I. Weapon System Acquisition Program

Program Manager Air (PMA)265 manages the variants and subsystems of the F/A-18, including its fourth variant, the EA-18G. The F/A-18E/F (Figure 1) is a twin engine (F414-GE-400), mid-wing, multi-mission tactical aircraft currently in operation and support at Naval Air Station (NAS) Lemoore, California; NAS Oceana, Virginia; and future stand-up at Marine Corps Air Station Cherry Point, North Carolina.

Figure 1: F/A-18

Figure 2: EA-18G Growler

The EA-18G (Figure 2) met the requirements for initial operational capability in early Fiscal Year (FY) 2010. EA-18Gs are currently deployed at NAS Whidbey Island, Washington. The EA-18G retains most of the F/A-18F capabilities while integrating Airborne Electronic Attack systems (e.g., tactical receivers and jamming pods). Follow-on test and evaluation (T&E) will continue for both the F/A-18 & EA-18G through FY 2013 at several United States (U.S.) Navy facilities and ranges, as PMA265 continues with capability upgrades to these aircraft platforms.

The PMA265 Environment, Safety, and Occupational Health (ESOH) Manager and the multi-disciplined Green Hornet Team (GHT) manage and monitor all ESOH aspects for the F/A-18E/F and EA-18G. This technical acquisition team defines solutions on ESOH issues with respect to the F/A-18 & EA-18G manufacture, T&E, integrated logistics, maintenance, operations, training, and eventual disposition of the aircraft at the conclusion of its life-cycle. The GHT executes ESOH initiatives, promotes ESOH technical data and risk exchange, and develops informed recommendations. The PMA265 ESOH Manager communicates directly with PMA265 specific platform acquisition managers (PMs) and is a key member of the PM weekly meetings with senior leadership. These meetings include reports on key efforts, schedules, budgets, top degraders, and risks. The PMA265 ESOH Manager also maintains solid working relationships with the Naval Air Systems Command (NAVAIR), Chief of Naval Operations (CNO), Office of Naval Research (ONR), and Fleet/user communities. For example, PMA265 routinely communicates with the NAVAIR Sustainability Office to address environmental planning and National Environmental Policy Act (NEPA)/Executive Order (EO) requirements associated with T&E at NAVAIR ranges (e.g., a Record of Categorical Exclusion for T&E actions at Patuxent River Complex – Naval Air Station Patuxent River, Webster Field, and the Special Use Airspace/Restricted Areas and Naval Air Warfare Center, Weapons Division China Lake).

PMA265 ESOH MANAGEMENT STRATEGY

- Develop and validate ESOH requirements and criteria.
- Identify ESOH hazards/issues, assign risk levels (probability and severity), and provide recommendations for resolution.
- Prioritize ESOH initiatives, integrate with acquisition plans, assign designated leads, and develop a plan of action and milestone.
- Identify and monitor ESOH initiatives, including the tracking and formal management acceptance of ESOH risks.

II. Incorporating ESOH Integration into Systems Engineering and the Weapon System Acquisition Program's Decision-making Process

Pursuant to Department of Defense (DoD) Instruction 5000.02, PMA265 updated the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) for the F/A-18E/F & EA-18G Program with leadership approval obtained in June 2009. The PESHE reflects PMA265's continuing ESOH initiatives and risk management strategy. We apply this to the production, test, operation, maintenance, and disposal of the aircraft. EA-18G system contracts and performance specifications incorporate ESOH requisites to include prohibited and restricted hazardous materials (HAZMAT)

considerations. Original Equipment Manufacturers (OEMs), system integrators, and sub-system contractors are to manage and incorporate ESOH risks and HAZMAT/pollution prevention (P2) initiatives into the systems engineering (SE) and maintenance processes for the F/A-18E/F & EA-18G. Acquisition system contracts encompass compliance with National Aerospace Standard 411, EOs (including EO 12114, 13423, and the newly signed 13514 of 5 October 2009), Federal Acts, International Treaties [e.g., The Montreal Convention banning Ozone Depleting Substances (ODS)] and eliminating or mitigating ESOH hazards pursuant to Military Standard (MIL-STD)-882D. Our proactive ESOH management practices ensure these Federal directives are in contract specifications and are flowed down to the OEMs and their subcontractors. One of the fundamental performance specification and contractual requirements is inclusion of the NAVAIR Chemical of Concern List (CoCL). System contractors are required to identify not only the type and quantity of HAZMAT delivered with and for maintenance of the system as part of their HAZMAT Management Program Reports, but also if any materials contain hazardous constituents listed on the CoCL (such as Class I and II ODS, hexavalent chromium and emerging contaminants).

