Narrative – Sustainability Team Award

Program Management

Command Overview:

The PMA-231 E-2C Hawkeye and E-2D Advanced Hawkeye (AHE) aircraft are all-weather, twin engine, carrier-based, Airborne Early Warning (AEW) aircraft designed to extend task force defense perimeters. The Hawkeye has operated as the Navy's prime provider of organic AEW and battle management for the Carrier Strike Group for the past 50 years. The Navy's active inventory includes 66 Hawkeye aircraft and four E-2D AHE aircraft. The E-2C Hawkeye 2000 is the baseline configuration for the E-2D AHE. The E-2D AHE program completed first flight in August 2007, and flight testing continues toward Initial Operational Test and Evaluation in 2013 and Initial Operational Capability in 2015. The centerpiece of the E-2D AHE is the APY-9 radar system, including significantly enhanced surveillance detection and tracking capability against advanced threat aircraft and cruise missile systems in the overland, littoral, and open ocean environments. Key capabilities include the Identification Friend or Foe (IFF) system and Electronic Support Measures for surveillance and combat ID, advanced mission processing, communications, data link, and sensor netting systems to share information across the battlespace. These capabilities allow the E-2D to provide a significant contribution to execution of other mission areas such as Strike, Combat Search and Rescue, and Homeland Defense.

PMA-231 ESOH Team Summary:

PMA-231 is committed to integrating an effective Environment, Safety, and Occupational Health (ESOH) program into the development, manufacture, use, maintenance, and disposal of its aircraft systems. As such, the program has assigned an Environmental Coordinator and team to assure successful integration of an effective life cycle ESOH program. The goals of the ESOH integration initiative are to identify ESOH risks, provide a strategy for integrating ESOH considerations into the systems engineering process, delineate ESOH responsibilities, and provide a method for tracking progress. The ESOH team advises PMA-231 on initiatives to eliminate or minimize ESOH impacts pertinent to the program. The ESOH team ensures that all environmental requirements are successfully integrated in the acquisition process, implements DoDI 5000.02 ESOH requirements, and assures compliance with all applicable pollution prevention Executive Orders (EO) and guidance. The ESOH team includes the Environmental Coordinator and support personnel, Naval Air Systems Command (NAVAIR) Environmental Legal Counsel, NAVAIR Environmental Policy, PMA-231 Systems Safety lead, Naval Health Clinic Industrial Hygienist, and prime contractor ESOH representatives.

Improved Material Management – E-2D HMMP Database: DoD policy directs hazardous material (HAZMAT) identification in weapon systems, and EO's 13148 and 13423 direct environmental management tasking. Hazardous materials on the E-2D are documented in the E-2D Hazardous Materials Management Program (HMMP) Database. Both the estimated weights of the substances containing the hazardous material, and the individual constituents of those substances (e.g., chromate, lead, etc.) are assigned to the various associated parts. All MSDSs for the hazardous materials are provided as digital files.

While some of the part specific hazardous material data was entered manually, most part specific data was estimated automatically by algorithms within the database itself. These algorithms utilized part raw material, stock size, processes, and finishes batch fed from the E-2 program drawing system. The way data is structured and stored within the database allows easy data mining via custom queries. For

example, a query could be developed that estimates the total amount of material containing chromate on the aircraft.

In FY09, the hazardous materials database was used in conjunction with Northrop Grumman's electronic drawing archival system to capture legacy E-2C component materials data for E-2C components that are common with E-2D AHE components. This increased documented E-2D AHE hazardous materials data from 34% to over 90%. The HMMP database has proven to be an invaluable automated data collection and retrieval tool.

