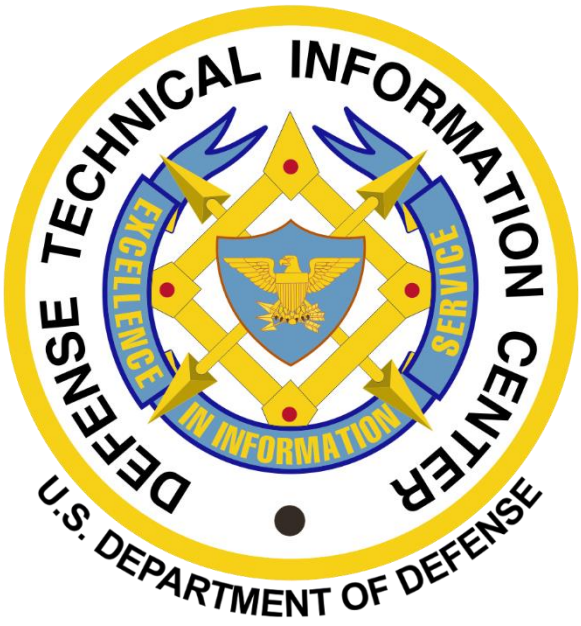
Missile Defense: A Selected Bibliography



DTIC-TR-2020-04

Distribution Statement A

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Introduction:

Missile Defense has been an important part of the U.S. military strategy since the advent of the Cold War. Missile Defense has been a growing topic in recent history as other world powers develop new weapons, such as hypersonic missiles, that can more easily maneuver and avoid traditional defenses. This selected bibliography provides U.S. Government sources about Missile Defense which includes the status of system and technical reports.

How this selected bibliography is organized:

This selected bibliography was created by using Technical Reports in the Defense Technical Information Center's repository and also Congressional Research Service Reports. The summaries are arranged by the subject within missile defense and then arranged in descending order by date. For access to the papers, simply place the accession number (AD) in the search box at https://search.dtic.mil/#/, or, for members of the public www.discover.dtic.mil.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
04-14-2020	Technical Report	2005-01-01 - 2020-02-27

4. TITLE AND SUBTITLE

Missile Defense: A Selected Bibliography.

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Fairchild, Christina L.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Defense Technical Information Center, 8725 John J. Kingman Road, Fort Belvoir, Virginia 22060-6218

8. PERFORMING ORGANIZATION REPORT

DTIC-TR-2020-04

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Defense Technical Information Center, 8725 John J. Kingman Road, Fort Belvoir, Virginia 22060-6218

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

DTIC-TR-2020-04

12. DISTRIBUTION / AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This is a selected bibliography on the topic of missile defense. The abstracts included cover assessments of the missile defense system, concepts of the system, threats to the United States, radars, sensors, Patriot missiles and the Aegis missiles.

15. SUBJECT TERMS: Missile Defense, Ballistic Missile Defense, Air Defense, Antimissile Defense Systems, Radars, Threats.

16. SECURITY CLASSIFICATION OF: Unclassified			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON:** Christina Fairchild
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	SAR	37	**19b. TELEPHONE NUMBER** *(include area code)*
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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Contents

Important U.S. Agencies:

Missile Defense Agency: https://www.mda.mil/system/system.html

> The Missile Defense Agency's (MDA) mission is to develop and deploy a layered Missile Defense System to defend the United States, its deployed forces, allies, and friends from missile attacks in all phases of flight.

Defense Advanced Research Project Agency: https://www.darpa.mil/

> DARPA's Mission: to make pivotal investments in breakthrough technologies for national security. DARPA is working on developing the Glide Breaker program, a potential defense against hypersonic weapons.

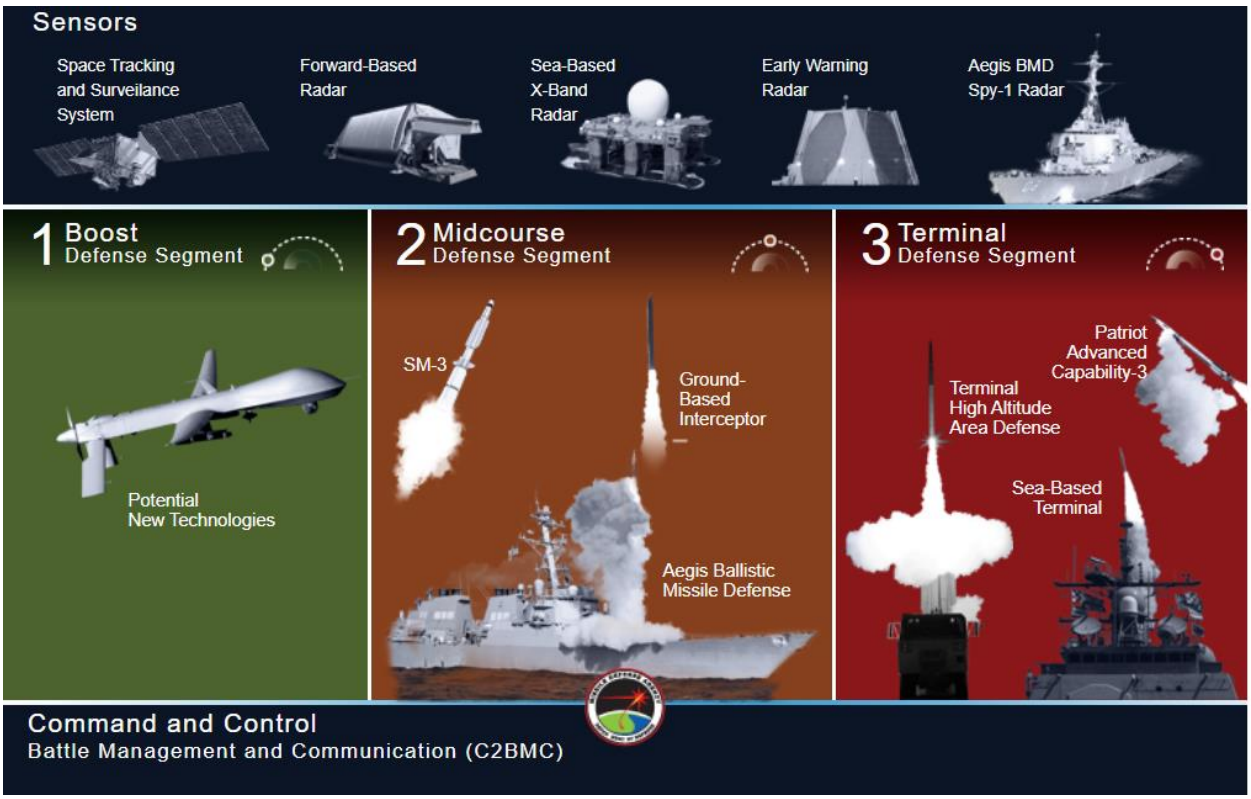
North American Aerospace Defense Command: https://www.norad.mil/

> The North American Aerospace Defense Command (NORAD) is a United States and Canada bi-national organization charged with the missions of aerospace warning, aerospace control and maritime warning for North America. Aerospace warning includes the detection, validation, and warning of attack against North America whether by aircraft, missiles, or space vehicles, through mutual support arrangements with other commands.

National Defense Industrial Association, Missile Defense: https://www.ndia.org/divisions/missile-defense

> The National Defense Industrial Association's (NDIA) goal is to foster close relationships between the U.S. government, military, academia, and defense industry to work towards the national security needs of the United States through dialogue, collaboration, and guidance. The NDIA has many divisions on a range of topics, one of which is the missile defense needs of the United States.

The Missile Defense Agency's Current Missile Defense System:



Source: https://www.mda.mil/system/system.html

The Missile Defense Agency (MDA) currently has a system in place with sensors, boost defense, midcourse defense, and terminal defense. The sensor system is comprised of sea based X-Band radars and Aegis BMD Spy 1 Radars, space tracking, early warning systems, and forward based radar. For interception, the MDA is looking at new technologies, such as boost defense systems for early interception of weapons. Midcourse defense includes the SM-3, ground base439d interceptors, and the Aegis Ballistic Missile System. The Aegis systems is the naval run system for defense. The terminal defense weapons include sea based terminals, Patriot missiles, and terminal high-altitude defense missiles. Finally, a system is only as strong as the ability to retain command and control. The MDA has the Command and Control, Battle Management, and Communication (C2BMC) system.

Assessments of the Missile Defense System:

Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092436	2/14/2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Hypersonics, Russia, China, Conventional Prompt Global Strike, Ballistic Missiles, Hypersonic Glide Vehicles, Rockets, Intermediate Range Ballistic Missiles, Test and Evaluation, Supersonic Combustion Ramjet Engines	
Identifiers:	N/A	
Members of Congress and Pentagon officials have placed a growing emphasis on U.S. programs to develop hypersonic weapons as a part of an effort to acquire the capability for the United States to launch attacks against targets around the world in under an hour. Hypersonic weapons, like all long-range ballistic missiles, can travel faster than Mach 5, or about 1 mile to 5 miles per second. 1 This interest is driven by both the perceived mission need for conventional prompt strike systems and concerns about falling behind Russia and China in the development of these technologies. 2 The United States is pursuing two key technologies for this purpose: boost-glide systems that place a hypersonic glider atop a ballistic missile booster or shorter-range rocket systems, and hypersonic cruise missiles that would use scramjet technologies.		

