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14. ABSTRACT

The Air Vehicle Stores Compatibility Division (AVSCD) Airborne Expendable Countermeasures (AECM) Integrated Product Team (IPT) (4.11.2.3) at NAWCAD, Patuxent River, MD, has formed an efficient working relationship with its primary sponsor, PMA-272J3. From ground and flight testing of innovative expendables to Lot acceptance testing, the AECM IPT team gets and stays involved in every step of the development/testing process. This ensures that the products being delivered to the fleet are not only cost effective, but also more importantly, safe and user friendly. The primary duty of the AECM IPT is to evaluate the flight test separation characteristics of new expendables. The AECM IPT conducts flight and ground testing through all phases of the acquisition cycle. Once the items are in the fleet, the AECM IPT continues it involvement in the form of Lot Acceptance Testing (LAT) and more importantly, Produce Improvement Programs (PIPs). These PIP's are extremely vital, as no amount of testing can provide the data that real world use and lessons learned provide. By incorporating these processes into future design changes, the items returning to the fleet provide increased warfighter survivability protection, which is the ultimate goal of the AECM IPT.

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Airborne Expendable Countermeasure Certification Techniques

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Abstract: The Air Vehicle Stores Compatibility Division (AVSCD) Airborne Expendable Countermeasures (AECM) Integrated Product Team (IPT) (4.11.2.3) at the Naval Air Warfare Center Aircraft Division, Patuxent River, MD, has formed an efficient working relationship with its primary sponsor, PMA-272J3. From ground and flight testing of innovative expendables to Lot acceptance testing, the AECM IPT Team gets and stays involved in every step of the development/testing process. This ensures that the products being delivered to the fleet are not only cost effective, but also more importantly, safe and user friendly. The primary duty of the AECM IPT is to evaluate the flight test separation characteristics of new expendables. The AECM IPT conducts flight and ground testing through all phases of the acquisition cycle. Once the items are in the fleet, the AECM IPT continues its involvement in the form of Lot Acceptance Testing (LAT) and more importantly, Product Improvement Programs (PIPs). These PIP's are extremely vital, as no amount of testing can provide the data that real world use and lessons learned provide. By incorporating these processes into future design changes, the items returning to the fleet provide increased warfighter survivability protection, which is the ultimate goal of the AECM IPT.

1.0 INTRODUCTION

As members of the Air Vehicle Stores Compatibility Division (AVSCD) at the Naval Air Warfare Center (NAWC) Patuxent River MD, our primary role is to ensure that all new stores can be safely carried and dispensed from a variety of Naval and Marine aircraft. This, by nature, includes ensuring they can be safely used in the shipboard environment, commonly called ship suitability. From laser guided bombs to aerial refueling hoses, our responsibilities cover a wide range of tactical and test ordnance. With the advent of Integrated Product Teams (IPT), members of our group were tasked by PMA-272J3 to become the Airborne Expendable Countermeasures (AECM) Stores Compatibility and Flight Clearance IPT (AECM IPT). The mission of PMA-272J3 is to design, develop, improve, test and procure expendable countermeasure self-protection devices for all Navy and Marine aircraft. This creates an ideal situation, as the goals of both PMA-272J3 and AVSCD is to get compatible stores to the fleet quickly, but more importantly, safely.

As stated above, the primary job of the AECM IPT is to ensure that every expendable countermeasure can be safely carried on and dispensed from the appropriate Navy and Marine aircraft. While the majority of this work is completed through flight testing, the AECM team has many other duties aside from flight testing which help PMA-272J3 achieve the goal of a less expensive, safer end product. By involving the AECM team in every step of the acquisition life-cycle of an expendable unit, PMA-272J3 is ensuring that the store compatibility concerns are always being addressed. The AECM team routinely tests, and attends design reviews for, items that are in

all acquisition phases ranging from the pre-acquisition and concept exploration phases to post Milestone (MS) III.

