys are encoded on a token, which is a credit card sized smartcard embedded with a microchip.
- DOD PKI supports the secure flow of information across the DOD Information Networks as well as secure local storage of information.
- DOD PKI uses commercial off-the-shelf hardware, software, and applications developed by the NSA.
  - The Defense Enrollment Eligibility Reporting System (DEERS) and Secure DEERS provide the personnel data for certificates imprinted on NIPRNET Common Access Cards and SIPRNET tokens, respectively.
  - DOD PKI Certification Authorities for the NIPRNET and SIPRNET tokens reside in the Defense Information Systems Agency Enterprise Service Centers in Oklahoma City, Oklahoma, and Mechanicsburg, Pennsylvania.
- Increment 1 is complete and deployed on the NIPRNET.
- The NSA is developing and deploying PKI Increment 2 in four spirals on the SIPRNET and NIPRNET. Spirals 1 and 2 are deployed, while Spirals 3 and 4 will deliver the

infrastructure, PKI services and products, and logistical support required by 15 user-prioritized capabilities.
- The Defense Information Systems Agency is supporting PKI operations, enablement, and security solutions.

Mission
- Military operators, communities of interest, and other authorized users will use DOD PKI to securely access, process, store, transport, and use information, applications, and networks.
- Commanders at all levels will use DOD PKI to provide authenticated identity management via personal identification, number-protected Common Access Cards or SIPRNET tokens to enable DOD members, coalition partners, and others to access restricted websites, enroll in online services, and encrypt and digitally sign e-mail.
- Military network operators will use Non-Person Entity certificates (e.g., workstations, web servers, and mobile devices) to create secure network domains, which will facilitate intrusion protection and detection.

Major Contractors
- General Dynamics C4 Systems – Scottsdale, Arizona (Prime)
- 90Meter – Newport Beach, California
- SafeNet – Belcamp, Maryland

Activity
- In December 2014, the PKI PMO and JITC conducted an integrated DT/OT for TMS release 3.0 to examine code signing, token PIN reset, certificate recovery, and additional token issuance capabilities.
- USD(AT&L), guided by the recommendation of the Director of NSA, directed the PKI Increment 2 PMO to evaluate the viability of whether a one-token and/or one-infrastructure approach could achieve the DOD PKI mission requirements for both the classified and unclassified networks. This resulted in a program delay of six months.
- USD(AT&L) signed an ADM in April 2015, which concluded that a one-token/one-infrastructure approach would cost more money, take longer to develop, and would not improve cybersecurity. The ADM, in conjunction with the Joint Requirements Oversight Council memorandum, directed the NSA to resume development of the PKI Increment 2 Program in accordance with previous plans developed prior to the strategic pause.
- In April and May 2015, JITC conducted a correction of deficiency verification test to resolve problems found in the integrated DT/OT for the TMS release 3.0.
- USD(AT&L) convened an Integrated Product Team to evaluate TMS release 3.0 in June 2015 and issued a fielding ADM in September 2015.
- USD(AT&L) approved the revised PKI Acquisition Program Baseline in July 2015, and approved the updated PKI Acquisition Strategy in September 2015 outlining the PKI PMO's plans to complete Spirals 3 and 4 by 2QFY18. The revised strategy focuses the remaining Increment 2 Spirals (3 and 4) on 15 user-prioritized capabilities. These capabilities are intended to improve the SIPRNET token management and reporting, improve system availability, and provide new infrastructures for the provisioning and management of the NIPRNET Enterprise Alternate Token System and Non-Person Entity certificates.
- The PMO and test community are finalizing the Spiral 3 Test and Evaluation Master Plan (TEMP) Addendum in November 2015 for signature approval in January 2016.
- The PMO is also updating the PKI System Engineering Plan, Life Cycle Sustainment Plan, and Transition Plan.
- The PMO had no major operational test events scheduled in FY15, but does have test events scheduled for 2QFY16 for TMS 4.1, 4.2, and 4.3 capabilities.

Assessment
- Delaying the capability deliveries until FY16, which were due to the six-month one-token/one-infrastructure strategic pause, negatively affected developmental and operational test planning and execution. TMS release 3.0 is a minor FY15 release that will not change the overall not effective/not suitable evaluations.
- FOT&Es I and II, conducted in January 2013, revealed effectiveness and suitability problems. Although no operational testing has been completed since then, the program manager is addressing the requirements definition and system engineering problems that led to these deficiencies, while also making program personnel and contract management process changes to improve the program's ability to achieve restructured goals.
- The PKI PMO's and JITC's integrated DT/OT, combined with the subsequent correction of deficiencies verification of TMS release 3.0 capabilities in April and May 2015, confirmed that Spiral 3 is adequate for DOD-wide fielding. USD(AT&L) issued a fielding ADM in September 2015 to authorize the use of the new capabilities including token PIN resets, encryption certificate key recovery, and issuance of new token types (Unique Identification-based and Administrator Identity-only certificates).
- The PKI PMO's methodology for measuring token reliability lacks sufficient rigor and focus. The PMO should focus their long-term reliability growth plan and testing on the end-state token. Furthermore, the current token reliability requirement requires 6,000 hours over 3 years, which equates to 35 hours a week. Many DOD users require a higher reliability. The DOD Chief Information Officer directed the PKI PMO to define a

higher reliability requirement for the tokens in August 2014 that remains unresolved.
- DOT&E conducted a Spiral 3 TEMP Addendum early review in September 2015, and the document is on track for approval in January 2016.

Recommendations
- Status of Previous Recommendations. The PKI PMO satisfactorily addressed the three previous FY14 recommendations.
- FY15 Recommendations. The PKI PMO should:
  1. Develop the Spiral 4 TEMP Addendum in accordance with the redefined PKI Increment 2 Acquisition Strategy to prepare stakeholders for the remaining deliveries, resource commitments, and T&E goals.
  2. Create a Spiral 4 transition plan defining roles and responsibilities for stakeholders to support a smooth transition and ensure minimal impact to PKI operations once the program enters sustainment.
  3. Define and validate sustainment requirements for PKI Spiral 4 capabilities.
  4. Provide periodic reports of token reliability, failure rates, and root cause analyses.

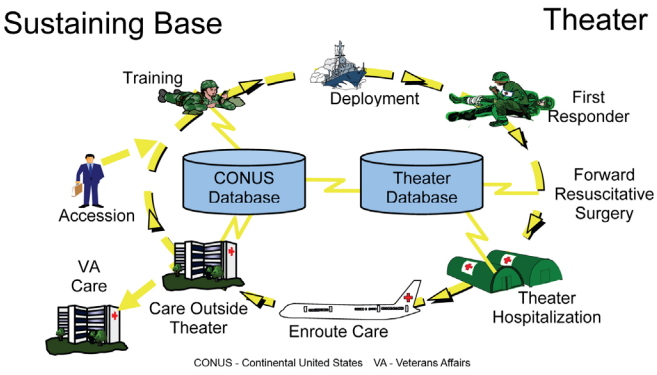
Theater Medical Information Program – Joint (TMIP-J)

Executive Summary

- The Army Test and Evaluation Command (ATEC) conducted a Multi-Service Operational Test and Evaluation (MOT&E) of Theater Medical Information Program – Joint (TMIP-J) Increment 2 Release 3, from August 13 – 21, 2015. The Air Force Operational Test and Evaluation Center, Marine Corps Operational Test and Evaluation Activity, United States Army Medical Department Board, the Air Force Medical Evaluation Support Activity (AFMESA), Marine Corps Tactical Systems Support Activity (MCTSSA), and the Joint Interoperability Test Command (JITC) all participated in the MOT&E.
- The Navy initiated its portion of the MOT&E aboard the USS *Carter Hall* (LSD-50) on November 2, 2015. The Navy Information Operations Command (NIOC) – Norfolk Red Team will conduct cybersecurity assessments aboard the USS *Carter Hall* (LSD-50) from January 7 – 11, 2016.
- The Army, Air Force, and Marine Corps completed MOT&E data collection at the end of FY15, and DOT&E began evaluation of the test data in early FY16.

System

- TMIP-J is a Major Automated Information System that integrates software from sustaining base medical applications into a multi-Service system for use by deployed forces. Examples of integrated applications include the theater versions of the Armed Forces Health Longitudinal Technology Application, Composite Health Care System, and Defense Medical Logistics Standard Support.
- TMIP-J provides the following medical capabilities:
  - Electronic Health Records
  - Medical command and control
  - Medical logistics
  - Patient movement and tracking
  - Patient data to populate the Theater Medical Data Store (theater database) and the Clinical Data Repository (Continental U.S. database)
- The Services provide their own infrastructure (networks and communications) and computer hardware to host the TMIP-J software.
- TMIP-J consists of two increments. The Program Executive Office fielded Increment 1 in 2003 and is developing



Increment 2 in multiple releases with the following fielding dates:
  - Increment 2 Release 1 – fielded in 2009.
  - Increment 2 Release 2 – fielded in 2014.
  - Increment 2 Release 3 was the system under test during 2015 and is the final TMIP-J release.
- The Program Executive Office initiated the Joint Operational Medicine Information Systems program in FY15. This program will replace portions of TMIP-J.

Mission

- Combatant Commanders, Joint Task Force commanders, and their medical staff equipped with TMIP-J can make informed and timely decisions about planning and delivering health care services in the theater.
- Military health care providers equipped with TMIP-J can electronically document medical care provided to deployed forces to support continuity of medical care from the theater to the sustaining base.

Major Contractors

- SAIC – Falls Church, Virginia
- Northrop Grumman – Chantilly, Virginia
- Akimeka LLC, Kihei – Maui, Hawaii

Activity

- ATEC conducted an MOT&E of TMIP-J Increment 2 Release 3, in accordance with the DOT&E-approved test plan, from August 13 – 21, 2015. The Air Force Operational Test and Evaluation Center, Marine Corps Operational Test and Evaluation Activity, United States Army Medical Department Board, AFMESA, MCTSSA, and JITC also participated in the MOT&E. ATEC tested the Army and Air Force components of TMIP-J at AFMESA, Fort Detrick, Maryland, and Marine Corps portions of TMIP-J at MCTSSA, Camp Pendleton, California.
- In January 2015, the Army Research Laboratory Survivability/ Lethal Analysis Directorate conducted a Cooperative

Vulnerability and Penetration cybersecurity assessment of the Army, Marine Corps, and Air Force portions of TMIP-J.
- In August 2015, the Threat System Management Office conducted a cybersecurity Adversarial Assessment for the Army, Air Force, and Marine Corps portions of TMIP-J in conjunction with the MOT&E.
- JITC reviewed all system interfaces and identified three joint interfaces that require interface testing to complete the TMIP-J Interoperability Certification process. JITC conducted interface testing in conjunction with the MOT&E in August 2015 and is collecting additional data in conjunction with the Navy portion of the MOT&E.
- The Navy initiated its portion of the MOT&E aboard the USS *Carter Hall* (LSD-50) on November 2, 2015. The NIOC – Norfolk Red Team will conduct cybersecurity assessments aboard the USS *Carter Hall* (LSD-50) from January 7 – 11, 2016.
- DOT&E will submit a TMIP-J MOT&E report for the Army, Air Force, and Marine Corps portions of TMIP-J and an addendum report to the Navy in 2QFY16.

Assessment
- The Army, Air Force, and Marine Corps completed data collection at the end of FY15, and DOT&E began evaluation of the test data in early FY16.
- DOT&E's MOT&E report will detail the results of testing on the Army, Air Force, and Marine Corps portions of TMIP-J.

Recommendations
- Status of Previous Recommendations. The program satisfactorily addressed all previous FY13 recommendations except for interface testing. JITC plans to complete interface testing in 1QFY16.
- FY15 Recommendations. None.

Army Programs

Army Programs

Network Integration Evaluation (NIE)

In FY15, the Army conducted two Network Integration Evaluations (NIEs) at Fort Bliss, Texas, and White Sands Missile Range, New Mexico. NIE 15.1 was conducted in October and November 2014, and NIE 15.2 was conducted in April and May 2015. The purpose of the NIEs is to provide a venue for operational testing of Army acquisition programs, with a particular focus on the integrated testing of tactical mission command networks. The Army also intends the NIEs to serve as a venue for evaluating emerging capabilities that are not formal acquisition programs. These systems, termed by the Army as "systems under evaluation," are not acquisition programs of record, but rather systems that may offer value for future development.

The Army's intended objective of the NIE to test and evaluate network components in a combined event is sound. The NIE events should allow for a more comprehensive evaluation of an integrated mission command network, instead of piecemeal evaluations of individual network components.

NIE 15.1

During NIE 15.1, the Army conducted an FOT&E for Warfighter Information Network – Tactical (WIN-T) Increment 2. An individual article providing an assessment of WIN-T Increment 2 can be found separately in this annual report.

NIE 15.2

During NIE 15.2, the Army conducted an FOT&E for the Distributed Common Ground System – Army and a Limited User Test for the Mid-Tier Networking Radio. Individual articles on these programs are provided elsewhere in this annual report.

NIE ASSESSMENT

NIE 15.1 and 15.2 were the eighth and ninth such events conducted to date. The Army has developed a systematic approach to preparing for and conducting NIEs and applying lessons learned from previous events. Overall, NIEs have been a satisfactory venue for conducting operational tests of individual network acquisition programs.

Operational Scenarios and Test Design. The Army Test and Evaluation Command's Operational Test Command, in conjunction with the Brigade Modernization Command, continue to develop realistic, well-designed operational scenarios for use during NIEs. Additionally, the 2d Brigade, 1st Armored Division, as a dedicated NIE test unit, is a valuable resource for the conduct of NIEs.

Future NIEs should continue to develop new and more demanding operational scenarios to reflect future combat operations. Future NIEs should include challenging and stressful combined arms maneuvers against regular conventional forces. Such scenarios would place greater stress on the tactical network and elicit a more complete assessment of that network. Within resource constraints, the Army should continue to strive to create a demanding operational environment at NIEs similar to that found at the Army's combat training centers.

Testing and Experimentation. Beginning in FY16, the Army will devote one NIE a year to operational testing and another annual event to experimentation and force development. The latter event is to be called an Army Warfighting Assessment, the first of which will be conducted in October 2015. This new approach is intended to pay dividends by focusing individual event design on the specific requirements of either testing or experimentation.

Instrumentation and Data Collection. The Army should continue to improve its instrumentation and data collection procedures to support operational testing. For example, the Army Test and Evaluation Command should devote effort towards developing instrumentation to collect network data for dismounted radios, such as the Manpack radio. Additionally, the Army needs to place greater emphasis on the use of Real-Time Casualty Assessment instrumentation, which is an essential component of good force-on-force operational testing, such as that conducted at NIEs. A Real-Time Casualty Assessment is intended to accurately simulate direct and indirect fire effects for both friendly and threat forces. Finally, the Army should continue to refine its methodology for the conduct of interviews,

focus groups, and surveys with the units employing the systems under test.

Threat Operations. An aggressive, adaptive threat intent on winning the battle is an essential component of good operational testing. The Army continues to improve threat operations during NIEs, particularly with respect to threat information operations, such as electronic warfare and computer network operations. NIEs should incorporate a large, challenging regular force threat that includes a sizeable armored force and significant indirect fire capabilities. Threat capabilities should be upgraded each year to reflect real-world threat developments.

NETWORK PERFORMANCE OBSERVATIONS

The following are observations of tactical network performance during NIEs. These observations focus on network performance deficiencies that the Army should consider as it moves forward with integrated network development.

Complexity of Use. Network components, both mission command systems and elements of the transport layer, remain excessively complex to use. The current capability of an integrated network to enhance mission command is diminished due to pervasive task complexity. It is challenging to achieve and maintain user proficiency.

Networking Waveforms. The Army is committed to using networking waveforms, such as the Soldier Radio Waveform and Wideband Networking Waveform, to implement a networked tactical communications network. While networked communications at lower tactical levels may create enhanced operational capability, the use of these networking waveforms brings negative attributes, which need to be fully evaluated and understood. For example, these waveforms, due to their higher frequencies, have shorter ranges and are more affected by terrain obstructions compared to the legacy Single Channel Ground and Airborne Radio System waveform. Establishing and maintaining networked communications is complex and difficult. For example, loading the initial network plans in all the necessary radios, updating the network to accommodate a new unit task organization, and conducting a communications security changeover are lengthy and cumbersome tasks requiring each individual radio to be manually updated. This process typically requires in excess of 24 hours for a Brigade Combat Team to complete; this is an excessive length of time for a unit conducting combat operations. Networked radios also have a much higher power consumption resulting in significantly higher battery consumption rates for dismounted radios. Finally, since networked communications are constantly emitting, they are much more vulnerable to threat electronic direction finding.

Armored Brigade Combat Team Integration. The challenge of integrating network components into tracked combat vehicles remains unresolved. Due to vehicle space and power constraints, the Army has yet to successfully integrate desired network capabilities into Abrams tanks and Bradley infantry fighting vehicles. It is not clear how the desired tactical network will be incorporated into heavy brigades.

Stryker Brigade Combat Team Integration. The WIN-T FOT&E conducted during NIE 15.1 revealed significant issues with the integration of WIN-T into Stryker vehicles. In both the Stryker Point of Presence vehicle and the Stryker Soldier Network Extension vehicle, WIN-T components were poorly integrated from a human factors perspective. The placement of these components in the vehicles interfered with Stryker crew operations and negatively affected unit mission execution.

Infantry Brigade Combat Team Integration. Integration of the tactical network into an Infantry Brigade Combat Team has not been evaluated at NIEs due to the lack of a light infantry unit assigned to the NIE test unit. Integration of the network into the light forces will be challenging given the limited number of vehicles in the Infantry Brigade Combat Team. Most of the key network components, such as Joint Battle Command – Platform, are hosted on vehicles. The challenge of linking into the tactical network is particularly acute at company level and below, where light infantry units operate dismounted.

Spectrum Management. The intended tactical network places a greater demand upon the available electromagnetic spectrum than has been the case with non-networked communications. The network topology requires more discrete frequencies, which will place greater stress on a tactical unit's capability to allocate and manage the available spectrum. This challenge will be even more significant for large tactical units, such as divisions, operating in the same geographical area of operations.

Survivability. An integrated tactical network introduces new vulnerabilities to threat countermeasures, such as threat computer network attacks, and the ability of a threat to covertly track friendly operations. The Army should continue to improve its capability to secure and defend its tactical network. The Army should ensure that brigade-level cybersecurity teams are appropriately manned and trained.

Air-Ground Communications. The Army has yet to integrate radios into its rotary-winged aircraft which are capable of operating in the same network as ground forces at the company level and below. This remains an important operational gap.

Dependence on Field Service Representatives. Units remain overly dependent upon civilian Field Service Representatives to establish and maintain the integrated network. This dependency corresponds directly to the excessive complexity of use of network components.

Abrams M1A2 System Enhancement Program Version 3 (SEPv3) Main Battle Tank (MBT)

Executive Summary
- DOT&E approved the Abrams M1A2 System Enhancement Program Version 3 (SEPv3) Main Battle Tank (MBT) Test and Evaluation Master Plan and LFT&E strategy on March 26, 2015.
- In FY15, the Army continued testing to characterize the performance of the M1A2 SEPv3 Next Evolutionary Armor (NEA) against multiple, operationally realistic threats.
- The Army conducted underbody IED testing against M1A2 ballistic hull and turrets (BH&T) to challenge vulnerability reduction measures taken to improve the protection provided by the tank against underbody IEDs. The Program Office used these test results to determine which design changes to integrate into the M1A2 SEPv3 to improve underbody IED protection.
- DOT&E is working with the Army to utilize data from ongoing test phases to support its final assessment of M1A2 SEPv3 survivability against existing and emerging threats in FY20.

System
- The Abrams M1A2 SEPv3 is an upgrade to the U.S. Army's current MBT. The M1A2 SEPv3 is a tracked, land combat, assault weapon system possessing significant survivability, shoot-on-the-move firepower, joint interoperability (for the exchange of tactical and support information), and a high degree of maneuverability and tactical agility.
- The Army intends the M1A2 SEPv3 to enable the crew to engage the full spectrum of enemy ground targets with a variety of accurate point and area fire weapons in urban and open terrain.
- The M1A2 SEPv3 includes multiple upgrades to improve:
  - Power generation and distribution to support power demands of future technologies
  - Network compatibility
  - Survivability against multiple threats by incorporating NEA, a new underbody IED kit and other vulnerability reduction measures to reduce the tank's vulnerability to IEDs. These measures include redesigned crew seating, additional floor stiffners, hardware to provide lower limb protection, and changes in the material and dimensions of internal structural supports.

  - Lethality by providing the ability for the fire control system to digitally communicate with the new large caliber ammunition
  - Energy efficiency (sustainment) due to the incorporation of an auxiliary power unit

Mission
- Units equipped with the M1A2 SEPv3 enable Army combined arms teams to close with and destroy the enemy by fire and movement across the full range of military operations.
- The Army intends the M1A2 SEPv3 to defeat and/or suppress enemy tanks, reconnaissance vehicles, infantry fighting vehicles, armored personnel carriers, anti-tank guns, guided missile launchers (ground and vehicle mounted), bunkers, dismounted infantry, and helicopters.
- The M1A2 SEPv3 is expected to support the full range of military operations by being fully integrated, expeditionary, networked, decentralized, adaptable, and lethal.

Major Contractor
General Dynamics Land Systems – Sterling Heights, Michigan

Activity
- DOT&E approved the M1A2 SEPv3 Test and Evaluation Master Plan and LFT&E strategy on March 26, 2015.
- In FY15, the Army continued testing to characterize M1A2 SEPv3 armor performance against multiple threat types

under the auspices of NEA, a separate materiel development verification and production effort. DOT&E is following the NEA development and verification program to leverage all relevant data to support the M1A2 SEPv3 survivability assessment. DOT&E is working with the Army to finalize M1A2 SEPv3 armor performance evaluation plans.

- In accordance with DOT&E-approved test plans, the Army continued underbody IED T&E against M1A2 BH&T in FY15, to finalize design plans intended to improve M1A2 SEPv3 IED protection.
- The Army will conduct additional testing in FY16 to better characterize the protection provided by the tank equipped with the new underbody kit and recently integrated vulnerability reduction features. These features include redesigned crew seating, additional floor stiffners, hardware to provide lower limb protection, and changes in the material and dimensions of internal structural supports.
- In FY16, the Army plans to continue testing to characterize NEA and explosive reactive armor performance, vulnerabilities associated with stowed ammunition and underbody IED protection.

Assessment

- DOT&E continues to assess data resulting from the Army's ongoing efforts to characterize the protection provided by NEA against expected, operationally-realistic threats.
- The underbody IED testing against non-operational BH&Ts with underbody protection kits has resulted in design changes expected to improve the M1A2 SEPv3's IED protection.
- All testing conducted thus far will inform the planning process for the final full-up system-level live fire testing of operational M1A2 SEPv3 MBTs scheduled in FY19.
- DOT&E will leverage all relevant vulnerability test data from the armor characterization and underbody IED test phases and evaluate all modeling and simulation tools available to support a FY20 final assessment of the tank's survivability to current and expected threats.

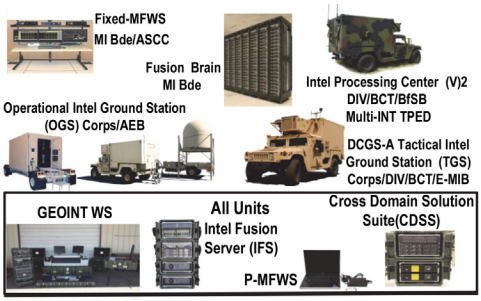
Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. None.

Distributed Common Ground System – Army (DCGS-A)

Executive Summary
- The Army conducted FOT&E of the Distributed Common Ground System – Army (DCGS-A) Increment 1, Release 2 at Fort Bliss, Texas, from May 2 – 14, 2015, during Network Integration Evaluation 15.2.
- The Program Office conducted additional laboratory testing in September 2015 to supplement the FOT&E evaluation of DCGS-A Release 2.
- The DCGS-A Increment 1, Release 2 is operationally effective. System availability and training were adequate, but the users rated the usability low-marginal. The system is not survivable against cybersecurity threats due to the vulnerability of the Army network.

System
- The DCGS-A provides an organic net-centric Intelligence, Surveillance, and Reconnaissance (ISR) capability from Battalion to Echelons Above Corps by combining 16 stove-piped legacy systems of record into one comprehensive network, including the capability to process Top Secret/Sensitive Compartmented Information.
- To resolve shortcomings discovered during the IOT&E in 2012, the Army reconfigured the system as Release 1 with only the Secret-level components. The Defense Acquisition Executive approved the full deployment of this configuration.
- The Army developed Release 2 to improve the capabilities that did not work effectively with Release 1. Release 2 is intended to provide enhanced capabilities to include:
  - Top Secret/Sensitive Compartmented Information capability
  - Workflows that aligned with how an intelligence section would employ the system
  - Methods for transferring data within the system and between systems more efficiently
  - Improved database structure
  - Enhanced fusion software for correlation of intelligence data
  - New materiel solution for transfer of information across security domains



AEB – Area Exploitation Battalion
ASCC – Army Service Component Command
BCT – Brigade Combat Team
Bde – Brigade
BfSB – Battlefield Surveillance Brigade
DIV – Division
E-MIB – Military Intelligence Battalion, Expeditionary
GEOINT – Geospatial Intelligence
MFWS – Multi-Function Work Station
MI – Military Intelligence
P-MFWS – Portable Multi-Function Work Station
TPED – Task, Process, Exploit and Disseminate
WS – Work Station

- In December 2014, USD(AT&L) approved modification to the acquisition strategy to end Increment 1 with completion of Release 2 deployment. Requirements that were allocated to Release 3, to include a cloud-computing capability to support worldwide intelligence analysis; database synchronization; and operations in disconnected or low-bandwidth environments, will now be allocated to Increment 2.

Mission
Army intelligence analysts use DCGS-A to perform: receipt and processing of select ISR sensor data, intelligence synchronization, ISR planning, reconnaissance and surveillance integration, fusion of sensor information, and direction and distribution of relevant threat, non-aligned, friendly and environmental (weather and geospatial) information.

Major Contractors
- Lockheed Martin – Gaithersburg, Maryland
- ManTech – Belcamp, Maryland
- Textron – Austin, Texas
- Northrop Grumman – Sacramento, California

Activity
- On December 4, 2014, USD(AT&L) issued an Acquisition Decision Memorandum (ADM) that ended the acquisition of Increment 1 with completion of Release 2 deployment. Previously, the DCGS-A Increment 1 was composed of three releases.
- The Full Deployment Decision ADM, dated December 14, 2014, required a plan for a developmental test with a representative operational test network structure using the scenarios and data collection/reduction tools expected to be used for the operational test. The Army planned and conducted Developmental Test 2 (DT2) at Fort Huachuca, Arizona, from September 13 – 27, 2014, to fulfill the ADM requirement.

- The U.S. Army Test and Evaluation Command (ATEC) conducted an FOT&E at Fort Bliss, Texas, during the Army's Network Integration Evaluation 15.2 in May 2015.
- ATEC failed to adequately collect, reduce, and analyze FOT&E test data in accordance with the DOT&E-approved test plan.
- The Program Office conducted a laboratory test September 14 – 24, 2015 to provide data for more rigorous evaluation of DCGS-A Release 2 data synchronization.
- DOT&E will issue a report on the DCGS-A Release 2 FOT&E in early FY16.

Assessment

- DT2 data were not sufficient for DOT&E to evaluate DCGS-A system performance. The Army's data collection, reduction, and analysis process failed to provide adequate quantitative answers to the key measures of performance.
- During the FOT&E, the test unit successfully employed DCGS-A to locate and take actions on all of the injected terrorist activities. The unit also accurately tracked the enemy troops and equipment movements, but did not always attribute the troops and equipment to the correct enemy unit. The Army injected supporting intelligence data for 10 intelligence vignettes into the test database, which also contained terabytes of other operationally representative intelligence data. During the test, the test unit successfully discovered and exploited the supporting data for all 10 vignettes and drew appropriate conclusions from the data within hours.
- FOT&E data collected by ATEC were not adequate to quantitatively evaluate fusion, targeting, and database synchronization. The program manager conducted a test of data synchronization in an operationally realistic laboratory facility in September 2015 and provided data to supplement the evaluation of data synchronization. Positive results of the vignettes indicate the fusion capability was adequate to support the mission during FOT&E.
- The data from the excursion showed that DCGS-A data synchronization can work effectively if the most efficient method is used. Users can choose from four different ways of synchronizing the data. During the FOT&E, the unit chose to use the ad-hoc Datamover method because they perceived this to be the most flexible method. The lab test showed using this method with a large number of entities (about 900 entities; the number emulates the database used during the FOT&E) could take about 2 hours, whereas moving the same data with a scheduled Datamover can be completed in less than 20 minutes. The Army plans to modify training to use the scheduled Datamover to synchronize large numbers of entities.
- DCGS-A availability was 0.99, satisfying the requirement of 0.90. Reliability, in terms of Mean Time Between Failure, ranged from 16 to 360 hours depending on the location and functions. Reliability and maintainability were sufficient to conduct the mission, but improvement in reliability would improve DCGS-A suitability.
- The system usability scale indicated system usability to be low-marginal.
- The system was not survivable against cybersecurity threats because of the vulnerabilities in the Army's tactical network.

Recommendations

- Status of Previous Recommendations. The Army did not successfully implement the FY14 recommendation to incorporate lessons learned from DT2 to conduct the FOT&E; the FOT&E data collection, reduction, and analysis had significant systematic shortfalls similar to those experienced during DT2.
- FY15 Recommendations. The Army should take the following actions:
  1. Institutionalize the training provided to the FOT&E test unit, so that all DCGS-A equipped units receive intensive, scenario-driven, collective training.
  2. Maintain DCGS-A unit readiness via continuous use of DCGS-A in garrison.
  3. Improve the cybersecurity posture in all Army tactical networks.
  4. ATEC should resolve systematic shortfalls with data collection, reduction, and analysis during testing.
     - Demonstrate the end-to-end process of collecting, reducing, and analyzing the data before an operational test.
     - Conduct a developmental test with operationally representative networks and the operational test instrumentation before an operational test of complex networked systems.
     - Attribute all performance anomalies to system performance, test process, or data collection and reduction before the test ends.
     - Analyze data sufficiently to identify and resolve anomalies and inconsistencies during the test.

Global Combat Support System – Army (GCSS-Army)

Executive Summary

- From March 30 to April 10, 2015, DOT&E monitored a Lead Site Verification Test (LSVT) of Wave 2 capability enhancements at two active Army units (2nd Heavy Brigade Combat Team, 1st Armored Division, and 11th Armored Cavalry Regiment); one Army Reserve unit (94th Training Division); and one Army National Guard unit (60th Troop Command).
- From January 2015 through June 2015, DOT&E analyzed system performance data to assess system scalability associated with Material Requirements Planning (MRP) batch jobs as the Army expanded the user base through continued fielding of the Global Combat Support System – Army (GCSS-Army) to additional units.
- GCSS-Army Wave 2 is operationally effective. The system successfully surpassed the 90 percent threshold for all Wave 2 critical mission functions attempted by users. Reports generated at all levels provided leaders with essential decision-making information to support force maintenance and sustainment.
- GCSS-Army is operationally suitable, with usability and resolution of help desk tickets needing some improvement. GCSS-Army exceeded the requirements for system reliability and availability.
- The system is survivable against an intermediate-level outsider threat, but is vulnerable to an intermediate-level insider cyber threat. Survivability against an advanced persistent outsider cyber threat was not tested.
- The GCSS-Army program continues to make progress in support of the legislative mandate to be financially auditable by 2017.

System

- GCSS-Army is an information technology system based on commercial off-the-shelf and government off-the-shelf software and hardware.
- GCSS-Army uses an adaptation of a commercially-available Enterprise Resource Planning system to integrate internal and external management information across an organization, including finance/accounting, manufacturing, sales and service, and customer relationship management. GCSS-Army centralizes and standardizes these activities and provides automation to assist users with common tasks, such as reporting.
- The hardware component of GCSS-Army is located on production servers in Redstone, Alabama, and Continuity of Operations servers in Radford, Virginia.
- The GCSS-Army program includes the Army Enterprise Systems Integration Program that provides the enterprise hub services, centralized master data management, and cross-functional business intelligence and analytics for Army Enterprise Resource Planning solutions, including the General Fund Enterprise Business System and Logistics Modernization Program.
- The Army is fielding GCSS-Army in two waves:
  - Wave 1 contains the retail supply and associated financial functions and will be completed in 2QFY16.
  - Wave 2 contains the remaining functions and will be fielded in FY16-17.
- GCSS-Army executes financial actions and is therefore subject to the 2010 National Defense Authorization Act requirement to be auditable by 2017.

Mission

Army logisticians use GCSS-Army to view, access, and exchange consolidated operational logistics data to conduct maintenance, material management, property accountability, financial management, and logistics planning.

Major Contractors

- Northrop Grumman Space and Mission Systems Division – Bon Air, Virginia
- LMI Consulting – McLean, Virginia
- InSAP Services, Inc. – Marlton, New Jersey

Activity

- The Army Research Laboratory Survivability/Lethality Analysis Directorate conducted cybersecurity vulnerability and penetration assessment testing of GCSS-Army in January 2015 in accordance with a DOT&E-approved test plan. The purpose of this testing was to identify vulnerabilities and allow time to fix them prior to a full-scope Adversarial Assessment and Cyber Economic Vulnerability Assessment.
- From January 2015 through June 2015, DOT&E analyzed system performance data to assess system scalability associated with MRP batch jobs as the Army expanded the user base through continued fielding of GCSS-Army to additional units.
- A Red Team from the Army's Threat Systems Management Office (TSMO) conducted a full-scope cybersecurity Adversarial Assessment and cyber economic vulnerability testing of GCSS-Army in February 2015. TSMO received support from a commercial financial auditing team for the cyber economic vulnerability testing.
- From February 23 through March 13, 2015, DOT&E observed independent government testing of deployment/redeployment functionality to and from both mature and immature theaters of operation. This was an integrated developmental test/operational test conducted at Fort Lee, Virginia, with Active Duty and Army National Guard Soldiers using the Program Office's developmental test client.
- From March 23 through April 10, 2015, DOT&E monitored an LSVT of Wave 2 capability enhancements at two active Army units (2nd Heavy Brigade Combat Team, 1st Armored Division at Fort Bliss, Texas, and 11th Armored Cavalry Regiment at Fort Irwin, California); one Army Reserve unit (94th Training Division at Fort Bragg, North Carolina); and one Army National Guard unit (60th Troop Command, Raleigh, North Carolina). This was an independent operational test involving typical users in an operationally realistic environment to assess specific risk factors for operational effectiveness, operational suitability, and survivability.
- From May 26 through June 9, 2015, the Army Test and Evaluation Command (ATEC) witnessed independent government testing of disconnected automated identification technology capabilities at the Program Management Office's facility in Petersburg, Virginia. This technology allows GCSS-Army users to conduct limited supply operations without an active communications network.
- From August 17 through September 3, 2015, ATEC reviewed the end-to-end deployment/redeployment standard operating procedure documentation at the Program Office's facility in Petersburg, Virginia. This documentation will be used by Army commanders to orchestrate deployment processes using GCSS-Army. Additionally, ATEC observed follow-on independent government testing of disconnected automated identification technology capabilities.
- A full transfer of operations to and from the continuity of operations location was not tested.
- DOT&E submitted an FOT&E report in November 2015 on the LSVT.

Assessment

- GCSS-Army Wave 2 is operationally effective.
  - The system successfully surpassed the 90 percent threshold for all Wave 2 critical mission functions attempted by users.
  - Reports generated at all levels provided leaders with essential decision-making information to support force maintenance and sustainment. However, users noted that some maintenance, finance, and logistics management reports took longer than expected to run or they timed out before completion, causing users to spend more time with multiple transaction attempts.
  - Server capacity can support continued Wave 1 fielding and the continuation of upgrades from Wave 1 to Wave 2.
  - During the LSVT, the new interface between GCSS-Army and the legacy Standard Army Management Information System systems for property book, maintenance, and unit supply worked properly.
- GCSS-Army is operationally suitable, with usability and resolution of help desk tickets needing some improvement. GCSS-Army exceeded the requirements for system reliability and availability.
- GCSS-Army was shown to be survivable against an intermediate-level outsider cyber threat, but was vulnerable to an intermediate-level insider cyber threat. Survivability against an advanced persistent outsider cyber threat using specialized tools or exploits was not tested. GCSS-Army has improved its cybersecurity capabilities since earlier testing.
- GCSS-Army demonstrated the ability to detect and react to cyber threats in support of the operational mission, data, and users. A Cyber Economic Vulnerability Assessment, performed as a table-top assessment based on vulnerabilities discovered and exploited during the Adversarial Assessment, did not reveal any additional significant risks. While analysis shows that the MRP reports are running slightly longer, it is not indicative of a capacity shortfall.
- During the migration to GCSS-Army Wave 2, the number of units running reports and the number of reports they are running was expected to increase. The weekly MRP report data provides the Program Office the ability to predict any future need to upgrade its servers to handle the increasing report processing workload.
- The 2010 National Defense Authorization Act requires financial audibility by 2017. GCSS-Army continues to work to achieve certification in accordance with the Federal Financial Management Improvement Act through various audits.

Recommendations

- Status of Previous Recommendations. The GCSS-Army program manager has addressed all previous recommendations and continues to make progress in support of meeting the legislative mandate to be financially auditable by 2017.
- FY15 Recommendation.
  1. The GCSS-Army Program Office should conduct a full transfer of operations to and from the continuity of operations location.

Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) M30E1

Executive Summary

- The M30E1 Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) surface-to-surface rocket meets the DOD unexploded ordnance policy requirements.
- The Army conducted the GMLRS-AW IOT&E from October through November 2014 at White Sands Missile Range. As part of the IOT&E, the Army conducted an Adversarial Assessment from October 15 – 17, 2014.
- On March 26, 2015 DOT&E submitted a classified combined IOT&E/LFT&E report detailing the results of testing. The Army Acquisition Executive approved full-rate production on April 8, 2015.
- Based on IOT&E results, DOT&E recommended the Army update GMLRS-AW tactics, techniques, and procedures (TTP). The Army revised the GMLRS-AW targeting procedures.
- Using the revised targeting TTP, the Army conducted a two-mission follow-on test at White Sands Missile Range from May 19 – 22, 2015, to address recommendations obtained from the IOT&E.
- In November 2015, DOT&E submitted an FOT&E classified report detailing the results of follow-on testing and assessed the following:
  - GMLRS-AW contains no submunitions to cause unintended harm to civilians and infrastructure associated with unexploded ordnance from cluster munitions.
  - GMLRS-AW is operationally effective with the Army's updated targeting TTP.
  - GMLRS-AW is accurate. The GMLRS-AW rocket is well within the required specification.
  - GMLRS-AW is operationally suitable. Including the follow-on test, 99 rockets were fired during developmental and operational testing. All 99 rockets were reliable.
  - GMLRS-AW is survivable.

System

- The 200-pound GMLRS-AW high-explosive rocket contains approximately 182,000 pre-formed tungsten fragments. GMLRS-AW M30E1 surface-to-surface rocket meets the 2008 DOD Policy on Cluster Munitions and Unintended Harm to Civilians.

- The GMLRS-AW rocket uses Inertial Measurement Unit and GPS guidance augmentation to engage area targets out to a range of 70 kilometers.
- GMLRS-AW uses the same rocket motor, guidance system, and control system as the existing M31A1 GMLRS Unitary rocket.
- The GMLRS-AW rockets can be fired from the tracked M270A1 Multiple Launch Rocket System and the wheeled High Mobility Artillery Rocket System.
- The procurement objective is 18,072 GMLRS-AW rockets. The Army entered full-rate production on April 8, 2015.

Mission

Commanders will use GMLRS-AW rockets to engage area- or imprecisely-located targets without the hazard of unexploded submunitions.

Major Contractor

Lockheed Martin Missiles and Fire Control – Dallas, Texas

Activity

- The Army conducted the GMLRS-AW IOT&E from October through November 2014, at White Sands Missile Range. As part of the IOT&E, the Army conducted an Adversarial Assessment from October 15 – 17, 2014.

- DOT&E submitted a classified combined IOT&E/LFT&E report on March 26, 2015, detailing the results of testing. The Army Acquisition Executive approved the full-rate production on April 8, 2015.
- From May 19 – 22, 2015, the Army conducted a two-mission follow-on test to demonstrate the newly-developed TTP. The Army fired the new TTP solutions at the follow-on test. DOT&E submitted a classified Operational Assessment report on November 3, 2015 detaining the results of the testing.
- The Army conducted all testing in accordance with the DOT&E-approved test plans.

Assessment

- GMLRS-AW munition does not contain submunitions to cause unintended harm to civilians and infrastructure associated with unexploded ordnance from cluster munitions and it meets the dud rate requirement.
- GMLRS-AW is operationally effective with the Army's updated targeting TTP.
  - In the IOT&E, GMLRS-AW met the Army's effectiveness requirements for 10 of 12 missions. A unit equipped with GMLRS-AW was not effective for certain targets. Details can be found in DOT&E's classified report on GMLRS-AW dated March 26, 2015.
  - Using IOT&E results, the Army developed new GMLRS-AW targeting TTPs.
- Targets executed in the follow-on test had the same targeting errors and countermeasures as the original IOT&E missions. Both missions met the Army's effectiveness requirements. Details of the follow-on test can be found in DOT&E's classified Operational Assessment report dated November 3, 2015.
- The GMLRS-AW rocket is accurate. During the IOT&E and follow-on test the GMRLS-AW rocket is well within the required specification.
- GMLRS-AW is suitable. Including the follow-on test, 99 rockets were fired during developmental and operational testing. All 99 rockets were reliable.
- GMLRS-AW is survivable. No cybersecurity vulnerabilities were found with the rocket or launcher. Some vulnerabilities were discovered with the missile test device used at depot to test rocket hardware. The Program Office is addressing the new cybersecurity issues.

Recommendations

- Status of Previous Recommendations. The Army addressed all previous recommendations.
- FY15 Recommendations. The Army should:
  1. Model the ability of a committed force to sustain GMLRS-AW munitions in full spectrum operations given the increase in rockets to manage the counter fire campaign.
  2. Model the effectiveness of GMLRS-AW munitions against targets with different types of countermeasures.

HELLFIRE Romeo

Executive Summary
- The HELLFIRE missile (AGM-114) is a family of air-to-surface, guided munitions consisting of missile body with different warhead types.
- The Air Force developed a new warhead, the HELLFIRE Romeo missile variant, to provide increased lethality against a variety of non-traditional targets.
- The Air Force will operate the HELLFIRE from MQ-1 Predator and MQ-9 Reaper unmanned aerial vehicles (UAVs). DOT&E assessed the HELLFIRE Romeo missile variant as lethal.
- The Air Force authorized fielding in December 2014, following an interim report submitted by DOT&E in November 2014. DOT&E submitted the final report on the HELLFIRE Romeo missile variant in August 2015, after the Air Force completed the HELLFIRE Romeo lethality testing against maritime targets.

System
- The AGM-114 HELLFIRE is a family of laser guided missiles for use against fixed and moving targets by both rotary and fixed-wing aircraft (including UAVs).
- The HELLFIRE Romeo missile variant:
  - Is an air-to-surface missile intended to be launched from Air Force UAV platforms. It uses a new warhead and a semi-active laser seeker to home-in on its target.
  - Will replace the HELLFIRE K2A fragmenting warhead variant and supplement the existing HELLFIRE R2 anti-armor variant currently fielded by the Air Force for air-to-surface engagements.
  - Is designed to provide improved lethality against combatants within building structures while maintaining lethality against non-armored targets.

  - Is compatible with other HELLFIRE missiles fired from other Air Force UAVs. Like other HELLFIRE variants, the HELLFIRE Romeo missile includes variable time delay fuzing options.

Mission
Commanders will employ the HELLFIRE Romeo missile variant to engage enemy combatants located within complex building and bunker structures, in non-armored vehicles, in small boats, and in the open from UAVs.

Major Contractor
Lockheed Martin Corporation, Missiles and Fire Control Division – Grand Prairie, Texas
(The missiles are manufactured in Ocala, Florida, and Troy, Alabama.)

Activity
- The Air Force successfully completed live fire testing of the HELLFIRE Romeo missile in February 2015. Testing was conducted in accordance with the DOT&E-approved live fire strategy and test plans.
- The HELLFIRE Romeo missile LFT&E program included arena tests, developmental dynamic tests against masonry targets, developmental flight tests against building and bunker targets, missile flight tests against mannequins, trucks, light armor, buildings, and bunkers, a rocket-on-a-rope test against a boat target, and a range of supporting lethality assessments using modeling and simulation.
- The Air Force approved fielding of the HELLFIRE Romeo missile variant in late 2014 following DOT&E's submission of an interim classified lethality report.
- DOT&E submitted a final classified lethality report for the HELLFIRE Romeo missile in August 2015 after the completion of the boat target testing.

Assessment
- The HELLFIRE Romeo missile demonstrated adequate lethality across a spectrum of expected targets, including small boats, light armor, technical vehicles (trucks), and personnel

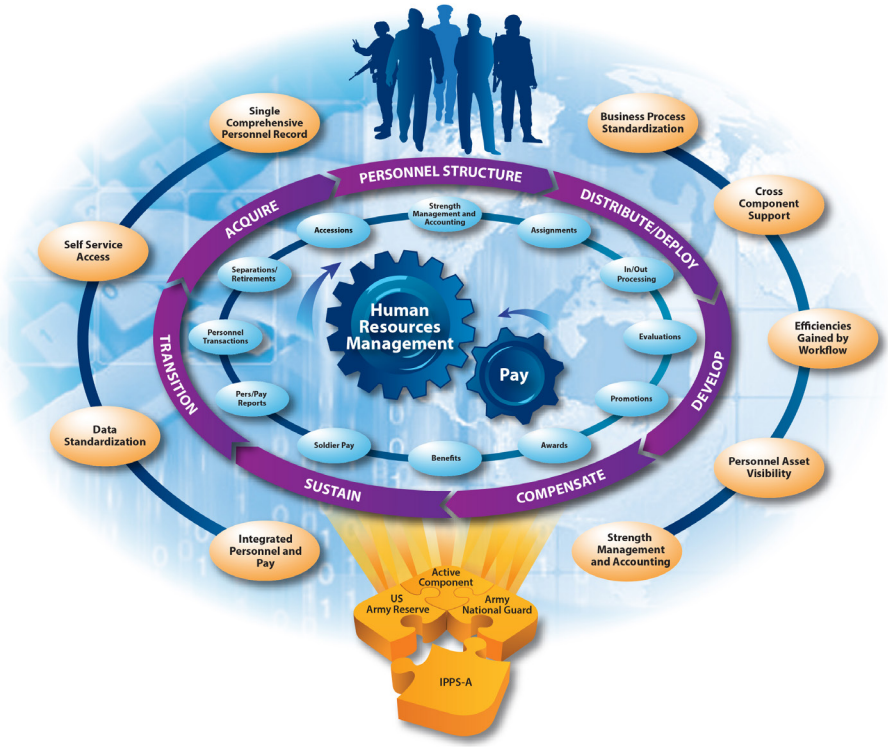
both in the open and behind/under a variety of masonry structures.
- The classified lethality report identified engagement circumstances and target conditions for which HELLFIRE Romeo lethality against specific targets either is not known, or which affect lethality against a particular target.

Recommendations
- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The Air Force or the HELLFIRE Romeo program should:
  1. Address the three recommendations in the classified report to further quantify lethality estimates against specific targets in specific conditions and engagement circumstances.
  2. Provide the classified test results to the Joint Technical Coordinating Committee for Munitions Effectiveness (JTCG/ME) for incorporation into JTCG/ME products as indicated in the final classified DOT&E report.

Integrated Personnel and Pay System – Army (IPPS-A) Increment I

Executive Summary

- Integrated Personnel and Pay System – Army (IPPS-A) is a two increment program that streamlines Army Human Resources processes and enhances the efficiency and accuracy of Army personnel and pay procedures to support Soldiers and their families. Through a three phased delivery approach, Increment I of the IPPS-A program provides the foundational data for a single, integrated military personnel and pay system for all three Army components: the active-duty Army, the Army Reserve National Guard, and the Army Reserve.
- The Army Test and Evaluation Command (ATEC) conducted a two-part FOT&E event from March 2014 through January 2015 in accordance with an ATEC-approved test plan.
- IPPS-A, as it exists in Increment I, is effective and suitable. IPPS-A is survivable against an outsider cyber threat. The capabilities available in this increment are limited; the program should continue to improve IPPS-A in order to deliver the full set of necessary capabilities.
- The IPPS-A Increment I system demonstrated the capability to produce its primary product, a Soldier's Record Brief (SRB), which is a single, integrated compilation of personnel and pay data collected from various, external authoritative sources.



System

- IPPS-A is a two increment program that streamlines Army Human Resources processes and enhances the efficiency and accuracy of Army personnel and pay procedures to support Soldiers and their families. Increment I interfaces with legacy applications to create a trusted, foundational database. All authoritative data remain in the legacy systems for Increment I. Increment II will become the authoritative data source as the necessary functionality of the legacy systems to be subsumed is incorporated.
- IPPS-A is a web-based tool, available 24 hours a day, accessible to Soldiers, Human Resources professionals, Combatant Commanders, personnel and pay managers, and other authorized users throughout the Army. The Army intends for IPPS-A to improve the delivery of military personnel and pay services and provide internal controls and audit procedures to prevent erroneous payments and loss of funds.
- IPPS-A interfaces with 15 other Army and DOD systems to acquire personnel and pay data, which it integrates into a single record for each Soldier. These systems include the Defense Enrollment Eligibility Reporting System – Personnel Data Repository, Electronic Military Personnel Office, Standard Installation and Division Personnel Reporting System – Guard, and Total Army Personnel Data Base – Reserve. IPPS-A's SRB acts as a trusted, but non authoritative, display of data contained in the various external systems; any changes required to the data must be made within the existing 15 Army and DOD personnel systems and cannot be accomplished within IPPS-A. The SRB displays a Soldier's military career personal information, qualification skills, training, assignment history, and various other Soldier attributes.

Mission

Commanders will employ IPPS-A as a comprehensive system for accountability and information to support command decisions regardless of component or geographic location. Army components will use IPPS-A to manage their members across

the full operational spectrum during peacetime, war, through mobilization and demobilization, capturing timely and accurate data throughout. Soldiers will use IPPS-A as a single, integrated personnel and pay system that will provide personnel and pay management functionality for all Army components.

Major Contractor
Increment I: EDC Consulting LLC – McLean, Virginia

Activity
- ATEC conducted a risk assessment of IPPS-A Increment I on June 19, 2014, in accordance with DOT&E Information and Business Systems Policy. Due to the low risk of the capabilities being delivered in Increment I, the risk assessment allowed for the delegation of test plan approval to ATEC.
- ATEC conducted an FOT&E event from March 2014 through January 2015. The FOT&E was conducted in two phases.
  - Phase 1 of the FOT&E utilized email surveys of a sample of the worldwide Army population including Active, Army National Guard, and Army Reserve personnel.
  - Phase 2 included specific test actions at Rock Island Arsenal, Illinois, and Camp Shelby, Missouri, in January 2015.
- In November 2014, ATEC conducted a cybersecurity assessment on IPPS-A Increment I; however, the test had several limitations. In April 2015, ATEC conducted a second cybersecurity assessment, which had fewer limitations. During these cybersecurity assessments, the Army's Threat Systems Management Office (TSMO) conducted operations remotely from Redstone Arsenal in Huntsville, Alabama, and onsite at the Human Resources Command in Fort Knox, Kentucky, and Acquisition, Logistics, and Technology Enterprise System and Services in Radford, Virginia. Testing was conducted in accordance with the DOT&E Information Assurance policy.
- DOT&E submitted a classified FOT&E report in April 2015 and a classified cybersecurity report in October 2015 detailing the results of testing.

Assessment
- IPPS-A Increment I, as delivered, provides an SRB that is viewable through a web interface and can be printed out. Increment I does not provide the capability to add or edit personnel data. The ability to edit personnel and pay data will be phased in during the four releases in Increment II.
- The results of the online survey indicate the system was easy to use and the resources necessary to obtain and interpret the data on the SRB were adequate. The results also indicate that the training received and online resources available were sufficient for most Soldiers. Very few of the Soldiers used the help desk, and the associated survey results did not provide a significant response as to whether they were satisfied with the help desk support.
- The SRB can be categorized into 11 sections and the Header and Footer sections. Participants found data errors in all 11 sections and the Header and Footer sections of the SRB. Sections where more than 50 percent of the participants had data errors include Personal/family data, Civilian Education, and Military Education. The FOT&E found that the legacy sources contributing to most errors are: Army Training Requirements and Resources System, Reserve Component Manpower System, and Standard Installation and Division Personnel Reporting System.
- During the FOT&E, as previously observed, data correctness continues to be a significant problem. Data displayed in the SRB, which is pulled from legacy Human Resources systems, have many problems, including missing and/or incorrect data. In addition, 93 percent of the Soldiers surveyed found errors in their records, as compared to the results from IOT&E in February 2014, where 95.2 percent of the Soldiers (181 of 190) found errors. This comparison shows the data correctness problem still exists and, as the sample size of users surveyed in the FOT&E is much larger (about 1 percent of the total Army military population) than in the IOT&E, the results are indicative of a widespread problem across the Active Duty Army, Army Reserve National Guard, and Army Reserve.
- The IPPS-A program manager does not have authority or mechanisms to correct data within legacy Human Resource systems. The IPPS-A Program Management Office and the Army G-1 are conducting a data correctness campaign that administers online surveys to facilitate reporting and resolution of data correctness issues. FOT&E results demonstrate that the Army is continuing to correct the data once a Soldier identifies an error and proactively initiates an action to get it corrected. However, the process is lengthy and difficult to fully accomplish due to legacy system limitations and documentation requirements.
- ATEC conducted a cybersecurity assessment of the fully deployed database in November 2014 using the Army's TSMO to portray the cyber threat. TSMO conducted operations remotely from Redstone Arsenal in Huntsville, Alabama, and onsite at the Human Resources Command in Fort Knox, Kentucky, and Acquisition Logistics and Technology Enterprise System and Services in Radford, Virginia.
  - The cybersecurity threat was not fully realistic due to limitations on time and rules of engagement at the Human Resources Command, Fort Knox, Kentucky. ATEC successfully completed a verification of fixes event addressing most of the findings on January 16, 2015. A follow-up cybersecurity assessment was conducted in April 2015.

  - The follow-up cybersecurity assessment was found to be threat-representative. Testing uncovered areas that need survivability improvement. This will require the data centers to work with cyber defenders to improve detection capabilities, ensuring IPPS-A and interfacing systems are following Personally Identifiable Information (PII) encryption policies and performing periodic Cooperative Vulnerability and Penetration Assessments and cybersecurity assessments at the data centers hosting IPPS-A.
- The details of the cybersecurity test findings can be found in DOT&E's classified cybersecurity report dated October 2015.

Recommendations

- Status of Previous Recommendations. The Army is making satisfactory progress in the previous FY14 recommendations.
- FY15 Recommendations. The Army should:
  1. Continue to monitor data correctness with the Army G-1 to ensure IPPS-A will have accurate data to facilitate accurate transactions in Increment II.
  2. Conduct a fully threat-representative cybersecurity assessment for IPPS-A Increment I.
  3. Verify vulnerabilities identified in the threat-representative cybersecurity assessment conducted in April 2015 have been mitigated in order to maintain the performance and integrity of the currently operating system.
     - Work with cyber defenders to improve cyber detection capabilities.
     - Ensure all PII encryption policies are followed.
     - Perform periodic Cooperative Vulnerability and Penetration Assessments and cybersecurity assessments at the data centers hosting IPPS-A.

Javelin Close Combat Missile System – Medium

Executive Summary

- In FY15, the Army continued development and test of the Javelin Spiral 1 and Spiral 2 missile improvements, and began funding the development of a Spiral 3 missile and a new Light Weight Command Launch Unit (CLU). The Army intends these efforts to reduce unit cost and weight, and improve lethality against non-armored targets.
- Early arena testing and lethality modeling of the Spiral 2 missile, which includes a new Multi-Purpose Warhead (MPWH), demonstrated improved warhead fragmentation versus the legacy warhead. LFT&E of the Spiral 2 missile will continue in FY16.
- Detection, Recognition, and Identification (DRI) characterization testing with Soldiers demonstrated that gunners using Javelin can detect, recognize, and lock-on to personnel in the open out to approximately 2,000 meters. The Javelin's required operational range against armored targets is 2,500 meters. Gunners required additional sources of field intelligence to consistently identify threat from non-threat personnel beyond 1,000 meters.
- DOT&E and the Army are in test planning discussions for the Spiral 3 missile and Light Weight CLU developments.

System

- The Javelin Close Combat Missile System – Medium (Javelin) is a man-portable, fire-and-forget, precision anti-tank missile employed by dismounted troops to defeat threat armored combat vehicles targets out to 2,500 meters. It uses a lofted trajectory to deliver a top-attack tandem shaped charged warhead. It also has a direct-fire mode.
- The Javelin system consists of a missile in a disposable launch tube assembly and a re-usable CLU. The CLU mechanically engages the launch tube assembly to provide a stable platform for firing, has day and night sights for surveillance and target acquisition, and electronically interfaces with the missile for target lock-on and missile launch. An operationally-ready Javelin system weighs approximately 49.5 pounds.
- The Army has planned four Javelin system improvements in order to reduce unit cost and weight, and improve lethality against non-armored targets. These improvements are referred to as missile Spiral 1, 2, 3, and Light Weight CLU.
  - The Spiral 1 effort will replace electronic components in the control actuator section of the missile for cost and weight savings.

  - The Spiral 2 effort will develop a MPWH, which uses enhanced fragmentation to improve lethality against non-armored targets and personnel in the open while maintaining lethality against armored threats.
  - The Spiral 3 effort will develop a new launch tube assembly and replace electronic components in the guidance section of the missile for cost savings.
  - The Light Weight CLU effort will develop an all new CLU that is smaller and lighter while maintaining or improving system performance.

Mission

- Infantry, Engineer, Reconnaissance, and Special Operation Forces within Army and Marine Corps ground maneuver units employ the Javelin to destroy, capture, or repel enemy assault through maneuver and firepower.
- Service members use the Javelin to destroy threat armor targets, light-skinned vehicles, and incapacitate or kill threat personnel within fortified positions. In recent conflicts Javelin was used primarily against enemy bunkers, caves, urban structures, mortar positions, snipers, and personnel emplacing IEDs.

Major Contractors

- Raytheon – Tucson, Arizona
- Lockheed Martin – Orlando, Florida

Activity

- In 2015, the Javelin Program Office continued development and testing of the Spiral 1 and Spiral 2 missile improvements.
- The Army Aviation and Missile, Development, and Engineering Center, in accordance with the DOT&E-approved

live fire strategy, conducted live fire arena tests of the MPWH to characterize missile and warhead fragmentation. Static and dynamic testing, and live warhead end-to-end firings against a range of targets will continue in FY16.
- The Javelin Program Office conducted two DRI tests with Soldiers in order to characterize the ability of gunners using only Javelin to detect, recognize, identify, and lock-on to secondary targets (IED team, mortar team, truck mounted machine gun) at various ranges in both daylight and night conditions. Tests were performed in February and July 2015, to capture both cold and hot ambient surroundings.
- DOT&E and the Army are in test planning discussions for the Spiral 3 missile and Light Weight CLU.

Assessment
- The preliminary results of available live fire data indicate the MPWH exhibits improved warhead fragmentation versus the legacy warhead. A comprehensive LFT&E program including static and dynamic testing, and end-to-end firings against a variety of targets is planned for FY16 to verify the MPWH performance prior to the production build beginning in FY17.
- Findings from the Javelin DRI characterization test include:
  - Military gunners using the day and night sights of the Javelin CLU without other field intelligence sources (binoculars, UAV feed, etc.), can detect and recognize personnel in the open, but cannot identify threat personnel from non-threat personnel throughout the operational range and environment.
  - Military gunners were able to maintain target acquisition throughout the process of readying the Javelin to fire upon secondary targets identified as threats.
  - Military gunners were able to maintain lock-on to individuals and small groups out to approximately 2,000 meters. Maintaining lock-on became more difficult due to the small signature presented by human sized targets beyond 2,000 meters.

Recommendations
- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendation.
  1. The Army should conduct an operational test before fielding Spiral 3 and/or Light Weight CLU to confirm that effectiveness and suitability has not been compromised, and compatibility with all fielded variants of the missile.

Joint Battle Command – Platform (JBC-P)

Executive Summary

- During October through November 2014, the Army conducted testing of JBC-P 6.0 to verify fixes of deficiencies noted during the May 2014 JBC-P 6.0 Multi-Service Operational Test and Evaluation (MOT&E). JBC-P continued to exhibit phantom Mayday messages and a new deficiency of delayed position location information (PLI) updates. The Army did not approve a full materiel release, but approved a conditional materiel release to field one Army brigade and continue testing because these deficiencies were not corrected.
- In June 2015, the Army conducted further testing of JBC-P 6.0 in conjunction with fielding of the first unit to verify correction of MOT&E deficiencies. The Army demonstrated:
  - A reduction in phantom Mayday messages (five during test), which were manageable through unit standard operating procedures.
  - Correction of delayed PLI updates.
  - Proper representation of map graphics and unit icons.

  The Army plans to pursue another conditional materiel release to pursue further fielding and testing of JBC-P 6.0.
- The Army intends to conduct an operational test of JBC-P Logistics (Log) using an Army sustainment brigade. The Army will also perform further cybersecurity testing to address deficiencies noted during the JBC-P MOT&E.

1 - JBC-P on Mounted Family of Computer Systems (MFoCS)
2 - JBC-P on Joint Version - 5 (JV-5) Block 2
3 - JBC-P Screen Shot
4 - JBC-P Log on Military Rugged Tablet Plus (MRT+)
5 - JBC-P on JV-5 Block 2

System

- JBC-P is a networked battle command information system that enables units to share near real-time friendly and enemy situational awareness information, operational maps and graphics, and command and control messages.
- The Army and Marine Corps intend JBC-P to achieve platform level interoperability for ground vehicles, dismounted Soldiers/Marines, and aviation assets operating in land/littoral and joint operational environments.
- JBC-P is an upgrade to the Force XXI Battle Command Brigade and Below Joint Capabilities Release and provides the following improvements:
  - Tactical chat combined with chat room capability, providing enhanced collaboration for commanders
  - Improved mission command applications for planning and execution
  - A more intuitive graphical user interface with an improved map and image display
  - Enhanced Blue Force situational awareness between mobile platforms, Tactical Operational Centers, and dismounted Soldiers equipped with Nett Warrior
  - JBC-P Log, which is a logistical variant of JBC-P that supports sustainment and enables logistics cargo tracking using Radio Frequency Identification tags
  - Hybrid capability to connect JBC-P across different networks using its Network Services Gateway and associated terrestrial and satellite radios
- JBC-P is fielded in both mobile and command post versions. JBC-P communications is supported by:
  - Blue Force Tracker 2 satellite communications for mobile operations
  - Tactical radios for connectivity between JBC-P-equipped vehicles and to support dismounted operations
  - Tactical Internet for command post operations

Mission

The Army, Marine Corps, and Special Operations Forces commanders use JBC-P to provide integrated, on-the-move, near real-time battle command information and situational awareness, from brigade, to maneuver platform, to dismounted Soldiers/Marines.

Major Contractor

Software Engineering Directorate, U.S. Army Aviation & Missile Research, Development & Engineering Center – Huntsville, Alabama

Activity

- In May 2014, the Army and Marine Corps conducted a JBC-P software build 6.0 MOT&E as part of the Network Integration Evaluation (NIE) 14.2 to support fielding decisions in both Services. The MOT&E was performed in accordance with a DOT&E-approved test plan.
- During October through November 2014, the Army conducted testing of JBC-P 6.0 as part of NIE 15.1 to verify fixes of deficiencies noted during the JBC-P 6.0 MOT&E. The Army assessed JBC-P using observations, surveys, and focus groups within the 2nd Brigade Combat Team, 1st Armored Division operating under realistic mission conditions at Fort Bliss, Texas. JBC-P continued to demonstrate phantom Mayday messages and exhibited a new deficiency of delayed PLI updates. Since the MOT&E deficiencies were not corrected, the Army did not approve a full materiel release, but approved a conditional materiel release to field one Army brigade and continue testing.
- In January 2015, DOT&E submitted a JBC-P 6.0 MOT&E report with a classified annex detailing results of testing during NIE 14.2.
- In June 2015, the Army conducted further testing of JBC-P 6.0 employing the 2nd Infantry Brigade Combat Team, 3rd Infantry Division operating under realistic mission conditions at Fort Stewart, Georgia, to verify correction of MOT&E deficiencies. As with NIE 15.1, the Army collected observations, surveys, and focus group data. The Army plans to pursue another conditional materiel release to pursue further fielding and testing of JBC-P 6.0.
- The Army intends to conduct an operational test of JBC-P Log using an Army sustainment brigade. The Army will also perform further cybersecurity testing to address deficiencies noted during the JBC-P MOT&E.

Assessment

- In the January 2015 JBC-P MOT&E report, DOT&E assessed JBC-P 6.0 as:
  - Not operationally effective due to low message completion rates, phantom Mayday messages, inaccurate representation of blue force icons, and the poor performance of JBC-P Log.
  - Not operationally suitable due to reliability that was below the Army's requirement for five of seven JBC-P hardware variants, deficiencies in training provided to leaders and Soldiers, and lack of a force structure to support JBC-P Log.
  - Not survivable due to cybersecurity vulnerabilities.
- During FY15, the Army verified fixes of several JBC-P 6.0 MOT&E deficiencies to include demonstrating:
  - A reduction in phantom Mayday messages (five during test), which were manageable through unit standard operating procedures
  - Correction of delayed PLI updates
  - Proper representation of map graphics and unit icons
- The following JBC-P 6.0 MOT&E deficiencies remain to be corrected and verified through testing:
  - Cybersecurity vulnerabilities identified in the JBC-P MOT&E classified report
  - Low message completion rates of shared survivability information (e.g., icons representing enemy minefields, an IED, or damaged bridge)
  - Poor performance and lack of force structure to support JBC-P Log
  - JBC-P reliability
- The Army has not yet developed its T&E strategy for further JBC-P enhancements and the planned transition to the Mounted Computing Environment.

Recommendations

- Status of Previous Recommendations. The Army made improvements in one of five previous recommendations, yet still needs to improve JBC-P message completion rates, reliability, JBC-P Log force structure, Soldier and leader training, and cybersecurity.
- FY15 Recommendations. The Army should:
  1. Continue to correct JBC-P 6.0 MOT&E deficiencies and conduct developmental and operational testing to verify fixes of MOT&E deficiencies to include cybersecurity vulnerabilities, low message completion rates, reliability, and JBC-P Log performance.
  2. Improve JBC-P leader and Soldier training.
  3. Update the JBC-P Test and Evaluation Master Plan to include testing to verify fixes and future JBC-P enhancements.

Joint Light Tactical Vehicle (JLTV) Family of Vehicles (FoV)

Executive Summary

- In August 2015, DOT&E published the Joint Light Tactical Vehicle (JLTV) Operational Assessment and classified LFT&E reports to support the Defense Acquisition Board JLTV Milestone C decision.
- The Defense Acquisition Executive approved the JLTV program to enter Milestone C low-rate initial production in August 2015.
- The Army awarded the JLTV low-rate initial production contract to Oshkosh Corporation in August 2015.
- In September 2015, Lockheed Martin Corporation protested the Army's decision to award the JLTV contract to Oshkosh Corporation. The General Accountability Office dismissed the protest in December 2015 because Lockheed indicated it would take the matter to the Court of Federal Claims.

System

- The JLTV Family of Vehicles (FoV) is the Marine Corps and Army partial replacement for the High Mobility Multi-purpose Wheeled Vehicle (HMMWV) fleet. The Services intend the JLTV to provide increased crew protection against IEDs and underbody attacks, improved mobility, and higher reliability than the HMMWV.
- The JLTV FoV consists of two vehicle categories: the JLTV Combat Tactical Vehicle, designed to seat four passengers, and the JLTV Combat Support Vehicle, designed to seat two passengers.
- The JLTV Combat Tactical Vehicle has a 3,500-pound payload and three mission package configurations:
  - Close Combat Weapons Carrier Vehicle
  - General Purpose Vehicle
  - Heavy Guns Carrier Vehicle
- The JLTV Combat Support Vehicle has a 5,100-pound payload and one mission package configuration:
  - Utility Prime Mover that can accept a Shelter Carrier.
  - Utility Prime Mover
- JLTV vehicles are equipped with vendor-unique solutions intended to significantly improve, relative to the HMMWV, crew protection against the effects of small arms, fragments, and underbody and underwheel blast loading from mines and IEDs. These include the design of the vehicle underbody hull structure, energy-attenuating seats, and floor specifically designed to mitigate blast loading to the occupants.
- JLTV vehicles are equipped with two separate armor levels: the A-kit, or base vehicle, which is intended for use in low-threat environments, and the B-kit, an add-on armor kit, for additional force protection in the intended deployment configuration but at the cost of additional weight.

Oshkosh Corporation JLTV

Lockheed Martin Systems JLTV

AM General JLTV

Mission

- Military units employ JLTV as a light, tactical-wheeled vehicle to support all types of military operations. JLTVs are used by airborne, air assault, amphibious, light, Stryker, and heavy forces as reconnaissance, maneuver, and maneuver sustainment platforms.

- Small ground combat units will employ JLTV in combat patrols, raids, long-range reconnaissance, and convoy escort.

Major Contractors
- Oshkosh Corporation, Oshkosh, Wisconsin
- Tested Contractors:
  - Lockheed Martin Corporation – Grand Prairie, Texas
  - AM General – South Bend, Indiana

Activity
- In April 2014, the Army and Marine Corps units conducted air assault missions during developmental/operational at Aberdeen Proving Ground, Maryland, using CH-47F and CH-53E helicopters. The Marine Corps unit conducted amphibious assault missions at Joint Base Little Creek, Fort Story, Virginia, using Landing Craft Utility ships.
- In October 2014, the Army Test and Evaluation Command completed the Engineering Manufacturing and Development ballistic phase of the LFT&E program of all three vendor-provided JLTV prototypes, which included:
  - Armor coupon testing against the medium machine gun, as well as fragments from side and underbody IEDs, and overheard artillery to assess if the ballistic protection performance of vendor armor solutions the JLTV requirements.
  - Ballistic structure testing on both the base A-kit structure and the up-armored B-kit structure. This consisted of exploitation testing to determine the vulnerability of unique armor features on each JLTV prototype, as well as blast-fragmentation IED testing conducted to determine the structural vulnerability, resistance to penetration, and force protection provided by JLTV prototypes.
  - System-level testing against underbody mines and IEDs, underwheel mines, side IEDs, rocket-propelled grenades, and explosively-formed penetrators to assess the vendors' compliance with force protection requirements, the vulnerability of the vehicle design, and vehicle recoverability post-event.
- In November 2014, the Army Test and Evaluation Command and Marine Corps Operational Test and Evaluation Agency conducted the JLTV Limited User Test (LUT) at Fort Stewart, Georgia, in accordance with the DOT&E-approved test plan. The Army test unit completed three, 96-hour scenarios and the Marine Corps test unit completed one, 96-hour scenario at the operational tempo consistent with the JLTV Operational Mode Summary/Mission Profile.
- The Joint Requirements Oversight Council approved the JLTV Capability Production Document in November 2014.
- The JLTV Program Office completed development of the JLTV FoV Milestone C Test and Evaluation Master Plan (TEMP) to reflect the T&E activities for the production and deployment phase in May 2015. The Army did not submit the Milestone C JLTV TEMP for OSD approval prior to the Milestone C.
- In August 2015, DOT&E submitted the JLTV Operational Assessment and classified LFT&E reports to support the Defense Acquisition Board JLTV Milestone C decision.
- The Defense Acquisition Executive approved the JLTV program to enter Milestone C low-rate initial production in August 2015.
  The Army awarded the JLTV low-rate initial production contract to Oshkosh Corporation in August 2015.
- In September 2015, Lockheed Martin Corporation protested the Army's decision to award the JLTV contract to Oshkosh Corporation. The General Accountability Office dismissed the protest in December 2015 because Lockheed indicated it would take the matter to the Court of Federal Claims.

Assessment
- Based on the LUT, the JLTV FoV provides enhanced protection and retains the up-armored HMMWV (UAH) FoV capabilities necessary for Army and Marine units to accomplish tactical and combat missions.
  - Platoons equipped with the Oshkosh JLTVs accomplished 15 out of 24 missions similar to the platoon equipped with the UAHs.
  - Platoons equipped with the AM General JLTVs accomplished 13 out of 24 missions.
  - Platoons equipped with the Lockheed Martin JLTVs accomplished 12 out of 24 missions.
  - The majority of failed platoon missions were attributed to combat losses for Oshkosh and Lockheed Martin JLTVs.
  - Platoons equipped with the AM General JLTVs and the UAHs experienced less combat losses against the Opposing Force during missions.
  - Platoons equipped with AM General JLTVs experienced reliability failures on nine missions that slowed the unit's pace and degraded mission performance.
- The JLTVs have similar mobility capabilities to the UAH without the Fragmentation Kit 5. During the LUT, units equipped with JLTVs experienced delays in maneuvering while awaiting adjustment of the vehicle suspension and the Central Tire Inflation System (CTIS). The slow suspension and CTIS adjustment times affected the Army and Marine Corps units' ability to quickly react to changes in the tactical situation and in some LUT missions increased the units' susceptibility to threats.
- Oshkosh JLTVs had improved mission reliability over the UAH and demonstrated 7,051 Mean Miles Between Operational Mission Failure (MMBOMF) versus its operational requirement of 2,400 MMBOMF. The UAH demonstrated 2,968 MMBOMF.

  - AM General JLTVs had less mission reliability versus the UAH and demonstrated 526 MMBOMF.
  - Lockheed Martin JLTVs had less mission reliability versus the UAH and demonstrated 1,271 MMBOMF.
- Marine Corps units equipped with JLTVs have enhanced capabilities to accomplish air assault missions over the UAH. Since the CH-53E has the capability to lift JLTVs with armor, units have better protected maneuver capabilities to counter threat activities at the Landing Zone compared to units equipped with the UAH.
- Army units cannot accomplish air assault missions with JLTVs with B-kit armor because the vehicle's gross weight exceeds the external lift capability of the CH-47F helicopter. The vendors' JLTVs with add-on B-kit armor weigh between 18,000 and 22,000 pounds.
- Marine Corps units equipped with the JLTVs demonstrated the ability to conduct amphibious assault missions during developmental/operational testing. JLTVs are slower to load, prepare for fording and transition to maneuver ashore than the UAH due to their larger size and movement delays awaiting adjustment of the vehicle suspension and tire pressure.
- The JLTVs do not have sufficient capability to carry mission equipment, supplies, and water for extended mission beyond one day of supply. This limits the type and duration of missions for which JLTV is effective. Units operating for long duration will require additional trailers or vehicles to sustain operations.
- The JLTV Utility variants do not have the capability to carry troops like the UAH Cargo/Troop Carrier. This is not a current JLTV requirement. These variants have no seats, no head room, and no underbody crew protection in the rear cargo area. Army and Marine Corps units employ the HMMWV Cargo/Troop Carrier to carry troops required for combat and combat support missions.
- The JLTVs suffered from poor command, control, and communication equipment integration by the vendor affecting the unit commander's ability to command and control platoons, maintain situational awareness, and complete mission tasks during the LUT.
- Due to small rear windows and blind spots around the vehicles, the JLTVs did not provide the Army and Marine Corps crews with sufficient visibility throughout the missions. Crews shared information of potential threats, movements, and activities while moving to maintain shared situational awareness for unit security.
- Both the Oshkosh and Lockheed Martin JLTV prototypes met all threshold force protection requirements and some objective-level requirements. Both of these prototypes provide protection superior to the up-armored HMMWV and similar to the MRAP All-Terrain Vehicle (M-ATV) without the Underbody Improvement Kit across the spectrum of tested threats. Oshkosh implemented lessons learned from the M-ATV program into their JLTV prototypes to provide M-ATV levels of underbody protection on a lighter vehicle. Lockheed Martin's prototype provided protection on par with the M-ATV. However, AM General's prototype would require a significant redesign to meet threshold force protection requirements. Detailed findings on the performance of the vehicle underbody hull structure, armor, energy-attenuating seat and floor designs, and their aggregate impact on survivability against the threshold and other operationally relevant threats, are outlined in DOT&E's classified JLTV LFT&E report.

Recommendations

- Status of Previous Recommendations. The program addressed all previous recommendations.
- FY15 Recommendations. The program should:
  1. Develop a plan to address recommendations identified in DOT&E's Operational Assessment and classified LFT&E reports before production.
  2. Submit the Milestone C JLTV TEMP prior to start of government developmental testing.

M109 Family of Vehicles (FoV)
Paladin Integrated Management (PIM)

Executive Summary

- The Army continued multiple phases of the M109 Family of Vehicles (FoV) Paladin Integrated Management (PIM) LFT&E program at Aberdeen Proving Ground, Maryland, to include testing of the underbody IED protection kit, Automatic Fire Extinguishing Systems (AFES), ballistic protection of modified armored areas, and system response to simulated damaged sub-systems. In FY15, the Army:
  - Validated modifications to the Self Propelled Howitzer's (SPH) Threshold 1 (T1) and Threshold 2 (T2) armor systems, including those made to address vulnerable areas identified in early testing. Most of the modified armored areas provide protection against requirement threats.
  - Integrated and tested changes to the crew compartment AFES in the Carrier, Ammunition Tracked (CAT). These measures mitigated the AFES deficiency identified in earlier, FY14 testing.
  - Verified that the SPH has the potential to provide underbody IED protection against the requirement threat and the objective level threat when equipped with the underbody blast kit. At this time, the Army does not intend to equip the SPH or CAT vehicles with the underbody kit.
- The Army did not address the deficiencies identified in fire survivability testing of the SPH crew compartment AFES and should take measures to reduce vulnerability to fires in the SPH crew compartment.
- The Army began full-up system-level testing of the SPH and CAT resupply vehicle in 1QFY16.

System

- The M109 FoV PIM consists of two vehicles: the SPH and CAT resupply vehicle.
  - The M109A7 SPH is a tracked, self-propelled 155 mm howitzer designed to improve sustainability over the legacy M109A6 howitzer fleet. The full-rate production howitzers will have a modified M109A6 turret with a high-voltage electrical system and a modified Bradley Fighting Vehicle chassis, power train, and suspension. The M109A7 does not include any upgrades to the cannon. A crew of four Soldiers operates the SPH and can use it to engage targets at ranges of 22 kilometers using standard projectiles and 30 kilometers using rocket-assisted projectiles.
  - The M992A3 CAT supplies the SPH with ammunition. The full-rate production ammunition carriers will have a chassis similar to the SPH. The ammunition carriers are designed to carry 12,000 pounds or 98 rounds of ammunition in various configurations. A crew of four Soldiers operates the CAT.

- The Army will equip the SPH and CAT with two armor configurations to meet two threshold requirements for force protection and survivability – Threshold 1 (T1) and Threshold 2 (T2).
  - The base T1 armor configuration is integral to the SPH and CAT. The T2 configuration is intended to meet protection requirements beyond the T1 threshold with add-on armor kits.
  - The Army plans to employ PIM vehicles in the T1 configuration during normal operations and will equip the SPH and CAT with T2 add-on armor kits during combat operations.
- The Army designed an underbody kit to determine the potential protection an SPH and CAT could provide against IEDs similar to those encountered in Iraq and Afghanistan. The Army purchased five underbelly kits for test purposes. At this time, the Army does not intend to equip the SPH or CAT with the underbody kit.
- The Army intends to employ the M109 FoV as part of a Fires Battalion in the Armored Brigade Combat Team and Artillery Fires Brigades, with the capability to support any Brigade Combat Team.
- The Army plans to field up to 557 sets of the M109 FoV with full-rate production planned for FY17.

Mission

Commanders employ field artillery units equipped with the M109 FoV to destroy, defeat, or disrupt the enemy by providing integrated, massed, and precision indirect fire effects in support of maneuver units conducting unified land operations.

Major Contractor

BAE Systems – York, Pennsylvania

Activity

- In FY15, the Army continued LFT&E of the M109 FoV PIM at Aberdeen Proving Ground, Maryland, to include the following:
  - Exploitation testing on the SPH 5A to validate armor modifications. The Army validated modifications to the SPH's T1 and T2 armor systems, including those made to address vulnerable areas identified in early testing.
  - Fire survivability testing. AFES testing in FY14 identified system deficiencies with the crew compartment AFES in both the SPH and CAT. To improve survivability, the Army made changes to the crew compartment AFES in the CAT vehicle. The Army integrated and challenged these changes in test. However, the Army did not address the deficiencies identified in fire survivability testing of the SPH crew compartment AFES.
  - Underbody blast testing against the "SPH 5A", a high-fidelity SPH prototype. The testing included two events with and without an objective-level underbody blast kit.
  - Controlled damage experimentation on selected subsystem (such as the high voltage electrical system) to determine the consequences of various types of damage.
- The Army conducted all testing in accordance with DOT&E-approved test plans.
- The Army began full-up system-level testing of the M109 SPH and CAT resupply vehicle in 1QFY16.

Assessment

- Over the course of the LFT&E program, the Program Office has taken considerable action to correct deficiencies identified in early testing and to validate associated fixes.
  - During armor exploitation testing, most of the modified armored areas demonstrated that they provide protection against Key Performance Parameter threats.
  - Changes to the crew compartment AFES in the CAT mitigate the deficiency identified in early testing and reduce the CAT's vulnerability to fires.
- The crew compartment AFES in the SPH was designed to only protect a localized area in the compartment and therefore remains deficient. The system should be redesigned to improve SPH survivability to fires.
- The Army verified that the base SPH has the potential to provide underbody IED protection against the requirement blast threat and the objective level threat when equipped with the underbody blast kit. Additional underbody blast testing of the SPH and CAT is required to quantify the benefit of equipping both platforms with the kit.

Recommendations

- Status of Previous Recommendations. In FY14, DOT&E recommended the Army correct deficiencies identified in fire survivability testing. In FY15, the Army made design changes to mitigate the deficiencies in the CAT's crew compartment AFES and validated those changes in test. The Army did not incorporate changes to address the deficiencies in the SPH's crew compartment AFES.
- FY15 Recommendation.
  1. The Army should correct the deficiencies in the SPH's crew compartment AFES and validate those fixes in test.

M270A1 Multiple Launch Rocket System (MLRS) Improved Armored Cab (IAC)

Executive Summary

- In December 2008, the Army directed that chassis improvement requirements identified in the approved High Mobility Rocket System (HIMARS) Operational Requirements Document be incorporated in the M270A1 Multiple Launch Rocket System (MLRS) launcher. This resulted in the development of an Improved Armor Cab (IAC) to replace existing M270A1 cabs, improved armor protection, and the addition of mine protective seating. The Army wanted to provide greater crew protection across all fielded MLRS launchers comparable to that provided by the HIMARS.
- The M270A1 IAC is designed to protect the crew against various direct fire, mine blast, and underbody fragmenting improvised explosive device threats.
- The Army completed the M270A1 IAC LFT&E program in September 2015. DOT&E's preliminary analyses of the armor coupon and exploitation test data, and system-level and full-up system-level live fire test data, indicate that the IAC protects the crew against the specified threats.

System

- The M270A1 MLRS is a tracked, indirect fire, field artillery system capable of firing all rockets and missiles in the MLRS Family of Munitions.
- The M270A1 IAC upgrades the crew protection of the currently-fielded M270A1 MLRS.
- This improvement in crew protection is intended to protect the M270A1 crew against a variety of threats, including direct fire, mine blast, and underbody fragmenting IED events.
- The upgrades include cab and hull modifications to improve occupant survivability, and suspension modifications to accommodate the vehicle's increased weight.
- This crew protection upgrade provides M270A1 crewmembers the same protection as currently provided to crews operating the wheeled HIMARS. Both HIMARS and MLRS operate in a similar manner and fire identical rocket and missile munitions.

Mission

Commanders will employ units equipped with the improved M270A1 launcher to provide medium-range field artillery rocket and long-range missile fires in support of ground forces to destroy, neutralize, or suppress the enemy, in accordance with applicable tactics, techniques, and procedures.

Major Contractors

- Lockheed Martin Missile and Fire Control Division Grand – Prairie, Texas (system integrator)
- BAE Ground Systems Division – Santa Clara, California (cab structure, chassis armor)

Activity

- The M270A1 IAC program is being conducted per a December 2008 memorandum from the Office of the Deputy Chief of Staff, G-3/5/7 requiring synchronization of protection requirements across all MLRS launchers. The M270A1 IAC will provide M270A1 crewmembers with protection comparable to that provided by the HIMARS. The IAC is an Engineering Change Proposal to the M270A1 and does not impact the launcher's system performance or the tactics, techniques, or procedures used during tactical operations.
- In January 2015, DOT&E approved the Army's test plan for the live fire testing of the M270A1 IAC. The Army will use the results of live fire testing to determine whether the IAC provides the required crew protection against the required operationally relevant conventional ballistic threats.
- From January through August 2015, the Army conducted six system-level and three full-up system-level live fire events using a production-representative IAC against specified

threats. These threats included mines, fragmenting IEDs, and an explosively-formed projectile.
- The Army also conducted armor coupon and exploitation testing against several threats. Coupon testing produced data that provided general vulnerability insights as well as specific information to support complex vulnerability modeling. Exploitation testing was conducted on a production-representative cab to obtain data on the ballistic protection capabilities of the cab at locations such as seams, edges, and bolts on the cab. The Army completed its exploitation testing in September 2015.
- In 2QFY16, DOT&E intends to submit a classified live fire report for the M270A1 IAC upon completion of testing and analysis of test results.

Assessment

Analysis of the test data is ongoing. DOT&E's preliminary analysis of the armor coupon and exploitation test data, and system-level and full-up system-level live fire test data indicate that the improved armored cab protects the crew against the specified threats. The classified DOT&E report will provide a detailed survivability evaluation of the M270A1 IAC.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. There are currently no recommendations, as analysis of test data is ongoing. DOT&E will include any recommendations in its final live fire report.

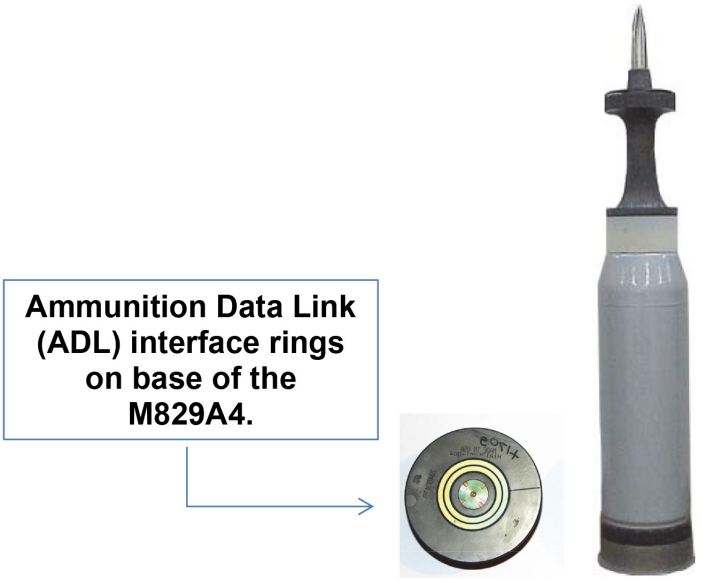
M829A4 (formerly M829E4) Armor Piercing, Fin Stabilized, Discarding Sabot – Tracer (APFSDS-T)

Executive Summary

- The M829A4 120 mm cartridge is a line-of-sight kinetic energy cartridge designed for the Abrams M1A2 System Enhancement Program version 3 (SEPv3) Main Battle Tank (MBT).
- In FY15, the Army implemented changes to the M829A4 cartridge production processes, after multiple test-fix-test iterations to address in-bore structural failures observed in early testing.
- In February 2015, the Army conducted Verification #2 testing at Yuma Proving Ground, Arizona, in order to validate that the newly configured cartridge met reliability requirements.
- In May 2015, the Army completed the seven remaining live fire test events, representing various engagement scenarios against threat target surrogates.
- In October 2015, the Army type-classified the M829E4 cartridge as the M829A4, establishing the cartridge's acceptability for Army use and enabling the Program Office to begin official planning for production and fielding of the cartridge.
- In December 2015, DOT&E submitted the classified M829A4 combined OT&E/LFT&E report and assessed the following:
  - The M829A4 cartridge is lethal and operationally effective. The cartridge's lethality and operational effectiveness are dependent on engagement conditions that are discussed in the classified combined OT&E/LFT&E report.
  - The M829A4 cartridge is suitable. It met its reliability requirement as a point estimate.
  - In comparison to previously fielded kinetic energy cartridges, the M829A4 cartridge is not expected to increase the vulnerability associated with the stowed ammunition in the Abrams M1A2 SEPv3 MBT, if engaged by an overmatching threat.
- The Army's Full-Rate Production decision was in December 2015.

System

- The M829A4 120 mm cartridge is a line-of-sight kinetic energy cartridge designed for the Abrams M1A2 SEPv3 MBT. It is the materiel solution for the Abrams' lethality capability gap against threat vehicles equipped with third-generation explosive reactive armor.
- The M829A4 cartridge is an Armor-Piercing, Fin-Stabilized, Discarding Sabot, with Tracer cartridge consisting of a depleted uranium long-rod penetrator with a three-petal composite sabot.



- The flight projectile includes a low-drag fin with a tracer, windshield, and tip assembly.
- The propulsion system of the M829A4 cartridge is a combustible cartridge case similar to that of the currently fielded suite of Abrams' 120 mm tank cartridges.
- The M829A4 has comparable characteristics to its predecessor, the M829A3, in length, weight, and center of gravity. The visible difference between the two cartridges is the Ammunition Data Link (ADL) interface rings on the base of the M829A4. The rings serve as the interface between the Abrams' fire control system and the M829A4. The ADL enables the Abrams' fire control system to send information to the M829A4.

Mission

Commanders will employ units equipped with Abrams MBTs that use the M829A4 120 mm cartridge to defeat current and projected threat tanks that are equipped with third generation explosive reactive armor and active protection systems. The Army intends the M829A4 to provide lethality beyond its predecessor, the M829A3, enhancing the Joint Forces Commander's capability to conduct decisive operations during Unified Land Operations.

Major Contractor

Alliant Techsystems Inc. (ATK) – Plymouth, Minnesota

Activity

- The Army proposed changes in design configuration and production processes to address in-bore structural failures observed in FY14 testing and improve the cartridge's reliability. After multiple test-fix-test iterations and failure analyses, the Program Office implemented four production process changes.
- In February 2015, the Army conducted Verification #2 testing at Yuma Proving Ground, Arizona, to validate that the newly configured cartridge met reliability requirements.
- The outcome of the second phase of verification testing in February 2015 enabled the Army to resume production of the cartridge and First Article Acceptance Testing.
- In May 2015, the Army completed the seven remaining live fire test events, representing various engagement scenarios against multiple threat target surrogates.
- DOT&E assessed data resulting from ammunition vulnerability testing conducted in FY14.
- The Army type-classified the M829E4 cartridge in October 2015 as the M829A4 establishing the cartridge's acceptability for Army use. This enabled the Program Office to begin official planning for production and fielding of the cartridge.
- DOT&E submitted the classified M829A4 combined OT&E/LFT&E report in December 2015.
- The Army's Full-Rate Production decision was in December 2015.

Assessment

- DOT&E assessed the following in the December 2015 OT&E/LFT&E report:
  - The M829A4 cartridge is lethal and operationally effective. The cartridge's lethality and operational effectiveness are dependent on engagement conditions that are discussed in the classified combined OT&E/LFT&E report.
  - The M829A4 cartridge is suitable. It met its reliability requirement as a point estimate.
  - If engaged by an overmatching threat, the M829A4 cartridge is not expected to increase the vulnerability associated with the stowed ammunition in the Abrams M1A2 SEPv3 MBT in comparison to previously fielded kinetic energy cartridges.

Recommendations

- Status of Previous Recommendations. The Army addressed all previous recommendations.
- FY15 Recommendation.
  1. The Army should address the recommendations detailed in the classified December 2015 Combined OT&E/LFT&E report.

Mid-Tier Networking Vehicle Radio (MNVR)

Executive Summary

- From April through May 2015, the Army conducted a Mid-Tier Networking Vehicle Radio (MNVR) Limited User Test (LUT) as part of the Network Integration Evaluation (NIE) 15.2 at Fort Bliss, Texas, in accordance with a DOT&E-approved test plan.
- DOT&E's evaluation based on the 2015 MNVR LUT is:
  - MNVR enhanced the unit's mid-tier network when operating within a full network, i.e. satellite communications were available.
  - In a reduced satellite network environment, the demonstrated MNVR Wideband Networking Waveform (WNW) network message completion rate was less than 76 percent, which does not meet the Army's MNVR requirement of 90 percent at-the-halt and 85 percent on-the-move.
  - The MNVR WNW network experienced faults that prevented 4 of 12 battalion MNVRs from sending or receiving any data for extended time periods (up to 36 hours).
  - The unit deployed security for MNVR retransmission vehicles (necessary to provide network area coverage). This security requirement reduced the unit's combat power by up to 10 percent.
  - Contractors using the Joint Enterprise Network Manager (JENM) were able to plan, configure, and load MNVRs prior to the MNVR LUT. Soldiers must perform this task in combat and during the MNVR IOT&E).
  - Using JENM, Soldiers could not monitor or manage MNVR networks.
  - The MNVR exceeded its reliability requirements.
  - MNVR was easy to use, but the integration of the radio into tactical vehicles and tactical operation centers (TOCs) requires improvement.
  - MNVR has cybersecurity vulnerabilities that could degrade the unit's ability to accomplish its mission.
- The Army is developing a Test and Evaluation Master Plan (TEMP) to support a January 2016 Milestone C decision to describe post-Milestone C developmental testing and an IOT&E.

System

- The Army's AN/VRC-118 MNVR program evolved from the terminated Joint Tactical Radio System, Ground Mobile Radio to provide software-programmable digital radios to support Army tactical communications requirements from company through brigade.
- The Army intends the MNVR to:
  - Operate at various transmission frequencies using the Soldier Radio Waveform (SRW) and the WNW.

  - Bridge the upper tactical communications networks at brigade and battalion with the lower tactical networks at company employing a terrestrial radio network.
  - Provide an alternative terrestrial transmission path in the absence or limited availability of satellite communications.
- The MNVR operates up to 75 watts maximum power output for WNW and up to 5 watts maximum power output for SRW.
- The JENM provides the means to plan, load, configure, and monitor MNVR networks.
- The MNVR includes both vehicle-mounted and TOC kit versions.
- The MNVR is a non-developmental item selected through multi-vendor competition.

Mission

- Army commanders intend to use the MNVR to:
  - Provide networked communications for host vehicles and TOCs during all aspects of military operations
  - Communicate and create terrestrial radio networks to exchange voice, video, and data using the SRW and the WNW.
  - Share data between different tactical communication networks and mission command systems
- Signal staffs intend to use the JENM to plan, load, monitor, control, and report on network operations of MNVR networks running SRW and WNW.

Major Contractor

Harris Corporation, Tactical Communications – Rochester, New York

Activity

- In November 2014, the Army conducted the Government Integration Test (GIT) at the Electronic Proving Ground in Fort Huachuca, Arizona. The GIT was the first MNVR developmental test and served to test the radio against its requirements. The purpose of GIT was to provide confidence that the MNVR was ready to proceed to the planned LUT. During GIT, MNVR:
  - Demonstrated WNW data and SRW voice and data requirements.
  - Did not meet message completion rate requirements over expected transmission distances of 6 – 10 kilometers.
  - Did not meet reliability requirements. Due to a large number of software faults, MNVR demonstrated less than half of its 477 Mean Time Between Essential Function Failure reliability requirement.
  - Did not interoperate with JENM to receive radio configuration files.
  - Did not employ WNW Anti Jam or SRW Electronic Warfare modes during test.
- In January and February 2015, the Army conducted the Government Regression Test (GRT) at the Electronic Proving Ground in Fort Huachuca, Arizona. The GRT tested capabilities that were not met or were not tested during the GIT, including the JENM, which was not available during the GIT. During GRT, MNVR:
  - Demonstrated the transfer of data files between mission command systems.
  - Routed SRW voice communications over multiple networks.
  - Established a gateway to the Warfighter Information Network – Tactical (WIN-T) Net Centric Waveform satellite network.
  - Interoperated with JENM to load MNVR radio configuration files.
  - Did not employ WNW Anti Jam or SRW Electronic Warfare modes during test.
- In April through May 2015, the Army conducted a MNVR LUT as part of the NIE 15.2 at Fort Bliss, Texas, in accordance with a DOT&E-approved test plan. During the LUT, the Army employed elements of the 2nd Brigade, 1st Armored Division consisting of a combined arms battalion, a field artillery battalion, and a brigade headquarters conducting missions under operationally realistic conditions. Testing assessed the operational employment of the MNVR providing a terrestrial communication pathway for the Joint Battle Command – Platform (JBC-P) and the WIN-T mission command systems, and the system's ability to establish a mid-tier network to link the lower tactical internet with the upper tactical internet.
- The Army is developing a TEMP to support a January 2016 Milestone C decision to describe post-Milestone C developmental testing and an IOT&E.

Assessment

- DOT&E's evaluation based on the 2015 MNVR LUT is:
  - MNVR enhanced the unit's mid-tier network when operating within a full network, i.e. satellite communications were available.
  - In a reduced satellite network environment, the demonstrated MNVR WNW network message completion rate was less than 76 percent, which does not meet the Army's MNVR requirement of 90 percent at-the-halt and 85 percent on-the-move.
  - The MNVR WNW network experienced faults that prevented 4 of 12 battalion MNVRs from sending or receiving any data for extended time periods (up to 36 hours). These MNVRs were within line-of-sight of other MNVRs and should have had communications. Existing test data do not identify whether the problem was due to the radio, WNW, or network configuration.
  - The unit deployed security for MNVR retransmission vehicles (necessary to provide network area coverage). This security requirement reduced the unit's combat power by up to 10 percent.
  - The unit's employment of the mid-tier network carried little data traffic and did not stress the bandwidth capacity of WNW.
  - Contractors using the JENM were able to plan, configure, and load MNVRs prior to the MNVR LUT. Soldiers must perform this task in combat and during the MNVR IOT&E.
  - Using JENM, Soldiers could not monitor or manage MNVR networks, and were not able to characterize the health of individual MNVR nodes or individual WNW links.
  - The MNVR exceeded its reliability requirements within the low network demands of NIE 15.2.
  - The MNVR was easy to use, but the integration of the MNVR into tactical vehicles and TOCs did not support Soldier ease of access during mission operations.
  - MNVR has cybersecurity vulnerabilities that could degrade the unit's ability to accomplish its mission.
- The Army still needs to conduct a complete IOT&E to test all features of MNVR and JENM within an operationally representative unit.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The Army should:
  1. Continue development of the MNVR to correct the deficiencies found during the MNVR LUT.
  2. Develop a Milestone C TEMP that addresses the developmental and operational testing that will support a Full-Rate Production decision.
  3. Plan and conduct an MNVR IOT&E using an Infantry Brigade Combat Team equipped with JBC-P, WIN-T Increment 2, and MNVR in accordance with an approved MNVR basis of issue plan.

Mine Resistant Ambush Protected (MRAP) MaxxPro Long Wheel Base (LWB) Ambulance

Executive Summary

- In May 2015, the Army Test and Evaluation Command (ATEC) conducted the Long Wheel Base (LWB) Ambulance Limited User Test (LUT) at Yuma Proving Ground, Arizona, in accordance with the DOT&E-approved test plan.
- The LWB Ambulance is operationally effective and operationally suitable. An Army unit equipped with the LWB Ambulance can provide safe, emergency medical care and protected transport for casualties in close proximity to enemy forces.
- The LWB Ambulance has improved capability to carry casualties over the Dash Ambulance:
  - Accommodates litter patients taller than 5 feet 11 inches
  - Holds more mission essential medical equipment
  - Provides sufficient space for medics to maneuver within the vehicle to treat casualties
- The LWB Ambulance is reliable. During the LWB ambulance LUT, the vehicle demonstrated 1,025 Mean Miles Between Operational Mission Failure (MMBOMF) versus its operational requirement of 600 MMBOMF.
- The LWB ambulance meets its required levels of force protection, and, in the case of underbody blast, exceeds the objective-level requirements at some locations. This assessment is based on testing conducted with the LWB ambulance, and leverages test data from the legacy MaxxPro Mine Resistant Ambush Protected (MRAP) and the MaxxPro Dash with MaxxPro survivability upgrade.

System

- The LWB Ambulance variant:
  - Is an all-terrain MRAP ambulance for evaluating and treating casualties from forward areas
  - Has a rail, trolley, and hoist system for litter loading/unloading and gun mounts with gunner protection kits on which to mount any one of a variety of weapons, such as the M240B medium machine gun, the M2 .50 caliber heavy machine gun, and the Mk 19 grenade launcher

MaxxPro Long Wheel Base (LWB) Ambulance

  - Incorporates current Service command and control systems and counter-IED systems
  - Incorporates the MaxxPro Survivability Upgrade kit that is installed on MaxxPro Dash variants
- The ambulance is operated by a crew of three medical Service members and accommodates two patients on litters, four ambulatory patients, or a combination of one litter patient and two ambulatory patients.

Mission

Army commanders will employ units equipped with the LWB Ambulance to provide safe, emergency medical treatment and protected transport for casualties in close proximity to enemy forces.

Major Contractor

Navistar Defense – Warrenville, Illinois

Activity

- As part of the Army MRAP enduring fleet requirement, the program is producing 301 ambulances to be placed in Army Pre-positioned Stocks and training base in June 2015. The Army procured the LWB Ambulance to resolve deficiencies with the small interior of the Dash Ambulance to effectively care and safely accommodate litter patients taller than 5 feet 11 inches.
- ATEC completed developmental testing at Aberdeen Proving Ground, Maryland, and Yuma Proving Ground, Arizona, in April 2015.
- In May 2015, ATEC conducted the LWB Ambulance LUT at Yuma Proving Ground, Arizona, in accordance with the DOT&E-approved test plan.

Assessment

- The LWB Ambulance is operationally effective and operationally suitable. An Army unit equipped with the LWB Ambulance can provide safe, emergency medical care and protected transport for casualties in close proximity to enemy forces. During the LWB Ambulance LUT, the unit successfully accomplished four out of five medical evacuation missions.
- The LWB Ambulance has improved capability to carry casualties over the Dash Ambulance:
  - Accommodates litter patients taller than 5 feet 11 inches
  - Holds more mission essential medical equipment
  - Provides sufficient space for medics to maneuver and treat casualties within the vehicle
- The LWB Ambulance demonstrated off-road mobility and maneuver capability similar to the Dash Ambulance.
- Although medics can load and unload litter patients with the LWB Ambulance using the rail, trolley, and hoist system, loading patients is hampered due to misalignment of the rails when the system is deployed.
- The LWB Ambulance is reliable. During the LWB Ambulance LUT, the vehicle demonstrated 1,025 MMBOMF versus its operational requirement of 600 MMBOMF. The vehicle can be maintained by Soldiers and is recoverable.
- The LWB Ambulance cannot safely accommodate litter patients taller than 6 feet 5 inches due to the location of medical and vehicle equipment in the patient compartment. The equipment is in close proximity to the patient's head on the litter that may cause additional injury to the litter patient.
- The height of the gunner stand/medic seat is not suitable for shorter Soldiers to effectively provide protective fires. During the LUT, shorter Soldiers positioned the gunner stand/medic seat in an unsafe manner to raise its height to observe their surroundings and engage threats.
- The LWB Ambulance lacks stabilizing handhold and inertial locking seat belts to allow medics to safely maneuver within the patient compartment and treat patients during transit. Medics required tactical halts to treat patients during the LUT.
- LFT&E conducted in FY14 indicates the vehicle provides underbody protection beyond its required levels. The LWB Ambulance was tested against underbody mines and IEDs to determine potential vulnerabilities introduced by the integration of LWB Ambulance mission equipment. Test data from legacy MaxxPro MRAPs establishing compliance with additional force protection requirements are applicable to the LWB Ambulance. Of the MRAP vehicles the DOD has retained, the MaxxPro MRAP variants set the standard for underbody blast protection.

Recommendations

- Status of Previous Recommendations. There were no previous recommendations for this variant.
- FY15 Recommendations. The program should:
  1. Relocate the installed medical and vehicle equipment with the objective of providing additional head space to accommodate litter patients taller than 6 feet 5 inches.
  2. Improve the litter rail hoist system to eliminate misalignment of the rail and improve patient loading time.
  3. Redesign gunner stand/medic seat to allow height adjustment to accommodate shorter medics.

MQ-1C Gray Eagle Unmanned Aircraft System (UAS)

Executive Summary
- The Army conducted the MQ-1C Gray Eagle Unmanned Aircraft System (UAS) FOT&E at Edwards AFB, California, and the National Training Center (NTC), Fort Irwin, California, May 14 through June 12, 2015, in accordance with the DOT&E-approved test plan and Test and Evaluation Master Plan.
- DOT&E submitted an FOT&E report in January 2016. In that report, DOT&E concludes:
  - The Gray Eagle-equipped unit was effective at conducting split-based operations while operating the system from two separate launch and recovery sites and can provide effective reconnaissance, surveillance, and security support to combat units.
  - Interoperability with the One System Remote Video Terminal (OSRVT) has improved since the 2012 IOT&E.
  - The Gray Eagle system is operationally suitable.
  - Army integration of Gray Eagle into employment concepts, and development of tactics, techniques, and procedures (TTP) have not matured since IOT&E, and training for the FOT&E unit before the test was not complete.

System
The Gray Eagle UAS is composed of the following major components:
- Twelve unmanned aircraft, each with a common sensor payload with an electro-optical/infrared (EO/IR) and a Laser Range Finder/Laser Designator capability, a STARLite Extended Range Synthetic Aperture Radar/Ground Moving Target Indicator (SAR/GMTI) radar, and an Air Data Relay (ADR) control capability
- Each aircraft is equipped with a Standard Equipment Package that includes a communications relay package, Identification Friend-or-Foe equipment, and Air Traffic Control radios
- Each aircraft has the ability to carry up to four HELLFIRE II P+ or R variant missiles
- Six Ground Control Stations designated as the Universal Ground Control Station (UGCS)

- One Mobile Ground Control Station
- Seven Tactical Common Datalinks Ground Data Terminals
- Three Satellite Communications Ground Data Terminals
- Twelve Satellite Communications Air Data Terminals
- Six Tactical Automatic Landing Systems

Mission
Commanders employ Gray Eagle companies to conduct reconnaissance, surveillance, security, attack, and command and control missions that support assigned division combat aviation brigade, division artillery, battlefield surveillance brigade, Brigade Combat Teams, and other Army and joint force units based upon the division commander's mission priorities.

Major Contractor
General Atomics Aeronautical Systems, Inc., Aircraft Systems Group – Poway, California

Activity
- The Army conducted the Gray Eagle FOT&E at Edwards AFB, California, and NTC, Fort Irwin, California, May 14 through June 12, 2015, in accordance with the DOT&E-approved test plan and Test and Evaluation Master Plan.
- The FOT&E unit conducted missions in support of the Brigade Combat Team conducting a training rotation at the NTC. This combination of testing with training created a realistic, challenging, and stressful test environment for the Gray Eagle Company. The company flew 1,147 flight hours during test.
- The Army collected data from the FOT&E to assess significant changes within the company's organizational structure and system components. These changes include:
  - Organizational structure from one flight platoon to three identical flight platoons

  - The capability of the company to conduct continuous and simultaneous split-based operations from two separate launch and recovery sites
  - The replacement of the One System Ground Control Equipment with the Universal Ground Control Equipment
  - The replacement of the three portable subsystems with one Mobile Ground Control Station
  - Upgrades to the payloads and the HELLFIRE missile, and significant software functionality enhancements made to the system since IOT&E
- During the FOT&E, Gray Eagle crews completed three autonomous HELLFIRE missile engagements of targets on the NTC range and examined the capability of the Gray Eagle UAS to interface with OSRVT Increment II.
- DOT&E submitted a combined Gray Eagle FOT&E and OSRVT IOT&E report in January 2016.

Assessment

- During FOT&E, the Gray Eagle-equipped unit demonstrated it was effective at conducting split-based operations from two separate launch and recovery sites and can provide effective reconnaissance, surveillance, and security support to combat units. Split-based operations testing exposed single points of failure in equipment and personnel within the Gray Eagle organizational structure.
- The Gray Eagle unit contributed to the situational awareness of supported units at NTC. In surveys of subject matter experts with the supported units, 32 of 36 respondents agreed that Gray Eagle provided all the information required. Gray Eagle crews located and reported enemy vehicles in 42 of 48 mission segments when at least one threat vehicle was in the designated search area.
- The Army has not effectively integrated the Gray Eagle capabilities into combined arms combat operations. Gray Eagle TTP have not matured since the 2012 IOT&E. Although not fully trained before the test, Gray Eagle Soldiers became more proficient during the test, but many remained weak on the fundamentals of reconnaissance, mission planning, and employment of Gray Eagle sensors. Neither the Soldiers in the Gray Eagle unit nor those requesting Gray Eagle support understood the capabilities, limitations, and employment of the SAR/GMTI radar.
- Compared to the OSRVT Increment I performance during the 2012 Gray Eagle IOT&E, OSRVT Increment II facilitated an increased level of situational awareness of the supported unit by providing more effective full motion video. Additional information on the OSRVT demonstrated performance may be found in the OSRVT Increment II Annual Report.
- Gray Eagle is operationally suitable. The Gray Eagle system demonstrated an operational availability of 87.4 percent, higher than the 76 percent availability demonstrated during IOT&E. High availability, low Mean Time To Repair, and system redundancy allowed operators to meet operational requirements.
- The Gray Eagle demonstrated Key System Attribute Mean Time Between System Abort of 23 hours versus the 42 hours requirement for the Ground Control Equipment; 67 hours versus 63 hours requirement for the aircraft; 1,146 hours versus 300 requirement for the common sensor payload; and 53 hours versus 89 hours requirement for the SAR/GMTI radar.
- Integration of the HELLFIRE II Romeo missile into the Gray Eagle system is complete. During FOT&E, the unit successfully demonstrated the ability to conduct engagements with the HELLFIRE II Romeo missile. Three autonomous engagements of targets on the NTC range complex were completed. The unit hit two of the three intended targets. The Army demonstrated HELLFIRE engagement via the ADR datalink in developmental testing.
- The Gray Eagle cybersecurity posture has improved, but the system remains vulnerable to cyber and electronic warfare threats.
- The Gray Eagle Operator's Manual states that flight through light rain for 1 hour falling at a rate of up to ½ inch per hour poses no hazards to the aircraft and that operation of the aircraft in heavier rain than this rate is not recommended. Visible moisture can induce mismatched pressure inputs to the engine computer resulting in a warning to operators to land as soon as possible, creating a mission abort. During FOT&E, the unit did not conduct flight operations when any visible moisture conditions (fog, clouds, and rain) were present. This practice limited and at times precluded tactical operations support.
- The design of the UGCS shelter is an improvement over the One System GCS seen in previous testing, but has a number of deficiencies that reduce operator efficiency and increase operator stress and fatigue. Those deficiencies include:
  - Operators reported that headsets became uncomfortable over a period of time and pose a health risk because the operators must share the few headsets.
  - The Aviation Mission Planning System is not well integrated into the UGCS set up /starting procedures. Operators must manually input most pre-mission data.
  - Payload and Air Vehicle Operators rated the usability of UGCS controls. Operators rated the controls for Link 16 and ADR datalink as not acceptable. Payload operators gave marginal ratings to the controls for the SAR/GMTI radar and to the interfaces between the radar and EO/IR sensor.
  - UGCS employs a thumb-force controller on the keyboard that replaced the mouse track ball in the One System GCS. Operators state that the thumb-force controller is not smooth or responsive during operation and after periods of non-use, the curser tends to drift. Both the Air Vehicle and Payload operators rated the thumb-force controller usability as not acceptable.
- Since IOT&E, the Army has incorporated improvements to ADR usability and has reduced the number of steps required to establish the ADR capability from 130 to 93. While the 28 percent reduction in the number of steps is admirable, further improvements need to be made.

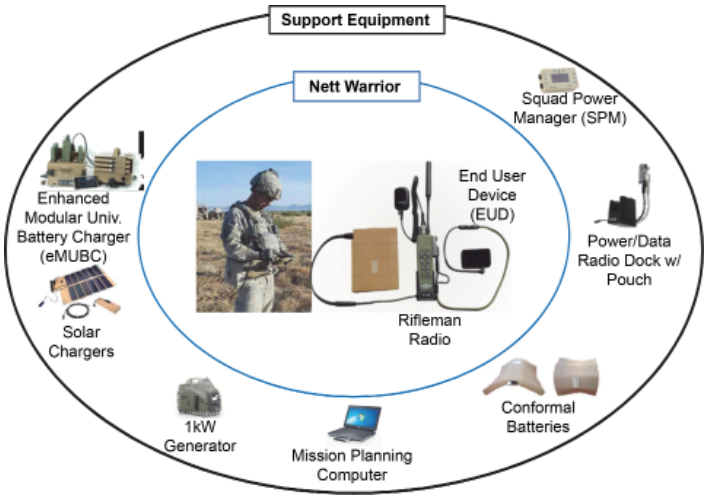
Recommendations

- Status of Previous Recommendations. The Army addressed three of the six FY12 recommendations. Outstanding previous recommendations include:
  1. Continue to develop doctrine, employment concepts, and TTP to fully integrate the Gray Eagle unit into combat operations.
  2. Train operators on fundamentals of reconnaissance, mission planning, and optimal employment of the Gray Eagle.
  3. Continue to simplify procedures for operators to establish ADR datalinks.
- FY15 Recommendations. The Army should:
  1. Implement plans to modify the engine computer sensor inputs that will allow flight in visible moisture.
  2. Develop TTP, and train Gray Eagle operators and supported combat units in the utility of and employment of SAR/GMTI radar and Link 16 capabilities.
  3. Simplify and integrate Aviation Mission Planning System into pre-mission UGCS setup procedures.
  4. Review unit organizational documents for personnel and equipment single points of failure affecting split-based operations and make adjustments to those documents as necessary.
  5. Eliminate cybersecurity vulnerabilities and confirm corrections in follow-on testing.
  6. Improve UGCS functionality by addressing the operator headset and thumb-force controller observations made during test.
  7. Integrate the SAR/GMTI radar controls and displays with the EO/IR controls and displays. Target detections from the MTI radar in particular should overlay the same map that displays the location of the air vehicle and the footprint of the EO/IR sensor.

Nett Warrior

Executive Summary
- The Army Test and Evaluation Command conducted the Nett Warrior IOT&E in two phases:
  - A mounted calvary troop conducted Phase 1 during Network Integration Evaluation 14.2 at Fort Bliss, Texas (May 2014).
  - A dismounted rifle company conducted Phase 2 at Fort Polk, Louisiana (November 2014).
- DOT&E published an IOT&E report in May 2015 to support an Army Full-Rate Production (FRP) Decision Review in June 2015. Nett Warrior is operationally effective in mounted formations at the platoon and troop levels. It improved situational awareness, pre-mission planning, land navigation, and command and control.
- In dismounted infantry units, Nett Warrior is effective at the platoon level, but not effective at the company level due to the Manpack radio's low message completion rate of position location information, which prevented the Company Commander from having full situational awareness of subordinate units during operations.
- Nett Warrior is operationally suitable and reliable.
- The Army Acquisition Executive (AAE) authorized a fourth low-rate initial production to procure up to 9,636 Nett Warrior systems.

System
- Nett Warrior is a dismounted leader situational awareness system for use during combat operations. Nett Warrior consists of the following:
  - End User Device, a commercial off-the-shelf Samsung smartphone
  - Government-furnished Rifleman Radio (AN/PRC-154A) (Rifleman Radio is a separate program of record, with a separate article later in this Annual Report.)
  - Conformal battery
  - Connecting cables
  - Supporting charging equipment
- Periodic Nett Warrior enhancements integrate improved commercial smartphone technologies.
- Nett Warrior graphically displays the location of an individual leader, other leaders, friendly vehicles, battlefield messages,



and enemy activity on a digital geo-referenced map image. Nett Warrior is connected through a secure radio to the Soldier Radio Waveform network to communicate among different echelons using voice, data, and position location information messages.

Mission
- Combatant Commanders employ Nett Warrior-equipped mounted and dismounted leaders as part of a Brigade Combat Team to conduct operations (offensive, defensive, stability, and defense support of civil authorities) against conventional or unconventional enemy forces in all types of terrain and climate conditions.
- Leaders within the Brigade Combat Team use Nett Warrior to provide improved situational awareness, command and control, and enhanced communications.

Major Contractors

AN/PRC-154A Rifleman Radio:
- General Dynamics C4 Systems – Scottsdale, Arizona
- Thales Communications Inc. – Clarksburg, Maryland

Activity
- The Army Test and Evaluation Command conducted the Nett Warrior IOT&E in two phases:
  - Phase 1, conducted by a mounted cavalry troop during Network Integration Evaluation 14.2 at Fort Bliss, Texas, in May 2014.
  - Phase 2, conducted by a dismounted rifle company at Fort Polk, Louisiana, in November 2014.
- DOT&E published an IOT&E report in May 2015 to support the FRP Decision Review in June 2015.

- The AAE deferred the FRP decision pending validation of interoperability of Nett Warrior with the FRP Manpack radio. The Army and DOT&E will validate interoperability during the Manpack radio's operational test in FY17.
- The AAE authorized a fourth low-rate initial production decision to procure up to 9,636 Nett Warrior systems totaling 20,503, which accounts for 33 percent of the Approved Acquisition Objective.
- The Army conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plans.

Assessment

- Nett Warrior is operationally effective in mounted formations at the platoon and troop levels. It improved situational awareness, pre-mission planning, land navigation, and command and control.
- In dismounted infantry units, Nett Warrior is effective at the platoon level, but not effective at the company level due to the Manpack radio's low message completion rate for position location information, which prevented the Company Commander from having full situational awareness of subordinate units during operations.
- Nett Warrior is operationally suitable and reliable.
- Nett Warrior demonstrated a reliability of 226 hours Mean Time Between Essential Function Failure. There is a 90 percent probability of operating for 24 hours without incurring an Essential Function Failure.
- Recharging batteries to support Nett Warrior is an increased logistical burden. The process to operate four to five generators and associated battery chargers to charge all batteries to equip a light infantry company takes three to four Soldiers, 12 to 15 hours a day.

Recommendations

- Status of Previous Recommendations. The Army addressed all previous recommendations.
- FY15 Recommendations. The Army should:
  1. Improve the Soldier Radio Waveform network and associated radios to increase the range at which Soldiers and leaders can use Nett Warrior.
  2. Conduct all future Rifleman Radio and Manpack radio operational testing with the Nett Warrior system.

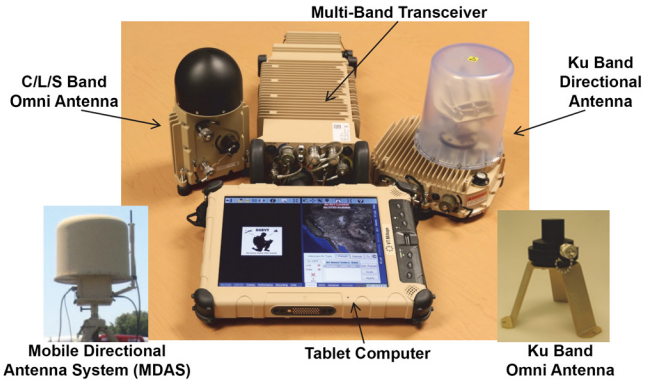
One System Remote Video Terminal (OSRVT) Increment II

Executive Summary

- The Army conducted the One System Remote Video Terminal (OSRVT) Increment II IOT&E in conjunction with the Gray Eagle Unmanned Aircraft System (UAS) FOT&E at Edwards AFB, California, and the National Training Center (NTC) in Fort Irwin, California, from May 14 through June 2, 2015. The Army conducted the test in accordance with the DOT&E-approved test plan and the Test and Evaluation Master Plan.
- During IOT&E, the OSRVT demonstrated the capability to interface with the Gray Eagle UAS and support combat operations.
- Compared to the OSRVT Increment I performance during the 2012 Gray Eagle IOT&E, OSRVT Increment II facilitated an increased level of situational awareness of the supported unit by providing more effective full motion video.
- The Army has simplified procedures for OSRVT operators to connect to and receive Gray Eagle video, but they remain arduous and at times not successful. In addition to receiving full motion video, OSRVT operators exercised control of the Gray Eagle electro optical/infrared (EO/IR) sensor. Operators achieved this capability, known as Level of Interoperability 3 (LOI 3), on six missions during the test, but had to frequently re-establish the LOI 3 datalink during each of those missions.

System

- The OSRVT system is a portable transceiver unit configured to receive imagery and metadata from selected manned and unmanned aircraft. It is modular in design and configured for mounted or dismounted operations or placement in a Tactical Operations Center.
- The OSRVT Increment II builds upon the capabilities of the currently fielded OSRVT Increment I. Increment I is a remote video, radio frequency-based, line-of-sight multi-band, receive-only system. In addition to the Increment I capabilities, the OSRVT Increment II provides a bi-directional communications capability that allows LOI 2 and 3 of unmanned aircraft platforms. LOI 2 allows direct receipt of imagery and/or data from a UAS. LOI 3 allows the OSRVT operator to control the UAS EO/IR payload. Increment II also provides a National Security Agency-approved Type-1 datalink encryption capability.
- The OSRVT has three major subsystems:
  - A Multi-Band Transceiver, capable of receiving and transmitting digital data
  - Display/Computing subsystem (Tablet Computer), to receive, view, and transmit video and run the software to provide the capability to overlay telemetry data or text onto moving maps for enhanced geo-spatial situational awareness
  - Antennas, including the Mobile Directional Antenna System for extended range beyond 50 kilometers



Mission

Commanders and Soldiers at all echelons employ the OSRVT system to gain and maintain situational awareness during an operation, thus enabling the user to visualize the battlefield by receiving full motion video at standoff ranges.

Major Contractor

Textron, Unmanned Systems – Hunt Valley, Maryland

Activity

- The Army conducted the OSRVT Increment II IOT&E in conjunction with the Gray Eagle UAS FOT&E at Edwards AFB, California, and the NTC in Fort Irwin, California, from May 14 through June 12, 2015, in accordance with the DOT&E-approved test plan and the Test and Evaluation Master Plan.
  - During tactical operations in the IOT&E, a Stryker Brigade Combat Team used OSRVT Increment II while conducting a training rotation at the NTC. The Brigade Combat Team employed the OSRVT Increment II from brigade down to company level.

  - The Army collected data during the OSRVT IOT&E to assess the OSRVT-equipped units' increased situational awareness and mission accomplishment as a result of the full motion video and LOI 3 capabilities that the OSRVT Increment II provides.
- DOT&E submitted a combined Gray Eagle FOT&E and OSRVT IOT&E report in January 2016.

Assessment

- Compared to the OSRVT Increment I performance during the 2012 Gray Eagle IOT&E, OSRVT Increment II facilitated an increased level of situational awareness of the supported unit by providing more effective full motion video.
- The Army has simplified procedures for OSRVT operators to connect to and receive Gray Eagle video, but they remain arduous and at times not successful. In addition to receiving full motion video, OSRVT operators exercised control of the Gray Eagle EO/IR sensor. Operators achieved this capability, known as LOI 3, on six missions during the test, but had to frequently re-establish the LOI 3 datalink during each of those missions.
- In a detailed analysis of missions supporting units at NTC, units receiving OSRVT video from Gray Eagle located threat targets in a shorter timeframe than other units that received Gray Eagle support, but without OSRVT video.
- Testing demonstrated that LOI 3 is capable in two of the three Gray Eagle modes of control, satellite communication and line-of-sight. Testing also demonstrated that during the Air Data Relay mode of control, the LOI 3 capability is not possible. This technical limitation cannot currently be resolved.
- The OSRVT Increment II has multiple cables, which connect the transceiver to the other system components. These cable connections on the transceiver are spaced too close together and connecting them is difficult, even under ideal conditions.
  - During test, when under limited-visibility conditions and while adhering to noise and light discipline, Soldiers were not able to use lights and therefore, the operators could not easily connect the cables to the transceiver. This caused the OSRVT operators to wait for daylight to complete emplacement resulting in loss of time that the system could have been operational. Operators stated that the multiple cables should be color coded to facilitate ease of system set up.
- The OSRVT is vulnerable to cybersecurity threats.
- The OSRVT Increment II Capability Production Document states there is no reliability requirement for the system. The OSRVT reliability characterization during test resulted in zero system aborts and two essential function failures during the total 892 LOI 2 (882.3 hours) and LOI 3 (9.7 hours) operating time, indicating the system is suitable to support combat operations.

Recommendations

- Status of Previous Recommendations. The Army addressed all previous recommendations in the FY12 Gray Eagle Annual Report concerning OSRVT operations. However, this is the first annual report for the OSRVT program.
- FY15 Recommendations. The Army should:
  1. Simplify procedures to establish and improve the reliability of LOI 3 connectivity.
  2. Investigate and if possible rectify the inability of LOI 3 functionality when the Gray Eagle aircraft is flown via the Air Data Relay mode of control.
  3. Increase the space between the cable connections on the transceiver to provide the operators more room to connect the required system cables and color code the cables to facilitate ease of system set up.
  4. Eliminate cybersecurity vulnerabilities and confirm corrections in follow-on testing.

Patriot Advanced Capability-3 (PAC-3)

Executive Summary
- The Army conducted Patriot Advanced Capability-3 (PAC-3) lethality high-speed sled testing in May 2015 through June 2015, and testing of lethality enhancements from July 2015 through October 2015.
- The Army began the Patriot Post-Deployment Build-8 (PDB-8) developmental T&E in July 2015.

System
- Patriot is a mobile air and missile defense system that counters missile and aircraft threats.
- The system includes the following:
  - C-band multi-function phased-array radars for detecting, tracking, classifying, identifying, and discriminating targets and supporting the guidance functions
  - Battalion and battery battle management elements
  - Communications Relay Groups and Antenna Mast Groups for communicating between battery and battalion assets
  - A mix of Patriot PAC-3 hit-to-kill missiles and PAC-2 blast fragmentation warhead missiles for negating missile and aircraft threats
- The newest version of the PAC-3 missile under development is the PAC-3 Missile Segment Enhancement (MSE). The MSE provides increased battlespace defense capabilities and improved lethality over prior configuration Patriot missiles.
- Earlier versions of Patriot missiles include the Patriot Standard missile, the PAC-2 Anti-Tactical Missile, the Guidance Enhanced Missile (GEM) family (includes the GEM-T and GEM-C missile variants intended to counter tactical ballistic missiles and cruise missiles), the PAC-3 (baseline), and the PAC-3 Cost Reduction Initiative variant.

Mission
Combatant Commanders use the Patriot system to defend deployed forces and critical assets from missile and aircraft attack and to defeat enemy surveillance air assets (such as unmanned aerial vehicles) in all weather conditions and in natural and induced environments.