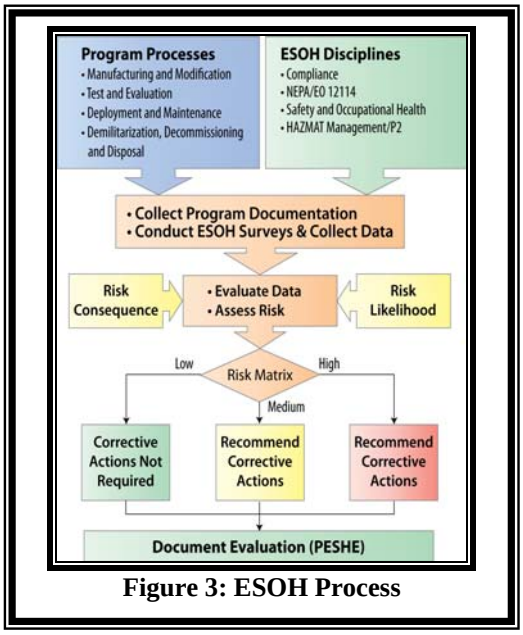


Figure 3: ESOH Process

PMA265's ESOH process is predicated on DoD and Naval risk management policies. It evaluates hazards and assesses their risk, implements mitigations, communicates those risks are to management and the user to assure a common understanding of program risk at all levels, and ensure appropriate authority acceptance for residual risk. The process as reflected in Figure 3 is based on the precedent to design out hazards using the techniques of both MIL-STD-882D and Naval SYSCOM Risk Management Policy. This offers a cohesive method for communicating both program management (cost, schedule, and technology maturity) and ESOH issues integral with SE and logistics management. A representative example is formal acceptance of risk caused by personnel exposure to jet noise by the Program Executive Officer for Tactical Aircraft Programs. This required the written concurrence by the Chief of Naval Air Forces (CNAF), the primary user of the F/A-18E/F & EA-18G. Additionally, CNAF provided a crucial letter of support endorsing the program's proposed technical solutions to this problem as discussed below.

Collaboration with NAVAIR 4.4 and 4.3, PMA265 system contractors, and more recently with the Navy Energy Coordination Office continues to further technology and material alternative opportunities for the F/A-18E/F & EA-18G Program. PMA265 is committed to environmental protection and energy efficient efforts as evident in offering aircraft assets and/or financial commitments to various DoD and U.S. Navy initiatives. The F414-GE Engine will become more energy efficient through development and incorporation of new technologies. Summer 2010 engine testing will demonstrate efficiency upgrades, which are projected to improve F/A-18E/F fuel efficiency by 3 percent (approximately 5.3 million gallons/year), exceeding the President's goal expressed in EO 13514 – "It is therefore the policy of the United States that Federal agencies shall increase energy efficiency…" Additionally, the F/A-18 platform accounts for about one quarter of the Navy's aircraft fuel consumption; consideration of fuel alternatives

FUEL EFFICIENCY UPGRADES
- Advanced aerodynamic compressor
- Advanced aerodynamic high pressure turbine
- Ceramic matrix composite turbine blades
- Performance seeking engine controls

is critical to the Navy's move towards energy security. The initial static F414 engine test using biofuel derived from Camelina as feedstock in a 50/50 blend with JP-5 was successfully conducted on 13 October 2009. This test will be followed by the flight of the "Green Hornet" (a F/A-18E/F) on Earth Day at NAS Patuxent River, MD. The "Green Hornet" is an important element in accomplishing the Secretary of Navy's five ambitious energy targets by 2020, centering around reducing the use of petroleum-derived fuels and increasing the use of energy from renewable sources. Camelina biofuel blended with JP-5 offers the potential for significant carbon emissions reductions (up to 80 percent), when used in military aviation applications, and has already been successfully tested in commercial airliners. Camelina derived biofuel has the potential to be a sustainable, environmentally friendly, domestic renewable alternative fuel (i.e., does not compete with other fuel crops, has a naturally high oil content, is drought tolerant, requires less fertilizer, can grow on marginal land, and should reduce carbon footprint).