There are two primary products that the AECM IPT is involved with the testing of, New developmental items, and Product Improvement Programs (PIPs). New developmental items may be necessary due to the increased capability of fielded threat systems and emergent threats which use the same basic guidance technology, but which have been enhanced through the addition of counter-countermeasure capability. Sustaining or improving the survivability of the aircraft/aircrew against these more lethal threats can be accomplished expeditiously and economically through an increase in performance and effectiveness of an existing countermeasure, and/or the development of a totally new capability. PIPs come about as modifications or upgrades to existing inventory are needed because of safety, producibility, reliability, environmental, or economic issues that surfaced after the original system configuration was produced. Advancements in the state of the art and/or improved manufacturing materials and processes may also evolve that justify a modification to the item.

2.0 GROUND AND FLIGHT TESTING THROUGHOUT THE ACQUISITION CYCLE

The phases of a new development or PIP and the development/test efforts are essentially identical to any other acquisition program, however, unlike most Research and Development (R&D) or larger ACAT programs, which can take from 10 to 15 years to field something new, the AECM programs typically take from 3 to 5 years. The PIP is unique in all of DOD in its demonstrated capability to devise, develop, test/qualify and field improved AECM, in a time frame of 1 to 3 years, thus benefiting the warfighter.

The AECM IPT is the cognizant activity for ensuring that a new or modified expendable is compatible with a particular aircraft. This includes conducting and compiling the data from ground tests, flight tests, and carrier suitability testing. These tests are conducted throughout the acquisition lifecycle.

- *PRE MILESTONE 0*

The current process involves a review in August/September of each year of all possible product improvements and new development items. As part of this annual process, the AECM IPT provides inputs on all ordnance related issues that they have discovered either through ongoing tests or through fleet inputs. These ongoing tests are a part of the AECM IPT's mandated tasking from PMA-272J3. Once these inputs are combined with inputs from the Airborne Expenable Radio Frequency Countermeasure (AERFCM) and Infrared (AEIRCM) IPTs, Analysis of Alternatives (AOAs) are conducted to determine if the current countermeasures are adequate, and if not, what the countermeasure requirement is to overcome the deficiency. The IPTs, including the AECM IPT, propose recommendations and plans to address the deficiencies in current AECM.

- *MILESTONE 0*

These recommendations and proposals are reviewed by PMA 272 through an established internal working group and are prioritized on the following criteria:

1. Completing current on-going PIPs

2. N88 direction
3. Fleet Input (OAG's)
4. New/emerging threats
5. Best Return on investment

The result of this is the annual priority list, which is the Milestone 0, and the marching orders for the AECM IPT.

- *CONCEPT EXPLORATION PHASE, PROGRAM DEFINITION/RISK REDUCTION: MILESTONE I, MILESTONE II*

Upon approval of a recommendation/proposal, the IPT assigned to that effort, either the RF or IR IPT, would commence work to evaluate the feasibility of turning the concept into a physical reality, and immediately begin the design effort. Because the modifications sponsored under the PIP are generally based on existing AECM, these two phases are easily combined. Likewise, through the integration and coordination of all the IPTs, including the AECM IPT, communication throughout all the design phases is greatly increased, ensuring the design is developed considering all aspects associated with performance, manufacturability, reliability, safety, and other key requirements.

Many times, the AECM IPT is called upon during this period to help weed out unrealistic ideas, or lend credence to valuable ideas in the forms of concept demos. A prime example of this is when the AV-8B community had a requirment for increased protection in the target area. Many viable alternatives were proposed, however adapting existing technology is the preferred method as it is usually the quickest and cheapest method. The AECM IPT was tasked to evaluate two of these adaptations on the centerline of the AV-8B, the Faired Countermeasure Dispenser (FCMD) and the Mongoose II Pod. The FCMD uses mechanical gearing to dispense packages of pyrophoric material, while the Mongoose II Pod relies on the traditional ALE-39 system and associated impulse cartridges to dispense the flares and chaff. These two solutions can be seen loaded on the AV-8B centerline in Figures 1 and 2.