Major Contractors
- Prime: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts (ground system and PAC-2 and prior generation missiles)
- PAC-3, Cost Reduction Initiative, and MSE Missiles: Lockheed Martin Corporation, Missile and Fire Control – Grand Prairie, Texas

Activity
- The Army conducted high-speed sled testing of the MSE missile against two threat sub-munition warheads at the High-Speed Sled Test Track in May 2015 through June 2015, at Holloman Air Force Base, New Mexico.
- The Army began the PDB-8 developmental T&E in July 2015, at White Sands Missile Range, New Mexico. The ground portion of this testing concluded in October 2015, with developmental flight testing scheduled for November 2015, December 2015, March 2016, and July 2016.
- The Army conducted testing of the MSE Lethality Enhancer titanium fragments against Composition B explosive to validate Jacobs-Roslund equations from July 2015 through October 2015, at Army Research Laboratory, Maryland. These equations predict when a high-explosive initiation should occur within a warhead impacted by fragments.
- The Army plans to conduct the next Patriot operational test, the PDB-8 IOT&E, beginning in September 2016. This IOT&E will provide information to support the Patriot Full-Rate Production decision (including the MSE missile).
- The Army conducted all testing in accordance with a DOT&E-approved test plan.

Assessment

- Problems previously discovered during the PDB-7 Limited User Test (LUT), if not corrected during PDB-8 development, could adversely affect PDB-8 effectiveness, suitability, or survivability. These problems, the details of which can be found in the classified April 2013 Patriot PDB-7 LUT report, include:
  - Patriot performance against some threats improved compared to PDB-6.5, but there were degradations in performance against other threats. Patriot had some effectiveness shortfalls.
  - Patriot ground system reliability did not meet the threshold requirement, but would have if the Patriot radar achieved its allocated reliability goal.
  - Patriot ground system maintainability did not meet the threshold requirement.
  - Patriot training remained inadequate to prepare operators for complex Patriot engagements. This was true during the PDB 6.5 and PDB-6 LUTs as well.
  - Patriot experienced some survivability and cybersecurity shortfalls.
- The MSE high-speed sled test data are being analyzed to validate lethality models of MSE lethality against the tested targets.
- The lethality enhancer contribution to MSE lethality against air-breathing targets is to be determined. The requirement for additional sled testing is contingent upon the results of simulations of air-breathing target engagements throughout the MSE battlespace.
- Data analysis for the PDB-8 DTE is ongoing.

Recommendations

- Status of Previous Recommendations. The Army satisfactorily addressed 14 of the previous 23 recommendations. The Army should continue to address the following recommendations:
  1. Conduct Patriot air and missile defense testing during joint and coalition exercises that include large numbers of different aircraft types, sensors, battle management elements, and weapons systems. Conduct Red Team penetration testing during joint exercises to test Patriot cybersecurity.
  2. Conduct a Patriot flight test against an anti-radiation missile target to validate models and simulations.
  3. Improve Patriot training to ensure Patriot operators are prepared to use the system in combat.
  4. Have Patriot participate with live missiles in Terminal High Altitude Area Defense (THAAD) flight testing to determine Patriot-to-THAAD interoperability and the capability for Patriot to intercept tactical ballistic missile targets that are not intercepted by THAAD.
  5. Collect operational reliability data on Patriot systems in the field so that the Mean Time Between Critical Mission Failure can be calculated.
  6. Use test units for future Patriot operational tests that have operationally representative distributions in Soldier proficiency.
  7. Conduct future operational flight tests with unannounced target launches within extended launch windows.
  8. Improve Patriot radar reliability.
  9. Obtain the data required to validate GEM missile blast lethality in the Lethality End Game Simulation.
- FY15 Recommendations. None.

Precision Guidance Kit (PGK)

Executive Summary

- In May 2015, the Army conducted the Precision Guidance Kit (PGK) IOT&E in accordance with a DOT&E-approved test plan.
- PGK's demonstrated accuracy and reliability achieved the Army's desired mission effects. Remaining reliability failure modes should be addressed to further enhance PGK effectiveness.
- In January 2016, DOT&E published an IOT&E report assessing the following:
  - PGK is operationally effective. A field artillery unit equipped with PGK can deliver effective, near-precision fires when firing PGK-fuzed conventional, unguided 155 mm high-explosive projectiles.
  - PGK is accurate. PGK exceeded its accuracy requirement of 50 meters Circular Error Probable (CEP) by demonstrating a median radial miss distance of 10 meters in accuracy testing. Accuracy data indicate that with 90 percent confidence, the true CEP is less than or equal to 20.9 meters.
  - PGK is operationally suitable. PGK met its reliability requirement of 92.0 percent at a point estimate (92.1 percent) but not with confidence. PGK's achieved accuracy causes PGK-fuzed projectiles to exceed expected effectiveness even with a reliability that does not meet the reliability requirement with confidence.
  - PGK is survivable. Cybersecurity assessments identified vulnerabilities that indicate PGK may be susceptible to cyber threats with physical access to the fuze.
  - Cybersecurity testing of PGK and the M777A2 lightweight, towed 155 mm howitzer identified vulnerabilities which affect the operational employment of PGK. Cybersecurity assessments of the Army's end-to-end artillery fire support mission-processing system should be conducted to identify and support mitigation of vulnerabilities, which could affect the effectiveness of all artillery fire support systems.
  - A Full-Rate Production (FRP) decision is scheduled for 2QFY16.

System

- PGK is a combined fuze and GPS guidance module that improves the ballistic accuracy of the current stockpile of high-explosive, field artillery projectiles.
- The Army developed PGK for 155 mm, high-explosive projectiles (M795 and M549A1) with a threshold accuracy of 50 meters CEP and objective accuracy of 30 meters CEP.

- The PGK will operate with existing and developmental artillery systems that have digital fire control systems and inductive fuze setters, such as the M777A2 Lightweight Towed Howitzer, the M109A6 Paladin Self-Propelled Howitzer, and the M109A7 Paladin Integrated Management Self-Propelled Howitzer.
- The procurement objective is 102,921 PGK fuzes. The Army plans to enter full-rate production in 2QFY16.

Mission

Field artillery units employ PGK-fuzed projectiles to support maneuver units with indirect fires with less than a 50-meter accuracy. PGK-fuzed projectile accuracy allows field artillery units to fire fewer projectiles to achieve comparable effects of conventionally-fuzed artillery ammunition.

Major Contractor

Orbital ATK Advanced Weapons Division – Plymouth, Minnesota

Activity

- Following an unsuccessful attempt to move the beyond low-rate initial production line from Minnesota to West Virginia in 2013, Orbital ATK moved the production line back to the original contractor production facility in Minnesota in 2014.
- In November 2014, the contractor delivered the First Article sample of PGK's from the Minnesota production line to the government. These PGK's successfully completed a First Article Acceptance Test and safety testing at Yuma Proving Ground, Arizona, in December 2014, and cold regions testing at Fort Greely, Alaska, in January 2015.
- In March 2015, the Army conducted a cybersecurity vulnerability and penetration assessment of the PGK fuze and the Army's M777A2 lightweight, towed 155 mm howitzer.
- DOT&E approved an updated PGK Test and Evaluation Master Plan on April 24, 2015.
- In April 2015, the Army conducted the first of four Lot Acceptance Tests (LATs) to be conducted in FY15 in support of the scheduled FRP decision. Following successful completion of these tests, the Army accepted 1,539 low-rate initial production PGKs for fielding to Army units.
- In May 2015, the Army conducted the PGK IOT&E in accordance with a DOT&E-approved test plan.
  - During the test, a towed howitzer battery from the Army's 10th Mountain Division fired 24 tactical PGK missions from M777A2 howitzers against an array of threat representative targets.
  - The Army conducted an Adversarial Assessment to determine the ability of a unit equipped with PGK to protect, defend, recover and restore effective unit operations while withstanding validated and representative cyber threat activity.
- In January 2016, DOT&E published an IOT&E report supporting the Army's planned FRP decision. The report analyzed data from testing, three of the four LATs, and multiple developmental performance and safety test events conducted prior to September 2015.

Assessment

- DOT&E assessed the following based on observations from the IOT&E and LATs 1 through 3:
  - PGK is operationally effective. A field artillery unit equipped with PGK can provide effective, near-precision indirect fires when firing PGK-fuzed conventional, unguided 155 mm high-explosive projectiles in support of maneuver units.
  - PGK is accurate. PGK exceeded its accuracy requirement of 50 meters CEP by demonstrating a median radial miss distance of 10 meters in accuracy testing. Accuracy data indicate that with 90 percent confidence the true CEP is less than or equal to 20.9 meters.
  - PGK is operationally suitable. In LATs 1 through 3, PGK met its reliability requirement of 92.0 percent at a point estimate (92.1 percent) but not with confidence. The lower bound of an 80 percent confidence interval is 88.7 percent. Correction of recurring reliability failure modes will permit PGK to meet its reliability requirement with confidence. PGK's achieved accuracy causes PGK-fuzed projectiles to exceed expected effectiveness even with a reliability that does not meet the reliability requirement with confidence.
  - PGK is survivable. Cybersecurity assessments identified vulnerabilities PGK may be susceptible to cyber threats. Cybersecurity testing showed a need for further testing of the Army's artillery fire support command and control systems.

Recommendations

- Status of Previous Recommendations. The Army addressed previous recommendations.
- FY15 Recommendations. The Army should:
  1. Continue to conduct failure mode investigations and take corrective actions to address remaining reliability shortfalls and meet PGKs reliability requirement with confidence.
  2. Perform cooperative and adversarial cybersecurity assessments on all elements of the artillery's end-to-end fire support mission processing system and take necessary actions to mitigate or eliminate these vulnerabilities.

Q-53 Counterfire Target Acquisition Radar System

Executive Summary

- In June 2015, the Army conducted the Q-53 radar IOT&E 2 at Yuma Proving Ground, Arizona. Soldier crews operated two Q-53 radars during five, continuous 72-hour record test scenarios observing mortar, artillery, and rocket fires. Soldiers conducted counterfire operations based on the tactical scenario.
- The Q-53 is operationally effective for single-fired rocket, artillery, and mortar munitions. The Q-53 is not operationally effective for volley-fired mortar munitions.
- The radar will report false targets when no projectiles are in the search area. A false target occurs when the radar determines that a threat weapon is firing, when none is present.
- The radar is required to characterize projectiles as a mortar, artillery, or rocket fire. The radar correctly characterized every single-fired mortar shot as a mortar. The radar often mischaracterizes single-fired rockets and artillery as mortars.
- The Q-53 demonstrated an operational availability of 0.99 during IOT&E 2 (0.95 required) indicating the radar is operationally suitable. The demonstrated performance of the Q-53 during IOT&E 2 indicates it is not meeting reliability or maintainability requirements.
- The Q-53 has improved cybersecurity from IOT&E 1 and is survivable.
- In October 2015, DOT&E submitted an IOT&E report detailing the results of testing.
- The Army Program Executive Officer for Missile and Space will make a Full-Rate Production decision in November 2015. The Army intends to procure 136 Q-53 Program of Record radars.

System

- The Q-53 Counterfire Target Acquisition Radar System is a mobile radar system designed to detect, classify, and track projectiles fired from mortar, artillery, and rocket systems using a 90-degree or continuous 360-degree search sector.
- The Army intends the radar to provide target location for threat indirect fire systems with sufficient timeliness and accuracy for effective counterfire.
- The Q-53 is designed to operate with the Counter – Rocket, Artillery, Mortar system and the future Indirect Fire Protection Capability system.

- The Army intends to field the Q-53 radar to the target acquisition platoons in Brigade Combat Teams, target acquisition batteries in Field Artillery Brigades and Division Artillery headquarters to replace the legacy AN/TPQ-36 and AN/TPQ-37 Firefinder radars.
- The Q-53 is operated by a crew of five Soldiers and transportable by C-17 aircraft. Two Family of Medium Tactical Vehicle trucks provide battlefield mobility.
- The Army contracted with Lockheed Martin Missile Systems and Sensors to develop and field 38 Quick Reaction Capability radars to support an Urgent Material Release. The Army intends to procure 136 Program of Record Q-53 radars.

Mission

Field Artillery units employ the Q-53 radar to protect friendly forces by determining the accurate location of threat rocket, artillery, and mortar systems for defeat with counterfire engagements. Air Defense Artillery units integrate the Q-53 radar into the Counter – Rocket, Artillery, Mortar and Indirect Fire Protection Capability System to warn friendly forces and to engage incoming threat indirect fires.

Major Contractor

Lockheed Martin Missile Systems and Training – Syracuse, New York

Activity

- Based on IOT&E 1 conducted at Yuma Proving Ground, Arizona, in May 2014, the Program Executive Officer for Missiles and Space decided to postpone the Full-Rate Production decision to November 2015 and conduct a second IOT&E in June 2015. The radar did not meet false target rate requirements, reliability requirements, cyber vulnerabilities, and had low probability of detection against volley-fired munitions during IOT&E 1.

- The Army completed Developmental Test Phase 5 from January through February 2015. Testing focused on software changes that addressed deficiencies discovered in IOT&E 1.
- The Army completed a developmental capstone event in March 2015. The Program Office designed the capstone event to be similar to IOT&E 2. The test used Soldier crews operating for four, 72-hour vignettes. Units deployed the radars in the 90-degree and the 360-degree modes.
- In May and June 2015, the Army conducted the Q-53 IOT&E 2 at Yuma Proving Ground, Arizona, in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
  - Soldier crews operated two Q-53 radars during a 48-hour pilot test and five, 72-hour record test scenarios observing mortar, artillery, and rocket fires.
  - The radars operated in 90- and 360-degree modes throughout IOT&E 2.
  - Army electronic warfare and cyber teams conducted attacks against the test unit during one 72-hour period.
- DOT&E submitted the Q-53 IOT&E 2 report in October 2015 and is working with the Army to develop the scope and details of all follow-on testing.

Assessment

- Based on IOT&E 2 results, DOT&E assessed the following:
  - The Q-53 is operationally effective for single-fired munitions and volley-fired artillery. The radar is not effective acquiring volley-fired mortars. Volley-fire is a common technique used by a variety of threat nations and an important component of an operational evaluation for the counterfire radar.
    - The Q-53 consistently and accurately detects single-fired munitions and volley-fired artillery.
    - For volley-fired weapons, the Q-53 provided consistent counterfire acquisitions for artillery projectiles while operating in the 90-degree modes.
    - The radar had problems acquiring volley-fired mortars in 360-degree and 90-degree modes and volley-fired artillery in the 360-degree mode. Volley-fired rockets were not tested. The radar does not characterize artillery and rockets properly. After acquiring a projectile, the radar is required to characterize the projectile as mortar, artillery, or rocket. The radar characterizes mortars correctly, but often mischaracterizes rockets and artillery as mortars. Incorrect characterizations could result in ineffective counterfire missions. The Program Office is investigating ways to improve Q-53's ability to characterize projectiles.
    - The Q-53 met false target rate requirements for the 360- and 90-degree normal operating modes, but not for the 90-degree short range optimized mode. While in the 360-degree, 90-degree normal, and 90-degree short range optimized modes, the radar averaged, 0.5, 0.7, and 6.6 false targets per 12 radiating hours, respectively. The Army requires the Q-53 radar to have no more than one false target location per 12 radiating hours. Operators are not able to distinguish between real and false targets, which can result in wasted counterfire missions and loss of confidence in the radar. When operating near an air station in IOT&E 2, the Q-53 had high false target rates while in the 90-degree normal operating mode. These rates are likely due to activity at the air station. The Program Office is investigating ways to reduce Q-53's false target rate.
    - The test did not include 240 mm rockets or 122 mm cannon artillery. These munitions will be addressed in FOT&E.
    - In the 90-degree modes, the radar incorrectly uses Digital Terrain Elevation Data to calculate the terrain mask, causing some projectile trajectories to travel below the radar beams. During IOT&E 2, 18 of 188 threat missions experienced this deficiency. The conditions under which this deficiency occurred are terrain dependent and may occur in mountainous terrain. The Program Office discovered this problem in developmental testing prior to IOT&E 2. The Program Office has developed a fix and are testing it.
  - The Q-53 is operationally suitable primarily due to its high operational availability. During IOT&E 2, the Q-53 radar was available for 496 of 500 hours (99 percent). This exceeded the 95 percent availability requirement.
    - The demonstrated performance of the Q-53 radar during the IOT&E 2 indicates that the program is not meeting reliability and maintainability requirements. The radar did not meet the reliability requirement because of the total number of failures.
    - The four hours of down time were the result of eight system aborts. Although the radar experienced more system aborts than allowed by the requirements threshold, the downtime for most aborts was small. The majority (5 of 8) of the system abort failures were software-related and five of the aborts required less than 30 minutes to resolve. The Q-53 is survivable and demonstrated significant improvement over cyber vulnerability from the IOT&E 1 in May 2014.

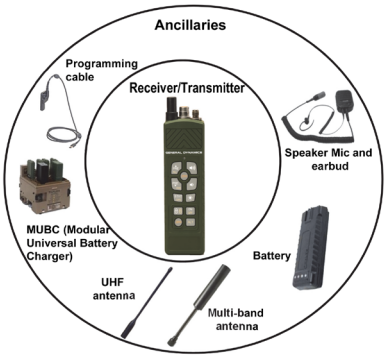
Recommendations

- Status of Previous Recommendations. The Army addressed two of the three previous recommendations. However, the Army still should improve the radar's capability of detecting volley-fired projectiles in both 90- and 360-degree modes.
- FY15 Recommendation. The Army should:
  1. Conduct an FOT&E to address 122 mm cannon and 240 mm rocket performance, as well as changes to improve false target rates, false target rates near air stations, volley-fire detection, characterization, cybersecurity, and generator replacement.

Rifleman Radio

Executive Summary
- The Army tested the AN/PRC-154A Rifleman Radio in support of company-level operations conducted in woodland and urban terrain during the Nett Warrior IOT&E at Fort Polk, Louisiana, in November 2014.
- The Rifleman Radio is the primary communications device for the Nett Warrior and was critical in assessing the Nett Warrior operationally effective in platoon and company-level mounted formations, as well as in dismounted platoon-level formations.
- The Rifleman Radio, when integrated into Nett Warrior, experienced two suitability deficiencies: a high occurrence of batteries overheating, and short battery life.
- The Soldier Radio Waveform (SRW) on the Rifleman Radio is not survivable against cyber attacks. Details are in DOT&E's classified annex to the Nett Warrior IOT&E report dated May 2015.
- The Army is conducting a full and open competition of the Rifleman Radio between the Thales AN/PRC-154B(V)1 and Harris AN/PRC-159(V)1 radios in FY16 with a projected delivery of 4,000 radios in 2QFY17.

System
- The Handheld, Manpack, and Small Form Fit program evolved from the Joint Tactical Radio System program and provides software-programmable digital radios to support the Army's tactical communications requirements. The two radios that comprise the Handheld, Manpack, and Small Form Fit program are the AN/PRC-154A Rifleman Radio and the AN/PRC-155 Manpack radio.
- The Army is replacing the General Dynamics/Thales AN/PRC-154A with either or both the Thales AN/PRC-154B(V)1 and the Harris AN/PRC-159(V)1.
- The Rifleman Radio is a handheld network radio with National Security Agency Type 1 encryption for Secret communications and data.
- The Rifleman Radio is capable of receiving/utilizing external Precise Position Service based services.
- In addition to functioning as a stand-alone, handheld radio, the Army is fielding the Rifleman Radio as the primary communication device for the Nett Warrior program. The Army is developing a vehicle-mounting kit for the radio.



Current Low-Rate Initial Production Rifleman Radio PRC-154A

Thales PRC-154B(V)1 | Harris PRC-159(V)1

Full and Open Competition Rifleman Radio PRC-154B(V)1 & PRC-159(V)1

- The AN/PRC-154A Rifleman Radio is a single-channel radio with a commercial GPS receiver to:
  - Operate at various transmission frequencies using the SRW, which enables the radios to form an ad-hoc data and voice communications network with other SRW-capable radios.
  - Provide 5 watts maximum power output in handheld, and 20 watts maximum power output in vehicle mount.
  - Allow Soldiers to transmit position location information across the SRW network. The position location capability of the Rifleman Radio is disabled when connected to Nett Warrior.

Mission

Army leaders and Soldiers use Rifleman Radios to communicate and create networks to exchange voice, video, and data using the SRW during all aspects of military operations.

Major Contractors
- General Dynamics, C4 Systems – Scottsdale, Arizona (AN/PRC-154A)
- Thales Communications, Inc. – Clarksburg, Maryland (AN/PRC-154A and AN/PRC-154B(V)1)
- Harris Corporation – Rochester, New York (AN/PRC-159 (V)1)

Activity
- The Army tested the AN/PRC-154A Rifleman Radio as part of the Nett Warrior IOT&E Phases 1 and 2 in accordance with DOT&E-approved test plans:
  - Phase I occurred in May 2014 during Network Integration Evaluation 14.2 at Fort Bliss, Texas.
  - Phase II occurred in November 2014 at Fort Polk, Louisiana.
- The Rifleman Radio, when integrated into Nett Warrior, experienced two suitability deficiencies: a high occurrence of batteries overheating, and short battery life.

- The Army is conducting a full and open competition of the Rifleman Radio for a Full-Rate Production decision.
- The Army released a Request for Proposal January 5, 2015.
- Harris and Thales submitted Rifleman Radio candidates for Army qualification testing in July 2015.
- The Army has planned IOT&E for the Thales AN/PRC-154B(V)1 and the Harris AN/PRC-159(V)1 for 4QFY16.

Assessment

- The AN/PRC-154A Rifleman Radio, when integrated into the Nett Warrior System, experienced two suitability deficiencies: a high occurrence of batteries overheating, and short battery life. These deficiencies contributed to Soldiers concluding that the radio was not yet acceptable for combat in its current Nett Warrior configuration. The Nett Warrior Program Manager made changes to the Nett Warrior system to mitigate Rifleman Radio suitability deficiencies.
- At the Nett Warrior IOT&E Phase 2 in November 2014, the AN/PRC-154A Rifleman Radio supported the infantry company's rifle platoons as they operated in woodland terrain with both voice and data communications.
- The SRW on the Rifleman Radio is not survivable against cyber attacks. Details are in DOT&E's classified annex to the Nett Warrior IOT&E report dated May 2015.
- The radio provided voice communications across the platoon's Area of Operations.
- The Rifleman Radio demonstrated improved reliability compared to previous test results, demonstrating a Mean Time Between Essential Function Failure of 328 hours, with a 248 – 441 hour 80 percent confidence interval. This translates into a 93 percent chance of completing a 24-hour mission without a failure. The Rifleman Radio has a requirement to complete a 24-hour mission 95 percent of the time without an Essential Function Failure, which translates into a Mean Time Between Essential Function Failure of 477 hours.
- The Thales and Harris Rifleman Radios passed qualification testing, which enables them to proceed to a product manager's customer test in 1QFY16.

Recommendations

- Status of Previous Recommendations. The Army addressed all previous recommendations.
- FY15 Recommendation.
  1. The Army should continue testing the Rifleman Radio in a configuration that is operationally representative of the way it will be employed as part of the Nett Warrior system.

Warfighter Information Network – Tactical (WIN-T)

Executive Summary

- In May 2015, the Defense Acquisition Executive (DAE) conducted a Warfighter Information Network – Tactical (WIN-T) Increment 2 Full-Rate Production (FRP) Defense Acquisition Board (DAB) based upon the October through November 2014, WIN-T Increment 2 FOT&E 2. The DOT&E evaluation was:
  - The Soldier Network Extension (SNE) with Combat Net Radio (CNR) Gateway was operationally effective. The Highband Networking Waveform (HNW), and Tactical Relay – Tower (TR-T) were not operationally effective.
  - The Mine Resistant Ambush Protected All-Terrain Vehicle (M-ATV) SNE and Point of Presence (PoP) were operationally suitable. The Stryker SNE and PoP were not operationally suitable.
  - While improved, WIN-T Increment 2 is not survivable due to cybersecurity vulnerabilities.
- In May 2015, the DAE published an Acquisition Decision Memorandum (ADM) that:
  - Authorized the Army to enter into FRP for the WIN-T Increment 2 program.
  - Discontinued quarterly reporting requirements on WIN-T Increment 2 reliability.
  - Directed the preparation of corrective action plans for HNW and Stryker WIN-T integration.
  - Directed an independent assessment of WIN-T cybersecurity with recommendations for improvement.
- In September 2015, the DAE delegated the Milestone Decision Authority for WIN-T Increment 2 to the Army.
- The Army did not complete the WIN-T Increment 2 FRP Test and Evaluation Master Plan (TEMP) prior to the FRP DAB. To complete the FRP TEMP, the Army continues to design an FOT&E to test WIN-T Increment 2 configuration items designed to support light brigades with downsized, air-transportable WIN-T assemblages.
- The Army continued planning for an FY16 WIN-T Increment 3 FOT&E to assess an improved version of the Net Centric Waveform (NCW) and network operations tools.

System

- The Army designed the WIN-T as a three-tiered communications architecture (space, terrestrial, and airborne) to serve as the Army's high-speed and high-capacity tactical communications network.
- The Army intends WIN-T to provide reliable, secure, and seamless communications for units operating at theater level and below.
- The WIN-T program consists of three funded increments. In May 2014, the DAE approved the Army's request to stop development of the Increment 3 aerial tier of networked, airborne, communications relays and limit Increment 3 to network management and satellite waveform improvements. The Army intends to increase procurement of WIN-T Increment 2 configuration items to satisfy the number of capability sets previously planned for Increment 3.
  - Increment 1: "Networking At-the-Halt" enables the exchange of voice, video, data, and imagery throughout the tactical battlefield using a Ku- and Ka-satellite-based network. The Army has fielded WIN-T Increment 1 to its operational forces.
  - Increment 2: "Initial Networking On-the-Move" provides command and control on-the-move down to the company level for maneuver brigades and implements an improved network security architecture.
  - WIN-T Increment 2 supports on-the-move communications for commanders with the addition of the PoP and the SNE, and provides a mobile network infrastructure with the Tactical Communications Node.
  - WIN-T Increment 2 provides a downsized, air-transportable variant of High Mobility Multipurpose Wheeled Vehicle (HMMWV) mounted configuration items to support the Army's Global Response Force and other light brigades.
  - Increment 3: "Full Networking On-the-Move" was to provide full mobility command and control for all Army field commanders, from theater to company level using networked airborne communication relays. With program reductions, WIN-T Increment 3 now provides enhanced network management and an improved satellite waveform to WIN-T Increments 1 and 2.

M-ATV Point of Presence

M-ATV Soldier Network Extension

Stryker Point of Presence

1 - Net-Centric Waveform Antenna
2 - High-Band Networking Waveform Antenna

M-ATV - Mine Resistant Ambush Protected (MRAP) All-Terrain Vehicle (M-ATV)

Tactical Comms Node

Mission

Commanders at theater level and below will use WIN-T to:

- Integrate satellite-based communications capabilities into an everything-over-Internet Protocol network to provide connectivity, while stationary, across an extended, non-linear battlefield and at remote locations (Increment 1)
- Provide division and below maneuver commanders with mobile communications capabilities to support initial command and control on-the-move (Increment 2)

Major Contractor

General Dynamics, C4 Systems – Taunton, Massachusetts

Activity

- In response to a September 2013 DAB, the Army conducted the WIN-T Increment 2 FOT&E 2 from October through November 2014, as part of Network Integration Evaluation (NIE) 15.1. The test employed the 2nd Brigade, 1st Armored Division using WIN-T Increment 2 under operationally realistic conditions at Fort Bliss, Texas, and White Sands Missile Range, New Mexico. The WIN-T Increment 2 FOT&E 2 assessed deficiencies noted during FOT&E 1, and assessed the integration of SNE and PoP configuration items into Stryker vehicles.
- In May 2015, DOT&E published a WIN-T Increment 2 FOT&E 2 report to support a May 2015, FRP DAB.
- In May 2015, the DAE conducted a WIN-T Increment 2 FRP DAB. The resulting ADM:
  - Authorized the Army to enter into FRP for the WIN-T Increment 2 program.
  - Authorized closure of the program's requirement to provide quarterly progress reports on reliability.
  - Directed the Army to submit by June 30, 2015, a corrective action plan that addresses Stryker integration issues and improvements to network operations tools and training to optimize performance of HNW, TR-T, and Range Throughput Extension Kit (RTEK). The Army met this submission requirement.
  - Directed the Army to provide an independent cyber design and implementation assessment by September 30, 2015, that identifies program cybersecurity vulnerabilities and corrective action recommendations for future implementation. The Army completed this requirement and forwarded the results to the DAE on October 30, 2015.
- The Army did not complete the WIN-T Increment 2 FRP TEMP prior to the FRP DAB. To complete the FRP TEMP, the Army continues to design an FOT&E to test WIN-T Increment 2 configuration items designed to support light brigades with downsized, air-transportable WIN-T assemblages.
- WIN-T Increment 3 continued to design an FOT&E for NIE 16.2 to test an improved NCW and enhanced network operations tools that will be fielded to WIN-T Increments 1 and 2 units.
- In September 2015, the DAE delegated the Milestone Decision Authority for WIN-T Increment 2 to the Army, designating the program Acquisition Category 1C.

Assessment

- In the May 2015 WIN-T Increment 2 FOT&E 2 report, DOT&E assessed the following:
  - The SNE with CNR Gateway was operationally effective, providing a means to bridge dispersed radio networks and link mission command applications across the brigade area of operations.
  - The PoP, SNE, and CNR Gateway provided improved performance for Soldiers which included:
    - An improved user interface that allows an intuitive, easy-to-use method for operations and troubleshooting.
    - Improved support for chat and voice communications.
  - The Net Centric Waveform was operationally effective, providing a stable satellite network to support WIN-T communications.
  - The HNW and TR-T were not effective due to limited transmission range and throughput for on-the-move links, poor quality at-the-halt links, inability to maintain a non-fragmented network in the absence of satellite, lack of use of the RTEK, and poor network operations tools.
  - The M-ATV PoP and SNE were operationally suitable and met their reliability requirements.
  - The Stryker PoP and SNE were not operationally suitable due to poor integration of WIN-T Increment 2 equipment that interfered with the Soldiers' performance of mission to include:
    - Displays in front of the gunner's position
    - Antennas that prevent 360-degree gun coverage
    - Operations with the engine off that drains batteries to the point of replacement
    - Operating with the Stryker running to support WIN-T does not allow "Silent Watch" operations
  - The Stryker PoP met its reliability requirement, while the Stryker SNE did not.
  - WIN-T Increment 2 is not survivable. Although improved, WIN-T Increment 2 continues to demonstrate cybersecurity vulnerabilities. This is a complex challenge for the Army since WIN-T is dependent upon the cyber defense capabilities of all mission command systems connected to the network.
  - Improved reliability that met reliability requirements for the M-ATV PoP and SNE, and the Stryker PoP. The

Stryker SNE did not meet its reliability requirement, but was borderline.

- WIN-T Increment 2 provides HMMWV mounted configuration items to support the Army's Global Response Force and other light brigades. The Army's WIN-T Increment 2 FOT&E planning for this configuration set has focused on the Tactical Communications Node – Light (TCN-L) and Network Operations and Security Center – Light (NOSC-L), but has not planned testing for the HMMWV mounted PoP and SNE (as equipped in light brigades). The HMMWV-mounted PoP and SNE have not been assessed in an operational test. This version of WIN-T Increment 2 is a significant redesign of the fielded M-ATV variants and requires an FOT&E to assess this version's effectiveness, suitability, and survivability.

Recommendations

- Status of Previous Recommendations. The program addressed one of four previous recommendations. They still need to conduct the planned NCW and network operations FOT&E in FY16, plan operational testing of future integration of WIN-T Increment 2 into combat vehicles, and improve the transmission range of HNW and employment of the TR-T.
- FY15 Recommendations. The Army should:
  1. Improve WIN-T Increment 2 cybersecurity and assess its survivability in a future operational test.
  2. Improve the employment of the HNW with TR-T and RTEK by providing tactics, techniques, and procedures with improved training and enhanced network operations tools.
  3. Complete the WIN-T Increment 2 FRP TEMP.
  4. Conduct an operational test to assess WIN-T Increment 2 HMMWV-mounted configuration items designed to support the Global Response Force and other light brigades.
  5. Conduct an operational test to assess the improved NCW and network operations tools provided by WIN-T Increment 3.
  6. Improve Stryker WIN-T integration and demonstrate these improvements in a future operational test.

Navy Programs

Navy Programs

Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) for AN/BQQ-10(V) Sonar

Executive Summary

- DOT&E submitted a classified FOT&E report on the Advanced Processing Build 2011 (APB-11) variant of the AN/BQQ-10(V) Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) sonar system in November 2015.
- From May 2013 through August 2014, the Navy completed operational testing on the APB-11 variant of the A-RCI sonar system.
  - Operational test phases conducted in FY14 consisted of Anti-Submarine Warfare (ASW) against a diesel electric submarine (SSK) target, cybersecurity, and situational awareness in a High Density Contact Management (HDCM) region with a Light Weight Wide Aperture Array (LWWAA).
  - Previously conducted test phases for this software variant include ASW against a nuclear submarine (SSN) target and situational awareness in an HDCM region with an Active Low Cost Conformal Array (ALCCA).
  - DOT&E assessed that overall mission performance was unchanged from previous variants of the system; however, APB-11 demonstrated improvements in ASW and situational awareness in HDCM missions with an LWWAA over previous APB variants.
  - DOT&E assessed APB-11 demonstrated improved reliability and was suitable.
  - All test phases were adequately conducted to assess system performance. However, there were a number of test limitations, which precluded a full assessment of capabilities. More prominent test limitations were:
  - A damaged TB-29 array limited the assessment of new single leg ranging capabilities and the use the new Range Azimuth (RAZ) and Range Triage Display (RTD).
  - The RAZ/RTD suffered a material casualty that precluded assessing their mission effect on situational awareness in an HDCM region.
- The Navy began to develop its operational test strategy and associated documentation to assess the upcoming APB-13 variant of the system. The Navy intends to conduct operational testing of APB-13 in late FY16.

System

The A-RCI sonar system:

- Is intended to maintain an advantage in acoustic detecting threat submarines.
- Processes data from the submarine's acoustic arrays (i.e., spherical array, large aperture bow array, hull array, wide aperture array, conformal array, and high-frequency array) along with the submarine's two towed arrays (i.e., the fat line array consisting of the TB-16 or TB-34, and the thin line array consisting of the TB-23 or TB-29).

Mission

The Operational Commander will employ submarines equipped with the A-RCI system to:

- Search, detect, and track submarine and surface vessels in open-ocean and littoral sea environments without being counter-detected
- Search, detect, and avoid mines and other submerged objects
- Covertly conduct Intelligence, Surveillance, and Reconnaissance
- Covertly conduct Naval Special Warfare missions
- Perform under-ice operations

Major Contractor

A-RCI: Lockheed Martin Maritime Systems and Sensors – Washington, District of Columbia

Activity

- From May 2013 through August 2014, the Navy completed operational testing on the APB-11 variant of the A-RCI sonar system.
  - Operational test phases conducted in FY14 consisted of ASW against an SSK target, cybersecurity, and situational awareness in an HDCM region with an LWWAA.
  - Previously conducted test phases for this software variant included ASW against an SSN target and situational awareness in an HDCM region with an ALCCA.
- In July 2014, the AN/BQQ-10(V) A-RCI sonar system was removed from DOT&E oversight due to resource constraints. It was restored to oversight in October 2014 because of

concern with the system's performance in support of both the *Virginia* and, eventually, *Ohio* Replacement submarine programs. DOT&E's resource constraint was resolved by eliminating other programs that were not as critical to *Virginia* and *Ohio* Replacement performance.
- In September 2014, DOT&E submitted an interim memorandum documenting the results of A-RCI APB-11 operational testing completed and analyzed prior to removal from oversight.
- In November 2015, DOT&E submitted a classified FOT&E report on the APB-11 variant of the A-RCI sonar system, which detailed testing phases performed and analyzed while temporarily off of DOT&E oversight.
- ASW testing and situational awareness testing with an ALCCA were conducted in accordance with a DOT&E-approved test plan. Situational awareness testing in HDCM with an LWWAA and cybersecurity testing were not conducted with a DOT&E-approved test plan due to the program being temporarily off DOT&E oversight.
- In October 2014, the Navy began test planning for the APB-13 variant of the system, which is expected to occur in late FY16. Expected test events include:
  - At-sea ASW performance assessment against an SSN or SSK target
  - In-lab ASW performance assessment against various threat targets
  - At-sea situational awareness in an HDCM region with an ALCCA and LWWAA
  - Cybersecurity

Assessment
- DOT&E determined that the APB-11 variant of the A-RCI sonar system's overall mission performance remains unchanged from previous assessments and further observed an improvement in system reliability. The recently released classified DOT&E FOT&E report, in conjunction with the classified interim assessment memorandum dated September 10, 2014, concluded the following regarding performance:
  - For ASW, APB-11 A-RCI passive sonar capability is effective against older classes of submarines in some environments, but is not effective in all environments or against modern threats. Despite an unchanged overall assessment, APB-11 demonstrated improved operator performance metrics over previous APB variants.
  - The APB-11 A-RCI sonar system is not effective in supporting operator situational awareness and contact management in areas of high-contact density; however, platforms equipped with an LWWA demonstrated improved performance over previous APB variants.
  - APB-11 cybersecurity is not effective and remains unchanged from previous variants.
  - The APB-11 A-RCI sonar system is operationally suitable.
- Although the APB-11 assessment was able to determine system effectiveness and suitability, there were several test limitations. Some of the major limitations were:
  - A damaged TB-29 array that limited the assessment of new single leg ranging capabilities and the use of the new RAZ/RTD.
  - The RAZ/RTD suffered a material casualty that precluded an assessment of its impact on situational awareness in an HDCM region.
- Due to the biennial software and hardware development cycle, the Navy generates and approves the requirements documents and Test and Evaluation Master Plans (TEMPs) in parallel with APB development and installation. As a result, the fleet assumes additional risk, since most operational testing is not completed before the system is initially deployed.
- The Navy's schedule-driven process prevents operational test results from directly supporting development of the follow-on APBs. For example, the Navy completed operational testing of the A-RCI APB-09 sonar system in early FY12. Due to the combination of the late completion of testing and the Navy's practice of issuing an updated version every 2 years, data from the test could not be included in the development of APB-11.

Recommendations
- Status of Previous Recommendations. The Navy made progress in addressing 22 of the 37 previous recommendations outlined in DOT&E's classified FOT&E report on APB-09 dated November 2012. Of the 15 remaining outstanding recommendations, the significant unclassified recommendations are:
  1. Conduct additional testing in shallow water to examine the ship's ASW capabilities in those conditions.
  2. Re-evaluate the use of the current time difference between system and operator detection times as the ASW Key Performance Parameter for a more mission-oriented metric to accurately categorize system effectiveness.
  3. Evaluate the covertness of the high-frequency sonar during a future submarine-on-submarine test.
  4. Determine the performance of the A-RCI sonar system in detecting near surface mines.
  - The following recommendations from the FY12 Annual Report remain open. In the upcoming fiscal year, the Navy should:
  1. Consolidate the A-RCI and AN/BYG-1 TEMPs and test plans into an Undersea Enterprise Capstone document to permit efficiencies in testing.
  2. Evaluate A-RCI metrics to improve performance under varying environmental conditions and to focus on earlier and longer range operator detections.
- FY15 Recommendations. DOT&E's APB-11 FOT&E report dated November 2015 detailed five new recommendations. The Navy needs to address the following significant unclassified recommendations:
  1. Carry forward all APB-11 test objectives not evaluated including the ALCCA, RAZ/RTD user interface, TB-34 triangulation ranging improvements, and TB-29 ranging algorithm to the APB-13 TEMP.

2. Perform an ASW event against a high-end SSK at least with every other APB variant and upon introduction of new wet end sensor or software capabilities improving ASW mission capability.
3. Conduct future HDCM situational awareness testing in areas that provide full radar coverage to support comparative analysis of data.

Aegis Modernization Program

Executive Summary

- The Navy is modernizing the Aegis Weapon System (AWS) installed on Baseline 3 USS *Ticonderoga* (CG 47) class cruisers and the Flight I USS *Arleigh Burke* (DDG 51) destroyers to the AWS Advanced Capability Build 2012 (Baseline 9A and 9C, respectively). New construction DDGs, beginning with USS *John Finn* (DDG 113), will be equipped with Baseline 9C as well.
- Testing completed to date is insufficient to make a determination of operational effectiveness or suitability for Aegis Baseline 9A or 9C.
- In accordance with National Defense Authorization Act of 2008, Section 231, DOT&E submitted Early Fielding Reports in July and November 2015 for each baseline incident in response to the Navy's deployment of USS *Normandy* and USS *Benfold,* and prior to the completion of operational testing. Testing on Baseline 9A and 9C ships to date suggest that area air defense performance against subsonic and supersonic high-diving targets is consistent with historical performance against comparable threats; however, during operational testing, the Navy has not yet demonstrated performance against more stressing presentations.
- In February 2015, the Navy commenced Baseline 9A operational testing on USS *Chancellorsville* (CG 62). One planned live fire event was deferred due to target availability, and two of four additional planned at-sea events were not completed because of test execution problems. These unexecuted operational test events are currently scheduled for late 1QFY16.
- From November 2014 through April 2015, as part of Combat System Ship Qualification Trials, the Navy conducted integrated developmental and operational testing in the air defense and Undersea Warfare mission areas on USS *John Paul Jones* (DDG 53), USS *Benfold* (DDG 65), and USS *Barry* (DDG 52). Data from these events will supplement data collected during dedicated operational testing for Baseline 9C. The Navy is scheduled to begin Baseline 9C operational testing on USS *John Paul Jones* (DDG 53) in FY16.
- The lack of an adequate modeling and simulation (M&S) suite of the Aegis Combat System, as well as the lack of an Aegis equipped Self-Defense Test Ship (SDTS) where the ship's full self-defense kill chain can be tested, precludes assessment of the Baseline 9 Probability of Raid Annihilation requirement.
- The Navy will not fully assess Aegis Integrated Air and Missile Defense (IAMD) until a validated M&S test bed is developed and validated. The test bed is planned to be available by FY20, but there is no agreed upon strategy to validate the model to support assessment of the close-in, self-defense battlespace. A limited IAMD assessment will be made during Baseline 9C operational testing on DDGs.

- The Navy fielded the Navy Integrated Fire Control – Counter Air (NIFC-CA) From-the-Sea (FTS) Increment I capability with the deployment of the first E-2D and Baseline 9-equipped Carrier Strike Group in FY15. NIFC-CA FTS Increment I developmental test events in FY13 and FY14 demonstrated a basic capability, but its effectiveness under operationally realistic conditions is undetermined.
- As discussed in the July 2015 Aegis Baseline 9A Early Fielding Report, DOT&E is concerned with results from the cruiser cybersecurity evaluation and performance in the Surface Warfare mission area. Follow-on cybersecurity and Surface Warfare operational testing will be required.

System

- The Navy's Aegis Modernization program provides updated technology and systems for existing Aegis-guided missile cruisers (CG 47 class) and destroyers (DDG 51 class). This planned, phased program provides similar technology and systems for new construction destroyers.
- The AWS, carried on DDG 51-guided missile destroyers and CG 47-guided missile cruisers, integrates the following components:
  - AWS AN/SPY-1 three-dimensional (range, altitude, and azimuth) multi-function radar
  - AN/SQQ-89 Undersea Warfare suite that includes the AN/SQS-53 sonar, SQR-19 passive towed sonar array (DDGs 51 through 78, CGs 52 through 73), and the SH-60B or MH-60R helicopter (DDGs 79 Flight IIA and newer have a hangar to allow the ship to carry and maintain its own helicopter)
  - Close-In Weapon System
  - A 5-inch diameter gun

  - Harpoon anti-ship cruise missiles (DDGs 51 through 78, CGs 52 through 73)
  - Vertical Launch System that can launch Tomahawk land attack missiles, Standard surface-to-air missiles, Evolved Seasparrow Missiles, and Vertical Launch Anti-Submarine Rocket missiles
- The AWS on Baseline 3 USS *Ticonderoga* (CG 47) class cruisers and Flight I USS *Arleigh Burke* destroyers is being upgraded to Baseline 9A and 9C, respectfully. Baseline 9 will provide the following new capabilities:
  - Full Standard Missile-6 (SM-6) integration
  - IAMD, to include simultaneous air defense and ballistic missile defense missions on Aegis destroyers equipped with the new Multi-Mission Signal Processor
  - NIFC-CA FTS capability
- Starting with USS *John Finn* (DDG 113), the AWS on new construction Aegis-guided missile destroyers is Baseline 9C.

Mission

The Joint Force Commander/Strike Group Commander employs AWS-equipped DDG 51-guided missile destroyers and CG-47-guided missile cruisers to conduct:

- Area and self-defense Anti-Air Warfare in defense of the Strike Group
- Anti-Surface Warfare and Anti-Submarine Warfare
- Strike Warfare, when armed with Tomahawk missiles
- Simultaneous offensive and defensive warfare operations
- Operations independently or in concert with Carrier or Expeditionary Strike Groups and with other joint or coalition partners

Major Contractors

- General Dynamics Marine Systems Bath Iron Works – Bath, Maine
- Huntington Ingalls Industries (formerly Northrop Grumman Shipbuilding) – Pascagoula, Mississippi
- Lockheed Martin Maritime Systems and Sensors – Moorestown, New Jersey

---

Activity

- The Navy conducted Baseline 9A cruiser operational testing on USS *Chancellorsville* in 2QFY15. One planned live fire event was deferred due to target availability, and two of four additional planned at-sea events were not completed because of test execution problems. These unexecuted operational test events are currently scheduled for late 1QFY16. In FY15, the Navy also conducted a cybersecurity assessment and maintenance demonstration.
- In July 2015 and November 2015, DOT&E submitted two Early Fielding Reports on Aegis Baseline 9A and 9C, respectively.
- The Navy conducted integrated developmental and operational testing in the Undersea Warfare mission area on USS *John Paul Jones* and USS *Benfold* as part of each ship's Combat System Ship Qualification Trials in 1QFY15 and 2QFY15, respectively. Data from these events will supplement data collected during dedicated operational testing for Baseline 9C. The Navy is scheduled to begin Baseline 9C operational testing on USS *John Paul Jones* (DDG 53) in FY16.
- The Navy successfully conducted a live fire IAMD event against threat representative cruise and ballistic missile surrogates on USS *John Paul Jones* in November 2014. The event, as conducted, included a less-stressing scenario than planned in the Aegis Modernization Test and Evaluation Master Plan, and it resulted in only one, vice two, SM-3 missiles being fired simultaneously with an SM-2 air defense missile. This was the only live fire event available to assess Baseline 9C's ability to simultaneously engage cruise missiles and ballistic missiles.
- The Navy conducted all testing in accordance with the DOT&E-approved test plans.

Assessment

- Baseline 9A and 9C testing completed to date was not sufficient to support an assessment of operational effectiveness or suitability prior the FY15 USS *Normandy* and USS *Benfold* deployments. In accordance with National Defense Authorization Act of 2008, Section 231, DOT&E submitted Early Fielding Reports for each baseline. Testing on Baseline 9A and 9C ships to date suggest that area air defense performance against subsonic and supersonic high-diving targets is consistent with historical performance against comparable threats; however, the Navy has not yet demonstrated performance against more stressing presentations during operational testing. Operational testing, to include more stressing presentations, is planned to continue through FY16.
- The Navy will not fully assess Aegis IAMD until an AWS M&S test bed is developed and validated. The test bed is under development and is planned to be available by FY20; however, there is no agreed upon strategy to validate the model to support assessment of the close-in, self-defense battlespace. A limited Baseline 9C IAMD operational assessment suggests that DDGs can simultaneously support limited air defense and ballistic missile defense missions, within overall radar resource

constraints. This assessment is supported by a successful live fire event, managed by the Missile Defense Agency, which included simultaneous live firing of SM-2 and SM-3 missiles against threat representative targets in an IAMD engagement.
- Results to date of 12 live flight tests events on Baseline 9A and 9C ships suggest that area air defense performance against single subsonic and supersonic high-diving targets is consistent with historical performance against comparable threats.
- Although not presented for operational testing, the Baseline 9A Surface Warfare performance, specifically counter high-speed surface threats in littoral waters, as demonstrated during developmental testing, indicated no improvements over previous Aegis baseline operational test results. For both Baseline 9A and 9C, these results indicate that AWS does not fully meet desired Surface Warfare performance levels.
- As appropriate, and until the full capability may be operationally tested, DOT&E will provide periodic capability assessments to inform Navy and OSD leadership, as well as Congress, on the progress of T&E of the IAMD mission area.
- Until an Aegis-equipped SDTS is available for testing, it is neither possible to characterize the self-defense capabilities of the Aegis cruisers and destroyers, nor possible to accredit an M&S suite to determine if the ships satisfy their Probability of Raid Annihilation requirements.
- The Navy's NIFC-CA FTS Increment I test events conducted to date are sufficient to demonstrate basic capability; however, these demonstrations were not conducted under operationally realistic conditions or against aerial targets representative of modern threats. Additionally, the scenarios conducted were not sufficiently challenging to demonstrate the NIFC-CA FTS requirements defined in the Navy's September 2012 NIFC-CA FTS Testing Capability Definition Letter. Further testing is planned for FY16; these tests, too, will not be sufficiently challenging to allow an operational effectiveness determination.
- The Navy's combined Baseline 9 and SM-6 FOT&E test events to date have been successful with no SM-6 integration issues revealed.
- The Navy's Aegis Baseline 9A cybersecurity testing revealed significant problems, which are classified. The nature of these problems is such that they could pose significant risk to the cybersecurity for the FY15 deployment. Details can be found in DOT&E's Early Fielding Report dated July 2015.
- Changes made to the radar software presented unexpected issues during the initial phase of the Aegis cruiser at-sea operational test. The Navy is addressing these issues and remaining cruiser and destroyer operational testing will provide opportunities to confirm these issues have been mitigated.
- During both integrated and operational test events, instability of the Aegis operator consoles adversely affected the conduct of test events. The Navy is addressing these issues and remaining cruiser and destroyer operational testing will provide opportunities to confirm these issues have been mitigated.
- Aegis Baseline 9C has incorporated software changes to address performance against certain stressing air defense threat presentations; however, the effects of these changes remain undemonstrated by testing. Developmental testing of these changes is planned for late 1QFY16.

Recommendations
- Status of Previous Recommendations. The Navy has not addressed the following previous recommendations from FY14. The Navy still needs to:
  1. Continue to improve Aegis ships' capability to counter high-speed surface threats in littoral waters.
  2. Synchronize future baseline operational testing and reporting with intended ship-deployment schedules to ensure that testing and reporting is completed prior to deployment.
  3. Provide the necessary funding to support the procurement of an advanced air and missile defense radar and Aegis-equipped SDTS that is needed to support Aegis Modernization, advanced air and missile defense radar, DDG 51 Flight III, and Evolved Seasparrow Missile Block 2 operational testing.
  4. Characterize Aegis Baseline 9A/C and NIFC-CA FTS Increment I capability against operationally realistic anti-ship cruise missile threats as soon as possible.
  5. Submit a Test and Evaluation Master Plan for DOT&E approval that describes and resources adequate operational testing of future NIFC-CA FTS increments before such capabilities are deployed.
  6. For Baseline 9A, develop and deploy necessary cybersecurity corrective actions and verify correction with a follow-on operational cybersecurity test.
- FY15 Recommendation.
  1. The Navy needs to complete the planned FOT&E events as detailed in the approved test plan as soon as practical.

AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program

Executive Summary

- The Advanced Anti-Radiation Guided Missile (AARGM) remains operationally suitable, but not operationally effective due to multiple deficiencies discovered during IOT&E in FY11-12.
- After delivery of missile flight software version R2.1, Navy test squadrons VX-31 and VX-9 conducted integrated testing in 4QFY14-1QFY15. Based on deficiencies discovered during this first round of integrated testing (Phase 1), testing was halted, significant software updates were required, and an additional integrated test phase was introduced (Phase 1a). Software version R2.2 was delivered in 3QFY15 for Phase 1a testing, which was conducted 3-4QFY15.
- Phase 1a test deficiencies required more software changes, which DOT&E, Commander, Operational Test and Evaluation Force, and VX-9 are currently analyzing. If these changes are deemed significant, or if additional changes become necessary during Phase 2 of integrated testing, an additional test phase may be required to produce the required data to assess test adequacy, operational effectiveness, and operational suitability.
- Several operational mission failures (OMFs) occurred in Phase 1a. Based on final scoring, if further OMFs are discovered in Phase 2, reliability and performance data may be insufficient to assess suitability. Additional captive carry and live fire tests may be required for adequate IOT&E.
- The Navy conducted two live fire test events during Phase 1a, both successfully engaging their targets and test objectives were achieved. The first test was against a moving maritime target on the Point Mugu Sea Range. The second test was against a traditional air defense unit on the China Lake range.
- There were no dedicated operational test events scheduled or conducted during FY15.

System

- AARGM supplements the AGM-88B/C High-Speed Anti-Radiation Missile (HARM) and is specifically designed to prosecute targets that stop radiating, executing point to point missions against traditional and non-traditional air defense systems. AARGM uses a new guidance section and a modified HARM control section and fins. The Navy intends to employ AARGM on F/A-18C/D/E/F and EA-18G platforms.
- AARGM incorporates digital Anti-Radiation Homing, a GPS, Millimeter Wave guidance, and a Weapon Impact Assessment transmitter.

  - Anti-Radiation Homing improvements include an increased field of view and increased detection range compared to HARM.
  - The GPS allows position accuracy in location and time.
  - The Weapons Impact Assessment capability allows transmission of real-time hit assessment via a national broadcast data system.
  - The Millimeter Wave radar technology allows target discrimination and guidance during the terminal flight phase.
- The Navy expects the AARGM Block 1 Upgrade (a software only upgrade) to deliver Full Operational Capability, including Block 0 capability improvements and software changes to provide deferred capability requirements and address deficiencies identified during IOT&E.

Mission

Commanders employ aircraft equipped with AARGM to conduct pre-planned, on-call, and time-sensitive reactive anti-radiation targeting to suppress, degrade, and destroy radio frequency-enabled surface-to-air missile defense systems.

Major Contractor

Orbital/Alliant Techsystems – Northridge, California

Activity

- There were no dedicated operational test events scheduled or conducted during FY15.
- In June 2015, DOT&E approved the AARGM FOT&E test plan developed by the Program Office. The test plan was adequate to address the testing of deferred capabilities and deficiencies discovered during initial developmental test and evaluation and IOT&E.
- In FY15, Phase 1 integrated testing continued. Based on analysis of weapon performance data, the Navy determined that a software update was required and subsequently stopped the remaining captive-carry and live fire test events. During this phase, VX-31 and VX-9 conducted four test events comprised of 79 captive-carry test runs.
- In FY15, Phase 1a of integrated testing was conducted after the software corrections of earlier deficiencies were completed. VX-31 and VX-9 conducted 11 test events, comprised of 228 captive-carry test runs, and 2 live fire test shots during this test phase. The Navy conducted the first live fire test against a moving maritime target on the Point Mugu Sea Range. The second live fire test was against a traditional air defense unit on the China Lake range.
- During Phase 1a, navigational errors were noted on several occasions. The Navy believes they have identified the cause of the navigational errors and proposed software changes be made to fix these during Phase 2 testing.
- Phase 2 of integrated testing will begin in the fall of 2015.

Assessment

- The FY15 status remains unchanged from the FY14 report.
- Based on IOT&E test data, AARGM was determined to be operationally suitable, but not operationally effective. The details of these deficiencies are discussed in the classified DOT&E IOT&E report published in August 2012.
- The AARGM program has continued developmental and integrated testing, based on the delivery of the R2.2 missile flight software and additional software modifications added from Phase 1 testing deficiencies. DOT&E does not have the final test results of Phase 1a testing. However, based on interim Phase 1a test results, additional software changes have been made to correct navigational errors. If these additional software changes are considerable, an additional phase of integrated testing will be required, including regression testing of capabilities already tested in Phase 1 and Phase 1a.
- Several hardware and software OMFs have been reported during Phase 1a testing. Depending upon final scoring of these potential Phase 1a OMFs and any found in Phase 2, there may not be sufficient flight hours remaining in the test program (both integrated and operational testing) to assess AARGM effectiveness and suitability. Additional captive-carry and live fire tests may be required for adequate IOT&E.
- The overall test design and identified resources should provide a rigorous evaluation of the corrections of deficiencies discovered in IOT&E and the deferred classified Key Performance Parameter, which is classified. The early integrated testing of captive-carry and live fire events are designed to provide insight and exposure to all capabilities and conditions. These initial test events should give an early indication of the performance of the missile and stability of the system.

Recommendations

- Status of Previous Recommendations. The Navy addressed all previous recommendations.
- FY15 Recommendations. The Navy should:
  1. Report the results of Phase 1a integrated testing in 1QFY16.
  2. Assess whether sufficient data exist to support independent operational test requirements based on results from Phase 1, Phase 1a, and Phase 2 integrated testing.
  3. Coordinate future AARGM operational test and resource requirements with DOT&E, as well as ensure production representative assets are used in the integrated test phase.

AIM-9X Air-to-Air Missile Upgrade

Executive Summary

- The Navy and Air Force originally began AIM-9X Block II IOT&E (OT-C1) with Operational Flight Software (OFS) 9.311 on April 27, 2012. On July 29, 2013, the Program Executive Officer for Tactical Aircraft Programs (PEO(T)) formally decertified AIM-9X Block II due to two major deficiencies discovered and documented during IOT&E that affected missile performance. These deficiencies were poor reliability of the inertial measurement unit and a software performance problem. The contractor implemented an improved production process and updated the missile software (OFS 9.313) to address the two primary deficiencies.
- The Services conducted IOT&E of the Block II missile with OFS 9.313 from June 2014 through March 2015. Testing included 19 scored missile launches; captive-carry testing to examine acquisition, tracking, and reliability; and modeling and simulation.
- IOT&E of the AIM-9X Block II hardware with OFS 9.313 demonstrated that the missile is effective against aircraft and cruise missile targets. Deficiencies discovered in earlier OFS 9.311 were found to be fixed. Additionally, testing demonstrated that the missile is suitable on the F-15 and F-16 aircraft and not suitable on the F/A-18 aircraft due to a high number of aircraft-related built-in test (BIT) failures on the F/A-18.
- The Navy achieved Initial Operational Capability of AIM-9X Block II on March 31, 2015, with Carrier Air Wing FIVE.
- The Assistant Secretary of the Navy (Research, Development, and Acquisition) approved Full-Rate Production (FRP) via an Acquisition Decision Memorandum dated August 17, 2015.
- The Air Force and Navy are in the final stages of test planning to conduct AIM-9X cybersecurity testing.

System

- AIM-9X is the latest generation short-range, heat-seeking, air-to-air missile. The currently fielded version of the Block I missile is OFS 8.220, which includes limited lock-on-after-launch, full envelope off boresight capability with a helmet-mounted cueing system, and improved flare rejection performance.
- AIM-9X Block II missiles are currently fielded with 9.314 software, which significantly builds from 8.220 software with datalink, lofted trajectories, full lock-on-after-launch capability, and improved high-off boresight capability and flare rejection.
- AIM-9X is highly maneuverable, day/night capable, and includes the warhead, fuze, and rocket motor from the previous AIM-9M missile.

- AIM-9X added a new imaging infrared seeker, vector controlled thrust, digital processor, and autopilot. F-15C/D, F-16C/D, and F/A-18C/D/E/F aircraft are capable of employing the AIM-9X, with ongoing integration activities being conducted for the F-15E, F-22, and F-35A/B/C.
- The AIM-9X Block II is the combination of AIM-9X-2 hardware and OFS 9.314. (OFS 9.314 is the designation following required security requirements implemented in the 9.313 OFS).
  - AIM-9X Block II is the latest hardware version and is designed to prevent parts obsolescence and provide processing capability for the OFS 9.4 upgrade. The AIM-9X-2 missile includes a new processor, a new battery, an electronic ignition safe/arm device, and the DSU-41/B Active Optical Target Detector fuze/RF datalink assembly.
  - OFS 9.4 is a future software upgrade that is intended to add improved lock-on-after-launch, target re-acquisition, improved fuzing, and surface attack.

Mission

Air combat units use the AIM-9X to:

- Conduct short-range offensive and defensive air-to-air combat
- Engage multiple enemy aircraft types with passive infrared guidance in the missile seeker
- Seek and attack enemy aircraft at large angles away from the heading of the launch aircraft

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- On July 29, 2013, the AIM-9X Program Office and Raytheon Missile Systems implemented hardware and software solutions to address the two primary deficiencies discovered in OFS 9.311 testing that led to PEO(T) decertification of the program from testing.
- On June 5, 2014, the Navy completed an Operational Test Readiness Review and PEO(T) re-certified AIM-9X Block II with OFS 9.313 for IOT&E. DOT&E approved a test plan change reducing the number of captive-carry missions to 28 (14 per Service) and removed one of the 17 live missile tests from the originally approved IOT&E plan.
- The Services conducted an IOT&E of AIM-9X Block II with OFS 9.313 from June 2014 through March 2015, in accordance with the DOT&E-approved test plan. Testing included 19 scored flight tests, 26 captive-carry acquisition and tracking missions, 2,402 hours of captive carry reliability data, and 20,000 modeling and simulation runs.
- The Assistant Secretary of the Navy (Research, Development, and Acquisition) approved FRP via an Acquisition Decision Memorandum dated August 17, 2015.

Assessment

- DOT&E assessed that the AIM-9X Block II missile with OFS 9.313:
  - Is effective. In flight testing, 15 of 19 scored missile launches achieved a lethal intercept. Captive-carry testing demonstrated solid acquisition and tracking performance. Demonstrated missile reliability is on track to meet requirements.
  - Is suitable on the F-15 and F-16 aircraft, but not suitable on the F/A-18 aircraft due to a high number of BIT failures related to F/A-18 software. In 2,402 hours of captive-carry reliability testing, 80 aircraft-related BIT failures occurred, all of which were on the F/A-18. .
  - Future F/A-18 software (H10 planned for FY16) addresses the power management errors behind the BIT failures that led to the not suitable assessment of Block II on F/A-18.
- IOT&E of the Block II hardware with OFS 9.313 demonstrated that the two previous deficiencies that led to decertification have been addressed successfully.
- The Air Force and Navy are in the final stages of test planning to conduct AIM-9X cybersecurity testing.

Recommendations

- Status of Previous Recommendations. The Navy is in the process of completing the FY14 recommendation to work closely with DOT&E and the Service Operational Test Agencies to establish the plan, requirements, and resources for OFS 9.400 testing, including the associated Test and Evaluation Master Plan update.
- FY15 Recommendations.
  1. The Navy should verify that F/A-18 H10 software resolves the BIT problems that led to a rating of not suitable.
  2. The Services should complete cybersecurity testing on the AIM-9X in accordance with the August 1, 2014 DOT&E policy memorandum.

AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite

Executive Summary

- Operational testing of the Advanced Capability Build 2011 (ACB-11) variant began in FY14 and is expected to conclude in FY16. However, the Navy has not yet scheduled all required IOT&E events. The Navy completed limited, at-sea testing in FY15 in conjunction with two fleet-training events.
- In December 2014, DOT&E submitted a classified Early Fielding Report on the ACB-11 variant of AN/SQQ-89A(V)15 Integrated Undersea Warfare Combat System Suite. The report was submitted due to the installation of the ACB-11 variant on ships that deployed prior to IOT&E. From the data collected, DOT&E concluded the system demonstrated some capability to detect submarines and incoming U.S. torpedoes in deep water. However, no data were available to assess its capability in shallow water, an area of significant interest due to the prevalence of submarines operating in littoral regions. Also, no data were available to assess performance against threat torpedoes.

System

- AN/SQQ-89A(V)15 is the primary Undersea Warfare system used aboard U.S. Navy surface combatants to locate and engage threat submarines. AN/SQQ-89A(V)15 is an open architecture system that includes biennial software upgrades (Advanced Capability Builds) and hardware upgrades called Technology Insertions every four years.
- AN/SQQ-89A(V)15 uses active and passive sonar to conduct Anti-Submarine Warfare (ASW) search. The acoustic energy received is processed and displayed to enable operators to detect, classify, localize, and track threat submarines.
- AN/SQQ-89A(V)15 uses passive sonar (including acoustic intercept) to provide early warning of threat torpedoes.
- The Navy intends to improve sensor display integration and automation, reduce false alerts, and improve onboard training capability to better support operations within littoral regions against multiple sub-surface threats.
- The system consists of:
  - Acoustic sensors – hull-mounted array, Multi-Function Towed Array (MFTA) TB-37 including a towed acoustic intercept array, calibrated reference hydrophone, helicopter, and/or ship-deployed sonobuoys
  - Functional segments used for processing and displaying active, passive, and environmental data

  - Interfaces with Aegis Combat System for MK 46 and MK 54 torpedo prosecution using surface vessel torpedo tubes, Vertical Launch Anti-Submarine Rocket, or SH-60B/MH-60R helicopters
- The system is deployed on a DDG 51 class destroyer or CG 47 class cruiser.

Mission

- Maritime Component Commanders employ surface combatants with AN/SQQ-89A(V)15 as escorts to high-value units to protect against threat submarines during transit.
- Maritime Component Commanders use surface combatants with AN/SQQ-89A(V)15 to conduct area clearance and defense, barrier operations, and ASW support during amphibious assault.
- Theater Commanders use surface combatants with AN/SQQ-89A(V)15 to locate and monitor threat submarines in theater.
- Unit Commanders use AN/SQQ-89A(V)15 to support defense against incoming threat torpedoes.

Major Contractor

Lockheed Martin Mission Systems and Training – Manassas, Virginia

Activity

- In January 2013, DOT&E sent a memorandum to the Assistant Secretary of the Navy (Research, Development, and Acquisition) outlining the need for a threat torpedo surrogate to support operational testing of the AN/SQQ-89A(V)15 and

requesting the Navy's plan to address this need. In June 2015, DOT&E sent a follow-up memorandum that reiterated the need for adequate torpedo surrogates in operational testing and identified that DOT&E is still waiting for the Navy's plan.
- In December 2014, DOT&E submitted a classified Early Fielding Report for the ACB-11 variant of AN/SQQ-89A(V)15 Integrated Undersea Warfare Combat System Suite. The report was submitted due to the installation of the ACB-11 variant on ships that deployed prior to IOT&E.
- The Commander, Operational Test and Evaluation Force continued IOT&E on the ACB-11 variant in May 2015. Testing was conducted in accordance with a DOT&E-approved test plan and included ASW transit search and area search operations using AN/SQQ-89A(V)15 onboard a DDG 51 class destroyer. Testing was conducted in conjunction with the following two fleet events:
  - Ship ASW Readiness and Evaluation Measurement 180 exercise in the Western Pacific that included search opportunities against a diesel submarine.
  - Submarine Command Course 44 Anti-Surface Warfare events at the Navy's Atlantic Undersea Test and Evaluation Center.
- In September 2015, the Navy completed a formal study to identify capability gaps in currently available torpedo surrogates and present an analysis of alternatives for specific investments to improve threat emulation ability.
- The Navy has not yet scheduled the remaining IOT&E events. Remaining ACB-11 operational testing is needed to understand ASW detection capability in shallow water (generally defined as water that is less than 100 fathoms in depth), an environment that was a focus for system improvement.

Assessment
- The final assessment of ACB-11 is not complete, as testing is expected to continue into FY16. DOT&E's classified Early Fielding Report and additional analysis conducted in FY15 suggest the following regarding performance:
  - The ACB-11 variant meets program performance metrics for submarine detection and classification in deep-water environments.
  - The ACB-11 variant demonstrated some capability to localize and support prosecution of a threat submarine in deep water.
  - The ACB-11 variant does not meet program performance metrics for torpedo detection as assessed against U.S. exercise torpedoes.
  - The ACB-11 variant is currently not suitable due to low operational availability. ACB-11 software reliability is sufficient; however, hardware failures resulted in significant periods of limited system capability. Extensive logistic delays, particularly with the repair of the MFTA, are the primary cause of low operational availability. MFTA repair, achieved by replacing the ship's array with a spare MFTA when the ship is in port, was delayed by fleet inventory and positioning of spare arrays
  - No assessment can be made against the smaller midget and coastal diesel submarines due to the Navy having no test surrogates to represent this prevalent threat.
- The Navy study on threat torpedo surrogates confirmed DOT&E's concerns that current torpedo surrogates have significant gaps in threat representation for operational testing and the study provided recommendations for improving current threat torpedo emulation. However, the Navy has yet to provide its plan to provide realistic torpedo surrogates to effectively characterize AN/SQQ-89A(V)15 performance in future operational tests. Improved torpedo surrogate capability is required to adequately evaluate future ACB variants.
- Analysis of the few completed IOT&E events in shallow water indicates that the ACB-11 variant has some capability to detect submarines in shallow water. However, the fleet exercises either did not support the necessary ranges to assess detection against system requirements or an exercise limitation excluded the use of the MFTA.

Recommendations
- Status of Previous Recommendations. The Navy is making progress and should continue to address all previous recommendations. Specific concerns include:
  1. Develop and integrate high-fidelity trainers and realistic, in-water test articles to improve training and proficiency of operators in ASW search and track of threat submarines, including midget and coastal diesel submarines.
  2. Pre-position spare TB-37 MFTA and spare MFTA modules at appropriate forward-operating ports to minimize logistic delays.
- FY15 Recommendations. The Navy should:
  1. Schedule and complete dedicated IOT&E to characterize ACB-11 operational performance in shallow water and assess cybersecurity vulnerabilities.
  2. Revisit system requirements to ensure that funded improvement in subsequent ACBs is supporting Navy objectives for ASW against current and imminent threat submarines.
  3. Address the four classified recommendations listed in the December 2014 Early Fielding Report.
  4. Develop and execute a plan to provide representative torpedo surrogates before evaluation of the next ACB development that is focused on torpedo recognition capability (detection and/or classification).

CH-53K – Heavy Lift Replacement Program

Executive Summary

- In FY16, the CH-53K program will provide four Engineering Manufacturing and Development (EMD) aircraft to support integrated developmental and operational flight testing. A Ground Test Vehicle (GTV) is being used to qualify key dynamic components and assess aircraft stresses, vibrations, and rotor performance. GTV also supports long term verification and reliability testing. The program achieved first flight of the CH-53K EMD-1 aircraft on October 27, 2015.
- Gear box failures discovered in ground testing in January 2015, most notably a quill shaft failure in the Main Gear Box, have contributed to program delays. The quill shaft and the Rear Module Assembly of the gear box have been redesigned and testing has resumed on the GTV.
- Initial environmental qualifications of the pilot armored seats experienced temperature-induced cracking in the seat bucket and wing armor, which has driven a redesign.
- The Navy reduced the cabin floor and sidewall armor requirements to allow for a lighter armor design. The accepted design was qualified and assessed as part of the CV-22 LFT&E program in FY14.
- In FY15, the Navy completed live fire vulnerability testing of the fuel system and flight-critical main and tail rotor system components. With one exception, preliminary assessment of the data revealed no unexpected vulnerabilities. The effect of the observed main and tail-rotor combat-induced damage on aircraft survivability will be assessed after the cyclic structural testing, scheduled for FY16.

System

- The CH-53K is a new-build, fly-by-wire, dual-piloted, three-engine heavy lift helicopter slated to replace the aging CH-53E. The CH-53K is designed to carry 27,000 pounds useful payload (three times the CH-53E payload) to a distance of up to 110 nautical miles and climbing from sea level at 103 degrees Fahrenheit to 3,000 feet above mean sea level at 91.5 degrees Fahrenheit.
- The greater lift capability is facilitated by increased engine power (7,500 shaft horsepower versus 4,380 horsepower per engine in the CH-53E) and a composite airframe. This composite airframe is lighter than the CH-53E metal airframe.
- The CH-53K design incorporates the following survivability enhancement features:

  - Aircraft Survivability Equipment to include Large Aircraft Infrared Countermeasures with the advanced threat warning sensors (combines infrared, laser, and hostile fire functions into a single system), AN/APR-39D(V)2 radar warning receiver, and AN/ALE-47 countermeasure dispensing system.
  - Pilot armored seats, cabin armor for the floor and sidewalls, fuel tank inerting, self-sealing fuel bladders, and 30-minute run dry capability gear boxes.
- The CH-53K maintains a logistics shipboard footprint equivalent to that of the CH-53E.

Mission

- Commanders will employ the Marine Air-Ground Task Force equipped with the CH-53K for:
  - Heavy lift missions, including assault transport of weapons, equipment, supplies, and troops
  - Supporting forward arming and refueling points and rapid ground refueling
  - Assault support in evacuation and maritime special operations
  - Casualty evacuation
  - Recovery of downed aircraft, equipment, and personnel
  - Airborne control for assault support

Major Contractor

Sikorsky Aircraft Corporation – Stratford, Connecticut

Activity

- In FY16, the program will provide four EMD aircraft to support integrated developmental and operational flight testing.
- The Navy intends ongoing GTV testing to qualify key dynamic components and assess aircraft stresses, vibrations, and rotor performance. GTV also supports long term

verification and reliability testing. The program achieved first flight of the CH-53K EMD-1 aircraft on October 27, 2015.
- In previous testing, the Navy completed qualification and live fire testing of the full-up and installed sponson fuel cell against operationally realistic, small arms threats.
- The pilots' armored seats experienced thermal cracking during initial environmental qualifications and had to be redesigned in FY13. The new design was qualified by analysis and has been part of the qualification program to date. Final environmental and live fire testing of the redesigned pilot seat armor against the specification small arms threat is scheduled for FY16.
- In FY15, the Navy changed the requirement and design of the cabin floor and sidewall armor to an achievable armor performance given the aircraft weight constraints. The new, albeit reduced, requirements allow for a lighter armor design that has already been qualified as effective against specific CV-22 ballistic threats.
- In January through August 2015, the Navy completed live fire testing of three flight-critical main and tail rotor system components. Testing was conducted against a range of operationally relevant, small arms threats and under static loads representative of flight conditions. Sikorsky will subject the damaged components to post-ballistic cyclic structural testing to assess the residual flight capability, representative of get-home flight and landing conditions. This testing is scheduled for FY16.
- The Navy is modifying the Aircraft Survivability Equipment to address cybersecurity requirements (data at rest protection), obsolescence (removable media and computer processors), and reduce life cycle cost (elimination of components). The Navy is upgrading the infrared countermeasure subsystem and adding hostile fire indication.
- The Program Office is revising the Test and Evaluation Master Plan (TEMP) to reflect programmatic changes and updates to the cybersecurity test strategy for Milestone C to include a Cooperative Vulnerability and Penetration Assessment and an Adversarial Assessment.
- The Navy conducted testing in accordance with a DOT&E-approved TEMP and a DOT&E-approved 2010 Alternative LFT&E plan.

Assessment
- Component level bench testing and GTV testing uncovered gear box failures, most notably a quill shaft failure in the Main Gear Box. The quill shaft and the Rear Module Assembly of the gear box required redesign before testing could resume on the GTV. New Rear Module Assemblies were installed on the GTV and the EMD aircraft and the subsequent qualification testing was completed to enable first flight on October 27, 2015.
- Preliminary assessment of the sponson fuel cell qualification test data indicates acceptable performance against small arms threats. Additional live fire ballistic tests will be performed on the GTV in FY19.
- During initial environmental qualification testing, the armored pilot seat did not fully meet environmental specifications, experiencing some thermal cracking. The Program Office initiated redesign of the seats, and final environmental testing, as well as live fire testing of the redesigned pilot seat armor against the specification small arms threat, is scheduled for FY16.
- Three of the four flight-critical main and tail rotor system components tested to date demonstrated the required ballistic damage tolerance to the specified projectile. The Navy will assess the consequent effect of the observed damage on aircraft survivability, in operationally representative conditions, after the completion of the respective structural cyclic endurance tests.
- Modification of the Aircraft Survivability Equipment accelerates inclusion of additional capabilities while reducing life cycle costs.

Recommendations
- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The program should:
  1. Update the TEMP in FY16.
  2. Review data resulting from a DOT&E funded joint live fire program to assess CV-22 armor performance against threats that the Navy did not address in the CV-22 Advanced Ballistic Stopping System LFT&E program. This will enable the Navy to better understand the effectiveness of the armor against additional, operationally realistic threats and adjust the tactics, techniques, and procedures, as needed.

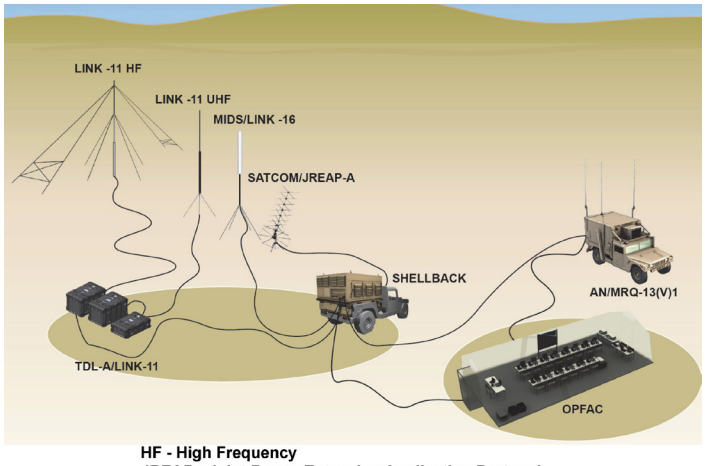
Common Aviation Command and Control System (CAC2S)

Executive Summary

- In October 2014, the Marine Corps Operational Test and Evaluation Activity conducted an operational assessment (OA) for the Common Aviation Command and Control System (CAC2S) Increment I Phase 2 during the Weapons and Tactics Instructors' (WTI) exercise at Marine Corps Air Station Yuma, Arizona. The OA was conducted in accordance with a DOT&E-approved test plan.
- During the OA, CAC2S Increment I Phase 2 demonstrated the ability to support mission accomplishment of the three Marine Corps aviation command and control agencies. Additionally, CAC2S demonstrated the ability to provide data fusion of real-time, near real-time, and non real-time information onto a single tactical display.
- In 2QFY15, the Assistant Secretary of the Navy, Research, Development, and Acquisition, as the Milestone Decision Authority, conducted a Milestone C review for CAC2S, which resulted in an approval to enter the Production and Deployment Phase of its lifecycle and to procure low-rate initial production items to support IOT&E.
- During 3QFY15 and 4QFY15, the Marine Corps conducted additional data fusion testing using updated operational scenarios, and integrated/interoperability testing with the Composite Tracking Network (CTN). At the end of FY15, the Marine Corps continued risk reduction efforts by conducting a full Tactical Air Command Center (TACC) functionality demonstration during a WTI exercise at Marine Corps Station Yuma, Arizona, as well as datalink testing and an integration demonstration with the Ground/Air Task Oriented Radar (G/ATOR).
- IOT&E for CAC2 Increment I Phase 2 is scheduled for 3QFY16.

System

- CAC2S consists of tactical shelters, software, and common hardware. The hardware components are expeditionary, common, modular, and scalable. Components may be freestanding, mounted in transit cases, or rack-mounted in shelters and/ or general-purpose tents that are transported by organic tactical mobility assets.
- CAC2S Increment I is being delivered in two phases. Phase I previously delivered hardware and software to fully support the Direct Air Support Center (DASC) mission requirements and partially support Tactical Air Operations Center (TAOC) mission requirements. Phase 2 combines the three legacy Phase 1 systems into two functional subsystems and fully supports the requirements of the DASC, TACC, and TAOC.



HF - High Frequency
JREAP - Joint Range Extension Application Protocol
MIDS - Multi-Functional Information Distribution System
OPFAC - Operations Facility
SATCOM - Satellite Communications
TDL - Tactical Data Link
UHF - Ultra High Frequency

- The Communication Subsystem provides the capability to interface with internal and external communication assets and the means to control their operation.
- The Aviation Command and Control System provides:
  - The operational command post and functionality to support mission planning, decision making, and execution tools to support all functions of Marine Aviation
  - An open architecture interface capable of integrating emerging active and passive sensor technology for organic and non-organic sensors to the Marine Air Command and Control System
  - The capability to display real-time, near real-time, and non real-time sensor data to support C2 of Marine Air-Ground Task Force (MAGTF) aviation assets

Mission

- The MAGTF Commander will employ Marine Corps aviation C2 assets, including the DASC, the TAOC, and the TACC equipped with CAC2S, to integrate Marine Corps aviation into joint and combined air/ground operations in support of Operational Maneuver from the Sea, Sustained Operations Ashore, and other expeditionary operations.
- The MAGTF Commander will execute C2 of assigned assets afloat and ashore in a joint, allied, or coalition operational environment by using CAC2S capabilities to:

- Share mission-critical voice, video, sensor, and C2 data and information to integrate aviation and ground combat planning and operations
- Display a common, real, and near real-time integrated tactical picture with the timeliness and accuracy necessary to facilitate the control of friendly assets and the engagement of threat aircraft and missiles
- Provide fusion of real-time, near real-time, and non real-time information to support the MAGTF
- Access theater and national intelligence sources from a multi-function C2 node
- Standardize Air Tasking Order and Airspace Control Order generation, parsing, interchange, and dissemination throughout the MAGTF and theater forces by using the joint standard for Air Tasking Order interoperability

Major Contractors

- Phase 1
  - Government Integrator: Naval Surface Warfare Center – Crane, Indiana
  - Component Contractor: Raytheon-Solipsys – Fulton, Maryland
- Phase 2
  - Prime Contractor (no Government Integrator): General Dynamics – Scottsdale, Arizona

---

Activity

- In October 2014, the Marine Corps conducted an OA of the CAC2S Increment I Phase 2 in accordance with a DOT&E-approved OA plan.
- In 2QFY15, the Assistant Secretary of the Navy, Research, Development, and Acquisition, as the Milestone Decision Authority, conducted a Milestone C review for CAC2S, which resulted in an approval to procure low-rate initial production items to support IOT&E.
- During May 2015, the Program Office conducted interoperability/integration testing with the CTN.
- In June 2015, and again in August 2015, the Marine Corps conducted data fusion testing using an updated and operationally realistic scenario that more adequately stressed the system.
- The Marine Corps conducted CTN connectivity testing during 3QFY15 and continued CTN evaluation during the fall 2015 WTI course.
- The Marine Corps continued risk reduction efforts with a datalink connectivity functionality demonstration during 4QFY15.
- During the fall 2015 WTI course, the Program Office conducted integrated testing of CAC2S for all operations cells within the TACC. In addition, operational endurance testing was conducted over the same period as risk reduction for the upcoming IOT&E. An integration demonstration of CAC2S with G/ATOR was also conducted during the WTI primarily as a risk reduction effort since the G/ATOR system is still under development.
- IOT&E for CAC2S Increment I Phase 2 is scheduled for 3QFY16.

Assessment

- Based on qualitative evaluation during the 1QFY14 OA:
  - CAC2S successfully demonstrated the ability to support the primary mission areas for all three agencies: direct air support for the DASC, control aircraft and missiles for the TAOC, and C2 aviation and planning support for the MAGTF commander in the TACC.
  - CAC2S demonstrated an ability to fuse real-time, near real-time, and non real-time data onto a single tactical display, at medium operational tempo densities of aircraft and targets against older/current generation threats.
  - DOT&E did not assess interoperability/integration of CAC2S with G/ATOR as that system is still undergoing development. However, testing did demonstrate the ability to connect the AN/TPS-59 radar sensor directly to CAC2S displaying both radar plot and track data.
  - Reliability, availability and maintainability data, collected during testing and throughout the remainder of FY15, indicate that CAC2S continues to make progress toward meeting its reliability objectives.
- During 3QFY15 and 4QFY15, the Marine Corps continued testing the CAC2S data fusion capability, successfully demonstrating the ability to fuse real-time, near real-time, and non real-time data against an updated operational threat scenario for the test venue.

Recommendations

- Status of Previous Recommendations. The Marine Corps addressed some previous problems and is in the process of addressing the remaining recommendations:
  1. Utilize a balanced use of air and ground combat forces during future test venues to provide a better assessment of CAC2S support to the MAGTF.
  2. Conduct 24-hour operations to ensure adequate hours for assessment of system reliability.
  3. Conduct interoperability and integration testing with CTN and G/ATOR in an operationally realistic environment prior to IOT&E in order to reduce risk if those systems are sufficiently mature.
  4. Conduct a Field User Evaluation prior to IOT&E that exercises all divisions/sections within the TACC.
- FY15 Recommendations. The Marine Corps should:
  1. Continue data fusion testing in support of the CAC2S IOT&E in FY16. Data fusion testing must be conducted using operationally realistic scenarios with the most

likely air threat available in a stressing operational tempo environment.
2. Conduct integration/interoperability testing of CAC2S with G/ATOR in order to assess system characteristics and support integration of G/ATOR when that system achieves its Initial Operational Capability.
3. Complete a user evaluation of all system functionality during a TACC support demonstration. Ensure that evaluations include those for the Future Plans, Future Operations, and Air Combat Intelligence cells in addition to the Current Operations cell in order to reduce risk prior to IOT&E.
4. Conduct datalink demonstration testing, and where feasible, use data in support of CAC2S IOT&E scheduled for 3QFY16. Ensure that functionality and system usability are assessed as part of the pre-operational test risk reduction effort.

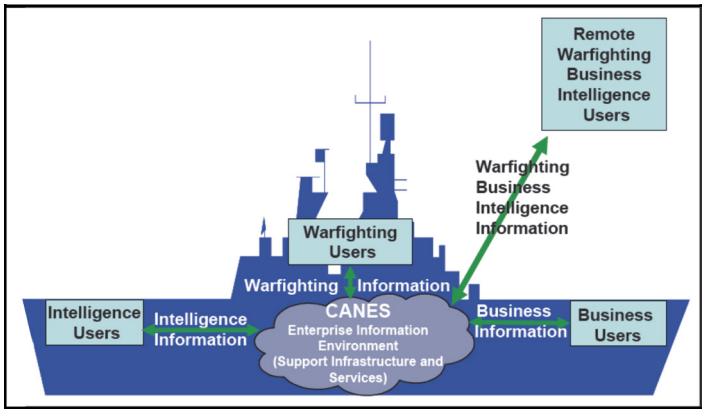
Consolidated Afloat Networks and Enterprise Services (CANES)

Executive Summary

- The Commander, Operational Test and Evaluation Force (COTF) completed the Consolidated Afloat Networks and Enterprise Services (CANES) IOT&E for the unit-level variant on USS *Higgins* (DDG 76) from August 2014 through March 2015. COTF suspended the test at the request of the program manager to allow correction of cybersecurity vulnerabilities.
- DOT&E assessed the unit-level variant as operationally effective, suitable, and survivable. CANES provides computing resources; throughput and transfer speed; and reliability, availability, and maintainability necessary for the ship's missions; however, the Navy should address deficiencies related to training, network mapping, and emissions control conditions. The USD(AT&L) approved the Full Deployment Decision (FDD) on October 13, 2015.
- COTF began the FOT&E of the force-level CANES variant on the USS *John C. Stennis* (CVN 74) in July 2015. The test will conclude in 2016 with cybersecurity testing. DOT&E's initial observations are that the force-level variant will provide the network and enterprise capability to enable the crew to complete assigned missions and tasks.
- The Navy plans to conduct an FOT&E for the submarine variant in FY18.

System

- CANES is an enterprise information system consisting of computing hardware, software, and network services (e.g., phone, email, chat, video teleconferencing, web hosting, file transfer, computational resources, storage, and network configuration and monitoring). CANES will replace legacy networks on ships, submarines, and shore sites.
- The CANES program will mitigate hardware and software obsolescence on naval vessels through the increased use of standard components and regularly scheduled hardware and software updates.



- The CANES network provides a single, consolidated physical network with logical sub-networks for Unclassified, Secret, Secret Releasable, and Top Secret security domains. It includes a cross-domain solution for information transfers across these security boundaries. This consolidation is expected to reduce the network infrastructure footprint on naval platforms and the associated logistics, sustainment, and training costs.

Mission

Shipboard users will use the CANES network to:

- Host their applications in support of naval and joint operations with computing resources and networks services
- Support weapon systems, command and control, intelligence, and business information applications

Major Contractors

- Northrop Grumman – Huntsville, Alabama
- BAE Systems – Rockville, Maryland
- Serco – Reston, Virginia

Activity

- COTF completed IOT&E for the CANES unit-level variant onboard USS *Higgins* from August 2014 through March 2015. COTF suspended testing at the program manager's request to allow for correction of cybersecurity vulnerabilities.
- In July 2015, DOT&E submitted an IOT&E report of the unit-level variant ships, detailing the results of testing to inform the FDD. USD(AT&L) approved the FDD on October 13, 2015.
- The CANES Program Office conducted an integrated test of the CANES force-level variant aboard USS *John C. Stennis* in June 2015. COTF conducted a maintenance demonstration concurrently.
- COTF began FOT&E on the force-level variant in July 2015 aboard USS *John C. Stennis*. The test period will end after cybersecurity testing in 2016.

Assessment

- DOT&E assessed the CANES unit-level variant as operationally effective, suitable, and survivable. Network performance among all security enclaves enabled the crew to complete assigned tasks and missions while pier-side and underway. Hardware and software met reliability, availability, and maintainability requirements.
- The program manager successfully mitigated cybersecurity vulnerabilities, including working with the fleet personnel to implement recommended procedures and security updates.
- Integrated testing of the CANES force-level variant in June 2015 demonstrated the system's ability to meet basic functional and performance requirements.
- DOT&E's initial observations of the FOT&E for the force-level variant are that the variant provided the required communications and information technology support that enabled the crew to complete assigned tasks and missions.

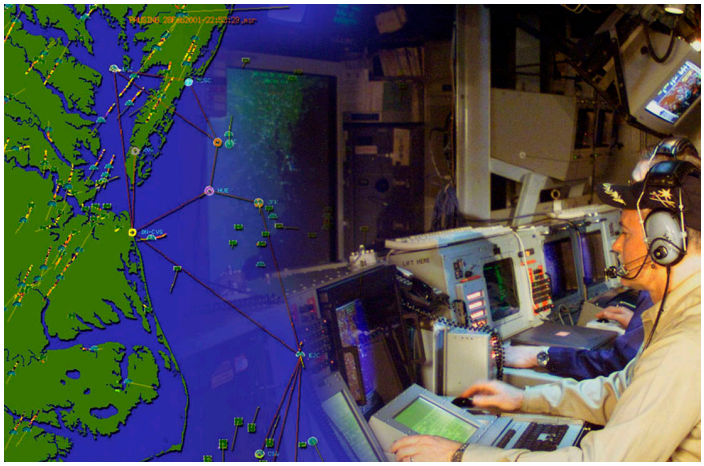
Recommendations

- Status of Previous Recommendations. The Navy addressed all previous recommendations.
- FY15 Recommendation.
  1. The Navy should begin planning the FOT&E for the submarine variant scheduled for FY18.

Cooperative Engagement Capability (CEC)

Executive Summary
- In July 2015, DOT&E submitted a classified Early Fielding Report on the Aegis Baseline 9A Combat System with the Cooperative Engagement Capability (CEC) USG-2B. In the report, DOT&E stated that test results to date showed the CEC USG-2B, as integrated in the Aegis Baseline 9A Combat System, is likely to perform comparably to previous CEC USG-2 and USG-2A variants.
- DOT&E will conduct a full assessment of the CEC USG-2B's operational effectiveness and suitability on Aegis platforms upon completion of the CEC USG-2B FOT&E.

System
- CEC is a real-time, sensor-netting system that enables high quality situational awareness and integrated fire control capability.
- There are four major U.S. Navy variants of CEC:
  - The USG-2/2A is used in selected Aegis cruisers and destroyers, LPD 17/LHD amphibious ships, and CVN 68 class aircraft carriers.
  - The USG-2B, an improved version of the USG-2/2A, is used in selected Aegis cruisers/destroyers as well as selected amphibious assault ships. The USG-2B is planned for use in the CVN 78 and DDG 1000 ship classes.
  - The USG-3 is used in the E-2C Hawkeye 2000 aircraft.
  - The USG-3B is used in the E-2D Advanced Hawkeye aircraft.
- The two major hardware pieces are the Cooperative Engagement Processor, which collects and fuses sensor data, and the Data Distribution System, which exchanges data between participating CEC units.
- The CEC increases Naval Air Defense capabilities by integrating sensors and weapon assets into a single, integrated, real-time network that:
  - Expands the battlespace
  - Enhances situational awareness



  - Increases depth-of-fire
  - Enables longer intercept ranges
  - Improves decision and reaction times

Mission
- Naval forces use CEC to improve battle force air and missile defense capabilities by combining data from multiple battle force air search sensors on CEC-equipped units into a single, real-time, composite track picture.
- Naval surface forces also use CEC to provide accurate air and surface threat tracking data to ships equipped with the Ship Self-Defense System.

Major Contractor
Raytheon Systems Co., Command, Control and Communications, Data Systems – St. Petersburg, Florida

Activity
- The Navy's Commander, Operational Test and Evaluation Force conducted FOT&E of the CEC USG-2B with the Aegis Baseline 9A Combat System in February 2015 in accordance with a DOT&E-approved test plan. Problems with test range and aerial target availability delayed completing the FOT&E until January 2016.
- DOT&E submitted a classified Early Fielding Report to Congress on the Aegis Baseline 9A Combat System with the USG-2B Cooperative Engagement Capability in July 2015.

Assessment
- Test results to date indicate that a number of effectiveness measures are below established performance goals. These measures included anti-jamming resistance, two data distribution measures, track continuity, identification accuracy, and interoperability.
- In the classified July 2015 Early Fielding Report on the Aegis Baseline 9A Combat System, DOT&E stated that test results to date showed that the CEC USG-2B, as integrated in the Aegis Baseline 9A Combat System, is likely to perform

comparably to previous CEC USG-2 variants. DOT&E will conduct a full assessment of the CEC USG-2B's operational effectiveness and suitability upon completion of the CEC USG-2B FOT&E.
- The CEC USG-2B cybersecurity testing conducted to date has not revealed any major deficiencies.

Recommendations
- Status of Previous Recommendations. The Navy has not satisfied the following previous recommendations to:
  1. Demonstrate corrections to the problem that degrades the USG-3B CEC's Track File Concurrence in a phase of FOT&E.
  2. Implement changes to the USG-3B CEC interface with the E-2D mission computer that would allow data from the E-2D's APY-9 radar to be used by the USG-3B CEC without first requiring the creation of an E-2D Mission Computer track.
  3. Reassess the USG-3B CEC reliability requirement and whether the logistic supply system can support the demonstrated USG-3B CEC reliability.
  4. Correct the cause of the electromagnetic interference between the USG-3B CEC and the E-2D radar altimeter and demonstrate the corrections in a phase of FOT&E.
  5. Take action on the recommendations contained in DOT&E's classified report to Congress on the CEC USG-3B FOT&E.
  6. Update the CEC Test and Evaluation Master Plan to include details of:
     - The second phase of the USG-3B FOT&E with the supersonic sea-skimming target scenario
     - FOT&E of corrections made to the CEC USG-3B
     - FOT&E of the CEC USG-2B with the Aegis Baseline 9 Combat System
     - FOT&E of the CEC USG-2B with the DDG 1000 *Zumwalt* Combat System
     - FOT&E of the CEC USG-2B with the CVN 78 Combat System
     - FOT&E of USG-3B CEC to demonstrate the system's ability to support the E-2D's Theater Air and Missile Defense and Battle Force Command and Control missions
     - The test program supporting the Acceleration of Mid-term Interoperability Improvements Project
- FY15 Recommendation.
  1. The Navy should complete the FOT&E of the CEC USG-2B with the Aegis Baseline 9 Combat System.

CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier

Executive Summary

- On February 2, 2015, DOT&E disapproved Test and Evaluation Master Plan (TEMP) 1610, Revision C because the CVN 78 Class Full Ship Shock Trial (FSST) had been changed in the approved 2007 TEMP 1610, Revision B from CVN 78 to CVN 79. The Revision C TEMP does provide improved integrated platform-level developmental testing, reducing the likelihood that platform-level problems will be discovered during IOT&E. In addition, the Program Office is in the process of refining the post-delivery schedule to further integrate testing.
- On August 7, 2015, the Deputy Secretary of Defense directed the Navy to complete the FSST before CVN 78's first operational deployment. The Navy is updating the TEMP to reflect the Deputy Secretary of Defense's decision.
- The Navy's Commander, Operational Test and Evaluation Force (COTF) began a new DOT&E-approved operational assessment in September 2015, which is planned to end in mid-2016 after CVN 78 completes Builder's Sea Trials and Acceptance Trials.
- DOT&E's assessment of CVN 78 remains consistent with the DOT&E Operational Assessment report submitted in December 2013. Poor or unknown reliability of newly designed catapults, arresting gear, weapons elevators, and radar, which are all critical for flight operations, could affect CVN 78's ability to generate sorties, make the ship more vulnerable to attack, or create limitations during routine operations. The poor or unknown reliability of these critical subsystems is the most significant risk to CVN 78.
  - Reliability for the catapults was last reported in December 2014. While catapult reliability is above the re-baselined reliability growth curve, the re-baselined curve is well below the reliability requirement and the catapults are unlikely to achieve required reliability.
  - Reliability for the arresting gear has not been reported in almost two years. The last reported reliability estimates for the arresting gear were well below the re-baselined reliability growth curve, and indicated that the system was unlikely to achieve required reliability. The Navy began measuring reliability again in 4QFY15, but does not expect to have new reliability estimates until the end of 2015. Additionally, reliability test data are not available for the radar and the weapons elevators.
  - Absent a major redesign, the catapults and arresting gear are not likely to meet reliability requirements.
- In FY14, testing at the Electromagnetic Aircraft Launching System (EMALS) functional demonstration test site at Joint Base McGuire- Dix- Lakehurst, New Jersey, discovered excessive airframe stress during launches of F/A-18E/F and EA-18G with wing-mounted 480-gallon external fuel tanks (EFTs). This discovery, until corrected, will preclude the Navy from conducting normal operations of the F/A-18E/F and EA-18G from CVN 78.

- In FY15, the Navy identified an inability to readily electrically isolate EMALS components to perform concurrent maintenance. This inability to readily electrically isolate EMALS components could preclude some types of EMALS maintenance during flight operations, decreasing EMALS operational availability.
- In October 2015, the Navy discovered that one of the three Prime Power Interface Subsystems (PPIS) Transformer Rectifiers (TRs) had been damaged during shipboard certification testing. Two of the three TRs are required for normal catapult operations. The TRs were designed to last the life of the ship. Earlier faults discovered during developmental testing resulted in stepwise improvements to the PPIS TR design and construction. This failed TR had one of the four improvements.
- In FY15, the Navy began performance testing of the Advanced Arresting Gear (AAG) at a jet car track site at Joint Base McGuire-Dix-Lakehurst, New Jersey. This testing is examining the performance of the redesigned arresting gear to meet the system specification with improve reliability.
- The CVN 78 design is intended to reduce manning. As manning requirements have been further developed, analysis indicates the ship is sensitive to manpower fluctuations; and workload estimates for the many new technologies such as catapults, arresting gear, radar, and weapons and aircraft elevators are not well-understood. Some of these concerns have already required re-designation of some berthing areas and may require altering standard manpower strategies to ensure mission accomplishment.
- The CVN 78 combat system for self-defense is derived from the combat system on current carriers and is expected to have similar capabilities and limitations. The ship's Dual Band Radar (DBR) is being integrated with the combat system

and is undergoing developmental testing at Wallops Island, Virginia. That testing has uncovered significant problems, typical of those seen in early developmental testing, affecting air traffic control and self-defense operations. The Navy is investigating solutions to these problems.
- It is unlikely that CVN 78 will achieve its Sortie Generation Rate (SGR) (number of aircraft sorties per day) requirement. The threshold requirement is based on unrealistic assumptions including fair weather and unlimited visibility, and that aircraft emergencies, failures of shipboard equipment, ship maneuvers, and manning shortfalls will not affect flight operations. DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the demonstrated performance of the *Nimitz* class carriers as well as to the SGR requirement.
- CVN 78 will include a new Heavy underway replenishment (UNREP) system that will transfer cargo loads of up to 12,000 pounds. Currently, only one resupply ship has Heavy UNREP on one station. The Navy plans to install a single Heavy UNREP station on each additional resupply ship beginning in FY21 with T-AO(X).
- The schedule to deliver the ship has slipped from September 2015 to April 2016. On September 22, the Navy announced that sea trials would be delayed six to eight weeks due to slower than expected progress in the shipboard test program. The development and testing of EMALS, AAG, DBR, and the Integrated Warfare System will continue to drive the timeline as the ship progresses into test and evaluation.

System
- The CVN 78 *Gerald R. Ford* class aircraft carrier program is a new class of nuclear-powered aircraft carriers. It has the same hull form as the CVN 68 *Nimitz* class, but many ship systems, including the nuclear plant and the flight deck, are new.
- The newly designed nuclear power plant is intended to operate at a reduced manning level that is 50 percent of a CVN 68 class ship and produce significantly more electricity.
- The CVN 78 will incorporate EMALS (electromagnetic, instead of steam-powered catapult launchers) and AAG, and will have a smaller island with a DBR (phased-array radars, which replaces/combines several legacy radars used on current aircraft carriers serving in air traffic control and in ship self-defense).
- The Navy intends for the Integrated Warfare System to be adaptable to technology upgrades and varied missions throughout the ship's projected operating life including increased self-defense capabilities compared to current aircraft carriers.
- The Navy redesigned weapons stowage, handling spaces, and elevators to reduce manning, increase safety, and increase throughput of weapons.
- CVN 78 has design features intended to enhance its ability to launch, recover, and service aircraft, such as a slightly larger flight deck, dedicated weapons handling areas, and an increased number of aircraft refueling stations. The Navy set the SGR requirement for CVN 78 to increase the sortie generation capability of embarked aircraft to 160 sorties per day (12-hour fly day) and to surge to 270 sorties per day (24-hour fly day) as compared to the CVN 68 *Nimitz* class SGR demonstration of 120 sorties per day/240 sorties for 24-hour surge.
- The Consolidated Afloat Networks and Enterprise Service (CANES) program replaces five shipboard legacy network programs to provide a common computing environment for command, control, intelligence, and logistics.
- CVN 78 is intended to support the F-35 and future weapons systems over the expected 50-year ship's lifespan. CVN 78 will include a new Heavy UNREP system that will transfer cargo loads of up to 12,000 pounds.
- The Navy will achieve CVN 78 Initial Operational Capability in FY17 after successful completion of Post Shakedown Availability and will achieve Full Operational Capability in FY19 after successful completion of IOT&E testing and Type Commander certification.

Mission

Carrier Strike Group Commanders will use the CVN 78 to:
- Conduct power projection and strike warfare missions using embarked aircraft
- Provide force and area protection
- Provide a sea base as both a command and control platform and an air-capable unit

Major Contractor

Huntington Ingalls Industries, Newport News Shipbuilding – Newport News, Virginia

---

Activity

Test Planning
- The CVN 78 *Gerald R. Ford* class carrier Program Office revised the TEMP 1610 to align planned developmental tests with corresponding operational test phases and to identify platform-level developmental testing. DOT&E disapproved this TEMP 1610 Revision C pending the rescheduling of the CVN 78 Class FSST from CVN 79 to CVN 78, before her first operational deployment.
- The Navy is updating the Post Delivery Test and Trials schedule to incorporate the FSST as directed by the Deputy Secretary of Defense.
- The Navy plans a live test to demonstrate the SGR with six consecutive 12-hour fly days followed by two consecutive 24-hour fly days. DOT&E concurs with this live test approach; however, resolution of how the Navy

will extrapolate the days of live results to the 35-day design reference mission on which the SGR requirement is based is yet to be decided. Until this year, the Navy planned to use a model in development by Huntington Ingalls Industries to extrapolate the live test results. In June 2015, COTF told the CVN 78 program manager that because several of the assumptions tied to this Key Performance Parameter are beyond the scope of operational test, COTF would not accredit the Navy's Virtual Carrier (VCVN) model for use during IOT&E. DOT&E agrees with COTF's concerns about the Key Performance Parameter assumptions, and the resulting limitations of the VCVN model.

EMALS

- The Navy is conducting installation and checkout of the EMALS in CVN 78. Initial dead load tests have been completed on the bow catapults, and testing continues on the waist catapults. To date, 109 dead loads and 191 no load tests have been completed on the bow catapults, and 55 no load tests have been completed on the waist catapults.
- The EMALS functional demonstration test site at Joint Base McGuire-Dix-Lakehurst, New Jersey, continues to test the electromagnetic catapult system. The Navy has also conducted over 3,500 dead-load launches (non-aircraft, weight equivalent, and simulated launches) and over 450 aircraft launches at the functional demonstration test site.
- In 2014, testing discovered excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon EFTs. During test launches, the stress limits of the aircraft were exceeded.

AAG

- The Navy is conducting installation and checkout of the AAG in CVN 78. Hardware checkout has occurred in preparation for initial shipboard testing.
- The Navy continues to test the AAG on a jet car track at Joint Base McGuire-Dix-Lakehurst, New Jersey. Earlier testing prompted system design changes that are now being tested. The jet car track testing has examined the F/A-18E/F performance envelope with the new design. Overall, land based jet car track testing has conducted a total of 1046 deadload arrestments; including, the completion of 76 performance deadload arrestments in 4QFY15.
- Testing has focused system performance of off center and angled (or skew) recoveries that create system instability. This instability is known as divergent trajectory and is created when an aircraft runout trajectory diverges from off center and/or skew engagement conditions.
- Previously, the Navy de-scoped the number 4 AAG engine, reducing the total arresting gear engines on the ship, including the barricade, to three, and diverted the equipment to Runway Arrested Landing Site in Lakehurst to support the test program.

CANES

- The Navy completed CANES integrated testing and currently is performing follow-on operational testing of the force-level CANES configuration used on the *Nimitz* and *Gerald R. Ford* classes. This FOT&E is scheduled to complete in 1QFY16.
- The Navy conducted integrated testing and IOT&E of the unit-level Aegis destroyer configuration in 3QFY14 and 2QFY15. The system was operationally effective, suitable, and survivable to the cyber threats represented in the test.

DBR

- The radar consists of fixed array antennas both in the X- and S-bands. The X-band radar is the Multi-Function Radar (MFR) and the S-band radar is the Volume Search Radar.
- The Navy is testing a production array MFR and an Engineering Development Model array of the Volume Search Radar at the Surface Combat System Center at Wallops Island, Virginia. The developmental testing of DBR resumed in 4QFY14 at Wallops Island and is expected to continue through 3QFY16. The MFR will then be installed on the Self-Defense Test Ship for further CVN 78 testing beginning 2QFY17.
- Testing of the production DBR has begun on CVN 78 in the shipyard. Initial checkout of the equipment has occurred.

Manning

- The Navy conducted CVN 78 Manning War Game III in July 2014 to identify CVN 78 unique manpower, personnel, training, and education planning and execution concerns.

LFT&E

- On August 7, 2015, the Deputy Secretary of Defense directed the Navy to complete the FSST before CVN 78's first operational deployment. The Revision A of the LFT&E Management Plan prepared by the Navy and approved by DOT&E on July 17, 2007, stated the FSST would be conducted on CVN 78. The Navy unilaterally reneged on the approved strategy on June 18, 2012. DOT&E did not approve of the Navy revisions to the new Live Fire Strategy and the Deputy Secretary of Defense concurred with DOT&E.

Assessment

Test Planning

- A TEMP 1610 revision is under development to address problems with the currently-approved TEMP 1610, Revision B. The Navy submitted a revised TEMP 1610, Revision C that was disapproved on February 2, 2015, because the Navy removed the previously (2007) agreed upon FSST. However, Revision C improved integrated platform-level developmental testing, reducing the likelihood that platform-level problems will be discovered during IOT&E. In addition, the Program Office is in the process of refining the post-delivery schedule to further integrate testing. With the Deputy Secretary of Defense's direction to the Navy to conduct the FSST before the initial deployment on CVN 78, the Navy desires to update TEMP 1610, Revision C. DOT&E has not seen the Navy's

revision plan and given the extent of the updates required may require a Revision D to TEMP 1610.

- The current state of the Navy's VCVN model does not fully provide for an accurate accounting of SGR due to a lack of fidelity regarding manning and equipment/aircraft availability. Due to these limitations, in June 2015, COTF rescinded the use of VCVN for extrapolating live test results. The Navy has not stated how it intends to extrapolate the live results to the 35-day design reference mission on which the SGR requirement is based. DOT&E agrees with the COTF decision. An alternative SGR modeling and simulation approach should be developed by the Navy.
- The schedule to deliver the ship has slipped from September 2015 to April 2016. On September 22, the Navy announced that sea trials would be delayed six to eight weeks due to slower than expected progress in the shipboard test program. The ship's post-shipyard shakedown availability will follow delivery in late 2016. During the post-shipyard shakedown availability, installations of some systems will be completed. The first at-sea operational test and evaluation of CVN 78 is scheduled to begin in September 2017.

Reliability

- CVN 78 includes several systems that are new to aircraft carriers; four of these systems stand out as being critical to flight operations: EMALS, AAG, DBR, and the Advanced Weapons Elevators (AWEs). Overall, the uncertain reliability of these four systems is the most significant risk to the CVN-78 IOT&E. All four of these systems are being tested for the first time in their shipboard configurations aboard CVN 78. Reliability estimates derived from test data for EMALS and AAG are discussed below. For DBR and AWE, reliability data collection has not yet been reported to DOT&E, but is expected to start at the completion of shipboard installation and checkout. Only engineering reliability estimates have been provided to date.
- CVN 78 will include a new Heavy UNREP system that will transfer cargo loads of up to 12,000 pounds. Currently, only one resupply ship has Heavy UNREP on one station. The Navy plans to install a single Heavy UNREP station on each additional resupply ship beginning in FY21 with T-AO(X).

EMALS

- EMALS is one of the four systems critical to flight operations. While testing to date has demonstrated that EMALS should be able to launch aircraft planned for CVN 78's air wing, present limitations on F/A-18E/F and EA-18G configurations, as well as the system's reliability remains uncertain.
- With the current limitations on EMALS for launching the F/A-18E/F and EA-18G in operational configurations (i.e.,during test launches with wing-mounted 480-gallon EFTs, the stress limits of the aircraft were exceeded), CVN 78 will be able to fly F/A-18E/F and EA-18G, but not in the configuration that is required for normal operations. If uncorrected, this problem would preclude normal employment from CVN-78. Presently, this configuration substantially reduces the operational effectiveness in of F/A-18E/F and EA-18G flying combat missions from CVN 78. The Navy has conducted deadload launches for changes to the EMALS Control Software to correct this issue in preparation for land based aircraft test launches in 3QFY16.
- In FY15, the Navy identified an inability to readily electrically isolate EMALS components to perform concurrent maintenance. For safety of personnel, maintenance and repair to catapults will likely be limited to non-flight operations periods. It is not possible to readily electrically isolate equipment during flight operations due to the shared nature of the Energy Storage Groups (ESGs) and Power Conversion Subsystem inverters in the four launcher/three ESG configuration. The primary means of physically disconnecting major subsystems and the launchers are the Cable Disconnect Units (CDUs). There is no circuit breaker or switch to secure power to the CDU; CDUs can only be disconnected by first securing all feeding power, dissipating all stored energy including spinning down the motor/generators, discharging capacitors, and then unbolting and removing the bus disconnect links. This provision would prevent certain maintenance and repair of launcher components while power is present in other components and while other launchers are conducting flight operations. In contrast, on *Nimitz* class carriers with steam catapults, maintenance on non-operating catapults while flight operations are performed on operating catapults is allowed and routine. The effects on operational performance of this are unclear, and will depend upon the extent to which EMALS redundancy permits catapult operations to continue not withstanding component equipment failures.
- In October 2015, the Navy discovered that one of three PPIS TRs had been damaged during shipboard certification testing. Two of the three TRs are required for normal catapult operations. The TRs were designed to last the life of the ship. Earlier faults discovered during developmental testing resulted in stepwise improvements to the PPIS TR design and construction. This failed TR had one of the four improvements. The PPIS is 130 inches wide, 74 inches deep, 80 inches high, and weighs over 35,000 pounds. The replacement PPIS will be shipped to and fault checked at Joint Base McGuire-Dix-Lakehurst, New Jersey, and then shipped to Newport News, Virginia, for installation on CVN 78. The removal of the old PPIS, which, due to the size and mass of the PPIS will require cutting a hole in the ship's hull, and installation of the new one will take several months, but is not expected to delay testing or ship's delivery.
- As of December 2014, the program estimates that EMALS has approximately 340 Mean Cycles Between Critical Failure (MCBCF) in the shipboard configuration, where a cycle represents the launch of one aircraft. While this estimate is above the re-baselined reliability growth curve,

the re-baselined curve is well below the requirement of 4,166 MCBCF. The failure rate for the last reported MCBCF was 3.7 times higher than should have been expected at this point in the development. Absent a major redesign, it is unlikely EMALS will be capable of meeting the requirement of 4,166 MCBCF.

AAG

- AAG is another system critical to flight operations. Testing to date has demonstrated that AAG should be able to recover aircraft planned for the CVN 78 air wing, but AAG's reliability is uncertain. The Program Office redesigned major components that did not meet system specifications during land-based testing. The Program Office last provided reliability data in December 2013 and estimated that AAG had approximately 20 Mean Cycles Between Operational Mission Failure (MCBOMF) in the shipboard configuration, where a cycle represents the recovery of one aircraft. The requirement is an MCBOMF of 16,500. The Program Office expects to have a reliability estimate for the new design by the end of 2015. The last reported failure rate was 248 times higher than should have been expected at this point in the development.

DBR

- Previous testing of Navy combat systems similar to CVN 78's revealed numerous integration problems that degrade the performance of the combat system. Many of these problems are expected to exist on CVN 78. The DBR testing at Wallops Island is typical of early developmental testing with the system still in the problem discovery phase. Current results reveal problems with tracking and supporting missiles in flight, excessive numbers of clutter/false tracks, and track continuity concerns. More test-analyze-fix cycles are necessary for DBR to develop and test fixes so that it can properly perform air traffic control and engagement support on CVN 78. Previous test results emphasize the necessity of maintaining a DBR/CVN 78 combat system asset at Wallops Island. The removal of the MFR and the conclusion of developmental testing was originally scheduled for 3QFY15, but the Navy decided to extend the Wallops Island testing through 3QFY16. DOT&E concurs with this schedule change and considers it a necessary part of delivering a fully-capable combat system in CVN 78.

SGR

- It is unlikely that CVN 78 will achieve its SGR requirement. The target threshold is based on unrealistic assumptions including fair weather and unlimited visibility, and that aircraft emergencies, failures of shipboard equipment, ship maneuvers, and manning shortfalls will not affect flight operations. DOT&E plans to assess CVN 78 performance during IOT&E by comparing it to the SGR requirement as well as to the demonstrated performance of the *Nimitz* class carriers.
- During the 2013 operational assessment, DOT&E conducted an analysis of past aircraft carrier operations in major conflicts. The analysis concludes that the CVN 78 SGR requirement is well above historical levels and that CVN 78 is unlikely to achieve that requirement. There are concerns with the reliability of key systems that support sortie generation on CVN 78. Poor reliability of these critical systems could cause a cascading series of delays during flight operations that would affect CVN 78's ability to generate sorties, make the ship more vulnerable to attack, or create limitations during routine operations. DOT&E assesses the poor or unknown reliability of these critical subsystems will be the most significant risk to CVN 78's successful completion of IOT&E. The analysis also considered the operational implications of a shortfall and concluded that as long as CVN 78 is able to generate sorties comparable to *Nimitz* class carriers, the operational implications of CVN 78 will be similar to that of a *Nimitz* class carrier.

Manning

- The latest Navy analysis of manning identified several areas of concern. The Navy has re-designated some officer rooms as Chief Petty Officer (CPO) berthing spaces to resolve a shortfall in CPO berthing.
- During some exercises, the berthing capacity for officers and enlisted will be exceeded, requiring the number of evaluators to be limited or the timeframe to conduct the training to be lengthened. This shortfall in berthing is further exacerbated by the 246 officer and enlisted billets (roughly 10 percent of the crew) identified in the Manning War Game III as requiring a face-to-face turnover. These turnovers will not all happen at one time, but will require heavy oversight and will limit the amount of turnover that can be accomplished at sea and especially during evaluation periods.
- Manning must be supported at the 100 percent level, although this is not the Navy's standard practice on other ships and the Navy's personnel and training systems may not be able to support 100 percent manning. The ship is extremely sensitive to manpower fluctuations. Workload estimates for the many new technologies such as catapults, arresting gear, radar, and weapons and aircraft elevators are not yet well-understood. Finally, the Navy is considering placing the ship's seven computer networks under a single department. Network management and the correct manning to facilitate continued operations is a concern for a network that is more complex than historically seen on Navy ships.

LFT&E

- The Navy has made substantial progress on defining the scope of the Total Ship Survivability Trial and the Analytical Bridge task. While these portions of the LFT&E Management Plan were adequately defined in the Revision B document, DOT&E returned the LFT&E Management Plan to the Navy solely on the basis of the FSST on CVN 79 verses CVN 78. With the Deputy Secretary of Defense's direction to the Navy to reinsert the FSST, a revised LFT&E Management Plan is under development.
- CVN 78 has many new critical systems, such as EMALS, AAG, AWE, and DBR that have not undergone shock trials

on other platforms. Unlike past tests on other new classes of ships with legacy systems, the performance of CVN-78's new critical systems is unknown. Inclusion of data from shock trials early in a program has been an essential component of building survivable ships. The current state of modeling and component-level testing are not adequate to identify the myriad of problems that have been revealed only through full ship shock testing.

- The FSST and component shock qualification test data could affect the design of future carriers in the class and are critical to the assessment of the CVN 78 survivability against operationally relevant threats. The FSST is scheduled to occur on CVN 78 in FY19.

Recommendations

- Status of Previous Recommendations. The Navy should continue to address the seven remaining FY10, FY11, FY13, and FY14 recommendations.
  1. Finalize plans that address CVN 78 Integrated Warfare System engineering and ship's self-defense system discrepancies prior to the start of IOT&E.
  2. Continue aggressive EMALS and AAG risk-reduction efforts to maximize opportunity for successful system design and test completion in time to meet required in-yard dates for shipboard installation of components.
  3. Provide scheduling, funding, and execution plans to DOT&E for the live SGR test event during the IOT&E.
  4. Continue to work with the Navy's Bureau of Personnel to achieve adequate depth and breadth of required personnel to sufficiently meet Navy Enlisted Classification fit/fill manning requirements of CVN 78.
  5. Conduct system-of-systems developmental testing to preclude discovery of deficiencies during IOT&E.
  6. Address the uncertain reliability of EMALS, AAG, DBR, and AWE. These systems are critical to CVN 78 flight operations, and are the largest risk to the program.
  7. Aggressively fund and address a solution for the excessive EMALS holdback release dynamics during F/A-18E/F and EA-18G catapult launches with wing-mounted 480-gallon EFTs.
- FY15 Recommendations. The Navy should:
  1. Ensure the continuation of funding and testing of the DBR at Wallops Island through 3QYFY16 address the problems discovered during initial developmental testing.
  2. Begin tracking and reporting on a quarterly basis systems reliability for all new systems but at a minimum for EMALS, AAG, DBR, and AWE.
  3. The Navy should ensure the continued funding for component shock qualification of both government and contractor furnished equipment.
  4. Submit a TEMP for review and approval by DOT&E incorporating the Deputy Secretary's direction to conduct the FSST before CVN 78's first deployment.

DDG 1000 *Zumwalt* Class Destroyer

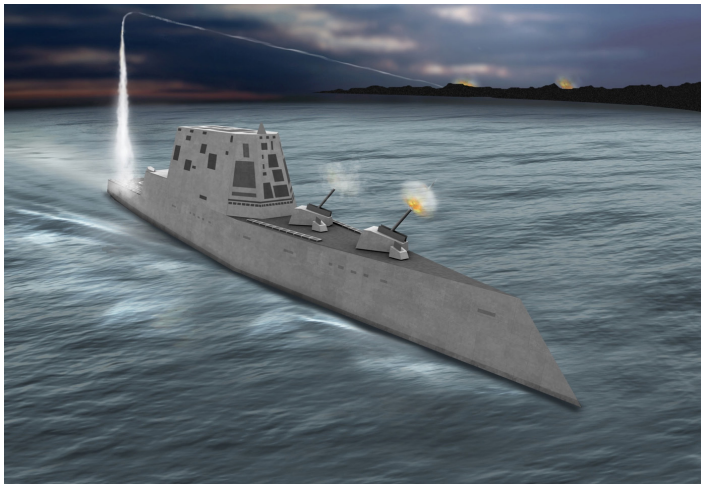
Executive Summary

- The first ship in the DDG 1000 *Zumwalt* class destroyers was launched on October 28, 2013. The Navy initiated pre-delivery testing in FY13 on DDG 1000 (lead ship), and testing will continue in FY16. The Navy plans to accept delivery of DDG 1000 in an incomplete condition and sail the ship to the West Coast in FY16. After the ship arrives on the West Coast, it will begin an 18-month post-delivery availability to complete installation, integration, and shipyard testing of mission systems. The Navy plans to conduct a second Acceptance Trial when that availability has been completed and expects IOT&E to commence in FY18.
- The Navy removed funding for the planned Full Ship Shock Trial (FSST) on DDG 1000 in September 2014, unilaterally deciding to conduct the event on DDG 1002. In October 2015, the Navy revised their decision and agreed to conduct FSST (specific ship to be determined) prior to the first deployment of any DDG 1000 *Zumwalt* class destroyer.
- To complete the survivability analysis, the Navy needs to restore funding and complete the component shock qualification program that is used to verify if the equipment installed in all three hulls meets the design requirements. The Navy also needs to address the shortfalls associated with the models that support the overall survivability evaluation.

System

The DDG 1000 *Zumwalt* class destroyers are new surface combatants with a wave-piercing tumblehome hull form designed both for endurance and low-radar detectability. The Navy currently plans to acquire three ships of the class. The DDG 1000 *Zumwalt* class destroyer is equipped with the following:

- Total Ship Computing Environment Infrastructure that hosts all ship functions on an integrated, distributed computing plant.
- Two 155 mm Advanced Gun Systems that fire Long Range Land Attack Projectiles (LRLAPs).
- AN/SPY-3 Multi-Function (X-band) radar modified to include a volume search capability. (The Navy removed the Volume Search Radar (S-band) from the ship's baseline design for cost reduction in compliance with an Acquisition Decision Memorandum of June 1, 2010.)
- Eighty vertical launch cells that can hold a mix of Tomahawk Land Attack Missiles, Standard Missiles, Vertical Launch Anti-Submarine Rockets, and Evolved Sea Sparrow Missiles.



- An integrated Undersea Warfare system with a dual frequency bow-mounted sonar and multi-function towed array sonar to detect submarines and assist in avoiding mines.
- An ability to embark and maintain MH-60R helicopters and vertical take-off unmanned aerial vehicles.
- An Integrated Power System that can direct electrical power to propulsion motors, combat systems, or other ship needs.

Mission

- The Joint Force Maritime Component Commander intends to employ the DDG 1000 *Zumwalt* class destroyer to provide:
  - Joint Surface Strike /Power Projection
  - Joint Surface Fire Support
  - Surface Warfare
  - Anti-Air Warfare
  - Anti-Submarine Warfare
- The DDG 1000 *Zumwalt* class destroyer is intended to operate independently or in conjunction with an Expeditionary or Carrier Strike Group, as well as with other joint or coalition partners in a Combined Expeditionary Force environment.

Major Contractors

- General Dynamics Marine Systems Bath Iron Works – Bath, Maine
- Huntington Ingalls Industries – Pascagoula, Mississippi
- BAE Systems – Minneapolis, Minnesota
- Raytheon – Waltham, Massachusetts

Activity

- The Navy continues to revise the Test and Evaluation Master Plan (TEMP). The most significant changes being addressed in the TEMP revision are:
  - Modification of the AN/SPY-3 Multi-Function Radar (X Band, horizon search radar) to provide the volume search capability that would have been provided by the

Volume Search Radar (S-band), which has been removed from the baseline design.
  - Replacement of two MK 110 57 mm close-in gun systems (integrated with the ship's combat system), with two standalone MK 46 30 mm guns (not integrated with the ship's combat system).
  - Incorporation of schedule adjustments that reflect shipyard delays and the Navy's plan to complete component installation, integration, and mission system testing on DDG 1000 during an 18-month availability at a West Coast shipyard. The Navy plans to conduct a second Acceptance Trial when that availability has been completed and expects IOT&E to commence in FY18.
  - Inclusion of detailed test designs for major mission areas, including Anti-Air Warfare, Anti-Submarine Warfare, Surface Warfare, fire support, and mine avoidance.
- The Navy completed LRLAP lethality testing in FY14. Modeling and simulation will be used to assess LRLAP performance against multiple targets in 2017.
- The Navy continues development of the DDG 1000 Probability of Raid Annihilation test bed, which is modeling and simulation that will be used, in conjunction with live fire testing using the Self-Defense Test Ship, to assess DDG 1000's capability to defeat threat anti-ship cruise missiles and aircraft.
- In January 2013, DOT&E sent a memorandum to the Assistant Secretary of the Navy (Research, Development, and Acquisition) outlining the need for a threat torpedo surrogate to support operational testing of DDG 1000 and other ships/submarines, and requesting the Navy's plan to address this need.
  - In June 2015, DOT&E sent a follow-up memorandum that reiterated the need for adequate torpedo surrogates in operational test and noted that DOT&E has yet to receive the Navy's plan.
  - In September 2015, the Navy completed a formal study to identify capability gaps in the currently available torpedo surrogates and to present an analysis of alternatives for specific investments to improve threat emulation ability.
- In September 2014, the Navy requested DOT&E concurrence to move FSST from the first ship of its class, DDG 1000, to the last of its class, DDG 1002. DOT&E disapproved the deferral request and opposed changing the schedule and test article resourcing within a TEMP revision. The Navy unilaterally removed the funding for the FSST and proceeded with their unfunded plan to conduct FSST on DDG 1002. In October 2015, the Navy revised their decision and agreed to conduct FSST (specific ship to be determined) prior to the first deployment of any DDG 1000 *Zumwalt* class destroyer. However, the component shock qualification program for DDG 1000 *Zumwalt* remains incomplete and is unfunded for completion.
- In April 2015, the Navy notified DOT&E that the underwater explosion (UNDEX) vulnerability assessments would be delayed due to problems with the full ship finite element analysis model. In addition, DOT&E was notified that the recently developed blast module for the air explosion (AIREX) vulnerability assessment of the as-built configuration of the ship cannot be operated within the Advance Survivability Assessment Program (ASAP) simulation due to integration problems with the two sets of computer code. The Navy intends to use available model and simulation tools and resultant vulnerability predictions that it previously concluded have significant limitations, as cited in a 2005 Verification and Validation Assessment Report of ASAP. The Navy report identified several measures that cannot be determined at the necessary accuracy or confidence using ASAP.

Assessment

- The Navy study on threat torpedo surrogates confirmed DOT&E's concerns that current torpedo surrogates have significant gaps in threat representation for operational testing and the study provided recommendations for improving current threat torpedo emulation. However, the Navy has yet to provide its plan to obtain adequate torpedo surrogates to effectively characterize DDG 1000 *Zumwalt* class destroyer performance in operational test.
- Conducting FSST on DDG 1000 is critical to finding and correcting failures in mission-critical capabilities prior to the classes first deployment and prior to placing this class of ships in harm's way. FSSTs routinely uncover mission-critical vulnerabilities that were not identified by component testing, analysis, and/or modeling and simulation alone.
- A component shock qualification program for assessing ship vulnerability to below-water threats is necessary for accurate damage simulations. However, the shock qualification program remains unfunded.
- All three ships of the DDG 1000 *Zumwalt* class have in common a significant amount of new designs, including the unique wave-piercing tumblehome hull form, as well as the new Integrated Power System, Total Ship Computing Environment (software, equipment and infrastructure), Integrated Undersea Warfare System, Peripheral Vertical Launching System, the Advanced Gun System, and the associated automated magazines. These systems and equipment have not been subjected to shock on previous ship classes. Moreover, the previously untried automation and small crew for a ship this size, limit the sailors' ability to conduct repairs to enable recovery from shock-induced damage.
- UNDEX and AIREX vulnerability assessments currently lack credible damage prediction models. The challenges and limitations in predicting ship vulnerability reinforce the need to complete FSST and component shock qualification before the first operational deployment of a DDG 1000 *Zumwalt* class destroyer. DOT&E will provide additional recommendations to mitigate or limit the unknown vulnerability of the

DDG 1000 *Zumwalt* class destroyer after completing a more detailed evaluation of the available model and simulation tools and their limitations.