III. ESOH Risk Management

Communicating acquisition ESOH requirements and responsibilities to leadership and personnel is fundamental for a Major Defense Acquisition Program. The PMA265 Orientation Program for new personnel includes an acquisition ESOH overview advising the employees on PMA265's approach to meeting ESOH requirements and integrating ESOH risks management into their systems acquisition responsibilities. As part of the ESOH process, PMA265 and the GHT monitor and assess potential concerns or risks in the areas of ESOH Compliance, NEPA)/EO 12114, Safety and Occupational Health, and HAZMAT Management/P2. PMA265 identifies, mitigates, and tracks ESOH hazards by using risk consequence and likelihood indicators identified in MIL-STD-882D: high, serious, medium, and low. Identified ESOH risks are tracked and managed by the PMA265 ESOH Manager, who ensures identified risks are appropriately communicated with the F/A-18E/F & EA-18G Program Managers, Integrated Product Team representatives, test and user communities, and other organizations as necessary. High and serious ESOH risks, and medium risks as necessary, are elevated and incorporated into the overall PMA265 risk databases and presented at both weekly management reviews and program risk assessment boards. Risk acceptance is carefully assessed, categorized, and presented to management and the user community during program reviews.

Encroachment constraints continue to affect DoD and U.S. Navy installations, and occupational safety risk to personnel from exposure to U.S. Navy jet aircraft noise is a long standing problem. PMA265's acknowledgement of these issues is reflected in a commitment to review and pursue feasible noise reduction technical solutions. PMA265 continues to engage NAVAIR 4.4 and 4.6, ONR, and OEMs to research and develop technical solutions that reduce community noise levels and minimize personnel exposure to jet noise levels. PMA265 has embarked on a robust engine noise reduction program using mechanical chevrons on the F414 jet engine nozzle (Figure 4). In partnership with ONR and General Electric (GE) Aviation, it is implementing a Rapid Technology Transfer project for variable exhaust nozzle (VEN) chevrons, a promising and viable solution to reducing jet engine noise for the F414/F404 engine, as well as other DoD tactical aircraft. VEN chevrons help mix the jet plume faster to reduce noise. This increased mixing and reduction of noise also reduces the extent and strength of the shock cells in the jet plume, which are known to generate noise through their interaction with the turbulent airflow. GE has successfully developed chevrons for the commercial aircraft engines, CFM56-5B and CF34, currently in revenue service.

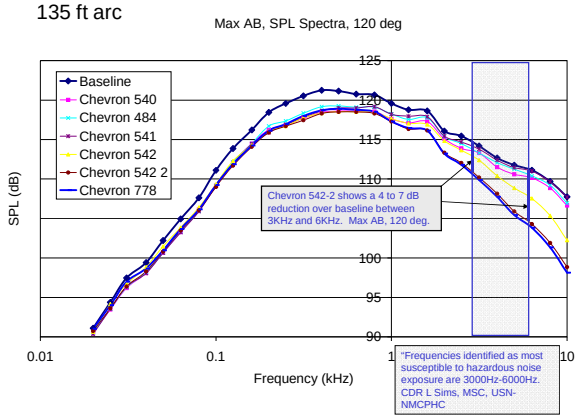
Figure 4: VEN Chevrons

HOW DO CHEVRONS WORK?

- Generate vorticity which mixes the two streams faster
- Reduces peak velocity faster and reduces noise
- Alters shock cell structure to reduce broadband shock noise

This technology was recently tested by NAVAIR Propulsion & Power/GE Aviation at Naval Air Warfare Center Lakehurst, New Jersey and demonstrated an approximate 2.5-3 decibel (dB) reduction over much of the frequency range. In the 3-6 KHz frequency range (identified as most susceptible to hazardous noise exposure), up to 7 dB reduction was demonstrated. Figure 5 displays encouraging noise reductions made by this technology. This configuration also shows no thrust impact through maximum afterburner engine settings at sea level static conditions, a critical criterion for Fleet acceptance of these technologies. PMA265 has secured $2 million in research and development funding from ONR; an additional $3.3 million of PMA265 funds are committed to complete the testing, design engineering, and manufacturing development phase. In addition, $98 million has been requested from our resource sponsor (CNO N88) to complete retrofit/installation on the F/A-18E/F inventory. This will be the ***first*** installation of jet noise reduction technology on ***any*** DoD high performance tactical aircraft.