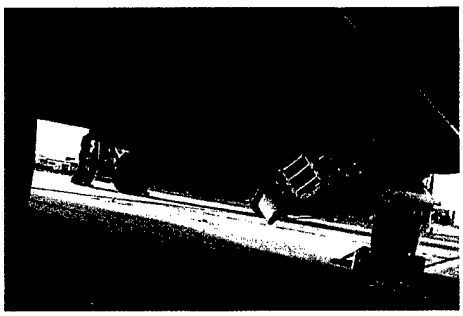

Figure 1: Dual FCMD On the AV-8B Centerline

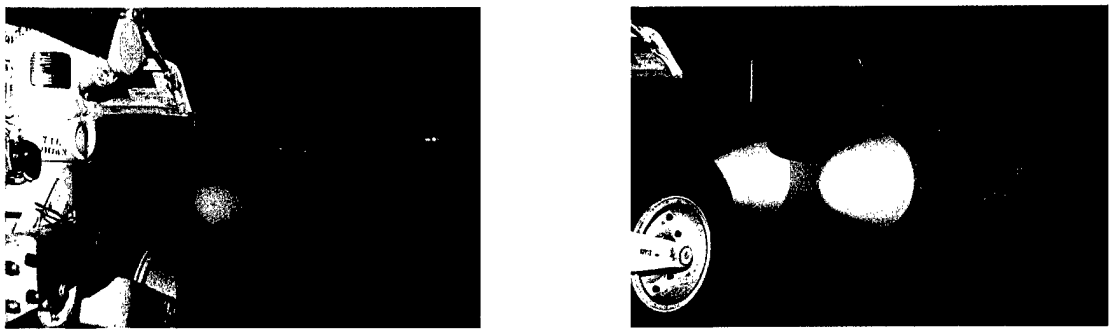

Figure 2: Single and Dual Mongoose II Pods on the AV-8B Centerline

Demonstration flight tests were conducted with the FCMD on centerline of the AV-8B, however, the results were unsatisfactory. When the MJU-52/B units were dispensed from the FCMD, they struck the fuselage underside. On the AV-8B, the fuselage underside is soaked in fuel and oil, which was ignited by the air reactive MJU-52/B flares. In an attempt to avoid this impingement on the aircraft, the Mongoose II pod solution was proposed. In figure 2, two Mongoose II pod solutions are depicted. This ground testing eliminated the dual Mongoose II pod configuration due to the lack of ground clearance in the compressed strut/flat tire situation, per MIL-STD-1289C, Requirement for Airborne Stores Ground Fit and Compatibility, reference 1. The single Mongoose II pod had a satisfactory fit, however, as of this date, it has not been flight tested.

Flight testing of Electronic Warfare Advanced Technology (EWAT) kinematic flares also occurred during the concept exploration phase. These units are thrusted flares, which fit into the current ALE-39 and ALE-47 countermeasure dispensing systems (CMDS). They are dispensed with the typical impulse cartridges, however, once dispensed, the units propel themselves forward to act as a unique target. Two contractor prototypes were flight tested during this evolution, each relying on different means to produce the thrust. The testing was unique in that safe separation testing was being performed simultaneously with effectivity testing. Acquisition reform at its best. While the both had the same specification for thrust, the flight tests revealed a large difference in safe separation characteristics and performance in deterring IR seekers. Getting the AECM IPT involved early on allowed NSWC Crane to realize what design changes were necessary, while paving the way for a full safe separation evaluation later this year. Pictures of the units can be seen in Figure 3.