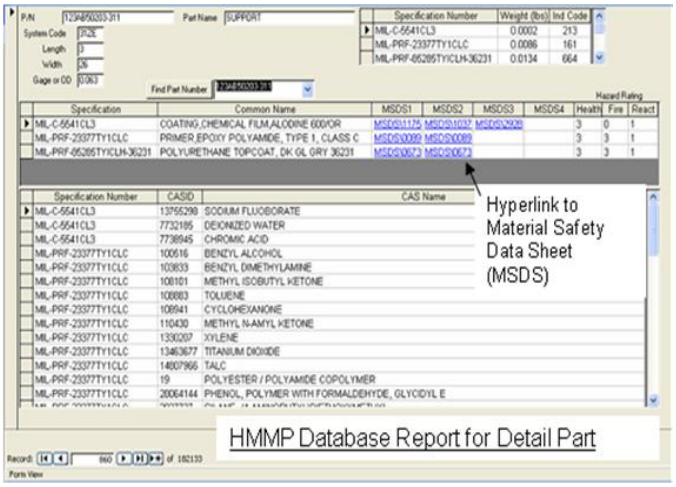

Figure 1: Hazardous Materials Database

While developed for the E-2D program, the database is readily transferable for use by other programs. Future enhancements could include improved hazardous materials accuracy estimates by integrating 3-dimensional part models for true volume and surface area, and auditing actual production procedures to develop process and finish correction factors that account for drag-out or overspray.

PMA-231 and OEM Program Management implemented several additional initiatives to improve both sustainability and fleet readiness throughout FY 2009-2010. These initiatives are described in detail throughout this nomination, but briefly, they include: in-service testing of non-chrome primers, the elimination of adhesive related HAZMAT, the elimination of Halon fire suppression, and meeting compliance of E.O 13514 through energy conservation efforts at the E-2D production facility. These accomplishments would not be possible without a strong management system to support such efforts. PMA-231 and the OEM are an integrated team comprised of members concerned with all aspects of the product lifecycle. This includes, but is in not limited to: logistics, engineering, accounting, and manufacturing.

Technical Merit

Material Substitution – Non-Chrome Primer: In 2009 Undersecretary of Defense for Acquisition, Technology, and Logistics [USD (AT&L)] issued a memorandum directing all Military Departments to minimize the use of hexavalent chromium (Cr^{6+}). In addition, Executive Orders 12856, 13148, 13423 and 13514 direct pollution prevention and exposure reduction tasking. The Department of Navy (DoN) approach to minimizing the use of Cr^{6+} is to assess alternatives as they become available and, when technically acceptable, incorporate the alternatives into existing and future acquisition programs via Original Equipment Manufacturers (OEM), subcontractors, and Fleet maintenance activities.

Products and processes using Cr^{6+} continue to be a critical part of materials and processing for Navy weapon systems. Cr^{6+} is used in 10 major metal finishing and corrosion-protection processes, including paint primers. Primers provide superior corrosion protection and adhesion performance between the weapon system metallic surface and topcoat paint. Chromates are widely accepted as the best performing corrosion inhibitors, particularly for applications involving harsh environmental exposure as commonly encountered in naval aviation. Even with the use of top performing chromate

corrosion inhibitors, current corrosion related costs are estimated to be $3.0B per year, resulting in a tremendous readiness degrader for naval aviation. Assessments also show that the cost impact of continued use of Cr^{6+} is highest for compliance with environmental, safety and health regulations when removing Cr^{6+}-containing coatings. Specifically, this results from costly engineering controls and protective equipment that are required to ensure worker exposures remain below regulatory thresholds during de-painting (ex. chemical stripping, sanding, Plastic Media Blasting) operations. E-2 maintenance activities use roughly 600-pounds of chromate primer, and generate almost 31,000-pounds of paint-related waste (includes the weight of paint-contaminated masking materials, filters, rags, water, etc), annually. The Navy supports replacing chromate-based technologies as acceptable alternatives are developed. Improper selection and use of non-chromate alternatives, however, pose negative risks, including safety of flight, increased maintenance costs, and reduced fleet-wide readiness.