2019 Missile Defense Review		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1066924	1/1/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Office Of The Secretary Of Defense Washington United States	
Descriptors:	Defense Systems, Guided Missiles, Ballistic Missiles, Cruise Missiles, Deterrence, National Security, Diplomacy, Foreign Relations, Military Operations, Department Of Defense	
Identifiers:	N/A	

2015 Assessment of the Ballistic Missile Defense System (BMDS)		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1011964	4/1/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Gilmore, J. M.	
Corporate Author:	Director, Operational Test and Evaluation Washington United States	
Descriptors:	Guided Missile Defense Systems, Test and Evaluation, Operational Effectiveness, Survivability, Area Defense, Command and Control Systems, Intercontinental, Ballistic Missiles, Guided Missiles, Reliability, Cruise Missiles, Flight Testing, Ground Based	

Identifiers:	BMDS (Ballistic Missile Defense Systems), GMD (Ground Based Midcourse Defense), Aegis BMD, THAAS (Terminal High Altitude Area Defense), Patriot, C2BMC (Command and Control Battle Management and Communications), Operational Realism

This report supports the congressional reporting requirements of the Director, Operational Test and Evaluation (DOT and E) as they pertain to the Ballistic Missile Defense System (BMDS). Congress specified these requirements in the fiscal year 2002 (FY02) National Defense Authorization Act (NDAA). The FY09 NDAA, Section 234, amends the FY02 NDAA to consolidate the reporting requirements of both the FY02 and the FY06 NDAAs. The FY02 NDAA, as amended, mandates that DOT and E each year characterize the operational effectiveness, suitability, and survivability of the BMDS and its elements that the Missile Defense Agency (MDA) has fielded or tested prior to the end of the preceding fiscal year. The act also requires DOT and E to assess the adequacy and sufficiency of the BMDS test program during the preceding fiscal year. This report assesses the performance and test adequacy of the BMDS, its four autonomous BMDS systems, and its sensor/command and control architecture. The four autonomous BMDS systems are the Ground-based Midcourse Defense (GMD), Aegis Ballistic Missile Defense (Aegis BMD), Terminal High-Altitude Area Defense (THAAD), and Patriot. The Command and Control, Battle Management, and Communications (C2BMC) element anchors the sensor/command and control architecture. This report covers the period from October 1, 2014 through December 31, 2015. Many of the details of the performance of the BMDS are classified, and are included in the classified version of this report.

Ballistic Missile Defense System (BMDS)

Accession Number:	**Report Date:**	**Access Restrictions:**
AD1018994	12/1/2015	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Syring, James D.	
Corporate Author:	Department of Defense, Missile Defense Agency Fort Belvoir United States	
Descriptors:	Budgets, Acquisition, Department Of Defense, Defense Systems, Foreign Military Sales, Test And Evaluation, Procurement, Contracts, Cost Estimates, Costs, Cost Analysis, Maintenance, Production, Ballistic Missiles	
Identifiers:	PB (Presidents Budget),SAR (Selected Acquisition Reports)	

The Missile Defense Agency (MDA) is committed to protecting the homeland, deployed forces, and international partners and friends from the expanding threat of ballistic missiles. Improvements in sensors, fire control, battle management, and interceptors have enabled our continued development and deployment of an increasingly integrated, layered, and affordable Ballistic Missile Defense System (BMDS) to counter threats expected over the near and far terms. MDA had many significant achievements in 2015.

Science and Technology Issues of Early Intercept Ballistic Missile Defense Feasibility

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA552472	9/1/2011	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Fallon, William, Lyles, Lester	

Corporate Author:	Defense Science Board Washington Dc
Descriptors:	Antimissile Defense Systems, Feasibility Studies, Adaptive Systems, Architecture, Countermeasures, Defense Systems, Flight, Guided Missiles, Interception, Intercontinental Ballistic Missiles, Intervals, Land Areas, Military Assistance, Task Forces, Theater Level Operations, Thrust Termination Systems
Identifiers:	N/A

The Defense Science Board Task Force on Science and Technology Issues of Early Intercept (EI) Ballistic Missile Defense Feasibility was convened in December 2009 and concluded its deliberations in May 2011. The Terms of Reference (TOR) for the Task Force focused on defense against regional-level adversary ballistic missiles. It directed the Task Force to consider both technology issues and architectural constructs to accomplish Early Intercept (defined in the TOR as that interval in a ballistic missile s flight between thrust termination and final deployment of warhead(s) and/or countermeasures). The complete terms of Reference are in Appendix A, and the Task Force membership is in Appendix B. A list of briefings to the Task Force is in Appendix C. In February 2010, the Department of Defense issued a key document that comprehensively outlined the objective of the Nation's ballistic missile defense program (Ballistic Missile Defense Review Report, February 2010). This document clearly spelled out the top priority role of regional ballistic missile defense wherein the U.S. committed itself to defend not only our military assets overseas, but also to provide missile defense assistance to our allies and partners. The U.S. has many allies and partners worldwide, so there is a wide range in the difficulty of achieving defensive coverage of their territories. The collection of allies in Europe represents the largest land mass to cover, and the Task Force devoted much of its analytics to this European theater. However, in examining the issues related to EI in the context of the Phased Adaptive Approach (PAA) in Europe (EPAA), the Task Force additionally considered a different kind of EI from that spelled out in the TOR, namely the issues related to using regional forward-based defenses to get an early shot at intercontinental ballistic missiles (ICBMs) heading to the U.S.

Ballistic Missile Defense: Historical Overview

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA470214	7/9/2007	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Hildreth, Steven A.	
Corporate Author:	Library Of Congress Washington Dc Congressional Research Service	
Descriptors:	Guided Missiles, United States Government, History, Treaties, Antimissile Defense Systems ,USSR, Legislation, Political Negotiations, Theater Missile Defense, Intercontinental Ballistic Missiles, Military Budgets, Interceptors, Strategic Defense Initiative, Threats, Short Range(Distance),Long Range(Distance))	
Identifiers:	Ballistic Missile Defense, Anti Ballistic Missile Treaty, SDI (Strategic Defense Initiative),GPALS(Global Protection Against Limited Strikes),Richard M Nixon Administration, Ronald Reagan Administration, George H W Bush Administration, Bill Clinton Administration, George W Bush Administration, Patriot Missiles	

For some time there has been a growing sense of urgency to develop and deploy effective missile defenses against a range of long-range and short-range ballistic missile threats. Although many people might believe this to be relatively new to U.S. national security objectives, such interest has been ongoing since the end of World War II. Many current technologies being investigated date their start to the 1980s, and earlier. This effort has been technically challenging and politically controversial. Some $110 billion has been spent on missile defense efforts since the mid-1980s; Congress appropriated $9.3 billion in FY2006. For FY2008, the Administration requested $8.9 billion for the Missile Defense Agency. This short report provides a brief overview of the history of the missile defense efforts undertaken to defend the United States. It begins with a brief summary of the provisions of the 1972 ABM Treaty, which shaped most of the history of the U.S. ballistic missile defense (BMD) effort, and includes a short review of U.S. programs leading to the current program. It may be updated periodically.

Integrated Missile Defense

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA519780	1/1/2007	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Campbell, Kevin T.	
Corporate Author:	National Defense University Washington DC Inst For National Strategic Studies	
Descriptors:	Attack, Antimissile Defense Systems, Intercontinental Ballistic Missiles, Reprints, Department Of Defense, Global, Interceptors, Multimission, Infrastructure, Military Operations, Military Forces(United States),Test And Evaluation, Activation	
Identifiers:	JFCC IMD(Joint Functional Component Command For Integrated Missile Defense), Missile Defense Agency, GCCS(Geographic Combatant Commands),Allies	

The Joint Functional Component Command for Integrated Missile Defense (JFCC-IMD) was established in January 2005. Its primary mission is to conduct functions for global missile defense to protect the United States, its deployed forces, friends, and allies from ballistic missile attacks. Because of the missile defense infrastructures available in Colorado Springs, Colorado, JFCC-IMD established its operations center at the Joint National Integration Center at Schriever Air Force Base. Both the Center and the base were specifically chosen to enable JFCC-IMD to leverage the plethora of developmental and test resources from the Missile Defense Agency, as well as to afford direct access to the Army's Ground-based Midcourse Integrated U.S. Navy Defense Missile Defense Element and U.S. Northern Command. By collocating at the Joint National Integration Center, JFCC-IMD is uniquely positioned to provide seamless collaboration between the warfighters and developers to operationalize ballistic missile defense system (BMDS) capabilities and to facilitate transition of dual-use and multi-mission capabilities to service various operations and development missions. This past year has seen operational achievement for integrated missile defense. JFCC-IMD, in partnership with the Missile Defense Agency and various geographic combatant commands (GCCs), activated limited defensive operations, a significant milestone for the integrated missile defense. The declaration of limited defensive operations was unprecedented in many ways; for the first time, the United States is protected from ballistic missile attacks.