Figure 5: FY09 Sound Pressure Level Spectra Comparison for the Mechanical Chevron Nozzle



PMA265 continues to support the Trapped Vortex Combustor (TVC), see Figure 6, as a promising technology initiative applicable to the GE Aviation F-4XX series engines to reduce emission levels. TVC project goals are to reduce carbon monoxide by 60 percent, nitrogen oxides (NOx) by 42 percent, and unburned hydrocarbons (HC) by 80 percent. Additional TVC development and new design testing, such as the Full Annular Ring (FAR), continue cooperatively among PMA265, NAVAIR 4.4, GE Aviation, and the Environmental Security Technology Certification Program. FAR testing in 2007 and 2009 has shown excellent high power emission reduction with no loss in performance capabilities. Of the design tests completed in 2009, TVC technology has demonstrated a 42 percent reduction in high power NOx (See Figure 7) and 17 percent reduction in HC at low power conditions. Additional testing to improve low power efficiency and an engine demonstration is still required. Should TVC technology be installed in the existing and/or future F/A-18 Fleet or other DoD aircraft, greenhouse gas reductions emitted could be dramatic and jet fuel savings achieved aboard aircraft carriers.

Figure 6: TVC FAR

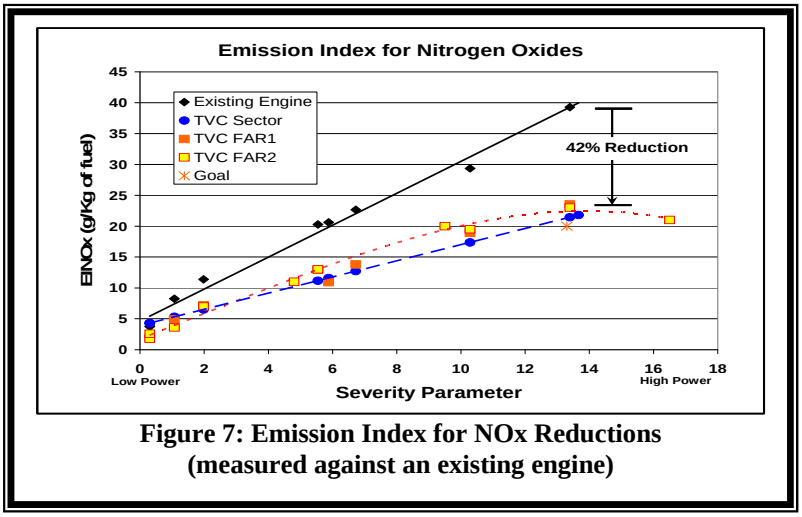


Figure 7: Emission Index for NOx Reductions (measured against an existing engine)

PMA265 proposed and is managing a Navy Small Business Innovative Research Phase I Feasibility Study to optimize modeling of operational flight profiles, thereby, offering another viable venue to help alleviate noise impacts around military airfields. Modeling the outcome of various operational flight procedures and profiles of tactical aircraft and determining an optimal jet noise reduction profile is an effective near-term/low cost solution. A generic operational airfield model was developed and used to conduct optimization exercises for F/A-18E/F departure flight tracks and flight profiles derived from recent noise studies. The objective was to identify the tracks and profiles that can minimize noise impact (that is population annoyance, sleep disturbance, and speech interference). Results of the Phase I study demonstrated such a model can be used for basic flight profiles of an operational airfield and could be expanded into even more complex flight scenarios (e.g., fleet carrier landing practices). This research is proceeding into Phase II. The vision is to further develop the model into a useful tool that can be used (1) as part of the NEPA process, (2) to provide guidance to installations on how to operate safe flight procedures and routes which minimize community noise impacts, and (3) to optimize flight profiles for reduced fuel consumption, a key goal and challenge expressed by the Secretary of the Navy.

IV. Hazardous Materials Management and Pollution Prevention

PMA265, Boeing, Northrop Grumman Corporation (NGC), Raytheon, and GE Aviation remain cognizant of HAZMAT Management/P2 responsibilities. Some of the identified HAZMAT for the F/A-18E/F & EA-18G is on the DoD Emerging Contaminants Action List (e.g. Hexavalent Chromium [Cr6+], Perfluorooctanoic Acid, and Beryllium). PMA265 is engaged with NAVAIR Material and Corrosion Branches to investigate viable alternatives to Cr6+ and proceed in addressing the requirements reflected in the DoD Memorandum for Secretaries of the Military Departments, *Minimizing the Use of Hexavalent Chromium (Cr6+),* of April 8, 2009. GHT initiatives include in-process alternative material analyses.