Figure 2: First E-2C Painted with Non-Chromated Primer, June 2009 FRC-SW

In a proactive effort to substantially reduce exposure to chromates during de-painting operations, Fleet Readiness Center-Southwest (FRC-SW) Fleet Support Team (FST) pursued use of non-chromate primer at the source, repainting. Between June 2009 and May 2010 the entire exteriors of four E-2C aircraft were painted with the leading non-chromate primer qualified to MIL-PRF-23377 Type I, Class N Epoxy, High Solids Paint Primer. Although the primer, Deft 02GN084, is military specification qualified, its performance in-service must be tested and found equal to or better than the legacy chromate primer before it can be authorized for use on Naval Aviation Enterprise (NAE) aircraft. This includes a minimum two-carrier deployments (on same aircraft) in-service test period for carrier-based aircraft. The E-2C is the first carrier-based aircraft on which non-chromate primer is being tested on the entire exterior of the aircraft. Close coordination with the Fleet is on-going, and maintenance work orders for the four non-chromate primed aircraft are being closely monitored for corrosion and paint-related discrepancies as compared to maintenance performed on chromate primed aircraft serving side by side. Thus far the corrosion and general adhesion performance of the non-chromate primed aircraft is proving as good as or better than the chromate primed aircraft. The first non-chromate primed, carrier-deployed E-2C is due back from its first carrier-deployment by early CY2011.

If the performance of the non-chromate primer is successful during the E-2C in-service flight test demonstrations, then NAVAIR will likely pursue transition of the non-chromate primer technology across all gloss paint systems Type/Model/Series. For the E-2/C-2 program this would be accomplished during regularly scheduled depot-level rework for all E-2C, E-2D and C-2A aircraft, and also during production at the OEM for the E-2D aircraft. Transition of E-2/C-2 aircraft to non-chromate primer will avoid the use of over 20,000 pounds of chromate primer over fleet lifetime. In addition, transition of non-chromate primers to other NAE aircraft with flat or specialty paint systems would be highly likely, dramatically reducing chromate primer usage even further.

Material Substitution – Adhesives Replacement: Northrop Grumman Materials and Processes (M&P), in conjunction with NAVAIR M&P, surveyed adhesives that would meet Northrop Grumman's specification requirements and reduce hazardous materials (HAZMAT).

FM-58 is a nitrile phenolic epoxy resin system. It is used for structural bonding of honeycomb sandwich and metal to metal constructions, covering a service temperature range of -67°F to 250°F. FM-58 contains formaldehyde and is considered a significant risk to human health. Small amounts of formaldehyde gas or vapor are released into the air during the cure cycle of FM-58 film adhesives, with even more significant exposure potential during adhesive manufacture. A formaldehyde-free product, FM-73, was evaluated and qualified as a technically acceptable replacement. FM-73 was implemented on the E-2 platform in May 2009, eliminating over 3,000 square-feet of the formaldehyde-based adhesive annually. FM-73 eliminates the risk of formaldehyde exposure without degrading technical performance.

FM-47 is a modified vinyl phenolic liquid adhesive, also covering a service temperature range of -67°F to 250°F. It is used for metal and composite bonding operations, as well as abrasion resistance and dampening. FM-47 contains toluene which can cause central nervous system damage and is a skin irritant. A toluene-free anti-chafe topcoat, CA8100, was identified as a technically acceptable replacement. CA8100 was implemented on the E-2 platform in November 2008, eliminating 200-gallons of the toluene-based adhesive annually. CA8100 completely eliminates the risk of toluene exposure without degrading technical performance.

Both FM-73 and CA8100 adhesives could be substituted in other NAE weapon systems that have similar structure and service applications, further reducing formaldehyde and toluene exposure.

Material Substitution – Halon Replacement: As a result of the Montreal Protocol of 1987, International Treaty, and U.S. Legislation, domestic production of halons and chlorofluorocarbons ceased 31 December 1993 and 31 December 1995, respectively. Navy and DoD have continuing mission-critical Ozone Depleting Substance (ODS) requirements including fire suppression systems. Although the Navy is able to obtain a limited amount of ODS material from the DoD ODS Reserve, it is DoD and Navy policy that alternative materials be used as possible.