Missile Defense Concepts:

U.S. Withdrawal from the INF Treaty: What's Next?		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092440	1/2/2030	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	United States Government, Department of Defense, Treaties, Russia, NATO, Nuclear Weapons, Military Operations	
Identifiers:	INF (Intermediate Range Nuclear Forces), INF Treaty	
On August 2, 2019, the United States withdrew from the Intermediate-Range Nuclear Forces (INF) Treaty. The United States withdrew from the treaty in response to Russia's deployment of an INF-range ground-launched cruise missile, which violated the treaty's ban on missiles with a range between 500 and 5,500 kilometers (see CRS Report R43832, Russian Compliance with the Intermediate Range Nuclear Forces (INF) Treaty: Background and Issues for Congress).		

Defense Primer: Ballistic Missile Defense		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092443	10/9/2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	N/A	
Identifiers:	N/A	

Blazing Skies		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1085098	6/14/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Jackson, David A.	
Corporate Author:	US Army Command and General Staff College Fort Leavenworth United States	
Descriptors:	War Games, Officer Personnel, Air Defense, Tactical Air Support, Defense Systems, Combat Support, Army Operations, Army Planning, Missions, Open Source Intelligence, Air Power	
Identifiers:	Wargaming, Missile Defense, Close Air Support ,Military Education, Air Defense Artillery	
This wargame thesis seeks to answer the question: Can Air and Missile Defense (AMD) concepts be effectively modeled to educate junior Air Defense Artillery (ADA) officers and senior non-air defense officers on the basic employment of AMD and its cost trade-offs in a competitive wargame?" Many wargames focus heavily on air to air combat or air support of ground units		

Viability of Medium-Sized Unmanned Surface Vehicles to Protect Surface Action Groups Against Anti-Ship Cruise Missiles		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1080173	6/1/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Clark, Alex J., Deascentis, Nathaniel E., Hammen, Joel M., Logan, Jonathan P., Nelson, Layna, Pullen, Kimberly T., Robertson, Darren B.	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Unmanned Surface Vehicles, Electronic Warfare, Anti-Ship Missiles, Cruise Missiles, Radar, Countermeasures, SURFACE TO AIR MISSILES, Weapon Systems, Threats, Naval Warfare, Defense Systems	
Identifiers:	Sea Hunter, Kill Chain, Surface Action Group	
This report describes equipping medium-sized unmanned surface vehicles and integrating them with surface action groups to improve defense against anti-ship cruise missile threats. Requirements for air search radar, electronic warfare, soft-kill deception countermeasure, surface-to-air missile, and close-in weapons systems are generated and allocated to physical components. Requirements for supporting subsystems, such as an integrated combat system and communications, electrical power, cooling, hydraulics, positioning, navigation, and timing systems, are also identified. The unmanned surface vehicles ability to extend sensor and weapons coverage for the surface action group is explored via modeling and simulation. The report presents quantitative analysis that employing unmanned surface vehicles equipped with systems to detect anti-ship cruise missile threats and soft-kill and hard-kill threat response options offers surface action groups a defensive advantage against those threats.		

Analysis of Ballistic Missile Defense Strike Operations Using Stochastic Simulation Modeling of a Left-of-Launch Network		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1080479	6/1/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Vogel, Matthew	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Theater Ballistic Missiles, Simulations, Discrete Event Simulation (Model),Stochastic Processes, Defense Systems, Active Defense	
Identifiers:	Discrete Event Simulation Modeling, Ballistic Missile Defense, Left Of Launch Network	
With the proliferation of hostile theater ballistic missiles (TBMs), the Department of Defense has focused on attack operations as a means of ballistic missile defense (BMD). This thesis develops a stochastic simulation of a network for analyzing and comparing BMD strike operations. Applying knowledge of mobile launch site procedures, we construct a TBM left-of-launch network (LLN) model using discrete-event simulation software. This comprehensive network models system components from the storage phase, transportation phase, and launch phase. The simulation model integrates congestion effects after strikes are executed on the LLN. We conduct simulation experiments representing various strike combinations to quantify and compare system metrics focused on increasing the delay of TBM launches. We demonstrate BMD strike effectiveness by analyzing time-valued metrics such as the mean TBM time in system and mean time to complete launches. Increasing		

the delay in TBM launches grants more time for strategic decision making and prepositioning of retaliatory forces. We present this notional model and experimentation method as a guide for determining the best locations for BMD strike operations.

Joint Air and Missile Defense Mission Command: A Singular, Intelligent Multi-Domain Platform and Culture		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1057654	5/29/2018	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Behrens, Anthony J.	
Corporate Author:	Gravely Naval Research Group, Naval War College Newport United States	
Descriptors:	Antimissile Defense Systems, Air Defense, Area Denial, Artificial Intelligence, Machine Learning, Threats, North Korea, Iran, China, Russia, Vulnerability, Command And Control, Battle Management, Case Studies, Deterrence, Ballistic Missiles, Military Forces (United States),Military Forces (Foreign)	
Identifiers:	Missile Defense, IAMD (Integrated Air And Missile Defense), JIAMD (Joint IAMD, BMD (Ballistic Missile Defense), A2AD (Anti Access Area Denial),AI (Artificial Intelligence), Intelligent Agents, IBM, Raytheon, Northrup Grumman, IBCS (Integrated Battle Command System), CEC (Cooperative Engagement Capability), C2BMC (Command And Control Battle Management And Communications),Modular Ai	
The Army's Integrated Battle Command System (IBCS) will integrate sensors, shooters and mission command with multiple defensive and counter-fire capabilities. The Navy's Cooperative Engagement Capability (CEC) is similarly designed. To maintain a position of advantage over the evolving air and missile threat, the Department of Defense requires a joint fire control and sensor optimization platform immediately adaptable and capable of updating mission command functions across the battlespace to effectively counter anti-access and area denial (A2/AD) strategies in a multi-domain operating environment.		

Defending the Nest: Updating Joint Doctrine to Mitigate the Threat of Ballistic and Cruise Missiles to Air Bases		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1062018	5/4/2018	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Conner, J. P.	
Corporate Author:	Naval War College Newport United States	
Descriptors:	Doctrine, Ballistic Missiles, Cruise Missiles, Countermeasures, Threats, Defense Systems, Military Facilities, Air Power, Air Force Facilities	
Identifiers:	N/A	
The increasing proliferation of long-range, highly accurate, ballistic and cruise missile technology is threatening to end the era of sanctuary for U.S. bases around the world. Because potential		

adversaries continue to advance their missile technology, the U.S. must improve missile defenses at forward U.S. air bases. Investment will follow joint doctrine, but the current categorization of countermeasures into active and passive defense is insufficient. Doctrine must be updated to group countermeasures by their role prior to, during, and following missile-delivered warheads impacting an installation. Moreover, the characteristics of defenses and nature of the threat dictates that the U.S. cannot mitigate risk by using a single type of countermeasure. Instead, investment should utilize a portfolio approach to missile defense that integrates three types of defenses to prevent, protect, and recover damage caused by attacking warheads. Additional research using the proposed joint doctrine framework is needed to determine the best mix of countermeasures for future investment.

Defensive Swarm: An Agent Based Modeling Analysis		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1053392	12/1/2017	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Padgett, Nathan E.	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Swarming Technologies, Agent Based Simulations, Object Oriented Programming, Graphical User Interface, Computer Simulations, Unmanned Aerial Vehicles, Artificial Intelligence, Military Applications, Collision Avoidance Systems, Warning Systems, Search And Rescue, Drones, Command And Control	
Identifiers:	ABM (Agent Based Models),UAS (Unmanned Aircraft Systems),Base Defense, Generalized Linear Models, ROC (Receiver Operating Characteristic)	

Security at remote military bases is a difficult, yet critical, mission. Remote locations are generally closer to enemy combatants and farther from supporting forces; the individuals charged with defending the bases do so with less equipment. These locations are also usually reliant on air-resupply missions to maintain mission readiness and effectiveness. This thesis analyzes how swarms of small autonomous unmanned aerial vehicles (UAVs) could assist in defensive operations. To accomplish this, I created an agent-based computer simulation model, which creates a tactical problem (enemies attempting to attack or infiltrate a notional base) that a swarm of UAVs attempts to defend against. Results indicate that a swarm can effectively deter 95% of attackers if each UAV is responsible for covering no more than 0.18 square miles and at least 40% of the UAVs are armed. I conclude that UAVs are an excellent addition to base defense and are particularly helpful at remote outposts with less organic capability (limited field of view, defensive assets, etc.). While this research deals specifically with countering a threat to a central base, the algorithms for swarm dynamics could be applied to future problems in mobile convoy or aircraft defense, and even peacetime applications like search and rescue.