Recommendations

- Status of Previous Recommendations. The Navy should address the following open recommendations from FY13 and earlier:
  1. Develop tactics and training that optimize employment of the MK 46 gun systems against surface threats.
  2. Fund and schedule component shock qualification to support the DDG 1000 *Zumwalt* class destroyer requirement to maintain all mission essential functions when exposed to UNDEX shock loading.
  3. Determine a development and test strategy that mitigates the risk of delivering substantial mission capability after ship delivery and transit to the West Coast.
  4. Develop a strategy to validate reliability of the accelerometers used in LRLAP prior to shipboard operational test.
  5. Develop and conduct an accreditation plan that validates the acceptability of the Probability of Raid Annihilation test bed to support operational test.
- FY15 Recommendations. The Navy should:
  1. Fund and schedule FSST prior to the first deployment of any DDG 1000 *Zumwalt* class destroyer and formalize this plan within revisions of the TEMP and LFT&E Management Plan.
  2. Complete the revision to the TEMP that accounts for DDG 1000 baseline changes and system delivery schedule.
  3. Develop torpedo surrogate(s) that can be used to characterize DDG 1000 *Zumwalt* class destroyer capability against threat torpedoes during operational test.

DDG 51 Flight III Destroyer/Air and Missile Defense Radar (AMDR)/Aegis Combat System

Executive Summary

- On December 10, 2014, the Deputy Secretary of Defense (DEPSECDEF) directed the Director, Cost Analysis/Program Evaluation (CAPE) to identify viable at-sea operational testing options that meet DOT&E adequacy requirements and recommend a course of action (with cost estimates, risks, and benefits) to satisfy testing of the Air and Missile Defense Radar (AMDR), Aegis Combat System, and Evolved Seasparrow Missile (ESSM) Block 2 in support of the DDG 51 Flight III Destroyer program.
- The CAPE study evaluated four options to deliver an at-sea test platform adequate for self-defense operational testing of the DDG 51 Flight III, AMDR, and ESSM Block 2 programs. Each option requires funding beginning no later than FY18 to ensure support of operational testing of these systems in FY22.
- A decision on whether to fund the advance procurement of the equipment needed to support the self-defense operational testing is pending.

System

- The DDG 51 Flight III Destroyer will be a combatant ship equipped with the:
  - AMDR three-dimensional (range, altitude, and azimuth) multi-function radar
  - Aegis Combat System
  - AN/SQQ-89 Undersea Warfare suite that includes the AN/SQS-53 sonar
  - MH-60R helicopter
  - Close-In Weapon System
  - 5-inch diameter gun
  - Vertical Launch System that can launch Tomahawk, Standard Missiles-2, 3, and 6, and the ESSM Blocks 1 and 2
- The Navy is developing the AMDR to provide simultaneous sensor support of integrated air and missile defense (IAMD) and air defense (including self-defense) missions. IAMD and air defense missions require extended detection ranges and increased radar sensitivity against advanced threats with high speeds and long interceptor fly-out times. The three major components of AMDR are:
  - The AMDR S-band radar that will provide IAMD, search, track, cueing, missile discrimination, air defense non-cooperative target recognition, S-band missile communications, surveillance capability for ship self-defense and area air defense, and S-band kill assessment support functions.
  - The AMDR X-band radar will provide horizon and surface search capabilities and navigation and periscope detection/discrimination functions. The Navy is delaying development of the X-band radar; the existing AN/SPQ-9B radar will provide these functions in the interim.
  - The AMDR Radar Suite Controller that will provide radar resource management and coordination and an open interface with the ship's combat system.
- The Aegis Combat System is an integrated naval weapons system that uses computers and radars to form an advanced command and decision capability and a weapons control system to track and guide weapons to destroy enemy targets.
- The ESSM, cooperatively developed among 13 nations, is a medium-range, ship-launched self-defense guided missile designed to defeat ASCM, surface, and low-velocity air threats. There are two variants of ESSM.
  - ESSM Block 1 is a semi-active radar-guided missile that is currently in-service.
  - ESSM Block 2 is in development and will have semi-active radar-guidance as well as active radar guidance.
- In comparison to the previous DDG 51 version (Flight IIA), Flight III includes, in addition to the Aegis Combat System and the AMDR, the following modifications:
  - An upgraded fire extinguishing system
  - New ship service turbine generators
  - Additional transformers
  - Power Conversion Modules
  - Modified controllers for the Machinery Control System and Multifunction Monitors
  - Upgraded air-conditioning plants
- Flight III is also structurally different from the prior DDG 51 version. The design will add starboard enclosures and a

stack of small boats, and additional structure in the fantail to increase reserve buoyancy and help compensate for additional weight increase. It will also include structural modifications to increase plate thicknesses to lower the ship's center-of-gravity and enhance girder strength.

Mission

- The Navy will use the DDG 51 Flight III Destroyer equipped with the Aegis Combat System and AMDR to provide joint battlespace threat awareness and defense capability to counter current and future threats in support of joint forces ashore and afloat.
- The Navy will use the AMDR S-band radar/Radar Suite Controller with the AN/SPQ-9B and the Aegis Combat System to support the following DDG 51 Flight III Destroyer missions:
  - Area air defense (to include self-defense with the ESSM) to counter advanced air and cruise missile threats and increase ship survivability
  - Detect, track, discriminate, and provide missile engagement support (including kill assessment) to counter ballistic missile threats
  - Counter surface threats through surface surveillance, precision tracking, and missile and gun engagements
  - Conduct Undersea Warfare with periscope detection and discrimination
  - Detect and track enemy artillery projectiles to support combat system localization of land-battery launch positions by the DDG 51 Flight III Combat System
  - Detect and track own-ship gun projectiles to support surface warfare and naval surface fire support

Major Contractors

- DDG 51 Flight III Destroyer: To be determined. Current DDG 51 Destroyer major contractors are:
  - General Dynamics Marine Systems Bath Iron Works – Bath, Maine
  - Huntington Ingalls Industries, Ingalls Shipbuilding Division – Pascagoula, Mississippi
- AMDR: Raytheon – Sudbury, Massachusetts
- Aegis Combat System: Lockheed Martin Marine Systems and Sensors – Moorestown, New Jersey
- ESSM Block 2: Raytheon – Tucson, Arizona

Activity

- On December 10, 2014, DEPSECDEF issued a memorandum directing CAPE to identify viable at-sea operational testing options that meet DOT&E adequacy requirements and recommend a course of action (with cost estimates, risks, and benefits) to satisfy testing of the AMDR, Aegis Combat System, and ESSM Block 2 programs in support of the DDG 51 Flight III Destroyer program.
- The CAPE study evaluated four options to deliver an at-sea test platform adequate for self-defense operational testing of these systems. Each option requires funding beginning in FY18 to ensure support of the DDG 51 Flight III, AMDR, and ESSM Block 2 operational testing in 2022.
- In September 2015, DOT&E met with DDG 51 Program Office representatives to start planning the Flight III LFT&E program.
- DEPSECDEF has not made a decision yet on the funding needed.

Assessment

- DOT&E's position continues to be that the Navy's operational test programs for the AMDR, Aegis Combat System, ESSM Block 2, and DDG 51 Flight III Destroyer programs are not adequate to fully assess their self-defense capabilities. They are also not adequate to test the following Navy-approved DDG 51 Flight III, AMDR, Aegis Combat System, and ESSM Block 2 requirements.
  - The AMDR Capability Development Document (CDD) describes AMDR's IAMD mission, which requires AMDR to support simultaneous defense against multiple ballistic missile threats and multiple advanced anti-ship cruise missile (ASCM) threats. The CDD also includes an AMDR minimum track range Key Performance Parameter.
  - The DDG 51 Flight III Destroyer has a survivability Key Performance Parameter requirement directly tied to meeting a self-defense requirement threshold against ASCMs described in the Navy's Surface Ship Theater Air and Missile Defense Assessment document of July 2008. It clearly states that area defense will not defeat all the threats, thereby demonstrating that area air defense will not completely attrite all ASCM raids and individual ships must be capable of defeating ASCM leakers in the self-defense zone.
  - The ESSM Block 2 CDD has a requirement to provide self-defense against incoming ASCM threats in clear and jamming environments. The CDD also includes an ESSM Block 2 minimum intercept range Key Performance Parameter.
- Use of manned ships for operational testing with threat representative ASCM surrogates in the close-in, self-defense battlespace is not possible due to Navy safety restrictions because targets and debris from intercepts pose an unacceptable risk to personnel at ranges where some of the engagements will take place. The November 2013 mishap on the USS *Chancellorsville* (CG 62) involving an ASCM surrogate target resulted in even more stringent safety constraints.
  - In addition to stand-off ranges (on the order of 1.5 to 5 nautical miles for subsonic and supersonic surrogates, respectively), safety restrictions require that ASCM

targets not be flown directly at a manned ship, but at some cross-range offset, which unacceptably degrades the operational realism of the test.
  - Similar range safety restrictions will preclude manned ship testing of eight of the nine ASCM scenarios contained in the Navy-approved requirements document for the Aegis Modernization Advanced Capability Build 16 Combat System upgrade. Restrictions also preclude testing of the AMDR minimum track range requirement against threat representative ASCM threat surrogates at the land-based AMDR Pacific Missile Range Facility test site.
  - To overcome these safety restrictions for the LHA 6, Littoral Combat Ship, DDG 1000, LPD 17, LSD 41/49, and CVN 78 ship classes, the Navy developed an Air Warfare/Ship Self-Defense Enterprise Modeling and Simulation (M&S) test bed, which uses live testing in the close-in battlespace with targets flying realistic threat profiles and manned ship testing for other battlespace regions, as well as soft-kill capabilities to validate and accredit the M&S test bed. The same needs to be done for the DDG 51 Flight III Destroyer with its AMDR, as side-by-side comparison between credible live fire test results and M&S test results form the basis for the M&S accreditation. Without a Self-Defense Test Ship (SDTS) with AMDR and an Aegis Combat System, there will not be a way to gather all of the operationally realistic live fire test data needed for comparison to accredit the M&S test bed.
- Since Aegis employs ESSMs in the close-in, self-defense battlespace, understanding ESSM's performance is critical to understanding the self-defense capabilities of the DDG 51 Flight III Destroyer.
  - Past DOT&E annual reports have stated that the ESSM Block 1 operational effectiveness has not been determined. The Navy has not taken action to adequately test the ESSM's operational effectiveness.
  - The IOT&E for ESSM Block 2 will be conducted in conjunction with the DDG 51 Flight III Destroyer, AMDR, and Aegis Combat System operational testing.
  - Specifically, because safety limitations preclude ESSM firing in the close-in self-defense battlespace, there are very little test data available concerning ESSM's performance, as installed on Aegis ships, against supersonic ASCM surrogates.
  - Any data available regarding ESSM's performance against supersonic ASCM surrogates are from a Ship Self-Defense System-based combat system configuration, using a completely different guidance mode or one that is supported by a different radar suite.
- The cost of building and operating an Aegis SDTS, estimated to be about $350 Million, is small when compared to the total cost of the AMDR development/procurement and the eventual cost of the 22 (plus) DDG 51 Flight III ships that are planned for acquisition ($55+ Billion). Even smaller is the cost of the SDTS compared to the cost of the ships that the DDG 51 Flight III Destroyer is expected to protect (approximately $450 Billion in new ship construction over the next 30 years). If DDG 51 Flight III Destroyers are unable to defend themselves, these other ships are placed at substantial risk.
- The modification/upgrades being planned for the DDG 51 Flight III are significant enough to warrant an assessment of the impact of these changes on ship survivability. The Navy has unofficially indicated the DDG 51 Flight III LFT&E strategy will include Component Shock Qualification, a Total Ship Survivability Trial, and a Full Ship Shock Trial. Other LFT&E program particulars are still under discussion to ensure DDG 51 Flight III adequately addresses survivability requirements against operationally relevant threats and recoverability requirements.

Recommendations

- Status of Previous Recommendations. The Navy has not addressed the following four previous recommendations. The Navy should:
  1. Program and fund an SDTS equipped with the AMDR, ESSM Block 2, and DDG 51 Flight III Aegis Combat System in time to support the DDG 51 Flight III Destroyer and ESSM Block 2 IOT&Es.
  2. Modify the AMDR, ESSM Block 2, and DDG 51 Flight III Test and Evaluation Master Plans to include a phase of IOT&E using an SDTS equipped with the AMDR and DDG 1 Flight III Combat System.
  3. Modify the AMDR, ESSM Block 2, and DDG 51 Flight III Test and Evaluation Master Plans to include a credible M&S effort that will enable a full assessment of the AMDR, ESSM Block 2, and DDG 51 Flight III Combat System's self-defense capabilities.
  4. Comply with the DEPSECDEF direction to develop and fund a plan, to be approved by DOT&E, to conduct at-sea testing of the self-defense of the DDG 51 Flight III Destroyer with the AMDR, ESSM Block 2, and Aegis Combat System.
- FY15 Recommendations. The Navy should:
  1. Provide program funding for an Aegis-equipped self-defense test ship to support adequate operational testing of the AMDR, Aegis Combat System, ESSM Block 2, and DDG 51 Flight III Destroyer programs as soon as possible so as not to disrupt the ESSM Block 2 development schedule.
  2. Provide DOT&E the DDG 51 Flight III LFT&E Strategy for approval prior to the end of FY16 in coordination with the Test and Evaluation Master Plan.

Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM)

Executive Summary

- The Navy conducted FOT&E on the Department of the Navy Large Aircraft Infrared Countermeasure (DoN LAIRCM) Advanced Threat Warning (ATW) upgrade installed on the CH-53E from December 2014 through July 2015.
- DoN LAIRCM ATW, as installed on the CH-53E, provides new capabilities integrated into the fielded DoN LAIRCM system, and is operationally effective in most environments, but not operationally suitable because of poor reliability and logistical supportability issues.
- The Navy began developmental tests and operational test planning for installation of DoN LAIRCM on the MV-22, KC-130J, and CH-53K platforms.

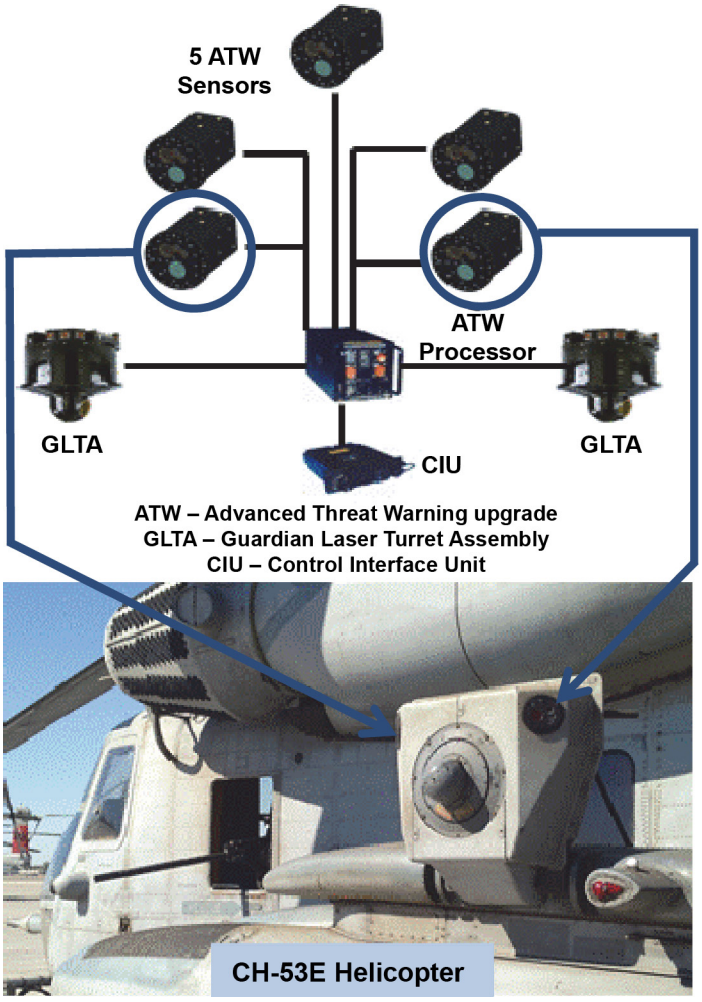
System

- The DoN LAIRCM system, a variant of the Air Force LAIRCM system, is a defensive system for Marine Corps helicopters designed to defend against surface-to-air infrared missile threats.
- DoN LAIRCM combines two-color, infrared Missile Warning Sensors with the Guardian Laser Transmitter Assembly (GLTA).
- The GLTA is equipped with a four-axis, stabilized gimbal system, an AN/AAR-24 Fine Track Sensor, and a ViperTM laser. The Missile Warning Sensor detects an oncoming missile threat and sends the information to the system processor, which, in turn, notifies the crew through the control interface unit and simultaneously directs the GLTA to slew to and begin jamming the threat.
- The ATW capability upgrades the processor and missile warning sensors to provide improved missile detection and adds hostile fire and laser warning capability and visual/audio alerts to the aircrew.
- The Navy plans to upgrade CH-53E DoN LAIRCM systems with ATW and install complete systems on the MV-22, KC-130J, and CH-53K platforms.

Mission

Combatant Commanders, while conducting normal take-off and landing, assault landing, tactical descents, re-supply, rescue, forward arming and refueling, low-level flight, and aerial refueling, will use DoN LAIRCM and its new capabilities to:

- Provide automatic protection of rotary-wing aircraft against shoulder fired, vehicle-launched, and other infrared-guided missiles
- Provide automatic hostile fire and laser warning capability for illuminators, beam riders, laser range finders, small arms, rocket-propelled grenades, unguided rockets, and anti-aircraft artillery



Major Contractor

Northrop Grumman, Electronic Systems, Defensive Systems Division – Rolling Meadows, Illinois

Activity

- The Navy completed the ATW engineering and manufacturing development phase in October 2014 with a CH-53E flight test that verified software fixes to failures that were identified during earlier developmental tests.
- The Navy conducted FOT&E on the DoN LAIRCM ATW upgrade installed on the CH-53E from December 2014 through July 2015 to support a fielding decision for ATW.
- During FOT&E, the Commander, Operational Test and Evaluation Force collected effectiveness and suitability data from the following tests:
  - Shipboard compatibility tests near and onboard the USS *Bataan*
  - Flight tests at Eglin AFB, Florida, and Marine Corps Air Station (MCAS) New River, North Carolina
  - False alert tests during a deployment to/from Yuma, Arizona
  - A maintenance demonstration at MCAS New River
  - A cybersecurity test at MCAS New River
- The Navy began developmental tests and operational test planning for installation of DoN LAIRCM on the MV-22, KC-130J, and CH-53K platforms.
- In early 2016, DOT&E is expected to submit an FOT&E report on DoN LAIRCM detailing the results of testing the system on the CH-53E platform.

Assessment

- DoN LAIRCM ATW, as installed on the CH-53E, provides new capabilities integrated into the fielded DoN LAIRCM system, and is operationally effective in most environments, but it is not operationally suitable because of reliability and logistical supportability issues.
  - The operational effectiveness for hostile fire indication and laser warning exceeded the classified threshold requirements, while the missile warning and infrared countermeasures capabilities were not degraded by the ATW upgrade.
  - The ATW system's Mean Time Between Operational Mission Failure was 26 hours with an 80 percent confidence, which is well below the threshold requirement of 130 hours.
  - Logistic supportability shortfalls are as follow:
    - The location of the control interface unit is poorly situated and not useful during combat maneuvering since its current location requires the pilot to look inside the cockpit during critical flight regimes.
    - Technical documentation and training regarding the operational employment aspects of in-flight power cycles need updating to avoid inadvertent loss of system availability during flight.
    - Obsolescence of the smart card utility software and the smart cards themselves will likely cause current/future maintenance and reprogramming challenges for the DoN LAIRCM system.
- ATW effectiveness in denied-GPS environments (or with GPS jamming) is unknown. GPS loss was not envisioned to impact the system; however, during a flight near the end of the test program, an unplanned loss of GPS caused some system anomalies that post-test analysis revealed traceable to aircraft GPS loss.
- While limited in scope, the cybersecurity assessment was sufficient for the federated installation on the CH-53E. A Cooperative Vulnerability and Penetration Assessment identified a vulnerability in the laptop computer which is used to program ATW sensors.
- All testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan and FOT&E test plan to support a fielding decision for the ATW upgrade on the CH-53E.

Recommendations

- Status of Previous Recommendations. The Navy satisfactorily addressed all previous recommendations on the legacy DoN LAIRCM program. This is the first annual report on the ATW upgrade.
- FY15 Recommendations. The Navy should:
  1. Continue to improve reliability of the ATW sensors, and monitor and report reliability growth to DOT&E.
  2. Resolve the logistic supportability obsolescence problems with the smart cards used to operate, maintain, and reprogram the DoN LAIRCM system.
  3. Resolve the logistic supportability and human factors problem with the location of the control indicator unit.
  4. Resolve the logistic supportability shortfall in the technical documentation and training regarding operational employment aspects of in-flight power cycles.
  5. Collect effectiveness data in a denied-GPS or GPS-jammed environment during FOT&E on either the MV-22 or KC-130J installations on DoN LAIRCM.

E-2D Advanced Hawkeye

Executive Summary

- The Commander, Operational Test and Evaluation Force (COTF) conducted the first E-2D Advanced Hawkeye FOT&E period in 2QFY14 to evaluate the E-2D Initial Operational Capability hardware and software configuration: Delta System/Software Configuration (DSSC) Build 1. COTF completed testing in 3QFY15.
- FOT&E showed the E-2D had no significant performance differences compared to IOT&E and was adequate to assess E-2D suitability and effectiveness for legacy E-2C missions. Unlike the IOT&E, FOT&E included adequate E-2D carrier testing. An evaluation on E-2D's capability to perform the Theater Air and Mission Defense (TAMD) mission cannot be made until future FOT&E periods. DOT&E will submit an FOT&E report on the E-2D in 2QFY16.
- Change 1 to the E-2D Test and Evaluation Master Plan (TEMP) revision D supports the second FOT&E period, which includes requirements or resources for integration and operational testing of Naval Integrated Fire Control-Counter Air (NIFC-CA) From the Air (FTA). Change 1 will address NIFC-CA FTA areas relevant to E-2D only, and to support DSSC Build 2 in 3QFY16 for FOT&E.

System

- The E-2D is a carrier-based Airborne Early Warning and Command and Control aircraft.
- Significant changes to this variant of the E-2 include upgraded engines to provide increased electrical power and cooling relative to current E-2C aircraft; a strengthened fuselage to support increased aircraft weight; replacement of the radar system, the communications suite, and the mission computer; and the incorporation of an all-glass cockpit, which permits the co-pilot to act as a tactical fourth operator in support of the system operators in the rear of the aircraft.
- The radar upgrade replaces the E-2C mechanically scanned radar with a phased-array radar that has combined mechanical and Electronically Scanned Array capabilities.

- The upgraded radar is intended to provide significant improvement in littoral and overland detection performance and TAMD capabilities.
- The E-2D Advanced Hawkeye Integrated Training System includes all simulators, interactive computer media, and documentation to conduct maintenance, as well as aircrew shore-based initial and follow-on training.

Mission

The Combatant Commander, whether operating from the aircraft carrier or from land, will use the E-2D Advanced Hawkeye to accomplish the following missions:

- Theater air and missile sensing and early warning
- Battlefield management, command, and control
- Acquisition, tracking, and targeting of surface warfare contacts
- Surveillance of littoral area objectives and targets
- Tracking of strike warfare assets

Major Contractor

Northrop Grumman Aerospace Systems – Melbourne, Florida

Activity

- COTF conducted E-2D carrier testing, a major shortfall of the IOT&E, in September and October 2014, onboard the USS *Theodore Roosevelt*.
- In 2QFY14, COTF conducted the E-2D's first FOT&E period to assess the operational effectiveness and suitability of hardware and software changes incorporated in DSSC Build 1 and to support the TAMD mission. The Navy conducted testing at Naval Air Station (NAS) Patuxent River, Maryland; Holloman AFB, New Mexico; White Sands Missile Range, New Mexico; NAS Point Mugu, California; NAS Norfolk, Virginia; USS *Theodore Roosevelt* (CVN 71); and Naval Air Weapons Station China Lake, California, in accordance with the DOT&E-approved TEMP and test plan. FOT&E completed in 3QFY15.
- Per the FOT&E test plan, the Navy only conducted a qualitative assessment on E-2D training devices (such as simulators) and student training time. The second FOT&E period will have a full training assessment.

- In 2QFY16, DOT&E will submit an FOT&E report on the E-2D.
- Change 1 to the E-2D TEMP revision D supports the second FOT&E period, which includes requirements for resources and integration of operational testing of NIFC-CA FTA. Change 1 will address NIFC-CA FTA areas relevant to E-2D only, and to support DSSC Build 2 in 3QFY16 for FOT&E. Change 1 will also include cybersecurity testing in accordance with DOT&E's guidelines detailed in Procedures for Operational Test and Evaluation of Cybersecurity Acquisition Programs, dated August 1, 2014.
- The Navy continues to correct deficiencies with E-2D Cooperative Engagement Capability performance with a plan to have deficiencies remedied in 1QFY19 with fielding of DSSC Build 3.

Assessment

- E-2D carrier suitability performance is similar to the aircraft's performance when it is disembarked.
- FOT&E showed the E-2D has no significant performance differences compared to IOT&E, but has similar shortfalls on some radar reliability, availability, and weapon system metrics. FOT&E was adequate to assess E 2D suitability and effectiveness for legacy E-2C missions. An evaluation on E-2D's capability to perform the TAMD mission cannot be made until future FOT&E periods.
- DOT&E's classified report will explain all findings in more detail.
- Change 1 to the E-2D TEMP revision D will address requirements and resources for integrated or operational testing of NIFC-CA FTA and will include more evolved cybersecurity testing. DOT&E is providing cybersecurity guidance to Change 1 and all subsequent TEMPs for future FOT&E periods.
- A full assessment of E-2D operational capabilities will require future FOT&Es and systematic updates.

Recommendations

- Status of Previous Recommendations. The Navy continues to improve radar and mission system performance and to improve radar and overall weapon system reliability and availability as previously recommended.
- FY15 Recommendations. The Navy should:
  1. Provide complete training on all components of the E-2D system and missions.
  2. Complete the Change 1 to the E-2D TEMP revision D and test plan.
  3. Incorporate DOT&E guidance in its cybersecurity testing for all subsequent FOT&E periods.
  4. Improve radar and overall weapon system reliability and availability.
  5. Continue to correct E-2D Cooperative Engagement Capability performance deficiencies.

F/A-18E/F Super Hornet and EA-18G Growler

Executive Summary

- The Navy conducted Software Qualification Testing of System Configuration Set (SCS) H10E for the F/A-18E/F Super Hornet and EA-18G Growler aircraft with fleet release planned for early 2016. Major upgrades tested during this period for the Super Hornet include improvements to multi-sensor integration, aircrew displays, short-range tracking, and combat identification. Growler improvements tested include the Joint Tactical Terminal Receiver, enhanced combat identification capabilities, and expanded jamming assignments.
- The F/A-18E/F Super Hornet weapon system continues to demonstrate operational effectiveness for most threat environments; however, the platform is not operationally effective in specific threat environments, which are detailed in previous DOT&E classified reports.
- Although the reliability of the APG-79 radar has improved over multiple phases of operational test, Active Electronically Scanned Array (AESA) radar software stability problems resulted in the continued failure of the radar to meet reliability and built-in test (BIT) performance requirements. DOT&E expects improved AESA reliability with SCS H10.
- DOT&E previously assessed the EA-18G Growler weapons system equipped with SCS H8E as operationally suitable and operationally effective with the same radar limitations as the F/A-18E/F.
- The Navy completed SCS 25X testing in 4QFY15 for non-Higher Order Language (HOL) software on F/A-18s and release to the fleet in 2QFY16. Early lot F/A-18E/Fs will remain in the Non-HOL configuration (SCS 25X) until mission computers are upgraded to operate HOL.

System

F/A-18E/F Super Hornet

- The Super Hornet is the Navy's premier strike-fighter aircraft and is a more capable follow-on replacement to the F/A-18A/B/C/D and the F-14.
- F/A-18E/F Lot 25+ aircraft provide functionality essential for integrating all Super Hornet Block 2 hardware upgrades, which include:
  - Single pass multiple targeting for GPS-guided weapons
  - Use of off-board target designation
  - Improved datalink for target coordination precision
  - Implementation of air-to-ground target aim points
- Additional systems include:
  - APG-73 or APG-79 radar
  - Advanced Targeting Forward-Looking Infrared System
  - AIM-9 infrared-guided missiles and AIM-120 and AIM-7 radar-guided missiles
  - Multi-functional Information Distribution System for Link 16 tactical datalink connectivity

  - Joint Helmet-Mounted Cueing System
  - Integrated Defensive Electronic Countermeasures

EA-18G Growler

- The Growler is the Navy's land- and carrier-based, radar and communication jamming aircraft.
- The two-seat EA-18G replaces the four-seat EA-6B. The new ALQ-218 receiver, improved connectivity, and linked displays are the primary design features implemented to reduce the operator workload in support of the EA-18G's two-person crew.
- The Airborne Electronic Attack system includes:
  - Modified EA-6B Improved Capability III ALQ-218 receiver system
  - Advanced crew station
  - Legacy ALQ-99 jamming pods
  - Communication Countermeasures Set System
  - Expanded digital Link 16 communications network
  - Electronic Attack Unit
  - Interference Cancellation System that supports communications while jamming
  - Satellite receive capability via the Multi-mission Advanced Tactical Terminal
- Additional systems include:
  - APG-79 AESA radar
  - Joint Helmet-Mounted Cueing System
  - High-speed Anti-Radiation Missile
  - AIM-120 radar-guided missiles

System Configuration Set (SCS) Software

- Growler and Super Hornet aircraft employ SCS operational software to enable major combat capabilities. All EA-18Gs and Block 2 F/A-18s (production Lot 23 and beyond) use high-order language or "H-series" software, while F/A-18E/F prior to Lot 23 and all legacy F/A-18 A/B/C/D aircraft use "X-series" software.

Mission

- Combatant Commanders use the F/A-18E/F to:
  - Conduct offensive and defensive air combat missions
  - Attack ground targets with most of the U.S. inventory of precision and non-precision weapon stores
  - Provide in-flight refueling for other tactical naval aircraft
  - Provide the fleet with an organic tactical reconnaissance capability
- Combatant Commanders use the EA-18G to:
  - Support friendly air, ground, and sea operations by countering enemy radar and communications
  - Jam integrated air defense systems
  - Support non-integrated air defense missions and emerging non-lethal target sets
  - Enhance crew situational awareness and mission management
  - Enhance connectivity to national, theater, and tactical strike assets
  - Provide enhanced lethal suppression through accurate High-speed Anti-Radiation Missile targeting
  - Provide the EA-18G crew air-to-air self-protection with the AIM-120

Major Contractor

The Boeing Company, Integrated Defense Systems – St. Louis, Missouri

---

Activity

- The Navy conducted F/A-18E/F and EA-18G H10 Software Qualification Testing from March through September 2015 in accordance with a DOT&E-approved test plan and in support of fleet introduction in 2QFY16. Test aircraft equipped with SCS H10E accumulated 1,820 flight hours.
- Major upgrades tested during this period for the Super Hornet include improvements to multi-sensor integration, aircrew displays, short-range tracking, and combat identification.
- Growler improvements tested include the Joint Tactical Terminal Receiver, enhanced combat identification capabilities, and expanded jamming assignments.
- The Navy has continued to defer development of the AESA's full electronic warfare capability to later software builds and plans to test this capability in SCS H12 and H14.
- Early lot F/A-18E/Fs will remain in the Non-HOL configuration (SCS 25X) until mission computers are upgraded to operate HOL.
- The Navy completed SCS 25X testing in 4QFY15 for earlier lot F/A-18s and is expected to begin releasing the non-HOL software to the fleet in 1QFY16.

Assessment

- DOT&E does not expect test results from SCS H10E FOT&E to alter the previous assessment made in F/A-18E/F and EA-18G reports regarding key deficiencies in operational performance. While both systems remain operationally effective in some threat environments, DOT&E has noted in classified reports that both systems remain not effective in the more stressful current air warfare environments. Though the Navy has begun to address long-standing deficiencies in air warfare by making incremental improvements in capability during recent FOT&E periods, DOT&E is unlikely to change this finding until deficiencies are resolved.
- Early results from SCS H10 testing suggest improvements in AESA reliability. The Navy has made incremental improvements in AESA radar reliability since the 2006 IOT&E. Radar software instability has resulted in the program's failure to meet reliability and BIT performance requirements in every test period. The AESA provides improved performance compared to the legacy APG-73 radar used on older F/A-18E/F aircraft.
- DOT&E determined that the EA-18G Growler was operationally effective and suitable, though subject to the same threat limitations as the Super Hornet, noting a need for improved jammer timeliness. SCS H10E FOT&E results are not likely to change this assessment.
- SCS H8E testing did not include an end-to-end multi-AIM-120 missile shot. This Navy operational capability has not been demonstrated previously in a successful test. The Navy has agreed to include a multi-missile shot during SCS H12 testing.

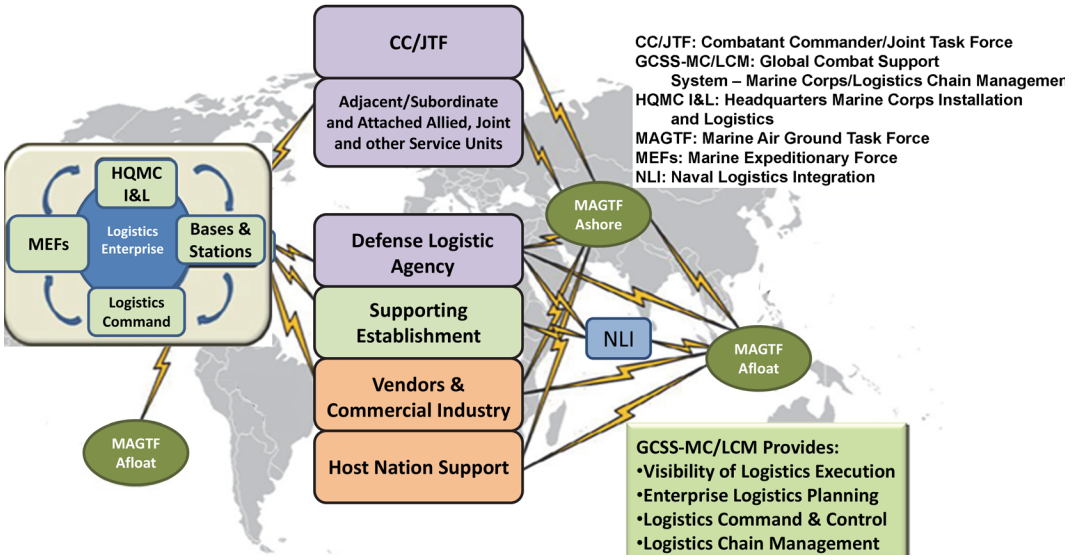
Recommendations

- Status of Previous Recommendations. Per previous recommendations, the Navy should continue to improve the reliability and BIT functionality of the AESA radar and develop and characterize the full electronic warfare capability of the APG-79 radar. DOT&E's recommendation to conduct an operationally representative end-to-end missile test to demonstrate APG-79 radar and system software support for a multiple AIM-120 missile engagement also remains.
- FY15 Recommendation.
  1. The Navy should focus on improvements that will allow the Super Hornet and Growler to be operationally effective in all threat environments.

Global Combat Support System – Marine Corps (GCSS-MC)

Executive Summary

- The Marine Corps Operational Test and Evaluation Activity (MCOTEA) conducted the FOT&E of the Global Combat Support System – Marine Corps (GCSS-MC) Release 1.1.1 from August through November 2014, in support of a Full Deployment Decision in early 2015. The test was conducted in Camp Lejeune, North Carolina and Okinawa, Japan, with actual users in a live environment.
- Of the three enhancements included in Release 1.1.1, two were operationally effective and one was not. One enhancement was operationally suitable, but two were not.
- The GCSS-MC Program Manager has taken action to address the issues found during FOT&E.
- In March 2015, USD(AT&L) granted a Full Deployment Decision.



- GCSS-MC Release 1.1.1 provides three capability enhancements to the currently fielded logistics system: Enterprise Automated Task Organization (EATO), Mobile Field Service (MFS), and Tactical-Wide Area Network (T-WAN) optimization

System

- GCSS-MC is the Marine Corps component of the joint GCSS Family of Systems. It is intended to provide a seamless end-to-end logistics chain requiring less reliance on forward-positioned materiel, and capitalizing on the availability of near real-time logistics information critical to supported and supporting units. GCSS-MC includes all transactional Combat Service Support systems related to supply chain management and enterprise asset management functionality, enabled with service management functions.
- GCSS-MC is a commercial off-the-shelf Enterprise Resource Planning system that uses the Oracle E-Business Suite to provide logistics chain management.
- GCSS-MC provides the Marine Corps with authoritative supply, maintenance, and transportation data in DOD data dictionary-compliant format.

Mission

- Combatant Commanders/Joint Task Force Commanders will use GCSS-MC to provide an end-to-end logistics chain that decreases reliance on forward-positioned materiel and capitalizes on the availability of near real-time logistics information critical to supported and supporting units.
- Marines operating in garrison and deployed Marine Air-Ground Task Force units will use GCSS-MC to conduct logistics missions that support Marine Corps operations.

Major Contractor

Oracle Corporation – Reston, Virginia

Activity

- MCOTEA developed and DOT&E approved an operational test plan for GCSS-MC FOT&E in August 2014.
- MCOTEA conducted the FOT&E from August through November 2014 in Okinawa, Japan, and Camp Lejeune, North Carolina, in accordance with a DOT&E-approved test plan. Testing supported an early 2015 Full Deployment Decision and was tied to the Philippines

Bilateral Exercise and the Bold Alligator Exercise. Marines from II Marine Expeditionary Force (MEF) and III MEF participated in the test.
- GCSS-MC Release 1.1.1 provides three capability enhancements to the currently fielded logistics system: Enterprise Automated Task Organization (EATO), Mobile Field Service (MFS), and Tactical-Wide Area Network (T-WAN) optimization. MCOTEA conducted separate events during the FOT&E to evaluate each of the enhancement solutions.
- DOT&E submitted an FOT&E report in February 2015 detailing the results of testing.
- In April 2015, the GCSS-MC Program Manager conducted MFS afloat demonstration testing aboard the USS *Essex* and USS *Rushmore* to provide additional data that were not collected during FOT&E.
- In March 2015, USD(AT&L) granted a Full Deployment Decision.

Assessment
- Based on FOT&E results DOT&E assessed the system as follows:
  - EATO is operationally effective. EATO performed as expected when properly operated, but lack of training and documentation led to user errors. EATO is not operationally suitable and required improved training and documentation.
  - T-WAN optimization is operationally effective and operationally suitable. T-WAN optimization reduced the data size for different transactions. Users were able to complete all tasks and System Usability Scale (survey scores were favorable).
  - MFS is not operationally effective and not operationally suitable. Implementation problems and lack of adequate training and documentation prevented some users from using the system as designed. At the time of test, Public Key Infrastructure-enabled MFS was unavailable and the users required strong, complex passwords. This led to frustration by the users because the passwords were difficult to enter and the system did not provide sufficient feedback when generating and inputting passwords. Additionally, this led to accidental account lockout and inability to complete tasks. The help desk had no knowledge of the system and was unable to provide any assistance. Users did not rate the system favorably using the System Usability Scale, and their favorability ratings decreased as testing progressed.
- The GCSS-MC Program Manager has taken action to address the issues found during FOT&E.

Recommendations
- Status of Previous Recommendations. The Marine Corps addressed all previous recommendations.
- FY15 Recommendations. The Marine Corps should:
  1. Implement, document, and monitor the process to train and educate the operating forces in a manner that will allow for users to properly operate the GCSS-MC R1.1.1. Confirm that such training and documentation are in place before full fielding of GCSS-MC R1.1.1.
  2. Address issues identified in the FOT&E Test Incident Reports and field a Public Key Infrastructure-enabled MFS to eliminate the need for complex passwords.
  3. Conduct a cybersecurity Adversarial Assessment of GCSS-MC. Ensure cybersecurity testing includes the 2015 Oracle E-Business System R12 upgrade.

H-1 Upgrades – U.S. Marine Corps Upgrade to AH-1Z Attack Helicopter and UH-1Y Utility Helicopter

Executive Summary

- The Navy conducted OT-IIIC FOT&E, from March through May 2015, focused on the evaluation of the aircraft System Configuration Set (SCS) 7.1 software, which is designed to enhance capabilities and correct previously identified deficiencies.
- The H-1 Upgrade aircraft with SCS 7.1 remains operationally effective and survivable. Pilots provided positive feedback on all enhancements except for the accuracy of geographic coordinates provided by the Brite Star Block II sensor on the UH-1Y.
- The new SCS 7.1 virtual targeting reticle reduces pilot workload for employment of the Advanced Precision Kill Weapon System (APKWS). Expansion of the reticle's indicating envelope is needed.
- APKWS performance was consistent with requirements. Improvements are needed in documentation and markings as well as enhancements in training to avoid inadvertently activating a special mode during preflight preparations.
- H-1 Upgrade aircraft are not suitable due to unsatisfactory measures of availability based on Full Mission Capable (FMC) and Mission Capable (MC) rates. OT-IIIC aircraft demonstrated a 63 percent MC rate because of long downtimes awaiting repair parts.

System

- This program upgrades two Marine Corps H-1 aircraft:
  - The AH-1W Attack Helicopter is upgraded to the AH-1Z
  - The UH-1N Utility Helicopter is upgraded to the UH-1Y
- The aircraft have identical twin engines, drive trains, four bladed rotors, tail sections, digital cockpits, and helmet mounted sight displays. By parts count, the aircraft are 84 percent common.
- The UH-1Y has twice the payload and range of legacy UH-1N aircraft and can deliver eight combat-ready Marines 118 nautical miles and return without refueling.
- The AH-1Z has improved payload and a high-fidelity targeting sensor for delivery of air to ground and air-to-air missiles, rockets, and guns.
- SCS 7.1 provides a virtual targeting reticle for employment of the APKWS from both aircraft. APKWS provides a laser-guidance section for more precise employment of the 2.75-inch rocket.
- As of October 2015, Bell Helicopter has delivered 123 of the planned 160 UH-1Y aircraft and 42 of the planned 189 AH-1Z aircraft.

UH-1Y (near) and AH-1Z (far)

Mission

Marine light/attack helicopter squadron detachments are typically deployed with a mix of UH-1Y and AH-1Z helicopters. During these missions:

- Detachments equipped with the AH-1Z use the attack helicopter to conduct rotary-wing close air support, anti-armor, armed escort, armed and visual reconnaissance, and fire support coordination missions.
- Detachments equipped with the UH-1Y use the utility helicopter to conduct command, control, assault support, escort, air reconnaissance, and aeromedical evacuation missions.

Major Contractor

Bell Helicopter – Amarillo, Texas

Activity

- The Navy conducted OT-IIIC FOT&E of the AH-1Z and UH-1Y aircraft from March through May 2015 at Marine Corps Air Station, Yuma, Arizona; Naval Air Station, Fallon, Nevada; Marine Corps Base Twenty-nine Palms, Camp Pendleton; and Naval Aviation Weapons Station China Lake, California.

- The Navy conducted testing in accordance with the DOT&E-approved test plan dated March 15, 2015.
- OT-IIIC focused on the evaluation of the newly installed SCS 7.1 software, which improves the management and presentation of mission and geographic data to pilots, and corrects previously identified deficiencies.
- Four aircraft (two AH-1Zs, and two UH-1Ys) completed a total of 205 flight hours in integrated and operational testing. Crews completed 18 operational missions during operational testing in realistic desert environments against simulated threat targets.

Assessment

- H-1 Upgrade units with SCS 7.1-equipped aircraft remain operationally effective. The test unit successfully completed 18 of 18 planned tactical missions. Pilots provided positive feedback on all SCS 7.1 enhancements over SCS 6.0 software.
- Geographic coordinates provided by the Brite Star Block II sensor on the UH-1Y were useful to assist with basic aircraft navigation and pilot situational awareness. While not a requirement, Brite Star Sensor Block II coordinates were not accurate enough for weapons employment.
- The virtual targeting reticle reduces pilot workload for APKWS employment while the aircraft is within the parameters for APKWS launch. Expansion of the reticle's indicating range is needed beyond the current APKWS launch envelope because whenever the aircraft is outside that envelope in any parameter, the reticle parks on the aircraft datum line and stays there. Pilots complained the parked reticle provides no information on how to get back within the launch window, which can hinder the ability to fire the APKWS accurately in that situation.
- APKWS performance on both UH-1Y and AH-1Z was consistent with requirements. Improvements are needed in maintenance crew training and documentation on the mechanisms for making preflight mode selections on the rockets (which cannot be changed after take-off). Six APKWS shots missed when crewmen unintendedly enabled the counter-countermeasure mode.
- OT-IIIC aircraft met reliability and maintainability requirements.
  - UH-1Y demonstrated reliability of 5.0 mean flight hours between failures against a requirement of being greater than or equal to 0.9 hours and demonstrated 3.5 unscheduled maintenance man hours per flight hour against a requirement of being less than or equal to 3.9 hours.
  - AH-1Z demonstrated reliability of 2.5 mean flight hours between failures against a requirement of being greater than or equal to 0.8 hours and demonstrated maintainability of 4.3 unscheduled maintenance man hours per flight hour against a requirement of being less than or equal to 4.3 hours.
- OT-IIIC and fleet aircraft showed unsatisfactory results for measures of availability based on FMC and MC rates, resulting from unsatisfactory logistics supportability. H-1 Upgrade aircraft did not meet the availability requirement of being 85 percent MC. The OT-IIIC unit demonstrated 63 percent MC because of long downtimes awaiting repair parts. The longest delay time for high-priority parts delivery during OT IIIC was 61.82 days. One sixth of all high-priority components ordered had a logistic delay time in excess of 10 days. Nineteen critical components that failed were cannibalized from other aircraft and/or units in order to facilitate operational test. All of these components were related to the fielded aircraft and were not attributable to SCS 7.1 enhancements.

Recommendations

- Status of Previous Recommendations. The Navy has made progress addressing the previous FY13 recommendation to improve self-sealing capabilities of fuel bladders but still needs to:
  1. Initiate the redesign of main transmission, other gearboxes, and rotor actuators to reduce survivability deficiencies previously identified during LFT&E.
  2. Address H-1 ballistic survivability concerns in the future when aircraft components are redesigned or replaced. Place particular emphasis on improving the run-dry capabilities of the main rotor transmission and combining gearbox housings following loss of lubricant.
- FY15 Recommendations. The Navy should:
  1. Limit the use of Brite Star II-derived geographic coordinates for precision targeting until corrections are identified, implemented, and tested.
  2. Expand the virtual targeting reticule's indicating range beyond the APKWS launch envelope and provide an indication when the aircraft is out of the APKWS launch envelope. Continue/complete development of the virtual targeting reticule implementation and address pilot complaints.
  3. Continue efforts to increase the availability of spare parts, especially rotor system components, to improve aircraft availability.

Infrared Search and Track (IRST)

Executive Summary

- The Assistant Secretary of the Navy (Research, Development, and Acquisition) issued a Milestone C Acquisition Decision Memorandum on March 24, 2015, approving entrance into the Product and Deployment phase and Lot 1 of Block I low-rate initial production (LRIP). The memorandum directed the program to complete a second operational assessment (OA 2) and to develop mitigation plans to address the significant risks to effectiveness (identified in OA 1, conducted in FY14) prior to approving Lot 2 LRIP.
- Developmental testing progressed during FY15, expanding the flight envelope in which the sensor can be employed through aeromechanical testing, characterizing sensor performance (including testing algorithm enhancement intended to address problems identified in OA 1), and testing integration with the F/A-18 weapons system.
- The problems identified in OA 1, discussed in detail in DOT&E's December 2014 classified OA 1 report, identified areas of concern. Mission-level operational testing is needed to demonstrate that the Infrared Search and Tracking (IRST) system will provide the F/A-18 an effective combat capability. VX-9 Conducted OA 2 in November 2015. OA 2 will help determine whether improvement seen in developmental testing will translate to the operational environment. OA 2 will help inform the decision to enter IOT&E and will support the Lot 2 LRIP decision.
- The Navy intends for the readiness review for IOT&E to occur in March 2016.

System

- The IRST system consists of a passive long-wave infrared receiver (IRR), a processor, inertial measurement unit (IMU), and environmental control unit (ECU). The IRR, processor, IMU, and ECU are housed within the Sensor Assembly Structure (SAS). The SAS attaches to the front of the Fuel Tank Assembly that is mounted to the aircraft on the BRU-32 bomb rack. The Navy designed the IRST to be flown on the F/A-18E/F and it will be built into a modified centerline fuel tank.

- The Navy is developing and fielding the system in two blocks: Block I will reach Initial Operational Capability in FY18 and use components from the F-15K/SG IRR that derive from the F-14 IRST system. Block II is planned to begin after the Block I Full-Rate Production Decision Review and will include an improved IRR and updated processors.
- The Navy intends to produce a total of 170 IRST systems. There will be 60 Block I systems, which will eventually be updated to the Block II configuration; the Navy will build an additional 110 Block II systems.

Mission

Commanders will use IRST in a radar-denied environment to locate and destroy enemy forces. The IRST system is intended to allow the F/A-18E/F to operate and survive against existing and emerging air threats by enhancing situational awareness and providing the ability to acquire and engage targets beyond visual range.

Major Contractors

- The Boeing Company – St Louis, Missouri
- Lockheed Martin – Orlando, Florida

Activity

- The Assistant Secretary of the Navy (Research, Development, and Acquisition) held a Milestone C Decision Review on December 2, 2014, and issued a Milestone C Acquisition Decision Memorandum on March 24, 2015, approving entrance into the Product and Deployment phase. The memorandum approved Lot 1 (6 systems) of Block I LRIP, but directed the program to complete a second OA (OA 2) and develop mitigation plans to address the significant risks to effectiveness identified in OA 1 (conducted in FY14) prior to a decision to award Lot 2 (12 systems) of LRIP.
- The program entered Integrated Test phase IT-C1 in December 2014 following the December Milestone C review. The objectives of this test phase are to clear the flight envelope in which the system can be employed, characterize sensor performance (including testing algorithm enhancements intended to address problems identified in OA 1), and test

integration of IRST with the F/A-18 weapons system. The Naval Air Systems Command (NAVAIR) IT-C1 report, in conjunction with the Commander, Operational Test and Evaluation Force OA 2 report, will support the program's decision review on whether to enter IOT&E.
- Based on the results of aeromechanical testing conducted by VX-23 at Patuxent River, Maryland, NAVAIR issued a flight clearance in May 2015 that allowed flight test with the full envelope of flight conditions when the fuel tank is empty. NAVAIR issued another flight clearance in July permitting flight with fuel in the tank, but under restricted conditions. Carrier qualification testing is expected to be completed in December 2015, which will be followed by further aeromechanical testing required to clear the full flight envelope, including fuel carriage.
- VX-31 at China Lake, California, conducted performance flight testing, providing data needed to verify specification compliance and to certify the system's readiness to transition to IOT&E. VX-31 has tested eight new releases of IRST software since OA 1. These releases include algorithm improvements intended to correct problems seen in OA 1. Expansion of the available flight envelope has permitted testing in more dynamic conditions and allowed participation by VX-31 in a large force exercise at Nellis AFB, Nevada, in June 2015.
- VX-31 conducted integration of the IRST system with the weapon system, including the ability to fuse IRST sensor information with other sensors (such as radar) into Multi-Sensor Integration (MSI) tracks on which weapons can be employed. A progression of simulated AIM-120 shots using captive carry missiles have been performed with more captive carry missions expected prior to a live AIM-120 shot against a QF-4 drone in 3QFY16 or 4QFY16.
- VX-9 conducted OA 2 in November 2015. The OA will include four simulated combat trials that will provide data to evaluate the ability of the system to support detection, tracking, and missile employment in a dynamic, operationally representative environment. OA 2 should help inform the decision to enter IOT&E as well as the Lot 2 LRIP decision.
- In July 2015, the Navy requested USD(AT&L) designate IRST as an Acquisition Category I (ACAT I) program (from ACAT II) because the program has exceeded the research and development dollar threshold due to the research development test and evaluation funding provided in the FY16 presidential budget to Congress for Block II development. The Navy also requested delegation of decision authority to the Navy (i.e., designation as an ACAT IC). Designation to ACAT IC is expected in November 2015.
- A Lot 2 LRIP decision is expected in December 2015 and the IOT&E readiness review is currently planned for March 2016.

Assessment
- The system tested in OA 1 could not detect and track targets well enough to support weapons employment in an environment that reflects realistic fighter employment and tactics.
- The Key Performance Parameter (KPP) and the derived contract specification for detection and tracking describe only a narrow subset of the operational environments where the Navy will employ IRST. Meeting the KPP (with a narrow reading of the KPP requirement) does not ensure a useful combat capability.
- The program has made an effort to develop a more robust tracking capability to provide capability outside the KPP conditions. This effort includes the introduction of a new tracking algorithm and the release and the testing of eight new IRST software versions since OA 1.
- While improvement has been seen in developmental testing, the nature of the problems with detection and tracking identified in OA 1 are such that mission-level operational testing is needed to demonstrate that these problems will not prevent IRST from providing the F/A-18 an effective combat capability. Until satisfactory performance has been demonstrated in an operationally-representative environment that includes jamming and dynamic maneuvering, the risk of an unsuccessful IOT&E is high.
- The Navy's decision to add a second OA that includes realistic mission scenarios prior to IOT&E will significantly reduce the risk of an unsuccessful IOT&E by providing test data in a dynamic maneuvering and jamming environment prior to the decision to enter IOT&E.
- The program has decided to use a mechanical boresight procedure instead of using the line-of-sight estimation algorithm known as servo-transfer alignment as originally planned. The Navy is assessing the impact on IRST logistics. The system's logistics will be affected by how long the boresight will hold and the support equipment that will be required. The contractor has reported that ground vibration testing shows the boresight should hold longer than three times the mean time between repairs. The program is tracking angular accuracy during flight test to look for any degradation. The maintenance task analysis for the intermediate-level (I-level) (aboard ship) and depot-level (D-level) to determine the maintenance tasks for each level is currently in process. However, based on the types of maintenance that will likely require realignment, I-level (aboard ship) and depot-level support equipment for alignment will may be needed for the I and/or D-levels.

Recommendations
- Status of Previous Recommendations. The Navy should continue to address the two FY14 recommendations:
  1. Explicitly state detection and tracking requirements for the range of operational conditions in which the Navy expects to employ the system. N98, which has responsibility for naval aviation warfighting requirements, is currently authoring a requirements clarification memorandum regarding the KPP scenario.
  2. Improve detection and tracking performance prior to entry into IOT&E. Improvements will be tested in OA 2 in November 2015.
- FY15 Recommendations. None.

Integrated Defensive Electronic Countermeasures (IDECM)

Executive Summary

- The Navy ended Integrated Defensive Electronic Countermeasures (IDECM) Block IV (IB-4) hardware testing on November 17, 2015. The Navy did not conduct FOT&E in accordance with the original DOT&E-approved test plan due to missed test points; however, the FOT&E that the Navy did accomplish is adequate for an operational assessment (OA) for the subsequent Software Improvement (SWIP) testing. The Navy, in collaboration with DOT&E, began conversion of the FOT&E to an OA in August 2015 since the Navy's intent is to field IB-4 hardware with mature SWIP software as the Navy's final configuration to counter modern threats.
- Preliminary analysis indicates that IB-4 hardware with precursor SWIP software is as effective on the F-18 E/F platform as the currently fielded IB-3 system.
- On May 26, 2015, the Assistant Secretary of the Navy for Research, Development, and Acquisition issued an Acquisition Decision Memorandum approving the FY15 buy for IB-4 hardware. In addition, the Deputy Assistant Secretary of the Navy for Air Programs issued a Program Deviation Report to the Assistant Secretary of the Navy for Research, Development, and Acquisition authorizing the Navy to equip three F-18 E/F squadrons with IB-4 hardware with precursor SWIP software as an early fielding step towards achieving Initial Operational Capability for the F-18 E/F fleet, and use data from the early fielded systems to enhance the reliability growth plan.
- DOT&E will submit a classified IB-4 OA report in early 2016 assessing preliminary system operational effectiveness and suitability.

System

- The IDECM system is a radio frequency, self-protection electronic countermeasure suite on F/A-18 aircraft. The system is comprised of onboard and off-board components. The onboard components receive and process radar signals and can employ onboard and/or off-board jamming components in response to identified threats.
- There are four IDECM variants: Block I (IB-1), Block II (IB-2), Block III (IB-3), and Block IV (IB-4). All four variants include an onboard radio frequency receiver and jammer.
  - IB-1 (fielded FY02) combined the legacy onboard receiver/jammer (ALQ-165) with the legacy (ALE-50) off-board towed decoy.
  - IB-2 (fielded FY04) combined an improved onboard receiver/jammer (ALQ-214) with the legacy (ALE-50) off-board towed decoy.

  - IB-3 (fielded FY11) combined the improved onboard receiver/jammer (ALQ-214) with a new (ALE-55) off-board fiber-optic towed decoy that is more integrated with the ALQ-214.
  - IB-4 with Software Improvement Program (SWIP) (currently in test) replaces the onboard receiver/jammer (ALQ-214(V)3) with a lightweight, repackaged onboard jammer (ALQ-214(V)4 and ALQ-214(V)5). IB-4 also replaces the ALQ-126B to provide advanced, carrier-capable jamming to the F/A-18C/D for the first time. IB-4 (without SWIP) fielded to three squadrons in FY15.
- The additional program to provide IB-4 the capability to either deny-delay targeting of the F/A-18 by enemy radars, known as the SWIP, is in early development with developmental test flights planned to begin in November 2015. The intent of SWIP is to allow IB-4 hardware to counter modern threats.
- The F/A-18E/F installation includes off-board towed decoys. The F/A-18C/D installation includes only the onboard receiver/jammer components and not the towed decoy.

Mission

- Combatant Commanders will use IDECM to improve the survivability of Navy F/A-18 strike aircraft against radio frequency-guided threats while flying air-to-air and air-to-ground missions.
- The Navy intends to use IB-3's and IB-4's complex jamming capabilities to increase survivability against modern radar-guided threats.

Major Contractors

- ALE-55: BAE Systems – Nashua, New Hampshire
- ALQ-214: Harris – Clifton, New Jersey
- ALE-50: Raytheon Electronic Warfare Systems – Goleta, California

Activity

IB-4

- The Navy decided in April 2012 to transition production of the IB-3 systems to IB-4 systems (production lot buy 9). The IB-4 system has been in full-rate production as of production lot buy 11 and the Navy no longer procures IB-3 systems.
- The IB-4 FOT&E experienced delays for several reasons. Problems with the Environmental Control System cooling and cabin pressure on test F/A-18 C/D aircraft with IB-4 hardware installed, as well as additional test aircraft unscheduled and phase maintenance, resulted in test aircraft being unavailable. Lack of test aircraft led to missed range periods at Nevada Test and Training (NTTR) and Electronic Combat Range (ECR). Another problem was unavailability of the China Lake ECR test range due to both scheduled and unscheduled maintenance of range threats.
- Due to the delays to IB-4 testing and the Navy's decision to no longer procure IB-3 systems, new F/A-18E/F aircraft would not include installed jammers. This resulted in the Navy's decision to field IB-4 with precursor SWIP software to three squadrons before the completion of FOT&E.
- On May 26, 2015, the Assistant Secretary of the Navy for Research, Development, and Acquisition issued an Acquisition Decision Memorandum approving the FY15 buy for IB-4 hardware. In addition, the Deputy Assistant Secretary of the Navy for Air Programs issued a Program Deviation Report to the Assistant Secretary of the Navy for Research, Development, and Acquisition authorizing the Navy to equip three F-18 E/F squadrons with IB-4 hardware with precursor SWIP software as an early fielding step towards achieving Initial Operational Capability for the F-18 E/F fleet, and use data from the fielded systems to support the reliability growth program.
- In late June 2015, DOT&E recommended the Navy convert the planned IB-4 FOT&E to an OA to facilitate SWIP development and support the SWIP FOT&E. DOT&E and the Navy pursued this approach since the final IDECM system expected to be fielded throughout the fleet is the IB-4 hardware with the SWIP software and the September 30, 2015 expiration of FY14 research and development funding for IB-4 testing. The Navy began FOT&E conversion to an OA in August 2015 and will continue IB-4 testing under SWIP operational testing.
- On November 17, 2015, the Navy declared end of test with the following completed on IB-4 hardware:
  - 89 of 160 planned test conditions at the ECR at China Lake, California, with 18 of 80 on the C/D and 71 of 80 on the E/F.
  - Sufficient test at NTTR to assess preliminary IDECM performance.
  - All planned laboratory testing, including a dense emitter scenario and closed-loop hardware-in-the-loop testing.
  - A limited maintenance demonstration.
- Failure scoring boards for the OA flights in support of assessing system reliability have not convened, but are scheduled for November 2015.
- DOT&E will submit a classified OA report detailing the results of IB-4 testing in early 2016.

SWIP

- The Navy completed the first major test event for the SWIP program in July 2015 at a systems integration lab at Edwards AFB, California, against a surrogate threat system.
- The Navy conducted an IDECM SWIP Flight Readiness Review on November 4, 2015. The Navy anticipates beginning IB-4 hardware regression flight testing with SWIP software in 2QFY16 at NTTR and ECR.

Assessment

IB-4

- DOT&E discovered suitability problems with IB-4 on the F/A-18C/D platform during integrated testing and confirmed them during FOT&E.
  - Cabin pressure problems and avionics cooling air degrades were observed at about 20,000 feet in altitude, which delayed FOT&E.
  - Cooling problems were observed with the Environmental Control System. The Navy made repairs to the aircraft under test; however, until they have also completed these repairs to the Environmental Control System on legacy IB-4 aircraft, DOT&E assesses it is likely not suitable as integrated on the F/A-18C/D platform.
- The Navy corrected the deficiency caused by interaction between the ALR-67(V)2 and (V)3 radar-warning receivers and IB-4 system, which caused false threat symbols to be displayed. However, the Navy deferred correcting the deficiency in which the APG-79 radar is falsely identified to the ALQ-214(V)4 by the ALR-67(V)2 and (V)3 radar-warning receivers to a wingman compatibility working group composed of multiple Program Offices.
- IB-4 testing revealed an effectiveness problem against an operational threat for the F/A-18C/D, which would decrease overall survivability for the aircraft if not corrected. Previous testing using developmental test aircraft and a previous software version, and not flying operational maneuvers, did not reveal an effectiveness problem. Further details on this problem are classified.
- The planned IB-4 FOT&E was not completed in accordance with its DOT&E-approved test plan due to missed test points. However, testing to date is adequate since the IB-4 FOT&E conversion to an OA supports the SWIP program.

SWIP

- While the OA supports the SWIP program, the missed IB-4 test points must be collected during SWIP integrated regression testing to ensure adequate data for analysis to determine performance.

- Preliminary analysis indicates the IB-4 hardware with precursor SWIP software, which the Navy chose for their three early fielding F-18 E/F squadrons, is as effective as the currently fielded IB-3 system on the E/F platform.

Recommendations

- Status of Previous Recommendations. The Navy addressed some previous recommendations; however, the following remain outstanding:

IDECM System

1. The Navy should reorganize complex IDECM software to minimize potential problems that could occur during the IDECM SWIP.
2. The Navy should develop hardware and/or software changes to provide pilots with correct indications of whether a decoy was completely severed.
3. The Navy should investigate the effects of IDECM on threat missile fuses.
4. The Navy should use the high-fidelity, accredited F/A-18 radar cross section (RCS) data when accomplishing analysis and hardware-in-the-loop testing, and ensure that the RCS models account for the entire F/A-18 airframe configuration.

Electronic Warfare Warfighting Improvements

5. In coordination with the Defense Intelligence Agency, the Navy should update the warhead probability of kill data in requirements documents to confirm IDECM effects are sufficient to enhance aircraft survivability.

- FY15 Recommendations. The Navy should:
  1. Improve data collection processes to allow for an adequate collection of suitability data during the SWIP/IB-4 operational test period.
  2. Use the results from IB-4 testing accomplished to date to prioritize system shortfall resolution for the SWIP FOT&E.
  3. The Navy should ensure that all resources needed for the SWIP FOT&E will be available by the start of testing in 1QFY17.
  4. The Navy should ensure that the ALR-67(V)3 radar-warning receiver interface with IDECM is updated so that aircrew have accurate situational awareness of the effectiveness of SWIP deny-delay countermeasures.
  5. In addition to the previous recommendation that the Navy should investigate the effects of IDECM on threat missile fuses, the Navy should include warhead fusing in this investigation.
  6. During SWIP integrated regression testing, the Navy should collect the missed IB-4 FOT&E test points.

Joint High Speed Vessel (JHSV) (Expeditionary Fast Transport)

Executive Summary

- Due to the unavailability of the Mobile Landing Platform with the Core Capability Set (MLP (CCS)) and the U.S. Navy's Sea, Air, Land Team (SEAL) Delivery Vehicle (SDV) during the FY13-14 IOT&E, and to further examine suitability, the Navy conducted an FOT&E on the Joint High Speed Vessel (JHSV) (now called Expeditionary Fast Transport) in FY14 and FY15.
- The Commander, Operational Test and Evaluation Force, in conjunction with Marine Corps Operational Test and Evaluation Activity, conducted three FOT&E events: the first two in June and October 2014, and the third in April 2015. The first two events consisted of mooring operations with the MLP (CCS). The third event consisted of launching and retrieving the SDV from the JHSV while at sea.
- On September 22, 2015, DOT&E submitted an FOT&E report and found the following:
  - JHSV interoperability with MLP (CCS) is not operationally effective since, by design (ramp limitation), it can only conduct vehicle transfers when conducted in sea states with significant wave heights of less than 0.1 meters (approximates a Sea State 1), which are normally found only in protected harbors. The JHSV is operationally effective at launch and recovery of the SDV.
  - Although JHSV testing continues to show the ship is operationally suitable in terms of minimum availability, the Ship Service Diesel Generators (SSDGs), waterjets, and Ride Control System (RCS) did not meet their individual reliability goals.
  - The operational restriction of the JHSV's Safe Operating Envelope (SOE) is a major limitation of the ship class that must be factored into all missions.

System

- The JHSV is a high-speed, shallow-draft surface vessel designed for intra-theater transport of personnel and medium cargo payloads for the joint force.
- JHSV bridges the gap between large-capacity, low-speed sealift and small-capacity, high-speed airlift.
- JHSV is a redesign of a commercial catamaran capable of accessing relatively austere ports. Classified as a non-combatant vehicle, JHSV has limited self-protection capability. Design characteristics include:
  - Propulsion provided by four, diesel engine-powered water jets
  - At-sea refueling capability

  - Support for 312 embarked troops for up to 96 hours or 104 troops for 14 days
  - An integrated ramp capable of loading/off-loading military vehicles, including combat-loaded main battle tanks
  - A flight deck with helicopter refueling capability

Mission

Combatant Commanders will use the JHSV to support the flexible, agile maneuver and sustainment of combat forces between forward operating bases, ports, austere littoral access points, and the sea base. Combatant Commanders may employ the JHSV in a transport/resupply role in benign, non-hostile environments to:

- Rapidly transport medium payloads of Marine Corps or Army cargo and combat-ready troops over intra-theatre distances between shore nodes
- Deliver troops, combat-loaded vehicles, and equipment ready to be employed, using only ports with pier or quay wall access and no other infrastructure
- Support sustainment of forces between forward operating bases, ports, and austere littoral access points that would be prohibitive for larger ships to access

Major Contractor

Austal USA – Mobile, Alabama

Activity

- From June 2014 through April 2015, the Navy's Commander, Operational Test and Evaluation Force and Marine Corps Operational Test and Evaluation Activity conducted an FOT&E on USNS *Spearhead* (JHSV 1) and USNS *Millinocket* (JHSV 3) during the following test periods:
  - Two separate events, one in June in the Long Beach harbor in California, and the other in October 2014 at sea off the coast of Camp Pendleton, California, were conducted to test the JHSV/MLP (CCS) interface.
  - Reliability, availability, and maintainability (suitability) data were collected during all underway periods of the USNS *Spearhead* from June 2014 through June 2015 during its transit and deployment to the 6th Fleet in the Mediterranean Sea and off the coast of West Africa.
  - The launch and recovery of the SDV from the JHSV while inside and outside Pearl Harbor, Hawaii, in April 2015. Testing did not include an evaluation of JHSV's ability to host a Special Operations Force (SOF) mission package.
- In September 2015, DOT&E submitted an FOT&E report detailing the results of testing.
- The Navy and the Marine Corps conducted all testing in accordance with a DOT&E approved test plan.

Assessment

- JHSV is not operationally effective interfacing with MLP (CCS) for open-ocean, at-sea transfer of vehicles. The JHSV ramp cannot handle the small, but continual, relative movement of the two ships when moored skin-to-skin. Although vehicles were successfully transferred inside a protected harbor, transfer operations at-sea failed.
- JHSV is operationally effective at launching and recovering the SDV through Sea State 3 (significant wave height up to 1.25 meters) although two issues arose during testing:
  - Pendulum motion of the SDV when lifted by the crane interfered with its recovery. Personnel handling tending lines were challenged with controlling the swinging of the SDV as they were returning the vessel to its trailer. Anti-pendulation systems for cranes are becoming commercially available, and they may help control this problem.
  - Waterborne Navy SOF personnel involved with the launch and recovery of the SDV reported high levels of exhaust gasses in the vicinity of the launch. These gasses may have an effect on SOF personnel readying themselves for missions requiring oxygen transits.
- JHSV remains operationally suitable although its availability has decreased from an estimated 98 percent reported at IOT&E to 87 percent when including FOT&E data. Main drivers of ship's unavailability were the SSDGs, waterjets, and the RCS.
  - The SSDGs installed in JHSV demonstrated poor reliability during both IOT&E and FOT&E test periods. Their target Mean Time Between Failure was 8,369 hours, but was measured to be only 208 hours in IOT&E and 1,563 hours during FOT&E.
  - The JHSV waterjets demonstrated poor reliability during the first ship's deployment. All four waterjets suffered broken or failing reversing plates.
  - The RCS internal mechanism for the forward foils has failed repeatedly. RCS provides active pitch/roll damping to not only smooth out the ride, but to limit structural loading on the ship bow.
  - The bow structure USNS *Spearhead* was damaged during her deployment due to sea slam events in higher sea state conditions. Because of this, the Navy is reinforcing the bows on all JHSVs under construction and back-fitting the reinforcement on hulls 1 through 4. The reinforcement of the bow structure does not expand the SOE, but should allow full use of the ship, within the original SOE, without continued risk of damage. The operational restriction of the SOE is a major limitation of the ship class that must be factored into all missions. To utilize the speed capability of the ship, seas must not exceed Sea State 3 (significant wave height up to 1.25 meters). At Sea State 4 (significant wave height up to 2.5 meters), the ship must slow to 15 knots. At Sea State 5 (significant wave height up to 4 meters), the ship must slow to 5 knots. Above Sea State 5, the ship can only hold position and await calmer seas.

Recommendations:

- Status of Previous Recommendations. The Navy has made progress in addressing previous recommendations from both FY13 and FY14; however, several recommendations remain outstanding. The Navy still needs to:
  1. Determine the best self-deployed transit speed to achieve the 4,700-nautical mile un-refueled range requirement.
  2. Determine a transit speed that allows for a 600 short ton load delivery to 1,200 nautical miles.
  3. Determine an outfitted weight for each hull to enable mission planners to characterize fully loaded transit capability.
  4. Evaluate design improvements identified during the Total Ship Survivability Trials and implement those that will enhance the ship's survivability.
  5. Demonstrate 11-meter Rigid Hull Inflatable Boat launch capability in Sea State 3 (wave heights up to 4 feet).
  6. Review and modify tactics, techniques, and procedures to safely launch Rigid Hull Inflatable Boats in sea states greater than Sea State 2.
  7. Consider a replacement for the Cargo Loading Trailer if a JHSV is utilized routinely to transport 20-foot storage containers.
  8. Implement a reliability growth program for the SSDGs.
  9. Resolve and retest the significant cybersecurity vulnerabilities identified in the classified DOT&E combined IOT&E and LFT&E report.
  10. Provide safety lanyards and harnesses for embarked security team members that man gun mounts. Additionally, provide

hands-free communication devices to help coordinate firing engagements.

11. Investigate the casualty problem with JHSV's ramp that occurred during the interface test with MLP (CCS) in October 2014. If necessary, reevaluate the need for at sea skin-to-skin operations between JHSV and MLP (CCS).

- FY15 Recommendations. The Navy should address the following recommendations from the September 2015 FOT&E report:
  1. Modify the JHSV ramp to increase its sea state rating, or develop a new, higher sea state rated ramp, then retest at-sea equipment transfers with MLP (CCS) in order to conduct open ocean equipment transfers between JHSV and MLP (CCS).
  2. Investigate the availability of a pendulation control system for the JHSV stern-mounted crane.
  3. Evaluate the effect of JHSV exhaust gases on SOF personnel readying themselves for oxygen transits.
  4. Evaluate JHSV capabilities to support personnel and equipment for various SOF mission packages.
  5. Evaluate whether repairs and alterations to the waterjet reversing buckets, along with alterations to the ship's autopilot system, resolve the failure mode of this equipment, or, alternately, investigate a replacement schedule to minimize waterjet casualty downtime.
  6. Evaluate whether the repairs and alterations to the internal operating mechanism of the forward ride control foils resolves the failure mode.
  7. Complete structural reinforcement of bow structure on the class.

Joint Standoff Weapon (JSOW)

Executive Summary

- The Navy began operational testing of the Joint Standoff Weapon (JSOW) C-1 in April 2015. Problems identified during FY12-13 integrated testing resulted in follow-on integrated testing in late FY14 and pushed operational testing to FY15. The JSOW C-1 operational testing is scheduled to complete in FY16.
- Preliminary results to date indicate:
  - Weapon impact accuracy for moving maritime targets is well within the accuracy requirement value, and accuracy performance against stationary land targets has been maintained.
  - The JSOW C-1 Mean Flight Hours Between Operational Mission Failure (MFHBOMF) remains below the requirement value, primarily the result of software-driven problems, but is showing progress towards meeting the requirement value by the end of operational testing. Achieving adequate assessment of MFHBOMF during operational testing is an area of moderate risk.
  - The pilot-vehicle interface (PVI) has improved, but there remain some minor challenges the aircrew must work around for successful mission execution. The Navy is incorporating fixes to address this into the F/A-18E/F H12 Operational Flight Program (OFP), scheduled for release in FY17.
- Testing of the implemented updates to the JSOW software to address these problems validate the use of developmental and integrated test data for DOT&E's operational evaluation of JSOW C-1.

System

- The AGM-154 JSOW family uses a common and modular weapon body capable of carrying various payloads. The JSOW is a 1,000-pound class, air-to-surface glide bomb intended to provide low observable, standoff precision engagement with launch and leave capability. All variants employ a tightly coupled GPS/Inertial Navigation System.
- AGM-154A (JSOW A) payload consists of 145 BLU-97/B combined effects submunitions.
- AGM-154C (JSOW C) utilizes an imaging infrared seeker and its payload consists of an augmenting charge and follow through bomb that can be set to detonate both warheads simultaneously or sequentially.

- AGM-154A and AGM-154C are fielded weapons and no longer under DOT&E oversight. AGM-154C-1 (JSOW C-1) adds moving maritime target capability and the two-way strike common weapon datalink to the baseline AGM-154C weapon.

Mission

- Combatant Commanders use JSOW A to conduct pre-planned attacks on soft point and area targets such as air defense sites, parked aircraft, airfield and port facilities, command and control antennas, stationary light vehicles, trucks, artillery, and refinery components.
- Combatant Commanders use JSOW C to conduct pre-planned attacks on point targets vulnerable to blast and fragmentation effects and point targets vulnerable to penetration such as industrial facilities, logistical systems, and hardened facilities.
- Units will use JSOW C-1 to conduct attacks against moving maritime targets and have the ability to retarget weapons post launch. JSOW C-1 will retain the JSOW C legacy capability against stationary land targets.

Major Contractor

Raytheon Company, Missile Systems – Tucson, Arizona

Activity

- Operational testing began in April 2015, with the first captive carry flight test in June 2015.
- During June and July 2015, the Navy completed six low humidity Stationary Land Target captive flight test (CFT)

events at China Lake, California, with 22 runs collected.
- During August and September 2015, the Navy conducted high humidity testing at Naval Air Station Key West, Florida. The testing included 28 high humidity CFT runs; one night, three morning, and three afternoon high humidity Moving Maritime Target events, and 48 CFT runs.
- The Navy did not complete any free flight testing in FY15 because of cancellations due to weather and aircraft availability. The Navy successfully completed one free flight test event on October 21, 2015.

Assessment
- The Navy began operational testing of the JSOW C-1 in FY15. Preliminary results to date indicate:
  - Weapon impact accuracy for moving maritime targets continues to be well within the accuracy requirement value and accuracy performance against stationary land targets has been maintained.
  - JSOW C-1 MFHBOMF is below the requirement value. This is primarily the result of software-driven problems. With the migration from F/A-18E/F H8 OFP to H10, the MFHBOMF is showing progress towards meeting the requirement value by the end of operational testing. Achieving adequate assessment of MFHBOMF during operational testing is an area of moderate risk.
  - The Navy has reduced the complexity of the PVI in the F/A-18E/F H10 OFP. There remain minor PVI challenges that could prevent successful mission execution. These challenges can be effectively overcome with proper training prior to employment. The Navy is addressing these challenges in F/A-18E/F H12 OFP, scheduled for release in FY17.
- A software upgrade for the Joint Mission Planning System, version 3.0.2, arrived in late September. This is expected to resolve issues with the placement of the network-enabled weapon Link 16 network load for the JSOW on the F-18, but this has not yet been verified.

Recommendations
- Status of Previous Recommendations. The Navy has partially addressed the previous recommendations. The Navy has demonstrated a reduction in software-driven failures during the extended integrated testing phase. While they have significantly reduced the complex PVI, their plan will not fully address this issue until the F/A-18E/F H12 OFP release, scheduled for FY17.
- FY15 Recommendation.
  1. The Navy should continue to reduce the PVI complexity between the JSOW C-1 and the F/A-18E/F to permit successful mission execution.

LHA 6 New Amphibious Assault Ship (formerly LHA(R))

Executive Summary

- The Navy identified a budget shortfall in September 2014 that prohibits the completion of IOT&E by the acquisition program's threshold of October 2016 for reaching Initial Operational Capability. The late delivery of the ship and the 3-month extension of the ship's Post Shakedown Availability (PSA) reduced its availability for operational testing prior to her deployment in FY17. The Navy and Marine Corps Operational Test Agencies developed a plan to complete Amphibious Warfare (AMW) IOT&E in conjunction with scheduled, pre-deployment fleet exercises. The Navy's Program Office is also seeking an agreement with fleet and Marine Corps leadership to conduct the Total Ship Survivability Trial (TSST) in conjunction with these fleet exercises to support an operationally realistic load out of the ship during the IOT&E.
- The Navy commenced LHA 6 IOT&E with a test of the Air Warfare Ship Self-Defense System (SSDS). LHA 6 combat system's testing was partially accomplished with mixed results. Challenges to combat system effectiveness persist and lead to questions about the platform's ability to defend against some threats. Several events remain outstanding for the completion of the approved test plans.
- LHA 6 entered her PSA on May 26, 2015, with an anticipated March 25, 2016 completion date. The Navy will implement changes necessary for Joint Strike Fighter (JSF) that will also benefit the incorporation of MV-22 Osprey operations on the LHA 6 during her PSA and will include these changes into the LHA 7 construction plan. LHA 6 will conduct her maiden deployment in mid-2017 with a standard Marine Expeditionary Unit Aviation Combat Element (MEU ACE) that includes AV-8B Harrier aircraft. LHA 6 will complete operational testing with an evaluation of the ship's ability to support a complement of 20xJSF aircraft in FY19.

System

- LHA 6 is a large-deck amphibious assault ship designed to support a notional mix of fixed and rotary-wing aircraft consisting of 12 MV-22 Ospreys, 6 F-35B JSFs (Short Take-Off/Vertical Landing variant), 4 CH-53Es, 7 AH-1s/UH-1s, and 2 embarked H-60 Search and Rescue aircraft, or a load out of 20 F-35Bs and 2 embarked H-60 Search and Rescue aircraft. Key ship features and systems include the following.
  - Greater aviation storage capacity and an increase in the size of the hangar bay, which is necessary to accommodate the enhanced aviation maintenance requirements for the MEU ACE with F-35B and MV-22. Additionally, two maintenance areas with high-overhead clearance are incorporated into the design of the ship to accommodate maintenance on MV-22s in the spread configuration (wing spread, nacelles vertical and rotors spread).
  - Shipboard medical spaces are reduced by approximately two thirds compared to contemporary LHDs to expand the hangar bay.
  - The combat system includes the SSDS MK 2, the Phalanx Close-In Weapon System Block 1B, and the MK 38 Mod 2 Gun Weapon System for defense against air threats and small surface craft. The SSDS MK 2-based combat system integrates with the following five major components:
  - The SSDS MK 2 Mod 4B control and decision system supports the integration and control of most other combat system elements
  - The ship's AN/SPS-48E and AN/SPS-49A air search radars and the AN/SPQ-9B horizon search radar
  - USG-2 Cooperative Engagement Capability radar tracking systems
  - The Rolling Airframe Missile and the Evolved Seasparrow Missile (ESSM), with the NATO Seasparrow MK 9 Track Illuminators
  - The AN/SLQ-32B(V)2 electronic warfare system with the Nulka electronic decoy-equipped MK 53 Decoy Launching System
- Two marine gas turbine engines, two electric auxiliary propulsion motors, and two controllable pitch propellers provide propulsion. Six diesel generators provide electric power.
- Command, Control, Communications, Computers, and Intelligence (C4I) facilities and equipment to support Marine Corps Landing Force operations are part of the program of record.

- LHA 8 is the lead ship for the Flight 1 variant of the LHA(R) Amphibious Assault Ship replacement program. It has a modified flight deck and reduced island intended to enable an aviation support capability similar to that of LHA 6. LHA 8 also includes a well deck for deploying surface connectors.

Mission

The Joint Maritime Component Commander will employ LHA 6 to:

- Serve as the primary aviation platform within an Amphibious Ready Group with space and accommodations for Marine Corps vehicles, cargo, ammunition, and more than 1,600 troops
- Serve as an afloat headquarters for a MEU Amphibious Squadron, or other Joint Force commands using its C4I facilities and equipment
- Accommodate elements of a Marine Expeditionary Brigade when part of a larger amphibious task force
- Carry and discharge combat service support elements and cargo to sustain the landing force

Major Contractor

Huntington Ingalls Industries, Ingalls Shipbuilding Division – Pascagoula, Mississippi

---

Activity

- DOT&E observed an enhanced acoustic trial on the LHA 6 in December 2014. This trial collected keel aspect acoustic signatures in addition to the beam aspect signatures. The data will be used by the Navy for the ship's mine susceptibility trial.
- DOT&E observed the Navy's Combat Systems Ships Qualification Trials for LHA 6 from March 9 – 13, 2015, and Final Contractor Trials (FCTs) from March 30 through April 2, 2015. These events are part of the developmental test strategy described in the DOT&E-approved Test and Evaluation Master Plan (TEMP).
- The Navy commenced LHA 6 IOT&E onboard LHA 6 with Enterprise Test (ET) 06 of the Air Warfare Ship Self-Defense capability. The test was conducted in accordance with a DOT&E-approved test plan from April 20 through May 1, 2015, and produced mixed results.
- The Navy released a Request for Proposal on June 25, 2015 directly to General Dynamics National Steel and Shipbuilding Company (commonly referred to as NASSCO) and Huntington Ingalls Industries for the construction of LHA 8. The two shipbuilders are deemed by the Service to be the only two in the country capable of building amphibious assault ships. The Navy anticipates responses for the LHA 8 Request for Proposal in FY16.
- The Navy is developing an LHA(R) TEMP Revision B to address design modifications to LHA 8 to include the addition of the well deck and changes to the flight deck, the island configuration, the combat system, medical spaces, fuel tanks, and supporting spaces. Marine Corps aircraft, surface connectors, and vehicles are also evolving. LHA 8 is intended to bring new operational capability to the fleet, which requires an AMW IOT&E to account for the advancements in modernization from LHA 6.
- In May 2015, the Navy delivered a draft Vulnerability Assessment Report (VAR) for the LHA 6, and is using the findings in its planning for LHA 6's TSST. The Navy has stated it is not planning to execute the Advanced Mine Simulation System (AMISS) trial, which would be used to establish the mine susceptibility of the LHA 6, as agreed to in the DOT&E-approved TEMP Revision A. To date, the Navy has not presented a valid alternative to conducting the AMISS trial.
- LHA 6 is scheduled to complete her PSA on March 25, 2016. The principle work accomplished during PSA are the design modifications to the flight deck to account for the deck strengthening, heat-resistant material improvements, and lighting positioning to accommodate the JSF F-35B and benefit MV-22 Osprey operations. The flight deck changes have been included in the LHA 7 design currently under construction at Huntington Ingalls shipyard.

Assessment

- The late delivery of the ship, the 3-month extension of the ship's PSA, and the additional requirements to serve as the JSF F-35B test platform, further reduce LHA 6's availability for dedicated operational testing prior to her deployment in FY17.
- The Navy identified a budget shortfall in September 2014 that will prevent the completion of IOT&E prior to the acquisition program threshold of October 2016. The Navy has developed an alternate path to complete the required testing in coordination with LHA 6's pre-deployment fleet exercises.
- During Combat Systems Ships Qualification Trials and FCT events, the ship performed well during deck (anchoring drop test), engineering (main propulsion and mobility), and operational evolutions (flight deck). The ship completed FCTs with an overall assessment of satisfactory.
- Combat system testing in LHA 6 during ET-06 and on the Self-Defense Test Ship during ET-05 (the Self-Defense Test Ship was set-up in the LHA 6 configuration for ET-05) produced mixed results. Several challenges persist to the efficacy of the ship's combat system against all threats. Integration and combat system shortfalls associated with the government furnished equipment provided to SSDS MK 2-based combat systems (as discussed in the DOT&E Self-Defense Operational Mission Capability Report dated November 5, 2012) must be resolved to permit LHA 6 to satisfy its Probability of Raid Annihilation (P_{RA}) requirement.

This is the greatest risk to the ship successfully demonstrating its survivability.

- Because LHA 6 does not have a well-deck, it will rely exclusively on air assets to move forces ashore. The Navy and Marine Corps are in the process of adjusting their tactics to optimize the capabilities of LHA 6. In particular, the aircraft mix and equipment load-out used on an LHD may not be optimal to rapidly mass combat power ashore from LHA 6. The Navy and Marine Corps need to finalize their tactics prior to the phase of IOT&E in which they will be used.
- LHA 6 TSST, which contributes to the survivability assessment of the ship, was planned to occur during the AMW event to minimize the cost of the test program. The Navy has rescheduled the test to occur just before the LHA 6 AMW Marine Integrated Training exercise, which is projected to occur in March 2017. The Navy is coordinating with the fleet and Marine Corps leadership to ensure the TSST is conducted in an operationally realistic manner.
- The LHA 6 SSDS has demonstrated capability against some classes of Anti-Ship Cruise Missile (ASCM) threats. However, based on combat system's testing on LHA 6 and other platforms, it is unlikely that LHA 6's SSDS MK 2-based combat system will meet the ship's P_{RA} requirement against all classes of ASCMs.
  - The Navy initiated the Fire Control Loop Improvement program (FCLIP) to correct some combat system deficiencies related to self-defense against ASCMs and has the potential to mitigate some of the vulnerabilities.
  - However, The Navy has completed Phase 1 of the FCLIP. What was formally known as FCLIP Phase 2 and 3 are now merged into FCLIP Phase 2, which is not yet funded.
- The MK 29-guided missile launch system used to launch the ESSM experienced several motor failures during ET-06. The ship's crew had to replace vertical train servo motors in both of the MK 29 mounts. Although this was just an inconvenient delay for test activities, motor failures during an unexpected attack could degrade the combat system's ability to intercept incoming threats with the ESSM. The Navy attributes the problem to the increased weight of the ESSM relative to the seasparrow missile it replaces. The Navy is investigating modifying or replacing the MK 29 launch system to handle the extra weight. In the short term, the Navy is addressing the problem through procedural (e.g., the use of counterweights when loading an ESSM into the launcher) and logistical (e.g., supplying crews with spare motors) efforts.
- In July 2015, the Navy identified it was having problems developing the needed Multi-Stage Supersonic Target. After a review of the options to support the planned IOT&E event, DOT&E determined the Navy did not have an affordable or viable target development plan and its alternative solution was not adequate. Hence, DOT&E recommended the Navy cease the Multi-Stage Supersonic Target development until the requirements are better defined and an affordable solution can be found.
- DOT&E does not agree that the Navy's proposed modeling and simulation-based approach to assessing the mine susceptibility of LHA 6 is adequate. The Navy should therefore plan to execute the AMISS trial as agreed to in the DOT&E-approved TEMP Revision A.

Recommendations

- Status of Previous Recommendations. The Navy has either addressed or established a process through which to address most of the previous recommendations. However, the Navy has not fully resolved the recommendation to correct systems engineering deficiencies related to SSDS MK 2-based combat systems and other combat system deficiencies so that LHA 6 can satisfy its P_{RA} requirement.
- FY15 Recommendations. The Navy should:
  1. Allocate sufficient resources to permit the IOT&E and TSST to be conducted as a stand-alone event for LHA 8 until the plan for executing AMW IOT&E and the TSST in coordination with fleet-exercises can be evaluated for LHA 6.
  2. Resolve the MK 29 launcher system motor failures due to the additional weight of the ESSM.
  3. The Navy and Marine Corps need to finalize their tactics, techniques, and procedures for LHA 6 prior to the phase of IOT&E in which they will be used.
  4. The Navy should plan and resource the mine susceptibility trial for the LHA 6 using the AMISS.

Light Armored Vehicle – Anti-Tank Modernization (LAV-ATM)

Executive Summary

- From January 12 through March 4, 2015, the Marine Corps Operational Test & Evaluation Activity (MCOTEA) conducted an operational assessment (OA) for the Light Armored Vehicle Anti-Tank Modernization (LAV-ATM) using two pre-Milestone C LAV-ATM prototypes in accordance with a DOT&E-approved test plan. Operational Marines from 1st Marine Division participated in the OA.
- The LAV-ATM demonstrated a turret reliability of 0.95, exceeding the requirement of 0.9 and an operational availability of 0.965 exceeding the requirement of 0.85. Because of the short duration of the OA, it cannot be concluded with statistical confidence that the reliability requirement has been met.
- The LAV-ATM met its classified probability of hit requirements.

System

- The LAV Family of Vehicles shares a common-base platform configuration and consists of seven variants.
- The LAV-ATM variant fires tube-launched, optically-tracked, wire-guided anti-armor missiles.
- The eight-wheeled LAVs have armor to protect units from some small arms, light machine gun fire, and artillery projectile fragments.
- LAVs are capable of operating on primary roads, trails, and cross-country terrain.
- LAVs have a limited swim capability for maneuvering waterways and river crossings.

Mission

Marine Corps commanders will use Light Armored Reconnaissance (LAR) battalions equipped with LAV-ATM vehicles to conduct reconnaissance, security, economy of force operations, and limited offensive or defensive operations.

- During offensive operations, the Marine Corps will employ the LAV-ATM to provide anti-armor fires that support maneuvering LAR companies and platoons.
- During defensive operations, the Marine Corps will use the LAV-ATM to provide LAR companies and platoons with long-range, stand-off anti-armor fires, and observation in all climate conditions and periods of limited visibility.

Major Contractor

Raytheon – McKinney, Texas

Activity

- From January 12 through March 4, 2015, MCOTEA conducted an OA for the LAV-ATM at the Marine Corps Air Ground Combat Center, Twentynine Palms, California, using two pre-Milestone C LAV-ATM prototypes. Operational Marines from 1st Marine Division participated in the OA. Testing was conducted in accordance with a DOT&E-approved test plan.
- The OA consisted of a training phase, a weapon systems comparison test, and a field firing test.
  - The training phase included a 40-hour new equipment training period for operators and maintainers.
  - The weapon systems comparison test phase included four 48-hour operational mission profiles. Mission routes covered desert terrain that included ravines, washouts, hills, rocks, and soft sand. In each operational mission profile, each platoon conducted eight missions, divided between offense and defense and between day and night.
  - The field firing test phase of LAV-ATM consisted of 44 live tube-launched, optically-tracked, wire-guided missile firings on an instrumented range and tactical movements conducted between missile firings to create operational stresses on the crews and system.

Assessment

- During the OA, the LAV-ATM's second generation, forward-looking infrared thermal sight demonstrated the following capabilities:
  - Enabled gunners to acquire targets at greater ranges
  - Provided an eye-safe laser range finder
  - Provided automatic boresighting
  - Aided the gunner in target tracking
  - Incorporated an embedded training capability
- The LAV-ATM can maneuver with its turret raised, providing a capability to detect and acquire targets on the move and engage targets more quickly than the current LAV-AT that takes two minutes to raise its turret. However, due to test limitations including the lack of the capability to conduct real-time casualty assessment, the OA did not provide results actually demonstrating the operational benefit of this improvement.
- The new vehicle commander's sight provides the vehicle commander with the same imagery seen by the gunner to improve target detection, acquisition, recognition, and identification and to increase the vehicle commander's situational awareness. Again, test limitations precluded demonstrating the actual operational benefit of this improvement.
- The LAV-ATM demonstrated a turret reliability of 0.95, exceeding the requirement of 0.9 and an operational availability of 0.965, exceeding the requirement of 0.85. Because of the short duration of the OA it cannot be concluded with statistical confidence that the reliability requirement has been met.
- The LAV-ATM met its classified probability of hit requirements.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendation.
  1. The Marine Corps should field the instrumentation capabilities, including real-time casualty assessment, necessary to conduct useful realistic operational testing of new combat vehicles and upgrades to existing vehicles.

Littoral Combat Ship (LCS) and Associated Mission Modules

Executive Summary

- In the report to Congress required by the National Defense Authorization Act (NDAA) for FY15, DOT&E concluded that the now-planned use of the Littoral Combat Ship (LCS) as a forward-deployed combatant, where it might be involved in intense naval conflict, appears to be inconsistent with its inherent survivability in those same environments.
- This same report also concluded that the ability of LCS to successfully execute significant aspects of its envisioned concept of operations (CONOPS) depends on the effectiveness of the mission packages. To date, the Navy has not yet demonstrated effective capability for either the Mine Countermeasures (MCM) or Anti-Submarine Warfare (ASW) mission packages. The Surface Warfare (SUW) mission package has demonstrated a modest ability to aid the ship in defending itself against small swarms of small boats, and the ability to conduct maritime security operations.
- During FY15, the Navy conducted developmental testing of the *Independence* variant LCS seaframe and Increment 1 MCM mission package aboard USS *Independence* (LCS 2). Although the Navy intended to complete that testing by June 2015 and conduct the operational test from July to September, it extended developmental testing through the end of August because of seaframe failures and MCM mission system reliability shortfalls. The Navy subsequently decided in October 2015 to postpone the first phase of IOT&E of the MCM mission package until sometime in 2016, at the earliest.
- The Navy chartered an independent program review of the Remote Minehunting System (RMS), including an evaluation of potential alternative MCM systems, in September 2015.
- DOT&E concluded in a November 2015 memorandum to the USD(AT&L) and the Navy, based on all testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or operationally suitable if the Navy called upon it to conduct MCM missions in combat and that a single LCS equipped with the Increment 1 MCM mission package would provide little or no operational capability to complete MCM clearance missions to the levels needed by operational commanders. The following summarize the primary reasons for this conclusion:
  - Critical MCM systems are not reliable.
  - The ship is not reliable.
  - Vulnerabilities of the Remote Multi-Mission Vehicle (RMMV) to mines and its high rate of failures do not support sustained operations in potentially mined waters.
  - RMMV operational communications ranges are limited.
  - Minehunting capabilities are limited in other-than-benign environmental conditions.
  - The fleet is not equipped to maintain the ship or the MCM systems.
  - The Airborne Mine Neutralization Systems (AMNS) cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
- During the MCM mission package Technical Evaluation (TECHEVAL), the Navy demonstrated that an LSC could detect, classify, identify, and neutralize only a fraction of the mines in the Navy's mine clearance scenarios while requiring extraordinary efforts from shore support, maintenance personnel, and contractors.
- The Navy also conducted both developmental and operational testing of the *Independence* variant LCS seaframe with the Increment 2 SUW mission package aboard LCS 4. Operational testing of the seaframe and Increment 2 SUW mission package is not yet complete because of pending changes to the ship's air defense system, Sea Rolling Airframe Missile (SeaRAM), and other elements of the ship's combat system and networks. A second phase of operational testing of the Increment 2 version of the SUW mission package and *Independence* variant seaframe is scheduled to occur in 3QFY16.

***Freedom* Variant (LCS 1)**

***Independence* Variant (LCS 2)**

- While equipped with the Increment 2 SUW mission package, LCS 4 participated in three engagements with small swarms of Fast Inshore Attack Craft (FIAC). Although all of the attacking boats were ultimately defeated, an attacker managed to penetrate the "keep-out" range in two of the three events. In all three events, however, the ship expended a large quantity of ammunition from the seaframe's 57 mm gun and the two mission package 30 mm guns, while contending with repeated network communication faults that disrupted the flow of navigation information to the gun systems as well as azimuth elevation inhibits that disrupted or prevented establishing firing solutions on the targets. LCS 4's inability to defeat this relatively modest threat beyond the "keep-out" range routinely under test conditions raises questions about its ability to deal with more challenging threats that could be present in an operational environment.
- In comparison to other Navy ships, the LCS seaframes have relatively modest air defense capabilities that cannot be characterized fully until planned tests on LCS 7 and LCS 8 and the Navy's unmanned self-defense test ship provide data for the Navy Probability of Raid Annihilation (P_{RA}) high-fidelity modeling and simulation analyses. The Navy plans to begin those tests in FY17. In FY15, DOT&E learned that the Program Executive Office for Integrated Warfare Systems (PEO IWS) stopped work on the P_{RA} Test Bed for the *Freedom* variant because a high-fidelity model of the ship's AN/SPS-75 radar was not being developed. Development of an acceptable radar model requires intellectual property rights that the Navy does not hold and is not actively seeking. Although less critical because of the combat system architecture of the *Independence* variant, the Navy has also been unable to develop a high-fidelity model of that ship's AN/SPS-77 radar for the same reason. In an August 2015 memorandum, DOT&E advised Navy officials that the lack of these radar models threatens the viability of the Navy's strategy for evaluation of LCS air defense capabilities and suggested alternative strategies specific to each seaframe variant. The Navy has not decided what course of action it wants to pursue.
- In August 2015, the Navy conducted the first shipboard live firing of the ship's SeaRAM system. The demonstration was not designed to be an operationally realistic test of the ship's capability. The aerial drone's flight profile and configuration were not threat representative.
- Test activities in FY15 allowed the collection of reliability, maintainability, availability, and logistics supportability data to support evaluation of the operational suitability of the *Independence* variant seaframe. Although incomplete, the data collected to date show that many of the *Independence* variant seaframe systems have significant reliability problems. During developmental testing, the LCS 4 crew had difficulty keeping the ship operational as it suffered repeated failures of the ship's diesel generators, water jets, and air conditioning units. LCS 4 spent 45 days over a period of 113 days without all 4 engines and steerable water jets operational. This includes a 19-day period in May when 3 of the 4 engines were degraded or non-functional. During the five-month MCM mission package TECHEVAL period, LCS 2 seaframe failures caused the ship to return to, or remain in, port for repairs on seven occasions. Similar to LCS 4, the ship's core systems, such as the air defense system, SeaRAM, the MK 110 57 mm gun, the electro-optical/infrared sensor (Sea Star Shipboard Airborne Forward-Looking Infra-Red Equipment (SAFIRE)) used to target the gun, and the ship's primary radar, experienced failures, leaving the ship with no air or surface defense capability for more than one-half of the test period. LCS 2 was unable to launch and recover RMMVs on 15 of the 58 days underway because of 4 separate propulsion equipment failures involving diesel engines, water jets, and associated hydraulic systems and piping.
- The Navy conducted the first of four periods of cybersecurity testing on the *Independence* variant while the ship was moored in Pensacola, Florida, during a comprehensive maintenance availability. The test comprised a Cooperative Vulnerability and Penetration Assessment (CVPA) of the seaframe and embarked Increment 1 MCM mission package. The CVPA details are classified but indicate that, like the *Freedom* variant seaframe, the *Independence* variant seaframe has cybersecurity deficiencies that significantly degrade operational effectiveness. Plans for the remaining period of the cybersecurity testing in LCS 2 are on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant seaframe for MCM operational testing. The Navy delayed the two periods of cybersecurity testing in LCS 4 until after it completes an upgrade of the ship's networks designed to enhance cybersecurity and correct known issues.
- DOT&E does not expect either LCS variant to be survivable in high-intensity combat because the design requirements accept the risk that the crew would have to abandon ship under circumstances that would not require such action on other surface combatants. Although the ships incorporate capabilities to reduce their susceptibility to attack, previous testing of analogous capabilities demonstrates it cannot be assumed LCS will not be hit in high-intensity combat.
- The LCS 3 Total Ship Survivability Trial (TSST) revealed significant deficiencies in the *Freedom* variant design. Much of the ship's mission capability would have been lost because of damage caused by the initial weapons effects or the ensuing fire. The weapons effects and fire damage happened before the crew could respond, and the ship does not have sufficient redundancy to recover the lost capability.

System

Seaframes

- The LCS is designed to operate in the shallow waters of the littorals that can constrain the ability of larger ships to maneuver.
- The Navy originally planned to acquire 55 LCSs, but reduced the planned procurement to 52 ships in 2013. In a February 24, 2014 memorandum, the Secretary of Defense announced that no new contract negotiations beyond 32 ships would go forward and directed the Navy to submit

alternative proposals to procure a more capable and lethal small surface combatant, generally consistent with the capabilities of a Frigate. Further discussion of the small surface combatant variant (now called a Frigate) is in a separate article in this annual report.

- The Navy is currently procuring two variants of LCS seaframes:
  - The *Freedom* variant (odd-numbered ships) is a semi-planing monohull design constructed of steel (hull) and aluminum (deckhouse) with two steerable and two fixed-boost water jets driven by a combined diesel and gas turbine main propulsion system.
  - The *Independence* variant (even-numbered ships) is an aluminum trimaran design with two steerable water jets driven by diesel engines and two steerable water jets driven by gas turbine engines.
- Common design specifications include:
  - Sprint speed in excess of 40 knots, draft of less than 20 feet, and an un-refueled range in excess of 3,500 nautical miles at 14 knots
  - Accommodations for up to 98 personnel
  - A common Mission Package Computing Environment (MPCE) for mission package control using Mission Package Application Software (MPAS) installed when a mission package is embarked
  - A Multi-Vehicle Communications System to support simultaneous communications with multiple unmanned off-board vehicles
  - Hangars sized to embark MH-60R/S and Vertical Take-Off Unmanned Aerial Vehicles (VTUAVs)
  - MK 110 57 mm gun (BAE/BOFORS)
- The designs have different core combat systems to provide command and control, situational awareness, and self-defense against anti-ship cruise missiles (ASCMs) and surface craft.
  - *Freedom* variant: COMBATSS-21, an Aegis-based integrated combat weapons system with a TRS-3D (AN/SPS-75) air and surface search radar (ASR) (Airbus, France), Rolling Airframe Missile (RAM) system supported by elements from the Ship Self-Defense System (Raytheon) (one 21-cell launcher), a Terma Soft Kill Weapon System (Denmark), and a DORNA EOD gunfire control system with an electro-optical/infrared sensor (Navantia, Spain) to control the MK 110 57 mm gun.
  - *Independence* variant: Integrated Combat Management System (derived from the Thales TACTICOS system (The Netherlands) with a Sea Giraffe (AN/SPS-77) ASR (SAAB, Sweden), one MK 15 Mod 31 SeaRAM system (Raytheon) (integrates the search, track, and engagement scheduler of the Phalanx Close-in Weapon System with an 11-round RAM launcher assembly), ALEX (Automatic Launch of Expendables) System (off-board decoy countermeasures) (Sippican, U.S.), and SAFIRE (FLIR, U.S.) for 57 mm gun fire control.

Mission Packages

- LCS is designed to host a variety of individual warfare systems (mission modules) assembled and integrated into interchangeable mission packages. The Navy currently plans to field MCM, SUW, and ASW mission packages. A mission package provides the seaframes with capability for a single or "focused" mission. Multiple individual programs of record involving sensor and weapon systems and off-board vehicles make up the individual mission modules. Summarized below is the current acquisition strategy for the incremental development of each mission module. However, the Navy recently began an effort to revise its plan, including the possibility of developing different components rather than some upgrades.

SUW Mission Package

- Increment 1 includes:
  - Gun Mission Module (two MK 46 30 mm guns)
  - Aviation Module (embarked MH-60R)
- Increment 2 adds:
  - Maritime Security Module (small boats)
- Increment 3 is expected to add:
  - Surface-to-Surface Missile Module Increment I, employing the AGM 114L Longbow Hellfire missile
  - One MQ-8C Fire Scout VTUAV to augment the Aviation Module
- Increment 4, if fielded, will add:
  - Surface-to-Surface Missile Module Increment II (replacing Increment I) to provide a longer range surface engagement capability

MCM Mission Package

- Increment 1 includes:
  - Remote Minehunting Module, consisting of two RMMVs (version 6.0 (v6.0)) and three AN/AQS-20A sensors. The Navy plans to incorporate an improved sensor (AN/AQS-20C) in a future increment.
  - Near Surface Detection Module, consisting of two Airborne Laser Mine Detection Systems (ALMDS). The Navy plans to incorporate improvements in a future increment.
  - Airborne Mine Neutralization Module, consisting of two AMNS units. In Increment 1, the AMNS does not include a near surface mine neutralization capability.
  - Aviation Module consisting of an MH-60S Block 2B or subsequent Airborne Mine Countermeasures (AMCM) Helicopter outfitted with an AMCM system operator workstation and a tether system.
- Increment 2 is expected to add:
  - Coastal Mine Reconnaissance Module, consisting of the Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I system and one MQ-8B VTUAV for daytime unmanned aerial tactical reconnaissance to detect and localize mine lines and obstacles in the beach zone.

- Increment 3 is expected to add:
  - Unmanned Mine Sweeping Module, consisting of the Unmanned Influence Sweep System (UISS) to actuate/detonate acoustic-, magnetic-, and combined acoustic/magnetic-initiated volume and bottom mines in shallow water.
  - Airborne Mine Neutralization (Near-Surface) Module
- Increment 4 is expected to add:
  - COBRA Block II system, which retains Block I capability and adds nighttime minefield and obstacle detection capability and day/night detection capability in the surf zone.
  - Buried Minehunting Module, consisting of the Knifefish Unmanned Undersea Vehicle, a battery-powered, autonomous underwater vehicle, employing a low-frequency, broadband, synthetic aperture sonar to detect, classify, and identify volume and bottom mines in shallow water.

ASW Mission Package (only Increment 2)

- Torpedo Defense and Countermeasures Module (Lightweight Tow torpedo countermeasure)
- ASW Escort Module (Multi-Function Towed Array and Variable Depth Sonar)
- Aviation Module (embarked MH-60R and MQ-8B Fire Scout VTUAV) (inclusion of Fire Scout is reportedly being deferred because of fiscal constraints.)

Mission

- The Maritime Component Commander will employ LCS to conduct MCM, ASW, or SUW tasks depending on the mission package installed in the seaframe. Because of capabilities inherent to the seaframe, commanders can employ LCS in a maritime presence role in any configuration. With the Maritime Security Module, installed as part of the SUW mission package, the ship can conduct Maritime Security Operations, including Visit, Board, Search, and Seizure of ships suspected of transporting contraband.
- The Navy can employ LCS alone or in company with other ships. The Navy's CONOPS for LCS anticipates that the ship's primary operational role will involve preparing the operational environment for joint force assured access to critical littoral regions by conducting MCM, ASW, and SUW operations, possibly under an air defense umbrella as determined necessary by the operational commander. However, the latest CONOPS observes, "The most effective near-term operational roles for LCS to support the maritime strategy are theater security cooperation and MSO [Maritime Security Operations] supporting deterrence and maritime security."

Major Contractors

- *Freedom* variant (LCS 1, 3, 5, 7, and follow-on odd-numbered ships)
  - Prime: Lockheed Martin Maritime Systems and Sensors – Washington, District of Columbia
  - Shipbuilder: Marinette Marine – Marinette, Wisconsin
- *Independence* variant (LCS 2, 4, 6, 8, and follow-on even-numbered ships)
  - Prime for LCS 2 and LCS 4: General Dynamics Corporation Marine Systems, Bath Iron Works – Bath, Maine
  - Prime for LCS 6 and follow-on even numbered ships: Austal USA – Mobile, Alabama
  - Shipbuilder: Austal USA – Mobile, Alabama
- Mission Packages
  - Mission Package Integration contract awarded to Northrop Grumman – Los Angeles, California

---

Activity

LCS Program

- In February 2014, the Secretary of Defense curtailed the planned Flight 0+ LCS procurement at 32 ships and required the Navy to submit alternative proposals for a capable small surface combatant that is more lethal and survivable than the current LCS design. In December 2014, the Secretary of Defense approved the Navy's proposal to procure a small surface combatant based on an upgraded Flight 0+ LCS with minor modifications.
- In January 2015, the Secretary of the Navy announced that the modified small surface combatant LCS would be designated a Frigate and noted that the Navy would consider re-designating earlier LCS variants as Frigates if/when they receive similar modifications. The Navy began work on a Capabilities Development Document in 2015, and plans to complete Joint Staffing of the requirements document in FY16. Additional information about the small surface combatant (now called a Frigate) modification to the LCS is provided in a separate article in this annual report.
- In February 2015, DOT&E provided the Secretary of the Navy certification that only one of each mission module is needed to support operational testing in compliance with Section 122 of the NDAA for FY15.
- In February 2015, DOT&E responded to the reporting requirement in Section 124 of the FY15 NDAA, which directed DOT&E to report on the Test and Evaluation Master Plan (TEMP) for LCS seaframes and mission modules.
- In April 2015, DOT&E provided USD(AT&L) an assessment of the capabilities and limitations of LCS ships and mission packages to support USD(AT&L)'s FY15 LCS Deep Dive and annual review of the program. That report summarized DOT&E's current assessment of both variants,

including an evaluation of the seaframes' cybersecurity, air defense, surface self-defense, reliability, and availability, and known survivability shortfalls. The report also summarized the most significant concerns for each of the mission packages in advance of the planned operational testing of both the SUW and MCM mission packages intended to occur in FY15.

- Also in April 2015, DOT&E submitted a report to Congress and the Secretary of Defense responding to Section 123 of the FY15 NDAA, which directed DOT&E and the Navy to address the current CONOPS and expected survivability attributes of each of the seaframes. This report included a review of the survivability testing, modeling, and simulation conducted to date on the two seaframes, and an assessment of the expected survivability of LCS in the context of its planned employment as described in the CONOPS.
- The Navy began efforts to revise the LCS TEMP in 4QFY15. The current version of the TEMP was only approved for the testing on the first increment of the MCM mission package, the second increment of the SUW mission package, and the initial ASW mission package. An update is now required since testing of the Increment 3 SUW mission package is expected to occur in FY16. Uncertainty in the Navy's plans for the mission packages as well as the uncertainty in ship availability in the out years is slowing the TEMP's development. The FY16 NDAA directed the Navy to submit a current TEMP for the LCS mission modules, approved by DOT&E, which includes the performance levels expected to be demonstrated during developmental testing for each component and mission module prior to commencing the associated operational test phase.
- In August 2015, DOT&E advised Navy officials of concerns that the Navy's current lack of access to the intellectual property needed to develop high-fidelity models of the AN/SPS-75 and AN/SPS-77 radars for use in the P_{RA} modeling and simulation test bed will preclude adequate evaluation of LCS air defense capabilities. The memorandum detailed alternative test strategies involving additional live testing that might be acceptable should the Navy be unable to obtain the necessary data rights.
- In December 2015, DOT&E published an assessment of the results of operational testing of the *Freedom* variant seaframe and SUW mission package (Increments 1 and 2).

Seaframes

- *Freedom* variant:
  - The Navy conducted a TSST in USS *Fort Worth* (LCS 3) from September 29, 2014 through October 3, 2014, in accordance with the DOT&E-approved trial plan.
  - In November 2014, LCS 3 deployed for extended operations in the Western Pacific with an Increment 2 SUW mission package and an aviation detachment that included an MH 60R helicopter and an MQ-8B Fire Scout VTUAV. The Navy expects LCS 3 to return to her homeport in 3QFY16.
  - In November 2015, the Navy placed USS *Milwaukee* (LCS 5) in commission.
- *Independence* variant:
  - In October 2014, USS *Independence* (LCS 2) hosted a scheduled phase of developmental testing focused on integrated seaframe and Increment 1 MCM mission package operations.
  - In January 2015, the Navy conducted developmental testing, including gunnery events, using LCS 2. The ship then sailed from San Diego, California, to the Gulf of Mexico, arriving in Pensacola, Florida, on February 17. Following installation and grooming of the Increment 1 MCM mission package, LCS 2 conducted crew training in MCM operations in preparation for TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package.
  - From May through August 2015, the Navy conducted developmental testing, including TECHEVAL, of the *Independence* variant seaframe and Increment 2 SUW mission package aboard LCS 4. This TECHEVAL integrated the test objectives of both the developmental and operational test communities. DOT&E and the Navy's Commander, Operational Test and Evaluation Force (COTF) are using the resulting data to supplement data collected during a subsequent operational test. DOT&E approved an operational test supplement to the developmental test plans, and DOT&E personnel observed the testing aboard LCS 4.
  - In June and July 2015, COTF conducted the cybersecurity CVPA phase of Operational Test C2 (OT-C2) of the *Independence* variant LCS and the Increment 1 MCM mission package aboard LCS 2 while the ship was moored in Pensacola, Florida. The operational testing was conducted in accordance with the test plan approved by DOT&E. COTF plans to complete the final phase of LCS 2 and MCM mission package operational cybersecurity testing and all other OT-C2 events during FY16.
  - In August 2015, the Navy conducted the first shipboard live firing of the ship's SeaRAM system against a subsonic aerial drone. The Navy had attempted to conduct the test event in June, but had to postpone the event due to seaframe equipment failures. The Navy had originally planned to conduct non-firing tracking runs against aerial drones, but these events were canceled because of the range safety restrictions for a manned ship that preclude conducting such test events with realistic geometries. The live fire demonstration was not designed to be an operationally realistic test of the ship's capability. The aerial drone flight profile and configuration were not threat representative.
  - In August and September 2015, the Navy conducted the first phase of operational testing of the *Independence* variant seaframe and Increment 2 SUW mission package (Operational Test C4) aboard LCS 4. Operational testing

was conducted in accordance with a DOT&E-approved test plan. That testing consisted of an examination of the seaframe's electronic warfare capability; several surface self-defense events against small boats (without the mission package); seaframe evaluations of endurance, sprint speed, and small boat launch and recovery for Visit, Board, Search, and Seizure missions of state. The testing also examined the ship's ability, when equipped with an Increment 2 SUW mission package, to combat a small swarm of FIAC.

- Because of changes to the ship's air defense system, SeaRAM, and additional modifications to the ship's combat system and networks, a second phase of operational testing of the Increment 2 version of the SUW mission package and *Independence* variant seaframe will occur in 3QFY16, which will examine the air warfare capabilities of the seaframe, cybersecurity upgrades, and the remaining SUW events.
- USS *Jackson* (LCS 6) completed acceptance trials in June 2015; the Navy accepted delivery in August 2015 and placed the ship in commission in December 2015.

SUW Mission Package

- During 3Q and 4QFY15, the Navy conducted developmental testing of the Increment 2 SUW mission package aboard LCS 4.
- In August and September 2015, the Navy conducted operational testing of the Increment 2 SUW mission package aboard LCS 4. This phase of the operational test examined the *Independence* variant's self-defense capability against small swarms of high-speed boats and its effectiveness for Maritime Security Operations requiring the crew to intercept and board a vessel suspected of transporting contraband when equipped with the Increment 2 SUW mission package. The testing was conducted in accordance with a DOT&E-approved test plan.
- COTF conducted a shore-based Quick Reaction Assessment of an MQ-8B Fire Scout VTUAV equipped with the AN/ZPY-4(1) radar in May and June 2015. The Navy's original plans for the Increment 2 MCM mission package called for the MC-8B VTUAV, but those plans are now in doubt. The Navy plans to embark the larger MQ-8C VTUAV with the SUW mission package starting with Increment 3, but initial plans do not call for the aircraft to be equipped with radar. COTF conducted a land-based operational assessment of the MQ-8C in November 2015, the results of which are not yet available.

MCM Mission Package

- During 1QFY15, the Navy completed the last scheduled phase of the Increment 1 MCM mission package developmental test DT-B2 aboard LCS 2.
- Having completed the land-based phase of an operational assessment of the AMNS in 3QFY14 with the MH-60S helicopter operating from Naval Air Station, Oceana, Virginia, the Navy conducted the ship-based phase of the operational assessment aboard LCS 2 in 1QFY15 during Increment 1 MCM mission package developmental testing. The ship-based phase focused on shipboard integration and the system's operational suitability, but was also able to collect limited effectiveness data.
- The Navy also completed the ship-based phase of an Airborne Laser Mine Detection Systems (ALMDS) operational assessment in 1QFY15 aboard LCS 2 during Increment 1 MCM mission package developmental testing. The test collected limited data to examine system effectiveness and the shipboard suitability of the MH-60S helicopter equipped with the ALMDS.
- The Navy canceled a scheduled operational assessment of Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I after a NASA Antares rocket exploded just after lift-off from the Wallops Island, Virginia, launch pad on October 28, 2014. Although all test preparations had been completed, both MQ-8B Fire Scout VTUAVs that were to host the COBRA system during the test suffered shrapnel damage from the rocket explosion. In December 2014, DOT&E returned the Navy's revised COBRA Block I TEMP for rework, noting that the schedule, test strategies, funding profile, and planned resources no longer reflected the state of the program following cancelation of the operational assessment.
- The Navy conducted shore-based developmental testing (DT-B1) of the RMS, consisting of the v6.0 RMMV and AN/AQS-20A/B from the contractor's facility at West Palm Beach, Florida. The Navy commenced testing in December 2014 with an upgraded version of the sensor, designated AN/AQS-20B, but in January 2015, the Navy determined the new sensor was not yet sufficiently mature and elected to complete testing with the AN/AQS-20A sonar. The Navy subsequently suspended testing in January 2015 to investigate RMMV reliability problems and complete corrective maintenance. The Navy resumed and completed testing in March 2015.
- From April through August 2015, the Navy conducted TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package aboard LCS 2. Although the Navy originally planned to conduct the test from April through June 2015, problems with failures of seaframe and MCM systems caused the testing to be extended. The Navy chose to extend the testing further, conducting another evolution of the MCM scenario, in order to provide confidence in the capabilities of the ship and mission package prior to entering the operational test period. Although this testing was developmental in nature, the test was designed to integrate the objectives of both developmental and operational test communities. DOT&E personnel observed the testing aboard LCS 2. If the Navy elects to continue with the same system hardware and software configurations, DOT&E and COTF will use the resulting data to supplement data collected during the operational test. If the Navy decides to go forward to operational testing with a new system, integrated test data collected in FY15 may not be representative of the system the Navy intends to field, and the Navy might need to repeat

some portions of previous tests to provide the requisite data. Although the Navy planned to complete operational testing of the Increment 1 MCM mission package in FY15, only the cybersecurity CVPA was completed. The Navy has delayed the remaining OT-C2 events, and they are unlikely to be conducted before the spring of 2016, at the earliest.

- In an August 2015 memorandum, DOT&E advised the USD(AT&L) that the reliability of the RMS and its RMMV poses a significant risk to the planned operational test of the *Independence* variant LCS and the Increment 1 MCM mission package and to the Navy's plan to field and sustain a viable LCS-based minehunting and mine clearance capability prior to FY20. DOT&E recommended that the acquisition strategy for these systems be reexamined to ensure that sufficient testing is performed to inform the procurement of additional vehicles and cautioned that continued development of this program without a fundamental change would be unlikely to result in a system that is effective and suitable.
- In September 2015, the Navy chartered an independent program review of the RMS, including an evaluation of potential alternative MCM systems. Their report is due in late 1QFY16. Additionally, USD(AT&L) delayed its review to consider approval to restart RMS low-rate initial production until at least 3QFY16.
- In November 2015, DOT&E provided the USD(AT&L), the Assistant Secretary of the Navy for Research Development and Acquisition, and the Program Executive Officer for Littoral Combat Ships a classified assessment of the performance of the *Independence* variant seaframe and Increment 1 MCM mission package. DOT&E based the assessment on the data collected during the TECHEVAL and earlier periods of development and operational testing.
- Also in November 2015, DOT&E provided comments to the Joint Staff on the Navy's draft Capability Production Document for the "Phase 1" (formerly Increment 1) MCM mission package.

ASW Mission Package

- The Navy did not conduct any at-sea testing of the ASW mission package in FY15 due to limited ship availability and changes to the system's design. The Navy continued its efforts on a weight reduction program for the components of the mission package, including the handling system and support structures for the variable depth sonar and multi-function towed array.

Assessment

This assessment is based on information from post-delivery test and trial events, fleet operations, developmental testing, results provided by the Navy Program Offices, operational assessments of MCM mission systems, operational testing of the *Independence* variant seaframe with the Increment 2 SUW mission package, and operational cybersecurity testing conducted in LCS 2. A summary of DOT&E's December 2015 report on the *Freedom* variant equipped with the Increment 2 SUW mission package is also provided below.

Program

- The Navy intends to field LCS capabilities incrementally as mission package systems mature and become ready for fleet use. Since the Navy expects each increment to deliver significant increases in mission capability, the approved TEMP calls for an appropriately-designed phase of OT&E on all delivered mission package increments on each seaframe variant. However, because the content of the later increments is not yet final, the details of the testing to be accomplished for later increments of mission package capability are yet to be planned.
  - Initial phases of operational testing were completed in FY14 for the *Freedom* variant seaframe and Increment 2 SUW mission package and partially completed in FY15 for the *Independence* variant seaframe and Increment 2 SUW mission package embarked on that variant. The final phases of operational testing will not be completed until the full mission package capability is available. The Navy expects to complete those final phases of operational testing in the FY18 timeframe, depending on the decision whether to pursue an Increment 4 of the SUW mission package. It is unknown when either the MCM mission package or ASW mission package operational test programs will be complete.
  - The Navy is finding it difficult to follow the plan in the approved TEMP. The integration of concurrently developed components into the MCM mission package has not been as easy as originally planned, and the Navy has appropriately decided to conduct additional developmental testing after making system changes in an attempt to correct the identified problems with subsystem performance. Decisions to include the ships in major fleet exercises and to press for establishment of a continuous, multi-LCS presence overseas in FY17 are also reducing the number of ships available to participate in the test program. The Navy is challenged to meet the simultaneous demands for LCS fleet operations, both forward deployed and in home waters, as well as mission package development and the necessary developmental and operational testing.
- Additionally, the Navy directed changes to the seaframe designs based on the results of early developmental testing and operations. The Navy has indicated that the seaframe designs will be stabilized in the third ship of each variant (LCS 5 and LCS 6).

Seaframes

- In the report to Congress responding to the FY15 NDAA, DOT&E noted that the envisioned missions, use of unmanned vehicles, and operating environments have shifted relative to the original LCS vision. DOT&E concluded that the use of LCS as a forward-deployed combatant, where it might be involved in intense naval conflict as now intended, appears to be inconsistent with its inherent survivability in those same environments. The ability of LCS to successfully execute significant aspects of the envisioned CONOPS depends on the effectiveness

of the mission packages. To date, the Navy has not yet demonstrated effective capability for either the MCM or the ASW mission package. The Increment 2 SUW mission package has demonstrated some modest ability to aid the ship in defending itself against small swarms of FIAC, and the ability to conduct maritime security operations.

- While both seaframe variants are fast and highly maneuverable, they are lightly armed and were not designed to provide any significant offensive capability without the planned Increment 4 SUW mission package or the Increment 2 ASW mission package. In comparison to other Navy ships, the LCS seaframes have relatively modest air defense capabilities that cannot be characterized fully until planned tests on LCS 7 and LCS 8 and the Navy's unmanned self-defense test ship provide data for the Navy P_{RA} high-fidelity modeling and simulation analyses. The Navy plans to begin those tests in FY17. In FY15, DOT&E learned that PEO IWS stopped work on the P_{RA} Test Bed for the *Freedom* variant because the high-fidelity model of the ship's AN/SPS-75 radar was not being developed. Development of an acceptable radar model requires intellectual property rights that the Navy does not hold and is not actively seeking. Although less critical because of the combat system architecture of the *Independence* variant, the Navy has also been unable to develop a high-fidelity model of that ship's AN/SPS-77 radar for the same reason. In an August 2015 memorandum, DOT&E advised Navy officials that the lack of these radar models threatens the viability of the Navy's strategy for evaluation of LCS air defense capabilities and suggested alternative strategies specific to each seaframe variant. The alternative test strategies suggest additional live testing that might be acceptable. Near-term resolution will be required to avoid delaying P_{RA} Test Bed analyses needed to finalize DOT&E's evaluation of LCS air defense effectiveness. The Navy has not decided what course of action they want to pursue.
- Neither LCS variant has been operationally tested to evaluate its effectiveness against unmanned aerial vehicles and slow-flying aircraft. Although the Navy had planned to test the *Independence* variant's capability to defeat such threats in FY15, the testing was canceled because of range safety requirements that would have precluded operationally realistic testing. DOT&E concurred with this decision because proceeding with an unrealistic test would have been a needless waste of resources.
- The seaframes include no systems designed to counter torpedo attacks or detect and avoid mines without the appropriately configured mission packages installed.
- Crew size limits the mission capabilities, combat endurance, maintenance capacity, and recoverability of the ships. The Navy continues to review LCS manning to determine appropriate levels and has added 20 berths to all seaframes. The increased berthing supports small increases in the size of the core crew, mission package and aviation detachments, but still leaves the ships heavily dependent on Navy shore organizations for administrative and maintenance support.
- *Freedom* Variant Seaframe (LCS 1 and 3):
  - Although not all aspects of operational effectiveness and suitability could be examined during the 2014 operational test, that testing identified shortcomings in cybersecurity, air defense, surface self-defense, reliability, maintainability, speed and endurance, air operations, and other operations.
  - **Cybersecurity.** Cybersecurity testing conducted aboard LCS 3 uncovered significant deficiencies in the ship's capability to protect the security of information and prevent malicious intrusion. Many of these deficiencies were previously discovered during the 2012 Quick Reaction Assessment that COTF conducted in USS *Freedom* (LCS 1). Although the Navy is developing plans to modify the network architecture in the *Freedom* variant ships to enhance cybersecurity, the severity of the cybersecurity problems will degrade the operational effectiveness of *Freedom* variant seaframes until the problems are corrected.
  - **Air Defense.** Aircraft tracking events conducted during operational testing aboard LCS 3 demonstrated that the crew was unable to detect and track some types of air threats well enough to engage them. The inability to engage these air threats leaves the ship without an effective air defense in some situations. As expected, tracking performance improved significantly when the LCS received tracking information via datalink from a nearby Aegis destroyer. Since the radar had demonstrated significantly better tracking performance during the Navy's TECHEVAL, when subject matter experts were embarked to advise and train the crew, it is possible that the crew's lack of proficiency in the use of the radar's controls during the initial test contributed to the poor performance.
  - The lack of integration between the WBR-2000 Electronic Support Measures (ESM) system and the RAM system limits the ship's capability to make best use of its limited RAM inventory. The inability to provide electronic signal measurements to RAM can reduce the likelihood that some of the missiles fired will acquire and home on the target, thus reducing the probability that the ship will be able to defeat an incoming raid of ASCMs.
  - **Surface Self Defense.** LCS 3 demonstrated the seaframe's core capability for self-defense against a small boat during two trials conducted under favorable conditions, but the operational test did not include enough trials to determine whether a *Freedom* variant LCS can defeat such a threat with regularity. Testing was not conducted in a realistic cluttered environment where identification of threats will be more challenging. Although the Navy attempted to collect additional data on the core seaframe's performance from swarm presentations, DOT&E determined that the data were

invalid. The 57 mm gun failed to achieve a mission kill during one swarm presentation, and the target killed by the 57 mm gun during a second swarm presentation had previously been engaged by the SUW mission package's 30 mm guns. The 57 mm gun itself performed reliably during the operational test, but the DORNA EOD system used to target the gun experienced numerous laser faults that interrupted some engagements and reduced the ship's effectiveness against attacking small boats. An inopportune fault could allow an attacker to close within his weapon range. The LCS 3 crew did not attempt to use the ship's AN/SPS-75 ASR for gun targeting during the operational test.