Figure 3: E-2D AHE Halon Replacement

The E-2D Advanced Hawkeye (AHE) maintains approximately 67% component commonality with the E-2C Hawkeye 2000 aircraft. Initially that commonality included the fire suppression system which uses Halon 1301, a Class I ODS. The system uses 13-pounds of Halon per aircraft for initial bottle fill, plus nine-pounds per year per aircraft annually (based on 31 July 1995 Naval Aviation 1301 Reserve Report).

Pursuant to domestic and international legislation, and DoD and Navy policy, the PMA-231 E-2D AHE program manager initiated a Halon replacement program. HFC-125 is the recommended replacement for Halon 1301 and is currently used on several other NAE aircraft. The use of HFC-125 requires higher

design concentrations, resulting in larger volume and heavier weight (approximately 2x heavier) fire extinguishing bottles, and significant distribution system modifications.

Due to cost and schedule constraints, and technical complexity, the E-2D AHE program originally planned to install the HFC-125 fire suppression system beginning with the 6th E-2D AHE aircraft (AA-6) during production. As a direct result of committed, efficient program management and an aggressive design and test program, the HFC-125 system was installed nearly one-year earlier, beginning with aircraft AA-3. By moving up HFC-125 installation to aircraft AA-3 during production, the program saved significant cost and schedule, and saved 100-pounds of Halon, by avoiding future retrofit of three aircraft. The E-2D AHE Halon replacement system was installed during aircraft AA-3 production in 2009. Numerous fit issues were successfully addressed during system installation. System qualification ground and flight testing was successfully completed in December 2009 and February 2010, respectively. All subsequent E-2D AHE aircraft will be delivered to the Navy without Halon 1301. Overall, 73 of 75 E-2D AHE aircraft will be equipped with non-ODS fire suppressant, avoiding the use of over 20,000-pounds of Halon-1301 over the lifetime of the program.

Halon fire suppression systems could be replaced with a suitable alternative in nearly any weapon system that is early in its lifecycle. Significant design changes are required compared to the Halon system to accommodate a larger volume of fire suppressant, including larger, heavier bottles and distribution system. Implementation is recommended during production since retrofitting existing vehicles would likely be cost prohibitive.

Transferability for HAZMAT Database, Non-Cr^{+6} Primer, Adhesive Replacement, Halon Replacement), the following example of reduced energy consumption is highly transferable. The efforts described are not unique, and could be applied to any manufacturing facility worldwide.

Compliance with E.O. 13514 – Energy Conservation: The St. Augustine Manufacturing Center (SAMC), E-2D's final assembly site, is committed to reducing energy and minimizing the environmental footprint related to its products and services. SAMC has implemented several initiatives directed at reducing energy consumption. These initiatives include an improved Heating, Ventilation and Air Conditioning (HVAC) Management Program and innovative Lighting Management and Compressed Air Optimization Programs.

1. **HVAC Management:** HVAC systems are one of the largest energy consumers during aircraft production. Specific elements of this program include optimization of Smart Building Management Systems, thermostat regulation and an aggressive replacement program where older systems near the end of their useful life are replaced with energy efficient systems. Together, these elements will reduce site energy consumption by 90,201 kWh and provide a greenhouse gas emission reduction of 54 metric tons of CO2 annually.