The Air Campaign vs. Ballistic Missiles Seeking the Strategic Win in the 21st Century		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1042198	6/1/2017	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Anderson, J. P.	

Corporate Author:	School of Advanced Air And Space Studies Maxwell Air Force Base United States
Descriptors:	Aerial Warfare, Air Power, Second World War, Ballistic Missiles, Case Studies, Surface To Surface Missiles, Air Defense, Persian Gulf War, Military Strategy, Weapon System Effectiveness, Military History
Identifiers:	WWII Germany ,V 1 Bomb, V 2 Rocket, Scud Missile, Air Warfare, Organizational Effectiveness
Most literature concerning the use of surface-to-surface missiles (SSMs) is focused on counter-proliferation. The authors are concerned with the emerging missile capabilities of rogue state missile arsenals. They fear that increasing ranges and accuracy will eventually threaten the US homeland. This concern is certainly warranted, but largely misses another potential consequence of enlarging SSM arsenals around the world: the threat of derailing 21st century strategic air campaigns.	

Nuclear Reign: Providing a Nuclear Umbrella to United States Pacific Partners		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1041957	4/6/2017	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Cooper, Philip J.	
Corporate Author:	Air War College, Air University Maxwell AFB United States	
Descriptors:	North Korea, China, Deterrence, Antimissile Defense Systems, Ballistic Missiles, Nuclear Weapons, Early Warning Systems, Policies, United States, Military Modernization, Threats, National Security	
Identifiers:	N/A	
China and North Korea greatly increased their threat postures toward U.S. allies and interests in the Pacific in 2016 and both continue to do so today. The new administration must make the U.S. Nuclear Posture Review a top priority in 2017. Specifically, President Trump and his administration must consider both the U.S. nuclear deterrence posture worldwide as well as extended deterrence to U.S. Pacific allies under the nuclear umbrella. This paper examines the growing threat in the Pacific from China and North Korea, proposes how the U.S. might best provide extended deterrence in the region, and concludes that maintaining the status quo will not be sufficient going forward.		

Reassuring Russia On BMD		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1037595	2/16/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	FEGLEY, MARK	
Corporate Author:	Air War College, Air University Maxwell AFB United States	
Descriptors:	Ballistic Missiles, Defense Systems, Russia, Homeland Defense, United States, Nuclear Weapons, International Law, International Relations	
Identifiers:	Ballistic Missile Defense (BMD)	
The United States Ballistic Missile Defense comprehensive strategy states that the United States homeland missile defense capabilities are not focused on Russia, are not intended to affect the strategic balance with them, and are not of sufficient capacity to deal with Russian large scale attacks.		

However, Russia sees the United States expansion of international efforts and cooperation on missile defense as a contentious issue. Of note, Russia has a strong disagreement with the United States about the extent of Iran's nuclear program, interprets the U.S. strategy as unilateral, is concerned over the degradation of their second strike capability, and is concerned with the U.S. and NATO eastward encroachment into their sphere of influence. Reflecting Russia's concerns over the U.S. ballistic missile defense strategy, Russia's President announced his State Armament Program 2020 which increases spending on next generation missiles and countermeasures as well as strategic missile troops and aerospace defense forces. Ultimately, this counter response risks triggering regional conflict, crisis instability, and a new arms race. To hand off these outcomes, this paper proposes cooperative actions the U.S. should take to ease Russia's threat perception to include declarations of openness, Russian participation in NATO missile defense summits, development of a joint threat assessment, sharing of early warning data, instituting a cooperative command and control for ballistic missile intercepts, and developing a joint NATO-Russia training program.

Interoperability In Multi-Layered Active Defense: The Need For Commonality And Robustness Between Active Defense Weapon Systems

Accession Number:	**Report Date:**	**Access Restrictions:**
AD1036894	2/16/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Dolov, Gil M.	
Corporate Author:	Air War College Maxwell AFB Al Maxwell AFB United States	
Descriptors:	Ballistic Missile Intercept Systems, Ballistic Missiles, Weapon Systems, Cooperation, Interoperability	
Identifiers:	THAAD (Terminal High Altitude Area Defense), BMC (Battle Management Center),Hit To Kill, Arrow Missiles, Patriot Missiles, RV (Reentry Vehicle),Multi Layered Architecture	

Since World War II nations have increasingly relied on ballistic missiles. The use of ballistic weapons allows the attacker to save resources and reduce the use of air power. These weapon systems are cheap, deadly and likely to be used by poorer countries. Furthermore, ballistic missiles are constantly being improved. In World War II the Germans bombed the United Kingdom with thousands of ballistic missiles, yet this threat did not change the face of the war nor tip the balance in favor of Germany. However, over the years by combining nuclear weapons and ballistic missiles, the influence of ballistic weapons has become much more threatening and strategic. The armament of ballistic weapons has become a worldwide proliferation phenomenon. During the last three decades the Arab countries, especially those in the Middle East, have begun to obtain ballistic weapons at an increasing rate. In 1998, a study published by Congressional Committees, stated that approximately 25-30 countries were seeking to develop non-conventional ballistic weapons. In 2006, more than one hundred ballistic missiles were launched around the world as part of ballistic missile firing tests. The increase of ballistic missiles and rocket tests rises each year by 10 percent. Today, all the countries which have a nuclear capability also have the ability to launch medium- and long-range ballistic missiles. In 2004, a report by the head of the International Atomic Energy Agency (IAEA) declared that over 40 countries have the capacity to produce nuclear weapons. As of 2009, the total ballistic missiles in the world not including the manufacturing countries such as the United States, Soviet Union and China stood at over 5,900 missiles. For example, in the Middle East, Syria has hundreds of ballistic missiles, especially large surface-to-surface missiles which are now mainly used against rebel forces.

Back to the Future: Integrated Air and Missile Defense in the Pacific		
Accession Number:	**Report Date:**	**Access Restrictions:**
ADA622600	2/1/2015	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Dorner, Kenneth R., Hartman, William B., Teague, Jason M.	
Corporate Author:	Air Univ Maxwell AFB Al Air Force Research Inst	
Descriptors:	Antimissile Defense Systems, Military Tactics, Access, Air Force, Cold War, Command And Control Systems, Control, Defense Systems, Environments, Guided Missiles, Integrated Systems, Models, Pacific Ocean, Reprints, Second World War, Security, Skills, Sources, Theater Level Operations, Threats, United States, Vulnerability	
Identifiers:	N/A	
Since the end of the Cold War, the United States has enjoyed relatively uncontested access from which to stage and generate air power worldwide. Coupled with the lack of a credible threat to airfields, access led the Air Force toward a model of air base operations that emphasized the use of main operating bases (MOB). These bases, fortified with substantial numbers of aircraft, had little concern for their vulnerability to high-end antiaccess, area-denial (A2/ AD) attack simply because a credible threat did not exist. In Clausewitzian terms, these MOBs are centers of gravity-not only a source of strength for the United States and its allies but also a potential vulnerability subject to attack and exploitation by a savvy and capable adversary. The A2/ AD formula is straightforward and persistent throughout history: use all available means to gain control of an area while simultaneously denying the enemy the ability to do the same, primarily by preventing access and disrupting operations. Although the concept is ancient, in the last decade, new and emerging A2/ AD tactics and technologies have allowed possible adversaries to challenge the US and coalition airpower advantage. In light of these increasingly capable A2/ AD systems and tactics, today's security environment demands that we operate differently, particularly in the Pacific theater where distance and diversity rule supreme and where controlling an area while denying the same to the opponent is particularly difficult.		

Cruise Missile Penaid Nonproliferation: Hindering the Spread of Countermeasures Against Cruise Missile Defenses		
Accession Number:	**Report Date:**	**Access Restrictions:**
ADA611506	1/1/2014	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Speier, Richard H., Nacouzi, George, McMahon, K. S.	
Corporate Author:	Rand National Defense Research Inst Santa Monica Ca	
Descriptors:	Cruise Missiles, Antimissile Defense Systems, Arms Control, Countermeasures, Penetration Aids, Technology Transfer	
Identifiers:	N/A	
This research describes an approach to hindering the spread of countermeasures against cruise missile defenses. (Such countermeasures, when incorporated in an attacker s missile or employed in conjunction with such a missile, are called penetration aids, or penaids.) This approach involved compiling an unclassified list of penaid-relevant items that might be subject to internationally agreed-upon export controls. The list is designed to fit into the export-control structure of the current		

international policy against the proliferation of missiles capable of delivering weapons of mass destruction. This policy, the Missile Technology Control Regime (MTCR), sets rules agreed to by 34 governments for restricting the export of items, listed in a technical annex. This report recommends controls on 18 penaid-relevant items and subitems. Because cruise missile penaids can have applications either not restricted by the MTCR (e.g., for manned aircraft) or subject only to the regime s less rigorous controls (e.g., for relatively small cruise missiles), the report recommends that the 18 items be subject to case-by-case export reviews under MTCR procedures. To be effective, these less rigorous controls will require energetic implementation, and cooperation by Russia and China will be critical.