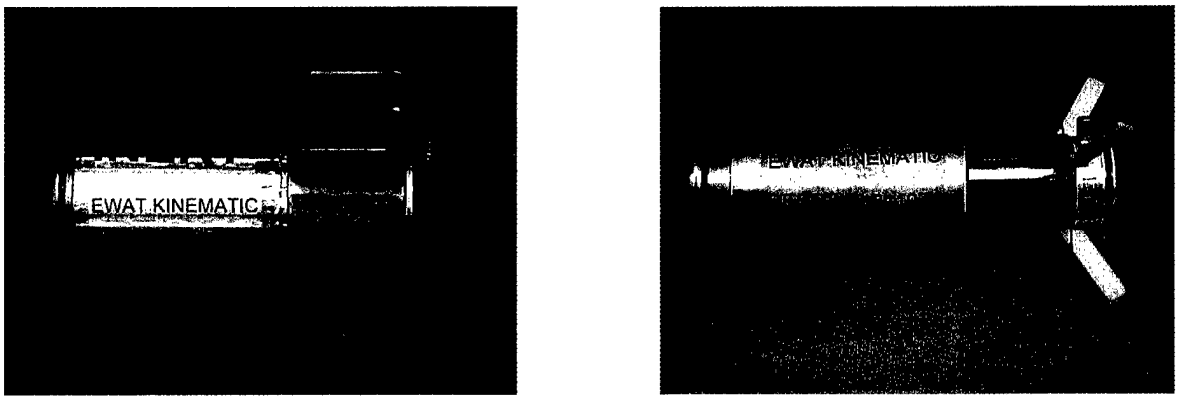

Figure 3: EWAT Kinematic Decoys

- *ENGINEERING AND MANUFACTURING DEVELOPMENT (E&MD)*

After the cognizant IPT has successfully designed the new item or modification and satisfactorily performed preliminary effectiveness tests, including modeling and simulation, test items are procured and the qualification tests and full scale development tests are conducted. Developmental testing and operational assessments are combined where ever, and when ever possible. Developmental testing includes not only effectiveness, but ship suitability and safe separation. The later two portions are performed by the AECM IPT. Upon completion of all DT requirements for a new development item or PIP, an Operational Test Readiness Review is scheduled with PEO(T) or delegated authority prior to entering OT.

Figure 4: RR-195/AL Units

The majority of the testing conducted by the AECM IPT is in this phase. Currently in the E&MD phase are the new 1 x 2 x 8 inch rectangular flares and chaff. These items are intended for use on the F/A-18 E/F aircraft. These items are designated as the MJU-56/B, MJU-58/B and RR-195/AL (shown in Figure 4). The flares were previously flight tested in a similar configuration as the MJU-51/B and MJU-53/B. These were limited envelope, quick look effectivity flights, 2 airspeeds, straight and level conditions. On board cameras were used to gain safe separation data on these units. See Figure 5 for pictures of this flight testing. The AECM IPT will conduct a complete safe separation and carrier suitability evaluation of these items on the E/F this coming spring. Ten safe separation flights, totaling 65 test points, are planned, and have been tailored around the previous ALE-47 safe separation testing on the E/F. It is hoped that once flight testing gets underway, many of these test points can be eliminated due to similarity of the separation characteristics.

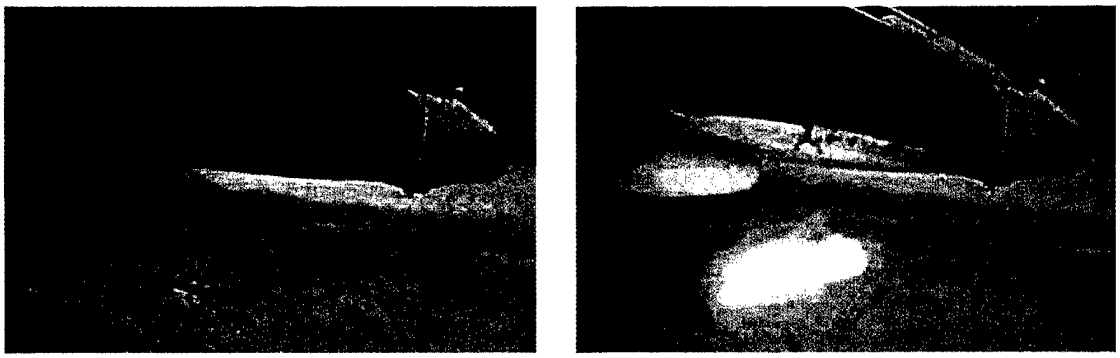

Figure 5: MJU-51/B (Left) and MJU-53/B (Right) Flight Testing

The F-18 E/F has a four dispensing magazines, two on each side of the centerline, just below the engine intake. See Figure 6 for the locations. Clearing a new expendable for flight requires that it can be safely dispensed from each of the four buckets. By reviewing the film of the previous MJU-51/B and MJU-53/B flight tests, it was determined that no discernable difference could be made between the separation characteristics of the inboard and outboard buckets. Incorporating this knowledge while developing the full safe separation envelope for the MJU-56/B, MJU-58/B and RR-195/AL, resulted in a significant savings. The number of test points required were cut in half.