- **Missions of State.** Operational testing confirmed earlier observations that, except for the ships' lack of fuel endurance, the *Freedom* variant is suited for Maritime Security Operations. LCS 3 readily demonstrated the capability to position, launch, and recover the 11-meter boats included in the SUW mission package when the launch, recovery, and handling system is operational.
- **Speed and Endurance.** During operational testing, LCS 3 did not demonstrate that it could achieve the Navy requirement for fuel endurance (operating range) at the prescribed transit speed or at sprint speed. Based on fuel consumption data collected during the test, the ship's operating range at 14.4 knots (the ship's average speed during the trial) is estimated to be approximately 1,960 nautical miles (Navy requirement: 3,500 nautical miles at 14 knots) and the operating range at 43.6 knots is approximately 855 nautical miles (Navy requirement: 1,000 nautical miles at 40 knots). In an emergency, the ship could use its aviation fuel (F-44) to extend the transit and sprint ranges by 360 and 157 nautical miles, respectively. The shortfall in endurance may limit the flexibility of the ship's operations in the Pacific and place a heavier than anticipated demand on fleet logistics. The Navy's report from calm water trials suggests that the ship can achieve an endurance range of 3,500 nautical miles at an average (but not constant) speed of 14 knots by using a more economical propulsion configuration (two propulsion diesel engines and two steerable water jets). The ship cannot attain a speed of 14 knots in this configuration when fully loaded with fuel.
- **Aircraft Operations.** The *Freedom* variant LCS has sufficient aviation facilities and meets Navy requirements to safely launch, recover, and handle the MH-60R helicopter while operating in up to Sea State 4 conditions. However, the ship frequently had trouble establishing and maintaining a Tactical Common Data Link (TCDL) with the aircraft during the FY14 operational test. The crew's efforts were hampered by an antenna failure and the lack of technical documentation on the operation and maintenance of the datalink. The TCDL is the primary conduit for sharing tactical information, including voice reports, radar tracks, and radar and electro-optical and infrared (EO/IR) sensor video between the MH-60R helicopter and the LCS.
- **Other Operations.** COTF exercised LCS 3 and her crew in a variety of other shipboard evolutions during an operational test, including anti-terrorism/force protection, damage control, mooring and unmooring, navigation, refueling at sea, vertical replenishment, man-overboard recovery, and communications. These evolutions yielded no quantitative data; COTF evaluated the ship's performance qualitatively. Except as noted below, DOT&E observers reported that the ship's performance during the observed evolutions was consistent with the Navy's expectations for any surface combatant.
  - The anchoring system could not securely anchor the ship in an area with a bottom composed of sand and shells. On several occasions, the ship was unable to set the anchor despite repeated efforts. It appears that the anchor and chain are too light and there is too much friction along the anchor chain's internal path from the chain locker to the hawse pipe to allow the anchor and chain to pay out smoothly. Inability to anchor the ship securely could force the ship to remain at sea when anchoring would be preferred and could hazard the ship if it loses power in coastal waters or encounters other circumstances where anchoring is required.
  - The fenders designed to guide the 11-meter Rigid Hull Inflatable Boats included in the SUW mission package during launch and recovery are fragile and occasionally sheared off when impacted by the boats during operational testing. Although the fenders had undergone several redesigns, they were not yet strong enough to sustain such impacts. Loss of one or more of the fenders could delay or preclude boat launch and recovery needed to support Visit, Board, Search, and Seizure operations.
- **Operational Suitability.** The *Freedom* variant LCS seaframe is not operationally suitable because many of its critical systems supporting ship operations, core mission functions, and mission package operations are unreliable; and the ship's crew does not have adequate training, tools, and technical documentation to diagnose failures or correct them when they occur. By design, the ship's small crew does not have the capacity to effect major repairs. Instead, the Navy's support concept depends on the use of remote assistance in troubleshooting problems and the use of Navy repair organizations and contractors for repair assistance. However, the Navy's limited stock of repair parts for LCS systems, many of which were sourced from offshore vendors, can result in long logistics delays and occasionally forces the Navy to resort to cannibalization of another ship in order to expedite repairs.
  - The FY14 operational test did not yield sufficient evidence to report whether the mission critical components were individually meeting the Navy's reliability thresholds; the combined data for all of

the components revealed the aggregate reliability of Propulsion and Maneuvering and Navigation and Ship Control functional areas were extremely low.
  - The aggregate reliability of the components that comprise the core mission area (e.g., total ship computing environment, air search radar, electro-optical tracking system, and electronic support measures) was also poor. Based on the operational test results, the probability of successfully completing a 30-day mission without a critical failure of a core mission subsystem that reduces the ship's full mission capability is less than 5 percent.
  - The aggregate reliability of the mission package support functional area (mission package support systems, mission package computing environment, waterborne mission equipment, and airborne mission equipment) was somewhat better than that of other functional areas but, at 0.38, still well below the Navy's reliability threshold (0.9).
  - Low reliability, maintenance challenges, and logistics delays reduced LCS 3's operational availability for Mobility (Propulsion and Maneuvering), Total Ship Computing Environment (TSCE), Seaframe Sensors and Controls, Communications, and Mission Package Support to below the Navy's threshold requirement (0.85). Failures of the Propulsion and Maneuvering subsystems and the TSCE, which are fundamental to ship operations, caused the ship to return to port for repairs or reduced readiness while at sea for 42 and 36 days, respectively. The demonstrated availability of six other mission-critical subsystems was above the Navy's threshold: Engineering Controls, Navigation and Ship Control, Electrical Power Generation and Distribution, Auxiliary Systems, Damage Control, and Seaframe Engagement Weapons. The LCS 3 seaframe was partially or fully mission capable just over 60 percent of the time in Air Warfare and nearly 85 percent of the time in Surface Warfare, but partial mission capability can result in a significant reduction in operational effectiveness.
- *Independence* Variant Seaframe (LCS 2 and 4):
  - DOT&E is still analyzing data on the performance of the *Independence* variant seaframe. During the period under review, LCS 2 underwent developmental testing and TECHEVAL with the Increment 1 MCM mission package embarked, as well as the first phase of operational cybersecurity testing (CVPA). Additionally, LCS 4, with the Increment 2 SUW mission package embarked, underwent developmental testing, TECHEVAL, and the first phase of planned operational testing. Observer reports and preliminary data analyses provide sufficient evidence of numerous *Independence* variant seaframe deficiencies that significantly degrade the ships' operational effectiveness and suitability. Many of these deficiencies are detailed below.
  - **Air Defense.** The *Independence* variant ships are the first to use the SeaRAM air defense system. Although SeaRAM has never been operationally tested, it shares many components with the Phalanx Close-In Weapon System, which is widely installed in the fleet as a secondary or tertiary close-in self-defense system. The Navy completed the first at-sea demonstration of the SeaRAM system in LCS 4 in 2015 during an engagement against a non-maneuvering, subsonic aerial target (BQM-74) with radio frequency and infrared augmentation that were not consistent with the characteristics of realistic threats. Because SeaRAM is a self-contained system that integrates the Phalanx radar, track processing, and ESM receiver it should provide an air defense capability on par with other RAM-equipped ships in the fleet as long as the AN/SPS-77 ASR radar can detect the incoming threat(s) and the crew can maneuver the ship to place the threat(s) in SeaRAM's engagement zone. However, as with the *Freedom* variant, the ship's air defense effectiveness will remain unproven until live operational testing is conducted on a manned ship, on the unmanned self-defense test ship, and using an appropriately designed P_{RA} Test Bed. That testing is scheduled to begin in 3QFY16 aboard the self-defense test ship and 1QFY17 aboard LCS 8. The Navy plans to complete testing utilizing the P_{RA} Test Bed in FY18, but those plans are in doubt due to issue with the radar modeling explained earlier in this report.
  - Upon learning that the Navy planned to upgrade the SeaRAM system installed in LCS 4 to bring it to the same configuration as the system being installed in Aegis destroyers, and that those upgrades and other combat system upgrades were to be installed in 1QFY16 and 3QFY16, DOT&E recommended that some of the *Independence* variant air warfare operational testing planned to complete in FY15 be delayed so it could be conducted with the ship in its deployment configuration. The Navy accepted the recommendation and now plans to conduct the air warfare tracking events in late FY16. The Navy plans to complete live SeaRAM testing on LCS 8 in FY17.
  - The Program Office conducted several developmental test events to evaluate the ship's capability to detect, track, and engage so-called Low Slow Flyers (LSF) (unmanned aerial vehicles, slow-flying fixed-wing aircraft, and helicopters) in mid-2015. The only sensor used to provide tracking information for engaging LSFs with the 57 mm gun is the SAFIRE EO/IR system. The test events demonstrated that SAFIRE was unable to provide reliable tracking information against some targets. Furthermore, the safety standoff requirements on Navy test ranges were so severe as to preclude meaningful live fire shooting engagements. Because of these constraints, the program decided to cancel all subsequent live fire events, conceding that

the *Independence* variant is unlikely to be successful consistently when engaging some LSFs until future upgrades of SAFIRE can be implemented. Live firing events planned during operational testing were also canceled, as the results from developmental testing were sufficient to conclude that the *Independence* variant will not likely be effective in these scenarios against some LSFs. Future testing against LSFs will not be possible until the Navy finds a solution to the severe safety constraints that preclude engaging realistic targets.

- **ESM Testing.** While most air warfare testing was delayed to FY16, COTF completed testing of the *Independence* variant's ES-3601 ESM system during the FY15 operational test. COTF used Lear aircraft equipped with ASCM seeker simulators to represent the ASCM threats. Although DOT&E analysis of the test data is not complete, DOT&E observed that the ES-3601 detected the presence of the ASCM seekers in most instances but did not reliably identify certain threats.
- **Surface Self-Defense.** The *Independence* variant seaframe's surface self-defense effectiveness was tested during developmental, integrated, and operational test firing events in 2015. These events tested the crew's capability to defeat a single small boat using the seaframe's 57 mm gun. DOT&E considered three of the developmental test events as sufficient to provide data for the operational effectiveness determination, in addition to the two dedicated operational test events for surface self-defense. Prior to these five events, the Navy also conducted three additional developmental test events, which revealed gun faults and fuzing errors. The program corrected these problems before proceeding to the integrated and operational test events. LCS 4 successfully defeated the attacking boat with the seaframe's MK 110 57 mm gun system during four of the five presentations considered either integrated or operational test events. The firing presentations were judged successful if a "mission kill" or "mobility kill" was achieved before the attacker could approach within the effective range of its weapon(s) – the prescribed "keep-out" range. Since, in the test environment, the attacker was the only boat in the area, it was easily classified as a threat well beyond the effective range of the ship's weapons. The Navy has not conducted any testing to determine how well the ship will perform when faced with an attack in a realistic cluttered maritime environment including both neutral and hostile craft; the Navy has also not conducted operational testing to determine how well the ship (without the SUW mission package) will perform against multiple attacking boats.
  - Two of the surface self-defense failures were caused by MK 110 57 mm gun malfunctions. During the first presentation, the gun operator's panel displayed multiple fault indications, and the operator was unable to change the fuze setting from proximity mode to the recommended point detonation (impact) mode. Technicians subsequently determined that a gun component had failed, and the gun was repaired on July 7, 2015. The second presentation on July 18 resulted in failure when the 57 mm gun loading mechanism jammed while the operator was attempting to reload the gun. With the assistance of a civilian gun system technician, the crew downloaded the remaining ammunition, cleared the jam, and restored the gun to "single-sided" operation in about 4 hours by consolidating good components. Until repaired on August 7, 2015, the gun was limited to firing 60 rounds before reloading. Technical issues with SAFIRE performance, including inability to track small surface craft automatically once acquired (auto-track), low targeting update rate, poor bearing accuracy, and unwieldy operator interface as well as persistent problems with gun system accuracy resulted in excessive ammunition consumption to achieve these modest results. The testing revealed that although successful in most of these events, had the ship been required to engage multiple small boats, the crew would be forced to reload the gun, which could interrupt engagements. Thus, the *Independence* variant seaframe will be challenged to defeat threat-representative boat swarms in an operational environment and could exhaust its supply of 57 mm ammunition if faced with multiple engagements.
  - LCS 4 found it necessary to supplement the watch team with an additional watchstander just to operate SAFIRE, leaving management of the gun to a second operator, even though the staffing plan calls for one operator to handle both functions. The small LCS crew does not include enough trained operators to maintain this watch arrangement for any appreciable length of time.
  - Gun accuracy problems have been observed in both LCS 2 and LCS 4, with the 57 mm gun consistently firing short of the target when shooting to port and beyond the target when shooting to starboard. The Navy has not yet identified the root cause of the problem but has reduced the error such that the operator can compensate using normal procedures.
  - On one occasion, the shock caused by firing the 57 mm gun unseated a network card, disabling the steering controls on the bridge and forcing the crew to steer the ship from an alternate location. On another occasion, gunfire shook network cables loose, disabling several combat systems, including the AN/SPS-77 ASR and the 57 mm gun. While the ship was able to recover from this failure within a few minutes and continue the engagement, these interruptions prolonged the ship's exposure to the advancing threat and reduced the crew's situational awareness during the repair. Failures of this nature demonstrate the need for full ship shock trials, which are currently planned to be conducted on LCS 6.

- **Missions of State.** LCS 4 completed six mock Missions of State during OT-C4 requiring the launch and recovery of two 11-meter Rigid Hull Inflatable Boats. LCS 4 met the 60-minute launch requirement, but on average was not able to meet the 60-minute recovery requirement. Faults in the Twin-Boom Extensible Crane (TBEC) and problems with the Surface Tow Cradle were responsible for the time delays during recovery operations. The cumbersome multi-step boat launch/recovery process has several 'single points of failure' that increase the likelihood of delays and the possibility of mission failure, including the Surface Tow Cradle, TBEC, the Mobicon straddle carrier, and a forklift. The failure of any of these components can halt boat operations and could leave a boat stranded at sea.
- **Endurance at transit speed.** LCS 4 demonstrated that the *Independence* variant seaframe's fuel endurance at a transit speed of 14 knots exceeds the Navy requirement. Assuming that all of the ship's "burnable" F-76 fuel could actually be consumed, LCS 4 demonstrated a fuel endurance of 5,345 nautical miles at 14 knots based on an hourly consumption rate of 421 gallons during a 6-hour trial. In reality, no ship would ever plan to consume all of its fuel during a transit because of the need to maintain a reserve for contingencies. If a 20 percent of fuel buffer were maintained, the ship's endurance would be 4,242 nautical miles.
- **Sprint speed and endurance.** COTF reported that LCS 4 demonstrated an average sprint speed of 37.9 knots during a 3-hour trial on September 10 (Navy requirement: 40 knots). Based on the fuel consumption rate and the amount of practically available fuel, an *Independence* variant ship would be able to travel nearly 1,000 nautical miles in 25 hours at this speed (Navy requirement: 1,250 nautical miles at 40 knots). COTF noted that the ship was unable to maintain the correct trim during the trial because the interceptors (components of the ride control system designed to assist with trim control) were inoperative and that the crew had to change five fuel oil pre-filters during the trial to keep the gas turbine engines on line. LCS 4 has long-standing problems with her ride control system hardware, including interceptors, fins, and T-Max rudders, that affect her maneuverability. The ship also had reported recurring problems with frequent clogging of the gas turbine engine fuel oil conditioning module pre-filters and coalescers, and found it difficult to maintain high speed for prolonged periods. The three-hour trial conducted on September 10 was reportedly the longest period of sustained high-speed operations in the ship's history.
- **Aircraft Operations.** Observers reported difficulties with the establishment and maintenance of the Tactical Common Data Link (TCDL), an encrypted point-to-point datalink. When available, the TCDL allows transmission of video, data, and voice communications between the aircraft and the LCS. However, like LCS 3, LCS 4 lacked adequate documentation on the operation and maintenance of TCDL equipment. Flight operations were disrupted by two failures of the ship's only JP-5 (F-44) fuel pump that precluded refueling any embarked aircraft for long periods. In addition to problems with TCDL, systems that support flight operations, such as the Advanced Stabilized Glide Slope Indicator, tactical air navigation system, and the wind-speed measurement system were frequently degraded or inoperative. These failures had little impact during the operational test because weather conditions were generally favorable, but in more challenging conditions, their failure could severely limit flight operations.
- **Other Operations.** COTF also exercised LCS 4 and her crew in a variety of other shipboard evolutions during OT-C4, including anti-terrorism/force protection, damage control, mooring and unmooring, refueling at sea, vertical replenishment, man-overboard recovery, communications, and receiving a tow. DOT&E observers reported that the ships performed as expected during the observed evolutions.
- **Cybersecurity.** In the only phase of operational testing completed to date in LCS 2, COTF conducted a CVPA of the seaframe and embarked Increment 1 MCM mission package in June and July 2015 while the ship was moored in Pensacola, Florida, during a comprehensive maintenance availability. COTF's cybersecurity team assessed all shipboard and mission package systems that were in scope except the MH-60S helicopter, SeaRAM, and software-defined radios. The CVPA details are classified but indicate that, like the *Freedom* variant seaframe, the *Independence* variant seaframe has cybersecurity deficiencies that significantly degrade the ship's operational effectiveness. Plans for the last phase of the cybersecurity operational testing, an Adversarial Assessment, are on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant seaframe for MCM operational testing. As noted earlier, all OT-C4 cybersecurity testing in LCS 4 has been delayed until the Navy completes upgrades to the ship's networks designed to enhance its cybersecurity and correct known issues.
- **Limitations on Watercraft Launch and Recovery.** Because of structural defects in LCS 2 and LCS 4 identified during rough water trials aboard LCS 2, the Navy has established a limit on the maximum allowable dynamic loading of the Twin-Boom Extensible Crane (TBEC) used to launch and recover the RMMV and other watercraft. Sea conditions that would have caused the limit to be exceeded precluded RMS operations on several occasions during the MCM mission package TECHEVAL aboard LCS 2. Additionally, the design of the *Independence* variant seaframe and the ship's watercraft launch, handling, and recovery system used with the TBEC, coupled with the turbulent wake

produced by the water jets, make launch and recovery of the RMMV and other watercraft complex and somewhat risky evolutions, requiring the ship's crew to exercise great care.

- **Operational Suitability.** COTF collected reliability, maintainability, availability, and logistics supportability data to support evaluation of the operational suitability of the *Independence* variant seaframe throughout the last half of FY15 and plans to continue that effort when MCM OT-C2 begins on LCS 2 and when OT-C4 resumes on LCS 4. Although incomplete, the data collected to date show that essential *Independence* variant seaframe systems have significant reliability problems. During developmental testing, the LCS 4 crew had difficulty in keeping the ship operational as it suffered repeated failures of the ship's diesel generators, water jets, and air conditioning units. Some of the failures proved to be problems with communications between the systems and the Engineering Control System, which forced the crew to place key systems into 'local' mode to resume operation. As a temporary expedient, this was generally effective, but because the reduced size of the crew was predicated on extensive use of automation, the added labor involved in monitoring and controlling these systems individually stretches the limits of the crew's ability to operate and maintain the ship's systems. In addition, because of the planned reliance on shore-based contractor support, in many cases the LCS crew lacks the documentation, training, test equipment, and tools required to troubleshoot and repair serious problems as they emerge. Lack of documentation and training contributed to recurring issues with the TSCE, integrated combat management system (ICMS) software, and communications systems.
- **LCS 2 Reliability and Availability.** LCS 2 equipment failures left the ship with limited mission capability throughout the 176-day data collection period and with no mission capability on two occasions. Many of the failures disrupted MCM operations, and caused the ship to return to, or remain in, port for repairs. The ship had to call for shore-based assistance to repair nearly all significant failures. The following are the most significant seaframe equipment problems observed during the data collection period.
  - LCS 2 had no Secret Internet Protocol Router Network (SIPRNET) connectivity for a period of four days at the beginning of the period because of a hard drive failure that had occurred the previous month. Lack of SIPRNET connectivity impedes the flow of classified information between the ship and the operational commander.
  - Failure of the navigation attitude server deprived critical combat systems of roll and pitch information for six days during the period and limited the capability of ICMS, SeaRAM, and the AN/SPS-77 ASR.
  - SeaRAM experienced four failures, leaving the ship with no air defense capability for a total of 120 days (68 percent of the period).
  - The MK 110 57 mm gun was inoperative for 114 days because of damage caused when gun components overheated, rendering the ship incapable of any defense against an LSF threat and leaving only crew-served machine guns for defense against surface threats.
  - SAFIRE was inoperative for a period of 25 days until the turret could be replaced, but this outage occurred while the 57 mm gun was inoperative, a period when the ship already had little capability to defend against a surface or LSF threat.
  - The AN/SPS-77 ASR had multiple outages of short duration (3 to 30 minutes) that required the crew to reboot an interface device and was restricted to limited use because of a failing antenna turntable gearbox for a period of 3 weeks until it could be repaired by a SAAB technician.
  - Failure of a power conversion unit that supplied 400 Hertz power to the mission bay deprived the ship of MCM mission capability for 20 days while the ship was in port undergoing repairs. The Naval Sea Systems Command was forced to locate a functional replacement because the failed unit was obsolete and could no longer be supported with repair parts.
  - The ship also lost the capability to supply 400 Hertz power to the aircraft hangar, where it is needed to conduct pre-mission checks on the MH-60S and AMCM systems. The ship was provided portable power units to fill the gap until the ship's power converter could be repaired. The Navy never determined the cause of the near-simultaneous failures of the two power conversion units, although technicians considered them related.
  - LCS 2 experienced multiple air conditioning equipment failures and was unable to supply enough cooling to support the ship's electronics on several occasions. One or more of the ship's 3 chilled water units was either inoperative or operating at reduced capacity for 159 days (90 percent of the period).
  - A Mobicon straddle carrier failure left the ship unable to conduct waterborne MCM operations for a period of four days until a technician could travel from Australia to diagnose the problem and make needed adjustments. This episode demonstrated the crew's paucity of documentation, training, and diagnostic equipment.
  - The boat davit failed while launching the lifeboat (7-meter RHIB) and forced the ship to accompany the boat into port. The ship remained in port with no usable mission capability for five days because the lifeboat is safety equipment and essential for operations at sea.

  - The ship experienced several Ship Service Diesel Generator failures during the period, but was never without at least two of four generators operable (sufficient to power all combat loads, but limited maximum propulsion speed).
  - LCS 2 was unable to launch and recover RMMVs on 15 days because of 4 separate propulsion equipment failures involving diesel engines, water jets, and associated hydraulic systems and piping. These failures would also have limited the ship's capability to use speed and maneuver to defend itself against small boat threats.
  - LCS 2 was unable to launch and recover RMMVs on 10 additional days because of 3 TBEC failures.
- LCS 4 Reliability and Availability. LCS 4 exhibited equipment failures that limited its operational availability and left the ship with limited mission capability at various points throughout the data collection period (113 days). The ship was fully mission capable less than 40 percent of that time. The following are the most significant seaframe equipment problems observed during the data collection period.
  - LCS 4 spent 45 days during this period without all 4 engines and steerable water jets operational. This includes a 19-day period in May when 3 of the 4 engines were degraded or non-functional. Since LCS relies on speed to augment its combat effectiveness and survivability, the loss of any engine (especially a gas turbine) can degrade the ship's effectiveness.
  - LCS 4 experienced multiple air conditioning equipment failures and was unable to supply enough cooling to support the ship's electronics for a two week period in May. One or more of the ship's 3 chilled water units was either inoperative or operating at reduced capacity for 56 days.
  - JP-5 fuel pump failures left the ship with no capability to refuel the embarked helicopter for 11 days.
  - A TBEC failure left the ship unable to recover an 11-meter RHIB until the day after it was launched. Once the RHIB was recovered, the TBEC remained in a degraded state for 23 days.
  - The 57 mm gun was either inoperative or operating in a degraded condition for 35 days.
  - SeaRAM, the ship's primary defense against ASCMs, was inoperative or degraded for 15 days.
  - The ship's ride control system, used for high-speed maneuvering, did not appear to be fully functional at any time during developmental or operational testing in FY15.
  - Similar to problems seen on LCS 2, the AN/SPS-77 ASR had multiple outages of short duration (3 to 30 minutes) that required the crew to reboot an interface or the radar itself.
  - Numerous interruptions in the flow of navigation data were noted during live fire events in September, seriously degrading the ship's combat effectiveness. Both combat and navigation systems require frequent updates about the ship's heading, roll, and pitch to operate correctly. Without this information, the ASR, SeaRAM, and ESM system cannot correctly determine the relative orientation of targets to the ship, and more critically, the 57 mm gun cannot fire. Even a momentary interruption of navigation data to these systems forces 57 mm operators to reestablish a track on the target via SAFIRE (a laborious process) and disrupts the crew's situational awareness.

SUW Mission Package

- In FY14 operational testing, LCS 3 (*Freedom* variant) and an embarked Increment 2 SUW mission package demonstrated the capability to defeat a small swarm of FIACs under the specific conditions detailed in the Navy requirement; however, the crew received extensive hands-on training that might not be available to crews on other ships. Testing conducted to date has not been sufficient to demonstrate LCS capabilities in more stressing scenarios consistent with existing threats or to demonstrate with high confidence that the *Freedom* variant LCS can defeat even small swarms with regularity when equipped with the Increment 2 SUW mission package.
- While equipped with the Increment 2 SUW mission package, LCS 4 participated in three engagements with small swarms of FIACs. The engagements used the same "keep-out" criteria as the single target self-defense engagements. Although all of the attacking boats were ultimately defeated, an attacker managed to penetrate this "keep-out" range in two of the three events. In all three events, however, the ship expended a large quantity of ammunition from the seaframe's 57 mm gun and the two mission package 30 mm guns, while contending with repeated network communication faults that disrupted the flow of navigation information to the gun systems as well as azimuth elevation inhibits that disrupted or prevented establishing firing solutions on the targets. The SAFIRE performance issues described in the seaframe section also presented the crew with challenges during the swarm engagements. LCS 4's failure to defeat this relatively modest threat routinely under test conditions raises questions about its ability to deal with more realistic threats certain to be present in theater.
- In the past, the 30 mm Gun Mission Modules have been prone to jams caused by separation of ammunition links and accumulation of spent cartridges in the ejection path. Although they can typically be cleared in a few minutes, ammunition jams interrupt firing and can be sufficiently disruptive to cause the ship to lose valuable time in a fast-moving engagement. FY14 testing conducted in LCS 3 showed the Navy's concerted effort to improve ammunition belts has had some positive effect, but the problem has not been eliminated. LCS 4 experienced numerous instances of link separation during FY15 developmental testing, but DOT&E observers report that modified ammunition can lids

introduced before the operational test have largely mitigated that problem.

- LCS 4 experienced a large number of azimuth elevation inhibits during FY15 developmental and operational tests, which momentarily interrupted 30 mm gun firing engagements. The azimuth elevation inhibit is designed to prevent the gun from firing when the pointing of the gun sight and gun are not in reasonable agreement. Observers reported that the inhibits occur with annoying frequency (a dozen or more times during a live fire engagement), severely impairing the flow of the engagement. The crew reported that the cause of the frequent inhibits was to have been corrected in a software patch, but the patch was either not installed or not effective.

MCM Mission Package

- DOT&E concluded in a November 2015 memorandum to the Secretary of Defense and the Navy, based on the testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or suitable if it were called upon to conduct MCM missions in combat and that a single LCS equipped with the Increment 1 MCM mission package would provide little or no operational capability to complete MCM clearance missions to the levels needed by operational commanders. The primary reasons for this conclusion are:
  - Critical MCM systems are not reliable.
  - The ship is not reliable.
  - Vulnerabilities of the RMMV to mines and its high rate of failures do not support sustained operations in potentially mined waters.
  - RMMV operational communications ranges are limited.
  - Mine hunting capabilities are limited in other-than-benign environmental conditions.
  - The fleet is not equipped to maintain the ship or the MCM systems.
  - The AMNS cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
- During the MCM mission package TECHEVAL, the Navy demonstrated that an LSC could detect, classify, identify, and neutralize only a fraction of the mines in the Navy's mine clearance scenarios while requiring extraordinary efforts from shore support, maintenance personnel, and contractors.
- During developmental testing, the Navy has not demonstrated that it can sustain LCS-based mine reconnaissance and mine clearance rates necessary to meet its strategic mine clearance timelines. Following TECHEVAL, DOT&E identified seaframe reliability and availability, poor reliability of MCM components—particularly the RMS/RMMV—system integration problems, and subsystem limitations as critical shortcomings that have substantially limited MCM effectiveness. In addition to the seaframe problems discussed earlier in this LCS report, this section discusses specific mission package shortcomings that, unless corrected, will continue to prevent the Navy from achieving its LCS MCM objectives, including the required timelines for large-scale mine clearance operations.
- As stated in the November 2015 DOT&E memorandum to the Secretary of Defense and the Navy, testing continues to show that employing these LCSs with the Increment 1 MCM mission package would require an exorbitant and costly shore infrastructure to make an insignificant contribution to the mine area clearance needs of operational commanders. In the pre-test work-ups and the TECHEVAL, the crew had to request on-site or remote assistance 33 times. The RMMVs during this same period required 291 shore-based actions necessitating 4,123 man-hours of effort to accomplish 107.7 hours of minehunting. The Navy significantly increased the shore-based support above their original support concept to complete the TECHEVAL.
- **Inability to Sustain Timely MCM Operations.** LCS MCM mission package testing since 2011 has shown that MCM mission-critical systems are often not available when needed and frequently fail after only short periods of operation, making it impossible for the *Independence* variant LCS to sustain timely MCM activities over long periods. Problems with seaframe support systems (discussed above), the Remote Minehunting Module, and MH-60S and AMCM modules have all contributed to lost MCM productivity. During TECHEVAL, in FY15, the Navy devoted approximately 80 of 132 test days to seaframe, RMS, and AMCM repair actions rather than minehunting operations. These TECHEVAL corrective maintenance demands prevented LCS 2 from demonstrating that it could provide rapid and sustained mine reconnaissance and mine clearance.
  - **RMS.** Severe RMS reliability problems continued to persist throughout FY15 testing. The table below provides a summary of RMMV and RMS reliability data collected that shows the reliability of the RMMV and RMS are consistently below the 75 hours Mean Time Between Operational Mission Failure (MTBOMF) prescribed by the Navy requirements.

RMS and v6.0 RMMV Reliability in 2014-2015 Testing

Test Event	Test Period	System Operating Time (Hours)	RMMV OMFs	RMMV MTBOMF (Hours)	RMS OMFs	RMS MTBOMF (Hours)
LCS MCM MP DT-B2 Ph4 Pd2	Sept 11 – Oct 20, 2014	139.0	3	46.3 *(20.8-126.1)*	6	23.2 *(13.2-44.1)*
DT-B1	Jan 13 –Mar 25, 2015	163.4	7	23.3 *(13.9-42.0)*	8	20.4 *(12.6-35.1)*
LCS MCM MP TECHEVAL	Apr 7 – Aug 30, 2015	265.7	15	17.7 *(12.5-25.8)*	17	15.6 *(11.3-22.2)*
All	***Sep 11, 2014 – Aug 30, 2015***	***568.1***	***25***	***22.7 (17.4-30.1)***	***31***	***18.3 (14.4-23.6)***

Note: Values in parentheses represent 80 percent confidence intervals.
MCM – Mine Countermeasures; MP – mission package; TECHEVAL – Technical Evaluation; RMMV – Remote Muti-Mission Vehicle; OMF – Operational Mission Failure; MTBOMF – Mean Time Between Operational Mission Failure

- As DOT&E indicated in an August 2015 memorandum to USD(AT&L), without changes, RMMV and RMS reliability problems threaten the Navy's capacity to field and sustain a viable LCS-based MCM capability. Since the RMS is critical to achieving the Navy's sustained area coverage rate requirement, this annual report also includes a separate article on the RMS that provides additional detail.
  - During TECHEVAL, four RMMVs and six AN/AQS-20As operated off-board LCS for 226 hours and conducted 94 hours of minehunting (employing the sonar to actively search for mines, revisit contacts, and identify bottom objects). On six occasions, an RMMV could not be recovered aboard LCS 2 and had to be towed to port by test support craft and then shipped to the remote operating site (simulating an in-theater depot-level maintenance activity) or prime contractor site (original equipment manufacturer intermediate- and depot-level repair facility) for repairs. On average, the LCS 2 completed a total of 5 hours of RMS minehunting per week (1.25 hours per week per RMMV), and an RMMV had to be towed to port for every 16 hours of RMS minehunting.
  - The pace of RMS operations demonstrated by one LCS with 4 RMMVs is less than 10 percent of the operating tempo for a single ship shown in the Navy's Design Reference Mission Profile for Increment 1 bottom-focused minehunting (shallow-water) operations. Based on the demonstrated pace of operations during TECHEVAL, all of the RMMVs the Navy plans to acquire to outfit 24 MCM mission packages would be required to search the area that the Navy originally projected a single LCS and MCM mission package could search.
  - Although the Navy considers one of the two RMMVs in the Increment 1 mission package an embarked spare that permits continued RMS operations even after one unit fails, LCS 2 averaged just 3.5 days underway before losing all RMS capability, that required a call for outside RMS repair assistance, or necessitated a return to port. LCS 2 was underway for more than one week with at least one mission-capable RMS embarked only once during TECHEVAL. On five occasions, LCS 2 operated for less than two days before encountering an RMS problem that required assistance from shore-based intermediate-level maintenance personnel to continue operations. In three cases, an RMMV was recovered without collecting minehunting data. These problems resulted in the RMMV returning to LCS 2 with at least some fraction of the expected mission data in only 15 of 24 launches (63 percent).
  - Mishaps also severely damaged two RMMVs, causing them to be returned to the contractor for extensive repairs.
  - Despite underway periods that were short relative to the expectations of the LCS Design Reference Mission Profile, both RMMVs embarked at the beginning of an underway period were unavailable to conduct minehunting missions six times during TECHEVAL.
  - On 3 occasions, totaling 19 days, all four v6.0 RMMVs in the Navy's inventory were unavailable to execute minehunting missions.
  - The Navy completed TECHEVAL with one of four RMMVs operational. However, post-test inspections revealed that the sonar tow cable installed in that unit was no longer functional.
- **AMCM.** During TECHEVAL, the MH-60S and its associated AMCM mission kit and mission systems also experienced problems that interrupted or delayed LCS MCM activities.
  - Nine MH-60S AMCM problems interrupted or delayed MCM missions. These problems included MH-60S rotor blade delamination, an MH-60S power distribution unit failure, a broken relief valve on an MH-60S hydraulic reservoir, multiple AMCM mission kit failures that required the MH-60S to return to port for repairs, and an AMNS neutralizer that failed to launch when commanded. The launch failure would have required the aircrew to jettison the launch and handling system if live rounds (operational assets)

been employed. As a result, LCS 2 demonstrated sustained MH-60S operations lasting more than one week just once during TECHEVAL.
  - On eight occasions, LCS 2 conducted MH-60S operations for two days or less before needing repairs that in many cases required the ship or helicopter to return to port for spare parts or repairs. In one case, after returning to port, the Navy elected to replace a helicopter embarked aboard LCS and in need of repairs rather than repair it.
  - In total, during 132 days of TECHEVAL, the LCS 2 Aviation Detachment employed two MH 60S helicopters for 141 flight hours.
  - Considering only the 58 days underway, LCS 2 was ALMDS-mission capable for 16 days, AMNS-mission capable for 26 days, and not capable of conducting the planned AMCM mission for 16 days primarily because of helicopter and mission kit problems. Nearly all the lost AMCM mission days occurred in the AMNS configuration. This is not surprising given that the AMNS mission is more stressing on the MH-60S and its AMCM mission kit because of the need to lower the loaded AMNS launch and handing system into the water and retrieve it at least once per sortie.
  - The MH-60S aircrew employed 2 ALMDS pods to search for mines for 33 hours and 3 AMNS launch and handling systems to launch 107 inert neutralizers against 66 targets.
  - Since the MH-60S AMCM capability is critical to achieving the Navy's sustained area coverage rate requirement, this annual report also includes a separate article on the MH-60S that provides additional detail.
- **Communications between LCS and its Unmanned Vehicles.** Two significant communications shortcomings limit the effectiveness of the current LCS MCM mission package system-of-systems. One centers on the limited range of high data rate communications between an off-board RMMV and the host LCS and the other is related to the persistent difficulty with establishing and maintaining the existing line-of-sight (LOS) and over-the-horizon (OTH) communications channels. The former limits the reach and productivity of LCS MCM operations, and the latter results in frequent mission delays and the potential loss of an RMMV with which the LCS is unable to communicate. Unless these problems are solved, the LCS and its MCM mission package will never be able to fulfill its wartime MCM missions within the timelines required.
- Although the RMMV can search autonomously while operating OTH from the LCS, it can only conduct Electro-optical Identification operations to reacquire and identify bottom mines when operating within LOS communications range of the LCS. This limitation will complicate MCM operations in long shipping channels, and will make it necessary to clear a series of LCS operating areas to allow the ship to follow MCM operations as they progress along the channel. The cleared operating areas must be close enough to the intended search area to maintain LOS communications and large enough to enable LCS operations, including ship maneuver to facilitate launch and recovery of the RMMV and MH-60S helicopter. The additional time required to clear these areas will increase the demand for mine clearance. Although a May 2012 Navy briefing proposed development of an airborne relay and a high frequency ground wave radio capability, along with other upgrades, to make the Increment 1 MCM mission package "good enough" for IOT&E, the Navy has not yet fielded either of those capabilities. Had LCS 2 been required to clear its operating areas during the 2015 TECHEVAL and the Area Coverage rate Sustained remained unchanged, the time required to complete MCM operations in the test field would have increased nearly three-fold. In the May 2012 briefing cited above, the Navy reached a similar conclusion regarding the operational consequences of limited RMMV communications ranges.
- During TECHEVAL, LCS 2 had frequent problems establishing initial communications between the ship and an RMMV using existing OTH and LOS channels and maintaining those communications links once established. These problems frequently delayed the start of RMS missions and periodically terminated missions prematurely. On one occasion, loss of communications during an attempt to launch an RMMV caused the ship to return to port with the RMMV suspended from the TBEC because the crew was unable to complete the launch or bring the vehicle back into the mission bay. On another occasion, loss of LOS communications resulted in extensive damage to an RMMV that required months of depot-level repair at the contractor's facility when the ship attempted to recover it using OTH communications. On a third occasion, an abrupt loss of power led to loss of communications with an RMMV, making it necessary for a test support craft to take the RMMV under tow. In addition to these incidents, the LCS crew routinely found it necessary to seek help from shore-based technicians to resolve communications problems. During the latter portion of TECHEVAL, the program manager embarked a team of subject matter experts to monitor LCS – RMMV communications, assist with troubleshooting, and collect diagnostics. Shortly after the TECHEVAL, the Program Office established a task force to analyze the communications problems and propose solutions. The task force has since recommended a multi-faceted approach that includes improving operating and troubleshooting documentation for the communications system-of-systems, enhancing crew training in initialization of communications links and fault troubleshooting, and, longer term, a reexamination of the communications architecture.
- **Potential Attrition of RMMVs When Employed in Mined Waters.** The combination of acoustic radiated

noise, frequent RMMV failures that prevent recovery aboard LCS, and the probability the vehicle and its sensor will get entangled with mines or other hazards all pose a risk to losing the RMS. Given the limited existing inventory of RMMVs (four v6.0 vehicles, four vehicles awaiting upgrades to v6.0, and two vehicles designated for training use only), any RMMV attrition would severely degrade the Navy's ability to conduct LCS-based MCM operations.

- RMMV acoustic radiated noise measurements, last collected during developmental testing in 2007/2008, indicated that existing RMMVs might be vulnerable to some mines. The RMS Program Office has not assessed radiated noise following recent vehicle configuration changes and has requested a waiver to deploy the system even through it did not previously meet its acoustic radiated noise specification. If RMMV radiated noise continues to exceed acceptable limits, systems could be lost during LCS-based minehunting and mine clearance operations depleting the Navy's limited inventory of assets. The magnetic signature of the v6.0 RMMV has not been measured.
- As noted earlier, only 18 of 24 RMMVs launched from LCS 2 ended with an RMMV recovery aboard LCS 2 during TECHEVAL. Frequent RMMV failures that preclude vehicle recovery aboard LCS might result in lost RMMVs and expose personnel who attempt to recover RMMVs in open waters to air, surface, and mine threats. Because of the number of incidents in which an RMMV could not be recovered, the Navy is now considering options that would provide LCS with additional support to recover RMMVs that it cannot recover otherwise. On four occasions during TECHEVAL, RMMV failures precluded LCS 2 from controlling the movements of an off-board RMMV. If similar failures occur during operations, the RMMV could become disabled in the minefield or drift into a minefield before salvage or support craft arrive to recover it.
- Even though test minefields are deliberately planned to reduce the risk of RMS striking a mine target or becoming entangled in its mooring cable, the RMS has snagged several tethered mines, and other surface and underwater objects during testing. These incidents often cause damage to the vehicle or its deployed sonar that leaves the system inoperable. In some cases, divers embarked on test support craft have entered the water to assist in recovery of assets following a snag. Although the Navy is still developing CONOPS to handle these situations during operations in a threat minefield, it is clear that if these incidents occur during wartime operations they will pose a risk to vehicles and potential recovery personnel. Furthermore, the repeated occurrence of these incidents presents both a tactical and a system design challenge for the Navy to resolve as it tries to minimize attrition when the system is operationally employed.
- In FY15, the Navy also disclosed that the AN/AQS-20 does not trail directly behind the RMMV when deployed to tactical minehunting depths. Instead, the sensor tows to starboard of the RMMV path. This offset causes the RMS to behave like a mine sweeping system as the sonar and its tow cable passes through the water, thereby increasing the risk of snagging a tethered mine.

- **System Minehunting Performance in Less Than Optimal Conditions.** Testing has revealed several shortcomings that, unless corrected, will delay completion of LCS-based mine reconnaissance and mine clearance operations.
  - The ALMDS does not meet Navy detection/classification requirements in all depth bins or the Navy's requirement for the average probability of detection and classification in all conditions over a region of the water column that extends from the surface to a reduced maximum depth requirement. When the system and operator detect and classify a smaller percentage of mines than predicted by fleet planning tools, the MCM commander will likely underestimate the residual risk to transiting ships following clearance operations. To account for this uncertainty, the Navy might find it necessary to conduct minesweeping operations. However, the Navy does not plan to include the mechanical minesweeping capability that would be required in the MCM mission package. In some conditions, the ALMDS also generates a large number of false classifications (erroneous indications of mine-like objects) that can delay near-surface minehunting operations until conditions improve or slow mine clearance efforts because of the need for additional search passes to reduce the number of false classifications. In favorable environmental conditions, the Navy's new multi-pass tactic has been successful in reducing false classifications to the Navy's acceptable limits at the cost of requiring more search and identification time.
  - The RMS program has not yet demonstrated that the AN/AQS-20A operating in its tactical single pass modes can meet its detection and classification requirements against deep water targets moored near the ocean bottom, near-surface moored mines that are not detected by the ALMDS, or stealthy bottom mines. Unless corrected, these problems will likely adversely affect the quality of LCS-based minehunting and mine clearance operations in some threat scenarios. As an alternative, additional RMS search passes could be employed with the sensor at other depths, but this will further slow minehunting and mine clearance operations.
  - The results of developmental and integrated testing to date continue to show that the RMS's AN/AQS-20A sensor does not meet Navy requirements for contact depth localization accuracy or false classification

density (number of contacts erroneously classified as mine-like objects per unit area searched). Contact depth localization problems complicate efforts to complete identification and neutralization of mines. False classifications, unless eliminated from the contact list, require identification and neutralization effort, result in the expenditure of limited neutralizer assets, and negatively affect the LCS sustained area coverage rate. To mitigate the problem of false classifications, the Navy has implemented tactics and software designed to compare the results of multiple search passes over the same area to "prune out" most false classifications and minimize the number conveyed for identification/neutralization. Under some conditions, the Navy has demonstrated these pruning tactics reduce false classification densities to the Navy's acceptable limits. However, as observed during developmental testing in 1QFY15, these new procedures do not reduce false classification densities appreciably in all operationally relevant conditions. The continued need for additional passes to "prune out" excessive classifications will prevent the LCS MCM mission package from achieving the Navy's predictions for Sustained Area Coverage Rates that were based on the expectation that RMS would be a "single-pass" system.

  - The Navy is developing AN/AQS-20 pre-planned product improvements (P3I) as a longer-term solution to improve probability of correct classification, reduce false classifications, and resolve contact localization accuracy problems. In early FY15, the Navy was optimistic that it could produce a mature P3I system prior to the first phase of LCS MCM operational testing then planned in late FY15. The Program Office now expects the P3I system to enter operational testing in FY18.
  - Developmental testing of the RMS in 2008 revealed that the system had problems reacquiring bottom objects for identification in deeper waters. Although the Navy implemented fixes in the v6.0 RMMV designed to correct this deficiency, the Navy has not yet conducted sufficient testing to evaluate the efficacy of its fix.
  - During an AN/AQS-20A operational assessment in 2012, operators had difficulty identifying bottom objects in areas with degraded, but operationally relevant, water clarity. Unless system performance in this environment improves, degraded water clarity will delay MCM operations.

- **Limited Mission Package Neutralization Capability.** The current increment of the MCM mission package cannot neutralize moored mines above the AMNS operating ceiling; an Explosive Ordinance Disposal Team or other means provided by another unit must be used. Unfortunately, this limitation will preclude neutralizing most of the mines expected in some likely threat scenarios. Within its operating range, AMNS performance is frequently degraded by the loss of fiber-optic communications between the aircraft and the neutralizer. The system has experienced loss of fiber-optic communications in a wide range of operationally relevant operating conditions, including those that are relatively benign. Although the Program Office has stated that it intends to develop an improved AMNS to extend its depth range and potentially improve performance in coarse bottom conditions and higher currents, none of these efforts are funded. The Navy is also considering other alternatives.
  - AMNS Increment 1 cannot neutralize near surface mines because of safety interlocks designed to protect the helicopter and crew from exposure to fragments, surge, and blast that might result from mine detonation; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
  - During the shore-based phase of an operational assessment completed in 2014, the system and its operators were unable to achieve the Navy's requirement for mine neutralization success in realistic conditions. Frequent loss of fiber-optic communications between the aircraft and the neutralizer was the primary cause of unsuccessful attack runs. The Navy attributed the failures to the bottom composition even though the bottom conditions experienced in the test area were not significantly different from those expected in some potential operating areas.
  - Following developmental testing in high-current environments in 2013, Navy Air Test and Evaluation Squadron Twenty One (HX-21) concluded that the AMNS destructor, as currently designed, is ineffective in swift water currents. Although the Navy completed additional developmental testing in 2015, the Navy's testing has not characterized system performance under operationally realistic conditions in even moderate currents that might be encountered in potential operating areas.
  - **Inability to Maintain Systems.** An earlier section of this LCS report noted that, consistent with the CONOPS, the LCS is reliant on shore-based support for assistance with diagnosis and repair of seaframe equipment problems and that the ship could be more self-reliant if the sailors were provided with better maintenance training, technical documentation, test equipment, and tools and a more extensive stock of spares. This holds true for the MCM mission systems as well, because the mission package detachment is also not equipped to handle anything beyond relatively uncomplicated preventive maintenance and minor repairs. For example, the Navy's records show that shore-based RMMV maintenance personnel completed more than 4,000 hours of RMMV maintenance over 6 months of TECHEVAL work-ups and testing to support approximately 108 hours of RMS minehunting. Not only is this level of support, 38 hours of maintenance per hour of minehunting, far beyond the capability of the embarked crew, it is also not sustainable for wide-area LCS MCM operations that must be completed quickly.

- **Problems with Developmental MCM Systems.** Two problems observed during early developmental testing of COBRA Block I, if not subsequently corrected, could adversely affect the operational effectiveness and suitability of the system and the Increment 2 MCM mission package.
  - During early developmental testing of the COBRA Airborne Payload System (CAPS) on a UH-1 helicopter, the system suffered multiple power losses because of an unstable power supply voltage to the power distribution assembly (PDA) caused by a bad reference ground. The PDA subsequently shut down CAPS as a precautionary measure, resulting in the loss of imagery.
  - During dynamic conditions, such as roll and pitch maneuvers, the COBRA Integrated Gimbal (IG) was unable to maintain the correct step-stare sequence to acquire a complete dataset. During flight operations, the IG must continuously look at a single spot (stare) while the system records multiple images. The IG must also adjust its look angle to step to the next spot to optimize its imagery acquisition. The inability to maintain the correct step-stare sequence can result in gaps in the imagery of the target area.

ASW Mission Package

- Although the Navy did not conduct any ASW mission package testing in FY15, problems observed in early developmental testing, if not corrected, could adversely affect the operational effectiveness and suitability of the mission package during a future operational test. In particular, the mission package exceeds the LCS mission package weight allowance. The weight of the Variable Depth Sonar and its handling system is a major contributor, and the Navy is pursuing weight reduction initiatives.

LFT&E

- Neither LCS variant is expected to be survivable in high-intensity combat because the design requirements accept the risk that the ship must be abandoned under circumstances that would not require such an action on other surface combatants. Although the ships incorporate capabilities to reduce their susceptibility to attack, previous testing of analogous capabilities in other ship classes demonstrates it cannot be assumed LCS will not be hit in high-intensity combat. As designed, the LCS lack the redundancy and the vertical and longitudinal separation of equipment found in other combatants. Such features are required to reduce the likelihood that a single hit will result in loss of propulsion, combat capability, and the ability to control damage and restore system operation.
- LCS does not have the survivability features commensurate with those inherent in the USS *Oliver Hazard Perry* class Guided Missile Frigate (FFG 7) it is intended to replace. The FFG 7 was designed to retain critical mission capability and continue fighting if need be after receiving a significant hit.
- The LCS 3 TSST revealed significant deficiencies in the *Freedom* variant design. Much of the ship's mission capability would have been lost because of damage caused by the initial weapons effects or from the ensuing fire. The weapons effects and fire damage happened before the crew could respond, and the ship does not have sufficient redundancy to recover the lost capability. Some changes could be made to make the ship less vulnerable and more recoverable without major structural modifications. Examples include providing separation for the water jet hydraulic power units, redesigning the Machinery Plant Control and Monitoring System, and reconfiguring the chilled water system into a zonal system with separation for the air conditioning (chilled water) plants.
- DOT&E is analyzing the initial internal blast test findings recently provided by the Navy. The Navy delayed completion of the planned fire testing and final internal blast tests until the spring of 2016 because of other Navy testing priorities.

Recommendations

- Status of Previous Recommendations.
  - The Navy partially addressed one FY09 recommendation to develop an LFT&E program with the approval of the LFT&E Management Plan; however, the lethality testing of the new surface-to-surface missile still needs to be developed.
  - The Navy partially addressed the FY10 recommendations to implement recommendations from DOT&E's Combined Operational and Live Fire Early Fielding Report and plans to address other recommendations in future ships.
  - With respect to FY11 recommendations regarding AN/AQS-20A and ALMDS, the Navy is adjusting tactics and, for the AN/AQS-20A, funding improvements to address deficiencies. The FY11 recommendation for the Navy to continue to report vulnerabilities during live fire tests remains valid.
  - For FY12 recommendations:
    - The Navy partially addressed the recommendations to complete the revised capabilities document defining the incremental approach to fielding mission packages.
    - The Navy has released requirements letters for Increments 1 and 2 SUW and Increment 1 MCM mission packages only; however, the requirements have not been codified in approved Capabilities Production Documents. The Navy published the LCS Platform Wholeness Concept of Operations Revision D in January 2013.
    - The Navy has not published the concept of employment for all the mission packages, but advises that it has completed initial manning level studies. The Navy has adjusted ship and mission package manning levels and is continuing studies to determine the final manning levels.
    - The Navy has stated that gun reliability problems identified during the Quick Reaction Assessment conducted aboard LCS 1 have been resolved based on limited testing conducted in October 2012. Subsequent testing has demonstrated that the gun reliability has indeed improved.

  - The Navy conducted LCS-based phases of the planned operational assessments of the MH-60S Block 2/3 and ALMDS and the MH-60S Block 2/3 and AMNS MCM systems in 1QFY15.
  - Throughout FY13/14, the Navy focused on correction of material deficiencies with seaframe launch and recovery systems, and procedural and training deficiencies that prevented safe shipboard launch and recovery of the RMS. Although the Navy has retired some problems, LCS 2 continued to experience some damage to equipment during RMMV launch and recovery in low to moderate sea states.
  - The Navy should still address the FY13 recommendation to provide a surface-to-surface missile LFT&E Management Plan for DOT&E approval for the recently selected surface-to-surface missile.
- For FY14 recommendations:
  - The Navy continues to monitor the reliability of LCS systems and, when warranted by available data, incorporates system changes to improve reliability and other aspects of performance as funding permits.
  - The Navy has planned corrective actions for the cybersecurity deficiencies identified during operational testing of the *Freedom* and *Independence* variants of LCS but installation of upgrades will be done in FY16. The Navy completed a CVPA in LCS 2 with the MCM mission package in FY15, but the schedule for the follow-on Adversarial Assessment has not been determined. The Navy should consider scheduling the Adversarial Assessment after the planned upgrade to the ship's cybersecurity configuration as was done for the LCS 4 with the SUW mission package, whose testing will now be done in 2QFY16 when it expects to complete its first phase of cybersecurity upgrades.
  - The Navy has not yet altered its plan for live fire swarm engagements during testing of the SUW mission package; testing conducted in LCS 4 duplicated that completed in LCS 3 in FY14. Nor has the Navy developed plans for testing Increments 3 and 4 of the SUW mission package.
  - Although the Navy has identified potential solutions, DOT&E is not aware of any funded effort to provide the OTH communication needed for RMS electro-optical identification operations.
  - Although the Navy is continually working to improve mission system (RMMV, ALMDS, AMNS, AMCM mission kit, AN/AQS-20A) reliability, FY15 testing showed that reliability, maintainability, and availability problems continue to prevent timely and sustained MCM operations and require extensive reliance on shore-based support.
  - The Navy made minor modifications to the AMNS system and trained operators to maintain forward neutralizer motion to reduce the risk of cutting the fiber-optic cable, but the system continued to have problems with early termination of fiber-optic communications during TECHEVAL. The Navy should continue to monitor AMNS operations to identify uncorrected causes of fiber breaks.
  - The Navy reported that a technical group is reviewing the ventilation lineup during condition ZEBRA, (the highest condition of material readiness) in the *Freedom* variant LCS to determine if the system is operating as intended.
  - The Program Office reports that the contractor is investigating problems with the Machinery Plant Control and Monitoring System fire alarm system in the *Freedom* variant LCS.
- FY15 Recommendations. The Navy should:
  1. Shift to a performance-based test schedule rather than continuing a schedule-driven program to provide the LCS program ample time and resources needed to correct the numerous serious problems that repeatedly have been identified before operational testing occurs.
  2. Accelerate efforts to obtain the intellectual property rights needed to develop high-fidelity digital models of the AN/SPS-75 and AN/SPS-77 radars for the P_{RA} Test Bed, or present plans to enhance air warfare testing aboard the self-defense ship for DOT&E to review.
  3. Improve the shock resistance of mission-critical electronics in the *Independence* variant LCS to improve continuity of operations during 57 mm gun engagements and other shock-inducing activities/events.
  4. Work with the vendor to develop SAFIRE changes needed to improve the human-machine interface, reduce the time required to develop a new track, improve tracking, and correct other performance issues noted in FY15 testing in order to enhance the *Independence* variant seaframe's effectiveness against surface and LSF threats.
  5. Investigate and correct the causes of *Independence* variant seaframe problems that disrupt gunnery engagements and other operations, including loss of navigation information to combat systems, 30 mm gun azimuth-elevation inhibits, and the 57 mm gun's azimuth-dependent range errors.
  6. Re-engineer the Multi-Vehicle Communication System, RMMV, and/or other essential system-of-systems components to improve interoperability and enable reliable LOS and OTH communications between LCS and RMMVs.
  7. Develop a safe method to realistically test the ships' ability to counter LSF threats.
  8. Provide LCS crews with better training, technical documentation, test equipment, and tools, along with additional spares to improve the crews' self-sufficiency and enhance LCS and mission package maintainability.
  9. Acquire additional organic U.S. Navy expertise in LCS systems to reduce the reliance on equipment vendors and other contractors, particularly those located overseas.
  10. Continue to investigate options to re-engineer the recovery of watercraft in order to reduce risk, delays, crew workload, and the likelihood of failures.
  11. Develop tactics to mitigate system vulnerabilities to mines, mine collision, and entanglement hazards, and other surface and underwater hazards.

MH-60R Multi-Mission Helicopter

Executive Summary

- Commander, Operational Test and Evaluation Force (COTF) completed a Quick Reaction Assessment (QRA) of the LAU-61G/A 2.75-inch Digital Rocket Launcher (DRL) armed with the Advanced Precision Kill Weapons System II (APKWS II) rockets in 1QFY15 in response to a U.S. Central Command Urgent Operational Need for enhanced Surface Warfare capability against threat-representative small-boat targets.
- On May 21, 2015, DOT&E provided the Secretary of the Navy a classified Early Fielding Summary and Scripted Brief that assesses the QRA test results.
- The MH-60R equipped with the DRL and APKWS II rockets demonstrated marginal Surface Warfare capability based on the limited QRA testing.

System

- The MH-60R is a ship-based medium lift helicopter designed to replace two different helicopters, the SH-60B and SH60F, and operate from cruisers, destroyers, frigates, littoral combat ships, and aircraft carriers.
- It incorporates dipping sonar and sonobuoy acoustic sensors, multi-mode radar, electronic warfare sensors, a forward looking infrared sensor with laser designator, and an advanced mission data processing system.
- It employs MK 46 and MK 54 torpedoes, HELLFIRE air-to-ground missiles, 2.75-inch family of rockets, and crew served mounted machine guns.
- It has a three-man crew: two pilots and one sensor operator.

Mission

The Maritime Component Commander employs the MH-60R from ships or shore stations to accomplish the following:

- Surface Warfare, Undersea Warfare, Area Surveillance, Combat Identification, and Naval Surface Fire Support missions previously provided by the SH-60B and SH-60F
- Support missions such as Search and Rescue at sea and, when outfitted with necessary armament, maritime force protection duties

Major Contractors

- Sikorsky Aircraft Corporation – Stratford, Connecticut
- Lockheed Martin Mission System and Sensors – Owego, New York

Activity

- COTF conducted a QRA of the MH-60R equipped with the DRL and APKWS II rockets in 1QFY15 in response to a U.S. Central Command Urgent Operational Need for enhanced Surface Warfare capability against threat-representative small-boat targets. This QRA provided limited testing of MH-60R capability for Surface Warfare when equipped with the APKWS II rocket. Testing was conducted in accordance with a DOT&E-approved test plan.
- DOT&E provided the Secretary of the Navy a classified Early Fielding Summary and Scripted Brief on May 21, 2015, that assesses the QRA test results.
- The Navy is preparing a Test and Evaluation Master Plan update for MH-60R FOT&E.
- The MH-60R FOT&E is not currently scheduled.

Assessment

- The MH-60R equipped with the DRL and APKWS II rockets demonstrated marginal Surface Warfare capability based on QRA testing.
- The limited scope of the QRA was not sufficient to fully characterize the mission effectiveness of the MH-60R equipped with the DRL and APKWS II rockets against threat-representative small-boat targets. The Navy needs to plan to conduct a complete operational test as soon as possible.

Recommendations

- Status of Previous Recommendations. The Navy has partially addressed the FY12 recommendation to test corrections made to resolve identified Multi-Spectral Targeting System (MTS) deficiencies in conducting FOT&E. The Navy has not acted or has yet to complete action on FY13 and FY14 recommendations to:
  1. Conduct comprehensive live fire lethality testing of the HELLFIRE missile against a complete set of threat-representative small-boat targets and to test the Surface Warfare mission capability of MH-60R equipped with HELLFIRE missiles.

2. Correct the remaining deficiencies with the MTS tracker.
3. Demonstrate the Surface Warfare mission capability of the MH-60R helicopter equipped with the HELLFIRE missile and MTS throughout the operational mission environment in FOT&E and LFT&E.
4. Conduct further evaluation of the Automatic Radar Periscope Detection and Discrimination (ARPDD) employment in high-clutter, high-contact density littoral environments.
5. Address the additional six recommendations in the classified IOT&E report on MH-60R with the ARPDD system.
6. Investigate and correct interoperability deficiencies of the MK 54 lightweight torpedo with MH-60R weapons control systems.

- FY15 Recommendation.
  1. The Navy should conduct MH-60R FOT&E to test the DRL armed with the APKWS II rocket and fully characterize Surface Warfare mission capability and lethality of this capability against the small-boat threat targets.

MH-60S Multi-Mission Combat Support Helicopter

Executive Summary

- DOT&E concluded in a November 2015 memorandum to the USD(AT&L) and the Navy, based on the testing conducted to date, that a Littoral Combat Ship (LCS) employing the current Mine Countermeasures (MCM) mission package would not be operationally effective or operationally suitable if the Navy called upon it to conduct MCM missions in combat. Three of the seven primary shortcomings supporting this conclusion are attributed, at least in part, to the MH-60S with Airborne Mine Countermeasures (AMCM) systems:
  - Critical MCM systems are not reliable.
  - Minehunting capabilities are limited in other-than-benign environmental conditions.
  - The Airborne Mine Neutralization System (AMNS), by design, cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team provided by another unit must be used.
- From April through August 2015, the Navy conducted Technical Evaluation (TECHEVAL) of the *Independence* variant LCS and Increment 1 MCM mission package, including the MH-60S and its AMCM systems, aboard LCS 2. During TECHEVAL, the MH-60S and its associated AMCM mission kit and mission systems experienced nine problems that interrupted or delayed LCS MCM activities. These problems included MH-60S rotor blade delamination, an MH-60S power distribution unit failure, a broken relief valve on an MH-60S hydraulic reservoir, multiple AMCM mission kit failures that required the MH-60S to return to port for repairs, and an AMNS neutralizer that failed to launch when commanded. The launch failure would have required the aircrew to jettison the launch and handling system if live rounds (operational assets) been employed. As a result, LCS 2 demonstrated sustained MH-60S operations lasting more than one week just once during TECHEVAL.
- The Airborne Mine Detection System (ALMDS) does not meet Navy detection/classification requirements. In particular, the system does not meet the Navy's requirements for minimum probability of detection and classification in all depth bins or for the average probability of detection and classification in all conditions over a region of the water column that extends from the surface to a reduced maximum depth requirement. When the system and operator detect and classify a smaller percentage of mines than predicted by fleet planning tools, the MCM commander will likely underestimate the residual risk to transiting ships following clearance operations. In some conditions, the system also generates a large number of false classifications (erroneous indications of mine-like objects) that can delay near-surface minehunting operations until conditions improve or slow mine clearance efforts because of the need for additional search passes to reduce the number of false classifications. In favorable conditions, such as those observed during TECHEVAL, detection performance meets the Navy's requirements and tactics, techniques, and procedures have been successful in reducing false classifications to the Navy's acceptable limits.
- The current increment of the AMNS cannot neutralize moored mines above a prescribed operating ceiling, which will preclude neutralizing most of the mines expected in some likely threat scenarios; an Explosive Ordinance Disposal Team provided by another unit must be used. Within its operating range, AMNS performance is frequently degraded by the loss of fiber-optic communications between the aircraft and the neutralizer. The system has experienced loss of fiber-optic communications in a wide range of operationally relevant operating conditions, including those that are relatively benign. Although the Program Office has stated that it intends to develop an improved AMNS to extend its depth range and potentially improve performance in coarse bottom conditions and higher currents, none of these efforts are funded and the Navy is considering other alternatives.

System

- The MH-60S is a medium lift ship-based helicopter manufactured in three variants (blocks) that are derived from the Army UH-60L Blackhawk.
- All three blocks share a common cockpit, avionics, flight instrumentation, and power train with the MH-60R.
- Installed systems differ by block based on mission:
  - Block 1, Fleet Logistics – precision navigation and communications, maximum cargo or passenger capacity.

- Block 2A/B, AMCM System – AMCM system operator workstation; a tether/towing system and the two MCM systems currently under development; ALMDS for detection and classification of near-surface mines; and the AMNS for neutralization of in volume and bottom mines. Any Block 2 or subsequent aircraft (e.g., Block 3 A/B aircraft) can be an AMCM aircraft.
- Block 3A, Armed Helicopter – 20 mm Gun System, forward-looking infrared with laser designator, crew served side machine guns, dual-sided HELLFIRE air-to-ground missiles, the 2.75-inch family of rockets, and defensive electronic countermeasures.
- Block 3B, Armed Helicopter – adds a tactical datalink (Link 16) to Block 3A capabilities.

Mission

The Maritime Component Commander can employ variants of MH-60S to accomplish the following missions:

- Block 1 – Vertical replenishment, internal cargo and personnel transport, medical evacuation, Search and Rescue, and Aircraft Carrier Plane Guard
- Block 2 – Detection, classification, identification, and/or neutralization of sea mines, depending on the specific AMCM systems employed on the aircraft
- Block 3 – Combat Search and Rescue, Surface Warfare, Aircraft Carrier Plane Guard, Maritime Interdiction Operations, and Special Warfare Support

Major Contractors

- Sikorsky Aircraft Corporation – Stratford, Connecticut
- Lockheed Martin Mission System and Sensors – Owego, New York

---

Activity

- Having completed the land-based phase of an operational assessment of the AMNS in 3QFY14 with the MH-60S helicopter operating from Naval Air Station, Oceana, Virginia, the Navy conducted the ship-based phase aboard USS *Independence* (LCS 2) in 1QFY15 during Increment 1 MCM mission package developmental testing. The ship-based phase of the assessment focused on shipboard integration and the system's operational suitability, but was also able to collect limited effectiveness data.
- The Navy also completed the ship-based phase of an ALMDS operational assessment in 1QFY15 aboard LCS 2 during Increment 1 MCM mission package developmental testing in accordance with the DOT&E-approved test plan. The test collected limited data to examine system effectiveness and the shipboard suitability of the MH-60S helicopter equipped with the ALMDS.
- From April through August 2015, the Navy conducted TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package, including the MH-60S and AMCM systems, aboard LCS 2. Although the Navy originally planned to complete the test in June 2015 and then complete operational testing in FY15, problems with failures of seaframe and MCM systems caused the testing to be extended. The Navy has delayed the operational testing until the spring of 2016, at the earliest.
- In May 2015, the Navy conducted AMNS medium current developmental testing from a surrogate platform in the Atlantic Ocean near the South Florida Test Facility. The Navy explored alternative tactics and collected data to inform possible system improvements.
- In June 2015, the Navy commenced ALMDS and AMNS cybersecurity operational testing concurrently with LCS 2 cybersecurity testing in accordance with the DOT&E-approved test plan. The initial phase of the cybersecurity operational test, a Cooperative Vulnerability and Penetration Assessment was completed in July 2015, but did not include the MH-60S. The final phase of the test, an Adversarial Assessment, is on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant LCS for operational testing.
- In November 2015, DOT&E provided the USD(AT&L), the Assistant Secretary of the Navy for Research Development and Acquisition, and the Program Executive Officer for Littoral Combat Ships a classified assessment of the performance of the *Independence* variant LCS and Increment 1 MCM mission package. DOT&E based the assessment on the data collected during the TECHEVAL and earlier periods of developmental and operational testing.

Assessment

- DOT&E concluded in a November 2015 memorandum to USD(AT&L) and the Navy, based on the testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or operationally suitable if the Navy called upon it to conduct MCM missions in combat. Three of the seven primary shortcomings supporting this conclusion are attributed, at least in part, to the MH-60S with AMCM systems:
  - Critical MCM systems are not reliable.
  - Minehunting capabilities are limited in other-than-benign environmental conditions.
  - The AMNS, by design, cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team provided by another unit must be used.
- During TECHEVAL, the MH-60S and its associated AMCM mission kit and mission systems experienced nine problems

that interrupted or delayed LCS MCM activities. These problems included MH-60S rotor blade delamination, an MH-60S power distribution unit failure, a broken relief valve on an MH-60S hydraulic reservoir, multiple AMCM mission kit failures that required the MH-60S to return to port for repairs, and an AMNS neutralizer that failed to launch when commanded. The launch failure would have required the aircrew to jettison the launch and handling system if live rounds (operational assets) been employed. As a result, LCS 2 demonstrated sustained MH-60S operations lasting more than one week just once during TECHEVAL.
  - On eight occasions, LCS 2 conducted MH-60S operations for two days or less before needing repairs that in many cases required the ship or helicopter to return to port for spare parts or repairs. In one case, after returning to port, the Navy elected to replace a helicopter embarked aboard LCS and in need of repairs rather than repair it.
  - In total, during 132 days of TECHEVAL, the LCS 2 Aviation Detachment employed 2 MH-60S helicopters for 141 flight hours.
  - Considering only the 58 days underway, LCS 2 was ALMDS-mission capable for 16 days, AMNS-mission capable for 26 days, and not capable of conducting the planned AMCM mission for 16 days due to helicopter, tow cable, and computer problems. Nearly all the lost AMCM mission days occurred in the AMNS configuration. This is not surprising given that the AMNS mission is more stressing on the MH-60S and its AMCM mission kit because of the need to lower the loaded AMNS launch and handing system into the water and retrieve it at least once per sortie.
  - The MH-60S aircrew employed 2 ALMDS pods to search for mines for 33 hours and 3 AMNS launch and handling systems to launch 107 inert neutralizers against 66 targets.
- The ALMDS does not meet Navy detection/classification requirements in all depth bins or for the average probability of detection and classification in all conditions over a region of the water column that extends from the surface to a reduced maximum depth requirement. When the system and operator detect and classify a smaller percentage of mines than predicted by fleet planning tools, the MCM commander will likely underestimate the residual risk to transiting ships following clearance operations. To account for this uncertainty, the Navy might find it necessary to conduct minesweeping operations. However, the Navy does not plan to include the mechanical minesweeping capability that would be required in the MCM mission package. In some conditions, the ALMDS also generates a large number of false classifications (erroneous indications of mine-like objects) that can delay near-surface minehunting operations until conditions improve or slow mine clearance efforts because of the need for additional search passes to reduce the number of false classifications. In favorable environmental conditions, such as those observed during TECHEVAL, detection performance meets the Navy's requirements and the new multi-pass tactic has been successful in reducing false classifications to the Navy's acceptable limits at the cost of requiring more search and identification time.
- The current increment of the AMNS cannot neutralize moored mines above a prescribed operating ceiling, which will preclude neutralizing most of the mines expected in some likely threat scenarios; an Explosive Ordinance Disposal Team provided by another unit must be used. Within its operating range, AMNS performance is frequently degraded by the loss of fiber-optic communications between the aircraft and the neutralizer. The system has experienced loss of fiber-optic communications in a wide range of operationally relevant operating conditions, including those that are relatively benign. Although the Program Office has stated that it intends to develop an improved AMNS to extend its depth range and potentially improve performance in coarse bottom conditions and higher currents, none of these efforts are funded and the Navy is considering other alternatives.
  - AMNS Increment 1 cannot neutralize near surface mines because of safety interlocks designed to protect the helicopter and crew from exposure to fragments, surge, and blast that might result from mine detonation.
  - During the shore-based phase of an operational assessment completed in 2014, the system and its operators were unable to achieve the Navy's requirement for mine neutralization success in realistic conditions. Frequent loss of fiber-optic communications between the aircraft and the neutralizer was the primary cause of unsuccessful attack runs. The Navy attributed the failures to the bottom composition even though the bottom conditions experienced in the test area were not significantly different from those expected in some potential operating areas.
  - During TECHEVAL, which was conducted in favorable environmental conditions against a narrower segment of mine threats, the Navy observed higher probabilities of AMNS neutralization success than observed during the 2014 operational assessment. However, preliminary results indicate performance is consistent with previous results in the same environment.
  - Following developmental testing in high-current environments in 2013, Navy Air Test and Evaluation Squadron Twenty One concluded that the AMNS neutralizer, as currently designed, is ineffective in swift water currents. Although the Navy completed additional developmental testing in 2015, the Navy's testing has not characterized system performance under operationally realistic conditions in even moderate currents that might be encountered in potential operating areas.
- Consistent with the concept of operations, the LCS is reliant on shore-based support for assistance with diagnosis and repair of MCM mission systems including ALMDS and AMNS. The mission package detachment lacks the wherewithal to handle anything beyond relatively uncomplicated preventive maintenance and minor repairs. Thus, when ALMDS and AMNS failures occur, the Navy assumes that in most cases these systems will be replaced by embarked or shore-based spares.

- Although TECHEVAL is intended to be developmental testing in nature, the test was designed to integrate the test objectives of both developmental and operational test communities. DOT&E personnel observed the testing aboard LCS 2. If the Navy elects to continue with the same system hardware and software configurations, DOT&E and the Navy will use the resulting data to supplement data collected during the operational test. If the Navy decides to go forward to operational testing with a new system, integrated test data collected in FY15 may not be representative of the system the Navy intends to field, and the Navy might need to repeat some portions of TECHEVAL to provide the requisite data.

Recommendations

- Status of Previous Recommendations. The Navy has partially addressed the FY11 recommendation to investigate solutions and correct the ALMDS False Classification Density and reliability deficiencies prior to IOT&E. The Navy has partially addressed the FY12 recommendation to assess corrections made to resolve previously identified Multi-spectral Targeting System (MTS) deficiencies by conducting FOT&E. The Navy has not acted or has yet to complete action on FY13 and FY14 recommendations to:
  1. Complete comprehensive survivability studies for MH-60S employing the 20 mm Gun System and the 2.75" Unguided Rocket Launcher.
  2. Conduct comprehensive live fire lethality testing of the HELLFIRE missile against a complete set of threat-representative small boat targets.
  3. Correct the tracking deficiencies in the MTS and conduct appropriate FOT&E in order to satisfactorily resolve the Surface Warfare Critical Operational Issue.
  4. Complete comprehensive IOT&E on the 2.75" Unguided Rocket and Advanced Precision Kill Weapon System II (APKWS II) to resolve the Surface Warfare Critical Operational Issue not resolved in limited assessments of system performance provided in Quick Reaction Assessments against small boat threats.
  5. Test the Surface Warfare mission capability of MH-60S helicopter equipped with MTS and the HELLFIRE missile throughout the operational mission environment in FOT&E and LFT&E.
  6. Complete vulnerability studies for MH-60S employing the LAU-61G/A Digital Rocket Launcher armed with APKWS II rockets.
  7. Conduct comprehensive lethality testing of the LAU-61G/A Digital Rocket Launcher armed with APKWS II rockets against a complete set of threat-representative small boat targets.
  8. Correct AMCM mission kit reliability issues that limit AMNS mission availability identified during the operational assessment.
  9. Develop corrective actions to eliminate early termination fiber-optic communications losses observed in the AMNS operational assessment.
  10. Conduct AMNS current testing from MH-60S.
- FY15 Recommendation.
  1. The Navy should provide LCS with a mine neutralization capability in water depths above the current AMNS operating ceiling.

Mine Resistant Ambush Protected (MRAP) Family of Vehicles (FoV) – Marine Corps

Executive Summary
- The U.S. Marine Corps will retain 2,510 Mine Resistant Ambush Protected (MRAP) vehicles in its enduring fleet including 300 Cougar Category (CAT) II A1 variants.
- Live fire testing conducted in FY15 indicates that the Cougar CAT II A1 variant with seat survivability upgrades will meet its required level of performance.
- The Marine Corps is planning to retrofit all retained Cougar variants with egress upgrades. Live fire testing of these upgrades will commence in 2QFY16, and the first test will be conducted on a CAT II A1 variant with both the seat and egress upgrades.

System
- MRAP Family of Vehicles (FoV) consists of medium-armored, all-wheel drive, tactical wheeled vehicles designed to provide protected mobility for personnel in a threat environment. Relative to the High Mobility Multipurpose Wheeled Vehicle, MRAPs provide improved crew protection and vehicle survivability against current battlefield threats, such as IEDs, mines, small arms fire, rocket-propelled grenades, and explosively formed penetrators.
- Based on a recommendation in DOT&E's 2010 assessment of the MRAP FoV to improve the seats in the Cougar A1 vehicles, the Marine Corps intends to retrofit the Cougar Cat II A1 vehicles with a seat survivability upgrade (SSU) kit. The SSU is primarily a redesign of the rear crew compartment of the Cougar, focusing on improved seating for vulnerability reduction, safety, and human factors integration. A Cat II A1 Cougar with the SSU can carry 10 Marines and 1 gunner.
- Currently, the Marine Corps will retain 2,510 MRAP vehicles in its enduring fleet, including 300 CAT II A1 vehicles. The Marine Corps will remain the Primary Inventory Control Activity for all Cougar platforms, including those vehicles divested to the Navy and Air Force.

Cougar Category (CAT) II A1

Mission
Commanders will employ Marine units equipped with the MRAP Cougar CAT II A1 to conduct mounted patrols, reconnaissance, communications, and command and control missions in a threat environment.

Major Contractor
General Dynamics Land Systems – Ladson, South Carolina

Activity
- The Marine Corps plans to retrofit a total of 263 Marine Corps, 41 Air Force, and 114 Navy CAT II A1 vehicles with the SSU upgrade. The SSU upgrade is designed to achieve Capabilities Production Document 1.1 objective-level force protection against underbody and under-wheel blast mines. The Marine Corps will also install egress upgrades on all of these vehicles, as well as other retained Cougar variants.
- From August 2014 through March 2015, the Marines Corps conducted three of four planned live fire tests of the CAT II A1 Cougar with the SSU. The fourth test, projected to occur in 2QFY16, will be conducted with both SSU and egress upgrades when egress modifications are available to be outfitted on the test asset.
- The Marine Corps conducted all testing in accordance with a DOT&E-approved test plan.

Assessment
- Live fire testing to date indicates that the Cougar CAT II A1 with the SSU meets its contract specifications and provides force protection at the required Capability Production Document 1.1 objective level. However, additional planned live fire testing remains to determine the response of the

Cougar Cat II A1 when outfitted with the both the SSU and egress modifications.
- The results from the legacy Cougar live fire test program (as found in the 2010 DOT&E report on the original MRAP FoV Cougar vehicles) relative to other tested threats such as IEDs, indirect fire, small arms fires, rocket-propelled grenades, and explosively-formed penetrators are applicable to the Cougar CAT II A1 with the SSU.

Recommendations
- Status of Previous Recommendations. The program is making progress implementing the previous recommendations regarding upgrading the seats in the Cougar CAT II A1 vehicles.
- FY15 Recommendations. None.

Mobile Landing Platform (MLP) Core Capability Set (CCS) (Expeditionary Transfer Dock) and Afloat Forward Staging Base (AFSB) (Expeditionary Mobile Base)

Executive Summary

- From August 25 through November 3, 2014, the Navy conducted the MLP (CCS) IOT&E.
- On July 6, 2015, DOT&E published a classified, combined IOT&E and LFT&E report and assessed that MLP (CCS):
  - Is capable of transiting the required 9,500 nautical miles at 15 knots unrefueled.
  - Can land and launch Landing Craft Air Cushion (LCAC) vehicles through Sea State 3.
  - Is operationally effective, achieving the primary timed requirement of enabling the transfer ashore of a reinforced rifle company's equipment within 12 hours from 25 nautical miles out to sea.
  - Can operate skin-to-skin, to include vehicle transfer through Sea State 3, with both the USNS *Bob Hope* (*Bob Hope* class) and USNS *Dahl* (*Watson* class) Large Medium Speed Roll-on roll-off (LMSR) ships.
  - Is not operationally effective in its interoperability with the Joint High Speed Vessel (JHSV) since it is only feasible when done in Sea State less than 1 (JHSV's ramp is limited to significant wave height of no more than 0.1 meters) conditions, which are normally only found in protected harbors. However, when tested in a more operationally relevant open-ocean environment, the JHSV ramp suffered a casualty.
  - Has satisfactory cybersecurity with no significant vulnerabilities. Even if a cyber-adversary gained access, overall ship's mission disruption would be minimal.
- The MLP program did not conduct any major live fire test events during FY15. The Navy plans to conduct the Total Ship Survivability Trial to obtain data for recoverability analysis on the MLP Afloat Forward Staging Base (AFSB) variant in FY16. The Navy plans to issue the final Survivability Assessment Report in FY17.

Core Capability Set (CCS)

Afloat Forward Staging Base (AFSB)

System

- The MLP (CCS) is now called the Expeditionary Transfer Dock, and the MLP (AFSB) is now called Expeditionary Mobile Base.
- The MLP is a modified heavy-lift ship based on the British Petroleum Alaska class oil tanker, procured by the Navy to use float-on/float-off technology.
- The Navy developed the MLP to host multiple mission sets, operate from international waters, and persist for extended periods providing a capability unencumbered by geo-political constraints to meet strategic goals.
- The MLP (CCS) requires 34 Military Sealift Command (MSC)-contracted mariners to operate and maintain the vessels. MLP AFSB requires 34 MSC civilian mariners and 101 permanent military crew to operate and maintain the vessels. MSC will serve as MLP Life Cycle Managers.
- The Navy delivered two MLPs with the CCS mission capabilities (hulls 1 and 2), and plans to deliver three MLPs with AFSB mission capability (hulls 3, 4, and 5).
- The MLP (CCS):
  - Supports Mobile Prepositioning Force operations by facilitating at-sea transfer and delivery of pre-positioned assets to units ashore.
  - Consists of a vehicle-staging area (raised vehicle deck), vehicle transfer ramp (VTR), large mooring fenders, an emergency-only commercial helicopter operating spot, and

three LCACs lanes/operating spots with barriers, catwalk, lighting, wash down, and fueling services.
  - Is equipped with a crane and work boat for placing of fenders used for skin-to-skin operations with an LMSR or JHSV.
  - Interfaces with the LMSR ships and LCACs and intends to interface with the follow-on Ship-to-Shore Connectors to permit off-load and transfer ashore of military vehicles ranging from High Mobility Multi-purpose Wheeled Vehicles to battle tanks (M1A2).
  - Is classified as a non-combatant with a limited self-protection capability.
- The MLP (AFSB):
  - Includes a two-spot flight deck, hangar facility, helicopter fueling capability, ordnance storage, operation planning and work spaces, and berthing for 101 permanent military crew and 149 personnel of an embarked military detachment.
  - Has a mission deck below the flight deck with a crane for storing and deploying the various mine-hunting and clearing equipment used with the MH-53E helicopters; explosive ordnance demolition boats and equipment may also be stored and handled on the mission deck.
  - Is classified as a non-combatant with a limited self-protection capability.
  - Is built to commercial standards with the ship structure remaining relatively the same as MLP (CCS). However, the aviation facilitates; forward house Command, Control, Communications, Computers and Intelligence suite; fueling at-sea station; and ordnance stowage and handling components are built to U.S. Navy standards.
  - Will be exposed to a larger number of threats than the MLP (CCS) variant; therefore, it will be dependent on other vessels to provide defense for more traditional anti-ship weapons encountered by naval vessels.

Mission
- Combatant Commanders will use the MLP (CCS) as a surface interface between other Mobile Prepositioning Force (future) squadron ships (such as LMSRs, and JHSVs), connectors (LCACs and Ship-to-Shore Connectors) and sea base to transfer personnel and equipment to facilitate delivery ashore of forces from the sea.
- Combatant Commanders will use the MLP (AFSB):
  - To support Airborne Mine Countermeasure operations including hosting a squadron of four legacy MH-53E helicopters
  - Provide storage and deploying capabilities of the various mine-detecting and clearing equipment, which are used with the helicopters
  - To support explosive ordnance demolition boats

Major Contractors
- MLP base ship and MLP AFSB: General Dynamic's National Steel and Shipbuilding Company (NASSCO) – San Diego, California
- CCS arrangement: Vigor Marine (Limited Liability Company) Shipbuilding – Portland, Oregon

---

Activity
- The Navy conducted the MLP (CCS) IOT&E from August 25 through November 3, 2014.
- DOT&E's FY14 Annual Report listed test activity through September 2014. This report outlines the last IOT&E events the Navy conducted from October through November 2014. The following test events were conducted at-sea, primarily in the vicinity of Camp Pendleton, California:
  - In October 2014, the Navy's Commander, Operational Test and Evaluation Force (COTF) conducted a 24-hour, 15-knot fuel economy trial as MLP 1 transited from the Seattle, Washington, area to Southern California waters.
  - In October 2014, COTF and the Marine Corps Operational Test and Evaluation Activity (MCOTEA) successfully conducted skin-to-skin operations through Sea State 3 with both the USNS *Bob Hope* (*Bob Hope* class) and the USNS *Dahl* (*Watson* class) LMSRs, to include vehicle transfer and LCAC operations in various tests.
  - On October 14, 2014, COTF and MCOTEA successfully completed the reinforced rifle company vehicle transfers via LCAC in a timed event. Although MLP 1 was not positioned 25 nautical miles from shore, the LCACs transited a route of 25 nautical miles both to shore and then back to MLP 1 for the next load to support the timed transfer requirement.
  - On October 29, 2014, COTF and MCOTEA attempted the open-ocean, day and night, interface test mooring of the JHSV to the MLP (CCS) vessel. USNS *Millinocket* (JHSV 3) moored skin-to-skin with USNS *Montford Point* (MLP 1 CCS) and a Marine Corps vehicle transited back and forth during daylight. An earlier mooring line problem, which occurred during a previous test (June 2014), was resolved but a JHSV ramp casualty precluded completion of the planned test.
  - In October 2014, COTF conducted a Critical System Maintenance Review with the ship's company to assist in evaluating suitability of both maintenance and logistics for the ship class.
  - On November 3, 2014, COTF and MCOTEA conducted a limited self-defense drill (no targets engaged) and a Structural Test Fire event that verified fields-of-fire and the 0.50 caliber machine gun mount structure suitability.
- USNS *Lewis B. Puller* (MLP 3 AFSB) launched in November 2014; completed builder trials in April 2015 and acceptance trials in May 2015; delivered in June 2015;

and conducted transit from San Diego, California, to Norfolk, Virginia, from August to October 2015.
- The MLP program did not conduct any major LFT&E events during FY15. The Navy plans to conduct the Total Ship Survivability Trial to obtain data for recoverability analysis of the MLP AFSB in FY16. The Navy plans to issue the final Survivability Assessment Report in FY17.
- In July 2015, DOT&E published a classified, combined IOT&E and LFT&E report on the MLP (CCS).
- The Navy conducted all testing in accordance with the DOT&E-approved Test and Evaluation Maser Plan and test plan.

Assessment
- Vehicle transfer at-sea with JHSV moored skin-to-skin with MLP (CCS) is not advised (mooring with JHSV is a secondary mission for MLP). The 0.1 meter significant wave height (Sea State 1) limitation of the JHSV ramp precludes operationally relevant at-sea vehicle transfers with MLP (CCS). Initial in-harbor testing was successful for vehicle transfers; however, while JHSV was moored skin-to-skin in calm seas with MLP (CCS), several mooring lines parted, precluding completion of the test event. During the second test event at-sea, the mooring line issue was resolved, but the JHSV ramp suffered a casualty and vehicle transfer had to be stopped. Sea state for the at-sea test was Sea State 3 (significant wave height up to 1.25 meters) although MLP (CCS) created a lee, effectively reducing the seas to just above Sea State 1 for the skin-to-skin mooring with JHSV.
- The MLP (CCS) is operationally effective provided that operations are conducted in a safe, well-guarded area with Sea State 3 conditions (equates to significant wave height up to 1.25 meters). When the MLP was positioned 25 nautical miles from the LCAC shore landing site, it met its timed transfer requirement, enabling Marine Corps equipment for a reinforced rifle company to be moved to shore in less than 12 hours.
- For operational scenarios that include Amphibious Assault Vehicles (AAVs) independently moving to shore, the MLP (CCS) demonstrated it could launch AAVs from within 5 nautical miles of the shore; launching AAVs that close to the shore is unlikely to be feasible in major combat. However, in that particular case, DOT&E estimates the transfer of a full reinforced rifle company's equipment set would span 52 hours and 49 minutes, owing to the time needed to move MLP (CCS) from 25 nautical miles to within 5 nautical miles from shore.
- Based on a 24-hour fuel economy trial, DOT&E estimates MLP (CCS) to have an un-refueled range of greater than 12,000 nautical miles, exceeding the 9,500-nautical mile requirement.
- The Navy demonstrated skin-to-skin operations and vehicle transfer through Sea State 3 with both the USNS *Bob Hope* (*Bob Hope* class) and USNS *Dahl* (*Watson* class) LMSRs.
- While conducting vehicle transfers between MLP (CCS) and LMSRs, the mild side-to-side rolling of the ships while moored skin-to-skin caused twisting of the VTR that must be monitored. Devices for monitoring the VTR twist were temporarily installed for testing. The sensitivity of the VTR to twisting warrants a permanent system.
- Accelerated wear of the Main Diesel Generators is expected due to prolonged electrical under-loading.
- Ship service electric power suffered from power spikes due to inadequate electronic grooming.
- The local cybersecurity test demonstrated that the network's host-based security system stopped most of COTF's cyber-attacks against unclassified and classified networks. As the ship's networks are not connected to the ship's critical systems, the loss of either unclassified or classified networks during operations would be an inconvenience, but would not hinder the ship's ability to conduct its mission since it has communication backups, including radios and standalone satellite phones.
- During the remote reconnaissance and cyber-attack evaluation, COTF was unable to gain a foothold on the MLP 1 networks with the toolset used for these assessments. However, the test did not explore the vulnerability of the ship to very advanced cyber threats due to security restrictions in place during the time of the test.
- MLP (CCS) is survivable only if used in benign and/or permissible environments.
  - MLP (CCS) is designed and built to commercial standards that do not include hull and equipment hardening or personnel protection features necessary to survive major weapon effects.
  - MLP (CCS) has no active or passive systems to reduce susceptibility to enemy weapons.
  - The design has only limited system redundancy and separation to improve vulnerability and recoverability.
- The effectiveness of area defense provisions was not assessed as part of this test and evaluation program.
  - Although the Embarked Security Teams, which consist of 12 members, are manned with well-trained individuals equipped with 0.50-caliber weapons, they can only support a 24-hour day manning of four stations. There are little test data to suggest they provide effective force protection.
  - For close-in self-defense, the security teams embark with their own weapons and ammunition.

Recommendations
- Status of Previous Recommendations. The Navy still needs to address the FY14 recommendation to re-evaluate the need for at-sea skin-to-skin operations between MLP (CCS) and JHSV.
- FY15 Recommendations. The Navy should:
  1. Install permanent VTR twist sensors and provide a display monitor on the MLP (CCS) ships to assist the MLP (CCS) Master during skin-to-skin operations.
  2. Install a separate Ship Service Diesel Generator to minimize periods of under-loading of the Main Diesel Generators.
  3. Install additional ship service electrical grooming equipment to alleviate ship service power spikes and minimize damage to sensitive electronic equipment.

4. Address the cybersecurity and live fire issues identified in the classified annex to the July 2015 DOT&E combined IOT&E and LFT&E report.
5. Conduct a robust, self-defense test utilizing live ammunition and realistic targets in support of the MLP (AFSB) IOT&E.

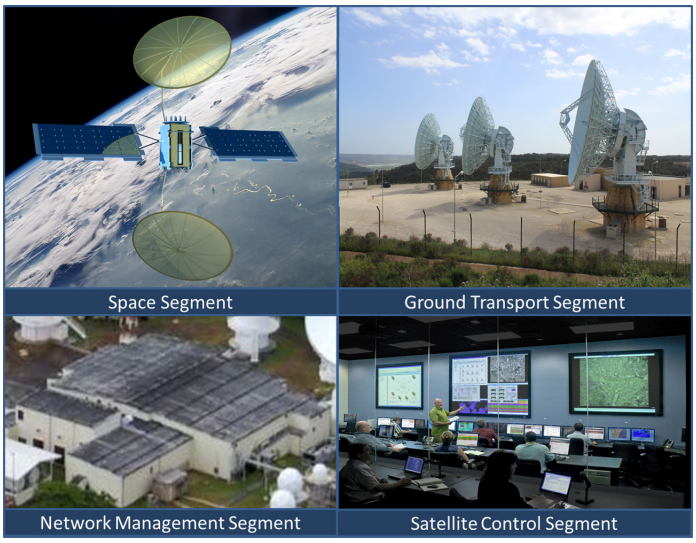
Mobile User Objective System (MUOS)

Executive Summary

- The Navy program manager conducted a government developmental test from June 1 – 30, 2015, in preparation for operational testing.
- The Navy's Commander, Operational Test and Evaluation Force (COTF) conducted the Mobile User Objective System (MUOS) Multi-Service Operational Test and Evaluation (MOT&E) from October 19 through November 20, 2015. COTF is planning to conduct a two-phased cybersecurity assessment on the MUOS system in conjunction with the MOT&E in November 2015 and 2QFY16.
- The program manager has made progress integrating the end-to-end MUOS capability. Technical Evaluation results suggest that deployed users can reliably make point-to-point data and voice calls and point-to-net data calls. MUOS group communications, which allows the system to maintain links between all users in group networks, is not as reliable and may lead to the loss of mission information and situational awareness for some users.
- As of October 19, 2015, there were over 200 high-priority hardware and software problems remaining on the system. The program manager has prioritized them and is fixing as funding allows; however, most of the problems will not be fixed in time for the MOT&E.
- The geolocation capability is still in development and therefore, will not be ready for testing in the 2015 MOT&E. This capability will need to be operationally tested once it is mature. Geolocation is the ability to locate a legacy Ultra-High Frequency (UHF) electromagnetic interferer on the ground.

System

- MUOS is a satellite-based communications network designed to provide worldwide, narrowband, beyond line-of-sight, point-to-point, and netted communication services to multi-Service organizations of fixed and mobile terminal users. The Navy designed MUOS to provide 10 times the throughput capacity of the current narrowband satellite communications. The Navy intends for MUOS to provide increased levels of system availability over the current constellation of UHF Follow-On satellites and to improve availability for small, disadvantaged terminals.
- MUOS consists of six segments:
  - The space segment consists of four operational satellites and one on-orbit spare. Each satellite hosts two payloads: a legacy communications payload that mimics the capabilities of a single UHF Follow-On satellite and a MUOS communications payload.
  - The Ground Transport Segment is designed to manage MUOS communication services and allocation of radio resources.



  - The Network Management Segment is designed to manage MUOS ground resources and allow for government controlled precedence-based communication planning.
  - The Ground Infrastructure Segment is designed to provide transport of both communications and command and control traffic between MUOS facilities and other communication facilities.
  - The Satellite Control Segment consists of MUOS Telemetry, Tracking, and Commanding facilities at the Naval Satellite Operations Center Headquarters and Detachment Delta.
  - The User Entry Segment provides a MUOS waveform hosted on MUOS-compatible terminals. The Army's Program Manager Tactical Radio is responsible for developing and fielding MUOS-compatible terminals. The Air Force and Navy are upgrading legacy UHF radios to be MUOS-compatible.

Mission

Combatant Commanders and U.S. military forces deployed worldwide will use the MUOS satellite communications system to accomplish globally assigned operational and joint force component missions, especially those involving highly mobile users. Such missions include major conventional war; regional conflicts; search and rescue; humanitarian or disaster relief (including severe weather events); homeland security; homeland defense; counter-narco-terrorism; non-combatant; evacuation operations; very important person travel; strategic airlift; global mobility; global strike; Intelligence, Surveillance, and Reconnaissance; training; logistics support; and exercise support.

Major Contractors
- Lockheed Martin Space Systems – Sunnyvale, California
- General Dynamics C4 Systems – Scottsdale, Arizona

Activity
- The Navy successfully launched the MUOS-3 satellite on January 20, 2015. The satellite is reached its geosynchronous orbital slot over the Atlantic Ocean on August 2, 2015.
- The Navy successfully launched the MUOS-4 satellite on September 2, 2015. The satellite is in transit to the geosynchronous orbital test slot in preparation for contractor testing in 1Q-2QFY16.
- In 1QFY14, MUOS-5 production began and the Navy anticipates a launch in 3QFY16.
- From January 2014 through May 2015, the program manager conducted end-to-end integration efforts with the Army-developed AN/PRC-155 Manpack radio using the MUOS waveform, including multiple satellites, the MUOS Ground Infrastructure and Transport Segments, and the Network Management Segment.
- In January through May 2015, the program manager conducted several communications demonstrations including one with U.S. Northern Command in the Arctic, one with the U.S. Pacific Command in the Antarctic, and a risk reduction demonstration with a MUOS terminal operating aboard a U.S. Air Force C-17 Globemaster III over the Pacific Ocean.
- The Navy program manager conducted a government developmental test from June 1 – 30, 2015 in preparation for operational testing.
- COTF conducted the MUOS MOT&E from October 19 through November 20, 2015, in accordance with the DOT&E-approved the Test and Evaluation Master Plan and test plan.
- The geolocation capability is still in development and therefore, will not be ready for testing in the 2015 MOT&E. This capability will need to be operationally tested once it is mature. Geolocation is the ability to locate a legacy UHF electromagnetic interferer on the ground.
- COTF is planning to conduct a two-phased cybersecurity assessment on the MUOS system in conjunction with the MOT&E in November 2015 and 2QFY16. COTF conducted the phase-one Cooperative Vulnerability and Penetration Assessment in November 2015 and is planning a phase-two Adversarial Assessment in 2QFY16.
- In September 2015, the program manager requested a deferral of the geolocation capability from the MOT&E.

Assessment
- The program manager has made progress integrating the end-to-end MUOS capability. Technical Evaluation results suggest that deployed users can reliably make point-to-point data and voice calls and point-to-net data calls.
- MUOS group communications, which allow the system to maintain links between all users in group networks, is not as reliable and may lead to the loss of mission information and situational awareness for some users.
- The ability of MUOS to create, analyze, and implement communications plans is problematic. The system occasionally freezes when analyzing what network resources are available and the network data MUOS produces is sometimes inaccurate. Without a valid and accurate communications plan, the MUOS cannot create configurations for all of the radios and users cannot establish communications with one another.
- The fault management system of the Network Management Segment provides a large number of faults, unclear faults, and erroneously prioritized faults to the system operators. This leads to poor failure awareness on the part of the system operators. Uncorrected failures could lead to loss of communications for deployed end-users.
- During developmental test periods, hardware failures at the Radio Access Facilities led to the loss of as much as half of the communications resources on a single satellite.
- As of October 19, 2015, there were over 200 high-priority hardware and software problems remaining on the system. The program manager has prioritized them and is fixing as funding allows; however, most of the problems will not be fixed in time for the MOT&E.
- The operational testers expect to find system deficiencies during the planned cybersecurity assessment based on known cybersecurity vulnerabilities discovered during the program manager's developmental testing.
- The geolocation capability is still in development and therefore, will not be ready for testing in the MOT&E.

Recommendations
- Status of Previous Recommendations. The Navy adequately addressed all previous recommendations.
- FY15 Recommendations. The Navy should:
  1. Update the Test and Evaluation Master Plan to include future testing of the geolocation capability once it is mature and re-testing any fixes to problems found during MOT&E.
  2. Fund the MUOS program at a level whereby they can address the high-priority hardware, software, and cybersecurity problems in time for the next operational test event.

MQ-4C Triton Unmanned Aircraft System (UAS)

Executive Summary

- The Navy began an operational assessment (OA) of the MQ-4C Triton Unmanned Aircraft System (UAS) in November 2015 in support of a planned 2QFY16 Milestone C decision. The OA is anticipated to complete in 1QFY16. DOT&E will submit a classified OA report in 3QFY16.
- Developmental flight testing of the MQ-4C with integrated mission systems and the Integrated Functional Capability (IFC) 2.2 software began in April 2015, following a delay due to a lag in development of IFC 2.2. Poor system stability and defect discovery consistent with early developmental testing slowed the progress of developmental testing of the mission systems. The delay in the development of IFC 2.2 and the slower than anticipated pace of IFC 2.2 developmental testing postponed the start of the OA.
- The program continues to pursue a solution providing traffic de-confliction and collision avoidance capability ("due regard") since stopping the development of the Air-to-Air Radar Subsystem. The program intends to select a technical solution in FY16 for delivery after Initial Operational Capability (IOC). The Navy is investigating alternative means of due regard compliance including procedures and other cooperative avoidance systems already integrated in the MQ-4C in order to support Triton operations at IOC.

System

- The MQ-4C Triton UAS is an Intelligence, Surveillance, and Reconnaissance system-of-systems consisting of the high-altitude, long endurance MQ-4C air vehicle, sensor payloads, and supporting ground control stations. The MQ-4C system is a part of the Navy Maritime Patrol and Reconnaissance family-of-systems and will provide multiple types of surveillance data over vast tracks of ocean and littoral areas; overland Intelligence, Surveillance, and Reconnaissance; signals intelligence and target acquisition capabilities designed to complement the P-8A Poseidon Multi-mission Maritime Patrol aircraft.
- The MQ-4C air vehicle design is based on the Air Force RQ-4B Global Hawk air vehicle with significant modifications that include strengthened wing structures and an anti-ice and de-icing system.
- Mission systems include a maritime surveillance radar to detect, identify, and track surface targets and produce high-resolution imagery.
  - An electro optical/infrared sensor provides full motion video and still imagery of surface targets and the electronic support measures system detects, identifies, and geolocates radar threat signals.
  - An Automatic Identification System (AIS) receiver permits the detection, identification, geolocation, and tracking of cooperative maritime vessels equipped with AIS transponders.
- Planned future system upgrades include an air traffic collision avoidance radar system and a signals intelligence collection system. Onboard line-of-sight and beyond line-of-sight datalink and transfer systems provide air vehicle command and control and transmit sensor data from the air vehicle to ground control stations for dissemination to fleet tactical operation centers and intelligence exploitation sites.

Mission

- Commanders use units equipped with MQ-4C to conduct long endurance maritime surveillance operations and provide high- and medium-altitude intelligence collection.
  - MQ-4C operators will detect, identify, track, and assess maritime and littoral targets of interest and collect imagery and signals intelligence information.
  - Operators disseminate sensor data to fleet units to support a wide range of maritime missions to include surface warfare, intelligence operations, strike warfare, maritime interdiction, amphibious warfare, homeland defense, and search and rescue.

Major Contractor

Northrop Grumman Aerospace Systems, Battle Management and Engagement Systems Division – Rancho Bernardo, California

Activity

- Developmental flight testing of the MQ-4C with integrated mission systems and IFC 2.2 began in April 2015. Poor system stability and defect discovery consistent with early developmental testing slowed the progress of developmental testing of the mission systems and delayed the start of the OA.
- The Navy began an OA of the MQ-4C in November 2015, in support of a planned 2QFY16, Milestone C decision. The OA is anticipated to complete in 1QFY16. DOT&E will submit a classified OA report in 3QFY16.
- The program continues to pursue a solution providing traffic de-confliction and collision avoidance capability since development of the Air-to-Air Radar Subsystem was stopped. The program intends to select a technical solution in FY16 for delivery after IOC. The Navy is investigating alternative means of due regard compliance including procedures and other cooperative avoidance systems already integrated in the MQ-4C in order to support MQ-4C operations at IOC.
- Since the MQ-4C is not yet authorized to operate on Navy operational networks, the Navy did not accomplish a cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) of the MQ-4C during the OA.

Assessment

- Traffic de-confliction and collision avoidance provide critical mission capability for operation of the MQ-4C in civil and international airspace in support of global naval operations. Any limitation to this capability at IOT&E will reduce the effectiveness of the MQ-4C.
- When Triton can operate on operational networks, the Navy should accomplish a CVPA to allow the program to determine any cybersecurity vulnerabilities in the system.

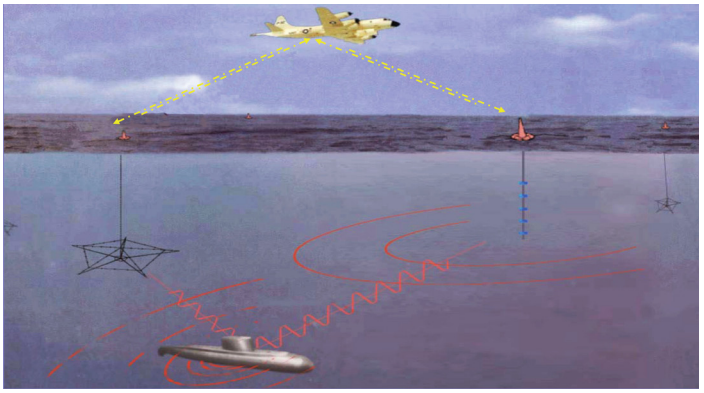
Recommendations

- Status of Previous Recommendations. The Navy began the planned OA in FY15 and intends to demonstrate the tactics and procedures necessary that will enable Triton to descend to low and medium altitude.
- FY15 Recommendations. The Navy should:
  1. Demonstrate any alternative means of compliance with the due regard requirement during developmental testing under operationally realistic conditions prior to IOT&E.
  2. Conduct a CVPA sufficiently in advance of the Adversarial Assessment during IOT&E to allow the program to correct any discovered vulnerabilities.

Multi-Static Active Coherent (MAC) System

Executive Summary
- The Navy completed the integration of the Multi-Static Active Coherent (MAC) Phase I system on P-8A Poseidon aircraft and conducted FOT&E in accordance with a DOT&E-approved test plan from March 2014 through February 2015.
- P-8A FOT&E results indicate that the MAC Phase 1 system provides P-8A aircraft with an early wide-area Anti-Submarine Warfare (ASW) search capability in some operational environments and in select scenarios, but it does not meet the MAC Phase I program's requirements in other environments or scenarios. The P-8A's MAC wide-area ASW search capability is similar to the capability on P-3C aircraft.
- The FOT&E did not fully examine the capability of MAC across all operational conditions, representative operational environments, and target types.
- DOT&E submitted an FOT&E report on the P-8A's wide-area ASW search capability with the MAC Phase 1 system in December 2015. The report also updated DOT&E's assessment of the ASW mission capability provided by the MAC system on the P-3C aircraft.
- The Navy plans to install MAC system software and display improvements on the P-8A with Increment 2 Engineering Change Proposal (ECP) 2 in FY15 and FY16 and conduct the P-8A aircraft wide-area ASW search assessment in mid-FY16.

System
- The MAC system is an active sonar system composed of two types of sonobuoys (source and receiver) and an acoustic processing and aircraft mission computer software suite. It is employed by the Navy's maritime patrol aircraft (P-3Cs and P-8As) to search for and locate threat submarines in a variety of ocean conditions.
- MAC replaces the Navy's current Improved Extended Echo Ranging (IEER) system, which employs non-coherent sources to produce loud sounds that reflect off submarine targets. MAC employs new coherent source buoys that enable multiple pings, optimized waveforms, and various ping durations, none of which the legacy IEER system provided. The Navy is planning a series of enhancements to the MAC software and improvements to the MAC buoys.



- To plan MAC missions, the Navy has updated the Active System Performance Estimate Computer Tool (ASPECT)/Multi-static Planning Acoustics Toolkit previously used to plan IEER system missions.
- The Navy intends to employ MAC on P-3C and P-8A aircraft in a limited set of acoustic environments. Future increments of MAC will be employed on P-8A aircraft and in a wider variety of acoustic ocean environments in order to span the operational envelope of threat submarine operations. MAC will be the primary wide-area acoustic search system for the P-8A.
- MAC is expected to have fewer effects on marine mammals and the environment than the legacy IEER system.

Mission

The Navy intends for P-3C and P-8A crews equipped with MAC to support the search, detect, and localization phases of the ASW mission. MAC is particularly focused on large-area active acoustic searches for threat submarines.

Major Contractors
- Lockheed Martin – Manassas, Virginia
- Sparton Electronics Florida, Inc. – De Leon Springs, Florida
- Ultra Electronics, Undersea Sensor Systems Incorporated (USSI) – Columbia City, Indiana
- Boeing Defense, Space, and Security – St. Louis, Missouri

Activity
- The Navy completed integrating the MAC Phase 1 system onto the P-8A aircraft and conducted FOT&E of the P-8A's early wide-area search capability with the MAC from March 2014 through February 2015. The Navy completed IOT&E of the MAC Phase 1 system on the P-3C Multi-mission Aircraft in October 2013. The Navy conducted the operational testing in accordance with a DOT&E-approved test plans.
- DOT&E submitted an FOT&E report on the P-8A's wide-area ASW search capability with the MAC system

in December 2015. The report also updates DOT&E's assessment of the ASW mission capability provided by the MAC system on P-3C aircraft.
- The Navy and DOT&E commenced developing a Test and Evaluation Master Plan (TEMP), which includes deferred MAC testing and plans for the MAC Phase 2 improvements. To efficiently utilize test resources, DOT&E required the test program be consistent with and utilize MAC events programmed in the approved P-8A Increment 2 TEMP. Because future MAC testing is planned to occur on the P-8A, the Navy intends to integrate the Phase 2 MAC test plan into the P-8A Increment 3 TEMP.
- The Navy and DOT&E started development of the P-8A Increment 2 ECP 2 FOT&E test plan, which allow the Navy to evaluate the P-8A's MAC system software and display improvements and complete deferred testing with diesel electric submarines.

Assessment
- DOT&E assessed that the MAC system provides the P-8A and the P-3C aircraft with a wide-area ASW search capability in some environments and for select target scenarios, but that MAC falls short of what the fleet identified as the capability needed to protect high-value units. Although testing identified P-8A's higher speed and revised buoy field installation tactics reduced the search field buoy installation time, DOT&E assessed MAC detection performance was similar to the P-3C's performance and independent of the aircraft platform. Testing identified that detection performance strongly relies on the characteristics of the ocean environment and the tactics employed by the target to evade detection. Testing to understand the effects different threat types and environments have on performance will continue through FY19 in conjunction with the P-8A Increment 2 test program.
- The P-8A FOT&E and the P-3C IOT&E did not fully examine the capability of MAC across all operational conditions, representative operational environments, and target types. DOT&E agreed to limit testing of the initial phase of MAC because the Navy planned to install MAC system software and display improvements on P-8A during Increment 2 ECP 2 and conduct additional testing to evaluate the P-8A's wide-area search capability in FY16.
- Although the MAC system demonstrated a detection capability against evasive undersea targets, acoustic operators were expected to quickly distinguish system submarine detections from a variety of non-submarine clutter detections, some of which appeared target-like. Complicating this task, completed test analysis identified that the MAC system detections of target and non-target clutter varies with environmental conditions and likely target types. The data also show operators are only able to recognize a small fraction of valid system submarine detections as a possible target and spent time assessing and prosecuting false targets.
- The Navy uses ASPECT/Multi-static Planning Acoustics Toolkit to develop MAC search plans and to estimate theoretical system performance. In addition to the incomplete environmental databases used by ASPECT when modeling many threat operating areas, the planning tool performance estimates are highly dependent on the wide-range of potential mission planning input parameters estimated by the mission planner. As a result, ASPECT performance estimates can widely vary when compared to test results. The Navy's Oceanographic Office is updating these environmental databases, focusing first on forward operating areas. Since ASPECT does not have a good estimate for the operator recognition of the submarine target, it overestimates ASW detection performance.
- Additional information is detailed in DOT&E's classified FOT&E report on the P-8A with MAC System dated December 2015, and the IOT&E report on the MAC System on P-3C aircraft dated July 2014.

Recommendations
- Status of Previous Recommendations. The Navy is making progress on the FY13 and FY14 recommendations. The status of significant unclassified recommendations remaining include:
  1. The Navy Program Office is investigating fleet exercise data to assess detection performance and to gather data for developing future algorithm and software improvements. The fleet exercise data include new environments where the fleet operates in peacetime. The Navy is planning the outstanding MAC operational testing against different target types. This testing will be in conjunction with P-8A Increment 2 ECP-2 FOT&E.
  2. The Navy has not completed development of a sustainable MAC training program or completed the formal updates to tactics guidelines and documentation.
  3. The Navy has not developed processes for aircrews to better understand the environmental conditions in the search area. The Navy developed a complex process for estimating the environmental conditions in operational test areas to improve ASPECT predictions; however, the process is not timely or usable by typical aircrews. The Navy should continue to investigate methods for aircrews to measure environmental conditions in the search area and to adjust the MAC search plan appropriately when the conditions change.
  4. The Navy is investigating the MAC system's capability for longer-range detections based on the environmental conditions in the search area.
- FY15 Recommendations. The Navy should implement the recommendations found in DOT&E's P-8A with the MAC system FOT&E report. DOT&E provided 14 recommendations to improve the MAC system performance and 6 recommendations to improve test realism, minimize test limitations, and improve data collection. Significant unclassified recommendations include:
  1. Investigate and develop tactics to improve the operator's ability to transition system detections to high confidence target detection. Consider measures to balance operator

workload and update search plans based on the actual conditions experienced in the search area.
2. Investigate the system's capability for longer-range detections based on the environmental conditions in the search area.
3. Investigate and develop improvements to the ASPECT planning system and the supporting databases.

MV-22 Osprey

Executive Summary

- The Navy conducted OT-IIIK FOT&E from March 2015 through August 2015 to evaluate the Mission Computer Obsolescence Initiative (MCOI) and upgrades to the Defensive Weapon System (DWS), the Ramp Mounted Weapon System (RMWS), and the Blue Force Tracker (BFT).
- Units equipped with the modified MCOI aircraft remain effective and suitable.
- The DWS was not effective because of safety restrictions that limit the use of the DWS during arrival or departure from landing zones and was not suitable due to poor reliability.
- RMWS effectiveness was limited by poor reliability during the operational test.
- BFT-2 is not mature. Text messages were slow and image transfers were unsuccessful.
- The MV-22 and supporting systems are vulnerable to nearsider and insider cybersecurity attacks.
- MV-22 OT-IIIK aircraft demonstrated reliability, availability, and maintainability consistent with the fleet.

System

- There are two variants of the V-22 Osprey: the Marine Corps MV-22 and the Air Force/U.S. Special Operations Command CV-22. The air vehicles for Air Force and Marine Corps missions are nearly identical, with common subsystems and military components sustainable by each Service's logistics system.
- The Marine Corps is replacing the now-retired CH-46 and CH-53D helicopters with the MV-22. The MV-22 is a tilt rotor aircraft capable of conventional wing-borne flight and vertical take-off and landing.
- The MV-22 can carry 24 combat-equipped Marines and operate from ship or shore. It can carry an external load up to 10,000 pounds over 50 nautical miles and can self-deploy 2,363 nautical miles with a single aerial refueling.
- Recent system upgrades include the following:
  - The MCOI computer hardware initiative designed to improve the performance of the existing Advanced Mission Computer architecture by adding greater processing speed and more data storage while maintaining the same functionality as the original computer.
  - GAU-17 DWS improvements (upgraded with a sensor-only mode that allows the gunner to use the electro-optical sensor when the gun turret is not being used). The DWS is a turreted, remotely operated, all-quadrant 7.62 mm defensive weapon system designed for fire suppression against ground troops and soft targets.
  - Updated BFT-2 GPS-enabled system that receives information on friendly, neutral, and hostile forces, as well as sends and receives text and image messages via a federated cockpit display.
  - GAU-21 .50 caliber RMWS replaced the GAU-18 RMWS.

Mission

- Squadrons equipped with MV-22s will provide medium-lift assault support in the following operations:
  - Ship-to-Objective Maneuver
  - Sustained operations ashore
  - Tactical recovery of aircraft and personnel
  - Self-deployment
  - Amphibious evacuation

Major Contractors

Bell-Boeing Joint Venture:

- Bell Helicopter – Amarillo, Texas
- The Boeing Company – Ridley Township, Pennsylvania

Activity

- The Navy conducted OT-IIIK FOT&E from March 2015 through August 2015 in accordance with the DOT&E-approved test plan dated February 20, 2015. This dedicated OT&E accumulated over 130 flight hours, which had been preceded by over 400 flight hours of integrated testing.

- Marine Corps pilots conducted testing at or near the Marine Corps Air Station New River, North Carolina; Kirtland AFB, New Mexico; and Marine Corps Air Station Yuma, Arizona, using three production-representative Advanced Mission Computer aircraft (which is the original pre-MCOI configuration) and one production representative MCOI aircraft.
- The Navy conducted cybersecurity testing of the MV-22 and its supporting systems at New River, North Carolina, in May 2015. DOT&E observed all operational and cybersecurity testing.
- DOT&E evaluated capabilities of the latest aircraft upgrades to include the MCOI, and upgrades to the DWS, RMWS, and the updated BFT-2.

Assessment

- Units equipped with MCOI aircraft remain effective and suitable. During the test, the unit successfully completed all assigned missions, but discovered deficiencies that hindered, but did not prevent, the ability of the unit to perform its mission.
  - MCOI aircraft are not compatible with the DWS. The program manager has identified a fix to this deficiency that will be implemented and tested in FY16.
  - The DWS was not effective because of safety restrictions that limit the use of the DWS during arrival or departure from landing zones, and was not suitable due to poor reliability demonstrated during the operational test.
  - The presence of the DWS sensor video in the cockpit improved target coordination between the gunner and the pilot. Pilots could now confirm the gunner was aiming at the correct target using the DWS cockpit video, something pilots previously could not confirm and which resulted in instances where the gunner mistakenly shot the wrong target.
  - RMWS effectiveness was limited by poor reliability during the operational test. The mean rounds between an uncommanded stoppage is 201, well below the requirement of 600 rounds.
  - BFT-2 image message capability is not yet mature and text messages can be slow and irrelevant by the time messages arrive at the intended recipient. No images were successfully received during operational testing. Pilot surveys indicated some transmitted text messages were not received
- The MV-22 and supporting systems are vulnerable to nearsider and insider cybersecurity attacks.
- The OT-IIIK MV-22 aircraft met reliability requirements and did not meet maintainability and availability thresholds. Demonstrated reliability, maintainability, and availability performance is consistent with that of the MV-22 fleet.

Recommendations

- Status of Previous Recommendations. The Navy has made progress addressing the previous FY14 recommendations to continue to execute its reliability growth program for the MV-22 fleet; focus on reliability issues with the greatest effect on operational availability and operational cost; and improve the icing protecting system, which will be tested in FY16.
- FY15 Recommendations. The Navy should:
  1. Address failure modes and supply issues that limit aircraft availability.
  2. Use Marine Air-Ground Task Forces to employ tactics, techniques, and procedures to compensate for limitations in the DWS.
  3. Integrate DWS with MCOI and test its capability in an operational test.
  4. Improve BFT-2 message latency.
  5. Investigate and improve RMWS reliability.
  6. Address cyber vulnerabilities of the MV-22 and its supporting systems.

P-8A Poseidon Multi-Mission Maritime Aircraft (MMA)

Executive Summary

- The Navy conducted P-8A Increment 2 Engineering Change Proposal (ECP 1) FOT&E with the Multi-Static Acoustic (MAC) Phase 1 sensor system from March 2014 through February 2015. The December 2015 DOT&E P-8A Increment 2 ECP 1 FOT&E report concludes that the MAC Phase 1 sensor system provides an early P-8A wide-area, Anti-Submarine Warfare (ASW) search capability similar to P-3C MAC search capability. DOT&E assessed that the P-8A's detection capability with the MAC Phase 1 sensor system is strongly dependent on the environmental conditions present in the search area and the actions taken by adversaries to avoid detection. Although the MAC Phase 1 sensor system provides an effective capability in some environments and scenarios, it fails to deliver the full capability described by the Navy P-8A ASW concept of operations and MAC operational requirement documents.
- The Navy completed a P-8A Data Storage Architecture Upgrade (DSAU) Verification of Correction of Deficiencies FOT&E event in November 2015. This test includes verification of corrective actions implemented for nine previously identified system deficiencies and includes evaluation of mission performance and cybersecurity after installation of an improved mission data storage architecture.
- The Navy continues to develop and test corrective actions for more than 60 open system deficiencies identified as operationally significant during previous test periods, including the 2012 P-8A Increment 1 IOT&E and 2013 P-8A Increment 1 FOT&E events. The next significant evaluation of deficiency corrections is planned to occur as early as the FY16 P-8A Increment 2 ECP 2 operational test.
- The Navy completed the second lifetime of the P-8A full-scale structural fatigue testing in June 2015. This phase of testing identified localized fatigue cracking in non-critical structural components, including replaceable pressure web and aircraft tail section components. Preliminary results have not identified any significant, near-term structural concerns or fleet operating limitations. The program is currently reviewing these results to identify fleet airframe inspection requirements and depot repair procedures to ensure the airframe meets the intended 25-year design life.

System

- The P-8A Poseidon Multi-mission Maritime Aircraft design is based on the Boeing 737-800 aircraft with significant modifications to support Navy maritime patrol mission requirements. It is replacing the P-3C Orion.
- The P-8A incorporates an integrated sensor suite that includes radar, electro-optical, and electronic signal detection sensors to detect, identify, locate, and track surface targets. An integrated acoustic sonobuoy launch and monitoring system detects, identifies, locates, and tracks submarine targets. Sensor systems also provide tactical situational awareness information for dissemination to fleet forces and Intelligence, Surveillance, and Reconnaissance (ISR) information for exploitation by the joint intelligence community.

- The P-8A carries MK 54 torpedoes and the AGM-84D Block 1C Harpoon anti-ship missile system to engage submarine and maritime surface targets.
- The P-8A aircraft incorporates aircraft survivability enhancement and vulnerability reduction systems. An integrated infrared missile detection system, flare dispenser, and directed infrared countermeasure system is designed to improve survivability against infrared missile threats. On and off-board sensors and datalink systems are used to improve tactical situational awareness of expected threat systems. Fuel tank inerting and fire protection systems reduce aircraft vulnerability.
- The Navy is integrating the MAC sensor system into the P-8A to provide a wide-area active, ASW search capability.
- Planned future upgrades include the addition of net-enabled ASW and ASW weapons, high-altitude ASW capabilities, MAC wide-area ASW search enhancements, signals intelligence sensors, and advanced mission system architectures and processing upgrades.

Mission

- Theater Commanders primarily use units equipped with the P-8A Multi-mission Maritime Aircraft to conduct ASW operations including the detection, identification, tracking, and destruction of submarine targets.
- Additional P-8A maritime patrol missions include:
  - ASW operations to detect, identify, track, and destroy enemy surface combatants or other maritime targets

- ISR operations to collect and disseminate imagery and signals information for exploitation by the joint intelligence community
- C3 operations to collect and disseminate tactical situation information to fleet forces
- Identification and precise geolocation of targets ashore to support fleet Strike Warfare missions

Major Contractor
Boeing Defense, Space, and Security – St. Louis, Missouri

Activity

- The Navy completed the MAC Phase 1 IOT&E on the P-3C aircraft in 2013, followed by integration of the MAC Phase 1 sensor system into the P-8A aircraft in November 2013.
- From March 2014 through February 2015, the Navy conducted the P-8A Increment 2 ECP 1 FOT&E with the MAC Phase 1 sensor system. During FOT&E, the Navy conducted 10 wide-area, ASW search events to obtain the 8 valid search events required by the DOT&E-approved test plan. Because MAC Phase 1 sensor system performance was similar to P-3C performance, DOT&E utilized both the P-3C MAC IOT&E data and the P-8A MAC FOT&E data to provide a statistically significant assessment of P-8A early wide-area, ASW search performance. DOT&E submitted the P-8A Increment 1 ECP 1 FOT&E classified report for the MAC Phase I capability in December 2015.
- The Navy completed a P-8A DSAU Verification of Correction of Deficiencies FOT&E event in November 2015. This test evaluated improvements in ASW and ISR mission data loading and storage following the DSAU modification. This test event also included testing to verify corrections for nine previously identified weapons bay, electronic signal collection, Information Assurance, and avionics integration deficiencies, as well as a system level cybersecurity assessment.
- The Navy continues to develop and test corrective actions for more than 60 open system deficiencies identified as operationally significant during previous test periods, including the 2012 P-8A Increment 1 IOT&E and 2013 P-8A Increment 1 FOT&E events. Operational testing of these improvements, including a complete re-evaluation of P-8A ISR mission capabilities, and re-evaluation of the P-8A's MAC wide-area, ASW search capability is planned as early as the FY16 P-8A Increment 2 ECP 2 FOT&E.
- The Navy continued P-8A Increment 3 test planning in FY15. This next phase of P-8A capability enhancements includes significant system architecture changes, communication system upgrades, radar and electronic signal sensor upgrades, and the AGM-84 Harpoon 2+ anti-ship missile. Developmental testing will begin in FY16 with operational test events planned for FY18, FY19, and FY22.
- In FY15, the Navy planned a series of limited, quick reaction tests to field P-8A system modifications or additional capabilities requested by fleet units or Combatant Commands. Quick reaction operational testing supported fielding of the UNI-PAC II Search and Rescue Kit and upgraded Directed Infrared Countermeasure sensors to provide full spherical video coverage around the P-8A aircraft.
- The Navy completed the second lifetime of the P-8A full-scale fatigue and durability testing in FY15 using the fifth P-8A production aircraft. Concurrent "off-aircraft" fatigue testing of the horizontal stabilizer completed the equivalent of two design lifetimes of testing. Residual strength testing on the full-scale test article and horizontal stabilizer will continue into FY16. Main and nose landing gear subassemblies completed the equivalent of three lifetimes of fatigue testing in FY15. Landing gear post-test teardown and data review is in progress. Final fatigue test analysis and results are expected to be available in late FY16.