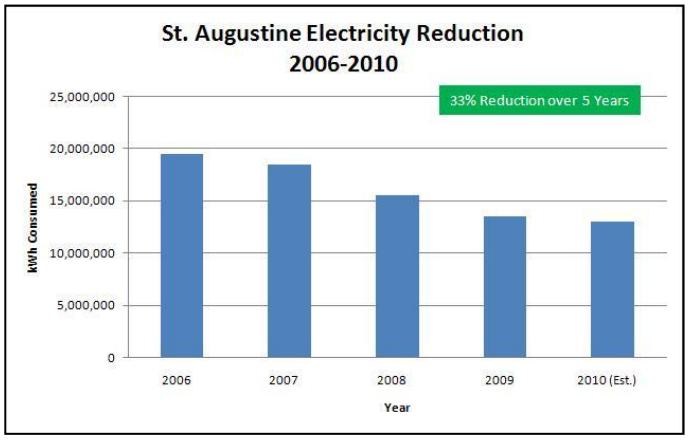

Figure 4: E-2D Production Facility Energy Consumption

2. **Lighting Management Program:** This program includes replacement of 32 watt lights with 25 watt lights. In 2010 nearly 7,000 lamps were replaced. The program also includes the installation

of Automated Lighting Control Systems and Occupancy Sensors. The program will save an estimated 305,205 kWh and reduce greenhouse gas emissions by 184 metric tons of CO2 annually.

3. **Compressed Air Optimization:** Compressed air is a vital component to the production of aircraft. Compressed air supports aircraft production tooling and must be of excellent quality and sufficient quantity. SAMC developed a plan to optimize the compressed air generation process such that high quality air is produced with the least environmental impact. Elements of this program include substantial re-piping, additional storage capacity and implementation of automated control capability throughout the Center. This aggressive approach is forecasted to save approximately 1.2 million kWh/year and reduce greenhouse gas emissions by over 700 metric tons annually.

The aggressive energy conservation initiatives implemented at SAMC since 2006 have reduced energy consumption by 6.4 million kWh, or 33%, compared to the 2006 baseline.

Orientation to Mission:

The NAVAIR PMA-231 ESOH Team promotes integration of environmental technology solutions across the platform and provides technical support for procurement of alternative environmental materials and equipment. E-2's depot facility, FRC-SW, pursued the use of non-chromate primer during E-2 repainting in an effort to mitigate chromate exposure during subsequent depainting operations. The entire exteriors of four E-2C aircraft were painted with the leading non-chromate primer for in-service performance testing. A minimum two-carrier deployments (on same aircraft) in-service test period is required for carrier-based aircraft. Close coordination with the Fleet is on-going, and maintenance work orders for the four non-chromate primed aircraft are being closely monitored for corrosion and paint-related discrepancies as compared to maintenance performed on chromate primed aircraft serving side by side. If the in-service performance of non-chromate primers is successful, and the technology is implemented fleet-wide, then chromate exposure potential to fleet maintainers will be dramatically reduced for decades to come.

The E-2D AHE program originally planned to install a Halon replacement fire suppression system (HFC-125) beginning with the 6th E-2D AHE aircraft (AA-6) during production. In an effort to mitigate significant future cost and schedule impact fleet aircraft, the HFC-125 system was installed nearly one-year early, beginning with aircraft AA-3. The program saved significant cost and schedule, and saved 100-pounds of Halon, by avoiding future retrofit of three aircraft. Numerous fit issues were successfully addressed throughout design and installation. Overall, 73 of 75 E-2D AHE aircraft will be equipped with non-ODS fire suppressant, avoiding the use of over 20,000-pounds of Halon-1301 over the lifetime of the program.

Stakeholder Interaction:

PMA-231 program management ensures appropriate resources are provided to allow the PMA-231 ESOH team necessary stakeholders are involved for sustainability initiative success. The PMA-231 ESOH team is supported by the program's government and OEM Air Vehicle Systems, Systems Engineering, Systems Safety, Test and Evaluation, and Product Support/Logistics team's personnel. The ESOH team works closely with a multi-disciplined sustainability team consisting of chemical, material and environmental engineers, and production personnel to provide solutions to process activities with significant environmental benefit. Together these teams work closely with NAVAIR, NAVFAC, Northrop Grumman, FRCSW, the City of Saint Augustine and the Florida Department of Environmental Protection to ensure compliance and reduce the PMA-231 environmental footprint. PMA-231 ESOH team is resourced by and report frequently to Deputy Program Managers Air (PMA-231) Air Vehicle Systems and Systems Engineering.