Penaid Nonproliferation: Hindering the Spread of Countermeasures Against Ballistic Missile Defenses

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA595558	1/1/2014	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Speier, Richard H., McMahon, K. S., Nacouzi, George	
Corporate Author:	Rand National Defense Research Inst Santa Monica Ca	
Descriptors:	Antimissile Defense Systems, Control, Countermeasures, Exports, Guided Missiles, Penetration Aids, Boost Glide Vehicles, Decoys, Department Of Defense, Dual Use Technology, Mass Destruction Weapons, Policies, Reentry Vehicles, Test Equipment, Test Facilities	
Identifiers:	Penaid Nonproliferation, Penaid Relevant Items, Penaid Export Controls, Missile Technology Control Regime, Missile Subsystems ,Missile Components, Dual Use Items, Countermeasure Subsystems, Complete Subsystems, Re Entry Vehicle Replicas, Re Entry Vehicle Decoys	

This research describes an approach to hindering the spread of countermeasures against ballistic missile defenses. Such countermeasures, when incorporated in an attacker's missile, are also called penetration aids, or penaids. The approach involved compiling an unclassified list of penaid-relevant items that might be subject to internationally agreed-upon export controls. The list is formatted to fit into the export-control structure of current international policy against the proliferation of missiles capable of delivering weapons of mass destruction. This policy, the Missile Technology Control Regime, creates two levels of control. One is a set of tight restrictions against a small number of items, such as complete missiles or their major subsystems. The other is a set of case-by-case export reviews for lower-level components and dual-use items. This report recommends controls on 19 penaid-relevant items. More specifically, it recommends the tightest controls on three of those items: complete, integrated countermeasure subsystems; complete subsystems for missile defense test targets; and boost-glide vehicles. It offers as candidates for the tightest controls 10 other items, such as re-entry vehicle replicas or decoys. But because these 10 items are not complete subsystems, it identifies the possibility of treating them to a case-by-case review to improve the negotiability of the controls. Finally, the report identifies six classes of items, including test facilities and equipment, that could appropriately be subject to case-by-case review because of their utility for other applications, such as peaceful satellites.

Threats:

China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092437	1-22-2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	O'Rourke, Ronald	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	China, Navy, Naval Operations, Fixed Wing Aircraft, National Security, Fighter Aircraft, Naval Warfare	
Identifiers:	N/A	
This report provides background information and issues for Congress on China's naval modernization effort and its implications for U.S. Navy capabilities. In an international security environment of renewed great power competition, China's military modernization effort, including its naval modernization effort, has become the top focus of U.S. defense planning and budgeting. The issue for Congress for this CRS report is whether the U.S. Navy is responding appropriately to China's naval modernization effort. Decisions that Congress reaches on this issue could affect U.S. and allied security, Navy capabilities and funding requirements, and the defense industrial base.		

Iran's Ballistic Missile and Space Launch Programs		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092438	1-9-2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	McCall, Stephen M.	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Iran, Ballistic Missiles, Short Range Ballistic Missiles, Intercontinental Ballistic Missiles, Medium Range Ballistic Missiles, Rockets	
Identifiers:	N/A	

Russia's Nuclear Weapons: Doctrine, Forces, and Modernization		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092439	1/2/2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Woolf, Amy F	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Russia, Nuclear Weapons, Modernization, Ballistic Missiles, Threats , Arms Control Treaties, National Security, Ballistic Missile Submarines	
Identifiers:	N/A	
Russia's nuclear forces consist of both long-range, strategic systems—including intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and heavy bombers—and shorter- and medium-range delivery systems. Russia is modernizing its nuclear forces, replacing		

Soviet-era systems with new missiles, submarines and aircraft while developing new types of delivery systems. Although Russia's number of nuclear weapons has declined sharply since the end of Cold War, it retains a stockpile of thousands of warheads, with more than 1,500 warheads deployed on missiles and bombers capable of reaching U.S. territory

North Korea's Nuclear and Ballistic Missile Programs		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092444	6/6/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Nikitin, Mary Beth D.	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Government (Foreign), Military Forces (Foreign), North Korea, Nuclear Weapons, Ballistic Missiles, Military Doctrine, Military Intelligence	
Identifiers:	Kim Jong-un	
North Korea has made recent advancements in its nuclear weapons and ballistic missile programs. Since Kim Jong-un came to power in 2012, North Korea has conducted over 80 ballistic missile test launches. In 2016, North Korea conducted 2 nuclear weapons tests and 26 ballistic missile flight tests on a variety of platforms. In 2017, North Korea test launched 18 ballistic missiles (with 5 failures), including 2 launches in July and another in November that many ascribe as ICBM tests (intercontinental ballistic missiles). Most recently, North Korea tested short-range ballistic missiles on May 4 and 9. It last conducted a nuclear test in September 2017. In April 2018, Kim Jong Un said that nuclear and ICBM testing was no longer necessary. U.N. Security Council resolutions ban all ballistic missile tests by the DPRK.		

Ballistic Missile Defense In The Middle East		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1073667	3/1/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Shahkaram, Malik M.	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Theses, Middle East, Antimissile Defense Systems, Weapons of Mass Destruction, Security	
Identifiers:	Ballistic Missile Defense	
Ballistic missile proliferation is a significant concern in the Middle East. Israel, Saudi Arabia, and Jordan have closely associated themselves with the United States. These nations are targets of American adversaries such as Iran, Syria, and terrorist groups. Findings of this study revealed the following: First, the U.S.s role in theater ballistic missile defense (TBMD) development and implementation in the Middle East is defined by its shift of the defense systems from its homeland to the region. Second, the possible avenues that could facilitate the development of a comprehensive		

and integrated TBMD system include facilities, training, exercises, and logistic support. Third, the current challenges in Israel, Saudi Arabia, and Jordan that are hindering the development include financial constraints, obligations associated with the creation of such a defense system, domestic politics, foreign policy, inefficiency associated with such a system, and strategic asymmetries. Fourth, the following vital ways these countries could cooperate include the transfer of advanced defense technologies, enhanced operational coordination, multilateral planning, alliance coordination mechanism, and intelligence and surveillance sharing.

China Military Power: Modernizing a Force to Fight and Win		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1066163	1/15/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Defense Intelligence Agency, Washington, D.C.	
Descriptors:	China, Military Operations, Fighter Aircraft, Military Applications, Aircrafts, Contingency Operations (Military), National Security, Military Organizations, Naval Operations, Combat Areas, Navy, Military Aircraft, Army	
Identifiers:	PLA (Peoples Liberation Army), Chinese Military, Chinese National Security Strategy, South China Seas, East China Seas, CCP (Chinese Communist Party), CMC (Central Military Commission), C4ISR9 (Command Control Communications Computers Intelligence Surveillance and Reconnaissance), BRI (Belt and Road Initiative)	
Contains: Introduction/Historical Overview, 1978. Present: Chinas Military Rise, National Military Overview, Threat Perceptions, National Security Strategy, The PLAs Role in National Security, Military Leadership, Stability Issues, External Defense Relations, Defense Budget, Military Doctrine and Strategy, Perceptions of Modern Conflict, National Military Command and Control, Core Elements of Command and Control Reform, Modernizing Joint Command and Control, Regional and Global Operations, Core Chinese Military Capabilities, Power Projection and Expeditionary Operations, Nuclear Forces and Weapons, Biological and Chemical Warfare, Space/Counterspace, Satellite Counterspace, Human Spaceflight and Space-Exploration, Probes, Space Launch, Cyberspace, Denial and Deception, Logistics and Defense-Industrial Modernization, Logistics, Defense-Industrial Base, Underground Facilities, Other Than War, Outlook: Developing a Robust Force.		

Defeat, Not Merely Compete: China's View of Its Military Aerospace Goals and Requirements in Relation to the United States		
Accession Number:	**Report Date:**	**Access Restrictions:**

AD1064033	11/1/2018	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Harold, Scott W.	
Corporate Author:	RAND Corp Santa Monica United States	
Descriptors:	China, Air Forces (Foreign),Defense Systems, Guided Bombs, Military Aviation, National Security, Air Power, Aerial Warfare, Aircraft Industry, Military Force Levels, Military Doctrine, Military Strategy, Air Force, United States	
Identifiers:	PLA (Peoples Liberation Army)	

Over the past two decades, the Chinese People's Liberation Army (PLA) has made rapid advances in building up new capabilities and operational concepts. Aerospace power has been a core feature of the PLAs rapid modernization. In particular, since 2004, the PLA Air Force(PLAAF) has pursued a service strategy aimed at developing the capacity to simultaneously prosecute offensive and defensive integrated air and space operations (,).During this period, Chinese military authors have written about transforming the PLAAF into what they refer to as a strategic air force, one that can move beyond its [traditional] focus on air defense of Chinese territory and directly support national policy objectives and achieve a wide range of strategic goals. 1 One recent study of Chinese military aerospace writings found that many PLA authors specifically cite the U.S. Air Force (USAF) as a model for at least some aspects of the PLAAFs transformation into a strategic air force.