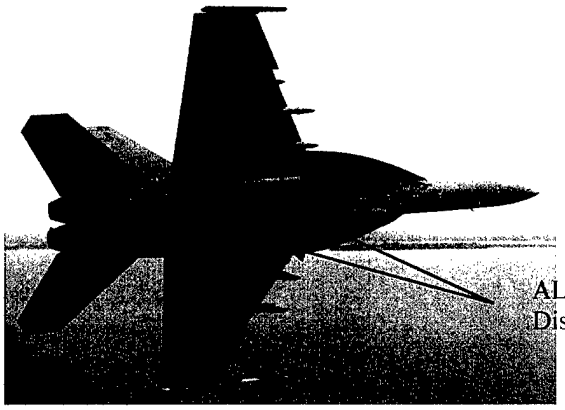

Figure 6: F-18 E/F Dispenser Magazine Locations

A unique aspect of this test, and flare and chaff testing in general, is decoy material impingement with the aircraft. As per MIL-HDBK-1763, Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures, reference 2, "material dispensed should not strike or narrowly miss (such that a repeat of the test might result in a hit) the aircraft." With chaff and pyrophoric flares (thin air reactive wafers), it is almost a given that some of the material will strike, or at the least, narrowly miss the aircraft. It has been observed that such a strike does not cause any damage to the aircraft, and does not require any unique maintenance procedures. What is a concern is "bird-nesting" of the chaff and pyrophoric material in cracks or openings of the aircraft skin. This could, in the worst case, cause disruptions to the flight controls, or in the case of the pyrophoric material, damage the aircraft skin with severe burns. In order to keep the flight test program moving at a normal pace, the test plans are written to reflect this uniqueness. Our tests are authorized to proceed with the normal strikes, however, should "bird-nesting" occur, or burns of the skin occur, testing ceases until a solution can be found.

The primary data objective in expendable flight testing is high-speed camera film. Depending on the scope of testing, different camera loadouts are used. The F-18 A-F will be used to discuss camera requirements. In quick look flight tests, where fleet representative wing station loadouts are not a concern, cameras mounted on hardbacks are typically loaded onto the mid-board stations. This gives a good close up view of the dispenser magazines, while allowing for a camera to be pointed aft for an overall view of the fuselage/tail. With the proper lenses, redundancy in the views can be obtained, as cameras do fail. When it comes to evaluating an expendable for fleet use, adjacent store loadings become an issue. Ideally, stations that can aerodynamically influence the dispenser magazines should be loaded with fleet representative stores. At the same time, camera requirements must be taken into consideration. More often than not, the best camera view is obtained by loading cameras onto a station that has the largest aerodynamic influence on the test items. Compromises must be made.

One solution to such compromises, is a test article currently under validation testing, and planned for use with the MJU-56/B. MJU-58/B, and RR-195/AL safe separation testing. This test article is an external fuel tank, modified to carry high speed video and film cameras. This can be seen in Figure 7. This pod has four windows on each side of the tank, in addition to one window looking aft, and one looking down. This pod allows a representative store to be carried on the centerline, as well as other stations, while at the same time obtaining the proper photo coverage. When fitted on the centerline of the E/F, two windows give excellent views of the dispenser magazines, allowing for close ups of the initial end cap separation.

Figure 7: External Fuel Tank Camera Pod

Other camera locations that can be used include nose cameras, keel cameras, and various wing and fuselage locations. With the integration of high-speed video telemetered real time to range control, the number of flights typically required for a full evaluation can be greatly reduced. Compared to bomb or missile safe separation, where they can only carry one or two bombs per flight, the F-18 E/F is capable of carrying 120 rounds of chaff or flares. With the conventional high-speed film, before pressing onto higher risk test points, film must be developed and analyzed. This requires a new flight, possibly a day or two later, costing time and money. Allowing for real time analysis during expendable flights is eliminates this added time and cost.

- *MILESTONE III*

Upon satisfactory completion of EMD phase and DT requirements, and upon receipt of an operationally effective and operationally suitable recommendation from Commander Operational Test and Evaluation Force (COTF), the program proceeds to a Milestone III production decision from the Milestone Decision Authority (MDA), or delegated authority for all new developmental items.