By way of example, the current Type II low infrared reflective primer used on the F/A-18 moldline surfaces, before applying the topcoat, contains a Cr6+ corrosion inhibitor. Boeing St-Louis and NAVAIR Materials have developed a laboratory test plan to qualify a non-Cr6+ primer. If testing is successful, then one more component of the F/A-18E/F & EA-18G will be Cr6+ free, offering yet another means to lessen the regulatory burden and personnel exposure risks associated with the use of Cr6+. Additional benefits include a reduction in the volatile organic compound (VOC) index in the primer. The current primer has a VOC of 575-600 g/l max while the new alternative primer would be under 340g/l max, per the specifications. Approximately 6 gallons of this primer is used per aircraft, so there would be a potential VOC savings of >5,300g per aircraft.

NGC is also investigating and/or implementing alternative coatings and primers to eliminate/reduce the use of Cr6+, such as a non-chrome version of TT-P-2760 flexible polyurethane primer (including replacement of MIL-PRF-81733 Type III) offering a potential to save weight and eliminate chromates from the spray seal. Other alternatives to reduce chromates associated with spray seal include the use of PR-1432GP. NGC also completed a project, Infrared Reflectance Imaging Technique (IRRIT), funded by DoD's Environmental Security Technology Certification Program. Developed by NGC Bethpage, the IRRIT visually detects corrosion under aircraft coatings. The IRRIT process allows for the non-destructive testing inspection of surfaces without the costly removal of paint from the aircraft. IRRIT offers an economical approach to the overhaul and repair cycles of operational military aircraft. Further, it has the potential to prevent airborne pollution associated with chemical paint strippers and mechanical stripping.

A major component of the F/A-18E/F & EA-18G engine, the F414 Outer Bypass Duct (OBD) as depicted in Figure 8, uses an industry standard high temperature composite material – PMR-15. It is also used in the Inlet Device and certain models of the F404 OBD. PMR-15 has been the standard resin among addition polyimides for 30 years. There are significant ESOH risks associated with using PMR-15 during manufacturing. Uncured PMR-15 has known Occupational Safety and Health Administration issues and restrictions during its use due to the presence of Methylenedianiline (MDA), a liver toxin. Federal legislation has also been introduced that would align U.S. rules on the use of MDA with European Union REACH rules. If signed into law, this legislation could restrict use of MDA after 1 July 2010. To mitigate the availability and ESOH risks, GE Aviation and Maverick Corporation are developing an environmentally friendly replacement material called MVK-14 FreeForm™, which has the same mechanical properties and temperature capability as the current OBD PMR-15 material. GE Aviation is directly involved in a number of programs being conducted to support introduction of MVK-14 FreeForm™, such as the National Center for Advanced Material Performance funded material property database program intended to achieve widespread dissemination of MVK-14 FreeForm™ material properties to aerospace community participants. Preliminary estimates in replacing PMR-15 with MVK-14 FreeForm™ predict a potential reduction in HAZMAT usage of about 7,000 pounds a year. Such benefits, with further development and introduction of MVK-14 FreeForm™, are consistent with PMA265's goals to reduce hazardous waste (i.e., reduced hazardous scrap disposal). Furthermore, MVK-14 FreeForm™ has potential application and similar benefits to other future commercial and DoD engine programs.

Figure 8: F414 OBD

PMA265 system contractors proactively pursue methods to reduce pollution and green the environment. Boeing-St Louis has stepped up its recycling efforts with additional bins for cardboard, scrap metals, paper, wood, and drinking containers. For example, its paint shops recently began recycling all packaging materials. As a result, shipping boxes are placed in the cardboard recycling bins, foam packing materials are palletized and shipped back to the paint manufacturer for re-use, plastic can rings are sent to a recycler, and the cans and lids are placed in a special metal recycling bin after they are emptied. This all leads to no generation of waste. Another initiative is the automatic double-sided printing of all documents with an estimated savings of about 116 million sheets of paper and 9,660 trees annually company wide.