Hypersonic Threats the Homeland		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1038122	3/28/2017	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Jeffress, Henry III R.	
Corporate Author:	Air War College Maxwell AFB Al Maxwell AFB United States	
Descriptors:	Directed Energy Weapons, Laser Weapons, Defense Systems, Early Warning Systems, Warning Systems, National Security, Intercontinental Ballistic Missiles, Homeland Defense	
Identifiers:	Hypersonic Threats, Hypersonic Weaponry, VUCA (Volatile Uncertain Complex And Ambiguous), LAWS (Laser Weapons System), ADAM(Air Defense Anti Munitions), SBIRS (Space Based Infrared Sensors), THAAD (Terminal High Altitude Area Defense), ICBM (Intercontinental Ballistic Missile)	

It is imperative the United States (US) accelerate its development within the field of directed energy weapons and guard against the emergence of hypersonic threats. Hypersonic weaponry shifts the strategic calculus of U.S. decision makers, increases stand-off capabilities and alters the deterrence equation of international actors. Directed energy weapons offer a feasible approach countering the proliferation of hypersonic threats to the homeland, safeguards the decision space of our nation's leaders and potentially strengthens military, diplomatic and economic instruments of power simultaneously.

The Russian Way of Warfare		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1053211	1/1/2017	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Boston, Scott: Massicot, Dara	
Corporate Author:	Rand Arroyo Center Santa Monica CA Santa Monica United States	
Descriptors:	Military Early Contingency Operations (Military), Warfare, Contingency Operations (Military),Early Warning Systems, Warning Systems, Indirect Fire, Artillery, Defense Systems, Combat Operations, Lessons Learned, Ground Based, Conventional Warfare, Air Defense, NATO, Military Doctrine, Doctrine, Artillery Units, Artillery Fire, Armored Vehicles, Ballistic Missiles, Special Operations Forces	
Identifiers:	NATO (North Atlantic Treaty Organization), BTG (Battalion Tactical Groups), ISR (Intelligence Surveillance And Reconnaissance), SOF (Special Operations Forces), SAM (Surface To Air Missiles)	
This Perspective is intended to serve as a primer that outlines in general terms how the Russian military would conduct combat operations in the event of a high-intensity conflict with a capable peer or near-peer adversary. The discussion here blends how Russian theorists and leaders have written about modern warfare with demonstrated Russian capabilities and history. Russia has shown the ability to tailor its combat operations to specific operational and strategic requirements. The Russian military does not have one standard way of conducting operations; rather, Russia likely has developed a series of contingencies for strategic planning, based on several variables like correlation of forces, military potential of opposing forces, strategic geopolitical context, escalation potential, and others. An accurate understanding of Russia's way of warfare is important for several reasons. Russia has in recent years carried out substantial reforms to its military forces, which have increased capability in several key areas. Russia's military has improved to the extent that it is now a reliable instrument of national power that can be used in a limited context to achieve vital national interests. Russia's capability has not improved to the extent that Russian leadership would use it against a near-peer adversary in the absence of a clear external threat to the survival of the Russian state. However, these new capabilities provide Russian leadership with more options to assert its positions and support national interests and are worth examining simply to better understand how Russia would fight.		

ART OF THE POSSIBLE: SECURING AIR FORCE SPACE COMMAND MISSION SYSTEMS FOR THE WARFIGHTER		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1040939	10/23/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Noonan, Timothy P.	
Corporate Author:	Air Command And Staff College Maxwell AFB Al Maxwell AFB United States	
Descriptors:	Computer Security, Computer Networks, Information Systems, Cyberattacks, Space Systems, Vulnerability, Network Protocols	

Identifiers:	AFSP (Air Force Space Command), Attack Surface, RMS (Risk Management Framework),Cyber Command, CSSP (Cyber Security Service Provider),Non State Actors, Critical Infrastructure

This research paper uses a problem/solution framework to identify how Air Force Space Command (AFSPC) can integrate and improve cybersecurity for legacy and modern weapon systems to reduce the cybersecurity attack-surface. With Department of Defense (DOD) networks and mission systems undergoing nearly 250,000 attacks a day, AFSPC must take immediate action to thwart the attacks from adversarial nation states and non-state actors alike. While there are numerous cybersecurity concerns, or non-compliant cybersecurity controls across all weapon systems, not all non-compliant controls contribute equally to the cyber-attack surface and overall vulnerability of weapon systems. For this reason, the major contributors or key issues surrounding the current cybersecurity attack-surface have been identified as policy, defense-in-depth, threat intelligence, and the DOD mandated transition from the DOD Information Assurance Certification and Accreditation Process to Risk Management Framework (RMF). Utilizing RMF and the National Institute of Standards and Technology (NIST) framework for improving critical infrastructure cybersecurity three alternative solutions are evaluated to identify the best option for AFSPC to systematically implement to reduce the overall cybersecurity attack-surface for its modern and legacy weapon systems.

US Army And The Emergence Of Unmanned Threats

Accession Number:	**Report Date:**	**Access Restrictions:**
AD1022201	5/26/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Predny, Michael J.	
Corporate Author:	US Army School for Advanced Military Studies Fort Leavenworth United States	
Descriptors:	Unmanned Aerial Vehicles, Air Power, Air Defense, Cruise Missiles, Military History, Lessons Learned, Remotely Piloted Vehicles, Risk, Military Capabilities	
Identifiers:	N/A	

The proliferation of unmanned technology, both unmanned aircraft and cruise missiles, challenges the decades-long assumption that the US Army will operate under conditions of air superiority. The expendability of unmanned platforms and lack of risk to pilot and crew change the threshold of risk an adversary is willing to accept. While unmanned threats perform many of the same roles as manned aircraft, contemporary and counterfactual case studies of Hezbollah and Chinese employment show that the relative advantages of unmanned threats significantly increase the probability and severity of adversary action through the air. Examination of the lessons learned operating under the threat of air attack in World War Two indicates several possible mitigations of this increased risk. Identified lessons in passive defense from World War Two remain relevant and were retained in Army capability and doctrine. However, lessons in organizing active defense and shaping conditions to protect US ground forces have been forgotten or are in need of adjustment to accommodate the emerging unmanned threat.

Russian Ballistic Missile Defense Rhetoric and Reality

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA625224	6/1/2015	Distribution Statement A. Approved for public release. Distribution is unlimited.

Author:	Giles, Keir
Corporate Author:	Army War College Carlisle Barracks PA Strategic Studies Institute
Descriptors:	Guided Missile Defense Systems, Air Defense, Europe, Military Strategy, Missions, Nuclear Warfare, Policies, Russia, Space Defense, Theater Level Operations
Identifiers:	N/A

Russia has made air and space defense, including ballistic missile defense (BMD), a top priority, while at the same time protesting vehemently against the deployment of U.S. missile defense technology in Europe, which Moscow claims upsets strategic stability and increases the danger of war. Russian declaratory policy provides U.S. policymakers with significant material to develop an approach intended to mitigate Russian obstructionism over European Phased Adaptive Approach (EPAA) and U.S. plans for BMD more broadly. Put simply, Russian complaints at the dangerous irresponsibility of the United States introducing new anti-missile capabilities ring hollow, when Russia is forging ahead with its own program to do precisely the same. U.S. officials have repeatedly attempted to allay Russian concerns over the potential for EPAA and its predecessor systems to compromise Russian strategic deterrence. These attempts have foundered on Russian concerns, some of which appear disingenuous, but others of which are genuinely rooted in an entirely different Russian approach to the purpose and status of nuclear weapons. Despite the current hiatus in relations, opportunities for meaningful dialog with Russia on missile defense will arise again in the future. At that point, U.S. representatives should be fully informed on the scope and ambition of Russia s own missile defense programs. This will allow them not only to rebut some of the more facile Russian accusations, but also to counter some persistent Russian arguments relating to strategic balance.

Prompt Global Strike: China and the Spear

Accession Number:	**Report Date:**	**Access Restrictions:**
AD1032427	4/1/2014	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Saalman, Lora	
Corporate Author:	Asia-Pacific Center for Security Studies Honolulu United States	
Descriptors:	China, Defense Systems ,Information Systems, Intercontinental Ballistic Missiles, Communication Systems, Strategic Weapons, Spacecraft, Unmanned Aerial Vehicles, Rockets, Warning Systems, Aircraft Equipment, Military Forces (Foreign)	
Identifiers:	PGS (Prompt Global Strike)	

A close examination of Chinese scientific journals reveals emerging perspectives on prompt global strike (PGS). As Chinese official defense white papers have become shorter in length, technical journals provide a clearer window into threat perceptions and direction of Chinese military modernization. They reveal that technical and military institutes in China are conducting substantial research into both countering and developing hypersonic, precision-guidance, and boost-glide technologies. The amount of this research dwarfs that heretofore available on their ballistic missile defense (BMD)-related technologies. In contrast to BMD, Chinese PGS-oriented literature combines scientific and strategic details, reflecting a broader shift to integrate strategic departments into its technical institutes.