Assessment

- The 2015 DOT&E P-8A Increment 2 ECP 1 FOT&E classified report concludes that P-8A MAC Phase 1 and P-3C MAC Phase 1 sensor systems provide similar wide-area, ASW search capabilities that are not currently provided by other passive search systems. Test results show that MAC Phase 1 sensor capabilities on both aircraft platforms are strongly dependent on search area environmental conditions and adversary evasive actions. During OT&E, MAC Phase 1 clearly provided an effective capability in some test environments and target evasion profiles, but failed to deliver the full capability required by the Navy's concept of operations and MAC operational requirement documents. Additional information on MAC Phase 1 performance is contained in the DOT&E P-3C MAC Phase 1 IOT&E classified report released in 2014.
- The Navy is making progress toward correcting the more than 60 open system deficiencies identified as operationally significant in previous test periods, including the 2012 P-8A Increment 1 IOT&E and 2013 P-8A Increment 1 FOT&E events. Some of these corrections are required to address the mission capability shortfalls identified in previous P-8A operational test reports, including both the Navy and DOT&E assessments that the fielded P-8A Increment 1 system is not operationally effective for the ISR mission. While the series of P-8A software and hardware improvements released for fleet use since 2012 have addressed some of these problems, the majority remain unresolved. Operational testing of these improvements, including a complete re-evaluation of P-8A ISR mission capabilities, is planned as early as the FY16 P-8A Increment 2 ECP 2 FOT&E event.

- The Navy completed the P-8A DSAU Verification of Correction of Deficiencies FOT&E event in November 2015. Initial test observations indicate that the DSAU modification provides improved mission data loading and storage capabilities. In addition, this test demonstrated at least partial correction of nine previously documented deficiencies to improve mission capabilities and operator interfaces. Preliminary cybersecurity test observations identified some system vulnerabilities that could potentially be exploited to create significant mission effects. Navy and DOT&E data review and analysis are in progress. Complete test results will be available in 2QFY16.
- The Navy completed the second lifetime of the P-8A full-scale structural fatigue testing in June 2015. This phase of testing identified localized fatigue cracking in non-critical structural components, including replaceable pressure web and aircraft tail section components. Preliminary results have not identified any significant, near-term structural concerns or fleet operating limitations. The program is currently reviewing results to identify initial fleet airframe inspection requirements and depot repair procedures to ensure the airframe meets the intended 25-year design life.
- The Navy conducted a limited user test in June 2015, to certify P-8A carriage of the self-contained UNI-PAC II Search and Rescue Kit. This payload provides delivery of a life raft and survival accessories for up to eight survivors. The Navy also conducted testing to support replacement of current Directed Infrared Countermeasure sensors with upgraded, two-color infrared sensors in July 2015. This test was in response to a Pacific Fleet Urgent Operational Need request to provide spherical video coverage for Maritime Patrol Reconnaissance Aircraft.

Recommendations

- Status of Previous Recommendations. The Navy made progress on all three FY14 recommendations. An FOT&E event to verify correction of an additional nine operationally significant system deficiencies is currently in progress, with a more significant deficiency correction FOT&E event planned for FY16. The initial phase of P-8A MAC wide-area, ASW search testing was completed in FY15, with additional testing planned for FY16. Test planning for P-8A Increment 2 and Increment 3 high altitude, ASW mission capabilities is also in progress.
- FY15 Recommendations. The Navy should:
  1. Continue to implement corrective actions for all operationally significant system deficiencies identified in previous P-8A operational test reports and conduct additional follow-on operational tests to verify improved mission capabilities.
  2. Continue to conduct planned P-8A Increment 2 MAC operational testing to evaluate ASW mission capability improvements.
  3. Submit a comprehensive P-8A Test and Evaluation Master Plan for DOT&E approval that incorporates a test strategy for previous operational deficiency corrections and the significant mission capability enhancements included in the P-8A Increment 3 program.

Remote Minehunting System (RMS)

Executive Summary

- In FY15, developmental and integrated testing of Remote Minehunting System (RMS) upgrades (consisting of a version 6.0 (v6.0) Remote Multi-Mission Vehicle (RMMV) and AN/AQS-20A/B sonar) did not demonstrate sufficient performance or successful integration with interfacing Littoral Combat Ship (LCS) systems to achieve the Navy's minimum Increment 1 warfighting capability. In particular, testing of the v6.0 RMMV provides no statistical evidence of reliability improvement, and the Navy continues to experience frequent problems with LCS-based launch, handling, and recovery equipment and communications systems essential for conducting timely and sustained Mine Countermeasures (MCM) operations. In addition, following problems encountered during testing in December 2014 and January 2015, the Navy abandoned its earlier plan to develop and field an improved sonar (designated AN/AQS-20B) by the end of FY15.
- In an August 2015 memorandum, DOT&E advised the USD(AT&L) that the reliability of the RMS and its RMMV poses a significant risk to the planned operational test of the *Independence* variant LCS and the Increment 1 MCM mission package, and to the Navy's plan to field and sustain a viable LCS-based minehunting and mine clearance capability prior to FY20. DOT&E recommended that the acquisition strategy for these systems be reexamined to ensure that sufficient testing is performed to inform the procurement of additional vehicles and cautioned that continued development of this program without a fundamental change would be unlikely to result in a system that is effective and suitable. Test data collected throughout FY15 continue to refute the Navy's assertion that vehicle reliability has improved. Moreover, the current estimates of RMMV and RMS reliabilities are 22.7 and 18.3 hours Mean Time Between Operational Mission Failure (MTBOMF), which are well-short of what is needed to complete MCM missions in a timely fashion and meet the Navy's desired mission timelines.
- The Navy chartered an independent program review of the RMS including an evaluation of potential alternative MCM systems in September 2015. The independent review team's report is due in late 1QFY16. Meanwhile, USD(AT&L) delayed its review to consider approval to restart RMS low-rate initial production until at least 3QFY16.
- DOT&E concluded in a November 2015 memorandum to USD(AT&L) and the Navy, based on the testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or operationally

suitable if the Navy called upon it to conduct MCM missions in combat. Five of seven primary shortcomings supporting this conclusion were attributed, at least in part, to the RMS:
  - Critical MCM systems, including the RMMV, are not reliable.
  - Vulnerabilities of the RMMV to mines and its high rate of failures do not support sustained operations in potentially mined waters.
  - RMMV operational communications ranges are limited.
  - Minehunting capabilities are limited in other-than-benign environmental conditions.
  - The LCS crew is not equipped to maintain the ship or the MCM systems.
- Developmental and integrated testing conducted in FY15 continued to show that the AN/AQS-20A sonar does not meet all Navy requirements. The RMS has not demonstrated the detection/classification and localization capabilities needed for an LCS equipped with an Increment 1 MCM mission package to complete timely mine reconnaissance and mine clearance operations in expected operational environments. In addition, testing has revealed several shortcomings that, unless corrected, will delay completion of LCS-based mine reconnaissance and mine clearance operations. The Navy expected to correct these deficiencies prior to operational testing by implementing pre-planned product improvements (the AN/AQS-20B version of the sonar) and integrating the improved sensor into the MCM mission package. However, system prototypes did not perform well in initial testing in FY14/15 and the Navy elected to proceed to LCS MCM mission package Technical Evaluation (TECHEVAL) with the

AN/AQS-20A sonar with known limitations outside the most benign conditions.
- Communications ranges afforded by current RMS radios will require operational commanders to clear a series of LCS operating boxes to support minehunting and clearance operations, particularly for bottom-focused mine-hunting operations. These operating boxes will be necessary to keep an LCS and its crew out of the minefield while operating the RMS in searches for mine-like objects or identifying bottom objects located within shipping lanes that are longer than demonstrated communications ranges. Additional effort to clear operating boxes will increase the demand for mine clearance and delay attainment of strategic objectives. During FY15 testing, LCS 2 also had frequent problems establishing initial communications between the ship and an RMMV using existing over-the-horizon (OTH) and line-of-sight (LOS) channels and maintenance of those communications links once established. These problems frequently delayed the start of RMS missions and periodically terminated missions prematurely.
- Although the Navy implemented materiel, training, and procedural improvements, incidents of equipment damage and launch and recovery failures continue to delay or prevent sustained operations. The Navy completed 16 RMMV launches and 14 RMMV recoveries during 23 days at sea in developmental testing completed in 1QFY15. During 58 days at sea during TECHEVAL, both the pace and success rate of RMMV launch and recovery regressed as LCS 2 completed 24 RMMV launches and only 18 RMMV recoveries. The increased frequency of unrecovered RMMVs is attributed to a larger number of off-board vehicle failures that precluded recovery aboard LCS 2 rather than new launch and recovery problems. Damage to shipboard launch and recovery equipment, LCS-RMMV communications problems, multiple RMMV hydraulics system failures, a suspected RMMV electrical system failure, and RMMV mast latch and fuel system failures contributed to the ship's inability to launch or recover the unmanned vehicle.
- The combination of acoustic radiated noise, frequent RMMV failures that prevent recovery aboard LCS, and the probability the vehicle and its sensor will get entangled with mine or other hazards all pose a risk to losing the RMS. Given the limited existing inventory of RMMVs (four v6.0 vehicles, four vehicles awaiting upgrades to v6.0, and two vehicles designated for training use only), any RMMV attrition would severely degrade the Navy's ability to conduct LCS-based MCM operations.

System
- The RMS is designed to provide off-board mine reconnaissance capability to detect, classify, and localize non-buried bottom and moored mines, and to identify shallow-water bottom mines only.
- The Navy plans to launch, operate, and recover RMS from both LCS Flight 0/0+ variants as part of the MCM mission package (when embarked).
- RMS includes an unmanned, diesel-powered, semi submersible vehicle called the RMMV. The RMMV tows an AN/AQS-20 variable depth sonar mine sensing subsystem. The AN/AQS-20 is a multi-mode, modular towed body that can house as many as five sonars. The sensor can also be fitted with an electro-optical identification device to identify mine-like objects. The Navy is developing an improved forward-looking sonar and new synthetic aperture side-looking sonars that it expects to field in the AN/AQS-20B/C by FY18/19. Following suspension of MH-60S tow missions in 2011, the RMMV is currently the only vehicle that tows the AN/AQS-20.
- A datalink subsystem provides real-time communications between the host ship and the RMMV for command and control and transmission of some sensor data. The RMS datalink subsystem, which includes ultra-high frequency LOS and low-band very high frequency OTH radios, interfaces with the multi-vehicle communications system that resides on both LCS variants.
- Shipboard operators control the RMMV using a remote minehunting functional segment integrated into the LCS mission package computing environment.
- RMS sensor data are recorded to a removable hard drive during minehunting operations. Following vehicle recovery, operators transfer data to an organic post mission analysis station and review sonar data to mark contacts as suspected mine-like objects.

Mission

MCM Commanders will employ the RMS from an MCM mission package-equipped LCS, to detect, classify, and localize non buried bottom and moored mines, and to identify shallow-water bottom mines in support of theater minehunting operations.

Major Contractors
- RMMV: Lockheed Martin – West Palm Beach, Florida
- AN/AQS-20 (all variants): Raytheon Corporation – Portsmouth, Rhode Island

---

Activity
- During 1QFY15, the Navy completed the last scheduled phase of the Increment 1 MCM mission package developmental test DT-B2 aboard USS *Independence* (LCS 2). This phase of testing marked the first time the Navy employed v6.0 RMMVs in the MCM mission package. The test also provided the first opportunity to assess ship-based RMS operations that were unable to be completed in earlier events, described by the RMS Test and Evaluation Master Plan (TEMP), because of

LCS unavailability and deferred integration of RMMV and LCS.

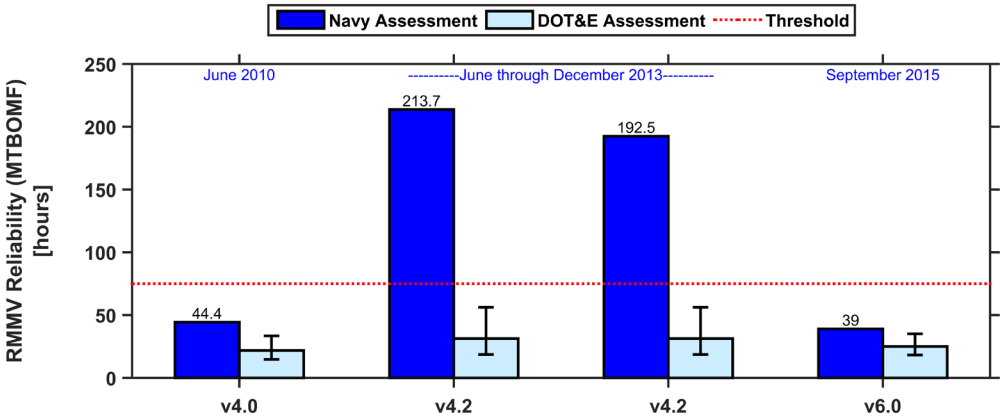
- The Navy conducted shore-based developmental testing (DT-B1) of the RMS, consisting of the v6.0 RMMV and AN/AQS-20A/B from the contractor's facility at West Palm Beach, Florida. The Navy commenced testing in December 2014 with an upgraded version of the sensor, designated AN/AQS-20B, but in January 2015 determined the new sensor was not yet sufficiently mature and elected to complete testing with the AN/AQS-20A sonar. The Navy subsequently suspended testing in January 2015 to investigate RMMV reliability problems and complete corrective maintenance. The Navy resumed and completed testing in March 2015.
- Although the Navy elected to proceed to LCS and Increment 1 MCM mission package TECHEVAL with the AN/AQS-20A, it continued to develop pre-planned product improvements for the sonar. This effort is intended to mitigate deficiencies observed during previous operational assessments and developmental testing of the RMS and AN/AQS-20A. Although the Navy no longer plans to field the AN/AQS-20B, it will continue to perform risk reduction testing of the v6.0 RMMV and the improved AN/AQS-20B sensor in FY16.
- From April through August 2015, the Navy employed four v6.0 RMMVs in TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package aboard LCS 2. Although the Navy planned to complete the test by June 2015, problems with failures of seaframe and MCM systems, including RMMVs, caused the testing to be extended. The Navy delayed operational testing of the Increment 1 MCM mission package, which it expected to complete in FY15, until the spring of 2016, at the earliest.
- In June 2015, the Navy commenced RMS cybersecurity operational testing concurrently with LCS 2 cybersecurity testing. The initial phase of the cybersecurity operational test, a Cooperative Vulnerability and Penetration Assessment was completed in July 2015, but the final phase of the test, an Adversarial Assessment, is on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant seaframe for operational testing.
- In an August 2015 memorandum, DOT&E advised the USD(AT&L) that the reliability of the RMS and its RMMV is so poor that it poses a significant risk to the planned operational test of the *Independence* variant LCS and the Increment 1 MCM mission package, and to the Navy's plan to field and sustain a viable LCS-based minehunting and mine clearance capability prior to FY20. DOT&E recommended that the acquisition strategy for these systems be reexamined to ensure that sufficient testing is performed to inform the procurement of additional vehicles and cautioned that continued development of this program without a fundamental change would be unlikely to result in a system that is effective and suitable.
- The Navy chartered an independent program review of the RMS, including an evaluation of potential alternative MCM systems in September 2015. Their report is due in late 1QFY16. Additionally, USD(AT&L) delayed its review to consider approval to restart RMS low-rate initial production was delayed until at least 3QFY16.
- In November 2015, DOT&E provided the USD(AT&L), the Assistant Secretary of the Navy for Research Development and Acquisition, and the Program Executive Officer for Littoral Combat Ships a classified assessment of the performance of the *Independence* variant seaframe and Increment 1 MCM mission package, including the RMS. DOT&E based the assessment on the data collected during the TECHEVAL and earlier periods of development and operational testing.
- In FY15, the Navy continued an effort, initiated in 2QFY14, to update the RMS and AN/AQS-20A TEMPs. DOT&E advised the Navy that both TEMPs should be further combined in the LCS TEMP, which is also being updated. It remains unclear when the Navy will complete updates to either the RMS or LCS TEMPs.

Assessment

- DOT&E's assessment is based on information from developmental and integrated testing, results provided by the Navy Program Offices, operational assessments of the RMS and AN/AQS-20A, and operational cybersecurity testing aboard LCS 2. A summary of the RMS portion of DOT&E's recent memorandum on LCS 2 and Increment 1 MCM mission package TECHEVAL is also provided below.

Reliability Growth

- The RMS program, which the Navy initiated in 1993, has a history of reliability problems. The Navy instituted reliability improvement initiatives when the v4.0 system did not meet its reliability or availability requirements during an aborted IOT&E in 2007. Following an operational assessment in 2008 and a Nunn-McCurdy review of the program in 2010, the Navy assessed v4.0 system reliability as 44.4 hours MTBOMF when it embarked on a three-phased reliability growth program (v4.1, v4.2, and v4.3) designed to retire RMMV failure modes and improve reliability. DOT&E assessed v4.0 RMMV reliability as 21.8 hours MTBOMF based on developmental and operational testing completed prior to June 2010. The figure below provides a comparison of Navy and DOT&E reliability assessments of v4.0 RMMV and subsequent vehicle configurations employed in developmental and integrated testing. The Navy assessed v4.2 RMMV reliability twice obtaining two different results.



- By June 2013, the Navy indicated it had grown reliability of the v4.2 RMMV configuration to 213.7 hours, and declared that the third phase of its reliability growth program (v4.3) was no longer necessary. Following developmental and integrated testing that fall, the Navy reported v4.2 RMMV reliability was 192.5 hours MTBOMF. Based on the same testing, DOT&E assessed that RMMV-only reliability was 31.3 hours MTBOMF when counting only failures that would have required intermediate- or depot-level intervention to fully correct. In addition, DOT&E's assessment noted that the Navy had inflated operating time estimates in its reliability calculation by assuming post-mission analysis time (when the vehicle is not in the water and not operating) could be counted. DOT&E also assessed that the Navy's calculation missed several critical failures that precluded continuation of operational missions. DOT&E's assessment of v4.2 RMMV reliability also identified specific deficiencies the Navy had not yet corrected in two phases of its reliability growth program but hoped to mitigate in conjunction with vehicle upgrades (v6.0) required to make it more compatible with LCS communications and launch, handling, and recovery systems. Although the Navy acknowledged these deficiencies, they determined that v4.2 RMMV testing had demonstrated that it met its Nunn-McCurdy exit criterion for reliability in preparation for a potential Milestone C decision and restart of low-rate initial production.
- In an August 2015 memorandum to USD(AT&L), DOT&E assessed that the v6.0 system the Navy is relying upon to underpin the first increment of the LCS MCM mission package continued to exhibit reliability problems in both shore- and LCS-based testing. In the same memorandum, DOT&E assessed that recent developmental testing provided no statistical evidence that the system was demonstrating improved reliability, and instead indicated that reliability plateaued nearly a decade ago. The figure above shows DOT&E and the Navy reporting comparable quantitative results for v6.0 RMMV reliability based on partial TECHEVAL data available at that time. Moreover, the Navy assessment of v6.0 RMMV reliability, 39 hours MTBOMF, provides evidence supporting DOT&E's conclusion that reliability has not improved despite multiple upgrade phases since the program exited its Nunn-McCurdy review in 2010. The figure also shows that the Navy's estimate for v6.0 RMMV reliability is still less than the Navy's estimate of v4.0 RMMV reliability at the outset of its reliability growth program.
- In total, RMS operated for 265.7 hours between April 7, 2015, when LCS 2 began scenario-based MCM workups, and August 30, 2015, when TECHEVAL concluded. During this test period, the RMS experienced 17 operational mission failures with 15 of those failures attributable to the RMMV. Thus, as shown in the table below, the reliabilities of RMS and v6.0 RMMV were 15.6 hours and 17.7 hours MTBOMF, respectively, during TECHEVAL. When TECHEVAL data are combined with previous data, reliabilities RMS and v6.0 RMMV are 18.3 hours and 22.7 hours MTBOMF.

RMS and v6.0 RMMV Reliability in 2014-2015 Testing

Test Event	Test Period	System Operating Time (Hours)	RMMV OMFs	RMMV MTBOMF (Hours)	RMS OMFs	RMS MTBOMF (Hours)
LCS MCM MP DT-B2 Ph4 Pd2	Sept 11 – Oct 20, 2014	139.0	3	46.3 *(20.8-126.1)*	6	23.2 *(13.2-44.1)*
DT-B1	Jan 13 –Mar 25, 2015	163.4	7	23.3 *(13.9-42.0)*	8	20.4 *(12.6-35.1)*
LCS MCM MP TECHEVAL	Apr 7 – Aug 30, 2015	265.7	15	17.7 *(12.5-25.8)*	17	15.6 *(11.3-22.2)*
All	***Sep 11, 2014 – Aug 30, 2015***	***568.1***	***25***	***22.7 (17.4-30.1)***	***31***	***18.3 (14.4-23.6)***

Note: Values in parentheses represent 80 percent confidence intervals.
MCM – Mine Countermeasures; MP – mission package; TECHEVAL – Technical Evaluation; RMMV – Remote Muti-Mission Vehicle; OMF – Operational Mission Failure; MTBOMF – Mean Time Between Operational Mission Failure

- As DOT&E assessed in August 2015, the reliability of existing systems poses a significant risk to the Navy's plan to field and sustain a viable LCS-based minehunting and mine clearance capability prior to FY20. In particular, recurrent failures preventing vehicle recovery aboard LCS, problems establishing and maintaining RMMV-LCS communications, the accelerated failure of control surface actuators, and the need for frequent intermediate- and depot-level assistance to initiate and continue sorties continue to handicap the crew's ability to sustain system operations. Unless corrected, these problems will continue to prevent the Navy from fielding an LCS and MCM mission package capable of replacing legacy systems or decreasing significantly the time required to conduct MCM operations.
- While the Navy agrees that existing RMMVs fail at a high rate and are demonstrating reliability that is less than required, it believes, the system and the MCM mission package can still accomplish their intended missions. This is incorrect. TECHEVAL provided numerous examples of system shortcomings that prevented the Navy from demonstrating RMS operating tempo over an extended period of time that was close to the expectations of the Navy's Design Reference Mission Profile for the LCS equipped with the MCM mission package.
  - During TECHEVAL, four RMMVs and six AN/AQS-20As operated off-board LCS for 226 hours and conducted 94 hours of minehunting (employing the sonar to actively search for mines, revisit contacts, and identify bottom objects). On six occasions, an RMMV could not be recovered aboard LCS 2 and had to be towed to port by test support craft, and then shipped to the remote operating site (simulating an in-theater intermediate- and depot-level maintenance activity) or prime contractor site (original equipment manufacturer depot-level repair facility) for repairs. On average, the LCS 2 completed a total of 5 hours of RMS minehunting per week (1.25 hours per week per RMMV), and an RMMV had to be towed to port for every 16 hours of RMS minehunting.
  - The pace of RMS operations demonstrated by one LCS with four RMMVs is less than 10 percent of the operating tempo for a single ship shown in the Navy's Design Reference Mission Profile for Increment 1 bottom-focused minehunting operations. Based on the demonstrated pace of operations during TECHEVAL, all of the RMMVs the Navy plans to acquire to outfit 24 MCM mission packages would be required to search the area that the Navy originally projected a single LCS and MCM mission package could search.
  - Although the Navy considers one of the two RMMVs in the Increment 1 mission package an embarked spare that permits continued RMS operations even after one unit fails, LCS 2 averaged just 3.5 days underway before losing all RMS capability, that required a call for outside RMS repair assistance, or necessitated a return to port.
  - LCS 2 was underway for more than one week with at least one mission-capable RMS embarked only once during TECHEVAL.
  - On five occasions, LCS 2 operated for less than two days before encountering an RMS problem that required assistance from shore-based intermediate-level maintenance personnel to continue operations.
  - In three cases, an RMMV was recovered without collecting minehunting data. These problems resulted in the RMMV returning to LCS 2 with at least some fraction of the expected mission data in only 15 of 24 launches (63 percent).
  - Mishaps severely damaged two RMMVs, causing them to be returned to the prime contractor's site for extensive repairs.
  - Despite underway periods that were short relative to the expectations of the LCS Design Reference Mission Profile, both RMMVs embarked at the beginning of an underway period were unavailable to conduct minehunting missions six times during TECHEVAL.
  - On three occasions, totaling 19 days, all four v6.0 RMMVs in the Navy's inventory were unavailable to execute minehunting missions.
  - The Navy completed TECHEVAL with one of four RMMVs operational. However, post-test inspections revealed that the sonar tow cable installed in that unit was no longer functional.

Minehunting Performance

- The RMS program has not yet demonstrated that the AN/AQS-20A can meet its detection and classification requirements over the prescribed depth regimes and simultaneously provide adequate coverage against all threats. Specifically, the RMS program has not yet demonstrated that the system, operating in its tactical single pass search modes, can meet its detection and classification requirements against deep water targets moored near the ocean bottom, near-surface moored mines that can only be detected by the Airborne Laser Mine Detection System in very clear waters, or stealthy bottom mines. Unless corrected, these problems will likely affect the quality LCS-based minehunting and mine clearance operations adversely in some threat scenarios. As an alternative, additional RMS search passes that will negatively affect the efficiency of minehunting and mine clearance operations might be required in some cases.
- The results of developmental and integrated testing to date continue to show that the RMS's AN/AQS-20A sensor does not meet Navy requirements for contact depth localization accuracy or false classification density (number of contacts erroneously classified as mine-like objects per unit area searched). Contact depth localization problems complicate efforts to complete identification and neutralization of mines. False classifications, unless eliminated from the contact list, require identification and neutralization effort,

result in the expenditure of limited neutralizer assets, and negatively affect the LCS sustained area coverage rate. To mitigate the problem of false classifications, the Navy has implemented tactics and software designed to compare the results of multiple search passes over the same area to "prune out" most false classifications and minimize the number conveyed for identification/neutralization. Under some conditions, the Navy has demonstrated that these pruning tactics reduce false classification densities to the Navy's acceptable limits. However, as observed during developmental testing in 1QFY15, these new procedures do not reduce false classification densities appreciably in all operationally relevant conditions. The continued need for additional passes to "prune out" excessive classifications will prevent the LCS MCM mission package from achieving the Navy's predictions for Sustained Area Coverage Rates that were based on the expectation that RMS would be a "single-pass" system.

- The Navy is developing AN/AQS-20 pre-planned product improvements (P3I) as a longer-term solution to improve probability of correct classification, reduce false classifications, and resolve contact localization accuracy problems. In early FY15, the Navy was optimistic that it could produce a mature P3I system prior to the first phase of LCS MCM operational testing originally planned in late FY15. The Program Office now expects the improved AN/AQS-20C system to enter operational testing in FY18.
- Developmental testing of the RMS in 2008 revealed that the system had problems reacquiring bottom objects for identification in deeper waters. Although the Navy implemented fixes in the v6.0 RMMV designed to correct this deficiency, the Navy has not yet conducted sufficient testing to evaluate the efficacy of its fix.
- During an AN/AQS-20A Operational Assessment in 2012, operators had difficulty identifying bottom objects in areas with degraded, but operationally relevant, water clarity. Unless system performance in this environment improves, degraded water clarity will delay MCM operations.
- Current tactics indicate the RMS will survey its tasking area multiple times before sailors are able to determine the absence or presence of mines or complete mine clearance operations. Following an initial search by the RMS, tactics advise sailors to plan additional RMS sorties to assess persistence of in-volume contacts marked as mine-like and to identify bottom contacts marked as mine-like as either mines or non-mines. When operators conclude that RMS in-volume contacts are persistent, those contacts are passed to a follow-on system for identification/neutralization.
- Although DOT&E's analysis of RMS data collected during LCS 2 and Increment 1 MCM mission package TECHEVAL is still in progress, preliminary results indicate that the RMS and its operators made multiple mine-like calls on some mines. This is an expected result when the sonar has multiple opportunities to detect the same mine in favorable conditions. The Navy's contact management tool is designed to post-process and compare the positions of the mine-like calls generated by multiple opportunities to produce a list of unique contact positions for follow-on action. During TECHEVAL, however, the Navy noted multiple cases where more than one RMS contact was generated for a single mine, passed through the contact management tool, and assigned to the Airborne Mine Neutralization System (AMNS) on multiple identification and neutralization attempts. In most of these cases, LCS 2 conducted additional, and unnecessary, AMNS attack runs even after the mine was successfully identified and neutralized. If large numbers of duplicate classifications are passed to the AMNS for follow-on action, LCS will expend needless resources and mine clearance rates will be reduced.

Communications

- Two significant communications shortcomings limit the effectiveness of the current LCS MCM mission package system-of-systems. One is the limited range of high data rate communications between an off-board RMMV and the host LCS and the other is related to the persistent difficulty with establishing and maintaining the existing LOS and OTH communications channels. The former limits the reach and productivity of LCS MCM operations, and the latter results in frequent mission delays and the potential loss of an RMMV with which the LCS is unable to communicate. Unless these problems are solved, the LCS and its MCM mission package will never be able to fulfill its wartime MCM missions within the timelines required.
- Although the RMMV can search autonomously while operating OTH from the LCS, it can only conduct electro-optical identification operations to reacquire and identify bottom mines when operating within LOS communications range of the LCS. This limitation will complicate MCM operations in long shipping channels, and will make it necessary to clear a series of LCS operating areas to allow the ship to follow MCM operations as they progress along the channel. The cleared operating areas must be close enough to the intended search area to maintain LOS communications and large enough to enable LCS operations, including ship maneuvering to facilitate launch and recovery of the RMMV and MH-60S helicopter. The additional time required to clear these areas will increase the demand for mine clearance. Although a May 2012 Navy briefing proposed development of an airborne relay and a high frequency ground wave radio capability, along with other upgrades, to make the Increment 1 MCM mission package "good enough" for IOT&E, the Navy has not yet fielded either of those capabilities. Had LCS 2 been required to clear its operating areas during the 2015 TECHEVAL and the Area Coverage Rate Sustained remained unchanged, the time required to complete MCM operations in the test field would have increased nearly

three-fold. In the May 2012 briefing cited above, the Navy reached a similar conclusion regarding the operational consequences of limited RMMV communications ranges.

- During TECHEVAL, LCS 2 had frequent problems establishing initial communications between the ship and an RMMV using existing OTH and LOS channels and maintaining those communications links once established. These problems frequently delayed the start of RMS missions and periodically terminated missions prematurely. On one occasion, loss of communications during an attempt to launch an RMMV caused the ship to return to port with the RMMV suspended from the Twin-Boom Extensible Crane because the crew was unable to complete the launch or bring the vehicle back into the mission bay. On another occasion, loss of LOS communications resulted in extensive damage to an RMMV that required months of depot-level repair at the contractor's facility when the ship attempted to recover it using OTH communications. On a third occasion, an abrupt loss of power led to loss of communications with an RMMV, making it necessary for a test support craft to take the RMMV under tow. In addition to these incidents, the LCS crew routinely found it necessary to seek help from shore-based technicians to resolve communications problems. During the latter portion of TECHEVAL, the program manager embarked a team of subject matter experts to monitor LCS-RMMV communications, assist with troubleshooting, and collect diagnostics. Shortly after the TECHEVAL, the Program Office established a task force to analyze the communications problems and propose solutions. The task force has since recommended a multi-faceted approach that includes improving operating and troubleshooting documentation for the communications systems, enhanced crew training for initializing of communications links and fault troubleshooting, and, longer term, a reexamination of the communications architecture.

Launch and Recovery

- The *Independence* variant LCS has had difficulty launching and recovering the RMMV because of the vehicle's erratic motion in the ship's wake. In past developmental testing, violent RMMV yaw and roll motions have overstressed and damaged the launch and recovery hardware and resulted in damage to the RMMV. Although the Navy implemented materiel, training, and procedural improvements, incidents of equipment damage and launch and recovery failures continue to delay or prevent sustained operations. The Navy completed 16 RMMV launches and 14 RMMV recoveries during 23 days at sea in developmental testing conducted in 1QFY15. During 58 days at sea during TECHEVAL, both the pace and success rate of RMMV launch and recovery regressed as LCS 2 completed 24 RMMV launches and only 18 RMMV recoveries. The increased frequency of unrecovered RMMVs is attributed to a larger number of off-board vehicle failures that precluded recovery aboard LCS 2 rather than new launch and recovery problems. Damage to shipboard launch and recovery equipment, LCS-RMMV communications problems, multiple RMMV hydraulics system failures, a suspected RMMV electrical system failure, and RMMV mast latch and fuel system failures contributed to the ship's inability launch or recover the unmanned vehicle.
- No RMMV launch and recovery operations have been conducted aboard a *Freedom* variant LCS at sea.

RMS Vulnerabilities

- The combination of acoustic radiated noise, frequent RMMV failures that prevent recovery aboard LCS, and the probability the vehicle and its sensor will get entangled with mines or other hazards all pose a risk to losing the RMS. Given the limited existing inventory of RMMVs (four v6.0 vehicles, four vehicles awaiting upgrades to v6.0, and two vehicles designated for training use only), any additional RMMV attrition would severely degrade the Navy's ability to conduct LCS-based MCM operations.
- RMMV acoustic radiated noise measurements, last collected during developmental testing in 2007/2008, indicated that existing RMMVs might be vulnerable to some mines. The RMS Program Office has not assessed radiated noise following recent vehicle configuration changes and has requested a waiver to deploy the system even through it did not previously meet its acoustic radiated noise specification. If RMMV radiated noise continues to exceed acceptable limits, systems could be lost during LCS-based minehunting and mine clearance operations depleting the Navy's limited inventory of assets. The magnetic signature of the v6.0 RMMV has not been measured.
- As noted earlier, only 18 of 24 RMMVs launches from LCS 2 ended with an RMMV recovery aboard LCS 2 during TECHEVAL. Frequent RMMV failures that preclude vehicle recovery aboard LCS might result in lost RMMVs and expose personnel who attempt to recover RMMVs in open waters to air, surface, and mine threats. Because of the number of incidents in which an RMMV could not be recovered, the Navy is now considering options that would provide LCS with additional support to recover RMMVs that it cannot recover otherwise. On four occasions during TECHEVAL, RMMV failures precluded LCS 2 from controlling the movements of an off-board RMMV. If similar failures occur during operations, the RMMV could become disabled in the minefield or drift into a minefield before salvage or support craft arrive to recover it.
- Even though test minefields are deliberately planned to reduce the risk of RMS striking a mine target or becoming entangled in its mooring cable, the RMS has snagged several tethered mines, and other surface and underwater objects during testing. These incidents often cause damage to the vehicle or deployed sonar that leaves the system inoperable. In some cases, divers embarked on test support craft have entered the water to assist in recovery of assets following a snag. Although the Navy is still developing concept of operations to handle these situations during operations in a threat minefield, it is clear that if these incidents occur during wartime operations they will

pose a risk to vehicles and potential recovery personnel. Furthermore, the repeated occurrence of these incidents presents both a tactical and a system design challenge for the Navy as it tries to minimize attrition when the system is employed operationally.

- In FY15, the Navy also disclosed that the AN/AQS-20A does not trail directly behind the RMMV when deployed to tactical minehunting depths. Instead, the sensor tows to starboard of the RMMV path. This offset causes the RMS to behave like a mine sweeping system as the sonar and its tow cable passes through the water, thereby increasing the risk of snagging a tethered mine.
- The RMS Program has not completed the final Adversarial Assessment phase of cybersecurity operational testing of the RMS hardware and software configurations intended for Initial Operational Capability in the LCS MCM mission package in FY16.

Maintainability

- Consistent with the concept of operations, the LCS is reliant on shore-based support for assistance with diagnosis and repair of seaframe equipment and MCM system problems. Although the ship could be more self-reliant if the sailors were provided with better maintenance training, technical documentation, test equipment, and tools and a more extensive stock of spares, the mission package detachment lacks the wherewithal to handle anything beyond relatively uncomplicated RMS preventive maintenance and minor repairs. As a result, the Navy's records show that shore-based RMMV maintenance personnel completed more than 4,000 hours of RMMV maintenance over six months of TECHEVAL work-ups and testing to support approximately 108 hours of RMS minehunting. Not only is this level of support, 38 hours of maintenance per hour of minehunting, far beyond the capability of the embarked crew, it is also not sustainable for wide-area LCS MCM operations that must be quickly completed.

Recommendations

- Status of Previous Recommendations.
  - The Navy made progress on all four FY13 recommendations. Shore-based testing completed in 1QFY14 and shipboard testing completed in 1QFY15 provided additional information regarding RMS, RMMV, and AN/AQS-20A reliability; RMS operational availability; and RMMV launch, handling, and recovery system performance. Although the Navy continues to develop and test AN/AQS-20A upgrades, it has not demonstrated in developmental or operational testing that it has corrected problems with false classifications and contact localization errors that will otherwise limit performance in operational testing. The Navy expects to complete its update to the RMS TEMP, which now includes the AN/AQS-20A sonar, in FY16.
  - The Navy has made progress on two of the nine FY14 recommendations. The Navy initiated RMS cybersecurity and conducted additional ship-based RMS testing to assess readiness for operational testing that it expected to complete in FY15. The Navy did not address the following FY14 recommendations:
    1. Identify the RMS configuration for operational testing of LCS equipped with the first increment of MCM capability and complete the required operationally realistic testing of that system prior to LCS MCM mission package TECHEVAL.
    2. When system maturity is able to support, conduct testing of the RMS consisting of the v6.0 RMMV and AN/AQS-20C in operationally realistic end-to-end minehunting missions to characterize AN/AQS-20B minehunting performance and accurately assess availability of the RMS and reliability of the RMMV and AN/AQS-20B.
    3. Investigate the use of communications relays and other solutions that might improve the standoff distance between an RMMV and its host ship to improve the efficiency of LCS MCM operations.
    4. Document a robust reliability monitoring and growth strategy for any new low-rate initial production vehicles procured following a planned FY15 Milestone C decision.
    5. Reassess v6.0 RMMV radiated noise following vehicle upgrades.
    6. Reexamine minimum vehicle and sensor reliability and LCS organizational-level maintenance support needed to complete timely and realistic operational scenarios without excessive reliance on intermediate- and depot-level support.
    7. Reconsider RMS minehunting requirements in the context of expected LCS tactics and operations.
- FY15 Recommendations. In addition to addressing outstanding FY14 recommendations, the Navy should:
  1. Review RMMV design alternatives as a solution for system reliability problems.
  2. Complete a comprehensive review of RMMV and mission package communications interfaces and, if necessary, re-engineer the Multi-Vehicle Communication System, RMMV, and/or other essential system-of-systems components to improve interoperability and enable reliable LOS and OTH communications between LCS and RMMVs.
  3. Develop tactics to mitigate system vulnerabilities to mines, mine collision, and entanglement hazards, and other surface and underwater hazards.
  4. Assess improvements to post mission analysis and contact management software and training to resolve problems observed during TECHEVAL when multiple RMS contacts on the same mine were passed to AMNS for identification and neutralization.
  5. Continue to develop and implement improvements for launch, handling, RMMV and recovery equipment and procedures.
  6. Provide LCS sailors better training, technical documentation, test equipment, and tools, along with additional spares to improve the crews' self-sufficiency and enhance RMS maintainability.

Rolling Airframe Missile (RAM) Block 2

Executive Summary

- Eight Rolling Airframe Missile (RAM) Block 2 developmental missile firings have been conducted in addition to 17 IOT&E missile firings the Commander, Operational Test and Evaluation (COTF) conducted from March 2013 through April 2015, at the Naval Air Warfare Center, Point Mugu, California, and the Naval Weapons Station, Yorktown, Virginia. IOT&E testing was conducted in accordance with a DOT&E-approved test plan.
- The results of developmental and operational testing completed to date indicate:
  - RAM Block 2 effectiveness is comparable to RAM Block 1A's effectiveness against older anti-ship cruise missiles (ASCM) threats. However, DOT&E cannot make a final determination of RAM Block 2 effectiveness against newer ASCM threats until completion of IOT&E in mid 2017.
  - RAM Block 2 has an improved kinematic capability to guide on maneuvering ASCMs and an improved capability to guide on certain ASCM threat emitters over RAM Block 1A.
  - RAM Block 2 demonstrated satisfactory missile reliability with no confirmed reliability failures in the 25 RAM Block 2 firings from the Self-Defense Test Ship (SDTS).
  - Deficiencies in RAM Block 2 integration with the Ship Self-Defense System (SSDS)-based combat system caused several RAM Block 2 missiles to miss their target during one of the IOT&E missile firing scenarios.
  - No assessment of RAM Block 2's capability against Multi-Stage Supersonic Target (MSST)-like ASCM threats is possible due to the lack of an MSST.
  - RAM Block 2 demonstrated lethality comparable to Block 1A and Block 0.
- DOT&E is currently preparing an Early Fielding Report to Congress on the completed testing and will conduct a full assessment of RAM Block 2 effectiveness, suitability, and lethality after IOT&E is completed.

System

- The RAM, jointly developed by the United States and the Federal Republic of Germany, provides a short-range, lightweight, self-defense system to defeat ASCMs. There are three RAM variants:
  - RAM Block 0 uses dual mode, passive radio frequency/infrared guidance to home in on ASCMs.
  - RAM Block 1A adds infrared guidance improvements to extend defenses against ASCMs that do not radiate radio frequencies.
  - RAM Block 2 incorporates changes to improve its kinematic capability and capability to guide on certain types of ASCM radio frequency threat emitters in order to defeat newer classes of ASCM threats.

Mission

- Naval component commanders will use RAM to accomplish ship self-defense missions.
- Naval surface forces will use RAM to provide a short-range, hard-kill engagement capability against ASCM threats.

Major Contractors

- Raytheon Missiles Systems – Tucson, Arizona
- RAMSys – Ottobrunn, Germany

Activity

- The Navy conducted 8 RAM Block 2 developmental missile firings and 17 IOT&E missile firings from the SDTS at the Naval Air Warfare Center, Point Mugu, California, from March 2013 through April 2015. COTF conducted the IOT&E missile firings in accordance with a DOT&E-approved test plan.
- COTF conducted an ammunition on-load demonstration as part of IOT&E onboard USS *Arlington* (LPD 24) in April 2015 at the Naval Weapons Station, Yorktown, Virginia.
- RAM Block 2 IOT&E for at-sea testing is ongoing and is scheduled for completion in mid-2016.

- COTF continued planning for the Probability of Raid Annihilation Modeling and Simulation test bed IOT&E test phase. This testing is scheduled to commence in late-2016.
- DOT&E is currently preparing an Early Fielding Report to Congress on the completed testing and will conduct a full assessment of RAM Block 2 effectiveness, suitability, and lethality after IOT&E is completed.

Assessment

- Results of testing completed to date indicate that RAM Block 2 performance is comparable to the RAM Block 1A performance against older ASCM threats. However, DOT&E cannot make a final determination of RAM Block 2 performance against newer ASCM threats until IOT&E is completed in mid-2017.
- RAM Block 2 demonstrated an improved kinematic capability and an improved capability to guide on certain ASCM threat emitters over RAM Block 1A.
- RAM Block 2 demonstrated satisfactory missile reliability with no confirmed reliability failures in the 25 RAM Block 2 firings from the SDTS to date.
- RAM Block 2 demonstrated lethality comparable to Block 1A and Block 0.
- Deficiencies in RAM Block 2 integration with the SSDS-based combat system caused several RAM Block 2 missiles to miss their target during one of the IOT&E missile firing scenarios. The Navy has initiated a formal Failure Review Board to determine the required corrections.
- The CVN and LHA 6 class ships defend themselves against ASCMs by first using the medium-range Evolved SeaSparrow Missile (ESSM) and then the shorter-range RAM. RAM uses radio frequency and/or infrared terminal guidance to home on ASCM threats. Hot debris from prior intercepts and warhead detonations can therefore interfere with RAM's infrared guidance. While the SSDS is designed to schedule RAM and ESSM engagements to avoid this type of interference, it failed to do so during testing.
- The AN/SLQ-32 Electronic Warfare System (EWS) with the Surface Electronic Warfare Improvement Program (SEWIP) Block 1 upgrade was not able to timely detect certain types of ASCM emitter signals. The late detections negatively affected the performance of RAM missiles that the SSDS employed against these ASCM threats. The Navy is addressing this deficiency with the SEWIP Block 2 upgrade to the AN/SLQ-32 EWS.
- Two BQM-74 aerial targets failed to maintain operationally realistic flight parameters in one of the IOT&E missile firing scenarios.
- Due to the lack of an MSST, no assessment of RAM Block 2's capability against MSST-like ASCM threats is possible.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The Navy should:
  1. Complete all planned RAM Block 2 missile firing IOT&E test events.
  2. Correct the identified integration deficiencies with the SSDS-based combat system and RAM Block 2. Demonstrate these corrections in a phase of operational testing.
  3. Correct the SSDS scheduling function to preclude interference from prior intercepts and warhead detonations with RAM's infrared guidance. Demonstrate corrections in a phase of operational testing.
  4. Investigate why the BQM-74 aerial targets failed to maintain operationally realistic flight parameters. Demonstrate any corrections prior to using these targets in similar operational test scenarios.
  5. Continue planning for the Probability of Raid Annihilation Modeling and Simulation IOT&E test phase.

RQ-21A Blackjack Unmanned Aircraft System (UAS)

Executive Summary

- The Navy's Commander, Operational Test and Evaluation Force, with assistance from the Marine Corps Operational Test and Evaluation Activity, conducted the RQ-21A IOT&E between January and December 2014 in three phases at Twentynine Palms, California; Camp Lejeune, North Carolina; and aboard USS *Anchorage* (LPD 23). Total flight time accrued from all three test locations was 233.6 hours during 38 flights.
- DOT&E submitted an IOT&E report in June 2015 based on the demonstrated performance during IOT&E to inform the Services' Full-Rate Production (FRP) decision, which was originally planned for October 2015, now scheduled for September 2016. The Navy plans to conduct additional developmental testing and is investigating the conduct of a Verification of Correction of Deficiencies before the September 2016 FRP decision. DOT&E intends to provide an updated assessment prior to the FRP decision to further support that decision. In the IOT&E report, DOT&E concludes:
  - The RQ-21A testing was adequate and conducted in accordance with the DOT&E-approved test plan.
  - The RQ-21A is not operationally effective.
  - The RQ-21A is not operationally suitable.
  - The system has exploitable cybersecurity vulnerabilities.

System

- Each system consists of five RQ-21A unmanned aircraft, surface components, and assorted government-provided equipment:
  - The surface components consist of two ground control stations, launch and recovery equipment, datalinks, multi-mission payloads, and support systems.
  - Government provided equipment includes vehicles and generators to transport and power ground components as well as intelligence workstations.
- The Marine Corps intends the RQ-21A system to have:
  - The reliability to support an operating tempo of 12 hours on station per day at a sustained rate for 30 days and the capability for one surge of 24 hours on-station coverage per day for a 10-day period during any 30-day cycle
  - An aircraft with 10 hours endurance, airspeed up to 80 nautical miles per hour, a service ceiling of 15,000 feet density altitude, and an operating radius of 50 nautical miles
  - An electro-optical sensor capable of providing the ground control station operator team sufficient visual resolution to support classification of a 1-meter linear sized object from 3,000 feet altitude above ground level and a sensor depression angle of 45 degrees, resulting in an assessment at a slant range of 4,242 feet
  - An infrared sensor capable of classifying a 3-meter sized linear object from 3,000 feet above ground level and slant range of 4,242 feet
  - An entire system transportable by CH-53E helicopter

Mission

- Marine Corps commanders will use the RQ-21A Blackjack to provide units ashore with a dedicated battlefield Intelligence, Surveillance, and Reconnaissance (ISR) capability that will reduce their dependence on higher headquarters for ISR support.
- Detachments from Marine Corps Unmanned Aircraft System Squadrons will embark the requisite personnel and equipment aboard L-class ships and will be capable of conducting ship to shore operations.

Major Contractor

Insitu, Inc. – Bingen, Washington

Activity

- The Navy's Commander, Operational Test and Evaluation Force, with assistance from the Marine Corps Operational Test and Evaluation Activity, conducted the RQ-21A IOT&E between January and December 2014 in three phases at Twentynine Palms, California; Camp Lejeune, North Carolina; and aboard USS *Anchorage* (LPD 23). Total

flight time accrued from all three test sites was 233.6 hours during 38 flights. The Navy and Marine Corps conducted the RQ-21A testing in accordance with the DOT&E-approved test plan.

- In May 2014, the Marine Corps deployed an Early Operational Capability RQ-21A system to support overseas combat operations. This deployed detachment consisted of up to eight aircraft, two launchers, and two recovery systems. Between May and September, the system flew approximately 121 flights for 995 flight hours. Data collected during the Early Operational Capability detachment's deployment overseas provided additional insights into system reliability.
- In June 2015, DOT&E submitted an IOT&E report based on the demonstrated performance during testing to inform the Services' FRP decision, which was originally planned for October 2015, now scheduled for September 2016. The Navy plans to conduct additional developmental testing and is investigating the conduct of a Verification of Correction of Deficiencies before the September 2016 FRP decision. DOT&E intends to provide an updated assessment prior to the FRP decision to further support that decision.

Assessment

- The detachment equipped with RQ-21A is not effective in supporting the ground commander's mission because of an inability to have an unmanned aircraft arrive on station at the designated time and remain on station for the duration of the tasked period. During the IOT&E, the RQ-21A-equipped unit provided coverage during 68 percent of the tasked on-station hours (83.8 of 122.7 hours).
- The electro-optical/infrared sensor provides accurate target locations. While the Capabilities Production Document does not specify a threshold value for sensor point of interest accuracy, Marine Corps guidance indicates that 100 meter accuracy is sufficient to support tactical operations. RQ-21A provides a 90-percent circular error probable target location error of 43.8 meters. Such accuracy is sufficient to support targeting in a conventional linear battlefield, but does not support targeting in a dense urban environment that requires more accurate target locations.
- The RQ-21A sensor does not meet one of the two target classification Key Performance Parameters (KPPs) established in the Capabilities Production Document. The electro-optical sensor does not provide a 50 percent probability of correct classification for 1-meter linear objects (weapons or tools). The infrared sensor does meet the 50 percent threshold probability for correctly classifying 3-meter objects (vehicle chassis type) by demonstrating 100 percent correct classification.
- The communications relay payload limits the commanders' tactical flexibility and mission accomplishment. It is constrained to a single frequency in each of the two radios that are set before launch. Once airborne, operators cannot change frequencies. This limits the communications relay payload to supporting pre-planned relay missions on a single pair of pre-set frequencies.
- Aircraft endurance meets the 10-hour KPP. The longest IOT&E flight lasted 12.3 hours.
- The recessed, nose-mounted electro-optical/infrared payload requires circular orbits over the top of the target to maintain continuous coverage and positive target identification. The use of offset orbits results in the fuselage blocking the payload field of view for significant periods of time. These offset orbits resulted in auto-track break locks and loss of positive identification of high-value targets. There are orbit shapes that would allow RQ-21A operators to maintain continuous coverage of a target, but the current RQ-21A operating system limits operators to circular orbits.
- The RQ-21A is not operationally suitable. The RQ-21A demonstrated a Mean Flight Hour Between Abort for the System of 15.2 hours versus the 50-hour requirement. Because of aircraft reliability, overall system availability did not meet the 80 percent KPP threshold (demonstrated value equals 66.9 percent).
- The average time between overhaul of the propulsion modules was 48.9 hours, which does not meet the manufacturer's stated 100-hour capability.
- The RQ-21A Naval Air Training and Operations Standardization manual is missing important information regarding mission computer logic. This lack of information is especially critical during emergencies where operators are unaware of which conditions enable/disable various aspects of aircraft functionality. This lack of system operations information contributed to the loss of an aircraft during the first IOT&E flight.
- To support shipboard operations, the Navy permanently installed some RQ-21A ground components (antennae interface modules, datalink antennae) on selected ships. The ships' personnel, and not the RQ-21A detachment, own and maintain these components. During IOT&E, none of the ship's personnel received training on maintaining these installed components. The ship did not receive spare parts, maintenance manuals, or wiring diagrams with which to facilitate repairs.
- Field service representatives are required to conduct maintenance in accordance with the Naval Aviation Maintenance Program. Instead of using the established Naval Aviation Logistics Command Management Information System to track maintenance and flight information, the field service representatives used a program called Sapphire, which resulted in the accurate archiving of 15 of 136 unscheduled maintenance actions. Because of these inaccuracies, the Marine Corps will not be able to determine the true maintenance burden associated with RQ-21A operations.
- Extended logistics delay times and production quality control issues contributed to the system's poor reliability and availability. In six instances, aircraft spent time in a non-mission capable status while awaiting spare parts. Incorrectly assembled/configured components received from the manufacturer increase the maintenance time to repair or replace components, resulting in reduced mission availability.
- The system has exploitable cybersecurity vulnerabilities.

Recommendations

- Status of Previous Recommendations. The Navy has made progress in the FY13 recommendation to accelerate annual operating hours in order to reach the projected 3,300 flight hours sooner than 2017, which would allow the Navy to identify and correct failure modes before committing to buy a significant number of systems. The remaining FY13 recommendation to conduct a comprehensive review of RQ-21A reliability versus requirements remains open.
- FY15 Recommendations. The Navy should:
  1. Improve the electro-optical sensor resolution to increase probability of correct classification for 1-meter sized targets.
  2. Increase the number of programmed aircraft loiter patterns to increase tactical flexibility and reduce fuselage obstruction of the payload.
  3. Fully integrate the communications relay payload into the aircraft architecture to allow for in-flight frequency changes and altering of other radio settings to increase tactical utility.
  4. Implement the cybersecurity recommendations listed in the classified annex to the IOT&E report to improve system security.
  5. Expand the systems description and flight characteristics section of the RQ-21A Naval Air Training and Operations Standardization manual to allow operators to safely react to system emergencies.
  6. Increase propulsion module service life and reliability to reduce maintainer workload, the number of spares required, and operating costs.
  7. Increase production quality control and implement thorough acceptance procedures for delivered systems and spare parts to reduce the number of faulty items received by fleet operators.
  8. Fully train and provide ship personnel with technical manuals, wiring diagrams, and spare parts related to RQ-21A shipboard components to increase RQ-21A full mission capability.
  9. Require field service representatives to utilize the Naval Aviation Logistics Command/Management Information System to track system maintenance to provide better maintenance burden data.
  10. Increase expenditures on spare parts to reduce administrative logistics delay times.
  11. Increase the number of spare parts in the pack-up kit to increase system availability.

Ship Self-Defense for LHA(R)

Executive Summary

- The Navy's Commander, Operational Test and Evaluation Force (COTF) conducted at-sea testing for the LHA(R) IOT&E on the USS *America* (LHA 6) in May 2015 and the Ship Self-Defense Test Ship (SDTS) from December 2014 through March 2015. At-sea testing is scheduled to complete in mid-2016. Testing was conducted in accordance with the DOT&E-approved test plans.
- Results of testing completed to date indicate that the LHA(R) has some ship self-defense capability against older anti-ship cruise missile (ASCM) threats. The LHA(R) ship self-defense performance against newer ASCM threats will remain undetermined until the LHA(R) Probability of Raid Annihilation (P_{RA}) modeling and simulation (M&S) test bed runs for IOT&E are completed in mid-2017.

System

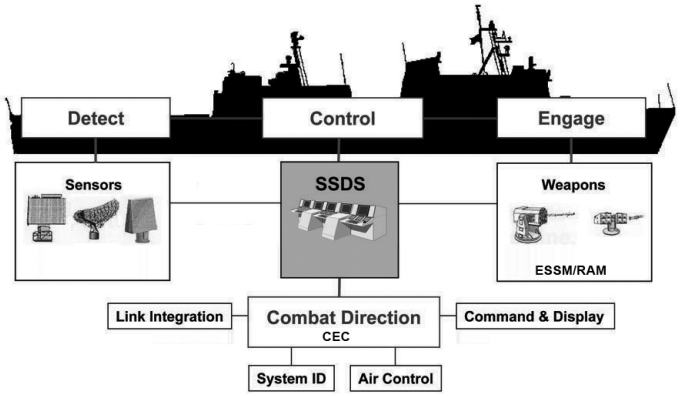
- Surface ship self-defense for the LHA(R) is addressed by several legacy combat system elements and five acquisition programs:
  - Ship Self-Defense System (SSDS)
  - Rolling Airframe Missile (RAM)
  - Evolved Seasparrow Missile (ESSM)
  - Cooperative Engagement Capability (CEC)
  - Surface Electronic Warfare Improvement Program (SEWIP)

SSDS

- SSDS is a local area network that uses open computer architecture and standard Navy displays to integrate a surface ship's sensors and weapons systems to provide an automated detect-track-engage sequence for ship self-defense.
- SSDS MK 1 is the command and control system for LSD-41/49 class ships.
- SSDS MK 2 has six variants:
  - Mod 1, used in CVN 68 class aircraft carriers
  - Mod 2, used in LPD 17 class amphibious ships
  - Mod 3, used in LHD 7/8 class amphibious ships
  - Mod 4, used in LHA(R) class amphibious ships
  - Mod 5, used in LSD 41/49 class amphibious ships
  - Mod 6, in development for CVN 78 class aircraft carriers

RAM

- The RAM, jointly developed by the United States and the Federal Republic of Germany, provides a short-range, light weight, self-defense system to defeat ASCMs.
- There are three RAM variants:
  - RAM Block 0 uses dual-mode, passive radio frequency/infrared guidance to home in on ASCMs.
  - RAM Block 1A adds infrared guidance improvements to extend defense against non-radio-frequency-radiating ASCMs.



  - RAM Block 2 is intended to extend the capability of RAM Block 1A against newer classes of ASCM threats.

ESSM

- The ESSM, cooperatively developed among 13 nations, is a medium-range, ship-launched, self-defense guided missile intended to defeat ASCM, surface, and low-velocity air threats.
- The ESSM is currently installed on LHA(R) and LHD 8 amphibious ships, DDG 51 Flight IIA destroyers, and CVN 68 class aircraft carriers equipped with the SSDS MK 2 Mod 1 Combat System.
- There are two variants of ESSM:
  - ESSM Block 1 is a semi-active radar-guided missile that is currently in service.
  - ESSM Block 2 is in development and will have semi-active radar guidance and active radar guidance.

CEC

- CEC is a sensor network with an integrated fire control capability that is intended to significantly improve battle force air and missile defense capabilities by combining data from multiple battle force air search sensors on CEC-equipped units into a single, real-time, composite track picture.
- The two major hardware pieces are the Cooperative Engagement Processor, which collects and fuses radar data, and the Data Distribution System, which distributes CEC data to other CEC-equipped ships and aircraft.
- CEC is an integrated component of, and serves as the primary air tracker for non-LSD class SSDS MK 2-equipped ships.
- There are two major surface ship variants of CEC:
  - The CEC AN/USG-2/2A is used in selected Aegis cruisers and destroyers, LPD 17/LHD/LHA(R) amphibious ships, and CVN 68 class aircraft carriers.

- The CEC AN/USG-2B, an improved version of the AN/USG-2/2A, is used in selected Aegis cruisers/destroyers as well as selected amphibious assault ships including the LHA(R) ship class and CVN 68 class aircraft carriers.

SEWIP

- The SEWIP is an evolutionary development program providing block upgrades to the AN/SLQ-32 Electronic Warfare (EW) System to address critical capability, integration, logistics, and performance deficiencies.
- There are three major SEWIP block upgrades:
  - SEWIP Block 1 replaced obsolete parts in the AN/SLQ-32 and incorporated a new, user-friendly operator console, an improved electronic emitter identification capability, and an embedded trainer.
  - SEWIP Block 2 is in development and will incorporate a new receiver antenna system intended to improve the AN/SLQ-32's passive EW capability.
  - SEWIP Block 3 is in development and will incorporate a new transmitter antenna system intended to improve the AN/SLQ-32's active EW capability.

Mission

- Naval Component Commanders use SSDS, RAM, ESSM, SEWIP, and CEC, and many legacy systems to accomplish ship self-defense missions.
- Naval surface forces use the:
  - SSDS to provide automated and integrated detect-to-engage ship self-defense capabilities against ASCM, air, and surface threats.
  - RAM to provide a short-range hard-kill engagement capability against ASCM threats.
  - ESSM to provide a medium-range hard-kill engagement capability against ASCM, surface, and low-velocity air threats.
  - CEC to provide accurate air and surface threat tracking data to SSDS.
  - SEWIP-improved AN/SLQ-32 as the primary EW sensor and weapons system for air defense (to include self-defense) missions.

Major Contractors

- SSDS (all variants): Raytheon – San Diego, California
- RAM and ESSM (all variants): Raytheon – Tucson, Arizona
- CEC (all variants): Raytheon – St. Petersburg, Florida
- SEWIP
  - Block 1: General Dynamics Advanced Information Systems – Fair Lakes, Virginia
  - Block 2: Lockheed Martin – Syracuse, New York
  - Block 3: Northrop Grumman – Baltimore, Maryland

Activity

- COTF conducted at-sea testing for the LHA(R) IOT&E on USS *America* (LHA 6) in April 2015 and the SDTS from December 2014 to March 2015, in accordance with DOT&E-approved test plans. Completion of these at-sea test phases is scheduled for mid-2016.
- COTF continued planning for conduct of the LHA(R) P_{RA} M&S test bed phase scheduled to commence in late-2016.

Assessment

- The results of testing completed to date indicate that the LHA(R) has some ship self-defense capability against older ASCM threats. The LHA(R) ship self-defense performance against newer ASCM threats will remain undetermined until IOT&E is completed.
- Deficiencies in RAM Block 2 integration with the LHA(R) SSDS-based combat system caused several RAM Block 2 missiles to miss their targets during one of the IOT&E missile firing scenarios on the SDTS. The Navy has initiated a formal Failure Review Board to determine the required corrections.
- SSDS MK 2 failed to properly evaluate its engagement doctrine for an inbound raid of ASCM surrogates. This issue resides within SSDS's Local Command and Control functionality and can result in missed engagements against ASCM threats. The Navy is still investigating this issue.
- An ESSM pre-detonated on debris before approaching its intended target. This issue also occurred during an earlier (non-LHA(R)) ESSM FOT&E event. When this issue occurs, the missile will fail to destroy its intended target.
- Inactive target emitters continue to be reported as valid by the AN/SLQ-32 Electronic Warfare System (EWS) with the SEWIP Block 1 upgrade after the target was destroyed. These false detections contributed to the SSDS re-engaging the already-destroyed target. This problem will accelerate the depletion of the ship's missile inventory and waste combat system resources that might be needed for engaging other ASCM threats.
- LHA 6 class ships defend themselves against ASCM by first using the medium-range ESSM and then the shorter-range RAM. RAM uses radio frequency and/or infrared terminal guidance to home on ASCM threats. Hot debris from prior intercepts and warhead detonations can therefore interfere with RAM's infrared guidance. While the SSDS is designed to schedule RAM and ESSM engagements to avoid this type of interference, it failed to do so during testing.
- The AN/SLQ-32 EWS with the SEWIP Block 1 upgrade was not able to timely detect certain types of ASCM emitter signals. The late detections negatively affected the performance of RAM missiles that the SSDS employed

against these ASCM threats. The Navy is addressing this deficiency with the SEWIP Block 2 upgrade to the AN/SLQ-32 EWS.

- The LHA(R)'s AN/SPQ-9B surface search radar demonstrated integration problems with the ship's SSDS-based combat system such that not all AN/SPQ-9B detections were used by the combat system when tracking targets. Since the AN/SPQ-9B is the ship's primary radar for detecting sea-skimming ASCMs, these missed detections significantly degrade the combat system's ability to schedule self-defense missiles against this type of ASCM threat.
- The LHA(R)'s AN/SPQ-9B surface search radar, which is this ship's primary radar for detecting sea-skimming ASCMs, demonstrated late detections of certain types of ASCM threats at distances much closer to the ship than predicted from historical data. Late detections of these threats resulted in reduced engagement times.
- Two BQM-74 aerial targets failed to maintain operationally realistic flight parameters in one of the IOT&E missile firing scenarios.
- Due to the lack of a Multi-Stage Supersonic Target (MSST), no assessment of the LHA(R) ship self-defense capability against MSST-like ASCM threats is possible.
- Three of four ESSM missiles failed to defeat their assigned targets during the two missile firing exercises on USS *America*. The Navy is investigating the causes of these failures.

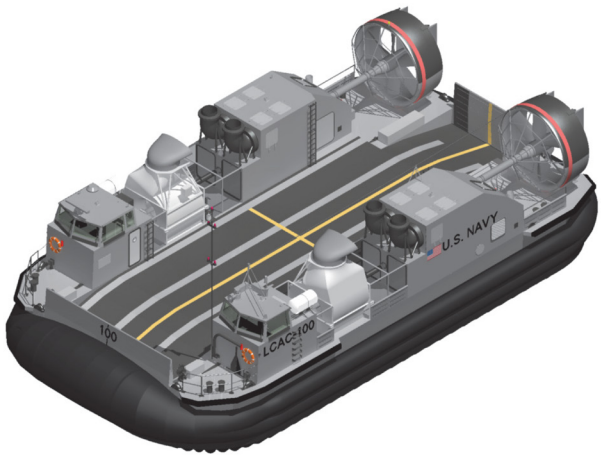
Recommendations

- Status of Previous Recommendations. The Navy has satisfactorily completed some of the previous recommendations. However, the Navy has not resolved the following previous recommendations related to LHA(R) ship self-defense:
  1. Optimize SSDS MK 2 weapon employment timelines to maximize weapon Probability of Kill.
  2. Develop a credible open-loop seeker subsonic ASCM surrogate target for ship self-defense combat system operational tests.
  3. Correct the identified SSDS MK 2 software reliability deficiencies.
  4. Correct the identified SSDS MK 2 training deficiencies.
  5. Develop and field deferred SSDS MK 2 interfaces to the Global Command and Control System – Maritime and the TPX-42A(V) command and control systems.
  6. Continue to implement the Program Executive Office for Integrated Warfare Systems' plan for more robust, end-to-end systems engineering and associated developmental/operational testing of ship self-defense combat systems.
  7. Improve the ability of legacy ship self-defense combat system sensor elements to detect threat surrogates used in specific ASCM raid types.
  8. Develop adequate and credible target resources for ship self-defense and EW operational testing.
  9. Continue to take action on the classified recommendations contained in the March 2011 and November 2012 DOT&E reports to Congress on the ship self-defense mission area.
  10. Improve the SSDS MK 2 integration with the MK 9 Track Illuminators to better support ESSM engagements.
  11. Develop combat system improvements to increase the likelihood that ESSM and RAM will home on their intended targets.
  12. Continue to implement and demonstrate with adequate operational testing the ship self-defense Fire Control Loop Improvement Program improvements.
- FY15 Recommendations. The Navy should:
  1. Correct the identified integration deficiencies with the LHA(R) SSDS-based combat system and the RAM Block 2 missile. Demonstrate these corrections in a phase of LHA(R) operational testing.
  2. Correct the cause of the ESSM missile failures and demonstrate the correction in a future phase of operational testing.
  3. Correct the SSDS Local Command and Control functionality issue. Demonstrate the correction in a future phase of SSDS operational testing.
  4. Investigate means to mitigate the chances of an ESSM pre-detonating on debris before approaching its intended target.
  5. Investigate why target emitters continue to be reported as valid by the AN/SLQ-32 EWS with the SEWIP Block 1 upgrade after the target is destroyed. Test any corrections in a future operational test phase.
  6. Correct the SSDS scheduling function to preclude interference from prior intercepts and warhead detonations with RAM's infrared guidance. Demonstrate corrections in a phase of operational testing.
  7. Correct the integration problems with the SSDS-based combat system and the AN/SPQ-9B radar to ensure that all valid AN/SPQ-9B detections are used by the combat system when tracking targets. Demonstrate the corrections in a phase of operational testing.
  8. Investigate the late detections by the AN/SPQ-9B radar of certain types of threats at distances much closer to the ship than predicted from historical data. Demonstrate any corrections in a future phase of operational testing.
  9. Investigate why the BQM-74 aerial targets failed to maintain operationally realistic flight parameters. Demonstrate any corrections prior to using these targets in similar operational test scenarios.
  10. Complete the LHA(R) IOT&E at-sea test phases and the planning for the LHA(R) P_{RA} M&S test bed IOT&E test phase.
  11. Update the LHA(R) Test and Evaluation Master Plan to include at-sea and P_{RA} test bed operational test phases to enable evaluation of ship self-defense capabilities on the LHA-8 equipped with new radar systems.

Ship-to-Shore Connector (SSC)

Executive Summary
- This is the first annual report for this program and it only addresses LFT&E.
- In June and July 2015, the Navy conducted full scale hull tests of the Ship-to-Shore Connector (SSC) hull and skirt system against an under-hull explosion and blast/fragmentation threat using a Landing Craft Air Cushion (LCAC) as a surrogate. The full hull tests generated data that will be used to evaluate the potential for crew and troop casualties and characterize the weapons effects on craft structure and machinery.
- The Navy tested the topside modules and structure of the LCAC, the system the SSC is replacing, against weapons effects from shaped charge, indirect fire, and land mine threats during its development in 2011 and 2012. The SSC Program Office used the results of these tests to identify knowledge gaps for the SSC and accordingly fund and plan additional testing to address these gaps.
- The first craft is scheduled for delivery in FY17, and initial operational capability for the SSC is projected to occur in FY20.

System
- The SSC is a fully amphibious air cushion vehicle intended to replace the existing LCACs.
- Compared to the existing LCAC, the Navy intends the SSC to have increased payload, reliability, and availability.
- The Navy intends to operate the SSC from the well decks of current and planned Navy amphibious ships and onboard the planned Mobile Landing Platform.



Mission
Commanders will employ amphibious crews equipped with the SSC to transport equipment, personnel, and weapons systems from ships through the surf zone and across the beach to landing points beyond the high water mark in a variety of environmental conditions.

Major Contractor
Textron Systems – New Orleans, Louisiana

Activity
- In 2011 and 2012, sections of an LCAC structure and topside modules were used to characterize the weapons effects from shaped charge, indirect fire, and land mine threats when the craft was on cushion. Data from these tests were used to develop the full hull test plan.
- In July 2013, the Navy conducted a test using a 1/10 scale SSC in a wave tank to evaluate the craft's ability to survive a 10-foot significant wave height sea condition. The scalability of these data will be validated by instrumented trials using the first SSC after delivery from the shipbuilder in FY17.
- In June and July 2015, the Navy completed full hull testing using an operational LCAC as a surrogate for the SSC. This included two tests against mines emplaced under the hull and skirt, as well as a full hull test against a blast/fragmentation threat. The Navy intends to install energy-attenuating seats in the Command Module of the SSC to increase ride comfort of the crew, but these seats were not available for the under-hull test.
- Armor characterization is scheduled for early FY16, pending procurement of the armor that meets the SSC specifications.
- The Navy conducted all testing in accordance with a DOT&E-approved test plan.

Assessment
- The LFT&E conducted to date have provided data that can be used to refine craft damage predictions and crew and troop casualty predictions. These data should be incorporated into the modeling and simulation of the SSC and the engineering assessments that will be utilized in the Navy's SSC survivability assessment.
- The energy-attenuating seats were unavailable for installation on the full hull test, but the Navy collected data to facilitate future analyses to evaluate the performance of the new seats, when they become available.

- Findings from the completed full hull testing are based on using LCAC as a surrogate. The Navy should complete an engineering assessment to determine if additional testing to examine SSC-specific components is required.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The Navy should:
  1. Evaluate the classified findings from the full hull test to determine if the risk for personnel casualties can be reduced.
  2. Evaluate the results of the full hull test to determine if the LCAC component performance following the weapons effects presented is adequately representing the predicted performance of SSC components and/or to determine if additional SSC-specific component testing is warranted.
  3. Test the energy-absorbing seat design for the pilot and co-pilot at the structural load levels measured during the full hull test. These seats were not available for installation at the time of the test.

Small Surface Combatant (SSC)
Modification to the Littoral Combat Ship (LCS)

Executive Summary

- In December 2014, the SECDEF approved the Navy's recommendation to limit the Small Surface Combatant (SSC) requirements to what could be accomplished within cost constraints using a modification to the existing Littoral Combat Ship (LCS) Flight 0+ baseline configurations.
- In August and October 2015, the Navy delivered two drafts of the Capability Design Documents (CDD) that relegate all mission performance measures, other than the two measures for force protection against surface and air threats, to Key System Attributes rather than Key Performance Parameters (KPPs), which permits the combat capabilities desired in these follow-on ships to be traded away as needed to remain within the cost constraints. As a result, the new SSC could, in the extreme, be delivered with less mission capability than desired and with limited improvements to the survivability of the ship in a combat environment. In fact, the SSC could meet all its KPPs without having any mission capability.

System

- In 2014, the SECDEF authorized the Navy to restructure the LCS program to build the final 20 ships in the program (ships 33 through 52) to a revised version of the LCS Flight 0+ baseline design. The revised design, potentially starting in FY19, is designated the SSC; the Navy is now also calling it a Fast Frigate. Some SSC components and design changes yet to be identified may also be incorporated into LCS hulls 25 through 32 (FY16 – FY18).
- The revised design that the Navy wants to use for the SSC includes additional or improved built-in equipment for Surface Warfare (SUW), Anti-Submarine Warfare (ASW), and Anti-Air Warfare. These ships are expected to be heavier than the Flight 0+ baseline LCS design and have a lower maximum sustained speed and un-refueled range. They would retain some modularity to enable them to be configured for either full SUW or ASW missions by swapping portions of the mission modules:
  - From the SUW mission package , the following would be removed to convert to full ASW mission capability:
    - 30 mm guns
    - Ship-launched (Longbow) HELLFIRE Missile
    - 11 m boats
  - From the ASW mission package , the following would be removed to convert to full SUW mission capability:
    - Variable Depth Sonar (active transmitter)
    - ASW Engagement Weapons for helicopter
- The SSC will not be able to perform the mine countermeasure mission.

- While the Navy has not released a final design, it is considering the following modifications to the LCS Flight 0+ baseline:
  - An improved three-dimensional air surveillance radar
  - An upgrade of the ship's air defense capability to include Sea Rolling Airframe Missile Anti-Ship Missile Defense System (already part of the *Independence* variant seaframe)
  - An over-the-horizon SUW anti-ship missile
  - An improved electronic warfare capability
  - Improved decoy systems for air defense
  - A multifunction towed-array passive sonar system
  - Torpedo defense and countermeasures equipment
  - Increased magazine armor
  - 25 mm guns
- The Navy has not made a decision on the SSC seaframe. Currently, two variants are produced:
  - The *Freedom* variant is a semi-planing monohull design constructed of steel (hull) and aluminum (deckhouse) with two steerable and two fixed-boost water jets driven by a combined diesel and gas turbine main propulsion system.
  - The *Independence* variant is an aluminum trimaran design with two steerable water jets driven by diesel engines and two steerable water jets driven by gas turbine engines.

Mission

- The Maritime Component Commander will employ SSC to conduct ASW or SUW tasks depending on the mission components fitted into the seaframe. Commanders can employ LCS in a maritime presence role in any configuration to build and strengthen maritime partnerships by training and operating with smaller, regional navies.
- The Navy has not yet published a Concept of Operations for the SSC, but the Navy reported in its 2014 SSC assessment

report that the SSC would operate as an ASW or SUW escort for high-value units, in a surface action group focused on ASW or SUW, or operate independently ahead of the strike group preparing the operational environment for joint force assured access to critical littoral regions. The level of Probability of Raid Annihilation requirement indicated in the draft CDD implies the SSC is likely to operate under an air defense umbrella provided by other units as determined necessary by the operational commander.

Major Contractors

An acquisition strategy for the 20 SSC has not been approved and no contracts have been authorized. The current LCS production lines are:

- *Freedom* class variant (mono-hull design)
  - Prime: Lockheed Martin Maritime Systems and Sensors – Washington, District of Columbia
  - Shipbuilder: Marinette Marine – Marinette, Wisconsin
- *Independence* class variant (trimaran design)
  - Prime: Austal USA – Mobile, Alabama
  - Shipbuilder: Austal USA – Mobile, Alabama
- Mission Packages
  - Future Mission Package Integration contract awarded to Northrop Grumman – Los Angeles, California

---

Activity

- In November 2014, in response to the SECDEF's February 2014 memorandum tasking the Navy to examine the needs of the fleet and propose alternate designs to procure a small combatant with capabilities consistent with modern frigates, the Navy recommended a SSC design based on minor modification to the LCS.
- In December 2014, the SECDEF directed the Navy to move forward with a multi-mission SSC based on the existing LCS Flight 0+ baseline configurations.
- The Navy is still in the process of developing the SSC acquisition strategy, the detailed ship designs, and selecting the systems and components for this modification.
- During 2-4QFY15, the Navy developed a draft CDD, which is currently under review but expected to be approved in FY16.
- In August and October 2015, DOT&E reviewed two versions of the draft CDD and provided critical comments on the document to the Joint Staff and the Navy.

Assessment

- The latest draft SSC CDD requires that the modified LCS be multi-mission capable, more lethal, and more survivable. The SSC is required to have mission system components from the LCS SUW and ASW mission modules to allow the ships to conduct some degree of the SUW and ASW missions simultaneously. Additionally, the draft SSC CDD cites that based on cost, schedule, and performance, components of an LCS mission package may be installed on a full time basis for space, weight, power, and cooling (SWaP-C) savings. However, because of SWaP-C limitations inherent in the current LCS design, the SSC most likely will not meet all of the requirements specified in the draft CDD simultaneously. It will most likely require swapping mission modules to provide either the full mission capability for SUW or ASW as directed by the Force Commander.
- The latest draft CDD relegates all mission performance measures, other than the two measures for force protection against surface and air threats, to Key System Attributes rather than KPPs, which permits the combat capabilities desired in these follow-on ships to be traded away as needed to remain within the cost constraints. As a result, the new SSC could, in the extreme, be delivered with less mission capability than desired and with limited improvements to the survivability of the ship in a combat environment. In fact, the SSC could meet all its KPPs without having any mission capability.
- The vulnerability reduction features proposed for the SSC provide no significant improvement in the ship's survivability. Notwithstanding potential reductions to its susceptibility due to improved electronic warfare system and torpedo defense, minor modifications to LCS (e.g., magazine armoring) will not yield a ship that is significantly more survivable than LCS when engaged with threat missiles, torpedoes, and mines expected in major combat operations.
- The current LCS seaframes do not have sufficient separation and redundancy in their vital systems to recover damaged capability. Because the SSC design is not substantially different from the LCS Flight 0+ baseline and will not add much more redundancy or greater separation of critical equipment or additional compartmentation, it will likely be less survivable than the Navy's previous frigate class.
- While the Navy is examining methods to reduce weight, it is anticipated the SSC will be heavier than the existing LCS resulting in a lower maximum sprint speed and less fuel endurance.

Recommendations

- Status of Previous Recommendations. This is the first annual report for this program.
- FY15 Recommendations. The Navy should:
  1. Improve the final CDD by developing clearly-defined mission-focused requirements for SUW, ASW, and Air Warfare, and specifying them as KPPs for each focused mission configuration.
  2. Consider implementing additional survivability improvement measures (e.g., shock hardening, redundancy of vital systems, etc.) to make SSC more survivable in combat.

SSN 774 *Virginia* Class Submarine

Executive Summary

- The Navy deployed the first *Virginia* class Block III submarine, USS *North Dakota* (SSN 784), in May 2015 with only limited developmental testing of the platform's major subsystem upgrades. Major testing phases included developmental testing of the new Large Aperture Bow (LAB) sonar array, testing of the system to support weapon system accuracy (this included sonar performance assessments), testing of the weapon system interfaces, and a limited operational assessment phase to support deployment certification.
- DOT&E submitted a classified Early Fielding Report in September 2015 detailing the results of the testing to date. DOT&E concluded that:
  - The *Virginia* class Block III submarine with the LAB array has the potential to perform as an adequate replacement for the spherical array used on previous *Virginia* class variants.
  - System reliability meets the Navy's thresholds.
  - The new LAB array and the Light Weight Wide Aperture Array (LWWAA) sonar processing systems suffer from some deficiencies. Although the Navy has implemented corrective action in each case, a full operational evaluation has not yet been conducted.
- The Navy intends to conduct a comprehensive operational test of the Block III system starting in 1QFY17 covering the Anti-Submarine Warfare (ASW), Anti-Surface Warfare (ASUW), Strike Warfare, and Intelligence collection mission areas in addition to suitability and cybersecurity assessments.
- The Navy has conducted four major test periods to assess the *Virginia* class Block I and Block II submarines. The overall results of these combined testing periods were:
  - *Virginia* class submarines are capable of hosting the Dry Deck Shelter system and can remain covert during Naval Special Warfare missions in some environments against some threat forces.
  - *Virginia* class submarines are effective at supporting general arctic operations.
  - *Virginia* class submarines are effective at conducting ASW missions in some environments against some threats.
  - Although the *Virginia* class submarine was not effective for some missions tested, it remains an effective replacement for the *Los Angeles* class submarine, providing similar mission performance and improved covertness.

System

- The *Virginia* class submarine is the Navy's latest fast attack submarine that is capable of targeting, controlling, and launching MK 48 Advanced Capability torpedoes and Tomahawk cruise missiles.

- The Navy is procuring *Virginia* class submarines incrementally in a series of blocks; the block strategy is for contracting purposes, not necessarily to support upgrading capabilities.
  - Block I (hulls 1-4) and Block II (hulls 5-10) ships were built to the initial design of the *Virginia* class.
  - Block III (hulls 11-18) and Block IV (hulls 19-28) ships include the following affordability enhancements starting with SSN 784, USS *North Dakota*:
    - A LAB array in place of the spherical array in the front of the ship.
    - Two *Virginia* payload tubes replace the 12 vertical launch tubes; each payload tube is capable of storing and launching six Tomahawk land attack missiles used in Strike Warfare missions.
  - Block V and beyond will increase strike payload capacity from 12 to 40 Tomahawk land attack missiles by adding a set of four additional payload tubes in an amidships payload module, capable of storing and launching seven Tomahawk missiles each, as well as providing the potential to host future weapons and unmanned systems.

Mission

The Operational Commander will employ the *Virginia* class submarine to conduct open-ocean and littoral covert operations that support the following submarine mission areas:

- Strike Warfare
- Anti-Submarine Warfare
- Intelligence, Surveillance, and Reconnaissance
- Mine Warfare
- Anti-Surface Ship Warfare
- Naval Special Warfare
- Battle Group Operations

Major Contractors
- General Dynamics Electric Boat – Groton, Connecticut
- Huntington Ingalls Industries, Newport News Shipbuilding – Newport News, Virginia

---

Activity
- The Navy completed the shock qualification testing for the *Virginia* Common Weapons Launcher and the *Virginia* Payload Tube hatch in late 2014. The analysis of the test results and redesign of a sub component has resulted in the hatch qualification being delayed until late 2015.
- The Navy has delayed the validation of the Transient Shock Analysis modeling method used for the design of *Virginia* class Block III items until mid to late 2016 to allow more time to complete their analysis.
- The update of the *Virginia* Class Vulnerability Assessment report, which will include the Block III modifications, will be delayed to late 2016.
- The following developmental testing events were completed prior to deploying the first *Virginia* class Block III platform with data from each event provided to DOT&E for analysis:
  - In September 2010, the Navy completed a full scale LAB array acoustic and vibration developmental test.
  - In October 2014, the Navy completed the first Block III *Virginia* class submarine Weapon System Accuracy Test, which assessed the overall systems ability to employ weapons.
  - In December 2014, the Navy conducted a limited free play test event to support an early system follow-on assessment to re-evaluate the LAB array sonar.
- In May 2015, the Navy conducted a limited free play developmental test event observed by DOT&E to evaluate the LAB array in support of an early deployment. In September 2015, DOT&E submitted a classified Early Fielding Report on the first *Virginia* class Block III submarine in response to an early deployment prior to the completion of developmental or operational testing.
- The Navy is planning to conduct a comprehensive operational test of the Block III system in early FY17 covering ASW, ASUW, Strike Warfare, and Intelligence collection mission areas, in addition to suitability and cybersecurity assessments.
- Due to material issues associated with Electric Boat sub-vendor work, all *Virginia* class Block III operational testing previously scheduled for completion in 3QFY16 has been delayed until 2QFY17.

Assessment
- The September 2015 DOT&E classified Early Fielding Report details the impact of the new major components of the system with respect to the intended mission during the early deployment. The report concluded the following:
  - The changes to the *Virginia* class Block III submarine do not appear to improve or degrade the system's ability to conduct submarine missions.
  - The LAB array demonstrates the potential to perform as an adequate replacement for the legacy spherical array.
  - Although the technical parameters are similar, the system initially presented a series of display artifacts, which could affect performance. The Navy has investigated these artifacts and has issued software fixes to mitigate the effects. This software has not been operationally tested.
  - The sonar LWWAA experienced a hardware fault, which limited the effectiveness of the system. The Navy investigated the issue, determined the root cause, and implemented a software update to help mitigate the issue.
  - Developmental testing of the system indicates that system software reliability meets the Navy's thresholds. Hardware reliability was not able to be evaluated because of the limited time available to testers for the evaluation. The LAB array outboard signal processing equipment has exhibited some early failures. The Navy issued fleet guidance for monitoring system performance and continues to investigate potential causes.

Recommendations
- Status of Previous Recommendations.
  - The Navy has made progress in addressing 25 of the 44 recommendations contained in the November 2009 and 2012 classified FOT&E reports. However, there are several that remain outstanding. The significant unclassified recommendations are:

1. Test against a diesel submarine threat surrogate in order to evaluate *Virginia's* capability, detectability, and survivability against modern diesel-electric submarines.
2. Conduct an FOT&E to examine *Virginia's* susceptibility to airborne ASW threats such as Maritime Patrol Aircraft and helicopters.

  - The following recommendations from the FY12 Annual Report remain open and the Navy should work to address them in the upcoming fiscal year:

1. Coordinate the *Virginia*, A-RCI, and AN/BYG-1 Test and Evaluation Master Plans and utilize Undersea Enterprise Capstone documents to facilitate testing efficiencies.
2. Complete the verification, validation, and accreditation of the Transient Shock Analysis method used for *Virginia* class Block III items.
3. Repeat the FOT&E event to determine *Virginia's* susceptibility to low-frequency active sonar and the submarine's ability to conduct ASUW in a low-frequency active environment. This testing should include a *Los Angeles* class submarine operating in the same

environment to enable comparison with the *Virginia* class submarine.

- The following recommendations from the FY13 Annual Report remain open and the Navy should work to address them in the upcoming fiscal year:

1. Reconsider the metrics used to assess the *Virginia* class submarine's ability to covertly conduct mass swimmer lockout operations using the Dry Deck Shelter.
2. Investigate and implement methods to aid the Special Operation Forces in identifying the submarine during operations in conditions of low visibility.
3. Investigate modifying the reducer in the air charging system to allow higher air pressure for the Seal Delivery Vehicle (SDV) Auxiliary Life Support System in order to provide increased flexibility for SDV missions that can be hosted from *Virginia* class submarines.
4. Continue to collect data on the susceptibility of the *Virginia* class to low-frequency passive systems and conduct a more quantitative assessment (e.g., determine detection ranges for different ship postures).

- FY15 Recommendations. The Navy should:

1. Address the three classified recommendations listed in the September 2015 Block III *Virginia* class Early Fielding Report.
2. Complete operational testing of the Block III *Virginia* class submarine as soon as practical.

Standard Missile-6 (SM-6)

Executive Summary

- The performance deficiency discovered during IOT&E and outlined in the classified Standard Missile-6 (SM-6) IOT&E report of May 2013 remains unresolved and continues to affect DOT&E's final assessment of effectiveness.
  - The Navy is assessing several options for a solution, each with varying degrees of complexity. A primary concern is to ensure the solution causes no degradation to the existing SM-6 performance envelope.
  - The Navy plans to incorporate these changes in Block I (BLK I) and Block IA (BLK IA) production variants in FY16.
- Upon completion of the current phase of SM-6 FOT&E, the Navy will have conducted testing that will allow an assessment of the SM-6 Capability Production Document performance requirement for interoperability.
- In FY16, the Navy expects to demonstrate the maximum range Key Performance Parameter (KPP) during SM-6 FOT&E and Aegis Baseline 9 operational testing as well as the launch availability KPP.
- The Navy commenced developmental testing of pre-planned product improvements to the SM-6 BLK I missile in FY14; these improvements are the SM-6 BLK IA configuration. A successful, pre-production developmental flight test (Guidance Test Vehicle-1 (GTV-1)) occurred in FY14. The Navy successfully conducted a second GTV mission (GTV-2) in FY15. The Navy plans to conduct a final SM-6 BLK IA GTV mission (GTV-3) in FY16. Operational testing of the SM-6 BLK I A is planned for FY16/17.
- The Navy conducted seven SM-6 BLK I missile tests during FY15. Of the planned launches, two of three successfully supported FOT&E with Aegis Baseline 9; one test resulted in a missile failure-to-launch (dud/misfire); one successfully supported Naval Integrated Fire Control – Counter Air (NIFC-CA) From-the-Sea (FTS) Increment 1 capability; and three successfully supported Missile Defense Agency (MDA) Sea-Based Terminal (SBT) testing.
- NIFC-CA FTS Increment 1 test events have demonstrated a basic capability, but its effectiveness under operationally realistic conditions is undetermined.
- DOT&E continues to monitor the uplink/downlink antenna shroud reliability during FOT&E. There are no recorded failures in testing since IOT&E in FY11.

System

- SM-6 is the latest evolution of the Standard Missile family of fleet air defense missiles.
- SM-6 is employed from cruisers and destroyers equipped with the Aegis combat systems.

- The SM-6 seeker and terminal guidance electronics derive from technology developed in the Advanced Medium-Range Air-to-Air Missile program.
- SM-6 retains the legacy Standard Missile semi-active radar homing capability.
- SM-6 receives midcourse flight control from the Aegis Combat System via ship's radar; terminal flight control is autonomous via the missile's active seeker or supported by the Aegis Combat System via the ship's illuminator.
- SM-6 is being upgraded to the BLK IA configuration to address hardware and software improvements and to address advanced threats.
- SM-6 Dual I capability is being added to provide SBT capability against short-range ballistic missiles.

Mission

- The Joint Force Commander/Strike Group Commander will use SM-6 for air defense against fixed-/rotary-winged targets and anti-ship missiles operating at altitudes ranging from very high to sea skimming.
- The Joint Force Commander will use SM-6 as part of the NIFC-CA FTS operational concept to provide extended range over-the-horizon capability against at-sea and overland threats.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- The Navy conducted seven SM-6 BLK I missile tests and one SM-6 BLK IA missile test during FY15. Of the planned launches, two of three successfully supported FOT&E with Aegis Baseline 9; one test resulted in a missile failure-to-launch (dud/misfire); one successfully supported NIFC-CA FTS Increment 1 capability; and three SM-6 Dual I missiles successfully supported MDA SBT and Air Warfare retention capability. The single SM-6 BLK IA was successful.

SM-6 BLK I FOT&E

- In March 2015, at Point Mugu, California:
  - An SM-6 BLK I FOT&E mission (D1I) successfully engaged a target that was using electronic attack against the SM-6 missile.
  - An SM-6 BLK I FOT&E mission (D1H) successfully engaged a target that was using electronic attack against the Aegis shipboard radar supporting the SM-6.
  - An SM-6 BLK I FOT&E mission (D1G) failed due to a failure-to-launch (dud/misfire).

NIFC-CA FTS Increment I

- In June 2015, a SM-6 BLK I, in support of NIFC-CA FTS testing, successfully engaged a full-scale fighter target at White Sands Missile Range, New Mexico.

SM-6 BLK IA

- In November 2014, the Navy successfully conducted a land based test launch of the pre-production SM-6 BLK IA at White Sands Missile Range, New Mexico. The missile successfully engaged a subsonic cruise missile target overland. This was the second flight test of the SM-6 BLK IA configuration. The Navy plans to conduct a final GTV mission in FY16 using the production configuration SM-6 BLK IA.

SM-6 Dual I

- In July 2015, at the Pacific Missile Range Facility, Kauai, Hawaii, the MDA and Navy successfully conducted:
  - A Multi-Mission Warfare (MMW) mission 1. In this mission, an SM-6 missile successfully engaged a short-range ballistic missile target.
  - An SM-6 Dual I Air Warfare capability retention MMW mission 3. In this mission, an SM-6 missile successfully engaged a supersonic high-diver target.
  - An SM-6 Dual I Air Warfare capability retention MMW mission 4. In this mission, an SM-6 missile successfully engaged a subsonic low-altitude cruise missile target.
- The Navy conducted these tests in accordance with the DOT&E-approved MDA Integrated Master Test Plan.

Assessment

- During FY15 flight tests, there were no occurrences of the uplink/downlink antenna shroud reliability deficiency. DOT&E and the Navy will continue to collect data on this deficiency throughout FOT&E flight-testing. In addition, there were no observations of additional anomalies during these tests.
- The March 2015 SM-6 BLK I mission D1G misfire remains under investigation by the Navy with no root cause determination to date.
- In the May 2013 SM-6 IOT&E report, DOT&E assessed SM-6 BLK I as suitable. This assessment considered combined data from the IOT&E and developmental/operational flight tests. During FY15 testing, DOT&E collected additional reliability data and assessed the SM-6 BLK I continues to remain suitable. DOT&E will continue to collect suitability and effectiveness data throughout SM-6 BLK I FOT&E testing in FY16, as well as during all SM-6 flight testing in support of NIFC-CA FTS, MDA, and Aegis software baseline development.
- The performance deficiency discovered during IOT&E and outlined in the classified IOT&E report remains unresolved and continues to affect DOT&E's final assessment of effectiveness. The Navy is assessing several options for a solution, each with varying degrees of complexity. A primary concern is to ensure the solution causes no degradation to the existing SM-6 performance envelope. The corrective actions will be incorporated into production of the SM-6 BLK I and BLK IA configurations and tested during FOT&E.
- In FY16, the Navy expects to demonstrate the maximum range KPP during SM-6 FOT&E and Aegis Baseline 9 operational testing as well as the launch availability KPP.
- Upon completion of the current phase of SM-6 FOT&E, the Navy will have conducted sufficient testing to allow an assessment of the SM-6 Capability Production Document performance requirement for interoperability.
- NIFC-CA FTS Increment 1 test events conducted during FY15 continue to be basic developmental tests not conducted in an operationally realistic manner. The Navy plans to continue testing the Increment 1 configuration with increasingly challenging scenarios; however, no operational test concept or test plans for NIFC-CA FTS increments have been provided to DOT&E.

Recommendations

- Status of Previous Recommendations. The Navy is addressing the previous recommendations from FY14 to complete corrective actions of the classified performance deficiency discovered during IOT&E and develop a flight test program to test those corrective actions; however, no final solution has been determined .
- FY15 Recommendation.
  1. The Navy should provide DOT&E with an operational test concept and operational test plan for NIFC-CA FTS Increment 2.

Surface Electronic Warfare Improvement Program (SEWIP) Block 2

Executive Summary

- In December 2015, DOT&E submitted an Early Fielding Report to Congress on the results of the first phase of the IOT&E for the AN/SLQ-32 Electronic Warfare System (EWS) equipped with the Surface Electronic Warfare Improvement Program (SEWIP) Block 2 upgrade. The Navy conducted a portion of the IOT&E from August 22 through November 7, 2014, on USS *Bainbridge* (DDG 96) in the Virginia Capes operating area.
- Analysis of the available IOT&E data showed that, while the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade provides more capability in detecting and classifying threat emitters than the legacy AN/SLQ-32 EWS, the system has problems in creating multiple tracks from a single emitter source, in addition to incorrectly categorizing emitter tracks and an inability to hold them after initial detection. These deficiencies overwhelm and desensitize the operator to potential threats. Other deficiencies include numerous software reliability problems and a lack of documentation in addition to inadequate crew training and proficiency causing the Commander, Operational Test and Evaluation Force (COTF) test team to provide operationally unrealistic assistance to the crew, which unduly influenced some test results. Until these deficiencies are corrected, the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade will not have operational utility.
- The Navy is correcting these deficiencies and is scheduling another phase of IOT&E for mid-2016.

System

- SEWIP is an incremental development program that is intended to improve the electronic warfare capability on all Navy surface combatants.
- The SEWIP Block 1 upgrade focused on replacing obsolete parts in the AN/SLQ-32 and incorporating a new operator console, a specific emitter identification capability, and an embedded trainer.
- The SEWIP Block 2 upgrade incorporates a new antenna system and enhanced processing capabilities, which are intended to improve the AN/SLQ-32's passive electronic support capabilities.
- The SEWIP Block 3 upgrade, which is in early development, will incorporate improvements to the AN/SLQ-32 active electronic attack to improve ships self-defense capabilities.

Mission

Navy surface ship crews will use SEWIP to enhance the AN/SLQ 32 EWS anti-ship missile defense, counter targeting, and counter-surveillance capabilities and to improve the system's ability to collect electronic data.

Major Contractor

Lockheed-Martin – Syracuse, New York

Activity

- COTF conducted the first phase of IOT&E from August 22 through November 7, 2014, on USS *Bainbridge* (DDG 96) in the Virginia Capes operating area.
- In December 2015, DOT&E submitted a classified Early Fielding Report to Congress on the results of the first phase of IOT&E of the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade.
- The severity of the identified deficiencies during this first phase caused the Navy to schedule another phase of IOT&E for mid-2016.

Assessment

- Analysis of the available IOT&E data showed that, while the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade provides more capability in detecting and classifying threat emitters than the legacy AN/SLQ-32 EWS, the system generates multiple tracks from a single emitter source in addition to incorrectly categorizing emitter tracks and an inability to hold them after initial detection. These deficiencies overwhelm and desensitize the operator to potential threats. Other deficiencies included a lack of

documentation and numerous software reliability problems that included display freezes, system crashes, and unscheduled warm and cold starts. Until these deficiencies are corrected, the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade will not have operational utility

- Inadequate crew training and proficiency caused the COTF test team to provide operationally unrealistic assistance to the crew, which unduly influenced some test results. These included providing assistance in setting up displays to make threat detection easier to recognize, showing operators which threats needed identification, helping operators identify extraneous emitter contacts, calibrating the system when the operators failed to perform the calibration the system required, and resetting the system in the form of unscheduled warm and cold starts.
- The Navy plans to correct these deficiencies and demonstrate the fixes in another phase of IOT&E in mid-2016.

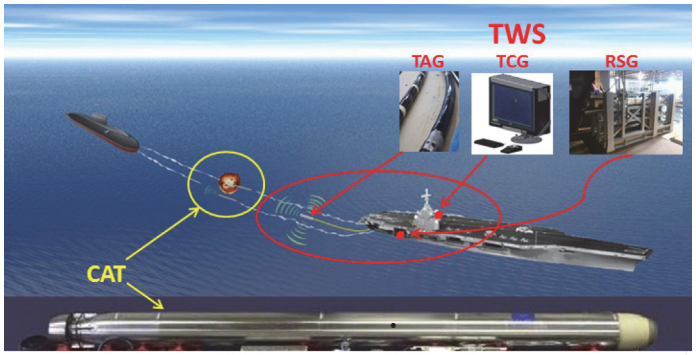
Recommendations

- Status of Previous Recommendations. The Navy has not resolved the following SEWIP Block 1 FY06 and FY08 previous recommendations to:
  1. Review and modify the SEWIP detection and classification algorithms to correct deficiencies discovered while operating in dense pulse and emitter environments. Verify the correction of these deficiencies during future SEWIP OT&E.
  2. Continue to collect in-service SEWIP hardware reliability data to gain a higher degree of confidence regarding achievement of this requirement.
  3. Continue to review and modify the SEWIP software to improve its reliability.
  4. Develop threat representative aerial target/threat seeker combinations and/or procure actual threat anti-ship cruise missiles for more realistic testing of future SEWIP block upgrades and other EWSs.
- FY15 Recommendation.
  1. The Navy should conduct the next IOT&E phase of the AN/SLQ-32 EWS equipped with the SEWIP Block 2 upgrade once the deficiencies identified in the first IOT&E phase are corrected.

Surface Ship Torpedo Defense (SSTD) System: Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT)

Executive Summary

- DOT&E submitted a classified Early Fielding Report in March 2015 on the Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT) system fielded aboard USS *Theodore Roosevelt* (CVN 71). The completed testing of the TWS (passive) and CAT Engineering Development Model-2 (EDM-2), powered by Stored Chemical Energy Propulsion System (SCEPS), fielded aboard *Theodore Roosevelt* (and previously on USS *George H. W. Bush* (CVN 77) has not demonstrated an effective capability against realistic threat country torpedo attack scenarios.
- The Navy's Quick Reaction Assessment (QRA) of TWS and CAT demonstrated a limited capability to detect and home on certain types of single torpedo threats. However, these versions of the system have not been fully tested and the Navy conducted most TWS and CAT testing in areas with benign acoustic conditions when compared to the expected threat operating areas, which may have biased the results high. Very few of the threat surrogates used during testing were conducting operationally realistic threat torpedo profiles due to safety constraints. Moreover, the lack of adequate testing has stymied the development of optimal tactics, techniques, and procedures and assessment of system availability and reliability, which negatively affects the system's suitability.
- The Navy installed a third version of the TWS and the CAT EDM-2 powered with SCEPS aboard the USS H*arry S. Truman* (CVN 75) during FY15. This version is similar to the permanent system installed on the *George H. W. Bush* in FY13 and includes the TWS Target Acquisition Group, the Tactical Control Group hardware, and two of the four planned CAT Ready Stow Group cradles. The TWS and CAT operational software is the same version installed for *Theodore Roosevelt* deployment to the Fifth Fleet in March 2015. The Navy fielded this version of TWS and CAT when the *Harry S. Truman* deployed in early FY16.
- In FY14 and FY15, the Navy installed a temporary-installation version of TWS and CAT (designated as a roll-on/roll-off system) aboard *Theodore Roosevelt* and conducted a second QRA in the Virginia Capes Operating Areas. Only two of the four planned QRA events and one of the five planned contractor test events were accomplished due to several factors including poor weather.
- The TWS program of record includes a Towed Active Acoustic Source (TAAS) to detect torpedoes using active sonar, but after exhibiting multiple critical reliability failures during the FY15 QRA, the Navy was unable to field the TAAS aboard *Theodore Roosevelt* as planned, and so, like *George H. W. Bush*, the ship deployed with a passive-only TWS.
- The Navy is currently installing a roll-on/roll-off version of TWS and CAT on USS *Dwight D. Eisenhower* (CVN 69) to support her next deployment and is in various stages of planning and installing the permanent version of the TWS and CAT early fielded hardware on selected CVNs before their next deployments.



CAT - Countermeasure Anti-Torpedo
RSG - Ready Stow Group
TAG - Target Acquisition Group
TCG - Tactical Control Group
TWS - Torpedo Warning System

System

- Surface Ship Torpedo Defense is a system-of-systems that includes two new sub-programs: the TWS (an Acquisition Category III program) and CAT (will not become an acquisition program until FY16). Combined, TWS and CAT are referred to as the Anti-Torpedo Torpedo (ATT) defense system.
- TWS is being built as an early warning system to detect, localize, classify, and alert on incoming threat torpedoes and consists of three major subsystems:
  - The Target Acquisition Group consists of a towed acoustic array, tow cable, winch, power supply, and signal processing equipment. Data from the array and the ship's radar system are processed into contact tracks and alerts to be forwarded to the Tactical Control Group. The array will be capable of both passive and active sonar operations.
  - The Tactical Control Group consists of duplicate consoles on the bridge and Combat Direction Center (on CVNs) that displays contacts, issues torpedo alerts to the crew,

and automatically develops CAT placement presets using information sent from the Target Acquisition Group. The operator will use this console to manage the threat engagement sequence and command CAT launches.
  - The Ready Stow Group will consist of the steel cradles housing the CATs. The permanent system consists of four steel cradles and associated electronics, each housing six ATTs at different locations (port/starboard and fore and aft on the CVN).
- CAT is a hard-kill countermeasure intended to neutralize threat torpedoes and consists of the following:
  - The ATT is a 6.75-inch diameter interceptor designed for high-speed and maneuverability to support rapid engagement of the threat torpedo.
  - The All-Up Round Equipment consists of a nose sabot, ram plate, launch tube, muzzle cover, breech mechanism, and energetics to encapsulate and launch the ATT.
  - The tactical CAT is powered by a SCEPS. The battery-powered electric motor CAT is for test purposes only. EDM-2 is the current hardware version of the CAT.
- The Navy developed a temporary version of TWS and CAT (designated a roll-on/roll-off system) in addition to the permanent-installation version. The Navy intends for this version to provide the same function as the permanent one.
  - The Ready Stow Group steel cradles are replaced by two lighter-weight and less-robust aluminum Launch Frame Assemblies that each hold four CATs.
  - The Tactical Control Group consists of two consoles contained in a container express box located on the carrier's hangar deck.
  - The towed acoustic array, tow cable, and winch are permanently installed on the carrier's fantail. The other components of the Target Acquisition Group are contained in the container express box located on the hangar deck.

Mission

Commanders of nuclear-powered aircraft carriers and Combat Logistic Force ships will use the Surface Ship Torpedo Defense system to defend against incoming threat torpedoes.

Major Contractors

TWS
- Ultra Electronics-3Phoenix – Chantilly, Virginia
- Alion Science and Technology – New London, Connecticut
- In-Depth Engineering – Fairfax, Virginia

CAT
- Pennsylvania State University Applied Research Laboratory – State College, Pennsylvania
- Pacific Engineering Inc. (PEI) – Lincoln, Nebraska

Activity

- The Navy installed a third version of the TWS and the CAT EDM-2 powered with SCEPS aboard *Harry S. Truman* during FY15. This version is similar to the FY13 installation aboard *George H. W. Bush* and includes the permanent installation of the TWS Target Acquisition Group and the Tactical Control Group hardware and two of the four planned CAT Ready Stow Group steel cradles. The TWS and CAT operational software is the same version as installed aboard *Theodore Roosevelt's* roll-on/roll-off system in FY14. The Navy fielded this version of TWS and CAT when the USS *Harry S. Truman* deployed in early FY16. The Navy is currently installing a roll-on/roll-off version aboard *Dwight D. Eisenhower* to support her next deployment and is in various stages of planning and installing the permanent version of the TWS and CAT early fielded hardware on selected CVNs before their next deployment.
- The Navy installed an initial version of TWS and the CAT EDM-2 aboard *George H. W. Bush* and conducted a QRA in the Virginia Capes Operating Areas in November 2013. The *George H. W. Bush*, which deployed with the TWS system and the CAT EDM-2 with the SCEPS propulsion system, returned from deployment to Fifth Fleet Operating Areas in November 2014.
- DOT&E submitted a classified Early Fielding Report in April 2014 on the TWS and CAT system fielded aboard *George H. W. Bush*. DOT&E submitted a classified update to the Early Fielding Report in August 2014, following the Navy's discovery of an anomaly in the CAT's Safety and Arming device. The Navy developed a correction for the anomaly in the CAT Safety and Arming device but could not install the correction in the fielded CATs due to safety concerns and USS *George H.W. Bush's* operational schedule.
- In FY14 and FY15, the Navy installed a roll-on/roll-off version of TWS and CAT aboard *Theodore Roosevelt* and conducted a second QRA in the Virginia Capes Operating Areas in November 2014. The QRA event was conducted in conjunction with a contractor test event. Only two of the four planned QRA events and one of the five planned contractor test events were accomplished due to several factors including poor weather. During each completed event, a single surrogate threat torpedo was fired at *Theodore Roosevelt* for the TWS system to detect and target. *Theodore Roosevelt's* crew, with the contractor support that accompanied the ship on their deployment, engaged the threat torpedo surrogate with a CAT during some of the events. All CATs that were fired used electric propulsion.
- The Navy's contractor redesigned the active source and the Navy planned to field it aboard *Theodore Roosevelt*, but there was insufficient time and resources to complete development

and testing prior to deployment. The redesigned TAAS failed during the November 2014 QRA, exhibiting new failure modes and failing in a similar fashion to the older one.

- The Navy fielded the roll-on/roll-off version of the TWS and the CAT EDM-2 powered by SCEPS aboard *Theodore Roosevelt* when she deployed in March 2015 to Fifth Fleet Operating Areas. The ship deployed with a passive-only TWS since the Navy was unable to deliver a functioning TAAS. DOT&E submitted a classified Early Fielding Report on the roll-on/roll-off version of TWS and CAT in March 2015.
- *Theodore Roosevelt* returned from deployment in November 2015. Due to operational limitations, the crew rarely deployed the TWS array during the deployment or while in the Fifth Fleet Operating Areas.
- In February and April 2015, the Navy and Pennsylvania State University Applied Research Laboratory conducted contractor testing of CAT on the Dabob Bay, Washington, and the Nanoose Bay, British Columbia, Canada, acoustic tracking ranges. The testing included runs to develop CAT's salvo capability and to evaluate the CAT's long-range passive fuzing capability.
- In August 2015, the Navy and the Naval Surface Warfare Center Carderock conducted warhead and Safety and Arming device airburst testing at Fort A.P. Hill, Virginia. This testing verified the arming, fuzing, and firing of the ATT warhead.
- In August 2015, the Navy and Pennsylvania State University Applied Research Laboratory conducted CAT contractor testing on the Dabob Bay, Washington, acoustic range. The testing supported developing the CAT's salvo capability.
- In August and September 2015, the Navy, Pennsylvania State University Applied Research Laboratory, and 3Phoenix conducted contractor testing of the TWS and CAT on the Nanoose Bay, British Columbia, Canada, acoustic tracking range. To accomplish this testing, the Navy removed the TWS array from *George H.W. Bush* and installed the repaired TAAS. This testing supported developing the TWS TAAS active waveforms and developing the end-to-end TWS detection and targeting and CAT intercept capability against threat torpedo salvos. On the third day, the TAAS array developed a short on one of the two TAAS transducer strings. The TWS contractor isolated the grounded string of transducers and continued the test with the remaining half of the TAAS transducers and the passive hydrophones.
- The Navy deployed the TWS (passive only system) and CAT EDM-2 powered by SCEPS aboard *Harry S. Truman* when she deployed in 1QFY16. Like the previous deployments, 3Phoenix contractor personnel deployed with the *Harry S. Truman* to operate the TWS system and to train the crew.
- During FY15, the Navy and DOT&E continued development of an enterprise Test and Evaluation Master Plan (TEMP) for the TWS and CAT systems. The Navy made their TWS Milestone B decision without a TEMP and is not planning to make the CAT system an acquisition program until FY16.

Assessment

- The completed testing of TWS (passive) and CAT EDM-2, powered by SCEPS, fielded aboard *George H. W. Bush* and *Theodore Roosevelt*, has not demonstrated an effective capability against realistic threat torpedo attack scenarios. The Navy's QRAs of TWS and CAT demonstrated limited capability to detect and home on certain types of single torpedo threats. However, these versions of the system have not been fully tested and the Navy conducted most TWS and CAT testing in areas with benign acoustic conditions when compared to the expected threat operating areas, which may have biased the results high. Very few of the threat surrogates used during testing were conducting operationally realistic threat torpedo profiles due to safety constraints.
- Moreover, the lack of adequate contractor and developmental testing has stymied the development of system detection; tracking and alerting software; operator tactics, techniques, and procedures; and assessments of system availability and reliability. Although the Navy and Pennsylvania State University Applied Research Laboratory are able to conduct independent structured CAT testing, 3Phoenix's TWS testing is limited because the prototype TWS arrays are rapidly fielded to the deploying CVN, leaving the 3Phoenix contractors without a full system to continue development. Further, the CVN's assigned operational areas in the Fifth Fleet Theater and the deployed operational profile limited use of the array. Thus, the amount of TWS data collected during the CVN deployments is less than expected.
- The Navy recently delayed the Initial Operational Capability of the TWS and CAT from 2018 to 2022. The Navy required the Program Office to deliver an early capability for the early fielded TWS and CAT. DOT&E assesses the Navy delivered a very limited capability, but that the early fielding approach is causing development delays and has resulted in a 3-4 year delay in delivering the Capability Development Document required torpedo defense capability to the CVNs. Because contractor resources are limited, the same Navy and contractor personnel are building TWS and CAT hardware sets and providing installation and in-service support to the CVNs, while also attempting to develop the required TWS and CAT capability.
- The Navy's decision to add a highly-trained contractor as the acoustic operator to supplement the automated detection and alerting functions of TWS, improved threat detection performance during the FY14 and FY15 QRAs. DOT&E assesses the majority of the TWS's detection and alerting capability is a result of the contractor acoustic operators monitoring the TWS displays to provide early alerts on threat torpedoes. However, the test areas did not offer the same number of opportunities for false alerts as expected in the

threat area; thus, it is not known if the presence of the operator could also reduce the false alert rate. For safety reasons, the QRA testing was highly structured and allowed the operators to focus on torpedo detections and firing the CAT. Therefore, QRA testing was inadequate to resolve the rate of false alerts or their effect on mission accomplishment.

- *George H. W. Bush's* and *Theodore Roosevelt's* deployments were useful in identifying TWS false alert sources, but system development done using these data needs to be assessed in testing to include the presence of both threat torpedo surrogates and assets that may cause false alerts simultaneously.
- During contractor testing and the FY14 and FY15 QRAs, a properly targeted CAT EDM-2 demonstrated a capability to detect and home on a single surrogate torpedo. However, nearly all of the surrogate threat torpedoes and CATs were operating deeper than most expected threat torpedoes due to safety reasons.
- During FY15, the Navy and Pennsylvania State University Applied Research Laboratory conducted shallower torpedo salvo scenarios that allowed the CATs to track and attack the surrogate threat torpedoes in more challenging areas of the water column. The Navy designed these scenarios to develop salvo tactics where the CATs conduct a coordinated attack on a threat torpedo salvo. During other events, the Navy, Pennsylvania State University Applied Research Laboratory, and 3Phoenix conducted scripted test events to create TWS and CAT detection opportunities and obtain data for TWS waveforms and detection, tracking and targeting software development, and CAT salvo development. Analysis of the test data is in progress; however, observations showed a mix of intercept and miss results in easier environmental areas. These tests were conducted with TWS and CAT developmental software that will not be fielded. The Navy conducted these tests at Dabob Bay, Washington, and Nanoose Bay, British Columbia, Canada. The Navy has not collected adequate data to assess CAT's overall ability to neutralize these threat salvos.
- During the FY15 Nanoose Bay testing, the TWS TAAS operated reliably and demonstrated a capability to alert on and to track targets during the first two days of the test, however half of the array's transducers grounded on the third day of testing. The contractor isolated one of the TAAS transducer strings, which allowed testing to continue. Analysis of the data is in progress, but initial observations suggest that the array was still able to provide active detections when half of the TAAS transducers were functioning, albeit with a degraded accuracy.
- The Navy developed and fielded a correction for the anomaly in the CAT Safety and Arming device. Analysis is still in progress, but observations from the airburst testing of the Safety and Arming Device and warhead indicates the correction was effective.
- Testing completed in FY15 indicates the new TAAS has both hardware and software reliability deficiencies, which the Navy's contractors are investigating.
- Additional information concerning the testing of TWS and CAT performance aboard *Theodore Roosevelt* is included in DOT&E's March 2015 classified Early Fielding Report.

Recommendations

- Status of Previous Recommendations. The Navy has made some progress on the FY13 and FY14 recommendations. However, the Navy should still:
  1. Complete the TEMP for the TWS and CAT system and an LFT&E strategy for the ATT lethality as soon as possible.
  2. Conduct additional testing in challenging, threat representative environments.
  3. Conduct additional CAT testing using operationally realistic threat target profiles closer to the surface to assess the CAT's terminal homing, attack, and fuzing within the lethality range of the warhead.
  4. Investigate test methods designed to reduce or eliminate the safety limitations that have previously prevented testing against operationally realistic target scenarios. The Navy should consider using geographic separation, range boundaries, and shallow draft ships for future TWS and CAT testing.
  5. Continue to investigate, correct, and retest deficiencies identified with the active source before planning to field TAAS.
- FY15 Recommendations. The Navy should:
  1. Adequately resource the TWS program to build dedicated test assets and conduct adequate dedicated contractor and developmental testing.
  2. Adequately resource the Program Office and its contractors to conduct TWS and CAT system development and testing.
  3. Investigate and implement the 14 outstanding recommendations in the March 2015 DOT&E Early Fielding Report.

Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar

Executive Summary

- The Commander, Operational Test and Evaluation Force completed IOT&E on Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar in January 2016. Testing was conducted in accordance with a DOT&E-approved test plan.
- DOT&E submitted an IOT&E report for SURTASS/CLFA in January 2015. It concluded that SURTASS/CLFA was not operationally effective for wartime Anti-Submarine Warfare (ASW) and that SURTASS/CLFA has significant cybersecurity vulnerabilities. SURTASS/CLFA was operationally suitable.

System

- SURTASS/CLFA is a low-frequency, passive and active, acoustic surveillance system installed on *Victorious* class tactical auxiliary general ocean surveillance (T-AGOS) ships as a component of the Integrated Undersea Surveillance System.
- SURTASS provides passive detection of nuclear and diesel submarines and enables real-time reporting of surveillance information to ASW commanders.
- CLFA is a low-frequency, active sonar system developed to provide an active detection capability of quiet submarines operating in environments that support long-range propagation.
- The system consists of:
  - A T-AGOS host ship with array-handling equipment
  - A towed vertical string of active acoustic projectors
  - A towed horizontal twin line (TL-29A) passive sonar array
  - An Integrated Common Processor for processing active and passive acoustic data
  - A High-Frequency Marine-Mammal Monitoring active sonar used to ensure local water space is free of marine mammals prior to and during low-frequency active transmission
  - A communications segment to provide connectivity to shore-based Integrated Undersea Surveillance System processing facilities and to fleet ASW commanders

Mission

Maritime Component Commanders:

- Employ *Victorious* class T-AGOS ships equipped with SURTASS/CLFA systems to provide long-range active and passive ASW detection, classification, and tracking of submarines in support of Carrier Strike Group and theater ASW operations.
- Use SURTASS/CLFA to provide blue force ASW screening and threat submarine localization information to theater ASW commanders to support coordinated prosecution of detected threat submarines.

Major Contractors

- Integrated Common Processor: Lockheed Martin – Manassas, Virginia
- CLFA Projectors: BAE – Nashua, New Hampshire
- TL-29A Towed Arrays: Lockheed Martin – Syracuse, New York

Activity

- In January 2015, the Commander, Operational Test and Evaluation Force completed IOT&E for SURTASS/CLFA. Testing was conducted in accordance with a DOT&E-approved test plan and included:
  - ASW area search operations that supported coordinated theater ASW during fleet exercises Valiant Shield 12 and Valiant Shield 14
  - Dedicated, at sea test phases in 2012 and 2014 that obtained performance data necessary to characterize detection capability against long-range submarine approaches
  - A cybersecurity assessment in January 2015

- In January 2016, DOT&E submitted a classified IOT&E report for SURTASS/CLFA based on observations and data collected during operational testing.
- One engineering development model and two production CLFA systems were available for operation on three of the four Western Pacific-based *Victorious* class T-AGOS ships during FY15.

Assessment

- The DOT&E classified IOT&E report concluded the following:
  - Testing was adequate to assess operational effectiveness and suitability.
  - SURTASS/CLFA was not operationally effective for wartime ASW. The fleet did not demonstrate sufficient capability to correlate non-submarine CLFA detections that were reported as possible submarines to real-time surface ship positions. Failure to exclude surface ship detections, coupled with limited numbers of available ASW-capable assets, will not support fleet prosecution of CLFA submarine localizations. Further details of the observed deficiencies are available in the classified report.
  - Although not the primary focus of this limited operational testing, SURTASS/CLFA can support coordinated ASW during peacetime. Long-range active detection and localization capability exceeds that of all non-SURTASS platforms. Without the risk of imminent attack, SURTASS/CLFA limitations can likely be overcome through extended analysis and comprehensive integration of other ASW platform and sensor data.
  - SURTASS/CLFA is operationally suitable, but exhibits reliability deficiencies during system initialization. Subsequent to a successful start-up of both the passive and active sonar arrays, SURTASS/CLFA demonstrated that it can operate without failure for extended and operationally relevant periods of time.
  - Cybersecurity evaluation identified significant problems, which are classified.

Recommendations

- Status of Previous Recommendations. The Navy should continue to address the FY13 recommendation to improve procedures and training for correlating CLFA non-submarine, active detections with real-time surface vessel positions.
- FY15 Recommendations. The Navy should:
  1. Mitigate identified cybersecurity vulnerabilities as soon as feasible for deployed SURTASS/CLFA and incorporate long-term corrections within future increments of SURTASS/CLFA.
  2. Address reliability failure modes observed during operational testing.
  3. Address the seven classified recommendations listed in the January 2016 IOT&E report.

Air Force Programs

Air Force Programs

AC-130J Ghostrider

Executive Summary

- U.S. Special Operations Command (USSOCOM) is developing AC-130J through the integration of a modular Precision Strike Package (PSP) onto existing MC-130J aircraft. An earlier version of the PSP was previously developed and tested on several AC-130W aircraft since 2009 and fielded in 2010.
- An in-flight Class A mishap in April 2015, which was caused by a second departure from controlled flight, grounded the only available aircraft and truncated the already-delayed developmental test and evaluation (DT&E) and concurrent operational assessment (OA).
- Aircraft #2 was delivered in the Block 10 configuration in June 2015.
- DT&E and the OA ended in July 2015 on aircraft #2 without completing either test plan due to both delays caused by the departures from controlled flight and limitations on weapon employment (PSP integration problems).
- Because of significant technical problems discovered during DT&E, the OA indicated the Block 10 AC-130J was at risk of not being ready for IOT&E. Per DOT&E's recommendation, the program will instead conduct IOT&E in 3QFY17 on Block 20 aircraft, which are a more operationally representative configuration of the aircraft desired for Initial Operational Capability.
- The program will conduct an Operational Utility Evaluation (OUE) on the Block 10 aircraft to support an early fielding decision and a Low-Rate Initial Production decision at Milestone C in 3QFY16.

System

- The AC-130J is a medium-sized, multi-engine, tactical aircraft with a variety of sensors and weapons for air-to-ground attack.
- USSOCOM is developing the AC-130J by integrating a modular PSP onto existing MC-130J aircraft, and replacing the MC-130J refueling pods with weapon racks. USSOCOM continues to develop new PSP capabilities on legacy AC-130W aircraft in parallel before they are introduced on the AC-130J in an evolutionary acquisition approach:
  - The Block 10 AC-130J PSP provides a weapons suite that includes an internal, pallet mounted 30 mm side-firing chain gun; wing-mounted GPS-guided Small Diameter Bombs; and Griffin laser-guided missiles mounted internally and launched through the rear cargo door.
  - The PSP also provides two electro optical/ infrared sensor/laser designator pods and multiple video, data, and communication links.
  - A dual-console Mission Operator Pallet (MOP) in the cargo bay controls all PSP subsystems with remote displays and control panels (including master arm and consent switches and a gun trigger) on the flight deck. An interim, limited-functionality, carry-on flight deck workstation for a Fire Control Officer (FCO) has been added to the Block 10 AC-130J.
  - Block 20 AC-130J will add, at a minimum, a 105 mm gun, a pilot helmet-mounted tactical display, and Large Aircraft Infrared Countermeasures. The aircrew will increase from seven to nine. The first Block 20 configuration is expected to be delivered on aircraft #4 in 4QFY16.
  - Future updates in Blocks 30, 40, and 50 are expected to include a permanent Fire Control Officer station, additional radar to provide all-weather engagement capability, wing-mounted HELLFIRE missiles, laser-guided Small Diameter Bombs, and radio-frequency countermeasures.
- The Block 10 AC-130J retains all survivability enhancement features found on the HC/MC-130J aircraft.
  - Susceptibility reduction features include the AN/ALR-56M radar warning receiver, the AN/AAR-47(V)2 missile warning system, and the AN/ ALE 47 countermeasure dispensing system.
  - Vulnerability reduction features include fuel system protection (fuel tank foam to protect from ullage explosion), redundant flight-critical components, and armor to protect the crew and the oxygen supply.
- The AC-130J will replace legacy AC-130H/U aircraft.

Mission

The Joint Task Force or Combatant Commander will use the AC-130J to:

- Provide persistent and precision strike operations for the missions of close air support and air interdiction
- Provide battlespace wide area surveillance, target geo-location, and precision munition application

Major Contractor
Lockheed Martin – Bethesda, Maryland

Activity

- The 18th Flight Test Squadron conducted an OA of the Block 10 AC-130J from October 2014 to July 2015. Testing consisted of 12 sorties and 47 flight hours during the DT&E period.
- Aircraft #1 experienced a Class A mishap in April 2015 during supplemental flying and handling qualities testing and has been grounded since the incident.
- Lockheed Martin delivered the second Block 10 AC-130J to USSOCOM in June 2015. Aircraft #2 became the test article for the remainder of DT&E and one final OA flight.
- The program concluded Block 10 DT&E in July 2015 after completing 97 flights comprising of 307 hours.
- Aircraft #3 began modification in August 2015 and is expected to be complete in the Block 10 configuration in March 2016. Aircraft #4 began modification in September 2015 and is expected to be complete in the Block 20 configuration by October 2016.
- Air Force Special Operations Command stood up Detachment 2 of the 1st Special Operations Group at Hurlburt Field, Florida, as the first unit to receive the AC-130J. Two crews from Detachment 2 began training on the AC-130J in August 2015 to support operational testing by December 2015.
- The Program Office submitted an updated Test and Evaluation Master Plan to DOT&E to support a Milestone C decision in 4QFY15 and IOT&E on Block 10 starting in 1QFY16. At DOT&E's recommendation, however, an OUE will be conducted on Block 10 instead of an IOT&E to support a USSOCOM early fielding decision for the Block 10 aircraft and a Low-Rate Initial Production decision at Milestone C.
- The 18th Flight Test Squadron will conduct IOT&E on a Block 20 aircraft in 3QFY17. Milestone C has been delayed to at least 3QFY16 in order to consider results from the Block 10 OUE and ongoing deficiency resolution efforts.
- The 780th Test Squadron is working with DOT&E to develop a weapons lethality test plan for the Griffin missile and 30 mm gun against representative targets to support the AC-130J lethality evaluation.
- The U.S. Air Force Combat Effectiveness and Vulnerability Analysis Branch is executing the Ballistic Vulnerability Analysis, Anti-Aircraft Artillery Susceptibility Analysis, Proximity Burst Analysis, and Occupant Casualty Analysis, in accordance with the DOT&E-approved LFT&E strategy, to support the AC-130J survivability evaluation.

Assessment

- The program took steps to address system integration problems discussed in last year's annual report:
  - The mounts for the electro-optical/infrared sensor balls have been modified to reduce the effect of the C-130J vibration environment on the picture clarity. Although testing of the newly mounted sensors has been qualitative and limited, preliminary results suggest the sensors can meet system threshold requirements.
  - The sensor operator stick controllers on the MOP that control the electro-optical/infrared sensors have been modified to harden them against radio frequency interference that could cause un-commanded sensor movements. Again, preliminary results from limited testing suggest this source of sensor movement may have been corrected.
- DT&E identified additional problems with the first AC-130J PSP integration:
  - Other instances of un-commanded sensor movement occurred that were not attributable to radio frequency interference problems. Investigation identified software mode switching, operator error, and rapid aircraft maneuvers, which exceeded the sensor's servo rotation rates as causes. The program has recommended crew workarounds to avoid the problem while it investigates corrective software updates.
  - The computers in the MOP were unable to keep up with the maximum computational demands placed on them. Operators frequently reported components of the mission management software locking up and requiring a reset, and in some cases, the hardware itself shuts down for thermal protection. Correcting this problem requires a modification of the MOP hardware and software. In the meantime, operators have been advised to operate the MOP in a degraded configuration with limited capabilities in order to reduce the likelihood of a shutdown, although this workaround does not guarantee system stability. The program has made an initial modification to the hardware and continues to collect MOP performance data during the crew training period.
  - Four other software issues generated Category 1 deficiencies that may not be corrected until the software update expected on the Block 20 aircraft. At least two of the deficiencies could hinder timely and accurate targeting of weapons because of data latency.
  - Operators experienced night vision compatibility problems on both the flight deck and the cargo compartment. A correction to the flight deck problem has been implemented and will be tested in the OUE and IOT&E.
- In April 2015, during supplemental flying and handling qualities (F&HQ) testing brought about by the first departure from controlled flight in February 2014, the aircraft experienced a second departure event. The recovery maneuver overstressed the aircraft and the damage resulted in a Class A

mishap. Aircraft #1 return to flight status is unknown. Preliminary results from the F&HQ testing suggest there are no significant differences in basic C-130J F&HQ caused by the AC-130J modifications.