Boeing is also pursuing an International Standard Organization project to replace a large greenhouse gas (GHG) contributor solvent. The current flush cleaner, Acc-U-Flush II, used to clean bays and surfaces that cannot be reached by hand is comprised of two "problem" constituents – Hydrofluorocarbon (HFC) 43-10mee and HFC-365mfc having a Global Warming Potential (GWP) of roughly 840. GWP is the degree of warming to the atmosphere that would result from the emission of one unit of a given GHG compared to one unit of carbon dioxide (CO_2) when measured against a 100 year timescale. Approximately ten of the nineteen 55-gallon drums used a year in production are attributed to the F/A-18E/F & EA-18G Program. Testing is currently underway on alternative materials with a minor to zero GWP. A complete switchover with this environmentally viable solvent is expected by the end of 2009.

PMA265 is also assessing the reduced environmental footprint of the F/A-18E/F & EA-18G that may be achieved with successful implementation of energy conservation and optimized mission planning innovations discussed above. The U.S. Navy currently operates more than 3,700 aircraft, and in 2008, combusted approximately 627 million gallons of fuel. This equates to approximately 6.1 million metric tons (MMT) of GHG emissions on a CO_2 equivalent (CO_2e) basis, which is equivalent to the annual GHG emissions of over 1.1 million passenger vehicles or the annual energy consumption of 846,000 homes. The

U.S. Navy is projecting fuel consumption to increase approximately 50 million gallons by 2020, adding another 0.5 MMT of CO_2e to the environment. CO_2e is the internationally recognized unit of measure for GHG developed to compare different GHGs in terms of the GWP potential of one unit of CO_2. Table 1 highlights PMA265's estimates on the potential GHG reductions achieved through incorporation of the promising technical and fuel efficiency advancements, which in turn help to reduce the Navy's overall carbon footprint.

Table 1: Potential Carbon Footprint/GHG Emissions Reductions

Energy Efficiency Advancements	Fuel Savings	GHG Emissions Reduction (Equivalent Number of Passenger Vehicles/Annual Home Energy Consumption)[1]
Minimized hot pit refueling (NAS Lemoore/Fallon)	2 million gallons (Fiscal Year 2009)	0.02 MMT (3,600/1,820)
VTC	1.2 million gallons	0.01 MMT GHGs (22,000/10,900)
Camelina Derived Biofuel	50% conventional fuel supply savings	84% reduction in carbon emissions on a life-cycle basis
Optimized training and readiness models	15 million gallons per year	0.15 MMT GHGs (27,000/20,800)
Enhanced simulation capabilities	9 million gallons per year	0.1 MMT GHGs (18,000/9,100))

1. The fuel savings shown is equivalent to removing this number of passenger vehicles from the road and this number of households from the electrical grid.

V. External Coordination

PMA265 and the ESOH Manager remain abreast of Federal, State, and international ESOH state of affairs and impart situational awareness on ESOH efforts or concerns associated with the F/A-18E/F and EA-18G Programs. Representative examples include the following:

- The PMA265 ESOH Manager participated and presented, *F/A-18 Program Office Management Environment, Safety, and Occupational Health Challenges*, at the Environment, Energy, and Sustainability Symposium, held on May 04-09, 2009.
- PMA265 actively participates in proactive efforts of the international jet noise community. The PMA265 ESOH Manager is a regular participant on the North Atlantic Treaty Organization (NATO) Research and Technology Organization, Advanced Vehicle Technology Panel: AVT-132/158 (a group focused on technology solutions to environmental noise issues associated with gas turbine powered military vehicles). He presents at their regular meetings the status of PMA265's and DoD's jet noise reduction and hearing conservation efforts.
- Foreign military sales of PMA265 acquisition systems are another area where the GHT assists with international environmental requirements. The Royal Australian Air Force (RAAF) needed to know if the entire F/A-18E/F system and support package were free of chrysotile asbestos due to their country's strict requirement for zero percent asbestos content in acquired systems. Careful review of HAZMAT and product data showed no usage of asbestos in gaskets and communication/navigation systems. A no asbestos requirement from the detailed aircraft specification is flowed down by Boeing to their vendors. PMA265 provided the RAAF all noise data and sound pressure levels generated by the F/A-18E/F aircraft to facilitate the development of Australian environmental documentation (similar to our NEPA required Environmental Impact Statement process).

In addition to PMA265's proactive stewardship for environmental readiness and sustainment, the PMA265 ESOH Manager is the President of the Board of Trustees for the Cove Point Natural Heritage Trust, Inc (CPNHT). The CPNHT is a charitable and educational organization that promotes preservation and protection of the Chesapeake Bay and other sensitive areas.