Sensors and Tracking

Practical Co-Prime and Nested Samplers and Arrays for Radar and Radar Sensor Networks		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1086317	12/5/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Liang, Qilian	
Corporate Author:	Univ. of Texas Arlington United States	
Descriptors:	N/A	
Identifiers:	N/A	

Leveraging Commercial Off-the-Shelf Technologies to Create Wireless Sensor Networks to Augment Air Base Ground Defense		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1060112	6/1/2018	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Wu, Caleb	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Wireless Sensor Networks, Infrared Detectors, Situational Awareness, Mesh Networks, Operating Systems, Network Topology, Mobile Phones, Air Power, Force Protection, Warning Systems, Facial Recognition, Radar	
Identifiers:	Air Base Ground Defense, Short Range Radar, Opencv, Raspberry Pi, FARPS (Forward Arming And Refueling Points)	
Forward-deployed maneuver sustainment operations, such as Forward Arming and Refueling Points (FARPs), are a critical center of gravity that adversaries seek to disrupt or destroy in order to jeopardize friendly scheme of maneuver and operations. With adversaries increased ability to attack such operating bases through indirect fire and infiltration, it becomes more difficult for perimeter defense assets to maintain situational awareness in order to respond to threats. A low-cost wireless sensor network composed of Raspberry Pi nodes equipped with short-range radars, cameras, and motion sensors was built to give force protection personnel early warning and to help them maintain situational awareness. While each layer alone had flaws, deployment of the wireless network of sensor nodes using the defense in depth principle proved capable of not only providing early warning to defenders, but also giving defenders detailed imagery and kinetic information on the intruder.		

Radar Envelope Visualization		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1060081	6/1/2018	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Tan, David A	
Corporate Author:	Naval Postgraduate School Monterey United States	
Descriptors:	Refractive Index, Radar, Terrain Masking, World Geodetic System, Frequency Bands, Simulations, Atmosphere Models, Aircrafts, Temperature Inversion, Direction Finding, Atmospheric Refraction, Very Low Frequency, Grids	

Identifiers:	Visualization, Moves, Horizon, X3D, Extensible, 3D, Graphics

The Navy and Marine Corps cannot expect to always operate aircraft within permissive environments. Potential employment scenarios include operations against advanced surface-to-air missiles and early warning radars with detection ranges advertised beyond 200 nautical miles. Low-observable aircraft are not a panacea. Very-low frequency radars and multistatic arrays offer limited direction finding and possible ranging of fifth-generation aircraft at tactically significant ranges in certain conditions. Radar directed weapons will continue to be the most capable and deadly weapons aviation must contend with for the foreseeable future. This project provides a proof-of-concept for a program that generates a three-dimensional volume representative of threat radar performance, which will aid planners in developing routes that avoid or minimize exposure to these threats and improve understanding of other radar phenomena. This representation includes a basic atmosphere model that demonstrates the effects of refraction, a depiction of the shadow zone, and terrain-masking effects. Future development would allow inclusion of location-specific weather and simulation of specific threat radars, allowing near real-time evaluation of radar capabilities that greatly exceed the abilities of current analytical tools.

Navy Needs to Establish Effective Metrics to Achieve Desired Outcomes for SPY1 Radar Sustainment (Redacted)

Accession Number:	**Report Date:**	**Access Restrictions:**
AD1014191	8/1/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Wicecarver, Jacqueline L.	
Corporate Author:	Department Of Defense Inspector General Alexandria United States	
Descriptors:	Naval Equipment, Radar, Radar Tracking, Target Detection, Phased Arrays, Performance Engineering, Missions, Weapon Systems, Logistics, Auditing, Cost Reduction	
Identifiers:	Navsup Wss (Naval Supply Systems Command Weapon Systems Support), Ballistic Missile Defense Missions, Spy1 Radar	

Objective We determined whether the performance metrics included in the Navy's AN/SPY1 Phased Array Radar (SPY1 radar) performance-based logistics contracts appropriately incentivized the support contractors. This audit is the second in a series on SPY1 radar spare parts. The SPY1 radar is an advanced, automatic detect and track radar system. The SPY1 radar is one of 13 major subsystems in the AEGIS Weapon System that searches, detects, and tracks air and surface targets to support Anti-Air Warfare and Ballistic Missile Defense missions.

Low Earth Orbit Satellite Tracking Telescope Network: Collaborative Optical Tracking for Enhanced Space Situational Awareness

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA616076	3/27/2015	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Salvador, Victor A.	
Corporate Author:	Air Force Institute Of Technology Wright-Patterson AFB Oh Graduate School Of Engineering And Management	

Descriptors:	Optical Tracking, Satellite Tracking Systems, Situational Awareness, Telescopes, Algorithms, Earth Orbits, Ground Based, Satellite Imagery, Space Environments, Space Objects, Space Surveillance, Theses
Identifiers:	Two Line Element Set, Space Surveillance Network

The Air Force Institute of Technology has spent the last seven years conducting research on orbit identification and object characterization of space objects through the use of commercial-off-the-shelf hardware systems controlled via custom software routines, referred to simply as TeleTrak. Year after year, depending on the research objectives, students have added or modified the system's hardware and software to achieve their individual research objectives. In the last year, due to operating system and software upgrades, TeleTrak became inoperable. Furthermore, due to a lack of student overlap, knowledge of the basic operation of the TeleTrak deteriorated. This research re-establishes the basic understanding of the TeleTrak System and develops a plan to improve the telescope tracking controller performance. This research uses a subset of the SE process via the operational and system views to understand the tracking subsystem and develop timing tests to observe delays that could impact tracking. Basic tests revalidate and improve understanding of how the Meade telescopes interface with MATLAB. Calibration camera parameters are then refined, allowing a new technique for calibrating existing control algorithms. The analyses of the findings demonstrate that it is possible to improve the tracking controller, but it also uncovers previously undocumented issues with the Meade telescope mount. Future students interested in continuing this research, regardless of which telescope mount is used with TeleTrak, will benefit from the findings of this research.

Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS)

Accession Number:	**Report Date:**	**Access Restrictions:**
ADA613304	12/1/2013	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Howard, Terrence L.	
Corporate Author:	Cruise Missile Defense Systems Project Office Redstone Arsenal Al	
Descriptors:	Fire Control Radar, Guided Missile Detection, Military Procurement, Search Radar, Acquisition, Budgets, Contracts, Costs, Cruise Missiles, Foreign Military Sales, Performance Tests, Production, Scheduling	
Identifiers:	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, SAR (Selected Acquisition Report), DAE (Defense Acquisition Executive), APB (Acquisition Program Baseline),Wide Area Surveillance Radar, Threshold Breaches	

Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) is a supporting program of the Army and Joint Integrated Air and Missile Defense, providing persistent, over the horizon surveillance and fire control quality data on Army and Joint networks enabling protection of the United States and coalition forces as well as geopolitical assets from Cruise Missiles, Aircraft, Unmanned Air Vehicles, Tactical Ballistic Missiles, Large Caliber Rockets, and Surface Moving Targets. JLENS uses advanced sensor and networking technologies to provide persistent, 360-degree, wide-area surveillance and precision tracking of Land Attack Cruise Missiles and other types of Air Breathing Threats. This information is distributed via joint service networks and provides fire control quality data to Surface-to-Air missile systems such as Army Patriot and Navy Aegis, increasing the weapons' capabilities by allowing systems to engage targets normally below, outside, or beyond

surface-based weapons' field of view. JLENS also provides fire control quality data to fighter aircraft allowing them to engage hostile threats from extended ranges, and contributes to the development of a single integrated air picture. A JLENS orbit consists of two systems: a fire control radar system and a wide-area surveillance radar system. Each radar system employs a separate 74-meter tethered aerostat, mobile mooring station, radar and communications payload, processing station, and associated ground support equipment. The systems are designed to work together, but can operate independently. The JLENS orbit is transportable by road, rail, sea, and air. JLENS does not replace an antecedent system.

Missile Systems:

Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092432	2/27/2020	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	O'Rourke, Ronald	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Ballistic Missiles, Navy, Ballistic Missile Submarines	
Identifiers:	N/A	
This report provides background information and potential oversight issues for Congress on the Columbia-class program, a program to design and build a class of 12 new ballistic missile submarines (SSBNs) to replace the Navy's current force of 14 aging Ohio-class SSBNs. The Navy has identified the Columbia-class program as the Navy's top priority program. The Navy wants to procure the first Columbia-class boat in FY2021. The Navy's proposed FY2021 budget requests $2,891.5 million in procurement funding, $1,123.2 million in advance procurement (AP) funding, and $397.3 million in research and development funding for the program.		

Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1092441	12/17/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Library of Congress Washington United States	
Descriptors:	Navy, Aegis, Ballistic Missile Defense, Test and Evaluation, Naval Operations, Rockets, Intermediate Range Ballistic Missiles, International Relations, National Security	
Identifiers:	N/A	
This report provides background information and challenges for Congress regarding the Aegis ballistic missile defense (BMD) program, which is carried out by the Missile Defense Agency (MDA) and the Navy. This program gives Navy Aegis cruisers and destroyers a capability for conducting BMD operations. The challenge for Congress is whether to approve, reject, or modify Department of		

Defense (DOD) acquisition strategies and proposed funding levels for the Aegis BMD program. Congress's decisions on the Aegis BMD program could significantly affect the U.S.

Mitigating Task Saturation for Patriot Engagement Control Station Crews: Research Product Development and Evaluation		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1077719	7/1/2019	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Powers, Faith, Dass, Sue, Aude, Steven, McMahand, Wesley, Drzymala, Natalie, Buehner, Tim, Graves, Thomas R.	
Corporate Author:	ICF Inc Fairfax VA Fairfax United States	
Descriptors:	Automation, Army Research, Skills, Army Personnel, Supervisory Control, Supervision, Cognition, Personnel Management, Control Systems, Operators (Personnel),Resource Management	
Identifiers:	Assessment Of Supervisory Control Skills Patriot Crew Development Task Saturation Mitigation Crew Resource Management Skill Development	
This research product report addresses the development and evaluation of a task saturation mitigation solution intended to enhance the supervisory control skills of Patriot crews. The term supervisory control refers to human supervision of an automated system, when operators manage and intervene in system operations on a continuum between controlling every system function (i.e., not automated) and the system operating autonomously without human control (e.g., fully automated). Based on prior research and a workshop conducted with Air Defense subject matter experts, the research product content, exercises, and assessment tools were developed to enhance crew competencies to mitigate task saturation, manage crew resources, and enhance supervisory control skills. The research product was piloted and evaluated by a small sample of Patriot operators. Generally, the product was viewed positively, and pre-/post-tests indicated increased knowledge and confidence concerning the targeted competencies among the crews. While the research focused on Patriot crews, the research product may be adapted for use with other crew/team configurations requiring competency development related to task saturation mitigation, crew resource management, and supervisory control.		

The Aegis BMD Global Enterprise: A High End Maritime Partnership		
Accession Number:	**Report Date:**	**Access Restrictions:**
AD1001895	4/13/2016	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	Hicks, Brad, Galdorisi, George, Truver, Scott C.	
Corporate Author:	Naval War College Newport United States	
Descriptors:	Navy, Cruisers, Antimissile Defense Systems ,Sea Based, Homeland Defense	
Identifiers:	BMD (Ballistic Missile Defense), BMDS (BMD System),Global Maritime Partnerships, Regional Security, Regional Defense	

For more than three decades, beginning soon after the end of World War II, the United States and the Soviet Union faced off against each other. The concept of mutual assured destruction (MAD), the U.S. threat of massive retaliation to a Soviet first strike became Americas Cold War de facto strategic defense policy. In March 1983, however, President Ronald Reagan asked whether ballistic missiles could be destroyed before they reached the United States or its allies, thus catalyzing efforts for a national ballistic-missile-defense program that would undermine the need for MAD. That same year, the U.S. Navy commissioned USS Ticonderoga (CG 47), the first of what is to become a fleet of more than eighty Aegis warships. In 2012, these trends have converged, and Aegis ballistic-missile defense (BMD) is an increasingly important component of a robust national BMD System (BMDS).

Patriot Advanced Capability-3 (PAC-3)		
Accession Number:	**Report Date:**	**Access Restrictions:**
ADA614933	12/1/2013	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Army Peo (Missiles And Space) Redstone Arsenal Al	
Descriptors:	Ballistic Missile Intercept Systems, Air Defense, All Weather, Area Defense, Contracts, Costs, Flight Testing (Guided Missiles), Foreign Military Sales, High Velocity, Interceptors, Long Range (Distance), Military Procurement, Performance (Engineering), Production, Rapid Deployment, Surface To Air Missiles, Terminal Defense, Theater Missile Defense	
Identifiers:	Hit To Kill, SAR (Selected Acquisition Reports), Interceptor Missiles, Terminal Air Defense, Missile Defense	

Patriot, the centerpiece of the Army's air defense forces, is an extremely capable, long range, low-to-high altitude air defense missile system, which provides air defense of ground combat forces and high-value assets. Patriot is designed to cope with enemy defense suppression tactics that may include Tactical Ballistic Missiles (TBM), cruise missiles, anti-radiation missiles, and advanced aircraft employing saturation, maneuver, sophisticated Electronic Countermeasures (ECM), and low radar cross-section. Patriot air defenses will be integrated into the overall area air defense plan in support of the combatant commander’s mission that can include other short-range, low altitude forward area and Joint assets for a theater of operations based upon the threat. The Patriot system can conduct multiple simultaneous engagements in all weather conditions and hostile ECM environments against high performance Air Breathing Threats (ABT) and TBMs with a high probability of target kill. System deployment is by Fire Unit (FU) at the battery-level, organized within a battalion. Each FU consists of an Engagement Control Station (ECS), one Radar Set (RS), an Electric Power Plant, and up to 16 Launching Stations (LS). The Patriot RS is a multi-function phased array radar, which performs a variety of surveillance, acquisition, and guidance tasks and is controlled by the ECS which provides the human interface for control of automated operations. The M902 LS (Configuration 3), with Enhanced Launcher Electronics System, supports the Patriot Advanced Capability-3 (PAC-3) missile as well as providing backwards compatibility with the PAC-2 missile variant. At the battalion level, command and control is exercised through the Information and Coordination Central, and associated communications equipment, including the Communications Relay Group. Both the FU and battalion have dedicated support, communications, and maintenance vehicles.

Patriot Medium Extended Air Defense System Combined Aggregate Program (Patriot/MEADS CAP)		
Accession Number:	**Report Date:**	**Access Restrictions:**
ADA614932	12/1/2013	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Army Peo (Missiles And Space) Redstone Arsenal Al	
Descriptors:	Ballistic Missile Intercept Systems, Air Defense, Area Defense, Contracts, Costs, Interceptors, Military Procurement, Performance (Engineering), Production, Rapid Deployment, Surface To Air Missiles, Terminal Defense	
Identifiers:	Beyond Line Of Sight, Distributed Systems, Insensitive Munitions, Interceptor Missiles, Missile Defense, SAR (Selected Acquisition Reports),Terminal Air Defense	
The Patriot/Medium Extended Air Defense System Combined Aggregate Program (Patriot/MEADS CAP) represents the process through which the Patriot system transitions to MEADS. The MEADS program is a Tri- National co-development program among the United States, Germany, and Italy to replace the U.S. Patriot air defense systems, Patriot and Hawk systems in Germany, and the Nike system in Italy. The MEADS mission will provide Joint and Coalition forces with critical asset and defended area protection against multiple and simultaneous attacks by low-to-medium altitude Air and Missile Defense (AMD) with the capability to counter, defeat, or destroy Tactical Ballistic Missiles, Air-Breathing Threats to include cruise missiles, unmanned aerial vehicles, tactical air-to-surface missiles, and anti-radiation missiles. The Patriot system provides a combat demonstrated capability against these threats. MEADS will employ a netted distributed architecture with modular components to increase survivability and flexibility of employment in a number of operational configurations. The Patriot Advanced Capability-3 (PAC-3) Missile Segment Enhancement (MSE) missile, as evolved from the current PAC-3 missile's Cost Reduction Initiative (CRI) design, provides a more agile, lethal interceptor missile resulting in substantial missile performance improvement while enhancing Insensitive Munitions (IM) compliance.		

Defense Science Board Task Force on Patriot System Performance. Report Summary		
Accession Number:	**Report Date:**	**Access Restrictions:**
ADA435837	1/1/2005	Distribution Statement A. Approved for public release. Distribution is unlimited.
Author:	N/A	
Corporate Author:	Defense Science Board Washington Dc	
Descriptors:	Performance (Engineering), Surface To Air Missiles, Warfare, Lessons Learned, Task Forces, Identification, Ballistic Missile Intercept Systems	
Identifiers:	Iraqi Freedom Operation, Pac 2 Missile, Pac 3 Missile, Patriot Missile Systems, Meads (Medium Extended Air Defense System)	
The Defense Science Board Task Force on Patriot System Performance began in August 2003 and concluded in June 2004. The Terms of Reference for the Task Force are given in Appendix A the Task Force Membership is in Appendix B and the briefings given to the Task Force are listed in Appendix C. This is the Report The complete Final Report is classified. The Task Force investigated the lessons learned from the Patriot system performance in Operation Iraqi Freedom (OIF) and assessed if these lessons could be incorporated into the continuing development of Patriot and its follow-on system		

the Medium Extended Air Defense System (MEADS). The Task Force concluded that the lessons can be incorporated into Patriot-MEADS. Two of the main shortfalls seen in OIF performance transcend just the Patriot system; they involve combat identification and situational awareness.

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