- PSP integration problems, along with the addition of high-priority F&HQ testing after the first departure from controlled flight in February 2014, extended the DT&E schedule into July 2015, delayed end-to-end testing of weapons employment to the end of DT&E, and refocused the program's efforts on a minimum essential set of subsystem demonstrations. As a result, the grounding of the only aircraft after the Class A mishap effectively ended the incomplete OA, and DT&E concluded prematurely soon after that without completing the full intended characterization of system capabilities. This left the planned IOT&E at risk of demonstrating several capabilities for the first time and discovering problems that are more appropriately addressed during DT&E.
- The OA conducted on the Block 10 AC-130J to support the Milestone C decision and ultimately entrance into IOT&E in 1QFY16, indicated the system lacked maturity and is at risk to not be ready for IOT&E. Survivability was largely unevaluated due to flight restrictions in place and deferred subsystem integration testing in DT&E. Furthermore, the acquisition strategy to procure at most three Block 10 aircraft, then focus on the Block 20 aircraft for Initial Operational Capability (with significant capability enhancements and deficiency corrections) indicates the Block 20 configuration is the operationally representative configuration for IOT&E.
- The program recently removed full operational capability of HELLFIRE missiles from the Block 20 requirement.
- A limited amount of live fire testing against representative targets is required to evaluate the lethality of the AC-130J munitions and confirm the predictions of existing lethality models. These tests are not expected to increase the number of live shots already planned for operational testing.
- Preliminary assessment of the AC-130J survivability against operationally realistic threats will begin in FY16 after the completion of the survivability and occupant casualty analyses. These analyses are currently informed by legacy aircraft survivability data. DOT&E will supplement them with additional AC-130J susceptibility data, after the completion of relevant developmental and operational tests.

Recommendations

- Status of Previous Recommendations. The program satisfied both FY14 recommendations regarding preparation for IOT&E, which has now been converted to an OUE on the Block 10 aircraft. However, the Program Office still needs to provide data to DOT&E on AC-130W reliability, which could inform the AC-130J evaluation.
- FY15 Recommendations. The Program Office should:
  1. Commit to the full accomplishment of lethality testing by the end of IOT&E and work with the 18th Flight Test Squadron to make resources available for such testing concurrent with operational test missions.
  2. Develop a clear and stable baseline for block capability development, test, and fielding, and brief this strategy to DOT&E.

Advanced Extremely High Frequency (AEHF) Satellite Communications System

Executive Summary

- Air Force Space Command declared Initial Operational Capability (IOC) on the Advanced Extremely High Frequency (AEHF) Satellite Communications (SATCOM) system on July 28, 2015, and provided a recommendation to the U.S. Strategic Command (USSTRATCOM) Commander that the system was ready for operations.
- From October 27, 2014, to January 16, 2015, the Air Force Test and Evaluation Center (AFOTEC) conducted Multi-Service Operational Test and Evaluation (MOT&E) on the AEHF SATCOM system. The MOT&E, when combined with integrated and anti-jam scintillation testing, was adequate to support an evaluation of the system's operational effectiveness, suitability, and survivability.
- The AEHF SATCOM system is effective in providing survivable, secure, and reliable strategic communications at low data rates (LDR) and tactical communications at medium and extended data rates (MDR and XDR). The AEHF system is effective in maintaining satellite command and control (C2), planning communications, and managing satellite resources.
- DOT&E submitted an MOT&E report to Congress in May 2015.
- The AEHF SATCOM system is suitable and survivable.

System

- The AEHF system represents the second generation of Extremely High Frequency SATCOM capability protected from nuclear effects and jamming activities.
- The AEHF system will follow the Milstar program as the protected backbone of the DOD's integrated military SATCOM architecture. The AEHF constellation of four interconnected satellites is expected to increase system throughput capacity by a factor of 10.
- The AEHF system has three segments:
  - Space segment – an integrated constellation of Milstar and AEHF satellites
  - Mission Control segment – includes fixed and mobile telemetry, tracking, and commanding sites; fixed and transportable communication planning elements; the test and training simulation element; and the operational support and sustainment element
  - Terminal (or User) segment – includes ground-fixed, ground-mobile, man-portable, transportable, airborne, submarine, and shipboard configurations

Mission

Combatant Commanders and operational forces worldwide use the AEHF system to provide secure, responsive, and survivable strategic and tactical military communications.

Major Contractors

- Lockheed Martin Space Systems – Sunnyvale, California
- Northrop Grumman – Redondo Beach, California

Activity

- AFOTEC conducted the AEHF MOT&E from October 27, 2014, to January 16, 2015, with participation from the Navy's Commander, Operational Test and Evaluation Force, the Army Test and Evaluation Command, and the Marine Corps Operational Test and Evaluation Activity. AFOTEC conducted the MOT&E in accordance with a DOT&E-approved Test and Evaluation Master Plan and test plan.
  - The Services tested the AEHF IOC capabilities to include strategic communications at LDR, tactical communications at MDR and XDR, satellite C2, communications planning, and satellite resource management.
  - AFOTEC augmented the MOT&E data with anti-jam and scintillation testing conducted from June 13, 2014, through July 18, 2014, and integrated testing conducted from July 15, 2014, to September 30, 2014.

  - AFOTEC, in coordination with the Massachusetts Institute of Technology's Lincoln Laboratory, performed threat representative jamming of AEHF's strategic communication capability and the nulling capability for tactical communications. Nulling is a capability that blocks out strong jammer signals in a specific geographical area so the collocated tactical user's communications signals can be heard.
  - Three Army locations, two Marine Corps locations, two Navy destroyers and two submarines, the E-4B National Airborne Operations Center, and the E-6B Airborne Command Post, all participated in the test.
  - AFOTEC used a combination of live operations, USSTRATCOM exercise "Global Thunder," test-driven scenarios, and user surveys to evaluate strategic and tactical missions of the AEHF system. The test team tested various tactical networks, including a representative Army Corps network, a Marine Corps Air-Ground Task Force network, Navy Time Division Multiple Access Interface Processor and broadcast networks.
- DOT&E wrote and submitted an MOT&E report to Congress in May 2015.
- Air Force Space Command declared IOC on the AEHF SATCOM system on July 28, 2015, and provided a recommendation to the USSTRATCOM Commander that the system was ready for operations.

Assessment

- Operational testing of the AEHF SATCOM IOC capability, when combined with integrated and anti-jam scintillation testing, was adequate to support an evaluation of the system's operational effectiveness, suitability, and survivability.
- The AEHF SATCOM system is effective in providing survivable, secure, and reliable strategic communications at LDR and tactical communications at MDR and XDR. The AEHF SATCOM system is effective in maintaining satellite C2, planning communications, and managing satellite resources.
- The Air Force deferred the XDR capability supporting strategic forces until the Final Operational Capability is available, as these networks can only be transitioned from LDR to XDR when all terminals on the strategic networks are XDR-capable. AFOTEC will operationally test XDR for strategic services in the FOT&E, tentatively planned for FY21.
- The AEHF SATCOM system is suitable. The AEHF ground control systems meet their threshold reliability requirements. The AEHF satellites and ground systems meet their dependability requirements. Maintenance repair times for ground control systems exceeded threshold requirements in almost all areas and need improvement; however, the long maintenance repair times did not adversely affect system dependability. DOT&E rated human factors, system usability, training, and documentation favorably.
- The AEHF SATCOM system is survivable in the presence of uplink jamming, scintillation, and external cyber attack. Strategic communications were not degraded by a threat-representative jammer. The nuller antenna performance can be enhanced with operational procedures.

Recommendations

- Status of Previous Recommendations. The Air Force has made satisfactory progress on addressing all previous recommendations.
- FY15 Recommendations. None

AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM)

Executive Summary
- The Air Force and Navy completed FOT&E of the AIM-120D Advanced Medium-Range Air-to-Air Missile (AMRAAM) in July 2014 and fielded the system in January 2015.
- AIM-120D System Improvement Program (SIP)-1 operational test activities began in FY15 and are expected to be completed in FY16. SIP-1 is one of several follow-on programs designed to enhance AIM-120D performance.
- The Air Force continued integrated testing on AIM-120 AMRAAM Basic Electronic Protection Improvement Program (EPIP), a software upgrade to AIM-120C3-C7 variants, under a separate Basic EPIP Test and Evaluation Master Plan that DOT&E approved in April 2012.
- The Air Force and Navy are in the final stages of test planning to conduct cybersecurity testing for all variants of the AMRAAM missile.

System
- AMRAAM is a radar-guided, air-to-air missile with capability in both the beyond visual-range and within visual-range arenas. A single-launch aircraft can engage multiple targets with multiple missiles simultaneously when using AMRAAM.
- F-15C/D/E, F-16C/D, F/A-18C/D/E/F, EA-18G, and F-22A aircraft are capable of employing the AMRAAM.
- The AMRAAM program periodically develops and incorporates phased upgrades. The AMRAAM Basic EPIP is a software upgrade to AIM-120C3-C7. An Advanced EPIP software upgrade is planned to add additional capabilities.
- A SIP-2 upgrade is currently in planning.
- As of October 14, 2015, Raytheon has delivered a total of 1,405 AIM-120Ds.

Mission
- The Air Force and Navy, as well as several foreign military forces, use various versions of the AIM-120 AMRAAM to shoot down enemy aircraft.
- All U.S. fighter aircraft use the AMRAAM as the primary, beyond visual-range air-to-air weapon.

Major Contractors
- Raytheon Missile Systems – Tucson, Arizona
- Rocket Motor Subcontractor: Nammo (Nordic Ammunition Group) – Raufoss, Norway

Activity
- The Air Force and Navy conducted all testing in accordance with the DOT&E-approved test plan.

AIM-120D
- AIM-120D FOT&E, which the Air Force and Navy completed in July 2014, consisted of multiple live missile shots and captive-carry events. The missile was fielded in January 2015.
- The Program Office conducted SIP-1 integrated testing with two live missile shots in March and May 2015. Operational testing for SIP-1 began in January 2016.
- As of October 14, 2015, Raytheon has delivered a total of 1,405 AIM-120Ds for the Air Force and Navy.

AMRAAM EPIP
- In September 2014, the Air Force completed Basic EPIP operational testing for AIM-120C-7 missiles.
- In October 2014, the Air Force and Navy began Basic EPIP operational testing for AIM-120C-3, -4, -5, and -6. Reporting on Basic EPIP operational test is expected to be completed in FY16.

AMRAAM SIP
- The Air Force identified deficiencies in the AIM-120D missile performance that did not significantly degrade overall effectiveness. The Air Force and Raytheon Missile Systems developed solutions for specific deficiencies and will assess them during SIP-1 testing.

Cybersecurity
- The Air Force and Navy are in the final stages of test planning to conduct cybersecurity testing for all variants of the AMRAAM missile.

Assessment

- AMRAAM continues to be operationally effective and suitable.
- Based on FY15 testing, the AIM-120D SIP-1 missile appears to be meeting performance and reliability requirements, although a final assessment will not be available until after completion of SIP-1 operational testing in FY16.
- Missiles equipped with Basic EPIP software appear to be meeting performance requirements, based on testing to date. A final assessment of Basic EPIP will be available in FY16.

Recommendations

- Status of Previous Recommendations. The Air Force satisfactorily addressed the previous recommendations.
- FY15 Recommendations. The Air Force should:
  1. Complete SIP-2 and Advanced EPIP operational testing to achieve the Services' desired mission effectiveness improvements for AMRAAM.
  2. Complete cybersecurity testing for all variants of the AMRAAM missile in accordance with the August 1, 2014 DOT&E policy memorandum.

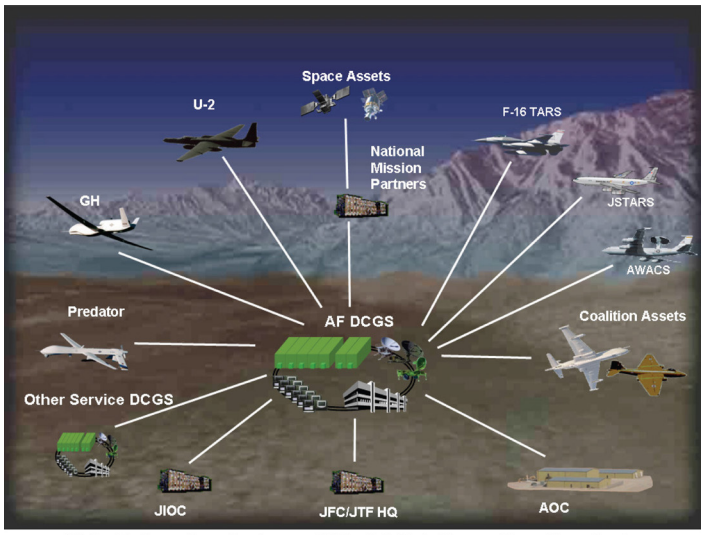
Air Force Distributed Common Ground System (AF DCGS)

Executive Summary

- Air Force intelligence units use the AF DCGS to produce intelligence information from data collected by a variety of sensors on the U-2, RQ-4 Global Hawk, MQ-1 Predator, MQ-9 Reaper, MC-12, and other Intelligence, Surveillance, and Reconnaissance platforms.
- The Air Force 605th Test and Evaluation Squadron completed Phase 1 of a three-phased Force Development Evaluation on the Geospatial Intelligence (GEOINT) Baseline 4.1 in June 2015. While GEOINT Baseline 4.1 did not harm any legacy capabilities, the only notable functional improvement was the ability to ingest synthetic aperture radar data from Global Hawk Block 40.
- The Air Force declared Full Operational Capability in 2009 and moved the program from the development phase into the sustainment phase despite the program's immaturity. In August 2015, the Air Force restructured AF DCGS from four Acquisition Category (ACAT) III programs into seven ACAT III programs. After the Air Force issued the Acquisition Decision Memorandum for the seven programs, it added one additional ACAT III program called DCGS Reference Imagery Transition (DRT), making a total of eight ACAT III programs. These programs lack current and accurate test and evaluation, systems engineering, and requirements documentation.

System

- The AF DCGS, also referred to as the AN/GSQ-272 SENTINEL weapon system, is an intelligence enterprise system that is composed of 27-geographically separated, networked sites, including 5 core sites across the globe.
- AF DCGS provides hardware and software tools for operators to plan, collect, process, exploit, and disseminate Intelligence, Surveillance, and Reconnaissance information. The DCGS Integration Backbone provides the framework that allows sharing of intelligence services and data via web services.
- The Air Force declared AF DCGS to be at Full Operational Capability in 2009, though it is continuing to develop the following four areas, each of which were ACAT III programs: Signal Intelligence (SIGINT) upgrades, GEOINT upgrades, Network Communications, and Data Links. In August 2015, the Air Force restructured AF DCGS from four ACAT III programs into seven ACAT III programs. Subsequent to the decision to transition to seven programs, the Air Force added one additional ACAT III program called DRT, making a total of eight ACAT III programs. Of the eight programs, only two programs—GEOINT Baseline 4.1 and the System Release 3.0—have been operationally tested.
- GEOINT Baseline 4.1 is part of the GEOINT upgrades portion of AF DCGS, is the merger of Bulk Release 10B with several deficiency corrections, and the integration of Airborne Cueing and Exploitation System-Hyperspectral (ACES-Hy) and Global Hawk Block 40.
- System Release 3.0 is a SIGINT upgrade, which makes SIGINT data and services available to internal and external users, improves operations with the Airborne SIGINT Payload low-band sensor, and improves processing, exploitation, and dissemination for high-band sensors.



AOC - Air Operations Center
AWACS - Airborne Warning and Control System
GH - Global Hawk
HQ - Headquarters
JFC - Joint Forces Command
JIOC - Joint Intelligence Operations Center
JSTARS - Joint Surveillance Target Attack Radar System
JTF - Joint Task Force
TARS - Tactical/Theater Airborne Reconnaissance System

Mission

- The Air Force uses AF DCGS for Intelligence, Surveillance, and Reconnaissance collection, processing, exploitation, analysis and dissemination.
- Air Force intelligence units use the AF DCGS to produce intelligence information from data collected by a variety of sensors on the U-2, RQ-4 Global Hawk, MQ-1 Predator, MQ-9 Reaper, MC-12, and other Intelligence, Surveillance, and Reconnaissance platforms.
- The Air Force uses AF DCGS to connect to the multi-Service DCGS Integration Backbone, manage requests for sensors, process sensor data, exploit sensor data from multiple sources, and disseminate intelligence products.

Major Contractors

- Raytheon – Garland, Texas
- Lockheed Martin – Denver, Colorado
- L-3 Communications – Greenville, Texas

Activity

- From November through December 2014, and in May 2015, the 46th Test Squadron conducted developmental and regression testing on GEOINT Baseline 4.1.
- In June 2015, the 605th Test and Evaluation Squadron conducted Phase 1 of the three-phased Force Development Evaluation at DGS-5 to assess the effectiveness and suitability of GEOINT Baseline 4.1 in support of a fielding decision following all three test phases.
- In May 2015, the 92nd Information Operations Squadron conducted a cybersecurity Cooperative Vulnerability and Penetration Assessment (CVPA) of System Release 3.0 (part of the SIGINT Upgrades program) at DCGS Ground Station – Experimental (DGS-X).
- In June 2015, the 46th Test Squadron conducted a cybersecurity CVPA of GEOINT Baseline 4.1 at DGS-X.
- The Air Force Program Executive Officer for Battle Management signed an Acquisition Decision Memorandum on August 6, 2015, to re-structure the program into seven Acquisition Category III programs: Sensor Integration, GEOINT Transformation, GEOINT Bulk Release 4.1, SIGINT Transformation, System Release 3.0, Infrastructure Transformation, and Multi-Intelligence. After the Acquisition Decision Memorandum, the Air Force added one additional ACAT III program called DRT, making a total of eight ACAT III programs. These programs lack current and accurate test and evaluation, systems engineering, and requirements documentation.
- The eight programs, when combined, exceed the funding threshold for a Major Automated Information System (MAIS) program. The Army and Navy versions of DCGS systems are MAIS programs.
- From September 10 through November 6, 2015, the Air Force Operational Test and Evaluation Center conducted an Operational Utility Evaluation on System Release 3.0. DOT&E will submit a report on the results of testing in early 2016.
- Testing was conducted in accordance with a DOT&E-approved test plan.

Assessment

- The program continues to lack current requirements and architecture documents, which inhibit the tester's ability to conduct an adequate evaluation.
- The program lacks a rigorous and comprehensive software problem tracking and reporting procedures. The Air Force is working to develop and implement software tracking and reporting via the AF DCGS Enterprise Service Desk.
- Multiple DGS users created ad-hoc DCGS analysis and reporting teams to perform intelligence fusion. These teams significantly enhanced situational awareness by integrating multiple intelligence disciplines. However, the Air Force did not formally resource these teams. Thus, the teams and lack personnel, doctrine, training, and material support.
- The ability of GEOINT Baseline 4.1 to ingest synthetic aperture radar data from the Global Hawk Block 40 is the only notable functional or performance gain over existing capability. The existing capability supports high- and medium-altitude planning, collection, processing and exploitation, analysis and production, and dissemination.
- Full motion video continues to have problems with freezing and degraded images. A Category 1 Urgent Test Problem Report has been open since June 2014 regarding full motion video software. Full motion video analysts continue to rely on software that is not a part of AF DCGS, and that the Air Force does not plan to continue to provide.
- Usability concerns remain as evidenced in the low System Usability Scale scores, particularly for full motion video operators. Mission processes are complex and poorly documented.
- Training is lacking in quality and frequency, and maintenance documentation and positional checklists are inadequate. The training survey forms indicate some operators and maintainers (19 of 143) did not receive any GEOINT Baseline 4.1 training, while others (10 of 143) specifically said they received training in October 2014, but did not start using GEOINT Baseline 4.1 until May or June 2015 with no refresher training. Analysts also commented that documentation and checklists were missing key information.
- Cybersecurity testing conducted at DGS-X discovered vulnerabilities. The details are classified. The Air Force is working on implementing fixes. Cybersecurity testing of an operational site is planned in FY16-17.

Recommendations

- Status of Previous Recommendations. The Air Force satisfactorily addressed, or made satisfactory process towards implementing, two of five previous recommendations. The three previous recommendations still outstanding are:
  1. Demonstrate the ability of AF DCGS to operate at anticipated workload levels. This requirement is still being waived by the Program Office prior to testing since much of the enterprise is not yet on a common baseline.
  2. Document the requirements for each delivery for each of the four, now eight, AF DCGS programs and conduct adequate test and evaluation based on a risk assessment in accordance with DOT&E guidelines. Adequate risk assessments have been conducted on all subsequent operational tests; however, requirements documentation is still lacking.
  3. Submit a Test and Evaluation Master Plan (TEMP) for DOT&E approval, which includes an accurate description of AF DCGS requirements, architecture, and interfaces sufficient to justify the test approach. The Program Office is making progress but has not submitted a complete draft TEMP.

- FY15 Recommendations. The Air Force should:
  1. Consider formally establishing and resourcing the DCGS analysis and reporting team, or a similar all-source fusion component, in each DGS.
  2. Develop and implement a software change request process including tracking of software metrics for problems open and closed by severity and time.
  3. Improve training, documentation, and checklists prior to the next phase of testing.
  4. Document all known cyber vulnerabilities in a plan of action and milestones and track the progress.
  5. Implement the planned new cybersecurity demilitarized zone architecture prior to the next CVPA at an operational site.
  6. Document and review operational processes and simplify where possible to support training and operations.

Air Operations Center – Weapon System (AOC-WS)

Executive Summary

- The Air Operations Center – Weapon System (AOC-WS) 10.1 is a system-of-systems that contains numerous third-party software applications, including the Global Command and Control System – Joint (GCCS-J), Theater Battle Management Core Systems – Force Level, Master Air Attack Plan Toolkit, and Joint Automated Deep Operations Coordination System.
- The Air Force tests AOC-WS 10.1 during a three-phase Recurring Event (RE) test cycle, which includes event-based test periods primarily focused on software upgrades. The software upgrades and associated test event are designated using similar terms; for example, AOC-WS 10.1 RE13 is the system upgrade tested during RE13.
  - Phase 1 developmental testing is conducted at the Combined Air Operations Center – Experimental (CAOC-X) at Joint Base Langley-Eustis, Virginia.
  - Phase 2 operational testing is conducted to assess effectiveness at CAOC-X.
  - Phase 3 operational testing is conducted at a fielded site to assess suitability.
- In October 2015, the Air Force delivered its final report on RE13 that included the results of Phase 3 operational testing at 613 AOC, Joint Base Pearl Harbor-Hickam, Hawaii.
- AOC-WS 10.1 RE13 has the capability to produce the primary products necessary to meet the established AOC battle rhythm at threshold levels. AOC-WS 10.1 RE13 demonstrated interoperability with other mission-critical systems.
- The Air Force fully assessed cybersecurity for AOC-WS 10.1 RE13 and identified 15 vulnerabilities posing significant risk to the AOC mission, 9 of which are attributable to third-party applications that are outside the control of the AOC-WS Program Office. The first-ever Adversarial Assessment of the AOC-WS demonstrated that significant cybersecurity risk to the mission exists.
- Following the completion of Phase 3 testing at 613 AOC, there was a single Category I (CAT I) Urgent functional deficiency. Air Combat Command conducted an analysis of this deficiency and has deferred the implementation of the responsible web-based application suite during RE13 fielding until the Program Office has remediated the deficiency.
- Air Combat Command accepted the mission risk posed by the 15 identified cyber vulnerabilities, and in November 2015 decided to field AOC-WS 10.1 RE13 to meet critical operational needs, while maintaining the expectation that the AOC-WS Program Office will fix unresolved CAT I deficiencies in an expeditious manner.
- AOC-WS 10.1 RE13 is built, configured, and maintained at operational sites with the assistance of a Program Office fielding team. The site leads the build and the fielding team augments at pre-planned points during complex segment installs. Tier 1 help desk support (AOC-WS helpdesk at Joint Base Langley-Eustis) was not effective during the test, but Tier 2 (program manager/vendor support) was adequate to support the system fielding and operations during the event. Subsequent fielding events will likely depend solely on Tier 2 help desk support.

System

- AOC-WS is the senior command and control element of the U.S. Air Force's Theater Air Control System and provides operational-level command and control of air, space, and cyberspace operations, as well as joint and combined air, space, and cyberspace operations. Capabilities include command and control of joint theater air and missile defense, time-sensitive targeting, and Intelligence, Surveillance, and Reconnaissance management.
- The AOC-WS 10.1 (AN/USQ-163 Falconer) is a system of systems that contains numerous software applications developed by third party vendors and commercial off-the-shelf products. Each third-party system integrated into the AOC-WS provides its own programmatic documentation.
- The AOC-WS consists of:
  - Commercial off-the-shelf hardware
  - Separate third-party software applications, including GCCS-J, Theater Battle Management Core Systems – Force Level, Master Air Attack Plan Toolkit, and Joint Automated Deep Operations Coordination System, from which the AOC-WS draws its capabilities
  - Additional third-party systems that accept, process, correlate, and fuse command and control data from multiple sources and share them through multiple communications systems
- AOC-WS 10.1 operates on several different local area networks (LANs), including Secret Internet Protocol Router Network, Joint Worldwide Intelligence Communications System, and a coalition LAN, when required. The LANs connect the core operating system and primary applications to

joint and coalition partners supporting the applicable areas of operation. Users can access web-based applications through the Defense Information Systems Network.
- The Air Force tests AOC-WS 10.1 software upgrades during REs. The Air Force refers to each software upgrade by the RE during which it was tested. For example, AOC WS 10.1 RE13 is the software upgrade tested during RE13.
- The future AOC-WS 10.2 is designed to deliver a modernized, integrated, and automated approach to AOC WS operations.

Mission

The Commander, Air Force Forces, or the Joint/Combined Forces Air Component Commander use the AOC-WS to exercise control of joint (or combined) air forces, including planning, directing, and assessing air, space, and cyberspace operations to meet operational objectives and guidance. An operational AOC is fundamental in enabling centralized command and decentralized execution of a theater air campaign.

Major Contractors

- AOC-WS 10.1 Production Center: Jacobs Technology Inc., Engineering and Technology Acquisition Support Services – Hampton, Virginia
- AOC-WS 10.2 Modernization: Northrop Grumman – Newport News, Virginia

---

Activity

- The Air Force typically uses a three-phase RE test cycle for major AOC WS 10.1 upgrades, along with lower-level testing events, to sustain interoperability and cybersecurity and provide low-risk upgrades to third-party systems as required.
  - Phase 1 developmental testing is conducted at CAOC-X Joint Base Langley-Eustis, Virginia.
  - Phase 2 operational testing is conducted at CAOC-X to assess effectiveness.
  - Phase 3 operational testing is conducted at a fielded site to assess suitability.
- From March through August 2015, the Air Force conducted operational testing of AOC-WS 10.1 RE13 in accordance with the DOT&E-approved test plans. AOC-WS 10.1 RE13 intended to deliver new operational and tactical analysis capabilities, upgraded infrastructure, updated versions of third-party applications, and improved system cybersecurity posture.
- In October 2015, the Air Force completed its report on RE13, which included data from integrated testing (Phases 1 and 2) at CAOC-X, Joint Base Langley-Eustis, Virginia, in December 2014, and results from Phase 3 operational testing at 613 AOC, Joint Base Pearl Harbor-Hickam, Hawaii, from March through August 2015. Testing at the 613 AOC focused on three areas: assessing the ability of the site system administrators to correctly install, configure, and transition the AOC from the legacy AOC-WS 10.1 RE12 version to the AOC-WS 10.1 RE13 capability; validating the functional evaluation data obtained during developmental test; and assessing operational effectiveness and suitability of the upgraded system.
- In August and September 2015, AOC-WS 10.2 completed the first of two scheduled phases of developmental testing at CAOC-X. The severity and quantity of the functional and cybersecurity deficiencies identified during the test resulted in the Air Force issuing a cure notice to the prime contractor.

Assessment

- The Air Force adequately tested AOC-WS 10.1 RE13 through a combination of developmental and operational testing; however, there were significant known limitations to Reliability, Availability, and Maintainability (RAM) data.
  - Testing was conducted in accordance with the DOT&E-approved test plans, which anticipated the lack of RAM data. The duration and nature of RE13 test events provided insufficient time to allow DOT&E to assess RAM under operationally realistic system usage.
  - The Air Force has assessed that the operational tempo in fielded AOCs precludes the level of manual data collection required to support thorough RAM analysis. However, the Air Force plans to implement a technical RAM collection solution in the modernization increment, AOC-WS 10.2, which will allow DOT&E to conduct thorough analyses for future test events.
- AOC-WS 10.1 RE13 has the capability to produce the primary products necessary to meet the established AOC battle rhythm at threshold levels. AOC-WS 10.1 RE13 demonstrated interoperability with other mission-critical systems.
- The Air Force fully assessed AOC-WS 10.1 RE13 for cybersecurity, conducting the system's first-ever Adversarial Assessment using a DOD cyber Red Team. The Cooperative Vulnerability and Penetration Assessment identified 11 vulnerabilities, 9 of which are attributable to third-party systems that could pose significant risk to the AOC-WS mission. The Adversarial Assessment identified an additional four vulnerabilities and produced associated operational effects that demonstrate significant risk to the mission exists.
- The Program Office successfully closed six of the seven functional CAT I deficiencies found during the RE13 test events. The single open RE13 CAT I functional deficiency is a result of implementing a suite of web-based applications for submitting, managing, and querying air mission reports; Intelligence, Surveillance, and Reconnaissance post-mission

summaries; and electronic warfare mission requests and reporting.
  - This deficiency affects operational suitability by requiring communications support personnel to create and maintain accounts for thousands of external users across the Services.
  - This deficiency could also affect operational effectiveness if personnel deploying to a theater were unable to establish accounts in a timely manner, or if aircrews transiting the theater without accounts were not able to submit mission reports. Both scenarios would negatively affect the ability of an AOC to conduct intelligence analysis required to accomplish mission tasks.
  - Following the completion of Phase 3 testing at 613 AOC, Air Combat Command conducted an analysis of this deficiency. The command has deferred the implementation of the web-based application suite during RE13 fielding until the Program Office has remediated the deficiency.
- Air Combat Command accepted the mission risk posed by the 15 identified cyber vulnerabilities, and decided to field AOC-WS 10.1 RE13 to meet critical operational needs, while maintaining the expectation that the AOC-WS Program Office will fix unresolved CAT I deficiencies in an expeditious manner.
- AOC-WS 10.1 RE13 can be built, configured, and maintained adequately at operational sites with Program Office-provided support during specific complex installation segments. Tier 1 help desk support was not effective for build support, but Tier 2 was adequate to support the system fielding and operations during the event. Subsequent fielding events will likely depend solely on Tier 2 help desk support.
- The key to successful testing and fielding of AOC-WS 10.1 continues to be close collaboration between the AOC-WS Program Office and the providers of third-party applications to ensure those applications meet the operational and cybersecurity needs of the AOCs. Early AOC-WS tester involvement in third-party testing continues to be necessary to identify critical problems for early corrective action.

Recommendations

- Status of Previous Recommendations. The Air Force has fully addressed one previous recommendation and has made progress towards two previous recommendations. The Air Force still needs to require AOC sites to collect and report RAM data to the Program Office. The Air Force has assessed that the operational tempo in fielded AOCs precludes the level of manual data collection required to support thorough RAM analysis. Therefore, the Air Force plans to implement a technical RAM collection solution in the modernization increment, AOC-WS 10.2, which will allow DOT&E to conduct thorough analyses for future test events.
- FY15 Recommendations. The Air Force should:
  1. Close identified cybersecurity vulnerabilities in cooperation with third-party system providers to mitigate risk to the AOC mission.
  2. Improve dynamic cyber defensive capabilities focusing on detecting and responding to cyber adversary attacks against the AOC-WS.
  3. Reassess the help desk-enabling concept to determine whether Tier 1 help desk personnel can be sufficiently trained to support the build process. For future build support, the Air Force should consider merging Tier 1 and Tier 2 functionality.

CV-22 Osprey

Executive Summary

- Air Force Special Operations Command (AFSOC) procured a removable armor package for the CV-22 in response to an urgent need request. LFT&E of the armor package demonstrated improved force protection of the CV-22 platform against selected small arms threats.
- Preliminary assessment of integrated testing of Suite of Integrated Radio Frequency Countermeasures (SIRFC) software version 8.02 did not demonstrate aircraft survivability improvements against selected radio frequency threats. SIRFC performance is consistent with previous test results and therefore does not meet survivability requirements against some threat systems.
- The Program Office addressed key deficiencies revealed during the developmental testing of the next Tactical Software Suite, new mission computer, and a new Color Helmet Mounted Display. Operational testing of these systems is scheduled for 1QFY16.

System

- The CV-22 is the AFSOC variant of the V-22. It succeeded Special Operations Forces MH-53 helicopters in 2008. The tilt-rotor design provides the speed and range of a conventional fixed-wing aircraft and vertical take-off and landing capabilities of a helicopter.
- The CV-22 has terrain-following/terrain-avoidance radar, an advanced multi-frequency radio communication suite, an integrated electronic defense suite and aerial refueling capability, allowing it to augment the AFSOC MC-130 fleet.
- The CV-22 electronic defensive suite includes the SIRFC and the Directional Infrared Countermeasures (DIRCM) System with the AAR-54 Missile Warning Sensor, Small Laser Transmitter Assembly jammer and the ALE-47 Countermeasure System capable of dispensing both flares and chaff. The Dedicated Electronic Warfare Display provides an integrated threat picture to the crews from SIRFC and DIRCM.
- The CV-22 can carry 18 combat-ready Special Operators 538 nautical miles and return. It can self-deploy up to 2,100 nautical miles with one aerial refueling.
- In response to CV-22 damage and passenger casualties in a December 2013 combat incident in South Sudan, AFSOC submitted an urgent need request for a removable armor package to protect passengers from small arms threats. AFSOC, in collaboration with the V-22 Joint Program Office (PMA-275), established requirements, and awarded the Advanced Ballistic Stopping System (ABSS) contract to The Protective Group, Inc. The final ABSS kit solution weighs 825 pounds. The vendor delivered 16 ABSS kits to AFSOC in September 2014.
- Bell-Boeing delivered 45 of 50 purchased aircraft; 42 are operational and 3 of the remaining 50 are in storage awaiting operational testing that is on hold, pending completion of deficiency report corrective actions for Mission Computer Obsolescence Initiative and the Color Helmet Mounted Display. The final two aircraft are expected to be delivered by the end of 2016.

Mission

Commanders will employ AFSOC squadrons equipped with the CV-22 to provide high speed, long-range insertion and extraction of Special Operations Forces to and from high-threat objectives.

Major Contractors

- Bell-Boeing Joint Venture:
  - Bell Helicopter – Amarillo, Texas
  - The Boeing Company – Ridley Township, Pennsylvania
- The Protective Group, Inc. – Miami Lakes, Florida

Activity

- In 2014, Naval Air Systems Command completed expedited live fire testing of the ABSS armor and evaluated its performance against the specification threat. To help meet the urgent need request for new armor, DOT&E did not require approval authority of the ABSS armor live fire test plan. Instead, DOT&E reviewed the test plan and ensured the test was conducted in accordance with the agreed upon test plan.

- AFSOC conducted operational testing in September 2014 to evaluate the ability of the unit to remove and install the armor and the ability of the crew to perform their normal mission with the armor installed.
- AFSOC completed a fraction of the upgraded SIRFC software version 8.02 tests in February through March 2015 at China Lake and Nevada Test and Training Range to address CV-22 SIRFC active counter-measure deficiencies. Remaining testing of the SIRFC software was completed in October 2016.
- The Navy has continued with developmental testing on the new Tactical Software Suite (TSS) 20.2.02, which has included testing of a new aircraft mission computer needed to address obsolescence problems. Operational testing of the TSS 20.2.02 and the Color Helmet Mounted Display is scheduled for 1QFY16.
- AFSOC also plans to conduct a Cooperative Vulnerability and Penetration Assessment of cybersecurity protections and vulnerabilities in the first half of FY16.

Assessment

- DOT&E assessed the conduct of the ABSS armor test against the specification threat was adequate.
- ABSS armor met the ballistic protection requirements for a selected range of engagement conditions. ABSS armor effectiveness against other operationally realistic threats was not assessed.
- Operational testing demonstrated that the CV-22 aircrew and maintenance personnel were able to perform their mission with the ABSS installed. Testing also demonstrated that the maintenance personnel would require approximately 8 hours to install (or remove) ABSS, prior to the mission. Due to added weight, installed armor imposes a limited penalty in combat range and in a number of combat-ready Special Operators on a mission.
- Preliminary data analyses suggest that the active counter-measure component of the SIRFC 8.02 system did not address the subsystem deficiencies. Consistent with previous results, the subsystem does not meet most survivability requirements.
- The AFSOC identified four deficiencies in the TSS 20.2.02 developmental testing during FY14: (1) the mission computer randomly dropped map symbols after the map symbology memory data reached its capacity; (2) vibrations, associated with certain flight conditions, degraded the readability of the Color Helmet Mounted Display; (3) the new data transfer unit for navigation, communication, and threat data created the possibility for data spillage between classified and unclassified systems; and (4) the Intelligence Broadcast Receiver, which provides near real-time updates on threat and survivor location throughout a mission, occasionally erased threat data during flight, even though erasure was not commanded. With the exception of the dropped map symbols issue, which is too extensive to make the current TSS 20.2.02 release and will be addressed in future software release, the Program Office addressed all key deficiencies. These activities, in part, delayed entry into operational testing until FY16.

Recommendations

- Status of Previous Recommendations. The Services have been working on addressing the two FY13 recommendations. The Navy completed developmental testing of the TSS 20.2.02 to attempt to address the SIRFC deficiencies while AFSOC has been working on test plans to start the radio-communication test in the context of end-to-end operational missions in a variety of operational and atmospheric conditions in FY16.
- FY15 Recommendations.
  1. The Navy should continue to address deficiencies in SIRFC active counter-measure performance and AFSOC should verify deficiency correction in future operational testing.
  2. DOT&E funded a joint live fire program to assess the performance of ABSS against threats not assessed in the CV-22 ABSS LFT&E program. The CV-22 Program Office and AFSOC should review these data to account for the effectiveness of the ABSS against these additional, operationally realistic threats and to adjust the tactics, techniques, and procedures, as needed.

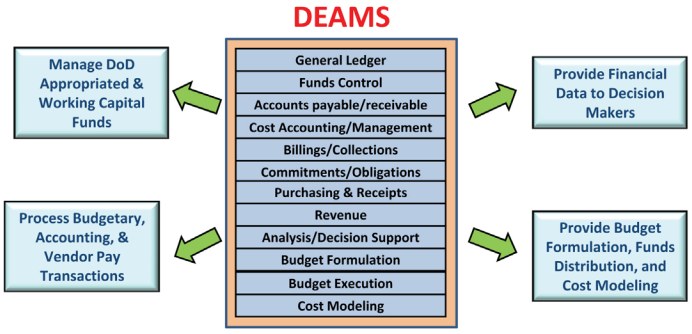
Defense Enterprise Accounting and Management System (DEAMS)

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted an IOT&E of the Defense Enterprise Accounting and Management System Increment 1 (DEAMS Inc 1) between October 1, 2014, and May 29, 2015, at seven bases that included three Air Force major commands, three U.S. Combatant Commands, and the Defense Finance and Accounting Service (DFAS). The Program Executive Officer paused testing twice to allow users to clear a backlog of failed or delayed transactions, which were affecting operational performance.
- Army and Air Force cybersecurity teams conducted a Cooperative Vulnerability and Penetration Assessment and Adversarial Assessment. The Joint Interoperability Test Command (JITC) evaluated the system's interoperability with external systems.
- DEAMS Inc 1 was not operationally effective, not operationally suitable, and not survivable against the cybersecurity threat. In preparation for the end-of-year close for FY15, a portion of software release 3 was fielded to support end-of-year accounting closeouts, which adversely affected operational performance during the IOT&E. DEAMS Inc 1 did not effectively perform several critical accounting and management tasks, four of which were Key Performance Parameters (KPPs).
- DEAMS Inc 1 is not survivable against the cybersecurity threat. Cybersecurity testing during the IOT&E showed that the system did not adequately protect its financial management information and neither operators nor administrators were able to detect cybersecurity intrusions. In February 2014, the 177th Aggressor Squadron conducted a Cyber Economic Vulnerability Penetration Assessment of DEAMS Inc 1 that revealed serious cyber vulnerabilities. DOT&E made several recommendations for mitigating these cyber vulnerabilities in its classified annex to the DEAMS Operational Assessment report dated June 2014, but during the IOT&E, the 177th found cyber vulnerabilities similar to those found in 2014.

System

- DEAMS Inc 1 is a Major Automated Information System that uses commercial off-the-shelf Enterprise Resource Planning software to provide accounting and management services.
- The DEAMS Inc 1 Program Office is following an evolutionary acquisition strategy that adds additional capabilities and users incrementally. There are seven scheduled releases. Release 3, currently fielded, had at least 5,000 users at the time of the IOT&E and is expected to have approximately 23,500 users worldwide by 2017.



- DEAMS Inc 1 is intended to improve financial accountability by providing a single, standard, automated financial management system that is compliant with the Chief Financial Officer's Act of 1990 and other mandates. DEAMS Inc 1 performs the following core accounting functions:
  - Core Financial System Management
  - General Ledger Management
  - Funds Management
  - Payment Management
  - Receivable Management
  - Cost Management
  - Reporting
- DEAMS Inc 1 interfaces with approximately 40 other systems that provide travel, payroll, disbursing, transportation, logistics, acquisition, and accounting support.
- DEAMS Inc 1 supports financial management requirements in the Federal Financial Management Improvement Act and DOD Business Enterprise Architecture; therefore, it is subject to the 2010 National Defense Authorization Act requirement to be auditable by 2017.

Mission

Air Force financial managers and tenant organizations use DEAMS Inc 1 to do the following across the Air Force, U.S. Transportation Command, and other U.S. component commands:

- Compile and share accurate, up-to-the-minute financial management data and information.
- Satisfy Congressional and DOD requirements for auditing of funds, standardizing of financial ledgers, timely reporting, and reduction of costly rework.

Major Contractor

Accenture Federal Services – Dayton, Ohio

Activity

- AFOTEC conducted an IOT&E of DEAMS Inc 1 between October 1, 2014, and May 29, 2015, at seven Air Force bases that included three Air Force major commands, three U.S. Combatant Commands, and DFAS at Limestone, Maine.
- The IOT&E did not run continuously during the 8-month period. The Program Executive Officer paused testing twice with DOT&E approval to allow Air Force financial managers and DFAS to clear a backlog of failed or delayed transactions, affecting operational performance of DEAMS Inc 1.
- In conjunction with the IOT&E, the Army Research Laboratory in White Sands Missile Range, New Mexico, conducted a cybersecurity Cooperative Vulnerability and Penetration Assessment at Maxwell AFB – Gunter Annex, Alabama. The 177th Information Aggressor Squadron followed this up with an Adversarial Assessment at McConnell AFB, Kansas.
- In August 2015, DOT&E submitted an IOT&E report with a classified annex detailing the results of the IOT&E testing.
- JITC evaluated DEAMS Inc 1 interoperability with external systems.
- AFOTEC conducted the IOT&E in accordance with the DOT&E-approved Test and Evaluation Master Plan and the test plan.

Assessment

- DEAMS Inc 1 demonstrated good progress during the second operational assessment in 2014, but a portion of software release 3 was fielded between the second operational assessment and IOT&E to support end-of-year accounting closeouts, which adversely affected operational performance during the IOT&E.
- DEAMS Inc 1 was not operationally effective. DEAMS Inc 1 did not effectively perform several critical accounting and management tasks, four of which were KPPs.
  - DEAMS Inc 1 failed to correctly balance available funds, close end-of-year accounts within the time frame prescribed by the Air Force, meet the 95 percent thresholds for balancing end-of-quarter and end-of-month accounts, and record transactions in a timely manner.
  - Poor DEAMS performance resulted in an increase in late penalty payments to $465.7 4 per $1 Million in January 2015, which was nearly 10 times the Air Force's FY15 goal of $49.00 per $1 Million.
  - DEAMS Inc 1 failed to process some transactions during IOT&E, resulting in a backlog of failed or delayed transactions. The DFAS users' workload increased as they tried to reduce the backlog. DEAMS usability will continue to be degraded until the backlog is reduced.
- Problems with DEAMS Inc 1's reporting tool (Discoverer) have been noted during the IOT&E and during previous DEAMS Inc 1 operational testing. Enhancements to DEAMS Inc 1 intended to correct reporting defects, including the Oracle Business Intelligence Enterprise Edition (OBIEE), were not fielded for the IOT&E, even though OBIEE was included in release 3 according to the DEAMS acquisition strategy. While OBIEE was not ready and not fielded, when it is fielded, it is expected to provide improved reporting. IOT&E survey results indicated that 48 percent of users did not use DEAMS Inc 1 for status of funds reporting, budget analysis and planning, or decision support, which meant that for this set of users, DEAMS Inc 1 reporting functionality was not being used for financial decision-making as intended.
- DEAMS Inc 1 is not operationally suitable. DEAMS Inc 1 continues to exhibit problems with software reliability growth as measured by an increase in the number of high-severity deficiencies, including many that had remained unresolved for 240 days or longer. Configuration management procedures regarding regression testing of resolved defects were either not followed by the Program Office or were inadequate to ensure that the defects were actually corrected in the software. DEAMS Inc 1 also did not meet Net-Ready KPP requirements for the exchange of critical information as reported by JITC. The results of the interoperability assessment demonstrated that 5 of the 22 available critical interfaces did not meet the required information exchange requirements.
- Although DEAMS Inc 1 training demonstrated gradual improvement since the second operational assessment, the training did not prepare most users to employ DEAMS Inc 1 effectively and did not provide knowledge to new users to adequately perform necessary accounting and reporting tasks. A long time gap between initial training and IOT&E degraded user proficiency, as much of what was learned had been forgotten. The training needs to align more closely with deployments rather than being given months in advance. Training alignment could prove a challenge for presently scheduled deployments to many thousands of new users and scores of new bases over the next year.
- In the June 2014 operational assessment report, DOT&E recommended that the Air Force modify DEAMS Inc 1 user training to focus more on functional understanding the DEAMS Inc 1 general ledger environment, rather than on navigation within the system. However, during the IOT&E, users indicated that the training focused on how to navigate within DEAMS Inc 1 rather than how to perform missions in the DEAMS Inc 1 environment. Additionally, the business process changes that accompanied DEAMS Inc 1 implementation were not intuitive to the users based upon their experience with legacy systems. Accordingly, users were not readily able to accomplish their tasks.
- Training that focuses on providing functional understanding will improve the suitability of DEAMS Inc 1.
- DEAMS Inc 1 is not survivable against the cybersecurity threat. In February 2014, the 177th Aggressor Squadron conducted a Cyber Economic Vulnerability Penetration Assessment of DEAMS Inc 1 that revealed serious cyber vulnerabilities. Cybersecurity testing showed that the system did not adequately protect its financial management information and neither operators nor administrators were able to detect cybersecurity intrusions. DOT&E made several

recommendations for mitigating these vulnerabilities in its classified annex to the DEAMS Operational Assessment report dated June 2014, but during the IOT&E, the 177th found vulnerabilities similar to those found in 2014.

Recommendations

- Status of Previous Recommendations. The Program Office did not implement FY14 recommendations successfully and still needs to:
  1. Correct balance accuracy defects to meet KPP requirements and to demonstrate progress towards DEAMS Inc 1 achieving of full auditability.
  2. Address cybersecurity recommendations provided in DOT&E's classified annex to the DEAMS Operational Assessment report.
- FY15 Recommendations. The DEAMS program manager should:
  1. Identify and implement processes, procedures, and software improvements to clear the transaction backlog to fix the lag time between transaction and posting and ensure accurate and timely reporting.
  2. Work with the DFAS to identify the root causes of imbalances between DEAMS Inc 1 and Treasury and change policies and procedures or implement software improvements to prevent further imbalances.
  3. Conduct regression testing to improve DEAMS Inc 1 performance and identify potential interface problems before fielding software updates and releases.
  4. Provide DEAMS Inc 1 training that prepares users to effectively employ DEAMS Inc 1 upon fielding.
  5. Work with AFOTEC to conduct follow-on operational testing to verify that the deficiencies have been corrected and that the new reporting tool is operationally effective, suitable, and cyber-secure, once corrections have been made and a new reporting tool has been fielded.

F-22A Advanced Tactical Fighter

Executive Summary

- F-22A Increment 3.2A is a software-only modernization effort integrating Link 16 Receive, enhanced combat identification, and enhanced electronic protection capabilities. Increment 3.2A developmental testing completed in early FY15; however, several software stability, radar, and Link 16 datalink performance shortfalls remained unresolved during developmental testing and were carried forward into FY15 FOT&E.
- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted FOT&E of Increment 3.2A from November 2014, through May 2015. FOT&E results demonstrated that the Operational Flight Program (OFP) software suite is operationally effective; however, shortfalls carried forward from developmental testing and re-discovered during FOT&E detract from overall operational capability.
- Increment 3.2A FOT&E results further indicated the OFP software suite is not operationally suitable as it did not meet the Air Force threshold Mean Time Between Avionics Anomaly requirement, and there is a high probability that pilots may not be able to complete combat missions without having to reset or restart avionics subsystems during flight.
- F-22A Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM 120D and AIM-9X missile systems and provide additional electronic protection enhancements and improved emitter geolocation capability. Ongoing developmental testing experienced several delays due to additional unplanned regression testing for Increment 3.2A and Update 5 OFP efforts, and associated competition for limited developmental test resources. Given the delays observed in FY15, it is unlikely the program will achieve the currently scheduled Milestone C date of April 30, 2016.
- Update 5 combines an OFP upgrade providing software-driven radar enhancements, Ground Collision Avoidance System software, and the incorporation of limited AIM-9X capabilities The Air Force Air Combat Command began a Force Development Evaluation (FDE) of Update 5 OFP software suite and limited AIM-9X integration. FDE testing completed in 1QFY16.
- Due to the Joint Strike Fighter (JSF) Program Office's recent decision to terminate funding for the F-35 version of the Air Combat Simulator (ACS), there is a high likelihood that a significant cost transfer to the F-22 program may occur in order to enable the overall development of the ACS and complete the integration of certain advanced threats into the ACS battlespace environment necessary to support Increment 3.2B IOT&E.

System

- The F-22A is an air-superiority fighter that combines low observability to threat radars, sustained high speed, and integrated avionics sensors.
- Low observability reduces threat capability to engage F-22As with current adversary weapons.
- The aircraft maintains supersonic speeds without the use of an afterburner.
- Avionics that fuse information from the Active Electronically Scanned Array radar, other sensors, and data linked information for the pilot enable employment of medium- and short-range air-to-air missiles, guns, and air-to-ground munitions.
- The Air Force designed the F-22A to be more reliable and easier to maintain than legacy fighter aircraft.
- F-22A air-to-air weapons are the AIM-120C radar-guided missile, the AIM-9M infrared-guided missile, and the M61A1 20 mm gun.
- F-22A air-to-ground precision strike capability consists of the 1,000-pound Joint Direct Attack Munition and the 250-pound Small Diameter Bomb Increment 1.
- The F-22A program delivers capability in increments. Incremental Enhanced Global Strike modernization efforts include the following current and near-term modernization efforts:
  - Increment 3.1 provides enhanced air-to-ground mission capability, to include geolocation of selected emitters, electronic attack, air-to-ground synthetic aperture radar

mapping and designation of surface targets, and Small Diameter Bomb integration. Increment 3.1 is currently fielded in operational F-22A units.
- Increment 3.2A is a software-only upgrade intended to provide improved electronic protection, Link 16 Receive, and combat identification capabilities in FY15. Increment 3.2A is a modernization effort within the scope of the F-22A Advanced Tactical Fighter baseline acquisition program of record. Increment 3.2A is currently fielding in operational F-22A units.
- Update 5 combines an OFP upgrade providing software-driven radar enhancements, Ground Collision Avoidance System software, and the incorporation of limited AIM-9X capabilities. Update 5 OFP FDE testing began in late FY15 and completed in 1QFY16.
- Increment 3.2B is a separate Major Defense Acquisition Program modernization effort intended to integrate AIM 120D and AIM-9X missile systems and provide additional electronic protection enhancements and improved emitter geolocation capability. The Increment 3.2B IOT&E is currently planned for FY17.

Mission

Commanders will use units equipped with the F-22A to:
- Provide air superiority over friendly and non-permissive, contested enemy territory
- Defend friendly forces against fighter, bomber, or cruise missile attack
- Escort friendly air forces into enemy territory
- Provide air-to-ground capability for counter-air, strategic attack, counter-land, and enemy air defense suppression missions

Major Contractor

Lockheed Martin Aeronautics Company – Fort Worth, Texas

Activity
- The Air Force conducted all testing in accordance with the DOT&E-approved Test and Evaluation Master Plan, FOT&E, and FDE test plans.
- Increment 3.2A developmental testing completed in early FY15; however, several software stability, radar, and Link 16 datalink performance shortfalls remained unresolved during developmental testing and were carried forward into FY15 FOT&E.
- AFOTEC conducted FOT&E of Increment 3.2A from November 2014, through May 2015. During the FOT&E, a software anomaly affecting legacy system performance deficiency was discovered resulting in a test pause and necessitating additional, unplanned developmental testing efforts to resolve the associated radar operation shortfall. Following completion of the FOT&E, the Air Force Air Combat Command released the Increment 3.2A software OFP for installation in operational F-22A units beginning in July 2015.
- Increment 3.2B developmental testing continued throughout FY15, but experienced delays due to the additional regression testing for Increment 3.2A and Update 5 OFP software suite. The Air Force is projecting a March 2016 Milestone C, and IOT&E is projected to begin in spring 2017.
- The JSF Program Office has recently announced that it plans to cancel the development of the Lockheed-Martin F-35 simulation and transfer the project to a government team. Both F-22 and F-35 JSF simulations currently share a common facility and software environment, including the battlespace environment and threat models. Each program leverages new threats and other capabilities added by the other. The ACS is a Lockheed-Martin facility that provides the F-22 operational test community the ability to simulate dense threat environments that cannot be replicated in open air. It has been used successfully for IOT&E and FOT&E since 2004. The ACS includes man-in-the-loop and OFP in the-loop F-22 systems, and capable man-in-the-loop adversary systems.
  - The F-22 Program Office plans to use the ACS for Increment 3.2B for operational effectiveness trials during FY17 IOT&E.
  - Several ACS upgrades are required to implement new 3.2B capabilities and to develop and integrate new weapons and threats into the ACS battlespace environment to support operational testing.
  - Increment 3.2B also requires the integration of new weapons on the F-22 simulation. The AIM-120D model has not yet been delivered to ACS by the weapon vendor.
- Air Force Air Combat Command began an FDE of the Update 5 OFP software suite. The FDE completed in 1QFY16.

Assessment
- Results of Increment 3.2A FOT&E testing demonstrated that the OFP suite is operationally effective; however, several unresolved radar and Link 16 datalink performance shortfalls carried forward from developmental testing and discovered during FOT&E detract from overall operational capability. The Increment 3.2A OFP is not operationally suitable as it did not meet the Air Force threshold Mean Time Between Avionics Anomaly requirement. Furthermore, based upon the demonstrated software stability performance during the FOT&E, there is a high probability that pilots may not be able to complete combat missions without having to reset or restart avionics subsystems during flight.

- Increment 3.2A cybersecurity testing consisted of compliance checks on security controls. Increment 3.2A did not meet standards for multiple compliance checks.
- Increment 3.2B developmental testing experienced several delays due to additional unplanned regression testing for Increment 3.2A and Update 5 OFP efforts, and associated competition for limited test resources. All F-22A modernization efforts and increments are tightly coupled, and recent years' reduction in developmental test force aircraft and personnel leaves little margin for unanticipated regression testing and correction of critical deficiencies when discovered in operational testing. Given these factors and delays observed to date, it is likely that the Air Force Milestone C decision will slip to late FY16.
- Update 5 OFP FDE testing to date included five AIM-9X missile live fire trials; a first for the F-22A operational test community. Four of the five performed nominally, yet the fifth failed to guide to the intended target. The root cause of the miss is under investigation.
- The primary schedule risk for completing ACS weapons model is the integration of a validated AIM-120D model. Delivery of the Raytheon AIM-120D model to Lockheed Martin for incorporation into the ACS is behind schedule. Other weapons and threats appear to be on track for planned delivery to support Increment 3.2B IOT&E.
- Due to the JSF Program Office's recent decision to terminate funding for the F-35 version of the ACS, there is a high likelihood that a significant cost transfer to the F-22 program may occur in order to enable the overall development of the ACS and complete the integration of certain advanced threats into the ACS battlespace environment necessary to support Increment 3.2B IOT&E. Fully-funded ACS capabilities are required to support F-22 Increment 3.2B IOT&E adequacy, regardless of whether or not F-35 funding is available.

Recommendations

- Status of Previous Recommendations. The Air Force continues to address previous recommendations, but did not resolve Increment 3.2A software anomalies and performance shortfalls before proceeding to formal AFOTEC FY15 FOT&E.
- FY15 Recommendations. The Air Force should:
  1. Place increased emphasis and devote necessary resources to ensure system performance shortfalls identified in developmental testing are effectively resolved before proceeding with operational testing.
  2. Improve F-22A avionics software stability to support operational mission execution and meet Air Force software stability requirements.
  3. Ensure the adequacy of the force structure and schedule margins necessary to support forthcoming F-22A developmental testing efforts
  4. Ensure adequate funding of ACS capabilities for F-22 operational test and evaluation regardless of F-35 funding decisions.
  5. Ensure AIM-120D models are delivered and incorporated into the ACS to meet Increment 3.2B scheduled FY17 IOT&E.

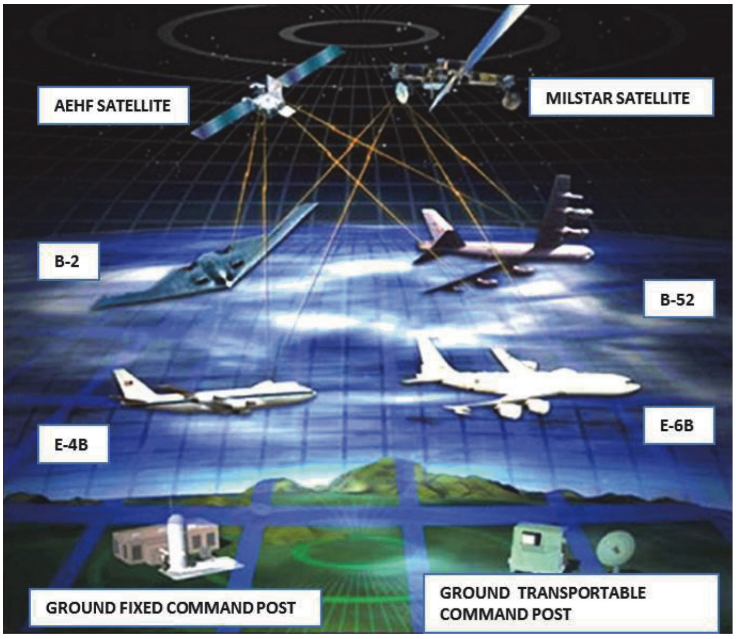
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)

Executive Summary

- The Air Force Operational Test and Evaluation Center (AFOTEC) conducted an Operational Assessment (OA) of the Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Command Post Terminals (CPTs) from December 5, 2014, through May 30, 2015. AFOTEC based the OA on Raytheon in-plant developmental testing and government developmental flight testing led by the Air Force's 46th Test Squadron. Testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
- During the OA, the FAB-T CPT demonstrated nuclear and non-nuclear command and control from ground-fixed, ground-mobile, and airborne terminals. The FAB-T CPT also demonstrated the ability to set up and control networks and point-to-point communication services over Milstar and Advanced Extremely High Frequency (AEHF) satellites.
- The FAB-T CPTs experienced hardware failures during the OA, and require additional reliability growth to demonstrate reaching the user requirements with 80-percent confidence. Analysis of the reliability growth tests shows a large degree of uncertainty in the Mean Time Between Critical Failure because of a sparsity of data.
- In February 2015, USD(AT&L) directed the Air Force to take responsibility for the acquisition management of the Presidential National Voice Conferencing (PNVC) capability from the Defense Information Systems Agency (DISA) to ensure integration and testing efficiency. The Air Force made the PNVC capability a separate program under the responsibility of the FAB-T program manager. DOT&E placed PNVC under its operational test and evaluation oversight in July 2015.
- USD(AT&L) conducted a Milestone C decision review for the Defense Acquisition Board on September 1, 2015, and authorized the FAB-T program to enter into low-rate initial production for the first 10 terminals.

System

- FAB-T consists of ground and aircraft communication terminals with two terminal types—CPTs and Force Element Terminals (FETs). FAB-T is part of the terminal and control segments of the AEHF satellite system and is designed to operate with AEHF Low Data Rate (75 – 2,400 bits per second (bps)) and Extended Data Rate (up to 8.192 Megabits per second) waveforms.
- The CPT is intended to replace existing airborne (E-4B and E-6B), ground-fixed, and ground-transportable Milstar command post terminals. The CPT will include satellite and network control functions, end-user telecommunication device interfaces, and the ability to operate the terminal from a distant location using a remote node.
- The FET is intended to be installed in airborne force elements (B-2, B-52, and RC-135). The FET is a program requirement but is currently neither funded nor on contract for development and production.



Mission

- The President, the Secretary of Defense, Combatant Commanders, and supporting Air Force component forces will use FAB-T to provide strategic nuclear and non-nuclear command and control with EHF, wideband, protected, and survivable communications terminals for beyond line-of-sight communications.
- U.S. Strategic Command will use the FAB-T to perform satellite Telemetry, Tracking, and Commanding functions for the AEHF/constellation, including management of the satellites, communication networks, and cryptologic keys.

Major Contractor

Raytheon Net-Centric Systems – Marlborough, Massachusetts

Activity

- AFOTEC conducted an OA of the FAB-T CPT from December 5, 2014, to May 30, 2015. AFOTEC based the OA on Raytheon in-plant developmental testing and government developmental flight testing led by the Air Force's 46th Test Squadron. Testing was conducted in accordance with the DOT&E-approved Test and Evaluation Master Plan and test plan.
- DOT&E submitted an OA report on the FAB-T CPT on July 23, 2015.
- The contractor conducted reliability growth testing in the lab simulating the operational mission profile in accordance with the FAB-T program manager's-approved plan from February through July 2015. The program manager tested the ground-fixed CPT for 1,947 hours and the airborne CPT for 1,396 hours. Reliability testing for the ground-transportable CPT and remote capability was not performed during the OA; however, the program manager is planning to conduct this reliability testing after the OA test period.
- The 92nd Information Operations Squadron conducted a Cybersecurity Cooperative Vulnerability and Penetration Assessment from December 16 – 18, 2014, on the ground-fixed CPT at the Raytheon contractor facility in Marlborough, Massachusetts.
- The program updated the DOT&E-approved the Test and Evaluation Master Plan on August 21, 2015.
- In February 2015, USD(AT&L) directed the Air Force to take responsibility for the acquisition management of the PNVC capability from DISA to ensure integration and testing efficiency. Therefore, DISA is now supporting the Air Force with PNVC baseband equipment development and engineering expertise for end-to-end testing of strategic conferencing services.
- In May 2015, the Air Force made the PNVC capability a separate program under the responsibility of the FAB-T program manager. DOT&E placed PNVC under its operational test and evaluation oversight in July 2015.
- USD(AT&L) conducted a Milestone C decision review for the Defense Acquisition Board on September 1, 2015, and authorized the FAB-T program to enter into low-rate initial production for the first 10 terminals.
- USD(AT&L) tasked the FAB-T Program Office to work with DOT&E and the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation to determine the appropriate amount of reliability growth testing for the next phase of the program.

Assessment

- During the OA, the FAB-T CPT demonstrated nuclear and non-nuclear command and control from ground-fixed, ground-mobile, and airborne terminals. The FAB-T CPT also demonstrated the ability to set up and control networks and point-to-point communication services over Milstar and AEHF. The FAB-T CPT did not have the satellite Telemetry, Tracking, and Commanding functions available to test.
- Government developmental flight testing during the OA revealed instances where nuclear emergency action messages were either not received or contained corrupted content. Failures in reception occurred after the ground-fixed FAB-T CPT transitioned from one satellite agile beam to another. Failures also occurred with messages created by the government-furnished Milstar Messaging Application connected to the ground-fixed CPT. Missed or inaccurate reproduction of the original message can cause significant problems in the command and control of nuclear assets during operations.
- The FAB-T program manager performed root cause analysis and determined the problems experienced during flight testing were caused by faulty software. The contractor fixed most of the software problems and the 46th Test Squadron conducted additional flight testing on June 24, 2015, to verify the fixes. The 46th Test Squadron determined most of the problems were fixed, but new ones were found.
- The FAB-T CPTs experienced hardware failures during the OA, and require additional reliability growth to successfully demonstrate reaching the user requirements with 80-percent confidence. Analysis of the reliability growth tests shows a large degree of uncertainty in the Mean Time Between Critical Failure because of a sparsity of data.
- The program manager used a non-standard methodology for reliability growth planning and analysis, whereas DOT&E OA reliability analysis employed the Army Materiel Systems Analysis Activity methodology, which resulted in lower reliability estimates.

Recommendations

- Status of Previous Recommendations. The Air Force has addressed all previous recommendations.
- FY15 Recommendations. The Air Force should:
  1. Continue to use reliability growth test periods to surface more failure modes and correct them to grow reliability and confidence in system performance.
  2. Update the reliability growth curves with results from DOT&E's OA for both ground-fixed and airborne CPTs. Updated curves would allow the program manager to determine how much more reliability testing is needed given the performance demonstrated during the OA.
  3. Work with DOT&E and the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation to determine the appropriate amount of reliability growth testing for the next phase of the program.

KC-46A

Executive Summary

- The Air Force Operational Test and Evaluation Center is currently conducting a second KC-46A operational assessment (OA) to support the Milestone C decision. DOT&E expects it to end February 2016, after the completion of Milestone C receiver flights.
- Delays in Engineering and Manufacturing Development (EMD) aircraft production and manufacturing have delayed program test milestones to include the Milestone C decision. DOT&E estimates April 2016 for Milestone C and May 2017 for the start of IOT&E. The first EMD aircraft (EMD-1), a 767-2C variant, began daily flight testing at the end of July 2015. First flight of the second EMD aircraft (EMD 2), the first fully configured tanker variant, began flights in late September 2015. Aerial refueling certification of 11 of the 18 different receiving aircraft planned for EMD will not be complete until after the start of the IOT&E.
- Testing in the Boeing lighting lab and wet fuels lab, each containing full-up installations of the respective aircraft systems is anticipated to complete in 2QFY16.
- The Air Force successfully completed the ballistic test phase of the live fire test program. Ballistic testing in FY15 investigated the KC-46A's response to dry bay fires and structural damage to the engines and engine pylon due to impact from man-portable air-defense systems (MANPADS). Preliminary review of the data did not reveal any unknown vulnerabilities to the threats tested.

System

- The KC-46A aerial refueling aircraft is the first increment of replacement tankers (179) for the Air Force's fleet of KC-135 tankers (more than 400).
- The KC-46A design uses a modified Boeing 767-200ER commercial airframe with numerous military and technological upgrades, such as the fly-by-wire refueling boom, the remote air refueling operator's station, 787 cockpit, additional fuel tanks in the body, and defensive systems.
- The KC-46A will provide both a boom and probe-drogue refueling capabilities. The KC-46A is equipped with an air refueling receptacle so that it can also receive fuel from other tankers, including legacy aircraft.
- The KC-46A is designed to have significant palletized cargo and aeromedical capacities; chemical, biological, radiological, nuclear survivability; and the ability to host communications gateway payloads.

- Survivability enhancement features are incorporated into the KC-46A design.
  - Susceptibility is reduced with an Aircraft Survivability Equipment suite consisting of Large Aircraft Infrared Countermeasures, the ALR-69A Radar Warning Receiver (RWR), and a Tactical Situational Awareness System. The suite is intended to compile threat information from the ALR-69A RWR and other on- and off-board sources and to prompt the crew with an automatic re-routing suggestion in the event of an unexpected threat.
  - Vulnerability is reduced by adding fuel tank inerting and integral armor to provide some protection to the crew and critical systems.

Mission

Commanders will use units equipped with the KC-46A to:

- Perform air refueling to accomplish six primary missions to include nuclear operations support, global strike support, air bridge support, aircraft deployment, theater support, and special operations support. Secondary missions will include airlift, aeromedical evacuation, emergency aerial refueling, air sampling, and support of combat search and rescue.
- Operate in day/night and adverse weather conditions globally to support U.S., joint, allied, and coalition forces.
- Operate in a non-permissive environment.

Major Contractor

The Boeing Company, Commercial Aircraft in conjunction with Defense, Space & Security – Seattle, Washington

Activity

- DOT&E approved the post-Milestone B Test and Evaluation Master Plan (TEMP) in January 2013, with concerns about adequate calendar time for correction of discrepancies or deficiencies between the end of developmental testing and the beginning of IOT&E. DOT&E has taken this into account while working with the program to develop the Milestone C TEMP.
- DOT&E approved the Air Force Operational Test and Evaluation Center's second KC-46A OA-2 plan in May 2015 to support the Milestone C decision. This plan included revised survey methodology consistent with DOT&E's guidance. Delays in EMD aircraft production and manufacturing have led to two extensions in the completion date for OA-2; DOT&E expects OA-2 to end February 2016, after the air refueling demonstration flights in support of Milestone C.
- Developmental and Federal Aviation Administration (FAA) test planning is substantially complete. The Air Force accepted the contractor's Stage 4 (final build) test plans in January 2015. Some test plans have been revised throughout the year due to FAA test planning or to improve test schedule efficiency.
- First flight of the first EMD aircraft occurred December 28, 2014, 6 months late, primarily due to electrical wiring design problems. After a single flight, the aircraft was down for planned finishing work; this down period was extended by a necessary redesign of the fuel pump manifold. The aircraft began near daily flight testing at the end of July 2015.
- EMD 2, the first fully configured tanker variant, began flying in late September. The planned first flight date was January 2015 as documented in the post-Milestone B TEMP.
- Testing in the lighting lab and wet fuels lab, each containing full-up installations of the respective aircraft systems, is anticipated to complete in 2QFY16.
- The Air Force used a standard Air Force MJ-1 weapons loader to install a boom on a KC-46 to show the feasibility of using current Aerospace Ground Equipment rather than developing new, unique equipment. The Air Force completed a refueling surge pressure test on a KC-135 and on a KC-10 to develop baseline data for comparison to surge pressures in the KC-46A. The technical order verification process is approximately one quarter complete and should be finished prior to IOT&E.
- All parties have agreed upon the open-air test venues for the ALR-69A RWR and the AAQ-24 Large Aircraft Infrared Countermeasures (LAIRCM) system and detailed test planning for each venue is near completion.
- Testers have completed laboratory tests of the defensive systems including the ALR-69A RWR and the AAQ 24 LAIRCM. Flight test planning for LAIRCM is nearly complete, while flight test planning for the RWR remains to be completed. Both flight tests are planned for fall 2016.
- The program conducted three live fire test series completing the ballistic test portion of the LFT&E program. The Air Force conducted testing in accordance with the DOT&E-approved LFT&E strategy.
- The Air Force is nearing completion of the KC-46A survivability assessment against radar guided surface-to-air missiles and the performance of the ALR-69A RWR against selected threats. Survivability evaluation against other operationally relevant threats, crew casualty assessment, and non-kinetic threat vulnerability analyses also remain to be completed.
- Boeing prepared a test plan for Electromagnetic Pulse (EMP) testing based on the contract specified design margin of 6 decibels (dB).
- The program accomplished an initial cybersecurity Cooperative Vulnerability Penetration Assessment (CVPA) in one of the Boeing system integration labs in August 2015. Future cybersecurity test plans include additional CVPAs accomplished in the system integration labs and on the aircraft, followed by an Adversarial Assessment accomplished on the aircraft during the IOT&E.

Assessment

- DOT&E assessed the ALR-69A RWR as installed on the C-130H as not operationally effective but operationally suitable based on tests conducted by the Air Force in October 2012.
  - The system did not consistently provide the aircrew timely and accurate threat information and the system demonstrated a random threat symbol splitting deficiency. Threat symbol splitting occurs when one threat signal received by the system produces multiple threat symbols at different azimuths on the cockpit display. This degrades the aircrew's situational awareness as to which displayed threats are "real" and where those real threats are located, and inhibits the aircrew's ability to appropriately react to the threat(s) in a timely manner. The details are presented in DOT&E's classified IOT&E report dated October 2012.
  - Although the Air Force System Program Office and Raytheon conducted hardware-in-the-loop (HWIL) tests to demonstrate the threat signal splitting deficiency has been resolved, DOT&E does not think HWIL testing by itself is adequate to verify the deficiency has been resolved and that the software update did not induce any other adverse system performance.
- The delay in first flight of the KC-46A has altered the planned certification schedule of air refueling receiving aircraft and accomplishment of the 26 Milestone B Acquisition Decision Memorandum Technical Performance Measures entrance criteria. This, in turn, will delay the August 2015 Milestone C decision (based on the post-Milestone B TEMP schedule) until April 2016.
- DOT&E identified several shortfalls in the planned test program that require resolution prior to Milestone C TEMP approval.
  - A current schedule based on reasonable test efficiencies must be included.

  - Planning should allow the operational test aircrew and maintenance personnel adequate time to develop system proficiency to support IOT&E.
  - Sufficient calendar time must be allotted for correction of discrepancies and/or deficiencies discovered during developmental testing prior to the planned start of operational testing.
  - Cyber vulnerability and penetration testing to date has not tested vulnerabilities on a production representative aircraft. Tentatively scheduled events are expected to fulfill this requirement, but need to be formally coordinated and scheduled.
- The expected IOT&E start date has been delayed 10 months from the post-milestone B TEMP schedule. DOT&E analysis of Boeing progress and schedules with regard to aerial refueling certifications and operator/maintainer training indicates that operational testing will likely be delayed a total of 12 months. This is in line with previous DOT&E estimates. Planning since Milestone B has moved air refueling certification of 11 of the 18 different receiving aircraft until after the start of IOT&E.
- Testing completed to date and planned testing of LAIRCM should be adequate to determine system effectiveness and suitability. Analyses of LAIRCM analytic model and laboratory test results are ongoing. To date, no significant discrepancies from expected performance have been noted.
- Flight testing of the RWR now includes testing at a government electronic warfare test range in addition to a training range. Initial planning for this test has begun.
- Preliminary analyses of live fire test data:
  - Confirmed the vulnerability of the KC-46A to threat-induced dry bay fires, including the wing-leading edge, wing-trailing edge, center wing dry bay, and fuselage body tank dry bays. The Air Force assessed the vulnerability to several threats including small arms and missile fragments. All live fire ballistic test results will be incorporated into the vulnerability analysis to confirm whether the KC-46A meets the 30-minute controlled flight vulnerability specification in FY16.
  - Quantified the threat-induced structural limitations of the KC-46A wings for selected engagement conditions. The Air Force will assess the survivability of the wing structure to a range of small arms, anti-aircraft artillery threats, and MANPADS engagements.
  - Demonstrated the vulnerability of the engine and the engine pylon to two specific MANPADS engagement conditions. Further analyses will assess the resultant aircraft survivability for engagement conditions, not tested.
  - Demonstrated the expected cockpit and boom operator station armor effectiveness against the specification threat with 80 percent confidence and assessed the effectiveness of the installed armor against the specification threat and two other operationally representative threats. The program will complete an evaluation of the effects of these data on the overall crew protection assessment in FY16. Live Fire ballistic test results incorporated into the vulnerability analysis confirms the KC-46A is meeting the crew station armor vulnerability specification against the specification threat.
  - Supported the updates to the initial aircraft vulnerability assessment, which quantified the aircraft's vulnerabilities to the specification and other expected threats for a range of operationally relevant engagement conditions, not tested. Boeing is scheduled to deliver their final analysis to the Air Force in FY16.
- The KC-46A EMP design margin was based on Military Standard (MIL STD)-464 and the threat defined in MIL-STD-2169. After the fixed-price contract was awarded, the DOD instituted a new MIL STD-3023 that requires tanker aircraft to meet a 20 dB EMP design margin versus the contractually required 6 dB EMP design margin. Unless additional tests are resourced, the Air Force or the U.S. Strategic Command will not know if the KC-46A meets the 20 dB EMP hardening requirement in MIL-STD-3023.
- During the CVPA, testers discovered several vulnerabilities. The program plans to correct some of them shortly while corrections to others that are related to government furnished equipment are under discussion.
- The integrated test team is working a cybersecurity strategy consistent with DOT&E guidance; however, specific details to conduct an adequate operational test are not yet defined.

Recommendations

- Status of Previous Recommendations. The Air Force addressed two of the FY12 recommendations to incorporate realistic assumptions in test plans and provide a plan for air refueling receiver certification; however, additional work is still needed. The Air Force still needs to address the remaining FY12 and FY13 recommendations to:
  1. Submit a TEMP with a schedule mitigating the shortfalls that may adversely affect IOT&E.
  2. Provide an approach to correct the ALR-69A RWR shortfalls prior to integration on the KC-46A.
  3. Plan to begin IOT&E at least 12 months later than the post-milestone B TEMP indicates to allow for completion of developmental test and initial training.
  4. Formally plan testing against realistic cybersecurity threats conducted on a production representative aircraft to identify vulnerabilities for correction. In addition, plan follow-on penetration testing to assess performance in terms of protect, detect, react, and restore functions.
- FY15 Recommendations. The Air Force should:
  1. Ensure all air refueling receiver aircraft are certified for use by operational aircrew early enough in IOT&E to permit sufficient operational testing.
  2. In conjunction with U.S. Strategic Command, determine whether its personnel can conduct the nuclear deterrence and strike missions with a KC-46A only having 6 dB EMP shielding as per the contract. If additional EMP shielding is deemed necessary, the Air Force should conduct testing as part of FOT&E to determine the actual KC-46A EMP design margin.

Massive Ordnance Penetrator (MOP)

Executive Summary
- In February 2015, the Air Force successfully completed one weapon drop from the B-2 aircraft on a representative target, and in April 2015, completed one weapon drop from the B-2 aircraft on a concrete slab. These tests, conducted at the White Sands Missile Range (WSMR), New Mexico, demonstrated weapon effectiveness after the Air Force incorporated planned enhancements and completed the Enhanced Threat Reduction (ETR) Phase 2 testing.
- DOT&E published a classified Early Fielding Report summarizing the ETR Phase 2 test results in April 2015.

System
- The GBU-57 Massive Ordnance Penetrator (MOP) is a large, GPS-guided, penetrating weapon with the ability to attack deeply-buried and hardened bunkers and tunnels. The warhead case is made from a special high-performance steel alloy and its design allows for a large explosive payload while maintaining the integrity of the penetrator case during impact.
- The B-2 Spirit is the only aircraft in the Air Force programmed to employ the MOP.
- The GBU-57 warhead is more powerful than its predecessors, the BLU-109 and GBU-28.
- The MOP is an Air Force-led, Quick Reaction Capability that is a Secretary of Defense special interest effort and is under DOT&E oversight.

Mission
Combatant Commanders use MOP to conduct pre-planned, day or night attacks against defended point targets vulnerable to blast and fragmentation effects and requiring significant penetration, such as hardened and deeply-buried facilities.

Major Contractor
The Boeing Company, Defense, Space & Security – St. Louis, Missouri

Activity
- In January/February 2015, the Air Force conducted one live weapon drop at WSMR, on a representative target to evaluate weapon effectiveness. An Air Force B-2 aircraft flew two missions to complete the drop; telemetry problems prevented weapon release on the first mission.
- In April 2015, the Air Force conducted an inert weapon drop at WSMR on a concrete slab target. This testing was to evaluate the effect of the ETR Phase 2 modifications to the weapon. An Air Force B-2 aircraft flew one mission to complete the drop.
- Both flight tests were successful and completed the ETR Phase 2 test.
- DOT&E submitted a classified Early Fielding Report in April 2015 detailing the results of ETR Phase 2.

Assessment
- A problem with telemetry data prevented weapon release in the planned January 2015 test. The program successfully completed the test in February 2015.
- Both of the flight tests were successful and demonstrated weapon effectiveness with ETR Phase 2 modifications.
- The Air Force will continue with ETR Phase 3 testing in FY16.

Recommendations
- Status of Previous Recommendations. There were no previous recommendations for this program.
- FY15 Recommendations. None.

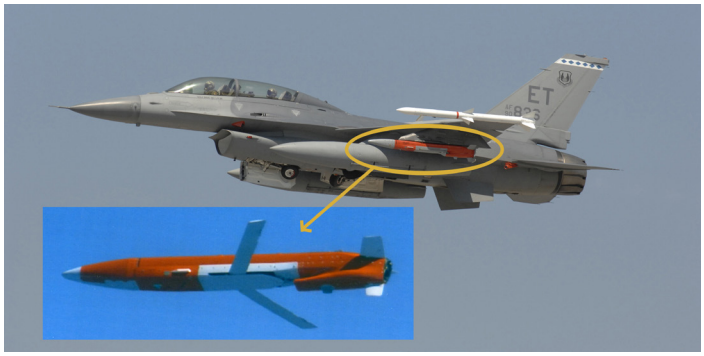
Miniature Air-Launched Decoy (MALD) and MALD-Jammer (MALD-J)

Executive Summary

- Miniature Air Launched Decoy – Jammer (MALD-J) is operationally effective with limitations and operationally suitable in specific environments as detailed in DOT&E's March 2015 classified IOT&E report. Not all operational environments could be assessed. The Air Force Operational Test and Evaluation Center completed mission level simulation testing, but certain operational elements were not included because of limitations in the Digital Integrated Air Defense System (DIADS).
- The Program Office completed open air testing for MALD-J (and MALD) with a software upgrade to address problems identified in GPS-degraded or denied environments.
- Suitability data show that the Air Force's corrective actions have improved the materiel reliability for MALD-J (and MALD).

System

- MALD is a small, low-cost, expendable, air-launched vehicle that replicates how fighter, attack, and bomber aircraft appear to enemy radar operators.
- MALD-J is an airborne stand-in jammer for electronic attack with the ability to loiter on station.
- MALD-J will jam specific Early Warning/Ground Control Intercept/Acquisition radars while retaining the capabilities of the MALD.
- MALD-J will stimulate and degrade an enemy's integrated air defense system.
- The F-16 C/D and B-52H are the lead aircraft to employ MALD and MALD-J.



Mission

- Combatant Commanders will use MALD and MALD-J to improve battlespace access for airborne strike forces by deceiving, distracting, or saturating enemy radar operators and Integrated Air Defense Systems.
- Combatant Commanders will use the MALD to allow an airborne strike force to accomplish its mission by deceiving enemy radars and air defense systems to treat MALD as a viable target.
- Combatant Commanders will use the MALD-J to allow an airborne strike force to accomplish its mission by jamming specific enemy radars and air defense systems to degrade or deny detection of friendly aircraft or munitions.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- In October 2013, the Air Force Operational Test and Evaluation Center completed full mission-level simulation testing using the DIADS.
- The 28th Test and Evaluation Squadron conducted a Force Development Evaluation (FDE), in conjunction with a MALD-J Reliability Assessment Program mission, to address problems identified in FY14. DOT&E observed this evaluation and used the FDE as an operational test.
- On October 24, 2015, during U.S. Air Forces Central Command characterization testing, MALD-J aborted its mission because of large values in the Geometric Dilution of Precision (GDOP) of GPS satellites used in navigation. The navigation system did not update the satellites to be used in the calculation of GDOP prior to launch.
- The FDE test included the launch of six MALD-J vehicles and one MALD vehicle with the software upgrade, which includes barometric aiding in the GPS Aided Inertial Navigation System (GAINS).
- In March 2015, DOT&E submitted an IOT&E report.
- In March 2015, the Program Office completed the Critical Design Review for the obsolescence upgrade to the GAINS, designating it GAINS2.
- All MALD-J (and MALD) testing was conducted in accordance with a DOT&E approved test plan.

Assessment

- The March 2015 IOT&E report concluded MALD-J is operationally effective with limitations and operationally

suitable in specific environments. Not all operational environments could be assessed because of simulation limitations of DIADS.
- The problem of the MALD-J aborting due to the navigation system not updating satellites in the GDOP calculation prior to launch will be corrected in software build nine.
- Barometric aiding improved vertical navigational accuracy (and stability) in a GPS-degraded or denied environment. No improvement in horizontal navigational accuracy was observed.
- A combination of MALD and MALD-J data were used to show a materiel reliability of 86±2 percent. Corrective actions have improved the material reliability of MALD-J (and MALD). Since no failures in the MALD-J payload have occurred to date, and the other systems are otherwise essentially identical, combining these data is appropriate.
- Mission planning test events determined B-52 aircrews planning a full load of 16 MALD-J may exceed the time required to support a 72-hour Air Tasking Order planning cycle.
  - The mission planning times from the IOT&E mission-planning events were: one MALD-J was 40 minutes, which is well under the 7-hour requirement to plan a single MALD-J; a fully-loaded F-16 (4-MALD-Js) was an average of 2 hours and 15 minutes; and a fully-loaded B-52 (16 MALD-Js) was an average of over 11 hours. The time to mission plan a full load B-52 is assessed as excessive and potentially unable to support a 72-hour Air Tasking Order planning cycle.
- In FY16, the Air Force intends to conduct mission planning events to demonstrate improved mission planning time performance.

Recommendations
- Status of Previous Recommendations. The Air Force satisfactorily addressed one of two FY14 recommendations. However, they still need to improve mission-planning capabilities for the MALD-J program to reduce the time needed to plan a full load of MALD-J vehicles.
- FY15 Recommendations. The Air Force should:
  1. Incorporate additional operational elements into the mission-level simulation in DIADS.
  2. Improve horizontal navigational accuracy of the MALD-J (and MALD) vehicle.
  3. Test the GAINS2 obsolescence upgrade to confirm equivalent or improved performance compared to the GAINS.

MQ-9 Reaper Armed Unmanned Aircraft System (UAS)

Executive Summary

- The MQ-9 program continues to face systemic challenges in prioritizing development and testing efforts between evolving program of record requirements and other capability development efforts outside of the system's program of record. Evolving priorities and competing development and fielding desires continue to stress operational test agency capacity to support both program of record testing requirements and accelerated fielding of capabilities desired by the Air Force.
- Planned FY14 FOT&E of the Block 5 Remotely Piloted Aircraft (RPA), Block 30 Ground Control Station (GCS), and software Operational Flight Program (OFP) 904.6 did not occur due to additional developmental testing to address thermal and power management problems. FOT&E did not occur in FY15. A combination of additional Block 5 RPA developmental testing and competing non-program of record development and test priorities overtaxed available operational test resources needed to support planned FY15 FOT&E. This FOT&E is planned to begin in 2QFY16.
- General Atomics delivered the final Block 1 RPA to the Air Force in 2QFY15 and transitioned the production line to Block 5 RPAs. There is no Full-Rate Production decision associated with MQ-9 deliveries; the Air Force will complete the MQ-9 fleet acquisition under low-rate initial production.
- The current DOT&E-approved MQ-9 Test and Evaluation Master Plan (TEMP) supports FOT&E of the Block 5 RPA, Block 30 GCS, and OFP 904.6. Upon completion of FOT&E of this configuration, a new TEMP will be required to document the incorporation of new program of record content (e.g., the Block 50 GCS) into the MQ-9 Increment 1 system.

System

- The MQ-9 Reaper Unmanned Aircraft System (UAS) is a remotely piloted, armed, air vehicle that uses optical, infrared, and radar sensors to locate, identify, target, and attack ground targets.
  - The MQ-9 RPA is a medium-sized aircraft that has an operating ceiling up to 50,000 feet, an internal sensor payload of 800 pounds, an external payload of 3,000 pounds, and an endurance of approximately 14 hours.
  - The GCS commands the MQ-9 RPA for launch, recovery, and mission control of sensors and weapons. C band line-of-sight datalinks are used for RPA launch and recovery operations, and Ku-band satellite links are used for RPA mission control.

- The MQ-9 RPA carries AGM-114, HELLFIRE II anti-armor precision laser-guided missiles, and GBU-12 500 pound laser guided bombs.
- The Air Force is using an evolutionary acquisition approach for meeting Increment 1 Capability Production Document requirements, with Block 1 and Block 5 RPAs and Block 15 and Block 30 GCSs.
- The Air Force is currently fielding the Block 1 RPA and the Block 15 GCS.
- The Air Force designed the Block 5 RPA to incorporate improved main landing gear, an upgraded electrical system with more power, an additional ARC-210 radio, encrypted datalinks, a redesigned avionics bay and digital electronic engine control system, the BRU-71 bomb rack, high-definition video, and upgraded software to allow the two-person aircrew to operate all onboard systems.

Mission

- Combatant Commanders use units equipped with the MQ-9 to conduct armed reconnaissance and pre-planned strikes. Units equipped with MQ-9s can find, fix, track, target, engage, and assess critical emerging targets (both moving and stationary).
- MQ-9 units can also conduct aerial intelligence gathering, reconnaissance, surveillance, and target acquisition for other airborne platforms.

Major Contractor

General Atomics Aeronautical Systems Inc. –San Diego, California

Activity

- The Air Force conducted all MQ-9 testing in accordance with the DOT&E-approved test plan and TEMP.
- The Air Force completed additional formal developmental testing on OFP version 904.6 Revision K for the Block 5 RPA and Block 30 GCS in 2QFY15. This software revision incorporated fixes to deficiencies and will be the OFP evaluated in the forthcoming FOT&E.
- FOT&E did not occur in FY15. A combination of additional Block 5 RPA developmental testing to address thermal and power management problems and competing non-program of record development and test priorities overtaxed available operational test resources needed to support planned FY15 FOT&E. FOT&E will not begin until 2QFY16.
  - The Air Force purchased a new, more powerful 5-ton cooling cart and modified the Block 5 RPA with a plenum to direct cooled air into the forward avionics bay to increase cooling capacity. Developmental testing in 4QFY15 demonstrated that these measures mitigated previous FY14 transmitter overheating problems.
  - Thermal and power management problems led to FY15 developmental test mission ground aborts due to depleted batteries that become too hot for charging on the ground prior to takeoff. As of the end of FY15, the Air Force had not determined a resolution to ongoing overheating problems.
- General Atomics delivered the final Block 1 RPA to the Air Force in 2QFY15 and transitioned the production line to Block 5 RPAs. As of 3QFY15, General Atomics had delivered 199 of 364 RPAs (Block 1 and Block 5 combined) to the Air Force. General Atomics plans to deliver the final Block 5 RPA in FY21. There is no Full-Rate Production decision associated with MQ-9 deliveries; the Air Force will complete the MQ-9 fleet acquisition under low-rate initial production.
- The final configuration of the MQ-9 Increment 1 UAS continued to evolve throughout FY15. The Air Force intends to incorporate an improved Multi Spectral Targeting System-B electro-optical/infrared sensor, additional weapons, avionics hardware, and further system software revisions into the Increment 1 program of record capabilities.
- In FY15, the MQ-9 UAS Program Office adopted a new hybrid acquisition strategy approach in response to changing non-program of record content desired by the Air Force and for delivering desired additional capabilities. Candidate capabilities are intended to be delivered in a series of bundled software/hardware releases under an accelerated development and testing schedule as an extension of the existing program of record.

Assessment

- The MQ-9 program continues to face systemic challenges in prioritizing development and testing efforts between evolving program of record requirements and other capability development efforts outside of the system's program of record. Evolving priorities and competing development and fielding desires continue to stress operational test agency capacity to support both program of record testing requirements and accelerated fielding of capabilities desired by the Air Force.
- Thermal management and overheating problems identified in FY14 were not fully resolved in FY15 despite the introduction of Block 5 RPA design changes and the introduction of additional ground cooling equipment. Although these measures mitigated RPA forward avionics bay redundant control module and transmitter overheating shortfalls, 4QFY15 hot weather developmental testing revealed power management problems that preclude charging batteries on the ground leading to depleted batteries prior to takeoff and leading to mission aborts. After an operationally representative taxi time in warm to hot weather, batteries that become too hot will be inhibited from charging to prevent battery overheating. If this occurs, required battery back-up power for takeoff may be insufficient and the mission could be aborted. As of the end of FY15, the Air Force had not identified a solution to the ongoing Block 5 RPA overheating problems. A combination of additional Block 5 RPA developmental testing and competing non-program of record development and test priorities overtaxed available operational test resources needed to support planned FY15 FOT&E. This FOT&E is planned to begin in 2QFY16.
- The Air Force originally intended to fulfill the MQ-9 Increment 1 Capability Production Document requirements with a final UAS configuration consisting of the Block 5 RPA, Block 30 GCS, and OFP 904.6. AFOTEC will conduct FOT&E of this configuration when ongoing thermal management problems are resolved. Subsequent AFOTEC FOT&E will be required consistent with the evolving MQ-9 program of record content, and at a minimum will include evaluation of the planned Block 50 GCS in conjunction with the appropriate system capabilities being delivered under the Air Force FY15 hybrid acquisition strategy.
- Electromagnetic Environmental Effects testing on the Block 5 RPA will not take place until after completion of planned FY16 FOT&E. Such testing recently completed on the Block 1 aircraft revealed vulnerabilities, and due to the similarities between the Block 1 and Block 5 aircraft, similar vulnerabilities may exist on the Block 5 aircraft.
- The current DOT&E-approved MQ-9 TEMP supports FOT&E of the Block 5 RPA, Block 30 GCS, and OFP 904.6. Upon completion of FOT&E for this configuration, a new TEMP will be required to document the incorporation of new program of record content (e.g., the Block 50 GCS) into the MQ-9 Increment 1 system.

Recommendations

- Status of Previous Recommendations. In FY15, the Air Force completed the development of the MQ-9 UAS to support planned FOT&E of the Block 5 RPA, Block 30 GCS, and OFP 904.6. The Air Force made progress toward, but did not fully satisfy, the FY14 recommendation to resolve the hot weather operating shortfalls.
- FY15 Recommendations. The Air Force should:
  1. Resolve the remaining Block 5 RPA thermal and power management shortfalls prior to the start of AFOTEC's FOT&E.
  2. Complete planned FOT&E of the Block 5 RPA, Block 30 GCS, and OFP 904.6.
  3. Upon completion of the planned FOT&E (Block 5 RPA, Block 30 GCS, and OFP 904.6), submit a new TEMP documenting the incorporation of new content and capabilities (e.g., Block 50 GCS) and the T&E strategy and resources required to mature and test these capabilities.

QF-16 Full-Scale Aerial Target (FSAT)

Executive Summary

- The Air Force conducted 99 QF-16 developmental and operational test sorties in FY13 and 14, completing IOT&E in September 2014. DOT&E's QF-16 IOT&E report submitted in January 2015 stated that the QF-16 is operationally effective and will provide a high-fidelity representation of fourth-generation air superiority threats for U.S. weapon systems testing and tactics, techniques, and procedures development. Additionally, the QF-16 is operationally suitable, and under the 53rd Weapons Evaluation Group Concept of Employment that provides a primary and spare target for each mission, the QF-16 achieved 98.3 percent mission supportability. Although there are deficiencies that prevent the QF-16 from meeting its Mission Supportability and Mean Time Between Failure (MTBF) requirements, they do not have significant operational impact. The program is not required to meet the MTBF requirement until the QF-16 reaches Full Operational Capability.
- The Air Force should accomplish cybersecurity testing in accordance with the DOT&E cybersecurity policy memorandum, dated August 1, 2014.
- The Air Force should ensure procurement funding provides at least 25 Full-Scale Aerial Target (FSAT) targets per year beginning in FY16 to meet Service-coordinated aerial target requirements, in compliance with Resource Management Decision 700.
- The Air Force should provide plans for Phase II of the Air Superiority Target program to address shortfalls in testing against fifth-generation airborne threats.

System

- The QF-16 is the latest FSAT designed to test and evaluate U.S. weapon systems and assist in developing tactics, techniques, and procedures to counter fighter-size airborne threats. The DOD is replacing the current FSAT, the QF-4, due to its increasing dissimilarity from current and projected air-superiority threats, declining supportability, and depletion of suitable F-4 airframes.
- The QF-16 system is composed of regenerated F-16 Block 15, 25, and 30 aircraft equipped with Drone-Peculiar Equipment to enable remote command and control, missile trajectory scoring, and safe flight termination. Like the QF-4, the QF-16 is capable of manned and Not Under Live Local Operator flight operations. It will operate from Tyndall AFB, Florida, using the Gulf Range Drone Control System, and Holloman AFB, New Mexico, using the White Sands Integrated Target System located at White Sands Missile Range, New Mexico.
- The QF-16 retains F-16 flight performance characteristics and payload capabilities including supersonic, after-burning engines, high-G maneuvering, complex electronic attack, and expendable countermeasures.

Mission

The DOD uses FSATs to:

- Provide threat-representative presentations for developmental and operational test and evaluation for U.S. weapon systems, as mandated by Title 10 U.S. Code, Section 2366
- Continuously evaluate fielded air-to-air missile capabilities while providing live missile training for combat air crews through Air Force and Navy Weapon Systems Evaluation Programs

Major Contractor

The Boeing Company – St. Louis, Missouri

Activity

- In January 2015, DOT&E submitted an IOT&E report on the QF-16 FSAT.
- On September 5, 2014, QF-16 completed its last IOT&E flight. In total, QF-16 flew 99 developmental and operational test sorties, 19 of which were integrated test, and 4 dedicated operational test sorties (2 manned and 2 Not Under Live Local Operator). The Air Force conducted the IOT&E in accordance with the DOT&E-approved test plan dated May 31, 2013.

Assessment

- As detailed in the IOT&E report, DOT&E found that the QF-16 is operationally effective and will provide a high-fidelity representation of fourth-generation air superiority threats for U.S. weapon systems testing and tactics, techniques, and procedures development.
  - The QF-16 demonstrated the full Mission Performance Key Performance Parameter (KPP) profile with the Target Control Systems at Tyndall AFB, Florida, and White Sands Mission Range, New Mexico. The Mission Performance KPP profile included ground operations, launch and climb out, flight maneuvers, post-shot procedures, and recovery.
  - The QF-16 successfully demonstrated the ability to carry, operate, and monitor all KPP-required mission pods used for countermeasures and electronic attack, including the Tactical Electronic Attack Missions System, ALQ-167, ALQ-188, ALE-56, and ALE-40. The QF-16 flew with AIM-9 sized pods and a centerline fuel tank, and successfully employed both internal and external expendables.
  - The QF-16 successfully demonstrated the Flight Termination System and Vector Scoring System (VSS), which provides miss distance between a missile and the QF-16.
- As reported in the IOT&E report, DOT&E found that the QF-16 is operationally suitable. Although there are deficiencies that prevent the QF-16 from meeting its Mission Supportability and MTBF requirements, they do not have significant operational impact.
  - Under the 53rd Weapons Evaluation Group Concept of Employment that provides a primary and a spare target for each mission, the QF-16 achieved 98.3 percent mission supportability.
  - Calculations from test data measure MTBF to be 31.1 hours with 80 percent confidence bounds of 23.74 hours and 41.21, short of the 45-hour Full Operational Capacity requirement. About half (12 of 25) of QF-16 drone-peculiar equipment failures were related to the VSS.
  - The drone-unique Mean Time to Repair is 28.4 ±17.2 minutes, well within the requirement of less than 90 minutes for events within the 90th percentile. Training and technical orders are adequate for both maintainers and operators.
- Initially, DOT&E exempted QF-16 from a cybersecurity Cooperative Vulnerability Penetration Assessment and Adversarial Assessment because the system had no direct connection to the internet and had a Flight Termination System independent of the control system. However, DOT&E published refined cybersecurity testing guidance for acquisition programs in August 2014. The Air Force Life Cycle Management Center, with the support of the Air Force Operational Test and Evaluation Center, is in the process of test planning to comply with DOT&E's additional cybersecurity testing requirements. The QF-16 program currently lacks funding for additional cybersecurity testing.
- The Air Force did not require QF-16 to represent fifth-generation airborne threat systems (including radio frequency low-observability characteristics, internally-carried advanced electronic attack, and low probability of intercept sensors). DOT&E continues to emphasize existing aerial targets, including the QF-16, are insufficient for adequate operational testing of U.S. weapon systems.
  - In the Air Superiority Target Phase I Analysis of Alternatives Final Report (March 15, 2007), the Air Force recommended further study to produce user consensus on critical characteristics of future aerial targets and to determine capabilities and shortfalls in existing test resources.
  - Multiple stakeholders within Congress, OSD, the Air Force, and the Navy, support the requirement for a fifth generation FSAT.
- In late June, Boeing performed sample inspections on a QF-16 at Cecil Field, Florida, and discovered workmanship deficiencies with wire splices, termination, and routing. As a result of these findings, they broadened the inspection population to the first three production aircraft already delivered to Tyndall AFB, Florida, and found similar problems. Corrective actions are ongoing and Air Combat Command is expected to declare Initial Operational Capability in FY16.

Recommendations

- Status of Previous Recommendations. The Air Force still needs to address the following outstanding recommendations:
  1. Complete radar cross section measurements for QF-16 to ensure current and future U.S. weapon systems programs have precise, reliable data on system performance against measured, low-observable target presentations. Of note, the program is on pace to complete all of the necessary measurements by February 2017.
  2. Ensure QF-16 procurement funding continues to comply with Resource Memorandum Decision 700-mandated levels of 25 aircraft per year beginning in FY16, in order to meet Service-coordinated and approved test and training resource requirements.
  3. Complete the user requirements and current capabilities studies and provide plans for Phase II of the Air Superiority Target program to address test and evaluation shortfalls for U.S. weapon systems with respect to threat-representative, fifth-generation FSATs.
- FY15 Recommendations. The Air Force should:
  1. Accomplish cybersecurity testing in accordance with the DOT&E cybersecurity policy memorandum, dated August 1, 2014.
  2. Continue to monitor VSS reliability to ensure the corrections that were implemented in low-rate initial production Lot 1 aircraft will support compliance with the QF-16's MTBF requirement.

RQ-4B Global Hawk High-Altitude Long-Endurance Unmanned Aerial System (UAS)

Executive Summary

- In February 2015, USD(AT&L) approved a multi-year, $3.5 Billion upgrade and modernization development program to accomplish the following: correct previous capability shortfalls identified during the 2011 RQ-4B Block 30 IOT&E; address emerging component obsolescence problems; and significantly upgrade system sensor, ground station, and communication systems. The Air Force is currently developing a comprehensive program test strategy and Test and Evaluation Master Plan (TEMP) to guide development and testing for the extensive system architecture and capability upgrades included in the new program baseline and future modernization programs.
- The Air Force is currently planning to conduct RQ-4B Block 30/Airborne Signals Intelligence Payload (ASIP) FOT&E in conjunction with the initial phases of the RQ-4B modernization program in FY18. This test should include a complete re-evaluation of the RQ-4B Block 30 Signals Intelligence (SIGINT) mission capabilities with the ASIP sensor as well as an assessment of previously identified ground station, air vehicle, communication system, interoperability, and cybersecurity shortfalls.
- Following numerous developmental test delays, the RQ-4B Block 40/Multi Platform Radar Technology Insertion Program (MP-RTIP) IOT&E began in September 2015 and completed in December 2015. The Air Force conducted testing in accordance with the DOT&E-approved test plan.

System

- The RQ-4B Global Hawk is a remotely-piloted, high altitude, long-endurance airborne Intelligence, Surveillance, and Reconnaissance (ISR) system that includes the Global Hawk unmanned air vehicle, various intelligence and communications relay mission payloads, and supporting command and control ground stations.
- The RQ-4B Global Hawk Block 30 system is equipped with a multi-intelligence payload that includes both the Enhanced Integrated Sensor Suite imagery intelligence payload and ASIP SIGINT sensor.
- The RQ-4B Block 40 system is equipped with the MP-RTIP synthetic aperture radar payload designed to simultaneously collect imagery intelligence on stationary ground targets and track ground-moving targets.
- All RQ-4B systems use line-of-sight and beyond-line-of-sight communication systems to provide air vehicle command and control and transfer collected intelligence data to grounds stations for exploitation and dissemination.
- The Air Force Distributed Common Ground System (AF DCGS) supports ISR collection, processing, exploitation, analysis, and dissemination for both Block 30 and 40 RQ-4B Global Hawk systems. The AF DCGS employs global communications architecture to connect multiple intelligence platforms and sensors to numerous Distributed Ground Stations where intelligence analysts produce and disseminate intelligence products.

Mission

- Commanders use RQ-4 Global Hawk reconnaissance units to provide high-altitude, long-endurance intelligence collection capabilities to support theater operations.
- Operators collect imagery and SIGNINT data to support ground units and to identify intelligence-essential elements of information for theater commanders. Units equipped with RQ-4B Global Hawk use line-of-sight and beyond line-of-sight satellite datalinks to control the Global Hawk system and transmit collected intelligence data.
- Ground-based intelligence analysts exploit collected imagery, ground-moving target, and SIGINT to provide intelligence products that support theater operations.
- Global Hawk can also provide imagery intelligence directly to forward-based personnel through direct line-of-sight datalink systems.

Major Contractor

Northrop Grumman Aerospace Systems, Strike and Surveillance Systems Division – San Diego, California

Activity

- The 2015 Presidential Budget fully funded the Global Hawk program, resolving several years of programmatic uncertainty. As of September 2015, the Air Force has taken delivery of 18 of 21 RQ-4B Block 30 air vehicles and all 11 RQ-4B Block 40 air vehicles, along with 9 Mission Control and 10 Launch and Recovery ground stations.
- In February 2015, USD(AT&L) approved a multi-year, $3.5 Billion upgrade and modernization development program to accomplish the following: correct previous capability shortfalls identified during the 2011 RQ-4B Block 30 IOT&E; address emerging component obsolescence problems; and significantly upgrade system sensor, ground station, and communication systems.
- The Air Force is currently developing a comprehensive program test strategy and TEMP to guide development and testing for the extensive system architecture and capability upgrades included in the new program baseline and future modernization programs.

Block 30

- No RQ-4B Block 30 operational testing was conducted in FY15. The Air Force continued to sustain operations for 18 Block 30 aircraft at Beale AFB, California, and at forward operating bases in U.S. Pacific Command (USPACOM), U.S. Central Command (USCENTCOM), and U.S. European Command (USEUCOM) operating areas.
- The Air Force is currently developing a comprehensive program test strategy and TEMP to correct previously identified RQ-4B Block 30 capability shortfalls and test a series of other modernization upgrades. This strategy will identify the next collection of significant RQ-4B Block 30 FOT&E events planned for FY18. Events include re-evaluation of previously identified ASIP/SIGINT mission capability shortfalls, interoperability deficiencies, MS-177 sensor integration, weather radar performance, mission planning upgrades, and other system modernization changes.

Block 40

- In FY15, the Air Force continued to employ two RQ-4B Block 40 development systems with limited operational capabilities in the USCENTCOM area of operations. Two additional systems are deployed in the USPACOM area of operations. These systems were fielded in FY13 and FY14 to support Combatant Command requests for additional airborne ISR support.
- Following numerous developmental test delays, the RQ-4B Block 40/MP-RTIP IOT&E began in September 2015, and completed in December 2015. The Air Force conducted testing in accordance with the DOT&E-approved test plan. Initial schedule delays were associated with synthetic aperture radar image quality problems and system stability problems observed during the FY13 RQ-4B Block 40 Operational Utility Evaluation (OUE). Delayed delivery of AF DCGS system software changes necessary to support RQ-4B Block 40 operations further delayed the start of IOT&E.
- DOT&E approved the Block 40 IOT&E test plan in May 2015.

Assessment

Block 30

- Since the combined RQ-4B Block 30/ASIP IOT&E in 2011, the Air Force has corrected most RQ-4B air vehicle reliability and availability problems and implemented a limited number of previously planned system improvements. However, due to the program uncertainty driven by the FY13 DOD decision to retire the RQ-4B fleet, and the subsequent reversal of that decision, the Air Force has not yet conducted a comprehensive FOT&E to verify correction of all major IOT&E deficiencies. Currently fielded RQ-4B Block 30 systems continue to operate with many of the same operational performance, interoperability, and SIGINT mission deficiencies identified during IOT&E.
- The Air Force is currently planning to conduct FOT&E in conjunction with the initial phases of the RQ-4B modernization program in FY18. This test should include a complete re-evaluation of the RQ-4B Block 30 SIGINT mission capabilities with the ASIP sensor as well as an assessment of previously identified ground station, air vehicle, communication system, interoperability, and cybersecurity shortfalls.

Block 40

- Since the FY13 RQ-4B Block 40 OUE, the Air Force has implemented a series of software changes to improve MP-RTIP sensor stability and performance. Field data from USCENTCOM early fielding activities indicate that software changes and procedural workarounds have improved sensor stability.
- IOT&E began in September 2015 and included 10 sorties that concluded in October 2015; additional data collection and analysis continued until the end of December 2015.
- DOT&E intends to submit a report on the RQ-4B Block 40 IOT&E in 2QFY16.

Recommendations

- Status of Previous Recommendations. The Air Force made limited progress toward addressing FY14 recommendations. The Air Force has not completed an RQ-4B Block 30 or RQ-4B Block 40 TEMP to guide developmental and operational testing of these systems or proceeded with an ASIP sensor FOT&E event to verify correction of performance deficiencies identified during the 2011 RQ-4B Block 30 IOT&E. The Air Force has identified and corrected some persistent RQ-4B Block 40/MP-RTIP sensor stability problems, but has not verified whether these corrections will provide enough improvement to correct the significant operational performance shortfalls that have been identified since the initial AFOTEC MP-RTIP operational assessment in 2008. The Air Force did implement corrective actions for the MP-RTIP synthetic aperture radar image resolution problems observed during the 2013 RQ-4B Block 40 OUE.

- FY15 Recommendations. The Air Force should:
  1. Develop an RQ-4B program TEMP to guide completion of post-IOT&E corrective actions and to define operational test requirements for future Block 30 and Block 40 system upgrades.
  2. Develop a plan to complete the FOT&E for the RQ-4B Block 30 SIGINT mission using the ASIP sensor.

Small Diameter Bomb (SDB) II

Executive Summary

- The Air Force Operational Test and Evaluation Center and the Navy's Commander, Operational Test and Evaluation Force, completed the Small Diameter Bomb (SDB) II Operational Assessment in February 2015.
- DOT&E published an Operational Assessment report in May 2015 to support a Milestone C (MS C) decision and entry into low-rate initial production.
- The Milestone Decision Authority approved the SDB II MS C in May 2015. Subsequently, the Program Office awarded the Lot 1 production option.
- The SDB II program test team is completing developmental flight testing. The program has accomplished 12 of the 16 Normal Attack (NA) mode Guided Test Vehicle (GTV) shots and 3 of the 6 NA Live Fire (LF) shots required to enter Government Confidence Testing (GCT). SDB II is on track to begin GCT in early 2016.
- The weapon is progressing well towards demonstrating its requirements in the NA mode. It has demonstrated in-flight target updates with both Ultra High Frequency and Link 16 networks.

System

- The SDB II is a 250-pound, air-launched, precision-glide weapon that uses deployable wings to achieve stand-off range. F-15E aircraft employ SDB IIs from the BRU-61/A four-weapon carriage assembly.
- SDB II combines Millimeter-Wave radar, imaging infrared, and laser-guidance sensors in a terminal seeker, in addition to a GPS and an Inertial Navigation System to achieve precise guidance accuracy in adverse weather.
- The SDB II incorporates a multi-function (blast, fragmentation, and shaped charged jet) warhead, designed to defeat non-armored and armored targets. The weapon can be set to initiate on impact, at a preset height above the intended target, or in a delayed mode.
- SDB II provides increased weapons load per aircraft compared to legacy air-to-ground munitions used against offensive counter-air, strategic attack, interdiction, and close air support targets in adverse weather.
- SDB II provides reduced collateral damage while achieving kills across a broad range of target sets by precise accuracy, small warhead design, and focused warhead effects.
- There are three principal attack modes: NA, Laser Illuminated Attack (LIA), and Coordinate Attack (CA). SDB II can be used against moving or stationary targets using its NA (radar/infrared sensors) or LIA modes, and fixed targets with its CA mode.

Mission

- Combatant Commanders will use units equipped with SDB II to attack stationary and moving targets in degraded weather conditions at stand-off ranges.
- An SDB II-equipped unit or Joint Terminal Attack Controller will engage targets in dynamic situations and use a weapon datalink network to provide in-flight target updates, in-flight retargeting, weapon in-flight tracking, and, if required, weapon abort.

Major Contractor

Raytheon Missile Systems – Tucson, Arizona

Activity

- The Air Force Operational Test and Evaluation Center and the Navy's Commander, Operational Test and Evaluation Force, completed the SDB II Operational Assessment in February 2015.
- DOT&E published an Operational Assessment report in May 2015 to support a Milestone C (MS C) decision and entry into low-rate initial production.
- The Milestone Decision Authority approved the SDB II MS C in May 2015; the SDB II Program Office awarded the Lot 1 production option for 144 Air Force weapons in June 2015.
- DOT&E approved the updated Test and Evaluation Master Plan in April 2015; the SDB II Program Office is preparing for IOT&E.

- As of 2015, the Air Force has successfully completed 12 GTV and 3 LF developmental tests against moving and stationary targets. Three of the GTV and one LF test were conducted with Ultra High Frequency updates while nine GTV and two LF test shots were conducted with Link 16 updates. All tests were conducted in the NA mode, which is the primary employment method for SDB II. LIA and CA will be tested in 2QFY16.
- The Program Office completed 12 rounds of seeker CFTs, resulting in over 1,833 target runs in a wide variety of terrain and environmental conditions providing terabytes of seeker performance data and over 439 hours of seeker operation without a single failure.
- The program has augmented and refined the Integrated Flight System (IFS) model by incorporating the results of over 1,833 CFT runs as well as weapon flight tests. IFS model verification and validation is expected to be complete by the end of calendar year 2015, and the Air Force Operational Test and Evaluation Center is expected to accredit it prior to the start of operational testing.
- The Program Office completed over 2,000 hours of ground reliability testing and nearly 200 hours of inflight reliability testing.
- The program is scheduled to begin a 28-shot NA mode GCT program in January 2016, which will test the weapon in more operationally realistic environments with operationally representative hardware and software. GCT will test the weapon versus maritime targets, countermeasures, and GPS-degraded environments.

Assessment

- The operational assessment showed the SDB II progressing well towards meeting its effectiveness, reliability, and lethality requirements in the NA mode, which is the primary employment method for SDB II. SDB II successfully engaged both moving and stationary targets, in which there were no free flight reliability failures. The program has implemented corrective actions and fixes for all failure modes discovered in test.
- The SDB II program met the MS C criteria. The SDB II Program Office is preparing for IOT&E with an adequately resourced test program and no unresolved major programmatic testing problems. IOT&E is scheduled to begin in 2QFY17.
- Two GTVs and one LF mission required additional attempts and were successfully repeated after completion of the failure investigation and implementation of corrective actions. All corrective actions to date have been successful in preventing repeats of the observed failure modes, with the exception of LF-5. LF-5, which was conducted on September 14, 2015, did not detonate and is currently under investigation. The test will be repeated after the investigation to adequately assess the lethality of the SDB II against the specific target.
- The weapon failed one environmental test related to the shipboard environment, but the program implemented a fix and completed design verification testing giving the Program Office confidence that the corrective actions will be successful.
- Preliminary comparisons of the IFS model pre- and post-flight predictions indicate the model is adequate for the kinematics flown in flight test to date. Raytheon Missile Systems will continue to develop and update the IFS model, which will be essential to the assessment of the results of live fire and operational testing. IFS, in combination with lethality data, will produce single shot kill probability values needed to assess end-to-end weapon effectiveness against a range of operationally relevant targets.
- The weapon is progressing towards demonstrating the required reliability. Further testing in GCT and CFT should provide increased confidence in weapon reliability.
- The weapon is on track to proceed to GCT.

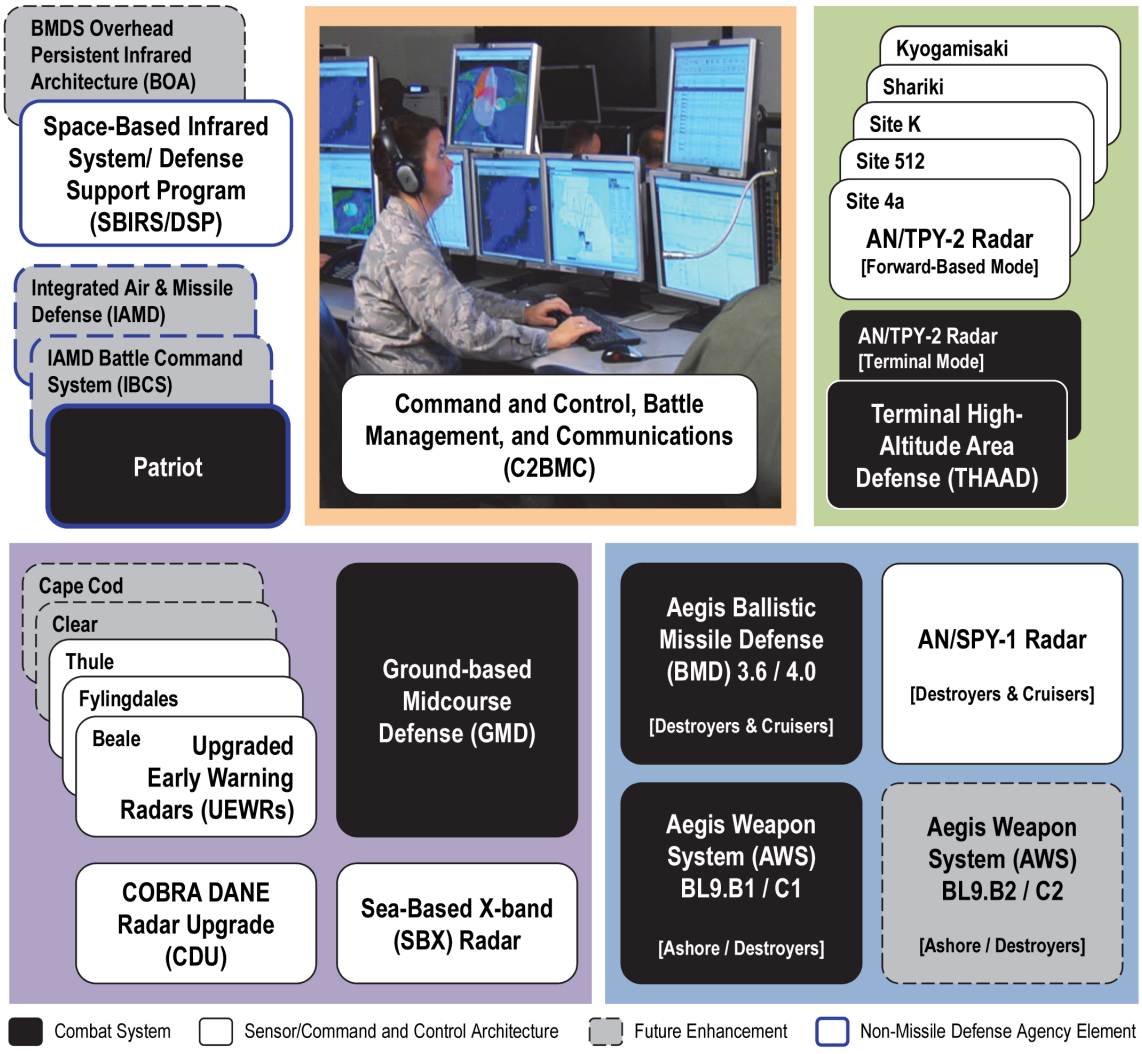
Recommendations

- Status of Previous Recommendations. The Air Force completed all previous recommendations.
- FY15 Recommendation.
  1. The Air Force should use the results of GCT to further refine the IOT&E test plan.

Ballistic Missile Defense Systems

Ballistic Missile Defense Systems

Ballistic Missile Defense System (BMDS)



Executive Summary

- The Flight Test, Operational-02 (FTO-02) Event 2 and Event 2a test demonstrated that the Ballistic Missile Defense System (BMDS) capability against theater/regional threats increased during FY15. The BMDS demonstrated layered defense against two threat-representative ballistic missile targets. However, the Standard Missile (SM)-3 Block IB Threat Update guided missile failed early in flight; an engineering Failure Review Board investigation is underway. Full assessment of the FTO-02 Event 2 and Event 2a test mission data with respect to BMDS operational effectiveness, operational suitability, and interoperability is ongoing.
- With no flight testing in FY15, the Homeland Defense assessment remains unchanged. The Ground-based Midcourse Defense (GMD) combat system demonstrates a limited capability to defend the U.S. Homeland from small numbers of intermediate-range or intercontinental ballistic missile threats launched from North Korea or Iran.
- The Missile Defense Agency (MDA) enhanced the Integrated Master Test Plan (IMTP) by including direct linkage between the BMDS test program and future capability enhancements.
- The MDA conducted numerous ground tests, wargames, and exercises. The capability to produce BMDS-level simulation-based performance assessments was limited. The MDA should increase the development priority and associated funding for the BMDS high-fidelity, end-to-end, digital modeling and statistically significant simulation capability.

System

The BMDS is a distributed system currently including five elements: four autonomous combat systems including dedicated

sensors and one global/regional sensor/command and control architecture.
- GMD (shooter), COBRA DANE Radar Upgrade (sensor), Upgraded Early Warning Radars (sensor), and Sea-Based X-band Radar (sensor).
- Aegis BMD (shooter), Aegis Ashore Missile Defense System (AAMDS) (shooter), and AN/SPY-1 Radar (sensor).
- Terminal High-Altitude Area Defense (THAAD) (shooter) and AN/TPY-2 Terminal Mode Radar (sensor).
- Patriot (shooter). Since Patriot is an Army program instead of an MDA program, testing of the Patriot is discussed in the Army section of this FY15 Annual Report.
- Space-Based Infrared System/Defense Support Program (SBIRS/DSP) (global sensor); AN/TPY-2 Forward-Based Mode (FBM) Radar (regional sensor); and Command and Control, Battle Management, and Communications (C2BMC) (command and control). SBIRS and DSP are currently Air Force operational assets. Due to hardware and software similarity to the AN/TPY-2 (Terminal Mode) Radar, testing of the AN/TPY-2 (FBM) Radar is covered in the THAAD annual report.

Mission
- U.S. Northern Command (USNORTHCOM), U.S. Pacific Command (USPACOM), U.S. European Command (USEUCOM), and U.S. Central Command (USCENTCOM) employ the assets of the BMDS to defend U.S. territory, deployed forces, and allies against ballistic missile threats of all ranges.
- The U.S. Strategic Command (USSTRATCOM) synchronizes operational-level global missile defense planning and operations support for the DOD.
- All Combatant Commanders use the C2BMC element of the BMDS to maintain situational awareness. USEUCOM, USCENTCOM, and USPACOM also use the C2BMC to provide sensor management of regional AN/TPY-2 (FBM) radars.

Major Contractors
- The Boeing Company
  - GMD Integration – Huntsville, Alabama
- Lockheed Martin Corporation
  - Aegis BMD, AAMDS, and AN/SPY-1 Radar – Moorestown, New Jersey
  - C2BMC – Gaithersburg, Maryland
  - SBIRS – Sunnyvale, California
  - THAAD Weapon System and Patriot Interceptors – Dallas, Texas
  - THAAD Interceptors – Troy, Alabama
- Northrop Grumman Corporation
  - DSP – Redondo Beach, California
  - GMD Fire Control and Communications – Huntsville, Alabama
- Orbital Sciences Corporation
  - GMD Booster Vehicles – Chandler, Arizona
- Raytheon Company
  - GMD Exo-atmospheric Kill Vehicle and Standard Missile-3 Interceptors – Tucson, Arizona
  - Patriot, AN/TPY-2 Radar, Cobra Dane Radar, Sea-Based X-band Radar, and Upgraded Early Warning Radars – Tewksbury, Massachusetts

---

Activity
- The MDA conducted all testing in accordance with the DOT&E-approved IMTP.
- The BMDS Operational Test Agency and the MDA attempted FTO-02 Event 1 in June 2015 at the Pacific Missile Range Facility on Kauai, Hawaii. The MDA intended to demonstrate the operational capability of the regional/theater European Phased, Adaptive Approach Phase 2 BMDS, anchored by the AAMDS, to defend Europe against medium-range ballistic missiles. The test was to be the first target intercept by the AAMDS and the first flight for the SM-3 Block IB with threat update guided missile. Due to a target malfunction, the test was not completed and the SM-3 guided missile was not launched. This test is scheduled to be attempted again in December 2015.
- The BMDS Operational Test Agency and the MDA conducted FTO-02 Event 2 and Event 2a in September and October 2015 at Wake Island and the broad-ocean area surrounding it. The Operational Test Agency designed the test mission to demonstrate a layered BMDS with multiple combat systems sharing common defended areas and shot opportunities against two threat-representative ballistic missiles. The primary test objective was to assess Aegis BMD system capability to prosecute a ballistic missile threat engagement in the presence of non-organic post-intercept debris, while simultaneously conducting Anti-Air Warfare. The THAAD combat system, using Lot 4 interceptors for the first time, generated the non-organic post-intercept debris scene for Aegis BMD.
- The MDA did not conduct Homeland Defense flight testing in FY15.
- During FY15, the MDA conducted four major ground tests.
  - Ground Test, Distributed-04e (GTD-04e) Part 2 and Ground Test, Integrated-06 (GTI-06) Part 3 in January and July 2015. These tests focused on USNORTHCOM and USPACOM scenarios, respectively.
  - GTI-06 Part 1 and GTD-06 Part 1 in May and October 2015. These tests focused on USEUCOM and USCENTCOM scenarios, respectively.

- The MDA also conducted several wargames and exercises designed to enhance Combatant Command BMD readiness and increase Service member confidence in the deployed elements of the BMDS.

Assessment

- The MDA, in collaboration with DOT&E, updated the IMTP to incorporate BMDS element maturity, program modifications, and fiscal constraints. The MDA included in the IMTP a much closer tie between individual tests and the planned BMDS technical capability increment deliveries.
- FTO-02 Event 2 and Event 2a demonstrated that the BMDS capability against theater/regional threats increased during FY15. THAAD interceptors hit one short-range and one medium-range threat-representative ballistic missile targets while Aegis BMD simultaneously engaged an air-breathing threat with SM-2 Block IIIA guided missiles. However, the SM-3 Block IB Threat Update guided missile also targeting the medium-range ballistic missile target, failed early in flight; an engineering Failure Review Board investigation is underway. Full assessment of the FTO-02 Event 2 and Event 2a test mission data with respect to BMDS operational effectiveness, operational suitability, and interoperability is ongoing.
- With no flight testing in FY15, the Homeland Defense assessment remains unchanged. The GMD combat system demonstrates a limited capability to defend the U.S. Homeland from small numbers of intermediate-range or intercontinental ballistic missile threats launched from North Korea or Iran.
- Ground testing was able to demonstrate interoperability and some command and control capabilities for Combatant Command architectures.
  - C2BMC tasked and managed the two USPACOM AN/TPY-2 (FBM) radars for the first time and exercised cross-area of responsibility data sharing between USEUCOM and USCENTCOM.
  - Ground tests also identified several tasking problems between C2BMC and AN/TPY-2 (FBM), which are under evaluation.
  - Many of the models and simulations used in the ground tests have no accreditation, which limits the MDA's capability to produce BMDS-level performance assessments. The MDA is developing a high-fidelity, end-to-end, digital performance assessment modeling and simulation capability for the BMDS; this effort will take several more years.