- *PRODUCTION, FIELDING, DEPLOYMENT, AND OPERATIONAL SUPPORT*

Once the items have been approved for full rate production, and fielded in the fleet, the AECM IPT along with the other PMA 272 IPTs continually monitor and solicit for items that need to be redesigned for either safety or effectiveness reasons. This, in turn, turns back into Pre-Milestone 0 phase, with the cyclic process never ending.

Flight testing during this phase comes in the form of Lot Acceptance Testing (LAT). This testing is done to ensure that each new production lot meets the specifications of the initial contract. Typically done on a P-3 aircraft using a test asset dispensing pod, typical measurements include RCS and flare intensity/burn time. The AECM IPT is involved in writing the test plans and reviews any film data that is collected.

- *TEST ARTICLE VALIDATION*

Many times, new items are required or designed, that are never intended to go to the fleet. Test articles such as these, still need to be tested and validated themselves before their use can begin throughout the test community. One such test article, already mentioned above, was the AN/ALE-56V Mongoose II Pod. This pod was originally designed as a test asset for use on the F-18 A/B/C/D in conjunction with the Aim 9x sidewinder project. It gives the carrying aircraft an additional 120 expendable items. The AECM IPT saw this pod as a perfect replacement/upgrade for the ALE-37 pod, currently used for a PIP/LAT test article used on the P-3 aircraft. Seen in Figure 8, the ALE-37 and its replacement, the Mongoose II pod, as loaded on the P-3. The Mongoose II Pod not only increases the safety and reliability as compared to the aging ALE-37 pod, but give greater flexibility in dispense intervals and counts. Interesting side note, on its last flight, a panel on top of the ALE-37 departed the pod during flight and struck the starboard aileron. The aileron was damaged and was removed for inspection by Aircraft Intermediate Maintenance Department. Hence, the need for the Mongoose II pod.

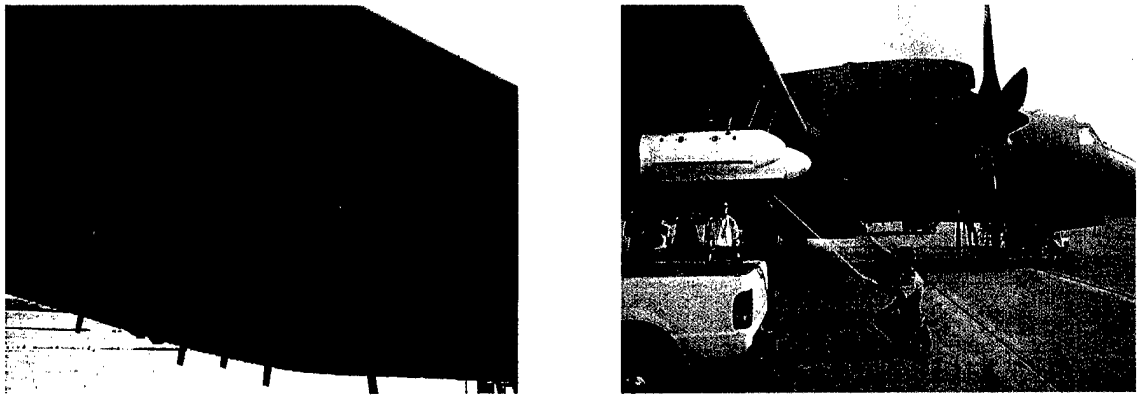

Figure 8: Ale 37 Pod (left) and Mongoose II Pod (right, foreground)

3.0 SUMMARY

By incorporating the AECM IPT throughout the lifecycle of an expendable countermeasure, PMA-272 is ensuring that safe and effective items efficiently reach the end user. Through the years, the AECM IPT has been able to provide positive influence on the design of numerous expendables and test assets.

4.0 REFERENCES

1. Military Standard MIL-STD-1289C, Airborne Stores Ground Fit and Compatibility Requirements for the Department of Defense, 17 January 1995.
2. Military Handbook, MIL-HDBK-1763, Aircraft/Stores Compatibility: Systems Engineering Data Requirements and Test Procedures, 15 June 1998.

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