Recommendations

- Status of Previous Recommendations. The MDA has addressed most previous BMDS recommendations. The following recommendations from FY14 remain outstanding:
  1. The MDA should continue to address recommendations made in the DOT&E FTO-01 assessment found in the classified DOT&E February 2014 BMDS Annual Report, Appendix E.
  2. The MDA should increase the development priority and associated funding for the BMDS simulation-based performance assessment capability. The ability to produce high-fidelity and statistically significant BMDS-level performance assessments is critical.
- FY15 Recommendation.
  1. The MDA should include Patriot in system-level operational flight test events in order to assess interoperability and integration between all of the BMDS combat systems and sensors.

Aegis Ballistic Missile Defense (Aegis BMD)

Executive Summary

- The Missile Defense Agency (MDA) conducted eight Aegis Ballistic Missile Defense (Aegis BMD) flight tests in FY15 and two in 1QFY16. All but one intercept attempt resulted in successful intercepts. Overall, Aegis BMD successfully engaged four ballistic missile targets and five anti-air warfare targets.
- In FY15, the Aegis BMD program conducted combined developmental testing/operational testing (DT/OT) and operational flight testing of the Aegis Baseline 9 system in its Aegis Ashore (Baseline 9.B1) and Aegis Afloat (Baseline 9.C1) configurations with Standard Missile-3 (SM-3) Block IB, SM-6 Dual I, and SM-2 Block IV guided missiles, and also conducted FOT&E of the Aegis BMD 4.0 system. The program continued conducting early developmental flight testing of the SM-3 Block IIA-guided missile in accordance with the DOT&E approved Integrated Master Test Plan. The Aegis Ashore configuration supports the President's European Phased-Adaptive Approach (EPAA) for the defense of Europe.
- Although the program completed FOT&E for the Aegis BMD 3.6.1 system in FY11, the program continued to use a variant of the Aegis BMD 3.6 system (i.e., 3.6.3) in system-level tests from January 2015 through October 2015, and a fleet exercise in October 2015 to assess system-level engagement capability and interoperability with the Ballistic Missile Defense System (BMDS) and foreign missile defense assets.
- Operational Aegis BMD assets and hardware-in-the-loop (HWIL) facilities underwent cybersecurity and reliability, maintainability, and availability testing, and participated in several flight and ground tests to assess Aegis Ashore and Afloat, BMD 4.0.2, BMD 4.0.3, and BMD 3.6.3 capabilities and interoperability with the BMDS.
- Testing demonstrated engagement capabilities against short-range ballistic missiles in both endo- and exo-atmospheric engagements and against anti-air warfare targets.
- During an Aegis BMD 4.0 test, the system demonstrated its Distributed Weighted Engagement Scheme (DWES), an automated engagement coordination capability involving multiple firing ships.
- Two third-stage rocket motor (TSRM) failures in FY11 and FY13 lower certainty in SM-3 Block IB missile reliability in its currently fielded configuration. Following failure investigations, the MDA made a software change and a hardware redesign of the TSRM aft nozzle. Ground testing of the redesigned nozzle began in FY14 and flight testing is expected in February 2016.
- A TSRM cold gas regulator (CGR) anomaly observed during testing is under investigation by the MDA.

Aegis Cruiser

Aegis Ashore and Vertical Launch System

- Flight testing, modeling and simulation, and ground testing have demonstrated Aegis BMD 4.0 and Aegis Afloat capabilities to perform Long-Range Surveillance and Track (LRS&T).

System

- Aegis BMD is a sea-based missile defense system that employs the multi-mission shipboard Aegis Weapon System, with improved radar and new missile capabilities to engage ballistic missile threats. Capabilities of Aegis BMD include:
  - Computer program modifications to the AN/SPY-1 radar for LRS&T of ballistic missiles of all ranges
  - A modified Aegis Vertical Launching System, which stores and fires SM-3 Block IA and Block IB guided missiles, modified SM-2 Block IV guided missiles, and SM-6 Dual I guided missiles
  - SM-3 Block IA and Block IB guided missiles that use maneuverable kinetic warheads to accomplish midcourse engagements of short-, medium-, and intermediate-range ballistic missiles
  - Modified SM-2 Block IV guided missiles that provide terminal engagement capability against short-range ballistic missiles
  - SM-6 Dual I guided missiles that provide terminal engagement capability against short-range ballistic missiles
- Aegis Ashore (Baseline 9.B1) is a land-based version of Aegis BMD, with an AN/SPY-1 radar and Vertical Launching System to enable engagements against medium- and intermediate-range ballistic missiles with SM-3 guided missiles. Once the MDA deploys Aegis Ashore to Romania, it will become the central, land-based component of the second phase of the European Phased-Adaptive Approach for the defense of Europe.
- Aegis BMD and Aegis Ashore are capable of performing autonomous missile defense operations and operations that exploit networked sensor information by sending/receiving cues to/from other BMDS sensors through tactical datalinks.

Mission

The Navy can accomplish three missile defense-related missions using Aegis BMD:

- Defend deployed forces and allies from short- to intermediate-range theater ballistic missile threats
- Provide forward-deployed radar capabilities to enhance defense against ballistic missile threats of all ranges by sending cues or target track data to other elements of the BMDS
- Provide all short- to long-range ballistic missile threat data to the Command and Control, Battle Management, and Communications (C2BMC) system for dissemination to Combatant Commanders' headquarters to ensure situational awareness

Major Contractors

- Aegis BMD Weapon System: Lockheed Martin Corporation, Mission Systems and Training – Moorestown, New Jersey
- AN/SPY-1 Radar: Lockheed Martin Corporation, Mission Systems and Training – Moorestown, New Jersey
- SM-3 and SM-6 Missile: Raytheon Company, Missile Systems – Tucson, Arizona

---

Activity

- From November 2014 through October 2015, the MDA conducted combined DT/OT and operational flight testing of the Aegis Baseline 9 system in its Aegis Ashore and Afloat configurations with SM-3 Block IB guided missiles, and conducted FOT&E of the Aegis BMD 4.0 system. Additionally, in June 2015, the MDA conducted early developmental flight testing of the SM-3 Block IIA guided missile.
- Although the program completed FOT&E for the Aegis BMD 3.6.1 system in FY11, the program continued to use a variant of the Aegis BMD 3.6 system (i.e., 3.6.3) in system-level tests and a fleet exercise in 1QFY16 to assess system-level engagement capability and interoperability with the BMDS and foreign missile defense assets.
- The Aegis BMD program planned to conduct nine flight tests in FY15, but only completed eight. The program also conducted two intercept missions in 1QFY16. Aegis BMD successfully engaged four ballistic missile targets and five anti-air warfare targets.
  - In November 2014, the MDA conducted Flight Test Standard Missile-25 (FTM-25), an Integrated Air and Missile Defense mission where an Aegis BMD 5.0 with Capability Upgrade destroyer, operating in Integrated Air and Missile Defense priority mode, detected, tracked, and performed an SM-3 Block IB intercept of a separating short-range ballistic missile, while simultaneously conducting an anti-air warfare raid engagement against a raid of two subsonic cruise missile surrogates.
  - The BMDS Operational Test Agency and the MDA attempted Flight Test Operational-02 (FTO-02) Event 1 in June 2015, at the Pacific Missile Range Facility on Kauai, Hawaii. The BMDS Operational Test Agency and MDA intended to demonstrate the operational capability of the regional/theater EPAA Phase 2 BMDS, anchored by the Aegis Ashore combat system, to defend Europe against medium-range ballistic missiles. The test was intended to be the first target intercept by the Aegis Ashore combat system and the first flight test of the SM-3 Block IB Threat Update guided missile. Due to a target malfunction, the test was not completed and the SM-3 guided missile was not launched. This test is scheduled to be attempted again in December 2015.
  - In a four-event Multi-Mission Warfare (MMW) test campaign in July 2015, an Aegis BMD 5.0 with Capability Upgrade destroyer detected, tracked, and engaged cruise missile and short-range ballistic missile targets. In MMW Event 1, the ship intercepted a short-range ballistic missile in the endo-atmosphere with an SM-6 Dual I missile. This was the first intercept of a ballistic missile using an SM-6 Dual I using the Baseline 9 sea-based terminal capability. In MMW Event 2, the ship intercepted a short-range ballistic missile target with an SM-2 Block IV missile, demonstrating retention of Aegis BMD 3.6.1 near-term sea-based terminal capability. Events 3 and 4 of the MMW campaign included SM-6 Dual I missile engagements of anti-ship cruise missile surrogates to demonstrate retention of air defense capability with the SM-6 Dual I missile.
  - At-Sea Demonstration-15 in October 2015 was a multi-event fleet exercise wherein assets from North Atlantic Treaty Organization member countries explored the exchange of air and ballistic missile message information across operational communication architectures during cruise missile and ballistic missile engagements. One of the nine events in the exercise included an engagement of a short-range non-separating ballistic missile by an Aegis BMD 3.6.3 destroyer with an SM-3 Block IA guided missile. In the live fire engagement, the ship detected, tracked, and intercepted the ballistic missile target. Participating assets also included an Aegis BMD 3.6.3 laboratory representation, an Aegis 5.3.10 air defense ship, C2BMC, and allied naval vessels from Great Britain, Spain, Netherlands, Italy, Canada, France, and Norway.
  - The BMDS Operational Test Agency and the MDA conducted FTO-02 Event 2 and Event 2a in September and October 2015 at Wake Island and the broad-ocean area surrounding it. The MDA designed the test mission to demonstrate a layered BMDS with multiple combat

systems sharing common defended areas and shot opportunities against two threat-representative ballistic missiles. The primary test objective was to assess Aegis BMD system capability to prosecute a ballistic missile threat engagement in the presence of non-organic post-intercept debris, while simultaneously conducting anti-air warfare against an air-breathing target. The Terminal High-Altitude Area Defense (THAAD) combat system generated the non-organic post-intercept debris scene for Aegis BMD.

- Aegis BMD participated in other live-target or live-interceptor test events in FY15.
  - In Flight Test Other-20 (FTX-20) in October 2014, the MDA used an Aegis BMD 5.0 with Capability Upgrade destroyer to conduct a simulated SM-3 Block IB engagement of a separating medium-range ballistic missile. Although no live or simulated missiles were fired at the target, the system did exercise several fire control, discrimination, and engagement functions.
  - In FTX-19 in February 2015, two Aegis BMD 4.0.2 destroyers detected, tracked, and conducted simulated SM-3 Block IB engagements against three short-range separating ballistic missile targets in a raid scenario. This was the first simulated engagement of a raid of three separating targets with the Aegis BMD 4.0 system and the first live-target mission involving Aegis BMD DWES, which provides automated engagement coordination between multiple firing ships. Additionally, an Aegis BMD 5.0 with Capability Upgrade destroyer participated in the test to explore the capability of that system to perform air and ballistic missile defense against a raid of ballistic missiles and a simulated raid of supersonic sea-skimming anti-ship cruise missiles using simulated guided missiles while operating in Integrated Air and Missile Defense priority mode with remote engagement authorized.
  - In June 2015, the SM-3 Block IIA Cooperative Development Control Test Vehicle-01 (SCD CTV-01) flight test demonstrated SM-3 Block IIA flight through nosecone deployment and TSRM flight. This was the first live fire event for the SM-3 Block IIA guided missile, which is a joint U.S.-Japanese development of a 21-inch diameter variant of the SM-3. This test was the third in a series of six test events to validate missile and canister designs for the Block IIA guided missile.
- In FY15, operational Aegis BMD assets and HWIL facilities underwent cybersecurity and reliability, maintainability, and availability testing, and participated in several flight and ground tests to assess Aegis Ashore and Afloat, BMD 4.0, and/or BMD 3.6.3 capabilities and interoperability with the BMDS.
  - In January 2015, Ground Test Distributed-04e (GTD-04e) Part 2, the MDA tested the engagement and sensor capabilities of fielded and to-be-fielded missile defense elements and sensors against ballistic missiles of all ranges in a distributed environment. Participants included Aegis BMD 4.0.2 and 3.6.3 (laboratory site with sailors from the USS *Lake Erie*, USS *Decatur*, and USS *Hopper* on console), C2BMC, Patriot, THAAD, Space-Based Infrared System (SBIRS), AN/TPY-2 (Forward-Based Mode (FBM)), Ground-Based Midcourse Defense (GMD), and Upgraded Early Warning Radars.
  - During Ground Test Integrated-06 (GTI-06) Part 1 in April and May 2015, the MDA tested the engagement and sensor capabilities of fielded and to-be-fielded missile defense elements and sensors against ballistic missiles of all ranges in an HWIL environment. A key focus of the test was the demonstration of the new Aegis Ashore and Afloat capabilities within a realistic BMDS architecture, including engagement coordination with and without the Aegis DWES capability. Participants included HWIL representations of Aegis Ashore and Afloat assets, Aegis BMD 4.0.2 and 3.6.3 (laboratory site with sailors from the Aegis Ashore Missile Defense Facility in Romania, USS *Arleigh Burke*, and USS *Lake Erie* on console), C2BMC, Patriot, THAAD, SBIRS, and AN/TPY-2 (FBM).
  - In GTI-06 Part 3 in July 2015, the MDA utilized a test architecture with HWIL representations to evaluate interoperability between Aegis BMD variants and GMD, and interoperability between GMD and other strategic assets. Assets included Aegis BMD 4.0.3, Aegis Afloat, C2BMC, SBIRS, AN/TPY-2 (FBM), and the Sea-Based X-band Radar that was represented but not operational.
  - The Commander, Operational Test and Evaluation Force conducted a cybersecurity Cooperative Vulnerability and Penetration Assessment of Aegis Ashore in August 2015 at the Aegis Ashore Missile Defense Facility in Romania. The MDA also planned to conduct an Adversarial Assessment following the Cooperative Vulnerability and Penetration Assessment; however, the MDA postponed this testing due to incomplete construction and system integration at the Aegis Ashore Site.
  - The Aegis Ashore Missile Defense Test Complex at Pacific Missile Range Facility underwent a maintenance demonstration in September 2015.
  - In GTD-06 Part 1 in October 2015 utilized a distributed test environment to demonstrate Aegis Ashore in Romania, Aegis Afloat, and AN/TPY-2 (FBM) capabilities within a realistic BMDS architecture. Other BMDS assets supporting the test included C2BMC, SBIRS, Upgraded Early Warning Radar, Patriot, THAAD, and laboratory representations of Aegis BMD 4.0.3 and Aegis BMD 3.6.3.

Assessment

- In FY15 and 1QFY16, the Aegis Afloat system underwent DT/OT and operational flight testing of that system's exo-atmospheric engagement capabilities (during FTX-20, FTM-25, and FTO-02 Event 2a) and its endo-atmospheric engagement capabilities with SM-6 Dual I and SM-2 Block IV missiles (during MMW Events 1 and 2). Testing demonstrated engagement capabilities against short-range ballistic missiles in both exo- and endo-atmospheric engagements. Additional flight testing and high-fidelity modeling and simulation

analyses are needed to quantitatively evaluate the effectiveness of the Baseline 9 system at engaging ballistic missiles in the exo- and endo-atmospheric phases of flight for a range of scenarios.

- FTM-25 demonstrated the use of Integrated Air and Missile Defense radar priority mode in a live engagement during which cruise missile and ballistic missile targets were simultaneously engaged, although only for a less-than-fully stressing case, with a single ballistic missile and a raid of two subsonic cruise missile targets.
- Three of the MMW events (Events 1, 3, and 4) demonstrated that SM-6 Dual I missiles can be used to conduct sea-based terminal engagements against short-range non-separating ballistic missiles, and that they retain the air defense capabilities that were demonstrated during SM-6 IOT&E and FOT&E flight testing.
- The MDA intended FTO-02 Event 2 and Event 2a to demonstrate the Aegis Afloat capability to prosecute a ballistic missile threat engagement as part of a layered BMDS in the presence of non-organic post intercept debris, while simultaneously conducting an anti-air warfare engagement in Integrated Air and Missile Defense priority mode. However, shortly following launch, the SM-3 Block IB Threat Update guided missile targeting the medium-range ballistic missile target failed. Prior to this, a THAAD interceptor intercepted the short-range ballistic missile target, generating debris that may enable accurate modeling and simulation of Aegis BMD combat system capability in the presence of post intercept debris. At the same time Aegis BMD was attempting to engage the ballistic missile target with the SM-3 missile, it succeeded in engaging an air-breathing target with two SM-2 Block IIIA guided missiles. An engineering Failure Review Board investigation is underway to determine the root cause of the SM-3 guided missile failure. A full assessment of the FTO-02 Event 2 and Event 2a test mission data with respect to Aegis BMD and BMDS operational effectiveness, operational suitability, and interoperability is ongoing.
- The Aegis BMD 4.0 system, which is the latest deployed version of Aegis BMD and is the primary sea-based firing asset for EPAA Phase 2, conducted follow-on testing in FY15 to supplement the IOT&E flight testing and modeling and simulation conducted in FY13 and FY14. The most significant capability demonstrated was the BMD 4.0 system's DWES, an automated engagement coordination capability, during the FTX-19 mission. In that mission, two Aegis BMD 4.0 ships demonstrated that the DWES capability can determine the preferred shooter for a given ballistic missile engagement when two Aegis BMD firing assets are present, thereby reducing missile wastage while ensuring BMD threat coverage.
- Prior IOT&E flight testing and supporting modeling and simulation demonstrated that Aegis BMD 4.0 has the capability to engage and intercept non-separating, simple-separating, and complex-separating ballistic missiles in the midcourse phase with SM-3 Block IB guided missiles. However, flight testing and modeling and simulation are not yet sufficient to assess the full range of expected threat types, threat ground ranges, and threat raid sizes. Details on the BMD 4.0 system's performance can be found in the classified December 2014 Aegis BMD 4.0 IOT&E report.
- Reliability, maintainability, and availability data collected during Baseline 9 BMD-related testing in early to mid FY15 shows that the Baseline 9 system does not currently meet its requirements for availability and the mean time to repair hardware, mostly due to a series of early Aegis Display System failures and an AN/SPY-1 radar coolant leak that downed the system for an extended period of time. The majority of the Aegis Display System problems have been resolved by the installation of new graphics cards for each console. Additional data collected during late FY15 to early FY16 are under review by data scoring boards. It is uncertain at present if additional data collection periods are needed to prove that the system's suitability is sufficient for operational use.
- The limited number of SM-3 Block IB firings (10 as of FTO-02 Event 2a) and the 2 TSRM failures (during FTM-16 Event 2 in FY11 and FTM-21 in FY13) lower certainty in overall SM-3 Block IB missile reliability in its currently fielded configuration. The program addressed and tested a correction for the first of the SM-3 TSRM failures when it modified the TSRM's inter-pulse delay time between axial thrust burns. This correction, which the MDA implemented following the FTM-16 Event 2 failure, did not prevent the TSRM failure in the second of two salvo-launched SM-3 Block IB guided missiles in FTM-21. The MDA established a Failure Review Board (FRB) to determine the root cause of this failure and the FRB uncovered enough evidence to determine that a redesign was needed for the TSRM aft nozzle. Ground testing of the new design began in FY14. Flight testing of the new design is expected in February 2016. The new nozzle design can be retrofitted into current SM-3 Block IA and Block IB missiles.
- The FTM-25 flight test and recent lot acceptance testing have shown that the TSRM Attitude Control System CGR, which the MDA re-designed following FTM-15, can produce anomalous low regulated pressure levels. In five flight tests following FTM-15, the TSRM showed no anomalous behavior. The CGR anomaly in FTM-25 did not preclude a successful intercept; however, the cold gas pressure observed was much lower than that commanded. If the regulated pressure from the CGR is too low, the Attitude Control System may not function properly. Analysis suggests that now defunct tooling procedures caused the FTM-25 CGR anomaly. The manufacturer built the CGR flown in FTM-25 using old tooling procedures (it was the second CGR built following the re-design after FTM-15). The MDA established an industry-led FRB to determine the root cause of the low pressure outputs from the CGRs, and its investigation is ongoing. The CGR anomaly is not related to the TSRM inter-pulse delay problem or the aft nozzle deficiency previously discussed.
- Flight testing, modeling and simulation, and ground testing have demonstrated the Aegis BMD 4.0 capability to perform

the LRS&T mission. The Flight Test Ground-Based Interceptor-07 (FTG-07) mission in FY13 highlighted the need to further explore and refine tactics, techniques, and procedures (TTPs) for the transmission and receipt of Aegis BMD track data for GMD use. The MDA demonstrated in GTI-06 Part 3 the Aegis BMD 4.0 software's ability to provide track data that GMD can use. The MDA will test Aegis Afloat systems in a future ground test.

- All components of the SM-3 Block IIA guided missile flight tested thus far during developmental testing have performed as designed. SCD CTV-01 in FY15 showed good missile performance from egress from the Vertical Launching System, to Stage 1 burn, to Stage 1/2 separation, to Second Stage Rocket Motor burn, to Stage 2/3 separation, to nosecone jettison, and to TSRM burn.
- At-Sea Demonstration-15 demonstrated that Aegis BMD can interoperate with North Atlantic Treaty Organization defenses, and exchange air and ballistic missile message information across operational communication architectures during cruise missile and ballistic missile engagements. In the live fire test, the Aegis BMD 3.6.3 ship detected, tracked, and intercepted a short-range non-separating ballistic missile target using an SM-3 Block IA guided missile.
- Cybersecurity testing results will be included in the classified 2015 BMDS Annual Report.
- The MDA continues to utilize Aegis BMD assets and HWIL representations in ground test events, which has helped to refine TTPs and overall interoperability of the system with the BMDS. However, the test events routinely demonstrated that inter-element coordination and interoperability are still in need of improvement.

Recommendations

- Status of Previous Recommendations. The program:
  1. Partially addressed the first recommendation from FY13 to conduct flight testing of the Aegis BMD 4.0 remote engagement authorized capability against a medium- or intermediate-range ballistic missile target using an SM-3 Block IB guided missile, when it conducted FTO-02 Event 2a. This assumes that DOT&E can use modeling and simulation results to determine if the Aegis combat system successfully supported the engagement. Although the MDA conducted FTO-02 Event 2a with an Aegis BMD 5.0 with Capability Upgrade destroyer, rather than a BMD 4.0 ship, the Aegis BMD 4.0 and Aegis Afloat remote engagement capabilities are similar. Due to the SM-3 guided missile failure during FTO-02 Event 2a, the MDA should plan to conduct an end-to-end remote engagement authorized flight test using track data from a forward-based sensor.
  2. Partially addressed the second recommendation from FY13 to conduct operationally realistic testing that exercises Aegis BMD 4.0's improved engagement coordination with THAAD and Patriot when it conducted FTO-02 Event 2a using Aegis Afloat and THAAD firing assets. The flight test did not include a Patriot firing asset, so engagement coordination with Patriot has not been flight tested to date.
  3. Addressed the fourth recommendation from FY13 to use the FRB process to identify the failure mechanism responsible for the FTM-21 second missile failure and determine the underlying root cause that may be common to both the FTM-16 Event 2 and FTM-21 second missile failures by completing the FRB process for the TSRM failures encountered to date. The MDA plans to flight-test the redesigned aft nozzle area of the TSRM in February 2016.
  4. Addressed the fifth recommendation from FY13 to deliver sufficient Aegis BMD 4.0 validation data and evidence to support BMDS modeling and simulation verification, validation, and accreditation (VV&A) of the Aegis HWIL and digital models. The program did so when the Commander, Operational Test and Evaluation Force provided VV&A evidence for the digital models used for element-level performance analyses in support of the operational assessment of the Aegis BMD 4.0 system with SM-3 Block IB guided missiles.
  5. Addressed the first recommendation from FY14 to conduct flight tests or high-fidelity modeling and simulation analyses to demonstrate the Aegis BMD 4.0 system's capability to perform LRS&T of a raid of long-range threats. The Aegis BMD 4.0.3 update improves the LRS&T of long-range threats and the MDA tested this capability in GTI-06 Part 3 for various raid sizes.
  6. Has partially addressed the second recommendation from FY14 to determine the appropriate LRS&T TTPs for the transmission and receipt of Aegis BMD 4.0 track data for GMD use. The MDA added GTI-06 Part 3 to the Integrated Master Test Plan to demonstrate that GMD can use data provided by Aegis BMD 4.0.3, which has improved LRS&T capability, when the data are transmitted as per design.
  7. Has partially addressed the third recommendation from FY14 to ensure that sufficient flight testing of the Aegis Afloat system is conducted to allow for VV&A of the modeling and simulation suite to cover the full design to Aegis BMD battlespace of threat ballistic missiles. Flight testing in FY15 and early FY16 provided additional VV&A data, but the BMDS Operational Test Agency has not accredited the high fidelity modeling and simulation suite for performance across the entire design battlespace.
  8. Has partially addressed the fourth recommendation from FY14 to conduct sufficient ground and flight testing of the redesign of insulation components in the nozzle of the SM-3 Block IB TSRM after completion and installation of the new design concept to prove the new design works under the most stressing operational flight conditions, when it began ground testing the new TSRM nozzle design. Flight testing is planned in February 2016.
- FY15 Recommendations. The program should:
  1. Use the industry-led FRB process to identify the root cause of the low cold gas pressure anomalies from recent lot acceptance testing of the SM-3 Block IB CGR, and determine the appropriate corrective actions needed to ensure proper functioning of that SM-3 component.

2. Conduct stressing simultaneous air and ballistic missile defense engagements with the Aegis Afloat system operating in Integrated Air and Missile Defense radar priority mode, with multiple ballistic missiles and anti-ship cruise missile threats being simultaneously engaged.
3. Perform high-fidelity modeling and simulation analysis over the expected Aegis Ashore engagement battlespace for EPAA Phase 2 to allow for a broad quantitative evaluation of engagement capability.

Command and Control, Battle Management, and Communications (C2BMC) System

Executive Summary

- The Missile Defense Agency (MDA) continued to mature the Command and Control, Battle Management, and Communications (C2BMC) system with the implementation of Spiral 6.4-2.2.0 (S6.4-2.2.0) software during FY15. The MDA demonstrated C2BMC battle management functions during ground and flight tests in FY15 including threat assessment, threat evaluation, sensor resource management, sensor track data processing, track reporting, target selection, sensor/weapon access determination, and engagement monitoring. The C2BMC engagement planner provided non-real-time performance analysis of the composition and location of U.S. and allied ballistic missile defense (BMD) assets, but does not currently provide a system-level capability to coordinate engagement decisions.
- C2BMC exercised additional sensor management, track processing, and track reporting functionality during real-world targets of opportunity, providing valuable insight into C2BMC operations with multiple sensors, networks, coalition partners, and weapon systems outside the scope of flight tests.
- C2BMC continued to demonstrate the capability for Combatant Command (CCMD) sensor managers to direct AN/TPY-2 Forward-Based Mode (FBM) radars to execute focused search plans and respond to precision cues and reporting of system track data during ground and flight tests. Ground testing demonstrated automated management of multiple AN/TPY-2 FBM sensors. Ground testing further demonstrated the successful tasking/managing of the Kyoga-Misaki AN/TPY-2 (FBM) sensor and boost phase cueing between multiple AN/TPY-2 (FBM) sensors.
- The MDA and Red Teams from the Threat Systems Management Office conducted cyber exercises of future spirals of the Ballistic Missile Defense System (BMDS) elements including C2BMC using the DOD Enterprise Cyber Range Environment (ECRE). The MDA continues to evaluate the results of this event to identify solutions to reduce the likelihood or mitigate the effects of a cyber intrusion. The MDA teamed with U.S. Cyber Command's (USCYBERCOM's) BMDS national Cyber Protection Team (CPT) to conduct specialized testing at C2BMC suites in U.S. Central Command (USCENTCOM) and U.S. European Command (USEUCOM).

System

- The C2BMC system is a CCMD interface to the BMDS. More than 70 C2BMC workstations are fielded at U.S. Strategic Command (USSTRATCOM), U.S. Northern Command (USNORTHCOM), USEUCOM, U.S. Pacific Command (USPACOM), and USCENTOM; numerous Army Air and Missile Defense Commands; Air and Space Operations Centers; and other supporting warfighter organizations.
  - The current C2BMC provides CCMDs and other senior national leaders with situational awareness of BMDS status, system coverage, and ballistic missile tracks by displaying selective BMDS data for strategic/national missile defense and for theater/regional missile defense, utilizing multiple message formats and diverse terrestrial and satellite communications paths.
  - The C2BMC also provides upper echelon planning at the CCMD and component level. BMDS elements (Aegis BMD, Ground-based Midcourse Defense [GMD], Patriot, and Terminal High-Altitude Area Defense [THAAD]) use their own command and control battle management systems and mission-planning tools for stand-alone engagements.
  - The C2BMC S6.4 suite provides command and control for the AN/TPY-2 (FBM) radar as well as track reporting to support weapon system cueing and engagement operations.
- Using the BMDS Communications Network, the C2BMC forwards AN/TPY-2 (FBM) and AN/SPY-1 tracks to GMD. C2BMC uses the Tactical Digital Information Link-Joint message formats to send system track data for THAAD, Patriot, and coalition system cueing and for Aegis BMD engagement support.
- The C2BMC S8.2 (projected for FY17/FY18) is intended to mature and expand S6.4 capabilities as the next major step toward integrated, automated sensor management and engagement coordination.

Mission

USSTRATCOM, USNORTHCOM, USEUCOM, USPACOM, and USCENTCOM use C2BMC to support ballistic missile defense engagements. CCMDs use C2BMC for:

- Deliberate and dynamic planning
- Situational awareness
- Track management
- AN/TPY-2 (FBM) sensor management and control
- Engagement monitoring
- Data exchange between C2BMC and BMDS elements
- Network management

Major Contractor

Lockheed Martin Corporation, Information Systems and Global Solutions – Gaithersburg, Maryland

---

Activity

- The MDA conducted C2BMC system and sensors testing during FY15 in accordance with the DOT&E-approved Integrated Master Test Plan.
- During 1QFY15, the MDA and Red Teams from the Threat Systems Management Office conducted cyber exercises of future spirals of the BMDS elements, including C2BMC, using the DOD ECRE. The MDA continues to evaluate the results of this event to identify solutions and/or procedures to reduce the likelihood of occurrence or mitigate the effect of a cyber intrusion. The MDA teamed with USCYBERCOM's BMDS CPT to conduct specialized testing at C2BMC suites in USCENTCOM and USEUCOM.
- In January 2015, the MDA conducted Ground Test Distributed-04e (GTD-04e) Part 2, an operational assessment of new USPACOM and USNORTHCOM C2BMC and AN/TPY-2 (FBM) radar functionality. The C2BMC managed two AN/TPY-2 (FBM) radars using operational communications. The radars detected and tracked simulated intermediate-range ballistic missile and intercontinental ballistic missile threats to support regional and strategic defense. The C2BMC also tasked the Kyoga-Misaki AN/TPY-2 (FBM) radar, managed boost phase cueing between the two AN/TPY-2 (FBM) radars, and exercised updates to the focused search plans and threat enumerations.
- In May 2015, the MDA exercised C2BMC in the Ground Test Integrated-06 (GTI-06) Part 1 test, a hardware-in-the-loop event to provide data on mutual sensor support between multiple AN/TPY 2 (FBM) radars equipped with updated search plan configurations and debris mitigation capabilities (radar software CX-2.1.0). C2BMC software version S6.4-2.2.0 managed multiple AN/TPY-2 (FBM) radar representations in a cross-area of responsibility (AOR) data sharing environment between USEUCOM and USCENTCOM. The AN/TPY-2 (FBM) radar representations detected and tracked simulated medium-range ballistic missile threats and forwarded the track data to the C2BMC.
- The BMDS Operational Test Agency and the MDA attempted Flight Test, Operational-02 (FTO-02) Event 1 in June 2015 at the Pacific Missile Range Facility on Kauai, Hawaii. The MDA intended to demonstrate the operational capability of the regional/theater European Phased, Adaptive Approach Phase 2 BMDS, anchored by the Aegis Ashore Missile Defense System (AAMDS), to defend Europe against medium-range ballistic missiles. The test was to be the first target intercept by the AAMDS and the first flight for the Standard Missile (SM)-3 Block IB with threat update guided missile. C2BMC software version S6.4-2.2.0 was to have managed an AN/TPY-2 (FBM) radar (software version CX-2.1.0) during the event. Due to a target malfunction, the test was not completed and the SM-3 guided missile was not launched. The MDA plans to attempt this test again in December 2015.
- In July 2015, C2BMC software version S6.4-2.2.0 participated in GTI-06 Part 3, a test designed to assess BMDS performance and interoperability across the USNORTHCOM mission space. C2BMC managed one AN/TPY-2 (FBM) radar (software version CX-1.2.3) and demonstrated track data forwarding to GMD Fire Control and cueing of Aegis BMD using AN/TPY-2 (FBM) track data.
- The BMDS Operational Test Agency and the MDA conducted FTO-02 Event 2 and Event 2a in September and October 2015 at Wake Island and the broad-ocean area surrounding it. The MDA designed the test mission to demonstrate a layered BMDS with multiple combat systems sharing common defended areas and shot opportunities against two threat-representative ballistic missiles. The primary test objective was to assess Aegis BMD system capability to prosecute a ballistic missile threat engagement in the presence of non-organic post-intercept debris, while simultaneously conducting Anti-Air Warfare. The THAAD combat system, using Lot 4 interceptors for the first time, generated the non-organic post-intercept debris scene for Aegis BMD. C2BMC software version S6.4-2.2.0 managed one AN/TPY-2 (FBM) radar, track reporting of sensor data to Link 16, and forwarded track data between Aegis BMD and THAAD systems.
- At-Sea-Demonstration-15 (ASD-15) was a multinational interoperability demonstration of coalition Integrated Air and Missile Defense. The event used new NATO data-sharing gateways in a live fire event. C2BMC software version S6.4-2.2.0 participated as a data-sharing component between U.S. Aegis BMD and three NATO partners.
- The BMDS OTA and the MDA conducted GTD-06 Part 1 in October 2015. The test assessed the BMDS European Phase, Adaptive Approach Phase 2 architecture against short-range and medium-range ballistic missile engagements in USEUCOM and USCENTCOM. C2BMC software version

S6.4-2.2.0 managed multiple AN/TPY-2 (FBM) radars and exercised cross-AOR data sharing.
- Throughout FY15, the MDA exercised C2BMC sensor management, track processing, and track reporting during real-world targets of opportunity. The system demonstrated dual radar management and track processing/reporting utilizing operational C2BMC suites and communications. These events also demonstrated USEUCOM-USCENTCOM cross-AOR data flows, and track correlation and reporting for AN/TPY-2 (FBM) and other elements (e.g., Aegis BMD, Arrow, and Patriot).

Assessment
- The C2BMC software version S6.4 Global Engagement Manager (GEM) suite provided automated management of multiple AN/TPY-2 (FBM) radars in a single AOR and enhanced track processing and reporting while requiring less operator involvement as compared to the S6.2 software and the S6.4 Combatant Command (COCOM) suite.
- C2BMC demonstrated dual AN/TPY-2 (FBM) sensor management in the USPACOM AOR and USEUCOM AOR during ground tests in FY15. Dual radars were not available for assessment during flight tests; however, C2BMC did exercise dual radar management, precision cueing, and system track formation during real-world targets of opportunity in both the USPACOM and USEUCOM AORs.
- During GTD-04e Part 2, C2BMC demonstrated boost phase cueing capabilities and focused search plan tasking while managing two AN/TPY-2 (FBM) radars in USPACOM, and demonstrated the AN/TPY-2 (FBM) radar's ability to support GMD engagement of intermediate-range ballistic missile and intercontinental ballistic missile threats. The radars provided data on the simulated missile threats to the C2BMC system that supported BMDS situational awareness, BMDS sensor tasking, and GMD engagement planning. C2BMC experienced limitations in its ability to task focused search plans during the test. The MDA is addressing the focused search plan limitations and will demonstrate the fixes in GTI-06 Part 2 in FY16.
- The MDA tested new data exchange conditions between USEUCOM and USCENTCOM during GTI-06 Part 1 and assessed data on new cooperative search fences. C2BMC generally performed nominally, receiving AN/TPY-2 (FBM) and Link 16 data and forwarding system tracks on Link 16. In addition, real-world events demonstrated NATO and Israel data flows, interoperability, and track correlation with C2BMC that could not be assessed in the ground test.
- The MDA demonstrated C2BMC software version S6.4-2.2.0 battle management functions during ground and flight tests in FY15 including threat assessment, threat evaluation, sensor resource management, sensor track data processing, track reporting, target selection, sensor/weapon access determination, and engagement monitoring. The C2BMC engagement planner provided non-real-time performance analysis of the composition and location of U.S. and allied BMD assets but does not currently provide a system-level capability to coordinate engagement decisions. CCMD sensor managers can use C2BMC to manually task a single AN/TPY-2 (FBM) radar to execute focused search plans, respond to a precision cue, or automate radar tasking of up to two radars.
- During test execution preparation for FTO-02 E1, a networking problem was discovered with the AN/TPY-2 (FBM) radar software version CX 2.1.0 that forced the Soldiers to use non-operational radar management tactics, techniques, and procedures. The problem was fixed and demonstrated in GTD-06 Part 1.
- The majority of FY15 testing used the C2BMC GEM suite. In the event of a GEM suite failure, C2BMC has an option to use the COCOM suite for management of a single AN/TPY-2 (FBM). This option was tested during FTO-02 E1a hardware-in-the-loop and GTI-06 Part 1 testing and demonstrated nominal performance.

Recommendations
- Status of Previous Recommendations. The MDA has addressed 12 of 13 previous recommendations for the C2BMC program and should continue to include cybersecurity assessments in BMDS-level testing. The MDA made progress on a C2BMC cyber testing strategy by performing basic testing and system scans during GTI-06 Part 1, investigating and demonstrating cyber testing techniques during multiple ECRE events, and teaming with USCYBERCOM's BMDS CPT to conduct specialized testing at C2BMC suites in USCENTCOM and USEUCOM.
- FY15 Recommendation.
  1. As the Warfighter BMDS concept of operations continues to evolve, the MDA should periodically assess the COCOM suite for its ability to provide adequate quality of service in cases of GEM suite failure.

Ground-Based Midcourse Defense (GMD)

Executive Summary

- Previous assessments that the Ground-based Midcourse Defense (GMD) system demonstrates a limited capability to defend the U.S. Homeland from small numbers of intermediate-range or intercontinental ballistic missile threats launched from North Korea or Iran remain unchanged.
- The Missile Defense Agency (MDA) did not conduct GMD flight testing in FY15. The GMD system did, however, participate in two BMDS hardware-in-the-loop ground tests where new mission functionality of the GMD Fire Control (GFC) software and interoperability between the GMD and Aegis Ballistic Missile Defense (BMD) combat systems was demonstrated.
- The Sea-Based X-band (SBX) radar acquired and tracked Minuteman III ballistic missiles during three Glory Trip (GT) missions.
- The MDA coordinated and received approval of the Re-designed Kill Vehicle Acquisition Plan and emplaced eight new Capability Enhancement-II (CE-II) Ground-Based Interceptors (GBIs) in the Flight Test, GBI-06b (FTG-06b) configuration.
- The U.S. Air Force became the lead Service for the Long-Range Discrimination Radar under development and selected Clear Air Force Station (AFS), Alaska, as its future location.

System

GMD is a BMDS combat system that counters intermediate-range and intercontinental ballistic missile threats to the U.S. Homeland. The GMD consists of:

- GBIs at Fort Greely, Alaska, and Vandenberg AFB, California
- GMD ground system including GFC nodes at Schriever AFB, Colorado, and Fort Greely, Alaska; Command Launch Equipment at Vandenberg AFB, California, and Fort Greely, Alaska; and In-Flight Interceptor Communication System Data Terminals at Vandenberg AFB, California; Fort Greely, Alaska; and Eareckson Air Station, Alaska
- GMD secure data and voice communications system including long-haul communications using the Defense Satellite Communication System, commercial satellite communications, and fiber-optic cable (both terrestrial and submarine)
- COBRA DANE Upgraded Radar at Eareckson Air Station (Shemya Island), Alaska. COBRA DANE is a fixed site, fixed orientation, phased array L-band radar with one radar face that provides 120-degree azimuth field of view
- Upgraded Early Warning Radars (UEWRs) at Beale AFB, California; Royal Air Force Fylingdales, United Kingdom; and Thule Air Base, Greenland. These sensors are fixed site, fixed orientation, phased array ultra-high frequency radars.

GMD

COBRA DANE

UEWRs

SBX

The radars at Beale AFB and Thule Air Base have two radar faces that provide 240-degree azimuth field of view; the Flyingdales radar has three radar faces that provide a full 360-degree field of view. In 2012, the MDA and Air Force Space Command awarded a contract and exercised an option to upgrade the EWRs at Clear AFS, Alaska, and Cape Cod AFS, Massachusetts, respectively.

- SBX radar, a mobile phased array sensor operated by the MDA and located aboard a twin-hulled, semi-submersible, self-propelled, ocean-going platform
- External interfaces that connect to Aegis BMD; North American Aerospace Defense/U.S. Northern Command Command Center; Command and Control, Battle Management, and Communications system at Peterson AFB, Colorado; Space-Based Infrared System/Defense Support Program at Buckley AFB, Colorado; and AN/TPY 2 (Forward-Based Mode (FBM)) radars at Japan Air Self-Defense Force bases in Shariki and Kyoga-misaki, Japan

Mission

Military operators from the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (the Army service component to U.S. Strategic Command) will use the GMD system to defend the U.S. Homeland against intermediate-range and intercontinental ballistic missile attacks using the GBI to defeat threat missiles during the midcourse segment of flight.

Major Contractors
- GMD Prime: The Boeing Company, Network and Space Systems – Huntsville, Alabama
- Boost Vehicle: Orbital Sciences Corporation, Missile Defense Systems – Chandler, Arizona
- Exo-atmospheric Kill Vehicle: Raytheon Company, Missile Systems – Tucson, Arizona
- Fire Control and Communications: Northrop Grumman Corporation, Information Systems – Huntsville, Alabama
- COBRA DANE, UEWRs, and SBX: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts

---

Activity
- The MDA conducted all testing in accordance with the DOT&E- approved Integrated Master Test Plan.
- The MDA did not conduct GMD interceptor flight testing in FY15. The MDA prepared to conduct a non-intercept Ground-based Midcourse Controlled Test Vehicle Flight (GM CTV-02+) currently scheduled for January 2016. This test will verify the effectiveness of the GBI's new Alternate Divert Thruster and collect data for use in developing Mid-Term Discrimination Improvements for Homeland Defense.
- The GMD system participated in two BMDS hardware-in-the-loop ground tests.
  - The MDA conducted Ground Test Distributed-04e (GTD-04e) Part 2 and Ground Test Integrated-06 (GTI-06) Part 3 in January and July 2015, respectively.
  - The MDA used hardware and software representations of the GMD system, the Space-Based Infrared System/ Defense Support Program, UEWRs, C2BMC, AN/TPY-2 (FBM) radar, Aegis BMD AN/SPY-1 radar in its long-range surveillance and track mode, and the SBX radar to investigate U.S. Northern Command strategic scenarios by stimulating the BMDS with intelligence-based intercontinental ballistic missile threats launched against the U.S. Homeland.
  - The COBRA DANE radar completed software build 2.7.1.1 Operations Trial Period Review Panel containing near-term discrimination improvements in March 2015 to support GTI-06 Part 3 in July 2015.
- The SBX Radar exercised detection and tracking performance in three U.S. Air Force intercontinental ballistic missile GT missions: GT 214 and GT 215 in March 2015, and GT 216 in October 2015.
- The MDA coordinated and received approval of the Re-designed Kill Vehicle Acquisition Plan and emplaced eight new CE-II GBIs in the FTG-06b configuration.
- The U.S. Air Force became the lead Service for the Long-Range Discrimination Radar under development and selected Clear AFS, Alaska, as its future location.

Assessment
- Previous assessments that state the GMD demonstrates a limited capability to defend the U.S. Homeland from small numbers of intermediate-range or intercontinental ballistic missile threats launched from North Korea or Iran remain unchanged.
- In GTD-04e Part 2, the MDA demonstrated interoperability between C2BMC and GFC Build 6B2.2. Further, GFC Build 6B2.2 processed data from the new AN/TPY-2 (FBM) radar in Kyoga-Misaki, Japan.
- In GTI-06 Part 3, the MDA demonstrated interoperability between Aegis BMD 4.0.3, Aegis BL9.C1, Beale UEWR 9.0.4, and GFC 6B2.2 through strategic and theater scenarios and supported the deployment of operational assets within the BMDS architecture for U.S. Pacific Command and U.S. Northern Command.
- In GT 214, GT 215, and GT 216, the SBX radar acquired and tracked the Minuteman III ballistic missile through the boost and midcourse phases of flight.
- The selection of Clear AFS, Alaska, for the future location of the Long-Range Discrimination Radar necessitates examining if additional sensor capability, beyond the AN/TPY-2 (FBM) radars located in Japan, is needed to defend Hawaii.

Recommendations
- Status of Previous Recommendations. The MDA has addressed most of the previous FY14 recommendations. However, the following remain outstanding:
  1. The MDA has not addressed the FY13 recommendation to retest the Capability Enhancement-I exo-atmospheric kill vehicle in order to accomplish the test objectives from the failed FTG-07 mission. The MDA plans to address this recommendation in 4QFY17 during FTG-11.
  2. The MDA has initiated, but not completed, the FY14 recommendation to extend the principles and recommendations contained in the Independent Expert Panel assessment report on the GBI fleet to all Homeland Defense components of the BMDS.
- FY15 Recommendation.
  1. The MDA should determine any additional sensor capability requirements for an effective Defense of Hawaii capability.

Terminal High-Altitude Area Defense (THAAD) and AN/TPY-2 Radar (Forward-Based Mode)

Executive Summary

- The Terminal High-Altitude Area Defense (THAAD) Project Office conducted one operational flight test in October 2015, in accordance with the DOT&E-approved Integrated Master Test Plan, intercepting two ballistic missile targets.
- The Army Test and Evaluation Command (ATEC) conducted a THAAD Reliability Growth Test (RGT) January 2015 through March 2015, which collected 922 hours of reliability data over 9 operational periods. This testing demonstrated some increases in reliability, with the notable exception of the launcher generators. The testing also revealed problems with the radar-to-operator interface.
- During FY15, THAAD participated in several Ballistic Missile Defense System (BMDS)-level ground tests, providing information on THAAD functionality and interoperability in various theater scenarios.
- The THAAD Program Manager continued to address the 18 material release conditions that need to be resolved before the Army will grant a Full Materiel Release for the first two fire units.

System

- THAAD is intended to complement the lower-tier Patriot system and the upper-tier Aegis BMDS; it can engage threat ballistic missiles in both the endo- and exo-atmosphere.
- THAAD consists of five major components:
  - Missiles
  - Launchers
  - AN/TPY-2 Radar (Terminal Mode)
  - THAAD Fire Control and Communications
  - THAAD Peculiar Support Equipment
- THAAD can accept target cues for acquisition from Aegis BMD, other regional sensors, and through command and control systems.
- The AN/TPY-2 (Terminal Mode) radar is used by THAAD. This section also discusses the AN/TPY-2 Forward-Based Mode (FBM) variant of the THAAD radar. Operated by the Army, this mobile/transportable phased array X-band radar provides regional and strategic ballistic missile threat data to the entire BMDS through the Command and Control, Battle Management, and Communications (C2BMC) system. The AN/TPY-2 FBM variant of the THAAD radar is currently deployed in Japan, Israel, Turkey, and the U.S. Central Command area of responsibility.

Mission

- U.S. Strategic Command deploys THAAD to protect critical assets worldwide. U.S. Northern Command, U.S. Pacific Command, U.S. European Command, and U.S. Central Command will use THAAD to intercept short- to intermediate-range ballistic missile threats in their areas of responsibility.
- All Combatant Commanders will use the AN/TPY-2 (FBM) radar to detect, track, classify, and engage ballistic missile threats that target the United States and its allies, and to provide data for situational awareness and battle management through the C2BMC.

Major Contractors

- Prime: Lockheed Martin Corporation, Missiles and Fire Control – Dallas, Texas
- AN/TPY-2 Radar (TM and FBM): Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts

Activity

- The Missile Defense Agency (MDA) conducted all testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- ATEC conducted a THAAD RGT, which collected 922 hours of reliability data over 9 operational periods. This was the first test conducted with the new Configuration 2 hardware and software, which addresses a large number of obsolescence issues. ATEC conducted this testing January 2015 through March 2015 at McGregor Range, New Mexico.
- THAAD provided hardware-in-the-loop representations for two BMDS-level ground tests: Ground Test Distributed-04e (GTD-04e) Part 2 in January 2015, using version 2.2 software and Ground Test Integrated-06 (GTI-06) Part 1 in May 2015, using version 2.2 software. These tests provided information on THAAD functionality and interoperability in various theater scenarios.
- AN/TPY-2 (FBM) participated in several BMDS-level ground tests. Two U.S. Pacific Command AN/TPY-2 (FBM) CX-1.2.3 radars participated in GTD-04e Part 2 in January 2015, HWIL representations of the AN/TPY-2 (FBM) CX-2.1.0 radars were used in the GTI-06 Part 1 in May 2015, and a HWIL representation of an AN/TPY-2 (FBM) CX-1.2.3 radar was used in the GTI-06 Part 3 developmental test. In these tests, C2BMC tasked and managed the Kyoga-Misaki, Japan AN/TPY-2 (FBM) radar, two AN/TPY-2 (FBM) radars exercised boost phase cueing, and C2BMC managed radar data in a cross-area of responsibility data sharing environment.
- The THAAD program also conducted several smaller test events including missile round pallet transportation testing in February 2015, and environmental testing of the radar prime power unit in June 2015.
- AN/TPY-2 (FBM) CX-2.1.0 participated in Flight Test Operational-02 (FTO-02) Event 1 in June 2015 at the Pacific Missile Range Facility in Kauai, Hawaii. The MDA intended to demonstrate the operational capability of the regional/theater European Phased Adaptive Approach Phase 2 BMDS, anchored by the Aegis Ashore combat system, to defend Europe against medium-range ballistic missiles. The radar would have cued Aegis Ashore in a medium-range ballistic missile engagement. Due to a target malfunction, MDA did not complete this test but has rescheduled it for early FY16.
- The MDA conducted BMDS-level FTO-2 Event 2 and Event 2a in September and October 2015 at Wake Island and the broad-ocean area surrounding it. This test used THAAD version 2.7 software and Lot 4 interceptors. THAAD completed near-simultaneous engagements of two targets: a complex short-range ballistic missile target and a medium-range ballistic missile target. The engagement of the medium-range target followed the failure of an Aegis BMD Standard Missile-3 Block IB guided missile to intercept the target. An AN/TPY-2 (FBM) radar also tracked the targets.
- The MDA continues to accumulate contractor-collected reliability data and score the data for the deployed AN/TPY-2 (FBM) radars. The THAAD Program Office and BMDS Operational Test Agency are also preparing for a 90-day reliability assessment period in FY16 to collect and compare reliability across the fleet of deployed AN/TPY-2 (FBM) radars.

Assessment

- FTO-02 Event 2 and Event 2a demonstrated that THAAD, AN/TPY-2 (FBM), and BMDS capabilities against theater/regional threats increased during FY15 and early FY16. THAAD Lot 4 interceptors, for the first time, hit one short-range and one medium-range threat-representative ballistic missile target while Aegis BMD simultaneously engaged an air-breathing threat with Standard Missile-2 (SM-2) Block IIIA guided missiles. An SM-3 Block IB with Threat Upgrade guided missile, which MDA intended to hit the medium-range ballistic missile target, failed early in flight. Full assessment of the FTO-02 Event 2 and Event 2a test mission data with respect to operational effectiveness, operational suitability, and interoperability is ongoing.
- ATEC collected RGT reliability data in a full battery configuration in an operational status and a desert environment with the new THAAD Configuration 2 hardware and software. In general, the system showed signs of reliability growth, although there were a few notable exceptions. There were an inordinate number of failures of the launcher generators. These failures do not necessarily cause system aborts, but the maintenance burden if these problems were to continue would be extremely high. ATEC also found that the radar does not properly alert the operators of the operating state of the radar.
- During GTD-04e Part 2 and GTI-06 Part 1, the BMDS Operational Test Agency reported several findings affecting both THAAD and AN/TPY-2 (FBM) that require further investigation. These findings affect volume of message traffic, radar resources, operator workload, deficient debris mitigation implementation, and deficiencies in cybersecurity scanning.
- The THAAD program continued work on achieving a Full Materiel Release of the first two THAAD batteries, which achieved a Conditional Materiel Release in February 2012. The THAAD Project Office continues to address the 18 open conditions that need to be resolved before the Army will grant a Full Materiel Release. Fixes and testing of the open conditions are scheduled through FY17. Of the original 39 conditions, 16 conditions were closed in FY12 – FY14 and 4 were closed in FY15:
  - Testing of the optical block in the missile Flight Sequencing Assembly
  - Establishing an institutional training base
  - Conducting a system supportability demonstration and modifying procedures based on the demonstration, as necessary
  - Providing and validating documented procedures for the Contractor Logistics Support personnel
  - Work also continues on additional materiel release conditions for follow-on THAAD software versions 1.3.1 and 1.4.0.

- The Army and MDA are also working on achieving Full Materiel Release of various versions of the AN/TPY-2 (FBM) software, and have made progress this year, although several of the conditions will take years to close. The materiel release conditions for version CX1.2.3_18 also includes the training and documentation required for Soldier operation of the radars. Soldiers began taking over some operations from contractors on some of the radars in July.

Recommendations

- Status of Previous Recommendations. DOT&E's classified February 2012 THAAD and AN/TPY-2 Radar OT&E and LFT&E report contained 7 recommendations in addition to the 39 Conditional Materiel Release conditions. In FY15, the MDA addressed one classified recommendation (Survivability #4) of the five remaining recommendations. The MDA should continue to address the two remaining classified recommendations (Effectiveness #2 and Effectiveness #5) and the two remaining unclassified recommendations. The MDA and the Army should:
  1. Implement equipment redesigns and modifications identified during natural environment testing to prevent problems seen in testing (Suitability #11). Some, but not all, of these deficiencies have been addressed by hardware modifications included in THAAD Configuration 2. Conducting additional ground testing with Configuration 2 (a standing FY14 recommendation) would also provide data to address this recommendation.
  2. Conduct electronic warfare testing and analysis (Survivability #3). The MDA conducted preliminary testing during FY13, but additional testing is required.
  - The program addressed the FY13 recommendation to reassess their reliability and maintainability growth planning curves.
  - The program partially addressed the FY14 recommendation to conduct thorough end-to-end testing of the THAAD Configuration 2 that incorporates considerable obsolescence redesigns of hardware and software. The MDA should continue to plan to rigorously ground-test the THAAD system to verify that these changes can withstand the range of environments and conditions required.
- FY15 Recommendation.
  1. The MDA should prioritize flight and ground testing that involves THAAD and Patriot engagement coordination to ensure that information passed between THAAD and Patriot does not disrupt organic intercept capabilities or contribute to increased interceptor wastage and threat missile leakage. The Integrated Master Test Plan 17.1 includes Patriot and THAAD participation during the FTO-03 operational flight test.

Live Fire Test and Evaluation

Live Fire Test and Evaluation

Live Fire Test and Evaluation (LFT&E)

Introduction

- In FY15, DOT&E executed LFT&E oversight for 121 acquisition programs, 3 LFT&E investment programs (Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME), Joint Aircraft Survivability Program (JASP), and Joint Live Fire (JLF)), and 3 special interest programs (Warrior Injury Assessment Manikin (WIAMan), Home Made Explosives (HME), and Small Boat Shooters' Working Group).
- In support of a range of acquisition decisions and activities, DOT&E published seven LFT&E reports and six combined OT&E and LFT&E reports. The reports include recommendations to the Services to further improve the survivability and lethality of the subject systems for a range of operationally relevant scenarios in existing and expected combat environments.
- JTCG/ME continued to develop and standardize methodologies for evaluating munitions effectiveness, including target vulnerability characterization, munitions lethality, weapon system accuracy, and specific weapon-target pairings driven primarily by operational lessons learned (Enduring Freedom, Iraqi Freedom, Odyssey Dawn, and Inherent Resolve), Joint Staff Data Call, and the needs of Combatant Commands. The two major JTCG/ME weaponeering products are the Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS) and Joint-Anti-air Combat Effectiveness (J-ACE). JTCG/ME is currently developing a third weaponeering product, a JMEM for cyberspace operations. The JWS and J-ACE enabled:
  - Ongoing Combatant Commands' operational targeting, weaponeering, and collateral damage estimation calls in direct support of operations, mission planning, and training; warfighters were able to put ordnance on target and as such, directly affect combat effectiveness and the war against terrorism.
  - The Air Warfare community, in particular the Navy Strike Fighter Weapons School and the Air Force Weapons School, to develop tactics, techniques, and procedures (TTP) manuals for air superiority applications and to perform post-shot analysis of missile firings following a training mission.
  - The onset of the development of building blocks for a Cyber JMEM (CJMEM).
  - DOD, joint, and Service planners for force-on-force modeling, mission area analysis, requirements studies, and weapon procurement planning.
  - The acquisition community in performance assessment, analysis of alternatives, and survivability enhancement studies.
  - United Kingdom, Canada, Australia, and other coalition partners to plan operational weaponeering and collateral damage estimates, support training and tactics development, and support force-level analyses.
- JASP funded 55 multi-year projects addressing aircraft survivability technologies and aircraft survivability evaluation tools. JASP's primary mission is to increase combat effectiveness of U.S. military aircraft in current and emerging threat environments through joint and Service staff coordination and development of survivability technologies and assessment methodologies. In FY15, JASP made progress in improving:
  - Aircraft ability to counter near-peer and second-tier threats by assessing innovative electro-optical and infrared countermeasures (EO/IRCM) and radio frequency countermeasures (RFCM).
  - Aircraft force protection by (1) addressing the ability to avoid threat detection/engagement, e.g., Hostile Fire (HF) detection, identification, and geolocation technologies to improve aircrew situational awareness, and (2) by implementing aircraft hardening technologies, e.g., armor solutions, self-sealing fuel tanks, and improved crashworthiness technologies including improved helicopter seats.
  - Aircraft survivability to fires, the primary threat-induced aircraft vulnerability.
  - The capabilities of survivability-related models with the inclusion of emerging threats, by automating the analysis and post-processing, and by continuing to validate the new and existing model capabilities.
- JLF supplemented LFT&E of fielded systems, addressed operational commander's needs, and characterized new survivability and lethality effects of fielded systems in response to exposure of U.S. systems to new threats or as a result of systems being used in new, unanticipated ways, or operated in new environments. Specifically, JLF:
  - Assessed the impact of fielded system design changes on survivability (e.g., rotary-wing aircraft with added internal auxiliary fuel tanks)
  - Assessed weapon lethality against new targets (e.g., fast attack craft, a new threat to U.S. ships)
  - Improved accuracy and fidelity of weapon data used as part of mission planning to estimate effectiveness with higher confidence (e.g., improved collateral damage estimates)
  - Advanced live fire test methodologies to keep pace with changing threats
  - Supported the development and improvement of modeling and simulation tools that contribute to survivability and lethality evaluations (e.g., new data to support improvements in predicting weapons effects against aircraft, vehicles, and military structures)

FY15 LFT&E PROGRAM

- LFT&E continued its oversight of three special interest programs:
  - The Warrior Injury Assessment Manikin (WIAMan) project, an Army-led effort, made significant progress in biomechanics testing and anthropomorphic test device (ATD) development to design a biofidelic prototype for assessing injuries to vehicle occupants during the underbody blast (UBB), but the Army has not programmed any funding for this project in FY17 or beyond.
  - The Home Made Explosives Characterization program (HME-C) completed multiple test phases, intended to investigate the repeatability of HME surrogate effects relative to those of TNT and the effects of soil condition and IED emplacement on HME threat performance.
  - The Small Boat Shooters' Working Group continues to synchronize live fire and other operational test approaches against this growing threat class, which operates in littoral waters.

LFT&E OVERSIGHT

The primary objective of LFT&E is to evaluate the survivability and lethality of acquisition programs and to identify deficiencies to be corrected before those platforms or munitions enter full-rate production. In FY15, DOT&E executed LFT&E oversight for 122 acquisition programs. Of those, 21 operated under the waiver provision of U.S. Code, Title 10, Section 2366, by executing an approved alternative LFT&E strategy in lieu of full-up system-level testing. DOT&E published seven LFT&E reports and six combined OT&E and LFT&E reports on the following programs during the past year:[1]

[1] Reports marked with an asterisk were sent to Congress.

LFT&E Reports	Combined OT&E and LFT&E Reports
Interim Report on the LFT&E of the Hellfire Missile Variant	Aegis Ballistic Missile Defense (BMD) 4.0 and Standard Missile-3 Block 1B*
Stryker Reactive Armor Tiles (SRAT) II Live Fire Test & Evaluation*	Lot 4 AH-64E Apache Attack Helicopter with classified annex*
Cartridge 7.62 Ball M80A1 Live Fire Test & Evaluation Report*	Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW)*
MaxxPro Dash with Independent Suspension System (ISS) and Maxx Pro Survivability Upgrade	GBU/53B Small Diameter Bomb, Increment II
Hellfire Final Lethality Report*	Mobile Landing Platform with Core Capability Set (MLP with CCS) and classified annex*
Littoral Combat Ship (LCS) 3 Total Ship Survivability Trial (TSST)	Air Intercept Missile – 9X (AIM-9X) Block II (with appendices)*
Joint Light Tactical Vehicle Live Fire Test & Evaluation Report	

- Four reports supported Full-Rate Production decisions:
  - Aegis Ballistic Missile Defense (BMD) 4.0 and Standard Missile-3 Block 1B reported on the lethality of the Standard Missile-3 Block 1B and included two recommendations to improve future evaluations of BMD lethality.
  - Guided Multiple Launch Rocket System – Alternative Warhead (GMLRS-AW) reported critical weapon lethality data as a function of target types, target areas, target location error, and countermeasures. LFT&E made three recommendations to improve weapon lethality including new targeting procedures and reassessment of the weapon effectiveness requirements to ensure they adequately represented warfighters' mission success needs.
  - Mobile Landing Platform with Core Capability Set (MLP w/CCS) confirmed the survivability shortfalls of this ship (built to commercial standards) including the lack of hull and equipment hardening or personnel protection features necessary to survive enemy weapon effects. LFT&E identified the limitation in data needed to assess the effectiveness of the Embarked Security Teams for close-in self-defense.
  - Air Intercept Missile-9X (AIM-9X) Block II reported on the effectiveness and lethality of the Block II missile. LFT&E assessed that new improvements to the AIM-9X Block II fuze did not degrade the missile's lethality or effectiveness compared to existing AIM-9X Block I missiles.
- Five reports supported a program decision:
  - Cartridge 7.62 Ball M80A1 LFT&E assessed the lethality capability of the new 7.62 mm cartridge, including effective range, as fired from two different weapons and against a range of targets of interest (e.g., soft targets, representative battlefield barriers, and personnel protection equipment). LFT&E identified additional operationally relevant targets that should be assessed for similar munitions in future programs.
  - Joint Light Tactical Vehicle (JLTV) LFT&E provided critical survivability information to the procurement decision makers, with a focus on the ability of each of the three vendor JLTV prototypes to provide protected ground mobility for Soldiers and Marines in a combat environment. LFT&E enabled a performance comparison among the three vendors and against legacy vehicles, and identified recommendations specific for each vendor to help improve crew and vehicle survivability.
  - GBU/53B Small Diameter Bomb, Increment II (SDB II) provided critical program status information to the

acquisition officials on SDB II's lethality and effectiveness when employed in the normal attack mode. LFT&E provided probability of single shot kill information for a range of moving and stationary, operationally representative targets, as a function of weapon accuracy and end-game geometry.
  - Lot 4 AH-64E Apache Attack Helicopter FOT&E with classified annex provided a survivability assessment of the Lot 4 AH-64E. LFT&E evaluated AH-64E survivability against the range of tested threats and recommended improvements and upgrades to several key survivability-related systems.
  - The interim report on the LFT&E of the Hellfire Romeo Missile Variant provided the Program Office with critical weapon lethality assessment when fired from unmanned aerial vehicles against a range of enemy targets of interest. LFT&E made four recommendations to further improve the understanding of the missile's capability against very specific targets of interest or as fired from additional platforms.
- Four reports provided system survivability or lethality evaluations for use by the Service and Program Office:
  - Stryker Reactive Armor Tiles (SRAT) II LFT&E provided critical data on the survivability of Stryker vehicles equipped with SRAT II. LFT&E provided multiple recommendations to the Army to improve survivability of SRAT II-equipped vehicles, as well as lessons learned for future LFT&E efforts involving complex armors.
  - MaxxPro Dash with Independent Suspension System (ISS) and Maxx Pro Survivability Upgrade evaluated the response of the vehicle and subsequent protection of its occupants, Soldiers and Marines, to attacks as those seen in Operation Iraqi Freedom and Operation Enduring Freedom. LFT&E demonstrated that the survivability upgrades provided significant improvement in force protection and set the standards for Mine Resistant Ambush Protected (MRAP)-level underbody blast protection. LFT&E also provided four recommendations to further improve crew protection and fuel fire mitigation.
  - Littoral Combat Ship (LCS) 3 Total Ship Survivability Trial (TSST) confirmed significant vulnerabilities in the Freedom-class. LFT&E provided insight into design changes to reduce ship vulnerability and improve recoverability. LFT&E identified several components and systems that could be redesigned or reconfigured to make the ship more survivable without requiring major structural modifications.
  - The final lethality report on the Hellfire missile provided additional evaluation of weapon lethality against specified maritime targets.
- DOT&E published one classified Special Report, the report on the LCS required by Section 123 of H.R. 3979, National Defense Authorization Act for FY15.

LFT&E INVESTMENT PROGRAMS

JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS EFFECTIVENESS (JTCG/ME)

The Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) continued to update and develop weapons and targets data and methodologies crucial for the development of force employment options for theater commanders and the resulting execution tasking orders for tactical units. The principal products of the JTCG/ME are the Joint Munitions Effectiveness Manuals, or JMEM. The JMEM include detailed data on the physical characteristics and performance of weapons and weapon systems; descriptions of the mathematical methodologies that employ these data to generate effectiveness estimates; software that permit users to calculate effectiveness estimates; and pre-calculated weapon effectiveness estimates. It permits a standardized comparison of weapon effectiveness across all Service communities. All JMEM weapon effectiveness products are integrated into a single program, the JMEM Weaponeering System (JWS), which includes the Joint Anti-Air Combat Effectiveness (J-ACE) product. The JWS is target oriented allowing users to adequately plan the mission by determining the effectiveness of weapon systems against a specified target for a range of weapon delivery modes.

Joint Munitions Effectiveness Manual (JMEM) Weaponeering System (JWS)

JWS is the DOD source for air-to-surface and surface-to-surface weaponeering, munitions, and target information used daily in the U.S. Central Command (USCENTCOM) and U.S. Africa Command (USAFRICOM) Areas of Responsibilities (AORs) in the deliberate planning process directly supporting Joint Publication 3-60 "Joint Targeting."

JWS enables Combatant Commands to efficiently prosecute their target sets. JWS incorporates accredited methodologies, certified munition characteristics, delivery accuracy, target vulnerability data, and numerous user aids to support the operational use of JWS to predict weapons effectiveness for fielded weapons and delivery systems. JWS is the calculation engine used to develop Quick Weaponeering Guides/Probability of Kill Lookup Tables to address time sensitive targets.

In FY15, in support of operational commanders, targeteers, weaponeers, and planners, the JTCG/ME released JWS v2.2 that included Digital Precision Strike Suite (DPSS) Collateral Damage Estimation (DCiDE) Tool Version 1.2.2 and Collateral Damage Estimation (CDE) Tables. JWS v2.2 includes approximately 220

methodology, functionality, weapon/warhead/fuze, and target updates. Development of JWS v2.2 is now complete. As a result, Combatant Commands have access to:

- Additional weapon data updates such as GBU-49; Advanced Precision Kill Weapon System-II; HELLFIRE variants; Joint Air-to-Surface Standoff Missile (JASSM) Delivery Accuracy; and M982 Excalibur trajectory/accuracy.
- Approximately 50 new or updated materiel targets, e.g., new building types such as brick office, pre-cast wall/slab office, earth-timber command post, etc., and new quasi-static blast capability.
- Increased mission planning efficiency through the inclusion of an initial DCiDE connectivity that improves both speed and throughput of data, as shown in Figure 1.

- The JTCG/ME released DCiDE v1.2.2 with enhancements to directly support the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3160.01A – "No-Strike and the Collateral Damage Estimation (CDE) Methodology."
  - The DCiDE tool is critical to the warfighters' ability to meet urgent operational needs for an accredited automated CDE tool that both expedites and simplifies the CDE process. DCiDE is the only automated CDE tool authorized for use in the USCENTCOM and USAFRICOM AORs. The JTCG/ME CDE tables are used in every planned kinetic strike in all AOR's to meet Commanders intent and to minimize civilian casualties. DOT&E has received positive feedback on the use of the Collateral Effect Radii (CER) values as a critical enabler in support of munitions employment against High Value Targets (HVTs).
  - JTCG/ME accredited CER Reference Tables for air-to-surface and surface-to-surface weapons, which are the basic data that supports the CDE methodology. Changes included additions for air burst munitions and nomenclature changes. Additional updates have been provided for newly fielded/updated systems, e.g., GBU-49/BLU-133; AGM-176A; 155 mm M109A, M549A1, and M795 with Guided M1156 Precision Guidance Kit (PGK) Fuze. In support of advanced CDE mitigation techniques, JTCG/ME also developed the Collateral Effects Library Tool.
  - The JTCG/ME trained multiple users at different Commands to support CDE decisions. Specifically the JTCG/ME trained warfighters from the III Corps (G2 and FIRES), 82nd Airborne Division, 3rd Special Forces Group (SFG), 5th SFG, Task Force (TF) 3-10, and CENTCOM Joint Targeting Element (JTE) in support of Operation Inherent Resolve.
- JTCG/ME reviewed and remarked JWS v2.2 to ensure all data were disclosable to facilitate coalition interoperability. Risk Management Framework testing is underway to facilitate release of the product to the field. Based on the current guidance and direction from the Joint Staff, the JWS v2.2 and future versions will be released to several key coalition partners in support of current operations under Foreign Military Sales agreements. This capability is critical to the effectiveness of U.S. targeting and fires personnel working in the combined environment.

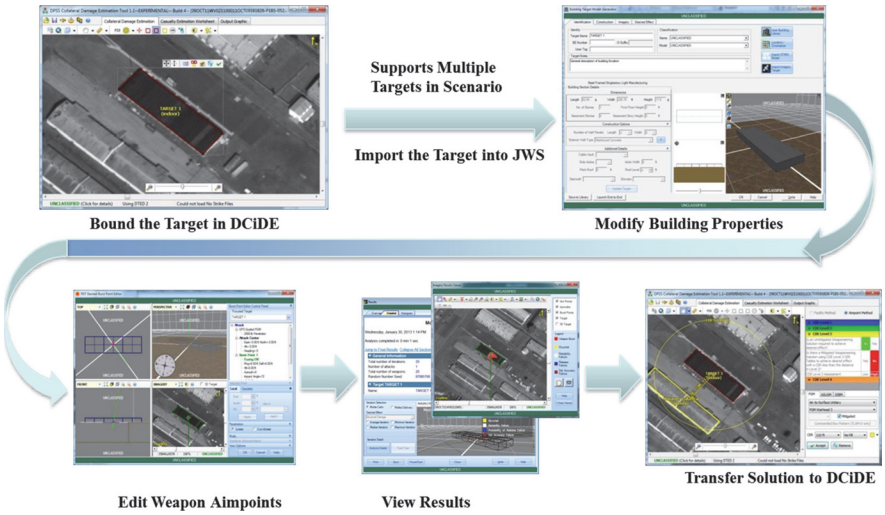


Figure 1. Connectivity between Weaponeering and Collateral Damage Assessment Enables Combatant Commanders to More Rapidly Prosecute Targets

- JWS v2.3 is under development and will include an interface to implement improved aimpoint development, which includes fields for weaponeering, CDE, and precision point mensuration (PPM). This data standard is currently in fielded mission planning systems. JWS v2.3 will also add an updated Gunship Delivery Accuracy Program module, Rotary-Wing Delivery Accuracy Program, and Fast Integrated Structural Tool ground shock kill updates that will improve effectiveness estimates.
- JTCG/ME is initiating efforts to support target production activities by enabling the automated integration of weaponeering, PPM, and CDE. These efforts will improve both timeliness and data throughput associated with these activities. In addition, connectivity to mission planning systems (Joint Targeting Toolbox) and databases (Modernized Integrated Database) is underway to allow data to flow seamlessly within the joint targeting processes.

Joint-Anti-air Combat Effectiveness (J-ACE)

J-ACE is used by U.S. Strategic Command (USSTRATCOM) in the support of route planning for the execution of strike packages. J-ACE simulates air-to-air and surface-to-air engagements. It includes accredited blue/red/gray (friendly/adversary/neutral) air-to-air missile (AAM) models and red/gray surface-to-air missile (SAM) fly-out models to provide probability of kill estimates. J-ACE is the umbrella program that includes both the Joint Anti-air Model (JAAM) and Endgame Manager, which provides a full kill chain end-to-end capability for mission analysis, tactics development, and training.

- J-ACE v5.3, currently under development, will provide extended and updated data sets for blue missile and aircraft target aero-performance, anti-air missile lethality, and red air target vulnerability. In particular, new or updated air-to-air or

surface-to-air government-furnished missile or weapon fly out models will be integrated.

- The JAAM (Figure 2) is integrated into automated systems used directly by the Air Warfare community, in particular the Navy Strike Fighter Weapons School and the Air Force Weapons School, to develop TTP manuals for air superiority applications and to perform post-shot analysis of missile firings following training missions. The JAAM is being updated to include the effect of weapon system reliability on the probability of a successful engagement (i.e., a reliability factor is applied to the weapon system, prior to finishing the tactics development; it is useful to understand outcomes and tactical options when shots fail to achieve the desired effectiveness).

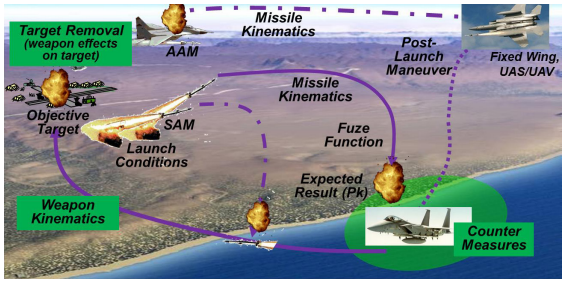


Figure 2. The primary J-ACE interface is through the Joint Anti-Air Model (JAAM). JAAM is a fast running simulation of Air-to-Air Missiles (AAM) and Surface-to-Air Missiles (SAM); and, aircraft aerodynamic performance.

Joint Non-Kinetic Effects – Cyber JMEM

JTCG/ME is continuing the development of non-kinetic tools and capabilities, the Joint Non-Kinetic Effects. Joint Non-Kinetic Effects is intended to be a single source for operational warfighters, analysts, targeteers, and planners to analyze offensive cyber capability effectiveness.

- In conjunction with the Air Force Targeting Center, the JTCG/ME is developing preliminary JMEMs for cyberspace operations. Current efforts are focused on developing the building blocks for a Cyber JMEM (CJMEM) including weapons characteristics, target vulnerability, and effects estimation tools (e.g., Cyber Capabilities Registry (CCR), Cyber Critical Elements/Weaponeering Guide). In FY15, JTCG/ME made progress in developing weapons characterization data and testing standards.

Operational Users Working Group

The Operational Users Working Group (OUWG) is a critical venue for receiving direct user feedback and development of future requirements from the operational community in regards to needed software enhancements and capabilities to support air-to-surface and surface-to-surface target engagements. Examples of user requirements are: the ability to release weaponeering information to coalition partners; connectivity between tools and mission planning systems; current weapon and fuze information; training materials, quick weaponeering guides, and graphical user interface enhancements; and improved blast/fragment methodologies in support of small precision munitions.

JTCG/ME continued to chair OUWGs to establish warfighter requirements for ongoing development of the JWS software and DCiDE tool. Representatives from USCENTCOM, USAFRICOM, USSTRATCOM, U.S. Pacific Command (USPACOM), U.S. Special Operations Command (USSOCOM), the Services, the Defense Intelligence Agency (DIA), the Defense Threat Reduction Agency (DTRA), the Fires Center of Excellence, Service School Houses, the Marine Aviation Weapons/Tactics Squadron, Operations Support Squadrons, Intelligence Squadrons, and numerous other operational units routinely participate.

JOINT AIRCRAFT SURVIVABILITY PROGRAM (JASP)

The primary mission of the Joint Aircraft Survivability Program (JASP) is to increase military aircraft combat effectiveness in current and emerging threat environments. This is accomplished through joint and Service staff coordination of research and development of aircraft survivability technologies, assessment methodologies, and combat data collection to support technology development and acquisition planning. In FY15, JASP funded 55 multi-year projects and delivered 33 final reports that focused on two major areas: aircraft survivability technology research and development and aircraft survivability assessment methods. JASP also investigated and catalogued combat damage incidents through the Joint Combat Assessment Team (JCAT).

Aircraft Survivability Technology Research and Development

JASP has focused the research and development on three major aircraft survivability technology areas to: (1) help defeat the near-peer and second-tier adversary threats by developing measures to avoid detection and engagement of advanced radio frequency-guided and infrared-guided threats; (2) improve aircraft force protection; and (3) improve aircraft survivability to combat-induced fires.

Defeat Near-Peer and Second-Tier Adversary Threats.

To advance U.S. air superiority and improve U.S. aircraft survivability against near-peer and second-tier adversaries, JASP focused on addressing feasible technologies and technology improvements that would effectively counter prevalent, current, and emerging threats.

- In FY15, JASP assessed measures to counter adversary radio frequency-guided threats and anti-access/area-denial capabilities. JASP funded the Naval Research Laboratory (NRL) to significantly advance electronic attack capabilities while continuing to support radio frequency-guided threat countermeasure jamming development:
  - Completed the development of algorithms for use on current and future jammers.
  - Demonstrated the potential of improved jammer techniques. The project tested these in the laboratory and will be flight tested in FY16.
- Many aircraft are equipped with active infrared jammers, flare dispensers, and missile approach warning systems to cue countermeasures deployment (Figure 3). These helped

reduce the helicopter loss rates during the invasion in Iraq and the subsequent counter-insurgency campaign. In FY15, JASP assessed measures to counter existing and emerging infrared homing threats and focused on identifying solutions to counter newer seeker technologies:

Figure 3. AH-64 Apache Helicopter Launching Flares in the Dark

- Matured a technology and technique to identify infrared-guided threats before or immediately after launch, thereby improving both the timeliness and effectiveness of countermeasures.
- Analyzed and optimized IRCM flare characteristics that affect the ejection velocity to improve countermeasure effectiveness. Ultraviolet spectral data were gathered on flares in flight test for the first time. The spectrometry data will be placed in the Tri-service Flare Database for the Services to use in expendable countermeasure development and assessment. These data will support the development of new flares and evaluate flare effectiveness against advanced EO/IR guided threats.
- Flight tested seven different IRCM flares to gather trajectory data and high fidelity signature data to improve the fidelity of tri-service IRCM effectiveness modeling and simulation.

Aircraft Force Protection. Aircraft and crew losses due to anti-aircraft artillery and other unguided threats like the rocket-propelled grenades (RPGs) remain a concern. Recent helicopter combat data analysis suggest that about 88 percent of the helicopter hits are due to small arms and automatic weapons resulting in about 28 percent of the aircraft losses and about 10 percent of the loss of life. RPG/rockets account for about 40 percent loss of aircraft and about 53 percent loss of life. To improve the ability of our aircraft to avoid threat detection and engagement and to mitigate damage and prevent destruction when hit, JASP has focused on several schemes to protect U.S. aircraft and crew against these threats: (1) improved situational awareness, and (2) aircraft system hardening solutions.

- **Situational Awareness.** Other than countermeasures, evasive maneuvers can be effective in evading gunfire and other unguided threats, but this is predicated on the crew's knowledge of the attack, and the location of the attack. Acoustic system detection and smart mission management systems that can leverage battlefield intelligence databases are a few promising technologies. JASP has been focusing on the development of an advanced hostile fire detection and shooter geo-location sensor compatible with current threat warning systems. JASP sponsored development of a sensor package that incorporates both mid-wave infrared (MWIR) and acoustic waveforms for detecting hostile fires and determining the location of the shooter. In FY15 (the first year of a three year program), the project developed a combined MWIR and acoustic detection and geo-location approach that enables reliable muzzle flash detection, hostile intent determination (determination that an aircraft is the intended target), and reduced false alarms for a dependable shooter geolocation.
- **Aircraft System Hardening Solutions.** Inevitably, aircraft will be drawn into close combat and will be engaged by anti-aircraft weapons systems, the results of which could be devastating as shown in Figure 4. The majority of JASP vulnerability reduction focus areas have been aimed at schemes that would help the aircraft system absorb the damage, avoid aircraft destruction, and save the crew during an attack or in the event of a crash. These include energy absorbing structure technologies, crash protective seats, innovative armor solutions, and include the assessment of aircraft survivability against unconventional threats, e.g., directed energy lasers.

Figure 4. Coalition Helicopter Crash in Afghanistan

  - Initiated a project to test hydrodynamic compliant structure concepts to determine their application to improving aircraft structure absorbing technologies. This project is scheduled to be completed in FY16.
  - Initiated a project to test an adaptive seat energy absorber with a goal of improving the crash protectiveness of aircraft seats. This project looks at the effect of advanced stroking seat technology and is scheduled to be completed in FY16.
  - Developed a lighter more protective transparent armor that defeats the 7.62x39 ball round (single shot) at reduced weight of 4.8 pounds per square foot (psf) (a 10 percent weight reduction). The project produced armors well within the expected design envelope and exceeded the ballistic goal. The success of this project has led to a second phase examining performance in different environments and to a more demanding threat.
  - Determined High Energy Laser effects against typical aircraft composite materials and determined the significance of vulnerability factors. These results will support Air Force Research Lab and NRL development of material solutions.

Aircraft Survivability to Combat-Induced Fire. Ballistically-induced fires are a primary contributor to aircraft vulnerability. Understanding the causes and likelihood of fire is a necessary part of developing survivable combat aircraft and

assessing their vulnerability to fire. In FY15, JASP focused on developing solutions to maximize residual flight capability in the event of threat-induced onboard fires.

- JASP contributed to development of a self-contained compact, low-weight, low-cost, high-efficiency universal smart nozzle fire suppression delivery system capable of directly discharging multi-phase agents to a fire zone. The system detects and locates a fire within 100 milliseconds of fire initiation (existing systems require 2 seconds to detect and react to a fire). The "smart nozzle" fire suppression system adjusts the orientation and momentum of the discharging fire suppressant jet directly towards the fire region. This directional capability reduces the amount of agent required while maintaining the ability to be used multiple times during the same flight. The current weight of the system is approximately 3.5 pounds with 1.75 ounces of agent. The units would be ideal for larger rotary-wing cabin areas where troops reside.

Aircraft Survivability Evaluation Tools

- JASP continues to provide the DOD with modeling and simulation capabilities to support Analysis of Alternative studies (for development and verification of aircraft requirements), to assess operational and live fire test results, and to plan and rehearse training missions. JASP focused on increasing the capabilities of five survivability-related models with the inclusion of emerging threats, by automating the analysis and post-processing, and by continuing to validate new and existing model capabilities: (1) Enhanced Surface-to-Air Missile Simulation (ESAMS), (2) BRAWLER (air-to-air combat), (3) Modeling System for Advanced Investigation of Counter Measures (MOSAIC), (4) Computation of Vulnerable Area Tool (COVART), and (5) Fire Prediction Model (FPM)/Next Generation Fire Model. In conjunction with the Defense Systems Information and Analysis Center (DSIAC), JASP has established a standard process for the distribution and maintenance of these key survivability models.
- In FY15, DSIAC distributed the latest versions of the survivability models: BRAWLER 8.1, COVART 6.5, ESAMS 5.0, and FPM 4.2.
  - Studies supported by BRAWLER in 2015 include: F-35 Initial Operational Capability Support and Block 4 capability studies, 4th Generation/5th Generation Force Mix Analysis, F-22 Modernization Candidate Selection, and the F-15 /F-16 Modernization and Service Life Extension Program (SLEP) Decisions.
  - COVART was used to support the F-35A, KC-46A, AC-130J, and CH-53K programs, particularly in terms of their design requirements and LFT&E programs.
  - FPM was also used extensively in the KC-46A LFT&E program for shot line selection and pre-test predictions.
  - ESAMS was used on several studies for defining requirements and operational concepts for upgrades to current Air Force platforms (F-22A, F-35, B-2A) and future Air Force concepts (Next Generation Bomber), Hypersonic Air-breathing Weapon Concept (HAWC), and the Advanced Air Refueling Capability Concepts (AARCC).
- In FY15, JASP funded three projects to enhance ESAMS (used for assessing radio frequency-guided SAM engagements, including countermeasure effects where possible) capabilities to respond to the requirements identified by operator and user needs. These enhancements:
  - Incorporated an advanced naval SAM model developed at the Office of Naval Intelligence
  - Updated the legacy model and developed a new model for advanced radio frequency chaff
  - Updated radar and missile guidance models for two SAM systems so they reflect the latest intelligence assessment of the systems capabilities
- JASP also supported the development of high fidelity flare models to design and evaluate flares against current and future EO/IR guided threats. These projects developed the requirements for high fidelity infrared flare models that will work in all the Services' hardware-in-the-loop (HWIL) EO/IR threat simulation facilities. The DSIAC distributed two validated flare models, the pyrotechnic MJU-32 and pyrophoric MJU-49, with the Flare Imagery Analysis Tool v1.0 in September 2015.
- JASP collaborated with Air Force Research Lab (AFRL) and the Large Aircraft Infrared Countermeasures (LAIRCM) Program Office to validate the MOSAIC simulation to augment the flight testing and HWIL modeling supporting IOT&E of the LAIRCM system. This capability will also support other future laser-based directed energy countermeasure programs.
- Within the vulnerability assessment technical area, JASP funded projects addressing the following two major issues:
  - Fire prediction capability by initiating the Next Generation Fire Model plan, which identifies four broad modeling and test areas that need substantial improvement: Penetration (particularly of fluid backed structures), Energy Deposition (from fragment flash and armor piercing incendiary flash), Fuel Deposition (from hydrodynamic ram phenomenology), and Ignition (the interaction between Energy Deposition and Fuel Deposition.
  - Rotorcraft crew casualty assessment by exercising the integrated Crew and Passenger Survivability (CAPS) methodology. The Army performed analyses using their DESCENT model to assess possible crash landing conditions based on data collected from the Navy Safety Center, the Combat Damage Incident Reporting System (CDIRS), and DSIAC relevant to a CAPS assessment for the CH-53E. Additionally, the Naval Air Systems Command will perform manned-simulator tests to assess what kind of system malfunctions may occur due to threat impacts, and whether these malfunctions would be survivable. The project will provide a better understanding of the Integrated CAPS methodology sensitivities to help prioritize future efforts to improve the modeling capability,

technology development, and rotorcraft occupant survivability.

Combat Damage Assessment

- JASP strengthened aircraft combat damage incident reporting in the Services and the DOD by continuing to support the Joint Combat Assessment Team (JCAT). The JCAT is a team of Air Force, Army, and Navy personnel that deploy to investigate aircraft combat damage in support of combat operations. JCAT ended its operation in Afghanistan in October 2014 with the return of deployed assessors to the United States. The team continued to support assessments remotely from the continental United States and is ready to deploy rapidly outside of the U.S. if necessary
- In FY15, the JCAT worked to review and update more than 10 years of combat damage reports in CDIRS.
- The JCAT and Joint Aircraft Survivability Program Office worked in coordination with the Office of the Deputy Assistant Secretary of Defense for Systems Engineering, OSD (Personnel and Readiness), and JS/J8 on an Aircraft Combat Damage Reporting (ACDR) Doctrine, Organization, Training, materiel, Leadership, Personnel, Facilities, and Policy(DOTmLPF-P) Change Request (DCR) proposal that would institutionalize ACDR through changes in joint doctrine, training, IT infrastructure, and policy. DOT&E approved the DCR, which was submitted to JS/J8 in October 2015.
- The JCAT trained the U.S. aviation community on potential aircraft threats and combat damage. This training includes but is not limited to: capabilities briefs, intelligence updates, recent "shoot-down" briefs to discuss enemy TTPs, and the combat damage collection and reporting mentioned above. The attendees include aircrews, maintenance personnel, intelligence sections, Service leadership, symposia attendees, and coalition partners.

THE JOINT LIVE FIRE (JLF) PROGRAM

In FY15, JLF funded 26 projects and delivered 24 reports. Focus areas for JLF included projects that either 1) characterized new survivability issues; 2) characterized new lethality issues; 3) improved accuracy and fidelity of weapon data; 4) improved test methods; or 5) improved modeling and simulation methods.

Characterization of New Survivability Issues

- The U.S. military operates numerous aircraft powered by the PT6A engine. Variants of the PT6A engine are installed on the C-12 aircraft and other comparable platforms that provide intelligence, surveillance, and reconnaissance; medical evacuation; and passenger and light cargo transport for the Army, Navy, Air Force, and Marine Corps in both hostile and non-hostile environments. In FY15, JLF assessed the survivability of these aircraft due to direct ballistic engagements to the aircraft propulsion system.
  - Despite PT6A design features such as multiple casings, vacuum pumps, and a centrifugal impellor that inherently reduce ballistic vulnerability, the PT6A engine components are vulnerable to small arms and fragmenting threats. These threats penetrated the engine's outer case at most engine sections. Although none of the resulting damage suggested a catastrophic failure of the engine, many of the test results would have likely resulted in a major loss of engine power within five minutes or less. The failure modes to the engine include either mechanical damage causing a loss of engine power or mechanical damage and oil starvation.
  - Vulnerability could be reduced further by incorporating redundant supply lines (fuel and oil) with smart valves in the hot section and shaped inlet screens on the oil pumps, and by rerouting critical lines to increase masking (to select threats). Additionally, ballistic shielding could be integrated with the aircraft's cowl structure to protect the engine.
- The CH-53E, CH-47F, and CV-22/MV-22 utilize auxiliary fuel tanks in order to extend their range and to support forward area refueling point (FARP) missions. The FARP mission requires CH-53E and CH-47F helicopters to carry up to three 800-gallon auxiliary fuel tanks placed in the aircraft cabins. The impact of these additional fuel tanks on aircraft survivability had to be assessed to identify and address any new system vulnerabilities:
  - JLF demonstrated an increase in aircraft vulnerability and increased potential for fire from an armor piercing incendiary threat-induced ullage explosion and dry bay fire effects of the non-inerted, non-self-sealing, 800-gallon auxiliary fuel tanks in the rotorcraft cabins.
  - The project recommended design improvements to: 1) incorporate technology (e.g., reticulated foam, ullage inerting system) to mitigate the potential of fuel vapor ignition in the tank; and 2) raise or upgrade the fielded tank's self-sealing performance to meet today's MIL-DTL-27422E self-sealing requirement (leak reduced to a damp seal within 2 minutes) for all surfaces on the tank.
- Survivability of U.S. ships to a recently identified asymmetric threat:
  - In FY15, The Naval Surface Warfare Center, Carderock Division built a full-scale bomb using the results of the previously conducted quarter and half scale tests, along with the results of a parametric study that varied different threat weapon parameters. The full-scale bomb will be stored, along with supporting documentation of weapon design, and safe handling and transport, until a suitable land or at-sea test opportunity becomes available.
  - A full-scale test is needed to show scalability and confirm the previously conducted tests, and to demonstrate the effects of this threat against actual ship structure.
- Previous aircraft LFT&E assessments included limited or no CAPS assessments. JLF conducted emergency egress testing on a CH-47F helicopter to determine the time it takes

occupants to exit the aircraft under a variety of realistic cabin conditions and Soldier combat gear loadouts.
  - Combined with the baseline fire assumptions developed under another JLF project, the results provide an increased understanding of the factors driving casualties during aircraft emergency egress for use in future LFT&E efforts.
  - Supplementing data available from the Federal Aviation Administration for commercial airlines, this project fills a data void for military helicopters with cabin fuel lines and unique Soldier equipment configurations. This data set baselines assumptions for the CH-47 in particular, and medium-sized cargo/troop class aircraft in general for use in CAPS assessments.

Characterization of New Lethality Issues

- Assessment of HELLFIRE missile lethality against fast-attack craft, a new threat to U.S. ships operating in the littoral environment.
  - JLF collected critical blast, fragmentation, and impact damage data to assess the capability of the HELLFIRE against the threat posed by fast-attack craft or other small boats to U.S. ships operating in the littoral environment (Figure 5).
  - The project demonstrated the utility of the unique rocket-on-a-rope testing technique to propel the missile to the target (a decommissioned Coast Guard target craft) in achieving the desired dive angle, impact velocity, and impact hit point.

Weapons Data Accuracy

- JLF obtained new arena test data on the HELLFIRE missile to permit improved collateral damage estimates, risk to personnel estimates, and lethality effectiveness of material targets for the HELLFIRE missile.
  - The HELLFIRE missile is frequently used by the warfighters to pursue high value targets. Given the location of these targets and the need to minimize collateral damage, additional test data increased the required accuracy and fidelity of the missile zonal data file. The added confidence for the HELLFIRE zonal data will allow the operational users to plan their missions and minimize collateral damage with higher confidence. Blast pressure data and shape charge penetration data were collected to more accurately model the blast and penetration capabilities to evaluate the effectiveness against material and personnel targets.

Figure 5. HELLFIRE against Fast-Attack Craft

  - Fragmentation files are a critical input to weapon effectiveness analysis programs that are utilized in JMEMs to provide the operational users with data that can be used for mission planning purposes.
- JLF was resourced to obtain new arena test data on the MK 84 due to concerns about the quality of the existing MK 84 characterization data. JTCG/ME will incorporate the results of this test into JTCG/ME products and tools.
  - Initial examination of the test data indicated a variance from the current characterization data. This variance has a strong potential to influence weapon usage for lethality, collateral damage estimates, and risk assessment.
  - Data will be compared with the output of shock physics predictive tools to improve the warhead detonation model to produce high fidelity results, potentially reduce the number of tests required for characterization, and to provide a better understanding of the fragment cloud.

Improvements of Live Fire Test Methods

- JLF investigated the feasibility of using a novel state-of-the art stereographic video technology to more efficiently and accurately characterize munition lethality.
  - Enables the collection of full hemispherical fragmentation data, individual fragment characterization, and rapid post-test analysis capability. This technology will also provide a vital method for collecting data for future weapon technology, specifically directional/focus munitions.
  - This technology was demonstrated on an MK 84 arena test. Utilizing advanced image processing techniques and a fragment tracking algorithm, tests were able to successfully demonstrate the identification and tracking of 1,016 fragments with stereographic video during the arena test event.
- JLF investigated test instrumentation to more accurately capture and evaluate the blast effects on armored vehicles subjected to live-fire mine and IED tests, and improve the ability to make test-to-test and test-to-simulation comparisons.
  - Legacy gauges used during these tests do not permit collection of the broader range of data needed to support additional analysis capabilities currently utilized.
  - High fidelity computer modeling is more commonly used in vehicle design and test planning, so correlating simulation and test data has become increasingly important.
  - This project identified gauge and mount combinations with capabilities more appropriately matched for the blast environment. In addition to providing data that supports best practices for gauge selection (data that describes instrumentation behavior in different frequency domains and, therefore, in different applications like hull response, local floor response, and seat input and response), the project also developed a test protocol to allow for the evaluation of new accelerometers and/or isolators being considered for use in LFT&E.
- JLF investigated test instrumentation to provide data for real-time crew kill assessments in maritime live fire test

events; more specifically a capability to remotely sense valid fragment strikes to pre-defined anatomical regions strategically located on a ballistic mannequin that provides for a limited case real-time assessment of rapid incapacitation.
  - JLF continued the development and demonstration of the concept of a hit sensor behind a calibrated plywood velocity barrier that successfully detects a valid fragment strike at a given velocity and provides proper positive indication of the hit to a remote station and display.
  - During FY14 and FY15, JLF identified the fragment group of interest, relevant crew work assignments, critical body regions, and developed the physical barrier. Sensor component development and testing of both the barrier and sensor will continue into next year.

Improvements of Live Fire Modeling and Simulation

- Fire is the largest contributor to the vulnerability of fixed-wing aircraft and a JLF project was used to support the fire prediction model capability improvements.
  - Test data determined fire initiation as a function of threat type, velocity, panel thickness, obliquity angle, and fuel temperature. This is part of a collaborative effort to develop the ignition module for the next generation fire prediction model.
- JLF provided a complete and traceable data set to validate blast/fragmentation predictions to support the Endgame Manager model development. When validated, this model can be applied to dynamic aircraft and missile engagements as part of an LFT&E program.
  - A WDU-17/B warhead and a warhead of a foreign surface-to-air missile were successfully tested against a full-up non-operating F-16 aircraft.
  - The JCAT, in conjunction with Air Force engineers, conducted a post-test damage assessment and validated key predictions and assumptions for current vulnerability assessment models (i.e. COVART).
  - This testing proved out a laser metrology data collection method to allow for accurate three-dimensional mapping of damage.
- JLF supported the improvement of the Behind Armor Debris (BAD) algorithm by collecting unprecedented, high-speed images of shape-charge warhead BAD using the pulsed laser illumination system (Figure 6).
  - Three-dimensional analyses of these images produced fragment speeds as a function of the fragment's angle from the residual jet.
  - Using the velocity field based on test data builds confidence in the modeling of the damage that BAD fragments cause to internal vehicle components, including personnel.
- The modeling and simulation challenges of weapons include not only the primary (blast and fragmentation) effects against urban structures, but also the potential for additional damage and casualties created by the failing structures.
  - Analytic tools for predicting weapon effects against structures were originally created to provide a conservative estimate of large (greater than 500 pounds) weapon effects against military structures.
  - Trends in weapon employment to smaller munitions to reduce collateral damage and increased use in urban environments have shown that the tools are inadequate in these regimes.
  - This shortfall resulted in joint Army/Air Force programs to more accurately determine the damaging effects of smaller munitions against urban structures and an international project agreement led by the Army Research Laboratory (ARL) to improve U.S. predictive capabilities in this area.
  - The Air Force Research Lab (AFRL) has managed development of a number of fast running structural response models for smaller weapon effects, but lacks the validation data needed to increase the confidence in the models and allow for their timely transition into the warfighter's weaponeering tool (JWS).
  - JLF project helped fund six live fire experiments against urban wall constructions to measure their response to the detonation and the potential damaging effects of the resulting debris against personnel and equipment. The test data will be used to provide improved estimates of weapons effects.
- JLF continued a joint effort with Germany to develop and validate the Dynamic Systems Mechanical Advanced Simulation (DYSMAS) hydrocode used to model bottom and near-bottom underwater explosions effects.
  - In FY14, several tests were conducted in the Briar Point test pond at the Aberdeen Test Center, Maryland, using a floating shock platform to collect data on platform response from charges located at mid-depth, near-bottom, and on the bottom.
  - The analysis of those test results was completed in FY15, providing additional validation for the use of DYSMAS in vulnerability assessments for the modeling of underwater explosion loading and ship responses in littoral or harbor environments, where bottomed or tethered mines are likely to be encountered.
- JLF supported the development of shaped charge jets effects model.

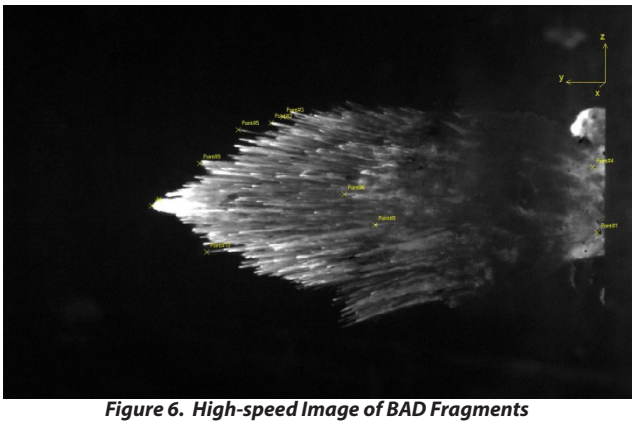


Figure 6. High-speed Image of BAD Fragments

- Initiation of stowed 25 mm ammunition is one of several lethal mechanisms that can impart catastrophic levels of damage to a ground vehicle. Testing on stowed 25 mm training rounds with shaped-charge jets of varying size and velocity collected quasi-static pressure versus time data that will be used to develop a new ammunition compartment vulnerability model.

LFT&E SPECIAL INTEREST PROGRAM

Warrior Injury Assessment Manikin (WIAMan)

- The Army will transition the WIAMan project to a program of record (POR) at Milestone B, projected to occur in FY18. The Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) will be the post-transition program manager. To ensure the injury biomechanics, anthropomorphic test device (ATD) expertise, and live fire testing experience of the WIAMan Engineering Office (WEO) remains a part of the project post-transition, the Army Research, Development, and Engineering Command (RDECOM) and PEO STRI are in the process of staffing a Memorandum of Agreement codifying the roles and responsibilities of their respective offices post-transition.
- In preparation for establishing the POR, the Army initiated an effort to create a Test Capability Requirements Document for the WIAMan system, which documents the key performance parameters and key system attributes the system is required to meet in order to progress through its milestones. This document will be signed by DOT&E, RDECOM, and the Army Test and Evaluation Command, and will include requirements to execute exploratory research on the response of females to underbody blast loading conditions to determine the scope a test program that would be required for the development of a female ATD.
- The WEO continued to demonstrate that the current ATD used in LFT&E, the Hybrid III, lacks biofidelity in the underbody blast (UBB) test environment, meaning it does not respond as a human does when exposed to similar loads. Establishing the human response to the UBB domain is essential in developing a military-specific ATD, and a critical first step is establishing biofidelity response corridors (BRCs) for the human body regions of interest.
  - In FY15, the project delivered 10 of an expected 16 total BRCs, with the remaining BRCs to be delivered by 3QFY16. These BRCs are focused on the human response in the head/neck, lumbar spine, pelvis, and lower leg/foot and ankle body regions. BRCs for the whole body are also under development.
  - In addition, the Army generated initial data on the tolerance of bones to severe loading conditions and developed human injury probability curves for foot and ankle fractures. The investigation of these foot and ankle injuries benefitted from updated analyses of injuries experienced by Soldiers in combat; these analyses revealed greater detail on the exact type and nature of the skeletal fractures suffered.
- In FY15, the WEO awarded a contract to Diversified Technical Systems (DTS) for a technical demonstrator of the ATD, which DTS is expected to deliver at the end of 1QFY16. The WEO and DTS utilized computational modeling to prescribe a range of candidate materials for the ATD and its parts; use of the proper materials is critical for establishing and ensuring the robustness of the ATD in UBB conditions, as well as to ensure the response of the ATD falls within the BRCs. DTS will perform iterative testing that includes matched pair BRC testing in multiple phases to allow opportunities to alter material selection and component geometry to improve biofidelity. The first tests of WIAMan ATD hardware of the cervical spine and pelvis were conducted at Duke University and the University of Virginia, respectively.
- The WEO is developing an optimized ATD finite element model (FEM) as test results become available. This FEM will support analyses to accelerate the re-design of the ATD to achieve strength-of-design, biofidelity, and usability goals. The FEM is also used to produce pre-test predictions to aid in test planning and identifying risks to the robustness of the design and the compliance of the materials. To date, a full three-dimensional description of the ATD has been created, along with models of the test devices in which the ATD will be evaluated.
- The technical achievements made by the WEO and the concerted effort by the Army to create the foundation for a formal acquisition program represent major steps forward for the WIAMan project, and the effort is poised to make addition progress in FY16 and beyond. However, the Army has not programmed funding for the WIAMan project past FY17. The T&E Resources section of this annual report provides additional information regarding the funding history of the WIAMan project.

Home Made Explosives (HMEs)

- DOT&E continues to participate in Army-led efforts to characterize a surrogate for IEDs often encountered in Afghanistan operations, also known as Home-Made Explosives (HME). The ongoing HME characterization (HME-C) effort originated to address concerns regarding the Department's ability to test operationally significant scenarios involving underbody blast threats, and to ensure adequate LFT&E of military vehicles now and in the future. The HME-C program intends to do the following:
  - Establish a threat surrogate for HME, approved by the Army's Office of the Deputy Chief of Staff, Intelligence.
  - Characterize the surrogate threat's effect on ground vehicle targets to determine its suitability for use in Title 10 ground vehicle LFT&E.
  - Ensure the HME surrogate's testability, repeatability, and measurability.
  - Conduct additional characterization of TNT, which is the military bulk explosive currently used in LFT&E. The DOD currently has insufficient data to relate testing under

current conditions to other operationally significant soils, test sites, and threats.
  - Establish a new soil standard for future LFT&E that includes buried underbody blast threats.
  - Investigate and develop new test protocols to ensure adequate and repeatable underbody blast threat testing in the future.
- In FY15, the HME-C program completed multiple test phases, which are intended to investigate the repeatability of HME surrogate effects relative to those of TNT and the effects of soil condition and IED emplacement on HME threat performance. DOT&E is currently working with the Army to analyze the data from the HME-C program to support decisions regarding the use of HME in LFT&E and the implementation of new soil standards (soil type, condition, and preparation) for underbody blast threat testing. The Department expects to make these decisions in FY16.

Small Boat Shooters' Working Group

- Small boats represent a growing threat class to ships operating in littoral waters, and are targeted by a wide variety of weapon systems.
  - In FY15, DOT&E sponsored the fourth annual Small Boat Shooter's Working Group, which examined the general nature of the small boat threat in littoral waters; summarized the threat classes and available targets and models available for ammunition, rocket, and tactical missile weapon systems; and attempted to synchronize various LFT&E and other operational test approaches among the various programs/Services by sharing the breadth of test and evaluation options available to evaluators.
  - The working group assessed the nature of the small boat threat; the availability of targets and lethality models representing those threats; the data collection, test techniques, and instrumentation that have been applied to small boats; and the performance of shipboard and aircraft weapons against small boat threats.
  - The working group identified the need for incorporating a broader variety of surrogate small boat targets into operational testing, and for gathering better live fire data from operational test events (e.g., HELLFIRE Romeo missiles fired against the ex-Coast Guard CG-41 FAC surrogate, and HELLFIRE longbow missiles vertically fired from a ship against High Speed Mobile Surface Targets as part of the Littoral Combat Ship (LCS) program).

RECOMMENDATION

1. The Army should identify and secure the funding outlined in the WIAMan Program Office Estimate so the project can continue uninterrupted. Any disruption in funding is likely to affect significantly the Army's ability to execute the project in its entirety. Any program delays will force the Department to continue using inadequate vehicle underbody blast test instrumentation and injury criteria.

Cybersecurity

Cybersecurity

Cybersecurity

SUMMARY

DOT&E observed improvements in several cybersecurity areas within the Department of Defense (DOD) this past year; however, the Department's warfighting missions and systems remain vulnerable to cyber-attack. Observed improvements include enhanced protection of some network elements, greater challenges for cyber opposing forces (OPFOR) attempting to gain access to networks, and greater awareness by DOD leadership of the potential impact that cyber attacks could have on key systems and the critical missions they support. However, these improvements are not enough to ensure mission success.

In FY15 operational tests and exercise assessments, the cyber OPFOR was frequently in a position to deliver cyber effects that could degrade the performance of operational missions. Exercise authorities seldom permitted cyber attacks from being conducted to the full extent that an advanced adversary would likely employ during conflict, so actual data on the scope and duration of cyber attacks are limited. Additionally, exercise authorities often declined to allow kinetic effects based on data exfiltrated by the cyber OPFOR.

DOT&E believes the reluctance by Combatant Commands (CCMDs) and Services to permit realistic cyber effects during major exercises is due to the requirement to achieve numerous other training objectives in those exercises. Additionally, exercise authorities have stated they fear that cyber attacks could distract from—and possibly preclude—achieving these objectives. However, based on the increasing frequency of cyber attacks throughout the world, CCMDs should expect cyber attacks to be present for all critical missions they may be ordered to execute. In order to attain a high state of mission readiness, CCMDs and supporting defenders should conduct realistic tests and training that include cyber attacks and effects representative of those that advanced nation states would execute.

Identified Cyber Vulnerabilities

As in previous years, assessment teams consistently found four categories of vulnerabilities in both system tests and exercise assessments:

- Exposed or poorly managed credentials
- Systems not configured to identified standards
- Systems not patched for known vulnerabilities
- System/network services and trust relationships that provide avenues for cyber compromise

Noteworthy Successes by Network Defenders

Although defenses need improvement, there were specific instances where defenses worked, including the following:

- The cyber OPFOR found that vulnerabilities routinely available in many networks were not present in some networks due to timely upgrades and software patches.
- A layered approach to stop primary attack vectors, such as phishing, proved effective at defending networks and forced the cyber OPFOR to expend more time and deploy more advanced capabilities. Layered defenses that occupy the adversary's time away from a target may buy sufficient time for the Blue Force to sustain its critical missions.
- Application whitelisting, where network defenders allow only "known good" applications to operate on a network, precluded the cyber OPFOR from expanding its foothold in the network.
- A local hunt team supported by a Cyber Protection Team (CPT) was effective at log reviews that resulted in detection of the cyber OPFOR's presence.

Detection tools used by network defenders were primarily signature-based and dependent upon commercial tools adapted for DOD use. However, the majority of adversarial accesses involved the use of "native" software normally available within the networks and operating systems. Since misuse of native software is less easily detected and eliminated than malware, the DOD should augment current network defenses with behavior-based and heuristic-type sensors.

Cyber Red Teams

The demand on DOD-certified Red Teams, which are the core of the cyber OPFOR teams, has increased significantly in the past 3 years. In the same timeframe, the private sector has hired away members of Red Teams, resulting in staffing shortfalls during a time when demand is likely to continue to increase. This trend must be reversed if the DOD is to retain the ability to effectively train and assess DOD systems and Service members against realistic cyber threats.

Persistent Cyber OPFOR (PCO) and Continuous Assessments

In FY15, U.S. Pacific Command (USPACOM) leadership approved year-round activities of a Persistent Cyber OPFOR (PCO) in order to portray a more realistic cyber adversary in training and assessment events, and make the most efficient use of scarce Red Team personnel. The PCO employs DOD-certified Red Teams in longer-duration activities to be more representative of enduring threat actors than can be portrayed in a brief exercise period. This PCO has already helped USPACOM find and remediate mission-critical vulnerabilities that might have otherwise gone undetected.

USPACOM also agreed to a Theater Cyber Readiness Campaign (TCRC) in FY15. The TCRC included more frequent cyber assessment activities and allowed USPACOM to optimize cybersecurity preparations in smaller events throughout the year, and then examine a larger array of challenges in a capstone exercise event. U.S. European Command (USEUCOM) and U.S. Northern Command (NORTHCOM) are also developing

TCRCs. In theaters where the PCO and continuous assessments are active, DOD is better positioned to find cybersecurity problems, develop solutions or mitigation strategies, and verify that fixes are in place and effective.

Cyber Protection Team (CPT) Assessments

In FY15, DOT&E continued a partnership with U.S. Cyber Command (USCYBERCOM) to experiment with evolving cyber range capabilities and the potential benefits of team-training for representatives from CPTs. Most participants stated the opportunity to experience cyber attacks as a team on a realistic range network that included a live OPFOR, and then engage with the OPFOR during after-action reviews, constituted the best training they had received to date. They also expressed a strong desire for this type of training at their individual duty stations. DOT&E observed CPTs with team training performed better than CPTs without team training, and expects that significant time on realistic ranges will be instrumental to CPTs attaining an effective operational capability. DOT&E also observed some individuals assigned to CPTs do not possess the proper training, background, or motivation to become effective CPT members. DOT&E acquired and enhanced survey tools that can help determine individual suitability for CPTs, and has offered these tools to USCYBERCOM and Service cyber components.

Cyber Ranges

The FY15 National Defense Authorization Act (NDAA) directed DOD to establish an Executive Agent (EA) for cyber training ranges and an EA for cyber testing ranges. DOT&E has often used cyber ranges for events that combine testing and training. Such combined events make efficient use of scarce cyber range resources. The creation of two separate EAs—with separate responsibilities and incentives—would make it difficult to conduct combined activities in a timely manner. A single EA should be designated with the authority to oversee funding and personnel for all DOD-owned cyber ranges.

Conclusions

During exercises, DOD network defenders continue to demonstrate low detection rates of cyber OPFOR activities. The Microsoft Corporation has recently adopted the assumption that all systems are compromised ("Assume Breach"), which is an appropriate posture for the Department as well. The DOD should experiment with and perfect—with rigorous test and evaluation—the tools, tactics, and operational procedures that can quickly identify and stop ongoing cyber attacks.

Combatant Commands should make serious preparations to conduct all critical missions in a cyber-contested environment, and perform periodic operational demonstrations to ensure mission success. These demonstrations should include operational units, all network defenders, and CPT elements that would be expected in support of each mission. DOT&E is prepared to provide support to plan, conduct, and evaluate such demonstrations on both operational networks and in appropriate cyber range environments.

Recommendations

DOT&E recommends the CCMDs and Services:

- Demonstrate the ability to sustain critical missions in a contested cyber environment, consistent with Secretary of Defense and Chairman, Joint Chiefs of Staff guidance.[1]
- Develop tools, tactics, and operational procedures and perform regular battle drills with playbooks to ensure mission accomplishment in the contested cyber environment.
- Allow threat-representative cyber effects, using a persistent cyber OPFOR, during all major exercises.
- Request the leadership of the DOD Enterprise Cyber Range Environment and programs of record create range environments to support the demonstration of cyber effects that are not suitable for operational networks, and the development and testing of remediation options for cyber vulnerabilities.

DOT&E recommends the DOD:

- Accelerate the implementation of key, cybersecurity best practices to include application whitelisting; secure system configurations; and rapid patch application.
- Reduce the number of users with administrative privileges.
- Increase cybersecurity training and accountability for all personnel who use DOD networks.
- Designate a single EA for cyber ranges with the authority to oversee funding and personnel for all DOD-owned cyber ranges.
- Develop options to attract and retain experienced cybersecurity personnel, especially personnel with Red Team and cyber test experience.

DOT&E recommends DOD network defenders implement the following critical cybersecurity measures:

- Limit the availability of native administrative tools that adversaries can exploit to only key personnel.
- Limit access to password and operational data only to authorized users with need-to-know.
- Increase network segmentation and remote authentication policies to create a layered defense of critical assets.
- Deploy heuristic and behavior-based intrusion-detection systems and procedures to assist in the identification of suspicious network and system activity.

DOT&E recommends the Services and EAs for the DOD cyber ranges:

- Provide all CPTs with ready access to range-network environments for routine training and tactics development.
- Employ survey and other testing means to identify candidates for the Cyber Mission Force and to determine their readiness to move into advanced training and mission status.

[1] For example, the DOD Cyber Strategy dated April 2015, and the DOD Cybersecurity Culture and Compliance Initiative memorandum, signed by the Secretary of Defense and the Chairman of the Joint Chiefs of Staff, dated September 30, 2015, and agency cyber commands), and Tier 1 (DOD-wide, e.g., U.S. Cyber Command)

DOT&E recommends that the Undersecretary of Defense for Acquisition, Technology and Logistics, require programs of record to demonstrate they have no critical cybersecurity vulnerabilities prior to proceeding to the next acquisition milestone and prior to fielding.

DOT&E recommends the Chief Information Officer (CIO) update DOD Instruction 8330.01 (Interoperability of Information Technology) to require performance of a cybersecurity risk assessment prior to connecting systems or networks for interoperability reasons.

FY15 ACTIVITIES AND OBSERVATIONS

DOT&E conducted 33 cybersecurity operational tests of acquisition programs and 13 assessments during CCMD and Service training exercises, as shown in Table 1.

Cybersecurity OT&E of Acquisition Programs

Cybersecurity operational testing has two phases, as prescribed by DOT&E in August 2014:

- Cooperative Vulnerability and Penetration Assessments (CVPA). Operational test agencies conduct overt and comprehensive vulnerability and penetration assessments in cooperation with the acquisition program manager to characterize the cybersecurity status of a system. CVPAs include all major system interfaces and operational environments.
- Adversarial Assessments (AA). Operational test agencies conduct AAs to determine the operational impact of system cyber vulnerabilities. AAs evaluate the ability of a unit equipped with the system to conduct assigned missions in the expected operational environment in the presence of a realistic cyber threat. The operational environment includes the local and higher-echelon cyber defenders that support the system under test during its mission.

In FY15, DOT&E reviewed and provided cybersecurity test input for 105 Service and DOD systems, including 65 Test and Evaluation Master Plans and 40 operational test plans.

The four common cybersecurity shortfalls found during tests of acquisition systems were:

- Exposed or poorly managed credentials
- Systems not configured to identified standards
- Systems not patched for known vulnerabilities
- System/network services and trust relationships that provide avenues for cyber compromise

The types of systems at risk from cyber threats include non-Internet Protocol networks such as the 1553 and Controller Area Network data buses. A number of programs incorporate sensitive industrial control systems and programmable logic controllers, or deploy capabilities on commercial clouds. The diversity of systems and services susceptible to cyber attack will require new test capabilities and environments for networks at all levels of security classification.

In order to plan and conduct adequate OT&E of these types of systems and networks, test teams will require in-depth knowledge about their operations and unique vulnerabilities. As the Services begin to use commercial cloud services for data storage, it is critical that DOD develop contracts, policies, and regulations that permit independent DOD cybersecurity testing of commercial services and sites.

Cybersecurity Assessments during CCMD and Service Exercises

DOT&E's Cybersecurity Assessment Program observes and reports on DOD efforts to improve cybersecurity and cyber functionality through assessments of the CCMDs and Services. With DOT&E oversight, the five DOD Operational Test Agencies and the Standing Test, Assessment, and Rehearsal Team (START) completed cybersecurity assessments during eight CCMD exercises, two Service exercises, and three assessments of operational sites. The START is the inclusive term for DOT&E partnerships with organizations and individuals who possess unique skills and experience across the cybersecurity, cyber range, and operational test domains. DOT&E used the START in FY15 to plan and conduct cyber assessments in USPACOM, to jump-start the testing of programmable logic controllers, to plan and conduct tests of offensive cyber capabilities, and develop and conduct cyber range events.

To ensure operational realism and standardization of assessments, in FY15, DOT&E also published an Assessment Handbook that outlines procedures; identifies required data elements; and states expectations for the planning, conduct, and reporting of cybersecurity assessments.

Cyber Assessment Master Plan (CAMP)

The Cyber Assessment Master Plan (CAMP) is a 3-year plan that identifies a CCMD's priority missions and specifies when the CCMD plans to assess those missions in a contested cyber environment. CAMPs are signed by CCMD and DOT&E leadership to focus resources and planning of assessments that will meet the requirements of the DOD cyber strategy. For each mission identified in the CAMP, DOT&E will plan a TCRC that will include multiple building block events that lead to a stressing capstone event for the mission to be assessed. A TCRC may span multiple years until the CCMD has demonstrated the TCRC mission will be effective when stressed by an advanced cyber adversary, and that key supporting networks and systems are sufficiently secure or resilient. In FY15, DOT&E began development of CAMPs with USPACOM, USEUCOM, and USNORTHCOM.

TABLE 1. CYBERSECURITY OPERATIONAL TESTS AND ASSESSMENTS IN FY15		
EVENT TYPE	**SYSTEM OR EXERCISE AUTHORITY**	
CVPA and AA	DOD Automated Biometric Information System	F-35 Lightning II Joint Strike Fighter
	Aegis Weapons System	Integrated Personnel and Pay System - Army
	Aegis Ballistic Missile Defense	Joint Warning and Reporting Network
	Air Force Distributed Common Ground System	KC-46 Pegasus – Tanker Replacement Program
	Consolidated Afloat Network and Enterprise Services	Littoral Combat Ship
	Defense Agencies Initiative	Logistics Modernization Program
	Distributed Common Ground System – Army	Mid-Tier Networking Vehicular Radio
	Defense Enterprise Accounting and Management System	MV-22 Osprey – Joint Advanced Vertical Lift Aircraft
	Defense Medical Information Exchange	Pueblo Chemical-Agent Destruction Pilot Plant
	Department of Navy Large Aircraft Infrared Countermeasures	XM1156 Precision Guidance Kit
	Defense Readiness Reporting System	AN/TPQ-53 Radar System
	F-22 – RAPTOR Advanced Tactical Fighter	Surface Electronic Warfare Improvement Program
	Global Combat Support System – Army	RQ-21A Small Tactical Unmanned Aerial System
	Global Combat Support System – Joint	Surveillance Towed Array Sensor System Low Frequency Active
	Guided Multiple Launch Rocket System – Alternative Warhead	Theater Medical Information Program –Joint
	MQ-1C Gray Eagle Unmanned Aircraft System	Space Classified Program
	Integrated Electronic Health Record	
Exercise Assessment	U.S. Africa Command Judicious Response 2015	U.S. Special Operations Command Tempest Wind 2015
	U.S. Northern Command Vigilant Shield 2015	U.S. Strategic Command Global Lightning 2015
	U.S. European Command Austere Challenge 2015	U.S. Transportation Command Turbo Challenge 2015
	U.S. Pacific Command Pacific Sentry 2015	U.S. Army Warfighter 2015-4
	U.S. Southern Command Integrated Advance 2015	U.S. Navy USS *Harry S. Truman* Sustainment Exercise
Site Assessment	U.S. Central Command Air Forces Central Command	U.S. Forces Korea Headquarters and Osan Air Base
	U.S. Air Force 613 Air Operations Center	
CVPA – Cooperative Vulnerability and Penetration Assessment; AA – Adversarial Assessment		

Cyber Blue and Red Teams

DOD cyber teams include organizations that provide OPFOR aggressors (Red Teams) as well as penetration testers and teams that perform other cybersecurity assessments (Blue Teams). DOT&E guidance establishes data and reporting requirements for cyber team involvement in both operational tests of acquisition systems and exercise assessments.

The demand on DOD-certified Red Teams, which are the core of the cyber OPFOR teams, has increased significantly in the past 3 years. In the same timeframe, the Cyber Mission Force and private sector have hired away members of Red Teams, resulting in staffing shortfalls at a time when demand is likely to continue to increase. This trend must be reversed if the DOD is to retain the ability to effectively train and assess DOD systems and Service members against realistic cyber threats.

In FY15, the almost non-stop pace of events for all cyber teams challenged their ability to provide complete data sets and complete reports. Without these data and reports, network defenders and trainers will not have the critical inputs they need to develop effective mitigations or perform effective training on new procedures. DOT&E worked with the Cyber Red Teams to improve data collection and reporting efforts, and is examining new capabilities such as graphical free-form databases and automated collection tools intended to reduce the burden on the teams while providing the required information for analysis.

Persistent Cyber Opposing Force (PCO)

Red Teams or cyber OPFOR require authority, typically called "ground rules" or "rules of engagement," to operate on DOD networks and systems for operational tests and training exercises. The creation and staffing of separate ground rules for each event, network, and participating cyber Red Team is an administrative burden that has delayed cybersecurity operational tests and the start of activities in support of training exercises. The PCO is intended to help overcome these problems and enhance cybersecurity assessments.

The PCO is the DOT&E-sponsored collection of Cyber Red Teams that perform long-duration adversarial

activities in approved CCMD and Service theaters. These threat-representative activities are designed to make more efficient use of Red Team personnel, provide more realistic cybersecurity assessment opportunities throughout the year, and provide better training opportunities for the CCMDs and the Cyber Mission Force. DOT&E believes that such training throughout the year will improve CCMD defensive and offensive cyberspace operations and readiness to conduct critical missions.

The U.S. Army Threat Systems Management Office provides day-to-day management of PCO activities and helps ensure that operations are threat-representative and that reporting and data collection are to standard. USPACOM and USNORTHCOM have established Standing Ground Rules that allow for PCO activities in their theaters.

In addition to ongoing assessment activities in FY15, the PCO supported cybersecurity operational tests of acquisition programs, and an Office of Cost Assessment and Program Evaluation study. The PCO provided this support in less time than a traditional Red Team could have due to the continual reconnaissance and network accesses that had already been authorized and established. This approach reduced the workload for Red Teams that are in high demand. During FY15, the PCO, operating outside of a formal test or exercise period, also identified an important vulnerability in networks supporting USPACOM. The PCO provided network authorities the technical details and operational implications of the vulnerability, worked with those authorities to identify solutions, and verified the vulnerability had been resolved in subsequent observations.

The PCO provides frequent and detailed reporting on PCO operations and identified vulnerabilities, and works with network authorities and CPTs to identify and implement solutions or mitigations. The PCO will verify the solutions or mitigations have been effectively implemented during follow-on operations. DOT&E has urged the leadership at other CCMDs to establish Standing Ground Rules to enable PCO operations in their theaters.

Advanced Cyber OPFOR (ACO)

The tool and skill sets of the Cyber Red Teams are not keeping pace with state-of-the-art, nation-state threats, and their operations tempo provides little time for operators to gain expertise with new tools or to learn exploits against non-standard systems. Furthermore, it is difficult for them to obtain advanced cyber tools through normal procurement processes.

DOT&E created the Advanced Cyber OPFOR (ACO) concept to augment DOD Red Teams and the PCO with advanced capabilities our cyber adversaries likely possess. The ACO enables developers of advanced cyber capabilities and practitioners of advanced techniques to assist in planning and execution of PCO operations. For example, during one FY15 exercise, the ACO provided capabilities from two developers to enable the PCO to traverse defensive infrastructure, which had been impeding PCO network attacks. The ACO assist was warranted because network defenses improved, previous exploits from the public domain no longer worked, and the intelligence community assessed the representative adversary to possess more advanced tools and techniques. DOT&E will employ the ACO routinely during FY16 in support of the PCO in similar situations.

Cyber Threat Assessments

DOT&E remains engaged with key intelligence agencies to ensure the latest cyber intelligence is incorporated into the planning for operational tests and cybersecurity assessments. The Defense Intelligence Agency's Exercise Support Team provides cyber adversary threat assessments, writes realistic cyber scenarios to support CCMD exercises, and provides the cyber threat lead during these exercises.

As network defenses continue to improve, the Intelligence Community will need to credit advanced cyber adversaries with capabilities that have not been observed in employment, but which are known to exist. Additionally, the Intelligence Community will need to improve the characterization of adversary cyber actions, which are expected during wartime. An adversary may reasonably limit cyber activities to development of accesses and exfiltration of information during peacetime, but more aggressive cyber activities may be expected when major combat platforms are committed and force-on-force operations are underway.

Testing of Industrial Control Systems

DOT&E is preparing to assess acquisition programs that employ commercial industrial control systems. DOT&E commissioned testing of four common industrial control systems with the help of Sandia National Labs, Pacific Northwest National Labs, and the Johns Hopkins University Applied Physics Lab. When complete, DOT&E will use the results from these tests to recommend test procedures, and will provide the results to programs to support development of mitigation strategies for discovered cyber vulnerabilities. DOT&E will also make the test environments and virtual instantiations available to the Cyber Mission Force and supporting cyber ranges.

DOD Cyber Strategy

DOT&E is participating in three Lines of Effort from the DOD Cyber Strategy:

- Exercise Assessments. In coordination with the Joint Staff, DOT&E will assess the ability of CCMDs to sustain critical missions in a cyber-contested environment. Activities led by DOT&E such as the PCO and CAMP development (discussed above) will assist in providing assessment opportunities and results.
- Computer Network Defense Metrics and Evaluation. Most systems rely on the host network or environment for cybersecurity protection. Additionally, in most cases, the Cybersecurity Defense Service Providers (CDSP) assumes the majority of key cyber defensive responsibilities and tasks. Therefore, measuring the effectiveness of CDSP capabilities is essential to evaluating the cybersecurity posture of every system. To that end, DOT&E will participate in the development of metrics and test methods to measure CDSP performance.

- Red Team Oversight. DOT&E, in coordination with the Chairman, Joint Chiefs of Staff, will establish an oversight system of all DOD Cyber Red Teams; these include opposing force aggressors, cyber system penetration testers, and teams that perform operational cybersecurity assessments. The demand for Cyber Red Teams in all three of these primary roles has grown over the past several years, and DOT&E projects the demand will continue to grow. This effort will help ensure that cyber Red Teams are resourced, organized, trained, and equipped to effectively meet the increasing mission requirements.

Cyber Protection Team (CPT) Training and Experimentation

DOT&E, in partnership with USCYBERCOM J7, conducted a pilot Collective Team Training course for CPTs from April 13 through May 19, 2015, at Camp Dawson, West Virginia. Participants included three, 15-man Quick Reaction Force (QRF) cyber teams from both Army and Navy CPT units. Students were initially trained in four functional cyber defensive groups (Harden, Monitor, Coordinate, and Pursue) and then brought together into a QRF team construct. DOT&E evaluated the performance of the three QRF teams during force-on-force cyber engagements designed to simulate typical CPT mission deployments.

DOT&E conducted a follow-up CPT Performance Assessment Experiment in July and August 2015 to compare performance of CPTs that received collective team training with CPTs that had no team training. Emerging results indicate CPTs that received team training performed significantly better than those without training. DOT&E also observed that some individuals assigned to CPTs do not possess the proper training, background, or motivation to become effective CPT members. DOT&E acquired and enhanced survey tools that can help determine individual suitability for CPTs, and offered these tools to USCYBERCOM and Service cyber components.

DOT&E will provide the aggregated results to USCYBERCOM and the Service cyber components to help inform decisions regarding future CPT training. DOT&E expects that significant time on realistic ranges will be instrumental to CPTs attaining an effective operational capability. This effort also demonstrated that an unclassified range has cost, schedule, and availability advantages over a classified range for a subset of CPT training needs.

Cyber Ranges

The DOD Enterprise Cyber Range Environment is a collection of four independent cyber range assets where classified training and testing can occur. In 2011, these ranges were experiencing budget cuts and were becoming unsustainable. DOT&E proposed critical enhancements for these cyber ranges and the establishment of an EA in 2012; additional funding was programmed in the FY13 Program Review, but there was no decision for an EA.

The FY15 NDAA directed DOD to establish an EA for cyber training ranges and an EA for cyber testing ranges; the NDAA does not preclude the EAs from being a single entity. As combined testing and training are mandatory for the ranges' efficient use, and more importantly for keeping pace with the rapidly evolving cyber threats, the creation of two separate EAs—with separate responsibilities and incentives—would make it difficult to continue to conduct combined activities in a timely manner. Despite this, the Department appears to be on a path to create two separate EAs. This will likely hinder the Department's ability to respond to rapidly evolving and increasingly sophisticated cyber threats. In order to provide the optimal cyber range posture for the DOD, a single EA should be designated for cyber ranges with the authority to oversee funding and personnel for all DOD-owned cyber ranges, and the authority to identify and certify commercial cyber range resources for DOD use, as appropriate.

Observations

In FY15, cybersecurity assessment teams consistently identified vulnerabilities which place DOD missions at high risk from cyber compromise, exploitation, and disruption. Although mission impacts are not always permitted during exercises, DOT&E assesses the likelihood and magnitude of impacts to missions based on accesses achieved by the Cyber OPFOR. In many cases, DOT&E has assessed that catastrophic kinetic impacts could be enabled by the information the Cyber OPFOR has accessed.

The limitations imposed upon the Cyber OPFOR by exercise authorities continue to reduce the value of both cybersecurity assessments and training of the Service member and network defenders. Exercise authorities for several CCMDs are working with DOT&E and assessment teams to identify or develop better venues in which cyber effects can be demonstrated to stress networks, defenses, and missions. In light of well-publicized intrusions into U.S. Government networks this fiscal year, exercise authorities should move aggressively to maximize training in realistic cyber-threat environments.

DOT&E observed a continued increase in the participation of CDSPs during FY15 exercises, and also noted growing involvement by CPTs. Although local network defenders, CDSPs, and CPTs need to work to optimize their combined efforts, DOT&E has observed that some cyber attacks were less effective in FY15 than in previous years. The following paragraphs discuss protective measures and reactive capabilities that were observed in FY15.

Protective Cyber Defense – Hindering Attacks. The first line of cyber defenses involves configuring networks and systems to prevent or hinder access by unauthorized parties. In FY15, assessment teams continued to find problems with software configuration and outdated patches, but also confirmed that networks with up-to-date patches and configuration best-practices noticeably hindered the Cyber OPFOR from gaining network access. Assessment teams also reported that successful attacks tended to exploit common information infrastructure via stolen or default credentials, and services such as email, SharePoint, and web portals.

Compared to previous years, assessment teams observed an increasing number of events where protective defenses thwarted lower-capability attacks. Phishing attacks were less successful in networks where email links to internet addresses were disabled; another reason for improvements is likely the heightened awareness and focused training that followed the publicized intrusions on U.S. Government networks.

Network defenders and CCMDs should continue to improve their defensive posture and recognize that more advanced threat capabilities exist. DOT&E is working with the PCO to develop more advanced tools and techniques that are representative of advanced adversary capabilities, which will begin to be employed during FY16 assessments.

Reactive Defense – Responding to Attacks. Reactive defense involves the detection and response to cyber adversaries that have penetrated the protective defenses and are operating within the networks and systems. Defenders typically rely on detecting the signatures of known exploits, noticing unusual activities, or responding to the effects of an attack after it occurs. In one exercise example, defenders identified an intrusion and conducted a coordinated response to shut down a Cyber OPFOR access point. The actions were effective against the original access point, but not sufficiently timely as the cyber OPFOR had already maneuvered to another foothold.

Early detections are critical to reduce the adversary's opportunity to obtain additional network privileges and move to additional network footholds. In another exercise, the assessment team observed effective and timely collaboration across operators and network defenders: an operator noticed an unusual change to a situational-awareness data display, reported the discovery while correcting the errors, and rapidly notified the network defenders who were able to thwart the cyber attack.

DOT&E engaged extensively with CPTs in FY15, developing a better understanding of their mission, how they will support network defense, and metrics for assessment of their performance. DOT&E also began assessment of CCMD processes associated with supporting offensive cyber operations.

Key Findings

CCMDs need an integrated and reactive cyber defense that supplements proper configurations, up-to-date software, and signature-based tools. In order to be effective against an advanced persistent threat, CCMDs will need to be supported by:

- Improved detection of non-signature-based activities such as exfiltration and unauthorized authenticated access
- Accurate cyber situational awareness and timely reporting to enable correlation of information to identify trends and attacks
- Effective response capabilities and playbooks to quickly upgrade defenses via local defenders, CDSPs, or CPTs
- Timely response actions by counter-cyber elements of the Cyber Mission Force

In the course of both operational tests and exercise or site assessments, the assessing organizations often identify vulnerabilities, practices (good and bad), and tools that may have enterprise implications and merit senior leadership review and action. For these vulnerabilities and enhancements, DOT&E publishes finding memoranda to the DOD entities best able to address the situation. In FY15, DOT&E initiated or published research on the following topics:

- Host Based Security System – DOT&E identified newly found shortfalls in the use of this enterprise-wide tool. The Defense Information Systems Agency (DISA) has acknowledged and addressed these findings.
- Special Handling Documents – DOT&E identified shortfalls in the procedures for electronically transmitting special-handling documents. The Joint Staff and Undersecretary of Defense for Policy have acknowledged and addressed these findings.
- Shipboard Tactical Systems – DOT&E identified vulnerabilities with the tactical datalinks supporting afloat platforms. The Navy has acknowledged and addressed these findings.
- Java Beans Open Systems Software – DOT&E identified a number of common vulnerabilities in this widely used software platform. The DOD CIO and DISA are reviewing solutions.
- Industrial Control Systems – DOT&E identified common vulnerabilities in key components of these systems. The Joint Staff, DOD CIO, DISA, and the Services are investigating solutions to the issues identified. DOT&E is sharing test data with the Office of Naval Research on new technology developments related to protecting key control system components.
- Information Condition (INFOCON) Guidance – DOT&E is researching contradictory or incomplete guidance for implementing INFOCON changes that reflect heightened cybersecurity states based on detected or anticipated cyber-adversary actions.
- Cyber tools – DOT&E is researching problems found with the use of Kerberos authentication, the availability of PowerShell utilities, and the effectiveness of software whitelisting and management tools such as AppLocker and Bit9.

Future Assessments

DOT&E plans to focus its FY16 assessment resources on those CCMDs who are willing to permit realistic cyber effects during major exercises and commit to the development of CAMPs and TCRCs. Table 2 provides a list of currently planned FY16 assessments.

TABLE 2. PLANNED CYBERSECURITY ASSESSMENTS IN FY16		
EVENT TYPE	**SYSTEM OR EXERCISE AUTHORITY**	
Exercise Assessment	U.S. Africa Command Epic Guardian 2016	U.S. Pacific Command Pacific Sentry 2016
	U.S. Air Force Red Flag 16-3	U.S. Southern Command PANAMAX 2016
	U.S. European Command Jackal Stone 2016	U.S. Special Operations Command Jackal Stone 2016
	U.S. Cyber Command Cyber Flag/Cyber Guard 2016	U.S. Strategic Command Global Lightning 2016
	U.S. Northern Command Vigilant Shield 2016	U.S. Strategic Command Global Thunder 2016
	U.S. Navy Valiant Shield 16	U.S. Transportation Command Turbo Challenge 2016
Site Assessment	U.S. Central Command Marine Corps Central Command	
	U.S. Marine Corps – II Marine Expeditionary Force Large Scale Exercise	
	U.S. Southern Command – Joint Task Force-Guantanamo	

Test and Evaluation Resources

Test and Evaluation Resources

Test and Evaluation Resources

Public law requires DOT&E to assess the adequacy of operational and live fire testing conducted for programs under oversight, and to include comments and recommendations on resources and facilities available for OT&E and on levels of funding made available for OT&E activities. DOT&E monitors and reviews DOD and Service-level strategic plans, investment programs, and resource management decisions to ensure capabilities necessary for realistic operational tests are supported. This report highlights general areas of concern in testing current systems and discusses significant issues, DOT&E recommendations, and T&E resource and infrastructure needs to support operational and live fire testing. FY15 focus areas include:

- Army Support of OT&E
- Cybersecurity Red Team Personnel Shortfalls
- Cyber Threat Support to T&E
- High Altitude Electromagnetic Pulse (HEMP) Test Capability
- Joint Strike Fighter (JSF) Advanced Electronic Warfare (EW) Test Resources
- Point Mugu Sea Test Range (STR) Enhancements to Support OT&E of Air Warfare Programs
- EW for Land Combat
- Navy Advanced EW Test Resources and Environments
- Equipping Self-Defense Test Ship (SDTS) for Aegis Combat System, Air and Missile Defense Radar (AMDR) and Evolved SeaSparrow Missile (ESSM) Block 2 Operational Testing
- Multi-Stage Supersonic Targets (MSST)
- Fifth-Generation Aerial Target
- Warrior Injury Assessment Manikin (WIAMan)
- Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare (ASW) Platforms and Systems
- Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes
- Signature Data Collection for Infrared (IR) Guided Surface to Air and Hostile Fire Threats to Support Model Development
- Threat Modeling and Simulation (M&S) to Support Aircraft Survivability Equipment (ASE) Testing
- Foreign Materiel Acquisition Support for T&E
- Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA)
- Testing in Urban Environments
- Biological Defense Testing at West Desert Test Center on Dugway Proving Ground, Utah
- Range Sustainability
- Continuing Radio Frequency Spectrum Concerns

Army Support of OT&E

In the 2014 Annual Report, DOT&E recommended that the Army restore the Operational Test Command (OTC) and Army Evaluation Center (AEC) budgets in order to maintain FY14 staffing levels, and ensure staffing levels of the Army T&E Executive are consistent with its mission. In a memorandum to the Secretary of the Army, dated November 12, 2014, DOT&E highlighted the importance of the office of the Army T&E Executive and recommended decisions to reduce staff be reversed. For FY16, the OTC budget has remained flat and the AEC budget has been reduced an additional 4 percent from FY15. Staffing levels at OTC have increased ~7 percent, and AEC staffing has decreased ~1 percent compared to FY14 levels.

During the DOT&E review of the Army's T&E budget and resources, the Army acknowledged that the current staffing levels may cause increased customer billing rates, the inability to conduct simultaneous operational test events, and longer timelines for the release of test reports. DOT&E is concerned that the reduced staffing equates to an inadequate number of experienced T&E staff needed to ensure efficient and timely preparation of TEMPs and test plans. Delays in test planning, execution, and reporting can result in delayed acquisition. The savings generated by further reducing the staff of OTC and AEC could be offset by cost penalties to acquisition programs that are proportional to their respective spend rates multiplied by the duration of delay. Other smaller but valuable programs may be delayed even longer, as priority will be given to the Major Defense Acquisition Programs.

DOT&E will continue to monitor the Army T&E workforce to ensure that it is able to support and not hinder the outcomes of the Army's acquisition programs.

Cybersecurity Red Team Personnel Shortfalls

The increasing demand for certified cyber red teams to support training, operations, and acquisition testing is placing considerable strain on this small professional community within the Department. This demand is driven by the growing desire for acquisition program managers to test their systems during development to discover and address cybersecurity vulnerabilities, the continuing need to perform threat-representative cybersecurity operational testing, and the cybersecurity training needs of the growing number of Cyber Mission Force personnel. The subset of red team personnel certified to operate on live networks are critical to conducting the operational testing and Combatant Command (CCMD) assessments described in the Cybersecurity section of this report. These highly qualified red teams are experiencing the highest

demand, and some of these teams have indicated to DOT&E that they will not be able to support all of the currently planned operational tests.

DOT&E has already seen instances in which tests were rescheduled or could not be performed as planned due to a lack of available cyber teams authorized to conduct cyber operations on live networks and enclaves. The high operational tempo of the red teams has reduced or eliminated opportunities for the teams to train, thereby eroding their ability to ensure their skill level is commensurate with advanced nation state cyber threats. The high operational tempo has also induced a number of experienced red team members to seek higher paying, lower demand jobs outside of the Department, further exacerbating the personnel shortfalls.

A number of initiatives would help address the increasing shortfall of cyber red team personnel:

- Creating pay and other incentives for cybersecurity personnel such as those afforded other highly-trained, critical DOD personnel (e.g. pilots)
- Creating a "Persistent Cyber Opposing Force (OPFOR)" composed of red team members from across the Services to provide efficient, flexible, and threat-realistic cyber effects
- Establishment of dedicated T&E cyber teams, core-funded, rather than program-funded, to preserve continuity of skills
- Creating and implementing "red team in a box" software which can automatically identify common cybersecurity vulnerabilities

Cyber Threat Support to T&E

DOT&E has recognized that the cyber threat has expanded into the wireless domain using radio frequency (RF) transmissions to deliver the threat effect to the intended victim. This new medium of delivery has expanded the testing required to define, analyze, and resolve U.S. weapon system vulnerabilities. The expansion of cyber threat delivery into the RF domain has created a much more diverse EW portfolio and has led the defense industry to begin recognizing the merging of cyber and EW into a much more diverse threat.

The $5.0 Million appropriations increase for Threat Resource Activities allowed DOT&E to expand its understanding of the "wireless" cyber threat and begin the process of defining, cataloging, and incorporating these threats into a classified, online Threat Database available to the Department in support of U.S. weapon system testing. This online tool defines the threat, provides the appropriate contact information for the responsible intelligence organization, and the status of available representations of that threat to include models and simulations, surrogates, and/or hardware/software representations.

DOT&E recognized that efficiencies in our operations could be gained by merging this cyber threat activity with ongoing cybersecurity activities supporting the CCMD and Service assessments as part of the Cybersecurity Assessment Program. DOT&E's Cyber Threat Folder developers, located within Defense Intelligence Agency (DIA), were transferred to the Threat Resource Activity to allow for continued residence in DIA Headquarters and direct access to all pertinent cyber threat data. These cyber threat analysts continue to support the CCMD Cybersecurity Assessment Program while also providing threat data for incorporation into DOT&E's online Threat Database. While working with the DOT&E analysts at DIA Headquarters, the Threat Resource Activity recognized there was a pressing need for the intelligence community and the users of cyber threat information to have a process for easily sharing Cyber Threat Folders. The Threat Resource Activity began the process of developing a Cyber Threat Folder repository that would allow intelligence organizations and the testing community to have access to Service and intelligence organization Cyber Threat Information. This is an ongoing activity that will be "Beta Tested" in FY16.

High Altitude Electromagnetic Pulse (HEMP) Test Capability

DDG 51 Ship Specification, Section 407 establishes requirements for DDG 51 Electromagnetic Pulse (EMP) Protection. Section 407 states that during the guarantee period of the ship, the Government will conduct a full ship EMP test to determine the performance of the ship's electronic systems under simulated EMP conditions.

The Navy currently does not have a capability to conduct a survivability assessment of a full ship to EMP effects. Current Navy practice is to conduct limited testing on ship systems and sub-systems, and then extrapolate these results to the entire ship. This test approach is not technically effective nor cost efficient since it is limited in scope, time consuming, and expensive due to the time required to complete testing a handful of spaces. More importantly, this testing methodology is not performed at sea in an operational mode and doesn't provide the data needed to adequately assess the full ship EMP survivability. Existing EMP modeling and simulation capabilities provide very limited information on ship survivability with significant uncertainties.

After a detailed assessment of current OSD nuclear range capabilities, the OSD Chemical Biological Radiological and Nuclear Survivability Oversight Group – Nuclear (CSOG-N) T&E Working Group Roadmap identified a full ship EMP Threat-Level Simulator (TLS) for warships as their most important T&E gap. Additionally, the Tri-Service Technical Working Group responsible for the development of MIL-STD-4023, HEMP Protection for Military Surface Ships, agreed that a full ship EMP TLS is required for warship EMP threat survivability assurance.

The Chief of Naval Research/Director, Innovation, Technology Requirements, and T&E (N84) has teamed with the Defense Threat Reduction Agency to establish a Ship EMP TLS Test Working Group to inform Navy leadership of the increasing criticality of this threat. The Defense Threat Reduction Agency determined that tests using a full ship EMP TLS is the best approach to demonstrate ship threat-level HEMP protection and mission assurance in accordance with standing Navy requirements. The costs to build a full ship EMP TLS capability are estimated to be $49 – 54 Million. Once operational, the costs to conduct the first nine tests are estimated at $17.5 – $18.6 Million. Full ship EMP TLS testing at sea

will support mission assurance by provide test data for HEMP modeling and realistic HEMP training scenarios for ship crews. At sea testing using this capability will demonstrate full ship EMP survivability and support the U.S. nuclear deterrent posture.

Joint Strike Fighter (JSF) Advanced EW Test Resources

Since February 2012, when DOT&E identified shortfalls in EW test resources, significant progress has been made in some instances, while progress is lacking in other areas. The EW assets being purchased are key to the development, testing, and timely fielding of numerous U.S. systems critical to operating successfully against threats that currently exist, are proliferating, or are undergoing an accelerating pace of significant upgrades. These systems include the JSF, F-22 Increment 3.2 A/B, B-2 Defensive Management System, Long-Range Strike Bomber, and the Next Generation Jammer for the EA-18G. The status of these EW upgrades is displayed in the Table immediately below.

Due to delays and inaction by the F-35 Joint Program Office, the situation at the JSF mission data file reprogramming lab has reached a critical, nearly unrecoverable point.

TABLE 1. RECOMMENDATIONS ON ELECTRONIC WARFARE TEST RESOURCES

DOT&E Recommendation	Current Status
Developing a combination of open- and closed-loop simulators in the numbers required for operationally realistic open-air range testing of JSF and other systems beginning in 2018.	Both the open- and closed-loop efforts are underway. The open-loop effort delivers nine systems between mid-2016 and mid-2017; and is planned to provide an additional 7, for a total of 16, in time to support F-35 IOT&E and other testing in 2018 and beyond. Delivery of the first two open-loop systems is expected by mid-2016. The closed-loop effort is also underway, but the mobile closed-loop systems required for operational testing are not scheduled to be available until mid- to late-2019, well after the planned F-35 IOT&E. The architecture of the open-loop systems will provide adequate test capabilities for F-35 Block 3F IOT&E, in lieu of closed-loop systems.
Upgrading the government anechoic chambers with adequate numbers of signal generators for realistic threat density.	Initial studies of materiel solutions to achieve realistic densities have begun: • The Navy chamber has procured initial test support equipment for direct injection capability and executed a limited F-35 EW test in September 2014. • The Air Force chamber has identified a path forward covering extensive upgrades through 2020. • The JSF program has yet to develop concrete plans to integrate chamber testing into the verification test strategy.
Upgrading the JSF mission data file reprogramming lab to include realistic threats in realistic numbers.	A JSF Program Office-sponsored study to determine upgrade requirements was completed in December 2014. It confirmed the shortfalls identified by DOT&E in February 2012, but also identified many other critical shortfalls preventing effective and efficient mission data file development and reprogramming. Unfortunately, inexplicable delays by the program since this study was completed have resulted in little to no progress in addressing these shortfalls. Also, the program plans to procure fewer signal generators than the study recommended, further jeopardizing the program's ability to generate effective mission data for IOT&E and Block 3F operations.
Providing Integrated Technical Evaluation and Analysis of Multiple Sources intelligence products needed to guide threat simulations.	Products have been completed and delivered, and are being used to support development of the open- and closed-loop threat radar simulators.

Point Mugu Sea Test Range (STR) Enhancements to Support OT&E of Air Warfare Programs

In 2015, the JSF Joint Operational Test Team (JOTT) determined that an ability to conduct operational test missions on the Point Mugu STR could considerably shorten the duration of F-35 IOT&E, the pace of which is currently constrained by the competition with other programs for a limited number of range periods available each week at the Air Force Western Test Range (WTR), in Nevada. Nearly all mission-level testing in IOT&E was originally scheduled to take place at the WTR.

The JOTT assessment concluded that the key to conducting F-35 IOT&E missions at STR was the timely completion and integration of the Air Warfare Battle Shaping (AWBS) system at the STR. AWBS is a variant of the Air-to-Air Range Instrumentation system at the WTR, where it is essential for scoring and post-mission reconstruction and analysis of OT&E missions. At the time of the assessment, the development and integration of AWBS at the STR was stalled due to a severe funding shortfall. In response to the JOTT assessment, DOT&E and USD(AT&L) together allocated $20 Million to fund the shortfall.

About the same time of the JOTT assessment and the DOT&E and USD(AT&L) decision to provide funding for AWBS at the STR, the JSF Program Office decided to discontinue the Lockheed Martin Verification Simulation (VSim), a high-fidelity manned simulation central to the program's operational test plans, and transfer responsibility for the program's manned simulator requirements to Naval Air Systems Command (NAVAIR). The JSF Program Office stopped work on the Lockheed Martin effort

due to severe cost overruns and their assessment that Lockheed Martin would be unable to deliver an adequate VSim capability in time for F-35 IOT&E.

DOT&E is convinced that NAVAIR will likewise be unable to deliver an adequate VSim capability in time for F-35 IOT&E, and that, in particular, NAVAIR will be unable to complete the project within the cost constraints imposed by the Program Office. At the same time, DOT&E recognized that additional infrastructure upgrades for the Point Mugu STR, in addition to the completion and integration of AWBS, would be required to make the STR a robust venue of F-35 operational testing. Specifically, DOT&E determined that the STR needed equipment and software for replicating the air surveillance and command and control infrastructures of a threat integrated air defense system.

Accordingly, DOT&E has recommended to the Secretary of Defense that a significant portion of the money currently allocated for VSim be reallocated to constructing the required integrated air defense system infrastructure at the STR. DOT&E recommendations include buying a variety of systems, a number of which are available off-the-shelf on the international defense market.

EW for Land Combat

Networked mission command systems that support the commander's mission execution across the Brigade Combat Team (BCT) are a cornerstone of the Army's modernization plan. These integrated network capabilities are distributed throughout a combat formation and its support elements, from the brigade command posts down to the individual dismounted Soldier. Commanders using tactical network systems have the unprecedented ability to transfer information such as voice, video, text, position location information, and high-resolution photographs throughout the BCT, and provide individual commanders access to information needed to complete their mission. The expanded use of radio frequency spectrum to support mission command systems with supporting data networks exposes the BCT to contemporary EW threat vectors available to a broad range of potential enemies. As the Army becomes more dependent on these sophisticated network technologies, it is critical that the developmental/operational test communities continue to identify and assess vulnerabilities of these systems. Decision makers must understand the inherent vulnerabilities, as well as the ways in which an enemy may choose to exploit and/or degrade the network.

During operational testing, threat EW is part of a broader capability set that is made available to the OPFOR commander. Ideally, the EW capabilities, tactics, techniques, and procedures employed by the OPFOR during test should represent those of our potential adversaries. At present, there are necessary and severe limitations placed on the location, frequency, time, and amount of power that may be emitted by the threat EW equipment, in order to avoid interference with commercial aircraft and the civilian populations adjacent to the test and training ranges. Realistic threat EW against communication satellites is not allowed during operational testing due to the potential of interfering with satellites supporting commercial and military operations. These limitations cause artificialities in the test environment and affect the OPFOR's ability to degrade the network and combine EW with other lethal attacks. DOT&E recommends that the Army continue to investigate potential technical and procedural solutions to the current limitations. These critical threat test capabilities are needed to support testing of Warfighter Information Network – Tactical Increment 2, Nett Warrior/Rifleman Radio, Mid-Tier Networking Vehicular Radio, Manpack Radio, and Joint Battle Command – Platform.

Navy Advanced EW Test Resources and Environments

Capability for Realistic Representation of Multiple Anti-Ship Cruise Missile (ASCM) Seekers for Surface EW Improvement Program (SEWIP) Operational Testing

This gap in test capability was initially identified in DOT&E's FY13 Annual Report as "Additional Electronic Warfare Simulator Units for Surface Electronic Warfare Improvement Program (SEWIP) Operational Testing." The Navy addressed it with development of a programmable seeker simulator that could represent different ASCM seekers by specifying the electronic waveform emission characteristics for one of several possible threats. However, the effective radiated power (ERP) was not among those characteristics, resulting in simulated attacks by ASCM representations displaying disparate levels of ERP that are unlikely to be encountered during a stream raid attack of two ASCMs (along the same bearing and elevation and within close proximity of one another). The programmable seeker simulator, termed the "Complex Arbitrary Waveform Synthesizer," needs to be modified such that its ERP more realistically represents the second ASCM of a dual ASCM stream raid.

The next SEWIP Block 2 OT&E is projected for FY19. This is to be followed by FOT&E on a Product Line Architecture compliant DDG 51 with Block 2 actually integrated with the Aegis Combat System. This integration was not part of the Block 2 IOT&E. Subsequent FOT&E would be with the DDG 1000 and CVN 78 combat systems. Estimated cost to add the ERP improvement is $5.0 Million.

Long-Term Improvement in Fidelity of ASCM Seeker/Autopilot Simulators for EW Testing

This gap in test capability was initially identified in DOT&E's FY13 Annual Report due to the continued reliance on manned aircraft for captive-carry of the ASCM seeker simulators. Such simulators will be unable to demonstrate a kinematic response to electronic attack by SEWIP Block 3 nor demonstrate the effect such kinematic responses will have on ships' hard-kill (e.g. missiles, guns) systems. Manned aircraft fly too high and too slowly for credible ASCM representation and are unable to represent ASCM maneuvers. Credible ASCM representation requires a vehicle that can fly at subsonic ASCM speeds and lower altitudes than the current Lear Jets; can home on a platform representing a SEWIP Block 3-mounted ship, using a threat-representative radar seeker and autopilot; and can respond realistically to Block 3 electronic jamming. An approach to satisfy this requirement is a recoverable, unmanned

aerial vehicle using embedded, miniaturized simulators that can maneuver at ASCM speeds and altitudes with encrypted telemetry to track seeker/autopilot responses to electronic attack. A human-controlled override capability would be required for safe operation. The remotely controlled Self-Defense Test Ship (SDTS) would tow a ship target for the unmanned aerial vehicles to home on. SEWIP Block 3 would be mounted on the SDTS along with hard-kill systems such that the integrated hard-kill/soft-kill (i.e. SEWIP Block 3) combat system capability could be demonstrated. Currently, such testing is at the discrete combat system element level, leaving integrated combat system capability unknown.

SEWIP Block 3 IOT&E is projected for FY19. FOT&E of Block 3 integrated with the DDG 1000 combat system, as well as FOT&E with the CVN 78 combat system, should occur subsequent to the IOT&E. The cost for development of these unmanned aerial vehicles (with simulators and telemetry) is estimated to be approximately $120.0 Million for development, testing, and acquisition. Estimated unit cost of each vehicle is not expected to exceed $15.0 Million.

Equipping Self-Defense Test Ship (SDTS) for Aegis Combat System, Air and Missile Defense Radar (AMDR) and Evolved SeaSparrow Missile (ESSM) Block 2 Operational Testing

The close-in ship self-defense battle space is complex and presents a number of challenges. For example, this environment requires:

- Weapon scheduling with very little time for engagement
- The necessity of the combat system and its sensors to deal with debris fields generated by successful engagements of individual ASCMs within a multi-ASCM raid
- Rapid multi-salvo kill assessments for multiple targets
- Transitions between ESSM guidance modes
- Conducting BMD and area air defense missions (i.e., integrated air and missile defense) while simultaneously conducting ship self-defense
- Contending with stream raids of multiple ASCMs attacking along the same bearing, in which directors illuminate multiple targets (especially true for maneuvering threats)
- Designating targets for destruction by the Close-In Weapons System

Multiple hard-kill weapons systems operate close-in, including the Standard Missile 2 (SM-2), the ESSM, and the CIWS. Soft-kill systems such as Nulka MK 53 decoy launching system also operate close-in. The short timelines required to conduct successful ship self-defense place great stress on combat system logic, combat system element synchronization, combat system integration, and end-to-end performance.

Navy range safety restrictions prohibit close-in testing on a manned ship because the targets and debris from successful intercepts will pose an unacceptable risk to the ship and personnel at the ranges where these self-defense engagements take place. These restrictions were imposed following a February 1983 incident on the USS Antrim (FFG 20), which was struck with a subsonic BQM-74 aerial target during a test of its self-defense weapon systems, killing a civilian instructor. The first unmanned, remotely controlled SDTS (the ex-Stoddard) was put into service that same year. A similar incident occurred in November 2013, where two sailors were injured when the same type of aerial target struck the USS Chancellorsville (CG 62) during what was considered to be a low-risk test of its combat system. This latest incident underscores the inherent dangers of testing with manned ships in the close-in battlespace.

While the investigation into the Chancellorsville incident has caused the Navy to rethink how they will employ subsonic and supersonic aerial targets near manned ships, the Navy has always considered supersonic ASCM targets a high risk to safety and will not permit flying them directly at a manned ship. The Navy has invested in a current at-sea, unmanned, remotely-controlled test asset (the SDTS) and is using it to overcome these safety restrictions. The Navy is accrediting a high-fidelity modeling and simulation (M&S) capability utilizing data from the SDTS, as well as data from manned ship testing, so that a full assessment of ship self-defense capabilities of non-Aegis ships can be completely and affordably conducted. While the Navy recognizes the capability as integral to the test programs for certain weapons systems (the Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 1) and ship classes (LPD 17, LHA 6, Littoral Combat Ship, LSD 41/49, DDG 1000, and CVN 78), it has not made a similar investment in an SDTS equipped with an Aegis Combat System, AMDR, and ESSM Block 2 for adequate operational testing of the DDG 51 Flight III Destroyer self-defense capabilities. The current SDTS lacks the appropriate sensors and other combat system elements to test these capabilities.

On September 10, 2014, DOT&E submitted a classified memorandum to the USD(AT&L) with a review of the Design of Experiments study by the Navy Program Executive Office for Integrated Warfare Systems, which attempted to provide a technical justification to show the test program did not require an SDTS to adequately assess the self-defense capability of the DDG 51 Flight III Class Destroyers. DOT&E found that the study presented a number of flawed justifications and failed to make a cogent argument for why an SDTS is not needed for operational testing.

On December 10, 2014, the Deputy Secretary of Defense issued a memorandum directing the Director, Cost Analysis/Program Evaluation (CAPE) to identify viable at-sea operational testing options that meet DOT&E adequacy requirements and recommend a course of action (with cost estimates, risks, and benefits) to satisfy testing of the AMDR, Aegis Combat System, and ESSM Block 2 in support of the DDG 51 Flight III Destroyer program. The CAPE study evaluated four options to deliver an at-sea test platform adequate for self-defense operational testing of the DDG 51 Flight III, AMDR, and ESSM Block 2 programs. Each option requires funding beginning in FY18 to ensure support of operational testing of these systems in FY22.

A decision on whether to fund the procurement of the needed equipment is pending.

DOT&E continues to recommend equipping an SDTS with capabilities to support Aegis Combat System, AMDR, and ESSM Block 2 OT&E to test ship self-defense systems' performance in the final seconds of the close-in battle and to acquire sufficient data to accredit ship self-defense performance M&S. The CAPE-estimated cost for development and acquisition of these capabilities over the Future Years Defense Program is approximately $350 Million. Of that, approximately half could be recouped after the test program completes by installing the hardware in a future DDG 51 Flight III Destroyer hull. The Navy previously agreed with this "re-use" approach in their December 2005 Air Warfare/Ship Self-Defense Test and Evaluation Strategy stating that "… upon completion of testing and when compatible with future test events, refurbish and return the test units to operational condition for re-use."

Multi-Stage Supersonic Targets (MSST)

The Navy initiated a $297 Million program in 2009 to develop and produce an adequate multi-stage supersonic target (MSST) required for adequate operational testing of Navy surface ship air defense systems. The MSST is critical to the DDG 1000 Destroyer, CVN 78 Aircraft Carrier, DDG 51 Flight III Destroyer, LHA(R), AMDR, Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 2 operational test programs. The MSST underwent a re-structure/re-baseline from 2013 – 2015 to address technical deficiencies as well as cost and schedule breaches, which would have postponed its initial operational capability (IOC) to 2020 and increased total program cost to $962 Million. Based on the re-structured/re-baselined MSST program's high cost and schedule delays as well as new intelligence reports, the Assistant Secretary of the Navy for Research, Development, and Acquisition in 2014 directed that alternatives be examined to test against these ASCM threats and subsequently terminated the MSST program. While the details of the final alternative are classified, DOT&E determined that it would be very costly (Navy estimates $739 Million), very difficult to implement, dependent on the results of highly segmented tests, and would suffer from severe artificialities that would hopelessly confound interpretation of test results. DOT&E informed the Navy that the proposed alternative was not adequate for operational testing and recommended that the Navy not pursue it.

The failure of the MSST program and the inadequate alternative proposal is perpetuating poor Fleet understanding of how well or how poorly their surface combatants will be able to defend themselves against MSST-like ASCM threats. The requirement for a viable, cost-effective, adequate MSST target for operational testing remains valid. Nonetheless, DOT&E agrees that terminating the failed MSST program was the correct decision.

Fifth-Generation Aerial Target

DOT&E initiated studies in 2006 on the design and fabrication of a dedicated fifth-generation aerial target to evaluate U.S. weapon systems effectiveness. The study team, comprised of Air Force and Navy experts, retired Skunk Works engineers, and industry, completed a preliminary design review for a government-owned design. DOT&E requested $27 Million in the FY17 program review to complete final design, tooling, and prototyping efforts. The prototyping effort will provide cost-informed, alternative design and manufacturing approaches for future air vehicle acquisition programs. This data can also be used to assist with future weapon system development decisions, T&E infrastructure planning/investment, and could support future analysis of alternative activities. The prototype design directly supports the U.S. Strategic Command, U.S. Pacific Command, and U. S. Northern Command's Defense Innovation Initiatives for persistent cooperative unmanned aerial systems engagement.

Warrior Injury Assessment Manikin (WIAMan)

In 2010, after the publication of the DOT&E survivability evaluation of the MRAP Family of Vehicles, the Secretary of Defense directed an evaluation of underbody blast (UBB) modeling and simulation (M&S) tools. This evaluation was to determine if an enhanced UBB M&S capability could identify potential vulnerabilities in ground combat vehicle designs while still in the early stages of development. The evaluation identified 10 major gaps preventing the development of a comprehensive, robust UBB M&S capability to accurately model the effects of UBB. The top three gaps were all associated with the shortcomings in available instrumentation and criteria to assess human injury in the UBB environment. The evaluation concluded that automotive crash test dummies used in LFT&E and the consequent injury criteria designed and developed for forces and accelerations in the horizontal plane as seen in automotive frontal impact-induced injuries were not adequate to assess the effects of the forces and accelerations in the vertical plane typically seen in combat-induced UBB events.

In 2010, DOT&E submitted an issue paper advocating the need to fund the identified gaps and shortcoming in current LFT&E practices. This led to the Warrior Injury Assessment Manikin (WIAMan) project with an $88 Million budget over the FY12-16 Future Years Defense Program. Under the WIAMan project, the Army initiated critical biomechanical research and the anthropomorphic test devices (ATD) development program to increase DOD's understanding of the cause and nature of injuries incurred in UBB combat events.

In 2013, the Army created a dedicated office (the WIAMan Engineering Office (WEO)) under the Army Research, Development, and Engineering Command (RDECOM) to manage the WIAMan project. In 2015, the office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology designated the WIAMan project as an Acquisition Category II acquisition program of record under the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI). PEO STRI and RDECOM finalized the WIAMan Test Capabilities Requirements Document and a formal Program Office Estimate for full funding of the program. The technical achievements made by the WEO and the concerted effort by the Army to create the foundation for a formal acquisition program

represent major steps forward for the WIAMan project, and the effort is poised to made additional progress in FY16 and beyond, assuming remaining funding is allocated to allow for its completion.

The Assistant Secretary of Defense (Health Affairs) has committed Science &Technology funding to the program post-Milestone B to ensure critical injury biomechanics research is completed, but this commitment has not been matched by a similar commitment from the Army to program for the ATD production and procurement. This led DOT&E to submit another issue paper for additional funding of $98 Million through FY21 that would enable the completion of research and development of injury criteria, predictive M&S, and development of the technical data package including two generations of prototype ATDs. The Army has still not provided funding past FY17 jeopardizing the continuity and completion of this project.

Some within the Army have questioned whether DOD still needs a combat-specific injury assessment capability but in the view of DOT&E, it is entirely appropriate for DOD, and in particular for the Army, to accord the same high priority to testing and verifying the protection provided to Soldiers by their combat vehicles that the commercial automotive industry accords to testing and verifying the protection provided to the U.S. public by their automobiles.

Torpedo Surrogates for Operational Testing of Anti-Submarine Warfare (ASW) Platforms and Systems

Operational testing of ASW platforms and related systems includes the ability to detect, evade, counter, and/or destroy an incoming threat torpedo. The determination of system or platform performance is critically dependent on a combination of the characteristics of the incoming torpedo (e.g., dynamics, noise, fusing, sensors, logic, etc.). Due to differences in technological approach and development, U.S. torpedoes are not representative in many of these torpedo characteristics for many highly proliferated torpedoes, particularly those employed in Anti-Surface Warfare by other nations. Operational testing that is limited to U.S. exercise torpedoes will not allow the identification of existing limitations of ASW systems and related systems against threat torpedoes and will result in uninformed decisions in the employment of these same systems in wartime. A January 9, 2013 DOT&E memorandum to the Assistant Secretary of the Navy for Research, Development, and Acquisition identifies specific threat torpedo attributes that the threat torpedo surrogate(s) must be evaluated against. A June 18, 2015 DOT&E memorandum to Assistant Secretary of the Navy for Research, Development, and Acquisition reiterated the need for representative threat torpedo surrogates in operational test and emphasized understanding threat torpedo behavior, including tactics and counter-measure logic, when evaluating adequacy of torpedo surrogates. The non-availability of threat-representative torpedo surrogates will prevent adequate operational testing for ASW platforms and related systems, as well as adversely affect tactics development and validation of these tactics within the fleet.

Naval Undersea Warfare Center (NUWC) Division Keyport commenced a study of threat torpedo surrogates in FY14. The $480,000 study is jointly funded by the Navy and DOT&E. The completed study, dated September 4, 2015, confirmed DOT&E concerns that current torpedo surrogates have significant gaps in threat representation for operational testing and provided recommendations for improving current threat torpedo emulation. However, the Navy has yet to provide its plan for adequate torpedo surrogates to effectively characterize system performance in future operational tests.

NUWC Division Keyport is pursuing a prototype technology development project that will deliver a threat-representative high-speed quiet propulsion system. The development of a propulsion system prototype is intended to overcome a critical gap identified in the torpedo threat surrogate capability gap analysis, discussed in the preceding paragraph. This effort is funded by DOT&E at approximately $1.0 Million with delivery scheduled in 4QFY16. The NUWC Division Keyport study and prototype development could support future development of a threat torpedo surrogate. Procurement of adequate threat torpedo surrogates, however, is dependent on future Navy decisions.

Submarine Surrogates for Operational Testing of Lightweight and Heavyweight Torpedoes

The Navy routinely conducts in-water operational testing of lightweight and heavyweight ASW torpedoes against manned U.S. Navy submarines. Although these exercise torpedoes do not contain explosive warheads, peacetime safety rules require that the weapons run above or below the target submarine with a significant depth stratum offset to avoid collision. While this procedure allows the torpedo to detect, verify, and initiate homing on the target, it does not support assessment of the complete homing and intercept sequence. One additional limitation is the fact that U.S. nuclear attack submarines may not appropriately emulate the active target strength (sonar cross-section) of smaller threats of interest, such as diesel-electric submarines. During the MK 50 lightweight torpedo operational test in May 1992, the Navy conducted some limited set-to-hit testing against manned submarines, which included impact against the target hull, but that practice has been discontinued.

In preparation for the 2004 MK 54 lightweight torpedo operational test, DOT&E supported the development and construction of the unmanned Weapon Set-to-Hit Torpedo Threat Target (WSTTT) using Resource Enhancement Project (REP) funding. The WSTTT was a full-sized steel mock-up of a small diesel-electric submarine, with an approximate program cost of $11 Million. As a moored stationary target, the WSTTT was limited in its ability to emulate an evading threat, but its use in the MK 54 operational test demonstrated the value of such a dedicated resource. Unfortunately, the Navy did not properly maintain the WSTTT and abandoned it on the bottom of the sea off the California coast in 2006. In subsequent years, the Navy was able to make some limited use of the WSTTT hulk as a bottomed target for torpedo testing.

In a separate effort, the Navy built the Mobile Anti-Submarine Training Target (MASTT), designed to serve as a full-sized threat surrogate for use in training by surface and air ASW forces. The Chief of Naval Operations initiated the program in 2010 with the goal of achieving operational capability by late 2011. After four years and an expenditure of approximately $15 Million, the Navy has yet to use the MASTT in training and seems to be on the brink of abandoning the asset. The Navy resisted design input from the operational test community and made it clear that the MASTT was not intended to support torpedo testing.

In support of a 2010 Urgent Operational Need Statement, the Navy funded the construction of the Steel Diesel-Electric Submarine (SSSK), a full-sized moored set-to-hit target consisting of an open steel framework with a series of corner reflectors to provide appropriate sonar highlights. Unfortunately, this surrogate does not, in fact, provide a realistic sonar signature. Nonetheless, the Navy used the SSSK as a target for the MK 54 torpedo in a 2011 Quick Reaction Assessment and 2013 FOT&E. As part of the Test and Evaluation Master Plan approval for the latter, DOT&E sent a memorandum indicating that the Navy must develop an appropriate mobile target to support future MK 54 testing.

Since early 2013, DOT&E has participated in a Navy working group attempting to define the requirements for a mobile set to hit torpedo target. The group has identified a spectrum of options and capabilities, ranging from a torpedo-sized vehicle towing a long acoustic array to a full-sized submarine surrogate. At the very least, the target is expected to be mobile, autonomous, and certified for lightweight torpedo set-to-hit scenarios. More advanced goals might include realistic active and passive sonar signatures to support ASW search and reactive capability to present a more realistically evasive target. Cost estimates range from under $10 Million for a towed target to over $30 Million for a full-sized submarine simulator.

Signature Data Collection for Infrared (IR) Guided Surface to Air and Hostile Fire Threats to Support Model Development

Threat M&S capabilities are essential for testing missile warning and countermeasure systems under development. However, models for IR guided surface to air and unguided threat weapons do not adequately represent the threat characteristics for testing modern missile warning systems and are deficient. To support threat model development, an integrated, transportable capability to measure and record high fidelity signature, Time Space Position Information, and related information for live fire testing of threat missile and hostile fire munitions (e.g., small arms and RPG) firings was ranked as a high priority need by the Infrared Countermeasures Test Resource Requirements Study (ITRRS) team and the Threat M&S Roadmap. Additionally, the Aircraft Survivability Equipment (ASE) Program Offices from each Service have endorsed this need for assessment of ground truth, anomaly resolution, and to enhance M&S capabilities for the development and T&E of aircraft self-defense systems.

DOT&E supports the use of common, authoritative threat M&S capabilities for ASE testing. For example, the DOT&E Center for Countermeasures serves as the executing activity for a Test Resources Management Center (TRMC) Central Test and Evaluation Investment Program (CTEIP) REP, known as Joint Standards Instrumentation Suite (JSIS). When available, the JSIS IOC will support Advanced Threat Warner and Department of the Navy (DoN) Large Aircraft Infrared Countermeasure (LAIRCM) operational testing. JSIS can be deployed to OCONUS static live fire venues where opportunities exist to measure and collect data for threat assets that are either not available, or of insufficient quantities domestically. JSIS data will support improvements to existing threat models and help create models of new threats. JSIS will provide a capability for use by each Service and support other operational testing needs.

However, the JSIS IOC capability only partially addresses the needs identified by the ITRRS team. For example, it will not provide the capability to measure missile attitude information for the entire missile flyout, nor will the JSIS IOC capability meet all needs related to signature collection fidelity (i.e., frame rates and resolution). Full operational capability is required to meet the needs of the Army's Common Infrared Countermeasures (CIRCM) program, Navy's Advanced Threat Warning, Air Forces' LAIRCM program, and Navy Research Laboratory's Distributed Aperture Infrared Countermeasure (DAIRCM) program. JSIS requires an additional investment of $25 Million to provide the full operational capability needed for Infrared Countermeasures (IRCM) T&E.

Threat Modeling and Simulation (M&S) to Support Aircraft Survivability Equipment (ASE) Testing

Acquiring actual threat systems for widespread testing may not be possible. To address this challenge, DOT&E has funded standard, authoritative threat M&S for systems T&E. In some cases, threat M&S used in T&E have not provided accurate representations, and different M&S instantiations of the same threats often produced different results. DOT&E's objective is to improve the fidelity and consistency of threat M&S at various T&E facilities while reducing overall test costs.

Throughout the T&E process, M&S representations of threat systems can be used when actual threat components are not available. M&S can provide a more complete testing capability than possible through open-air facilities alone. It supports testing when flight safety precludes live testing, such as missile launches against manned aircraft. Threat M&S may be used to extend the results of live missile test events across a broader range of test conditions, with different threats, ranges, altitudes, aspect angles, atmospheric conditions, and other environmental variables affecting weapon system performance.

DOT&E has a T&E Threat M&S Configuration Management System to implement controls and distribution management for threat M&S. This Configuration Management System ensures integrity and consistency of test results among various T&E M&S regimes. This system also provides mechanisms to identify and correct anomalies between a threat and its M&S representations. It assists in controlling model configuration changes, maintaining critical documentation such as interface

descriptions and validation documents, and sharing updated threat M&S with multiple T&E facilities. The T&E Threat M&S Configuration Control Board, comprised of representatives from the T&E community and intelligence organizations, prioritizes existing threat M&S developments and changes to ensure updates are provided efficiently to T&E user facilities. Requests for T&E threat M&S, anomaly reports, and change requests are managed by DOT&E.

During FY15, the T&E Threat Resource Activity provided standardized authoritative threat M&S to multiple T&E facilities operated by the Army, Navy, and Air Force in support of Aircraft Survivability Equipment (ASE) testing. DOT&E has engaged our closest allied nations in implementing the same authoritative threat M&S for allied T&E. This allows the U.S. and its allies to efficiently leverage each other's ranges and facilities.

DOT&E developed and updated a Threat M&S Roadmap for ASE T&E to provide a comprehensive plan for future threat M&S. A good example is JSIS, which will capture threat data from live test events. The Roadmap identifies projects to conduct systematic analyses of the JSIS data to feed the development of threat-representative M&S to support U.S. and allied missile warning and infrared countermeasure systems.

Foreign Materiel Acquisition Support for T&E

DOT&E is responsible for ensuring U.S. weapons systems are tested in realistic threat environments using actual threat systems to create these threat environments whenever possible and appropriate. DOT&E develops an annual prioritized list of threat requirements tied to upcoming testing of programs. This list is submitted it to the DIA Joint Foreign Materiel Program Office. These requirements are consolidated with Service needs and then processed through various Service and intelligence community collection activities. DOT&E coordinates with the Department of State to identify resource providers to increase opportunities to acquire foreign materiel for use in OT&E.

Foreign materiel requirements span all warfare areas, but DOT&E continues to place a priority on the acquisition of Man-Portable Air Defense Systems (MANPADS) to address significant threat shortfalls that affect testing for IRCM programs like CIRCM, LAIRCM, and DoN LAIRCM. In some programs, a large number of MANPADS are required for development of threat M&S, for use in hardware-in-the-loop laboratories, and for LFT&E, to present realistic threats to IRCM equipment. Using actual missiles and missile seekers aids evaluators in determining the effectiveness of IRCM equipment. This past year, several ongoing Foreign Material Acquisition efforts have led to new opportunities to acquire IRCM equipment.

When acquiring specific hardware is not possible, the acquisition of technical documentation may be possible. Evaluating technical documentation is valuable because it supports the development of specific threat simulators to be used at T&E ranges and facilities.

Due to the inherent challenge of developing reliable sources for foreign materiel, negotiating the acquisition of foreign materiel, and the difficulty of using annual appropriations for foreign materiel acquisitions, DOT&E supports the establishment of dedicated, non-expiring funding authority within the DOD Foreign Materiel Program to support foreign materiel acquisitions.

Tactical Engagement Simulation with Real Time Casualty Assessment (TES/RTCA)

Realistic operational environments and a well-equipped enemy intent on winning are fundamental to the adequate operational test of land and expeditionary combat systems. Force-on-force battles between tactical units represent the best method of creating a complex and evolving battlefield environment for test and training. Simulated force-on-force battles must contain realism to cause commanders and Soldiers to make tactical decisions and react to the real-time conditions on the battlefield. TES/RTCA systems integrate live, virtual, and constructive components to enable these simulated force-on-force battles, and provide a means for simulated engagements to have realistic outcomes based on the lethality and survivability characteristics of both the systems under test and the opposing threat systems. TES/RTCA systems must replicate the critical attributes of real-world combat environments such as direct and indirect fires, IEDs and mines, realistic battle damage, and casualties. TES/RTCA systems must record the time-space position information and firing, damage, and casualty data for all players in the test event as an integrated part of the test control and data collection architecture. Post-test playback of these data provides a critical evaluation tool to determine the combat system's capability to support Soldiers and Marines as they conduct combat missions.

DOT&E has recommended the Army Test and Evaluation Command (ATEC) and the Marine Corps Test and Evaluation Activity (MCOTEA) leverage existing TES/RTCA capabilities to support upcoming operational tests and make necessary investments to meet known capability shortfalls and future requirements. Shortfalls include the ability to seamlessly simulate indirect fire weapons, IEDs/mines, and air-to-ground/ground-to-air combat including manned and unmanned teaming. Future requirements include new and upgraded combat vehicles, expanded use of remote weapon stations, and evolving threat systems.

In FY15, the Army increased their planned funding for the Integrated Test Live, Virtual, and Constructive Environment (ITLE) project, which was created to address the known TES/RTCA capability shortfalls and future Army requirements. ITLE will adapt and integrate a number of currently disparate capabilities and take advantage of recent investments made by the Army training community. DOT&E is encouraged by the increase in dedicated TES/RTCA resources and the continued cooperation between the test and training communities in the Army. Beginning in FY16, ATEC is working to resolve issues with its airborne TES/RTCA capability in support of upcoming operational tests of the Apache, Gray Eagle, and Shadow manned/unmanned teaming capability. Funding for this upgrade was anticipated to be provided by the CTEIP REP, but was

diverted to other higher priority efforts. DOT&E continues to support CTEIP and ATEC funded efforts to provide this needed capability.

The Marine Corps' current force-on-force training system, the Instrumented Tactical Engagement Simulation System II, does not support combat vehicle engagements. MCOTEA had planned a substantial upgrade beginning in FY16 to support the upcoming operational testing of the Amphibious Combat Vehicle and Amphibious Assault Vehicle – Survivability Upgrade programs. Funding for this upgrade was anticipated to be provided by the CTEIP REP, but was diverted to other higher priority efforts. DOT&E continues to support CTEIP and MCOTEA funded efforts to provide this needed capability.

TES/RTCA capabilities are essential for realistic force-on-force testing of current and future land and expeditionary warfare systems; DOT&E requires these capabilities for systems such as Amphibious Combat Vehicle, Bradley and Abrams Upgrades, Armored Multi-purpose Vehicle, AH-64E Block III, Joint Light Tactical Vehicle, and Stryker Upgrades.

Testing in Urban Environments

Operations in urban environments present unique challenges to the military Services and their equipment. Degraded mobility, communications, and situational awareness; a large civilian presence; the risk of collateral damage; reduced stand-off distances; and unique threat profiles are some of the conditions present during urban operations. These challenges and a world population that is becoming increasingly urban, reinforce the requirement that systems conduct operational testing in realistic urban environments.

From 2009 to 2011, the Army conducted the Urban Environment Test Capability study that collected data on cities around the world and characterized aspects of urban environments important to military operations. The Urban Environment Test Capability final report was used to support a Test Capabilities Requirements Document for the Army led Joint Urban Test Capability (JUTC) project. The JUTC planned to build a reconfigurable urban area with modular structures from one to five stories tall on the White Sands Missile Range (WSMR), New Mexico. The JUTC began design and development efforts in 1QFY12, but was canceled in 2QFY15 due to programmatic delays, a de-scoping of the original requirement, and cost growth.

The result of the cancellation of JUTC is that the long-standing urban environment operational and developmental test capability shortfall has not been addressed. DOT&E recommends that the Army focus research funding on the fundamental engineering challenges of producing an affordable structure concept that could be applied not only at WSMR, but also on other test and training ranges where operational tests are conducted. The JUTC Test Capability Requirement should be revisited to capture current T&E requirements and future efforts should take into consideration the lessons learned from the failure of JUTC.

Biological Defense Testing at West Desert Test Center on Dugway Proving Ground

In late FY15, DOD suspended the production of and testing with biological select agents and toxins (BSAT) and derivatives of BSAT materials at Dugway Proving Ground pending an investigation and review of safety and surety protocols and procedures. The suspension has temporarily imposed limitations to DOD's ability to test and evaluate biological defense systems. As directed by Deputy Secretary of Defense, a Biosafety Task Force is reviewing all DOD activities engaged in handling BSAT and providing recommendations to ensure the safety and surety of DOD protocols and procedures. The West Desert Test Center Life Sciences Division will be required to implement improved biosafety and surety protocols and procedures before seeking Centers for Disease Control and Prevention certification to operate at Bio Surety Level Three to resume full test capabilities. West Desert Test Center has unique biological testing facilities that provide operationally realistic T&E of biological defense systems.

Range Sustainability

Adequate mission space to conduct operationally realistic testing on DOD's air-land-sea test and training ranges is a critical resource for developing weapons systems that are effective, reliable, and lethal. DOD test and training ranges face environmental and mission compatibility encroachment challenges that, if not resolved successfully, will adversely affect test capabilities. Accordingly, DOT&E continues efforts on behalf of the T&E community to assess, mitigate where possible, and resolve compatibility challenges so that DOD's mission space is preserved for operationally realistic testing.

DOT&E is focusing on improvements to compatibility evaluation processes, so that deficiencies can be addressed promptly, and with analytical rigor and documentation to support decision makers. The continuing major areas of concern for compatibility evaluations are:

- Wind energy and transmission line projects
- Outer Continental Shelf (OCS) oil and gas leasing
- Foreign investment
- Threatened and endangered species

Wind energy projects, can adversely affect testing capabilities by interfering with test range radars and datalinks. DOD receives, on average, 66 such projects a month for evaluation of risk to mission capabilities. A significant improvement in the DOD evaluation process in 2014 resulted in more timely and effective consideration of projects undergoing review. For example, where a wind turbine project was found to have the potential to seriously degrade radar cross section testing at the Naval Air Warfare Test Center, Patuxent River, Maryland, a timely DOD objection on the basis of Adverse Impact to National Security was filed with the Department of Transportation based on a

thorough evaluation by DOD, and the developer subsequently withdrew the application for the project.

There has been an increase of over 20 percent, between 2014 and 2015, in the number of transmission line projects referred to DOD for review for compatibility concerns. DOT&E actively participated in the review of these projects, and coordinated its evaluations with those of other DOD components. In the case of the SunZia transmission line project, DOT&E-led test-related reviews determined that the proposed line routing would impair networked missile intercept testing at WSMR. DOD reached an agreement with the Bureau of Land Management to bury portions of the transmission lines in areas most critical for missile intercept testing. Subsequently, DOT&E conducted a post-decision SunZia lessons learned study intended to help improve DOD evaluation processes, and to include more effective interaction with other federal agencies.

DOT&E continues to work with the office of the Assistant Secretary of Defense (Readiness) to coordinate the DOD response to the Bureau of Ocean Energy Management on proposed oil and gas lease plans for the OCS. Areas considered for such leases are often the same areas where DOD testing must be conducted. Continued use of these areas is critical so that test realism is achieved and public safety is preserved. Consequently, DOT&E is engaged in evaluating test capability risk from proposed leaseholds in the OCS and representing those risks in developing the Bureau of Ocean Energy Management 2017 to 2022 lease plan so that weapons system testing requirements are balanced with national energy needs.

Foreign investment in the United States near test ranges is a new concern due to possible security risks for foreign data collection. Recognizing this concern, DOD refers some 20 projects per month from the Congressional Committee on Foreign Investment in the United States to DOT&E for evaluation. An analysis methodology, developed by DOT&E, is being used to determine whether there are potential risks to test resources.

Species and habitat environmental concerns continue to be issues for test ranges. There are 145 candidate species now awaiting U.S. Fish and Wildlife Service listing determinations, including 25 species which could potentially impact military test and training. To ensure a balance of testing requirements with species protection, DOT&E monitors potential impacts to test ranges. In collaboration with other DOD and Federal Agencies, DOT&E continues to seek proactive solutions that will minimize negative impacts for use of range space.

DOT&E's range sustainability work also relies on outreach with regional partnerships to include the Southeast Regional Partnership for Planning and Sustainability, Western Regional Partnership, Land Trust Alliance, other Federal agencies, the Range Commanders Council, and Service Program Executive Offices. This outreach provides a mechanism for mutual understanding of DOD and external-to-DOD requirements in addressing range sustainability issues. This outreach enables DOD to educate external organizations on why resources are needed for test purposes, and at the same time gives DOD improved access to, and awareness into, external-to-DOD information and processes.

Continuing Radio Frequency Spectrum Concerns

Adequate frequency spectrum is a critical resource for testing. It is required to both upload and download test data between the article being tested to test instrumentation, and to control resources during test operations. At the World Radiocommunication Conference 2007 (WRC-07), the United States position was that there is a large and growing shortfall of global or regional Aeronautical Mobile Telemetry (AMT) allocations. With increasing data rates associated with the testing of new and emerging technologies, the United States believed that an additional 650 Megahertz (MHz) would be required for AMT.

Test range use of frequency spectrum continues to be challenged by pressures to repurpose spectrum to broadband wireless and to support emerging technologies such as small unmanned airborne systems. With domestic and international spectrum being repurposed for non-defense wireless transmission needs, DOT&E remains actively engaged with the DOD Chief Information Officer, Deputy Assistant Secretary of Defense (Developmental Test and Evaluation), and TRMC, to ensure that frequency spectrum allocations are sufficient for the conduct of test operations, and also that these operations use frequency efficiently. This spectrum efficiency goal is being actively pursued through the TRMC administered Science and Technology program and CTEIP.

DOT&E documented the pending loss of the 1,755 – 1,780 MHz band and compression into 1,780 – 1,850 MHz in its FY13 Annual Report. This loss occurred during the Advanced Wireless Services – 3 auction, which concluded January 29, 2015. The impacts to the Services' T&E infrastructure for transitioning AMT capabilities from this spectrum in the L-band are:

- Army T&E requires ~ $27.7 Million to retrofit Aerial Telemetry Systems at WSMR and to compress operations into the 1,780 – 1,850 MHz band. An additional $1.0 Million is required to replace point-to-point datalinks at Aberdeen Test Center, Aberdeen Proving Ground, Maryland. Testing of robotics will be relocating to 4 Gigahertz (C-band), which will require new equipment to be installed.
- Navy T&E requires ~ $108 Million to compress AMT operations into the 1,780 – 1,850 MHz band and to make smart investments in ground and airborne infrastructure to utilize C-band AMT frequencies where practicable. In accordance with the National Telecommunications and Information Administration, Federal Communications Commission (FCC) and Office of Management of Budget approved transition plan, the Navy will modify ground and airborne AMT systems, including incorporating more efficient telemetry modulation techniques, adding multi-band antennas, and installing interference-monitoring equipment. The Navy transition plan also accounts for Missile Defense Agency (MDA)

requirements. Timelines for transition range from 36 months (MDA) to 102 months, depending on the installation. To minimize impacts on operational military mission capabilities, the Navy will also purchase five mobile/transportable telemetry units to supplement capacity while AMT receiver sites are offline for modification.

- Air Force T&E requires ~ $348 Million to compress into the 1,780 – 1,850 MHz band. The funds are required to modify ground and airborne systems, including incorporating more efficient modulation techniques, adding multi-band antennas, and installing interference-monitoring equipment. Timelines for this transition range from 66 to 120 months, depending on the installation. To minimize impacts on operational military mission capabilities, the Air Force will also purchase six mobile/transportable telemetry units to supplement capacity while AMT receiver sites are offline for modification.

Table 2 illustrates the frequency bands used for T&E, and identifies resource deficiencies and their potential mitigations. As the table below points out, both the range's primary L- and S-bands have been identified for study to support the National Broadband plan, published in March 2010 whereby 500 MHz would be repurposed from federal and non-federal bands for broadband wireless use. The spectrum now allocated to test is used full time during the range day (i.e., from 6:00am to 6:00pm), and continued unimpeded use is critical to allow for collection of the increasing volume of test data (e.g., that of the F-35 JSF).

The test ranges' are currently working two problems in the primary band for telemetry, 1,435 – 1,525 MHz:

1. The first problem is the recently approved FCC rulemaking to allow sharing of the spectrum with wireless microphones used for major concerts and sports events. DOD has worked successfully with industry to adopt the use of agreements (such as not-to-interfere agreements) and electronic keys to coordinate band usage. However, the development of the electronic key technology has not been done and its reliability has not been demonstrated.
2. The second problem has greater potential impact to the test community and stems from proposed WRC repurposing of AMT allocated spectrum for worldwide wireless broadband use, which both Canada and Mexico support. The United States has notified its neighbors it intends to continue using the band for telemetry albeit in accordance with any protection agreements concluded with each neighbor. Due to the location of many of the test ranges in the Southwest continental United States and commercial aircraft manufacturers' testing proximate to the U.S. and Canadian border, repurposing of the 1,435 – 1,525 MHz spectrum for wireless broadband is of major concern due to its potential to interfere with AMT operations. Canada has engaged with DOD and the aircraft industry to define protection criteria for both U.S. and Canadian systems to take effect when Canada begins using the band for wireless broadband service. Mexico has also been approached to work mitigation strategies for the same reason.

The second most-used band for test range telemetry is the 2,360 – 2,390 MHz spectrum. Again the issue confronting the ranges is the potential interference with AMT operations from assignment of adjacent spectrum (2,345 – 2,360 MHz) to wireless broadband use. The vendor for operations in this spectrum has agreed to use of the International Telecommunications Union recommendation that prescribes out-of-band emissions protection for telemetry systems. DOD continues to work this issue with both the FCC and the vendor.

Frequency spectrum is a limited resource with many more demands than available supply. The DOD published its Electromagnetic Spectrum Strategy at the end of 2013, followed by the Roadmap and Action Plan that will guide the strategy implementation in 2015. A major element of the strategy is an emphasis on spectrum sharing vice spectrum reallocation, because both DOD and the private industry sector demands are growing at rapidly.

TABLE 2. FREQUENCY ALLOCATIONS USED FOR TESTING AND DOD RESOURCE ISSUES AND POTENTIAL MITIGATIONS				
Frequency	**Use**	**Users**	**Resource Issue and Potential Mitigation**	**Notes**
406.1 – 420 MHz	Land mobile radio	Test control and field operators		
1350 – 1390 MHz	Time, Space, Position Information	Critical to almost all open-air tests; range surveillance radar (Air Route Surveillance Radar-4)	Band is part of 1300-1400 MHz band under consideration for reallocation to broadband at WRC-15. US will declare a no-change position if it comes to fruition, but will need to constrain operations along boarders if Mexico and/or Canada adopt such a change.	Band is where position location systems (TSPI) operate. Used at most test ranges, some training ranges.
1435 – 1525 MHz	L-Band Telemetry - Primary Telemetry Band	SDB, UH1/AH, T-45, SH-60, VH-S, V-22, F-18, F-18E, F-22, F-35, B-2, F-16, B-1, B-2, B-52, Global Hawk	• Issue: Wireless microphone use. • Potential Mitigation: Alternate user coordination with assigned key codes for spectrum access in allotted time periods. • Issue: WRC assignment to worldwide wireless broadband use. • Potential Mitigation: Ongoing negotiations with Canada and Mexico.	Regardless of outcomes of Canada & Mexico negotiations, usage would still be constrained along borders.
1675 – 1710 MHz	Weather, including wind speed measurement	Critical to almost all open-air tests		
1755 – 1780 MHz	L-Band Telemetry	F/EA-18G, Aerostar, ASVS, SM-2, RAM, SSRT, Classified UAV (WSMR), ARAV, X-47, the only band for miss-distance indicators used to score missile shots	• Issue: Advanced Wireless Services – 3 auction completed. • Mitigation: Use compression and relocation to 4400 – 4940 MHz and 5091 – 5150 MHz with Spectrum.	Regardless of mitigation, loss of capacity cannot be mitigated over long term.
1780 – 1850 MHz	L-Band Telemetry	F/EA-18G, Aerostar, ASVS, SM-2, RAM, SSRT, Classified UAV (WSMR), ARAV, X-47, the only band for miss-distance indicators used to score missile shots		This spectrum may be auctioned over the next 10 years. DOD working towards sharing vice reallocation.
2200 – 2290 MHz	S-Band Telemetry	AIM-9X, AIM-120, JAASM, JDAM, WCMD, JSOW, SDB, Aerostar, ASVS, WSI, 6DOF, MDA, Patriot, SM-2, ATACMS, F-15, F-16, F-22, F-35, T-38, B-1, B-2, B-52, C-17, Global Hawk, X-51 Waverider	Band has been found to be exceptionally vulnerable to emissions from Long Term Evolution wireless broadband towers operating more than 50 MHz below the band edge. Mitigation is being worked.	
2360 – 2390 MHz	Upper S-Band Telemetry	F-18E/400, E2-D, P-8A, Exdrone, Silver Fox, THAAD, F-16, F-22, B-1, B-2, B-52, C-17, Global Hawk	• Issue: Wireless communications in 2345-2360 can interfere with operations in this band. • Potential Mitigation: Pending.	Working with industry to try to solve interference problems.
2390 – 2395 MHz	Upper S-Band Telemetry	F-18E/400, E2-D, P-8A, Exdrone, Silver Fox, THAAD, F-16, F-22, B-1, B-2, B-52, C-17, Global Hawk		Shared for additional Upper S-Band coverage.
2700 – 2900 MHz	Range surveillance radar	Critical to almost all open-air tests		
4400 – 4940 MHz	Range Telemetry	F-15SA, F-15 (pending), fixed point-to-point microwave, tactical radio, UAV, threat simulators		Band is just now coming into use.
5091 – 5150 MHz (Region 2: 5091 – 6700 MHz)	Range Telemetry	F-15SA		Shared with Federal Aviation Administration. Band is just now coming into use.

Joint Test and Evaluation

Joint Test and Evaluation

Joint Test and Evaluation (JT&E)

The primary objective of the Joint Test and Evaluation (JT&E) Program is to provide solutions rapidly to operational deficiencies identified by the joint military community. The program achieves this objective by developing new tactics, techniques, and procedures (TTP) and rigorously measuring the extent to which their use improves operational outcomes. JT&E projects may develop products that have implications beyond TTP. Sponsoring organizations submit these products to the appropriate Service or Combatant Command as doctrine change requests. Products from JT&E projects have been incorporated into joint and multi-Service documents through the Joint Requirements Oversight Council process and through coordination with the Air, Land, Sea Application Center. The JT&E Program also develops operational testing methods that have joint application. The program is complementary to, but not part of, the acquisition process.

The JT&E Program has two test methods available for customers: the traditional Joint Test and the Quick Reaction Test (QRT). Additionally, a Special Project is available for command directed or customer funded test projects.

The traditional Joint Test is, on average, a two-year project, preceded by a six-month Joint Feasibility Study. A Joint Test involves an in-depth, methodical test and evaluation of issues and seeks to identify their solutions. DOT&E funds the sponsor led test team, which provides the customer periodic feedback and useable, interim test products. The JT&E Program charters two new Joint Tests annually. The JT&E Program managed seven Joint Tests in FY15 that focused on the needs of operational forces. Projects annotated with an asterisk (*) were completed in FY15:

- Four Pillars of Integrated Air and Missile Defense (4-PI)
- Joint Base Architecture for Secure Industrial Control Systems (J-BASICS)
- Joint Counter Low, Slow, Small Unmanned Aircraft Systems (JCLU)*
- Joint-Fiber Laser Mission Engagement (J-FLaME)
- Joint Pre-/Post-Attack Operations Supporting Survivability And Endurability (J-POSSE)
- Joint Tactical Air Picture (JTAP)
- Unmanned Aircraft Systems – Airspace Integration (UAS-AI)*

QRTs are intended to solve urgent issues in less than a year. The program managed 25 QRTs in FY15:

- Command and Control of Ballistic Missile Defense (C2BMD)*
- Cyber Agility and Defensive Maneuver (CAADM)*
- Civil Military Engagement Development Joint Targeting/Non-Lethal (CMED-JT/NL)
- Cyber Threat Information Exchange (CTIX)*
- Homeland Underwater Port Assessment Plan (HUPAP)
- Joint Assessment Doctrine Evaluation (JADE)*
- Joint Automated Net-Centric Satellite Communications Electromagnetic Interference Resolution (J-ANSER)*
- Joint Biological/Radiological Mortuary Affairs Contaminated Remains Mitigation Site (JBRM)
- Joint-Cyber Synchronization into Air Tasking Order (J-CAT)
- Joint Cyber Integration of DOD Information Network Operations (J-CID)
- Joint Cyberspace Intelligence, Surveillance, and Reconnaissance (JCISR)*
- Joint Decision Support – Air (JDeS-A)*
- Joint Homeland Mining Prevention and Response (JHMPR)*
- Joint Integrated Air and Ground Situational Awareness (JIAG SA)*
- Joint Intelligence Surveillance and Reconnaissance in a Contested Area (JICA)
- Joint Integrated Standoff Weapons Employment (JISOWE)*
- Joint Laser Anti-Satellite Mitigation Mission Planning (J-LAMMP)
- Joint National Capital Region Air Surveillance Concept of Operations (CONOPS) – Accelerated (JNASC-A)*
- Joint Personnel Recovery Information Digital Exchange (J-PRIDE)
- Joint Precise Timing (JPT)*
- Joint Sniper Performance Improvement Methodology (JSniPIM)
- Joint Unmanned Aerial Vehicle Swarming Integration (JUSI)
- Mortuary Affairs Contaminated Remains Mitigation Site (MACRMS)*
- Theater Joint Land Forces Component Commander Common Operational Picture (T-COP)
- Joint Target Development: Target System Analysis Standards and Procedures (T-SaP)

As directed by DOT&E, the program executes Special Projects that address DOD-wide problems. Special Projects generally address emergent issues that are not addressed by any other DOD agency, but that need a rigorously tested solution. The program managed three Special Projects in FY15:

- Joint and Community Attributes-Based Access Control Authorization for Transportation Services (J-CAATS)
- Joint National Capital Region Enhanced Surveillance Tactics, Techniques, and Procedures (J-NEST)
- Joint Personnel Recovery Collaboration and Planning (JPRCaP)*

JOINT TESTS

FOUR PILLARS OF INTEGRATED AIR AND MISSILE DEFENSE (4-PI)

Sponsor/Start Date: U.S. European Command, U. S. Army Space and Missile Defense Command, and U. S. Air Forces Europe-Air Forces Africa/August 2014

Purpose: To develop TTP that enable sharing of existing sensor data to enhance the concurrent execution of integrated air and missile defense (IAMD) active defenses, passive defenses, attack operations, and battle management command, control, communications, and intelligence in response to ballistic missile attacks across Combatant Command areas of responsibility (AOR) in a coalition.

Products/Benefits:
- TTP that share data to support concurrent offensive and defensive counter-air operations in order to better defend against, and mitigate the effects of, a ballistic missile attack across AOR boundaries between U.S. European Command, U.S. Central Command, and NATO.
  - Utilize missile launch point of origin data derived from Overhead Persistent Infrared systems to initiate joint targeting cycles and coordinate targeting priorities across AORs
  - Leverage cross-AOR sensor data sharing to provide earlier warning; enhance ballistic missile radar coverage, threat detection, track management, and missile engagement procedures; and system redundancy
  - Utilize existing radar data to provide refined ballistic missile impact point predictions that will enhance the effectiveness of early warning and actionable consequence management
- Standardizes battle management command, control, communications, and intelligence capabilities and Global Command and Control System – Joint configurations to maximize efficiencies, support command and control collaboration, and enable sharing of IAMD sensor data
- Supports development of an enhanced civil-military passive defense/missile warning process for NATO nations, extensible to other Combatant Command Shared Early Warning partners
- Delivers a leave behind exercise framework for cross-AOR IAMD exercises
- Supports the National Geospatial Intelligence Agency in implementing a Chairman of the Joint Chiefs of Staff instruction-directed common area and point reference system across Combatant Commands—the Global Area Reference System and the Military Grid Reference System

JOINT–BASE ARCHITECTURE FOR SECURE INDUSTRIAL CONTROL SYSTEMS (J-BASICS)

Sponsor/Start Date: U.S. Cyber Command (USCYBERCOM)/February 2014

Purpose: To develop, test, and evaluate Advanced Cyber Industrial Control System (ICS), or (ACI), TTP to improve the ability of ICS network managers to detect, mitigate, and recover from nation-state cyber attacks.

Products/Benefits:
- ACI TTP and related ICS network manager training packages will provide the following capabilities:
  - Resiliency (fight-through capability) to DOD ICS networks and immediate supporting IT infrastructures
  - Advanced means, in the form of TTP, for ICS network managers to: detect nation-state presence in DOD ICS networks; mitigate damage to underlying processes supported by the ICS in the event of a cyber attack; and quickly recover the ICS network to a fully mission-capable condition
  - Increased Commander confidence resulting from the ability of ICS managers to accurately detect active nation-state attacks and execute defensive measures in ICS networks, ensuring mission readiness of ICS-dependent activities
  - Policy and implementation guidance recommendations for ICS network security to Commander, USCYBERCOM and the Assistant Secretary of Defense for Acquisition, Technology, and Logistics (Energy, Installations and Environment)

JOINT COUNTER LOW, SLOW, SMALL UNMANNED AIRCRAFT SYSTEMS (JCLU)
(CLOSED APRIL 2015)

Sponsor/Start Date: Air Force/August 2012

Purpose: To develop, test, and evaluate IAMD operator TTP to increase operators' ability to detect, track, and identify adversary low, slow, and small unmanned aircraft systems (UAS) and provide timely notification to the Area Air Defense Commander.

Products/Benefits:
- TTP that increased the operators' ability to detect, track, and identify this UAS threat category.
- Integrated information from National Technical Means into a tactical datalink to support situational awareness and target identification
- Developed operational architecture and organizational relationships that will increase the cross-sharing of tactical information to increase the operators' ability to execute the joint engagement sequence

JOINT FIBER LASER MISSION ENGAGEMENT (J-FLAME)

Sponsor/Start Date: Naval Surface Warfare Center, Dahlgren Division/August 2014

Purpose: To develop TTP to integrate emerging directed-energy laser (DEL) capabilities to conduct joint fires and force protection missions.

Products/Benefits:
- The DEL Operations in the Joint Battlespace TTP will:

- Leverage capabilities of emerging DEL to conduct joint fires and air defense missions
- Integrate DEL systems into joint fires planning and execution, focusing on coordinating measures needed for deconfliction, integration, synchronization, and safety of these DEL systems in a complex and congested battlespace
- Address the force protection mission against asymmetric threats (UAS and small boats), focusing on unique aspects of DEL that impact the joint battlespace (for example, new or different coordinating measures) that personnel at both operational and tactical levels need to consider

JOINT PRE-/POST-ATTACK OPERATIONS SUPPORTING SURVIVABILITY AND ENDURABILITY (J-POSSE)

Sponsor/Start Date: U.S. Strategic Command (USSTRATCOM)/February 2015

Purpose: To develop, test, and evaluate TTP to provide joint operators the ability to survive an electromagnetic pulse (EMP) event in order to ensure continuous mission functionality.

Products/Benefits:
- Standardized procedures that provide overarching guidance for required actions before and after an EMP event in order to survive it.
  - Pre-event actions include preparations taken during routine operations, as well as emergency actions taken once notified of an imminent EMP event
  - Post-event actions include endurability operations to maintain mission functionality for a specified period of time following an EMP event
- Results inform future resourcing decisions regarding physical enhancements
- Extensible to other mission systems potentially vulnerable to EMP effects (e.g. missile defense, space, cyber)

JOINT TACTICAL AIR PICTURE (JTAP)

Sponsor/Start Date: U.S. Pacific Command (USPACOM)/February 2014

Purpose: To develop, evaluate, and validate TTP to improve the joint air picture and engagement opportunities, which decreases the risk of preemptive hostile attack and fratricide.

Products/Benefits:
- Link 16 implementation procedures that reduce radio frequency network loading by moving participants to Internet protocol architecture resulting in a greater number of timeslots available for participants
- Multi-Service Integrated Air and Missile Defense TTP that enhances integrated fire control between ground sensors and air shooters for defensive counter air engagements thereby increasing the number of available tracks containing fire control quality data

UNMANNED AIRCRAFT SYSTEMS AIRSPACE INTEGRATION (UAS-AI)
(CLOSED JULY 2015)

Sponsor/Start Date: North American Aerospace Defense Command (NORAD)-U.S. Northern Command (USNORTHCOM), and the Army Test and Evaluation Command/August 2012

Purpose: Standardize and evaluate procedures to safely, effectively, and efficiently operate UAS in the National Airspace System (NAS).

Products/Benefits:
- Increased collaboration between the DOD Policy Board on Federal Aviation, Federal Aviation Administration, National Aeronautics and Space Administration, and Customs and Border Protection on UAS NAS integration issues
- UAS NAS Flight Operations Standardized Procedures for operating UAS in the NAS under routine, lost command link, lost two-way radio communications, and lost detect and avoid conditions
- UAS-specific aeronautical charting guidelines for use by the National Geospatial-Intelligence Agency
- Chase Aircraft and Airborne Visual Observer TTP for pre-mission planning and briefings that lead to safe UAS operations utilizing chase aircraft in the NAS

QUICK REACTION TESTS

COMMAND AND CONTROL OF BALLISTIC MISSILE DEFENSE (C2BMD)
(CLOSED JUNE 2015)

Sponsor/Start Date: USSTRATCOM, Air Force Joint Test Program Office/February 2014

Purpose: To develop and test TTP leveraging current Command and Control, Battle Management and Communications system capabilities resident, but not fully utilized, to enhance intra- and inter-theater joint ballistic missile defense (BMD) operations planning and re-planning efforts.

Products/Benefits:
- Improved BMD coordination among the Air Operations Center, Maritime Operations Center, and Army Air and Missile Defense Command in support of intra- and inter-theater BMD operations
- Enhanced ability of theaters to successfully plan and employ limited organic BMD assets

- Improved exploitation of capabilities resident, but underutilized, in fielded Command and Control, Battle Management and Communications 6.4 software

CYBER AGILITY AND DEFENSIVE MANEUVER (CAADM) (CLOSED JANUARY 2015)

Sponsor/Start Date: USPACOM/August 2013

Purpose: To develop and test TTP to enhance moving target technologies to enable cyber agility and defensive cyber maneuver for the protection of selected critical information resources and command and control capabilities from advanced threats. Also, to provide recommendations for amendments of joint doctrine (principally Joint Publication 3-12, Cyberspace Operations) to introduce more comprehensive operational concepts for defensive maneuver in cyberspace.

Products/Benefits:
- Developed TTP and recommended changes to joint doctrine to provide the following:
  - Assisted Commanders and network defenders in overcoming disadvantages inherent in static cyber defenses
  - Decreased vulnerability to enemy surveillance of and attacks against DOD network enclaves
  - Enhanced ability to rapidly adapt cyber defenses in the face of changing missions and threats
  - Improved capability to counter and observe enemy actions in cyberspace
  - Increased wherewithal to shift initiative from attackers to network defenders
  - More effective application of technology for agile defense of key terrain in cyberspace
  - Developed the foundation for more effective joint planning and operations for defense of critical-enabled capabilities and information resources

CIVIL MILITARY ENGAGEMENT DEVELOPMENT-JOINT TARGETING/NON-LETHAL (CMED-JT/NL)

Sponsor/Start Date: U.S. Army Civil Affairs & Psychological Operations Command (Airborne)/February 2015

Purpose: To develop, test, and validate civil-military engagement development (CMED) TTP to improve the non-lethal aspects of the joint targeting process. To increase the Combatant Command staff's ability to integrate civil information and analysis products into the joint targeting cycle and improve basic, intermediate, and advanced joint target folder development, entity-level development, prioritization (phase two of the joint targeting process), and no strike and restricted target lists.

Products/Benefits:
The CMED-JT/NL-developed TTP will provide Commanders the ability to integrate civil military information into phase two of the joint targeting process.

CYBER THREAT INFORMATION EXCHANGE (CTIX) (CLOSED SEPTEMBER 2015)

Sponsor/Start Date: USPACOM/June 2014

Purpose: To develop and test TTP for timely, relevant exchange of cyber threat data with joint and coalition cyber defenders and cyber operations centers in support of joint and combined operations with the focus on developing effective formats and processes to enable automated and man-in-the-loop cyber threat information exchanges.

Products/Benefits: A CTIX-developed TTP to exchange relevant cyber threat data between joint and coalition partners and cyber operations centers during both joint and combined operations.

HOMELAND UNDERWATER PORT ASSESSMENT PLAN (HUPAP)

Sponsor/Start Date: NORAD-USNORTHCOM/June 2015

Purpose: To develop and assess TTP for underwater port assessments to include: specific details about the roles and responsibilities of the stakeholders; identify available local, state, and federal force multipliers; provide data collection, compilation, and sharing guidance; and identify gaps in response considerations.

Products/Benefits:
- TTP that provides specific details of conducting an underwater port assessment
- A supporting implementation plan that prescribes all aspects of manning, funding support, and coordination to execute these critical assessments

JOINT ASSESSMENT DOCTRINE EVALUATION (JADE) (CLOSED JUNE 2015)

Sponsor/Start Date: U.S. Central Command/February 2014

Purpose: To develop and improve the integration of Theater Campaign and Operation Assessment into the planning and execution phases at the Joint Force Commander level. To document and inform the Joint Doctrine Note being developed by the Joint Staff J7, including specific changes to Joint Publication (JP) 3-0, Joint Operations, and JP 5-0, Joint Operation Planning.

Products/Benefits: Findings and recommendations regarding doctrine, leadership and education, and training; draft comments and text for inclusion in revisions to JP 3-0 and JP 5-0; including suggested terminology changes associated with the operation assessment lexicon.

JOINT AUTOMATED NET-CENTRIC SATELLITE COMMUNICATIONS ELECTROMAGNETIC INTERFERENCE RESOLUTION (J-ANSER) (CLOSED NOVEMBER 2014)

Sponsor/Start Date: USSTRATCOM, Air Force Joint Test Program Office/November 2013

Purpose: To develop satellite communications (SATCOM) electromagnetic interference TTP leveraging recently fielded, net-centric systems to immediately detect, characterize, and cue geolocation assets.

Products/Benefits:
- Allowed Commanders and operators to advance operations in a SATCOM denied or degraded environment by visually displaying SATCOM lines of communication health and status
- Improved SATCOM operators responsiveness to SATCOM interference
- Enhanced real-time situational awareness by reducing SATCOM electromagnetic interference resolution timelines from hours to minutes
- Integrated SATCOM common operating picture TTP among the SATCOM operators

JOINT BIOLOGICAL/RADIOLOGICAL MORTUARY AFFAIRS CONTAMINATED REMAINS MITIGATION SITE (JBRM)

Sponsor/Start Date: U.S. Army Quartermaster School/June 2015

Purpose: To develop and assess TTP for the safe processing, identification, and preparation for evacuation of biologically or radiologically contaminated human remains. To improve the Mortuary Affairs Contaminated Remains Mitigation Site effectiveness and safety for operational mission requirements, including hazard mitigation, preserving forensic evidence, establishing chain of custody, supporting positive identification processes, and preparing remains for evacuation.

Products/Benefits:
- Updates to Army and joint doctrine, with primary focus on Army Techniques Publication 4-46.2, Mortuary Affairs Contaminated Remains Mitigation Site Operations, as related to biological or radiological contaminated human remains
- Verifiable data and tools to the mortuary affairs community for the purpose of improving TTP for use in both USNORTHCOM homeland defense missions and DOD's worldwide contingency operations

JOINT-CYBER SYNCHRONIZATION INTO AIR TASKING ORDER (J-CAT)

Sponsor/Start Date: USPACOM/October 2014

Purpose: To develop and test TTP for Combatant Commands to direct regionally synchronized and globally deconflicted cyber fires. Specifically, TTP will integrate offensive cyberspace operations into a Combatant Command's air tasking order development and execution processes in order to synchronize cyber operations with other joint fires, as well as provide coordination and deconfliction of global cyber operations with USCYBERCOM's cyberspace tasking order.

Products/Benefits: TTP that provide the best practices for synchronization of cyber fires into the joint fires process for deconfliction of regional cyber fires with global cyberspace operations.

JOINT CYBER INTEGRATION OF DOD INFORMATION NETWORK OPERATIONS (J-CID)

Sponsor/Start Date: USPACOM/June 2015

Purpose: To develop a concept of operations (CONOPS) and TTP for the Combatant Commands' Joint Cyber Center that will enable them to fully integrate the organization, authorities, and capabilities of DOD Information Network commands in support of joint theater cyber operations.

Products/Benefits: CONOPS and TTP that provide best practices for the support of regional operations, situational understanding, and decision making for cyberspace operations between regional DOD Information Network commands and regional Joint Cyber Centers.

JOINT CYBERSPACE INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (JCISR)
(CLOSED JANUARY 2015)

Sponsor/Start Date: USPACOM/January 2014

Purpose: To develop and evaluate TTP that enable a Joint Cyber Center to integrate the intelligence community's (IC) cyberspace Intelligence, Surveillance, and Reconnaissance (ISR) products into joint operation planning, joint targeting, and operations.

Products/Benefits:
- Established processes for full integration of the IC cyberspace ISR products into planning, targeting, and execution of offensive cyber operations by Combatant Commander's Joint Cyber Center
- Provided a framework for the IC to communicate with newly-formed Combatant Command Joint Cyber Center
- Developed a doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy change request on factors that impede IC support for offensive cyber operations
- Validated TTP through an assessment of developed processes across Combatant Commands

JOINT DECISION SUPPORT- AIR (JDES-A)
(CLOSED NOVEMBER 2014)

Sponsor/Start Date: NORAD/November 2013

Purpose: To develop and test TTP for use by operators of the Air/Event Information Sharing Service (A/EISS) that prevent incomplete or inaccurate air event data from being provided to senior decision makers. To enhance situational awareness and enable the Commander, NORAD and USNORTHCOM, Civil Aircraft Engagement Authorities, Canadian Recommending Authorities, and all participating joint, interagency, intergovernmental, and multinational air defense and security mission partners to make timely decisions during air events over North America.

Products/Benefits: Enhanced A/EISS TTP and training and evaluation products to deliver air domain situational awareness and decision support in support of Operation Noble Eagle.

JOINT HOMELAND MINING PREVENTION AND RESPONSE (JHMPR)
(CLOSED NOVEMBER 2014)

Sponsor/Start Date: NORAD-USNORTHCOM/August 2013

Purpose: To develop a cross-departmental, interagency CONOPS to enable a mine countermeasures response to a mine incident in a port in the United States.

Products/Benefits: CONOPS for the rapid, accurate, and standardized information exchange between the Department of Homeland Security mission of mine detection and prevention and the DOD's mine countermeasures response.

JOINT INTEGRATED AIR AND GROUND SITUATIONAL AWARENESS (JIAG SA)
(CLOSED SEPTEMBER 2015)

Sponsor/Start Date: Joint Staff J6/June 2014

Purpose: To provide TTP to employ the Tactical Radio Application eXention (TRAX) to integrate multiple tactical datalinks through a joint integrated air and ground common operational picture. This TTP increases the tactical decision-makers' situational awareness, shortens the kill chain, reduces the potential of fratricide, and facilitates airspace de-confliction and rapid target correlation for digitally-aided operations.

Products/Benefits: A joint special operations forces TRAX TTP that describes set-up and installation, platform specific integration considerations, and tactics for TRAX integration in selected forcible entry operation scenarios.

JOINT INTELLIGENCE SURVEILLANCE AND RECONNAISSANCE [ISR] IN A CONTESTED AREA (JICA)

Sponsor/Start Date: 25th Air Force/October 2014

Purpose: To develop, test, and validate TTP to improve information flow from national ISR capabilities to operational and tactical-level customers in an anti-access/area denial environment. To provide criteria to define an ISR denial/degradation "trigger" to begin assembling data collected by national assets against pre-identified targets and procedures for the Air and Space Operations Center ISR Division personnel to request ISR support from national ISR capabilities to supplement or replace theater and tactical ISR assets that cannot be utilized due to threat vulnerability.

Products/Benefits:
- TTP for Air and Space Operations Center or Maritime Operations Center ISR Division personnel to effectively obtain access to national intelligence information in an anti-access/area denial environment
- Allow operational and tactical warfighters a better chance of survivability and mission success by ensuring the most accurate intelligence is provided to them, even when theater and tactical ISR assets are degraded or denied

JOINT INTEGRATED STANDOFF WEAPONS EMPLOYMENT (JISOWE)
(CLOSED JULY 2015)

Sponsor/Start Date: USPACOM/February 2014

Purpose: To develop, test, and evaluate TTP to employ standoff weapon systems that include the Joint Air-to-Surface Standoff Missile, Tomahawk Land Attack Missile, Conventional Air Launched Cruise Missile, Miniature Air Launched Decoy, and the EA-18G aircraft.

Products/Benefits:
- Operational-level planning TTP that integrated standoff weapon systems
- A report of the capabilities and limitations of existing standoff weapons, decoys, and airborne jammer systems
- A report on which modeling and simulation tools provided the best operational planning capability

JOINT LASER ANTI-SATELLITE MITIGATION MISSION PLANNING (J-LAMMP)

Sponsor/Start Date: U.S. Air Force Warfare Center/June 2014

Purpose: To develop and evaluate TTP to mitigate anti-satellite threats from stationary, ground-based, low-power lasers targeting low Earth orbit satellites with an optical payload.

Products/Benefits:
- TTP that incorporate payload susceptibility information and Commander's risk acceptance level into mission planning at both the operational and tactical levels of space operations
- TTP will provide a standard, methodical process to respond to laser anti-satellite threats by assisting operational-level users to identify risks, determine the decision authority's risk acceptance level, notify affected tactical users, and assisting tactical users to develop courses of action to mitigate risk while maintaining support and communication to the warfighter and feedback to the operational level

JOINT NATIONAL CAPITOL REGION AIR SURVEILLANCE CONCEPT OF OPERATIONS – ADVANCED (JNASC-A)
(CLOSED OCTOBER 2014)

Sponsor/Start Date: NORAD-USNORTHCOM/August 2013

Purpose: To develop and test CONOPS and TTP to integrate the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) into NORAD's Battle Control System – Fixed (BCS-F). To develop procedures to enable JLENS to detect, track, and characterize items of interest within the JLENS field of view supporting the air surveillance of the national capital region and surrounding areas to positively identify contacts and increase the time available to take action to counter air and missile threats.

Products/Benefits: TTP for JLENS allowed Eastern and Western Air Defense Sector operators to efficiently and effectively exploit available detection and identification capabilities to improve the NORAD homeland defense mission within the national capital region.

JOINT PERSONNEL RECOVERY INFORMATION DIGITAL EXCHANGE (J-PRIDE)

Sponsor/Start Date: Joint Staff J7/June 2015

Purpose: To develop and test TTP to pass critical information across existing hybrid networks between isolated personnel, recovery forces, and command and control nodes during joint personnel recovery (PR) mission execution.

Products/Benefits:
- TTP to provide efficient and effective use of digitally generated mission critical information across operational and tactical PR nodes to enhance mission effectiveness and increase survivability
- To provide guidance to achieve complete, accurate, timely, and persistent joint PR capabilities

JOINT PRECISE TIMING (JPT) (CLOSED JANUARY 2015)

Sponsor/Start Date: Office of the Chief of Naval Operations/August 2013

Purpose: To develop and test TTP to provide overarching guidance and best practices for the standardization and operation of DOD Precise Time and Time Interval systems.

Products/Benefits:
- Provided guidance for the standardization and operation of DOD Precise Time and Time Interval distribution systems
- Formalized and documented best practices and guidelines to improve the reliability, redundancy, and assurance of DOD systems
- Enabled the joint force to achieve and sustain accurate, synchronized time of day and frequency worldwide to support joint operations

JOINT SNIPER PERFORMANCE IMPROVEMENT METHODOLOGY (JSNIPIM)

Sponsor/Start Date: U.S. Marine Corps Weapons Training Battalion/October 2014

Purpose: To develop and test TTP and training methodologies to confidently employ sniper teams and focus on their ability to identify, range, lead, and engage human motion-type moving targets at distances of 300 to 1,000 meters at speeds of up to 10 miles per hour.

Products/Benefits:
- A sniper-carried memory aid and a training support package that includes learning objectives, period of instruction materials (including a training video), an instructor guide, and a student handout
- Enable instructors to teach, test, and qualify students on engaging moving targets at distances of 300 to 1,000 meters at speeds of up to 10 miles per hour
- Update curriculums for all DOD sniper schools

JOINT UNMANNED AERIAL VEHICLE SWARMING INTEGRATION (JUSI)

Sponsor/Start Date: USPACOM/February 2015

Purpose: To develop and test a TTP and concept of employment to plan and execute integrated attacks using unmanned aerial vehicle swarms carrying electronic warfare payloads against advanced air defense systems.

Products/Benefits:
- A concept of employment and TTP to plan and execute joint integrated standoff attacks against a modern air defense system
- Identified capabilities and limitations of existing planning and modeling and simulation tools for this mission area

MORTUARY AFFAIRS CONTAMINATED REMAINS MITIGATION SITE (MACRMS) (CLOSED JUNE 2015)

Sponsor/Start Date: U.S. Army Quartermaster School/February 2014

Purpose: To assess and validate TTP for processing contaminated human remains and their personal effects resulting from a chemical, biological, radiological, or nuclear incident.

Products/Benefits:
- Updated Chapter 4, Processing of Chemical Contaminated Human Remains, in the U.S. Army Techniques Publication (ATP) 4-46.2, Mortuary Affairs Contaminated Remains Mitigation Site
- Provided changes to ATP 4-46.2 based on data and observations

THEATER JOINT LAND FORCES COMPONENT COMMANDER COMMON OPERATIONAL PICTURE (T-COP)

Sponsor/Start Date: USPACOM/February 2015

Purpose: To develop, test, and validate TTP for USPACOM's land components and implement a standard operating procedure for Combatant Command-level operations that establish a T-COP across the Services.

Products/Benefits: Enhanced command and control capability to conduct timely analysis and recommendations to support crisis and contingency responses.

JOINT TARGET DEVELOPMENT: TARGET SYSTEM ANALYSIS STANDARDS AND PROCEDURES (T-SAP)

Sponsor/Start Date: Joint Staff J2/February 2015

Purpose: To develop, test, and validate TTP for targeteers and intelligence analysts to conduct target system analysis in support of target development for joint force operations.

Products/Benefits:
- Target system analysis TTP to support joint force planning and update Chairman of the Joint Chiefs of Staff Instruction 3370.01, Target Development Standards
- A findings, conclusions, and recommendations memorandum on applicable doctrine change recommendations that will be transitioned to the Joint Staff J2

SPECIAL PROJECTS

JOINT AND COMMUNITY ATTRIBUTES-BASED ACCESS CONTROL AUTHORIZATION FOR TRANSPORTATION SERVICES (J-CAATS)

Sponsor/Start Date: U.S. Transportation Command/February 2015

Purpose: To develop and validate TTP and CONOPS for providing secure, yet timely and appropriate, data access for DOD users using an attributes-based access control approach.

Products/Benefits: A process for utilizing user attributes that eliminates the need to establish a new, unique account often requiring additional usernames and passwords when a new user seeks access to an information system.

JOINT NATIONAL CAPITAL REGION ENHANCED SURVEILLANCE TACTICS, TECHNIQUES, AND PROCEDURES (J-NEST)

Sponsor/Start Date: NORAD/October 2014

Purpose: To develop, test, and validate TTP to incorporate emerging sensor capabilities into the NORAD and USNORTHCOM family of systems to support the air defense mission.

Products/Benefits:
- Provide TTP that enable tactical, operational, and strategic command and control nodes to more fully employ the expanded detection, improved identification, and enhanced engagement of cruise missile threats to the national capital region
- Seamlessly integrate these critical capabilities and leverage the full benefit of an advanced family of sensors into the "no fail" mission of defending the national capital region
- Codify processes and standardize TTP utilizing advanced equipment capabilities to execute an effective joint engagement sequence for cruise missile defense

JOINT PERSONNEL RECOVERY COLLABORATION AND PLANNING (JPRCAP)
(CLOSED JANUARY 2015)

Sponsor/Start Date: Joint Personnel Recovery Agency/January 2013

Purpose: To develop, test, and evaluate procedures that will formalize planning, crisis response, and information sharing between the geographic Combatant Commands (GCC) and defense attachés (DATT) prior to and during personnel recovery responses where a State Department chief of mission, generally the ambassador, and not a DOD official, is the lead U.S. Government authority for activity in a country.

Products/Benefits:
- Formal personnel recovery planning and training protocols that informed GCCs and DATTs in U.S. embassies on how to build and implement country-specific personnel recovery plans to develop DOD support options tailored for the chief of mission
- A handbook that provided DATTs a reference for the who, what, and why of responsibilities for personnel recovery when DOD supports a chief of mission-led personnel recovery response
- A web-based program, Automated Development Tool, that took roles, responsibilities, and activities, and used GCC and DATT inputs to produce a country-specific DOD personnel recovery supplement

Center for
Countermeasures

Center for
Countermeasures

Center for Countermeasures (CCM)

The Center for Countermeasures (the Center) is a joint activity that directs, coordinates, supports, and conducts independent countermeasure/counter-countermeasure (CM/CCM) test and evaluation (T&E) activities of U.S. and foreign weapons systems, subsystems, sensors, and related components. The Center accomplishes this work in support of the Director, Operational Test and Evaluation (DOT&E), Deputy Assistant Secretary of Defense for Developmental Test and Evaluation ((DASD(DT&E)), weapon systems developers, and the Services. The Center's testing and analyses directly support evaluations of the operational effectiveness and suitability of CM/CCM systems.

Specifically, the Center:

- Determines performance and limitations of missile warning and aircraft survivability equipment (ASE) used on rotary-wing and fixed-wing aircraft
- Determines effectiveness of precision guided weapon (PGW) systems and subsystems when operating in an environment degraded by CMs
- Develops and evaluates CM/CCM techniques and devices
- Operates unique test equipment that supports testing across the DOD
- Provides analyses and recommendations on CM/CCM effectiveness to Service Program Offices, DOT&E, DASD(DT&E), and the Services
- Supports Service member exercises, training, and pre-deployment activities

During FY15, the Center completed over 35 T&E activities. The Center's support to these activities resulted in analysis and reporting on more than 27 DOD electro-optical systems or subsystems, with special emphasis on rotary-wing survivability.

The Center participated in operational/developmental tests for rotary- and fixed-wing ASE, PGWs, hostile fire indicator (HFI) data collection, experimentation tests, and pre-deployment/exercise support using CM/CCM. To best represent the level of effort resourced to support T&E, the Center tracks funding expended in each test area:

- Approximately 51 percent of the Center's efforts were spent on ASE testing, with the majority of these efforts in support of rotary-wing aircraft
- About 22 percent of the Center's efforts were spent on PGW, foreign system, and other types of field testing not related to ASE
- Approximately 7 percent of the Center's efforts were dedicated to overseas contingency operations support, with emphasis on CM-based pre-deployment training for rotary-wing units
- Approximately 17 percent of the Center's efforts were spent on internal programs to improve test capabilities and to develop test methodologies for new types of T&E activities
  - The Center continued to improve, develop, and validate multiple test tools for evaluating ASE infrared countermeasure (IRCM) systems and HFI systems
  - In addition, the Center is improving its electronic warfare capability by developing and validating the high-power Portable Range Threat Simulator (PRTS) that will provide a more comprehensive, integrated ASE T&E environment
- The Center dedicated about 3 percent of its efforts to providing subject matter expertise to numerous working groups (WGs) and task forces

The activities conducted by the Center during the past year are detailed in the subsections that follow.

ASE AND HFI ACTIVITIES

RESEARCH AND DEVELOPMENT ACTIVITY

Foreign: Trial OXIDIZER 2

- Sponsor: The Center/Joint Countermeasures Test and Evaluation (JCMT&E) WG
- Activity: The Center collected radiometric signature data on weapon firings at the Mount Bundey Training Area, Northern Territory, Australia. Participation was under the provisions of the bilateral U.S./Australia ASE Cooperative Test and Evaluation Project Arrangement.
- Benefit: Data collected in the hot, humid environment during OXIDIZER 2 will be used to compare to data collected in less humid environments to better understand sensor performance in high humidity environments and to scale models for the effects of humidity.

Foreign: Infrared Threat Warning System Technical Demonstration Program

- Sponsor: The Center/JCMT&E WG
- Activity: The Center provided subject matter expertise and assisted with planning the collection of Time-Space-Position Information (TSPI) before the United Kingdom (UK) Defence Science and Technology Laboratory conducted hostile fire indication testing at the [UK's] Ministry of Defence Pendine facility.
- Benefit: The Center's advice helped Defence Science and Technology Laboratory to improve the quality of TSPI collected during the event while minimizing the cost to the program.

Navy: Distributed Aperture Infrared Countermeasure 2 (DAIRCM2) Laser Warning, Phase 1
- Sponsors: Naval Research Laboratory
- Activity: The Center conducted static ground tests of the laser warning function in the DAIRCM2 sensors.
- Benefit: The data collected from this effort allowed the sponsor to improve laser detection algorithms and reduce the risks associated with a follow-on flight test of the DAIRCM system.

ROTARY-WING AND FIXED-WING TEST EVENTS

Air Force: Large Aircraft Infrared Countermeasures (LAIRCM) Next Generation HC/MC-130J Flight Test
- Sponsor: 46th Test Wing Test Squadron, Defensive Systems and Mobility Directorate, Air Force Life Cycle Management Center
- Activity: The Center provided one Joint Mobile IRCM Testing System (JMITS), one Multi-spectral Sea and Land Target Simulator (MSALTS) missile simulator, and personnel to perform two-color, infrared (IR) simulations to collect system response data to assess the LAIRCM system, as installed on the HC/MC-130J. The Air Force conducted the test at Eglin Air Force Base (AFB), Florida.
- Benefit: The testing provided the Air Force with a cost-effective test venue to collect critical data needed to assess performance of the LAIRCM system installed on a new platform, the HC/MC-130J.

Air Force: LAIRCM System Processor Replacement Altitude Reference Unit Replacement Flight Test
- Sponsor: 46th Test Wing Test Squadron, Defensive Systems and Mobility Directorate, Air Force Life Cycle Management Center
- Activity: The Center provided an MSALTS missile simulator and personnel to perform two-color, IR, and ultra-violet (UV) simulations to collect system response data needed to assess the upgraded system software with the new altitude reference unit. The Air Force conducted the tests at Eglin AFB, Florida.
- Benefit: The testing provided the Air Force with critical data needed to assess performance of the upgraded LAIRCM system.

Army: Reduced Optical Signature Emissions Solution Infrared CM Test 8.1
- Sponsors: U.S. Army Technology Application Program Office (TAPO) and 160th Special Operations Aviation Regiment Systems Integration and Maintenance Office
- Activity: The Center provided subject matter expertise and a JMITS van with four reactive-configured IR seekers during the IRCM effectiveness test for the MH-60M and MH-47G aircraft. These tests evaluated new flare CM sequences and variations of current flare CM sequences using improved flares, or different flares within the sequences. The Center provided near real-time data reduction and flare sequence analysis to assist the sponsor in making test decisions on flare sequence performance and to provide recommendations on flare sequence timing and/or pattern adjustments. After the test, the Center provided an independent assessment and a briefing of test results to TAPO leadership.
- Benefit: The data collected from this effort allowed TAPO to use the test results to procure new flares needed to enhance protection of the MH-60M and MH-47 aircraft against IR Man Portable Air Defense Systems (MANPADS).

Army: Evaluation of IRCM during Missile Simulations Flight Testing
- Sponsor: U.S. Army Project Management Office, Aircraft Survivability Equipment (PMO-ASE), Program Manager, Countermeasures Sensors
- Activity: The Center provided a JMITS for UV simulations, four reactive-configured IR seekers, and subject matter expertise during the testing for the UH-60M, AH-64E, and CH-47F aircraft. These tests evaluated the performance of each IRCM (laser jammer and/or flare sequence) installed on the aircraft against the static IR seekers.
- Benefit: The data collected from this effort allowed PMO-ASE to assess the performance of the common missile warning sensor and IRCM installed on the UH-60M, AH-64E, and CH-47F aircraft.

Navy: MV-22 Universal Urgent Needs Statement, Department of the Navy (DoN), LAIRCM Integration Test Phase 1
- Sponsor: Navy Program Executive Office (PEO), Advanced Tactical Aircraft Protection Systems Program Office
- Activity: The Center provided the MSALTS two-color IR missile simulations, along with jam beam radiometers, threat-representative laser beamriders, a designator, rangefinder, and radar threat simulations using the PRTS.
- Benefit: The testing provided the critical data needed to support a fleet introduction decision for the DoN LAIRCM Advanced Threat Warning (ATW) as installed on the U.S. Navy MV-22 aircraft.

Navy: Verification of Correction of Deficiencies Test of the CH-53E DoN LAIRCM ATW Sensor
- Sponsor: Navy PEO, Advanced Tactical Aircraft Protection Systems Program Office
- Activity: The Center provided the MSALTS two-color IR missile simulators and jam beam radiometers.
- Benefit: The testing allowed the Navy to collect critical data needed to assess the performance of the DoN LAIRCM ATW hardware and software upgrades.

Navy: Follow-On Operational T&E of the CH-53E DoN LAIRCM ATW Sensor Phase I & II
- Sponsor: Navy PEO, Advanced Tactical Aircraft Protection Systems Program Office
- Activity: The Center provided the MSALTS two-color IR missile simulations, along with jam beam radiometers, threat-representative laser beamriders, a designator, and rangefinder systems during the CH-53E DoN LAIRCM ATW system flight testing.
- Benefit: The testing provided a cost-effective test venue for collecting critical missile warning sensor and laser warning

sensor data needed to evaluate and assess the readiness of the CH-53E DoN LAIRCM ATW system for fleet deployment in theatre.

Navy: P-8A Poseidon LAIRCM Flight Test
- Sponsor: Navy Air T&E Squadron 20
- Activity: The Center provided the MSALTS two-color IR missile simulator for flight testing of the P-8A ASE. The Center provided all data collected to the sponsors for assessment.
- Benefit: The testing provided the Navy with the data necessary to assess the performance of the LAIRCM system as installed on the P-8A.

Navy: KC-130J Integration Flight Test
- Sponsor: Navy PEO, Advanced Tactical Aircraft Protection Systems Program Office
- Activity: The Center provided MSALTS two-color IR missile simulations during flight testing of the KC-130J Integration Flight Test. The Center provided all data collected to the sponsor for assessments.
- Benefit: The testing provided the critical data needed to support a fleet introduction decision for the DoN LAIRCM ATW as installed on the KC-130J aircraft.

National Atlantic Treaty Organization (NATO): Trial MACE XVI
- Sponsor: The Center/JCMT&E WG
- Activity: The Center provided three analysts to help process data and produce reporting products during Trial MACE XVI at the Military Training Area in Lešť, Slovakia.
- Benefit: Trial MACE provided the Center and DOD with an opportunity to understand the current NATO radio-frequency (RF) test methodologies and to review actual threat capabilities.

LIVE FIRE TEST EVENTS

Navy: DoN LAIRCM Dugway Live Fire 2015
- Sponsor: Navy PEO, Advanced Tactical Aircraft Protection Systems Program Office
- Activity: The Center provided MSALTS UV and two-color IR missile simulations and laser threats to support updates to the DoN LAIRCM system, MV-22, KC-130J, and CH-53E configurations.
- Benefit: The testing provided critical data needed to assess DON LAIRCM missile and laser warning performance against various threats, including missiles in free flight, and to support the Validation and Verification of the Digital System Module.

PGW CM ACTIVITIES

Army: Joint Air-to-Ground Missile (JAGM) Obscurants Test
- Sponsor: U.S. Army JAGM Product Office
- Activity: The Center, in conjunction with the sponsor and the Army Missile and Aviation Research and Development Center, coordinated, directed, and conducted tower-mounted seeker tests of the JAGM seeker in obscurant environments against static ground targets.
- Benefit: This effort was designed to mature seeker tactical designs supporting the Technology Development program and provided an opportunity for the JAGM Product Office to verify the modeling and simulation tools for JAGM.

OSD: Vigilant Hammer 1
- Sponsor: Assistant Secretary of Defense for Research & Engineering
- Activity: The Center participated in a Joint Electronic Advanced Technology RF experiment. The Center provided a Millimeter-wave Electronic Attack Simulator to support range detection and susceptibility experiments with the Naval Air Warfare Center, Weapons Division.
- Benefit: Including the Millimeter-wave Electronic Attack Simulator in the experiment helped create a complex and dense RF environment that challenges participant systems to detect, classify, and geo-locate emitters.

CM-BASED PRE-DEPLOYMENT TRAINING FOR SERVICE MEMBER EXERCISES

1-6 CAVALRY MANPADS RF Training – Fort Riley, Kansas
Joint Forcible Entry/Advanced Integration – Nellis AFB, Nevada
3D Marine Aircraft Wing (Part 1) – Camp Pendleton, California
Red Flag 15-1 – Nellis AFB, Nevada
Red Flag 15-2 – Nellis AFB, Nevada
509th Weapons Squadron KC-135 Support (Part 2) – Roswell, New Mexico
Emerald Warrior 15 – Hurlburt Field, Florida
3D Marine Aircraft Wing (Part 2) – Camp Pendleton, California
- Sponsors: Various
- Purpose: The Center's equipment and personnel provided a simulated threat environment and subject matter expertise to observe aircraft sensor/ASE systems and crew reactions to this environment. Specifically, the Center emphasized simulated MANPADS and RF threat engagements for participating aircraft. The Center also provided MANPADS capabilities and limitations briefings to pilots and crews and conducted "hands-on" training at the end of the briefings.
- Benefit: These exercises provided realism to the training threat environment for the Service member pilots and crews to facilitate understanding and use of CM equipment, especially ASE. The Center provided the data collected to the trainers to assist units in developing and refining techniques, tactics, and procedures to enhance survivability.

T&E TOOLS

The Center has continued to develop tools for IRCM systems T&E funded by the Undersecretary of Defense (Acquisition, Technology and Logistics); the Test Resource Management Center; and the Central T&E Investment Program. Currently, the Center is leading the development of the MSALTS and the Joint Standard Instrumentation Suite (JSIS).

- The MSALTS is a small, mobile missile simulator that can fire while moving and simulate all current, Tier 1 missile threats. The Center has designed the MSALTS to provide simulated signatures for the new and more capable missile-warning systems, such as LAIRCM Next Generation, DoN LAIRCM, and the DoN ATW. The Center initiated development of the first two systems in FY11 and the third system in FY12. The developer completed fabrication, assembly, integration, and government acceptance testing in December 2014. The Center successfully transitioned all three systems in 1QFY15 to reach an Initial Operational Capability. In October 2014, the Center proposed an enhancement of the UV emitter to Undersecretary of Defense (Acquisition, Technology and Logistics) to support Common IRCM System operational testing slated for 2QFY17. The Common IRCM System is a component of the integrated IRCM suite planned to defend U.S. aircraft from advanced IR-guided missiles. The system will initially be employed on the Army UH-60 and Marine MV-22 aircrafts.
- The JSIS is a transportable, fully-integrated instrumentation suite that will be used to collect signature, TSPI, acoustic, and related threat missile and hostile fire munitions metadata. The transportability of JSIS will allow it to be used both in the United States and abroad to reduce costs and expand the types of threat data available in the United States. The JSIS has been endorsed by the U.S. Navy (PMA – 272), Army (PMO – ASE), and the Air Force (LAIRCM System Program Office) and will be an integral part of each Program Office's ASE development. In FY14, the Center partnered with the Arnold Engineering Development Center and actively created program plans, refined requirements from the ASE T&E community, created and refined a concept of operations, and began identifying specific instrumentation that meets JSIS requirements. The Center conducted a successful Critical Design Review in May 2014. In FY15, the Center conducted two integrated project reviews to check the status of the technical performance, schedule, and financial health of the development. Development of an Initial Operational Capability is expected to be completed in FY16, with a risk reduction demonstration slated for 1QFY16. In FY15, the Center developed and received the Doppler Scoring Radar under the JSIS program. The radar is capable of providing three-dimensional TSPI on hostile, live-fire activities, including small arms, anti-aircraft, rockets, and MANPADS. The system also could be used to report position information on aircraft flight tracks.

Additionally, as a result of an internal electronic warfare study conducted by the Center in FY13, and the increasing demands for test tools that support multi-spectral, integrated ASE threat environments, the Center internally funded the procurement of two RF threat emitters. A low-powered PRTS system was delivered and started validation testing in late FY15 and a high-powered PRTS capability is scheduled to be delivered in early FY16. These systems are being designed to replicate short-range acquisition and targeting radar systems. Both systems will be validated to support operational testing of the APR-39 B/D.

The Center continues to develop and improve tools for threat, live-fire IRCM testing. In FY14, the Missile and Space Intelligence Center began development on a new remote-missile launcher for the Center. This launcher system was developed to support remote firing of larger vehicle-launched IR surface-to-air missiles. The system was delivered and operationally deployed in FY15 for a number of live-fire events. In FY16, continued improvements will be considered to increase the number of threat types due to sponsor's requests.

The Center continued leading the development of the Hostile Fire Signature (HSIG) model enhancements to support HFI T&E activities. The baseline HSIG Model project has developed a validated, physics-based electro-optic model that produces signatures for the 12.7 mm Armor Piercing Incendiary Tracer round and a rocket-propelled grenade (RPG 7) tracer and hard body, sponsored by the Threat Systems WG with oversight by the T&E Threat Resource Activity. The Center initiated spiral enhancements in 1QFY15 to incorporate RPG back blast and small-arm muzzle flash features to the models. This effort will include data certification by the Intelligence Community and an updated validation report.

JOINT COUNTERMEASURES TEST AND EVALUATION WORKING GROUP

The JCMT&E WG is co-chartered by DOT&E and DASD(DT&E) to measure, test, and assess:

- Aircraft self-protection, countermeasures, and supporting tactics
- Live-fire threat weapons and open-air T&E
- System performance in operationally relevant aircraft installations and combat environments
- T&E methodologies, instrumentation, analysis, and reporting
- Overseas threat and air electronic warfare systems performance and effectiveness data in coalition warfare environments

The JCMT&E WG includes participation by DOT&E, DASD(DT&E), all four of the U.S. Services, Australia, Canada, New Zealand, the UK, and the NATO Air Force Armaments Group Sub-Group 2 (SG/2). The WG is tasked

with actively-seeking mutually-beneficial T&E opportunities to measure performance and suitability data necessary to provide relevant operational information to deploying joint/coalition Service members and for U.S. acquisition decision makers. Specific efforts include:

- The JCMT&E WG was the U.S. Technical Advisor to the official negotiations of the Multinational T&E Program Memorandum of Understanding with Australia, Canada, New Zealand, the UK, and the United States that was signed into effect for the U.S. by the HON Dr. J. Michael Gilmore, DOT&E, in 2015.
- The JCMT&E WG conducted exploratory meetings to identify interest in developing bilateral or multinational T&E program agreements with the following nations in order to conduct mutually advantageous development of T&E instrumentation, methodology, and installed performance testing and to measure live threat weapon firing data: Denmark, Finland, Norway, Sweden, Germany, Italy, Spain, and Switzerland.
- The JCMT&E WG worked with the Office of the Deputy Assistant Secretary of the Army Defense Exports and Cooperation to develop the four-nation Aircraft Electronic Warfare Cooperative T&E Project Arrangement to coalesce much of the redundant testing conducted by Australia, Canada, the UK, and the U.S. to significantly expand performance and to collect suitability data to improve aircraft survivability and reduce cost for all four nations. Initiated identification of required T&E infrastructure, personal, training, and funding required to conduct expected Project Arrangement activities.
- The JCMT&E WG worked with Australia to plan a combined MANPAD/RF threat trial at the Woomera Test Range, South Australia, in September 2016, to further expand the integrated ASE test methodology to the open-air environment using captive seekers and actual and simulated emitters for fixed- and rotary-wing aircraft equipped with flares and decoys.

The JCMT&E WG is cooperating with U.S. allies to provide opportunities that obtain and expand operationally relevant data useful for U.S. operating forces, programs of record, and intelligence organizations to reduce costs and field new capabilities rapidly. Of particular interest is obtaining validated data on simultaneous RF/electro-optical/IR surface-to-air missiles, HFI, and anti-tank guided missile firings by active air-defense units and test organizations. The JCMT&E WG is building on the successful NATO Trial PULSATILLA of May 2014, by coordinating live weapons firings in Bulgaria, Finland, and Slovakia. These efforts will provide measured operational performance of actual, modern, multi-function radars and integrated air defense systems that will likely be used against U.S. forces.

Index

Index

FY15 INDEX OF PROGRAMS

A

Abrams M1A2 System Enhancement Program Version 3 (SEPv3) Main Battle Tank (MBT) 105
AC-130J Ghostrider 17, 19, 23, 309
Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI) for AN/BQQ-10(V) Sonar 17, 19, 159
Advanced Extremely High Frequency (AEHF) Satellite Communications System 313
Aegis Ballistic Missile Defense (Aegis BMD) 17, 19, 22, 361
Aegis Modernization Program 17, 19, 163
AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) Program 19, 23, 167
AIM-9X Air-to-Air Missile Upgrade 17, 169
AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) 16, 22, 315
Air Force Distributed Common Ground System (AF DCGS) 17, 22, 23, 317
Air Operations Center – Weapon System (AOC-WS) 317, 19, 22, 321
AN/SQQ-89A(V)15 Integrated Undersea Warfare (USW) Combat System Suite 17, 19, 22, 23, 171

B

Ballistic Missile Defense System (BMDS) 16, 17, 19, 22, 23, 357

C

Center for Countermeasures (CCM) 419
CH-53K – Heavy Lift Replacement Program 13, 19, 173
Command and Control, Battle Management, and Communications (C2BMC) System 367
Common Aviation Command and Control System (CAC2S) 16, 175
Consolidated Afloat Networks and Enterprise Services (CANES) 16, 179
Cooperative Engagement Capability (CEC) 16, 17, 181
CV-22 Osprey 17, 19, 325
CVN 78 *Gerald R. Ford* Class Nuclear Aircraft Carrier 35, 183
Cybersecurity 389

D

DDG 51 Flight III Destroyer/Air and Missile Defense Radar (AMDR)/Aegis Combat System 193
DDG 1000 *Zumwalt* Class Destroyer 189
Defense Agencies Initiative (DAI) 17, 25
Defense Enterprise Accounting and Management System (DEAMS) 17, 19, 22, 23, 327
Defense Medical Information Exchange (DMIX) 17, 19, 22, 23, 27
Defense Readiness Reporting System – Strategic (DRRS-S) 31
Department of Defense (DOD) Teleport 33
Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM) 13, 17, 19, 197
Distributed Common Ground System – Army (DCGS-A) 16, 19, 23, 103, 107

E

E-2D Advanced Hawkeye 16, 199

F

F-22A Advanced Tactical Fighter 17, 19, 331
F-35 Joint Strike Fighter (JSF) 23, 35, 169, 184, 219
F/A-18E/F Super Hornet and EA-18G Growler 14, 16, 17, 19, 22, 201
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) 19, 335

G

Global Combat Support System – Army (GCSS-Army) 16, 109
Global Combat Support System – Marine Corps (GCSS- MC) 17, 203
Global Command and Control System – Joint (GCCS-J) 17, 19, 83
Ground-Based Midcourse Defense (GMD) 371
Guided Multiple Launch Rocket System – Alternate Warhead (GMLRS-AW) M30E1 ..... 16, 17, 113

H

H-1 Upgrades – U.S. Marine Corps Upgrade to AH-1Z Attack Helicopter and UH-1Y Utility Helicopter 17, 205
HELLFIRE Romeo 115

I

Infrared Search and Track (IRST) 17, 19, 22, 23, 207
Integrated Defensive Electronic Countermeasures (IDECM) 14, 17, 19, 209
Integrated Personnel and Pay System – Army (IPPS-A) Increment I 16, 17, 117

J

Javelin Close Combat Missile System – Medium 121
Joint Battle Command – Platform (JBC-P) 19, 23, 104, 123
Joint High Speed Vessel (JHSV) (Expeditionary Fast Transport) 17, 22, 213
Joint Information Environment (JIE) 87
Joint Light Tactical Vehicle (JLTV) Family of Vehicles (FoV) 16, 22, 125
Joint Standoff Weapon (JSOW) 217
Joint Test and Evaluation (JT&E) 411
Joint Warning and Reporting Network (JWARN) 17, 22, 91

K

KC-46A 16, 337
Key Management Infrastructure (KMI) Increment 2 ..... 18, 19, 23, 93

L

LHA 6 New Amphibious Assault Ship (formerly LHA(R)) 18, 23, 219
Light Armored Vehicle – Anti-Tank Modernization (LAV- ATM)....16, 223
Littoral Combat Ship (LCS) and Associated Mission Modules....14, 15, 17, 18, 19, 22, 23, 225, 273
Live Fire Test and Evaluation (LFT&E)....377

M

M109 Family of Vehicles (FoV) Paladin Integrated Management (PIM) 129
M270A1 Multiple Launch Rocket System (MLRS) Improved Armored Cab (IAC)....131
M829A4 (formerly M829E4) Armor Piercing, Fin Stabilized, Discarding Sabot – Tracer (APFSDS-T) 23, 133
Massive Ordnance Penetrator (MOP)....16, 341
MH-60R Multi-Mission Helicopter 18, 247
MH-60S Multi-Mission Combat Support Helicopter 17, 19, 249
Mid-Tier Networking Vehicle Radio (MNVR)....18, 19, 103, 135
Mine Resistant Ambush Protected (MRAP) Family of Vehicles (FoV) – Marine Corps....253
Mine Resistant Ambush Protected (MRAP) MaxxPro Long Wheel Base (LWB) Ambulance 16, 137
Miniature Air-Launched Decoy (MALD) and MALD – Jammer (MALD-J) 18, 22, 343
Mobile Landing Platform (MLP) Core Capability Set (CCS) (Expeditionary Transfer Dock) and Afloat Forward Staging Base (AFSB) (Expeditionary Mobile Base)....18, 23, 255
Mobile User Objective System (MUOS)....19, 259
MQ-1C Gray Eagle Unmanned Aircraft System (UAS)....18, 139, 145
MQ-4C Triton Unmanned Aircraft System (UAS)....19, 23, 261
MQ-9 Reaper Armed Unmanned Aircraft System (UAS) 19, 23, 345
Multi-Static Active Coherent (MAC) System....14, 22, 263
MV-22 Osprey....18, 22, 67

N

Nett Warrior 16, 19, 143, 153
Network Integration Evaluation (NIE) 103

O

One System Remote Video Terminal (OSRVT) Increment II....16, 139, 145

P

P-8A Poseidon Multi-Mission Maritime Aircraft (MMA)....14, 18, 19, 22, 269
Patriot Advanced Capability-3 (PAC-3) 19, 23, 147
Precision Guidance Kit (PGK)....16, 23, 149
Public Key Infrastructure (PKI) Increment 2....23, 97

Q

Q-53 Counterfire Target Acquisition Radar System 17, 22, 151
QF-16 Full-Scale Aerial Target (FSAT) 16, 22, 349

R

Remote Minehunting System (RMS) 19, 23, 225, 273
Rifleman Radio 153
Rolling Airframe Missile (RAM) Block 2 281
RQ-4B Global Hawk High-Altitude Long-Endurance Unmanned Aerial System (UAS) 23, 351
RQ-21A Blackjack Unmanned Aircraft System (UAS) 23, 283

S

Ship Self-Defense for LHA(R) 13, 14, 18, 287
Ship-to-Shore Connector (SSC) 291
Small Diameter Bomb (SDB) II 355
Small Surface Combatant (SSC) Modification to the Littoral Combat Ship (LCS) 293
SSN 774 *Virginia* Class Submarine 18, 19, 295
Standard Missile-6 (SM-6) 16, 299
Surface Electronic Warfare Improvement Program (SEWIP) Block 2 ..... 18, 19, 301
Surface Ship Torpedo Defense (SSTD) System: Torpedo Warning System (TWS) and Countermeasure Anti-Torpedo (CAT) 17, 18, 19, 22, 303
Surveillance Towed Array Sensor System (SURTASS) and Compact Low Frequency Active (CLFA) Sonar 18, 22, 307

T

Terminal High-Altitude Area Defense (THAAD) and AN/TPY-2 Radar (Forward-Based Mode) 373
Test and Evaluation Resources 397
Theater Medical Information Program – Joint (TMIP-J) 101

U

W

Warfighter Information Network – Tactical (WIN-T) 18, 19, 23, 103, 104, 155

X

Y

Z

DOT&E Activity and Oversight

DOD Programs

Army Programs

Navy Programs

Air Force Programs

Ballistic Missile Defense Systems

Live Fire Test and Evaluation

Cybersecurity

Test and Evaluation Resources

Joint Test and Evaluation

Center for Countermeasures

Index

www.dote.osd.mil