FY 2017 SECDEF
Environmental Awards Program
Environmental Excellence in Weapon System Acquisition - Large Program

F/A-18 & EA-18G Program Office PMA265 - Green Hornet Team

Introduction, Background, and Program Description

The F/A-18 and EA-18G Program Office is responsible for acquiring, delivering, and sustaining the F/A-18 C/D Hornet, F/A-18 E/F Super Hornet, and EA-18G Growler aircraft (Figure 1), which provide naval aviators with capabilities that enable mission success. In addition to the United States (U.S.) Navy and U.S. Marine Corps, the Program Office serves seven international customers.

Figure 1: F/A-18

The F/A-18 Hornet was developed in the early 1980s as an all-weather aircraft and is used as an attack aircraft, as well as a fighter. The F/A-18E/F Super Hornet is a combat-proven platform with demonstrated capabilities in multiple warfighting roles. The Block II high performance, tactical aircraft provides enhanced capabilities over its predecessors. The EA-18G Growler is a mission-changing electronic attack aircraft that combines the demonstrated capability of the Super Hornet's suppression of enemy air defenses with superior jamming abilities in reactive, pre-emptive, standoff, and escort roles.

Aircraft Contractors

- Boeing (Prime-Airframe)
- Northrop Grumman (Airframe and Airborne Electronic Attack)
- General Electric (Engines)
- Raytheon (Radar)

The Green Hornet Team (GHT), comprised of Naval Engineering and Acquisition Components and major prime aircraft contractors, manages the Environment, Safety, and Occupational Health (ESOH) program for Program Manager Air (PMA)265 within the Naval Air Systems Command (NAVAIR).

Incorporating ESOH Integration into Systems Engineering

The GHT continues to proactively integrate ESOH requirements into the Systems Engineering (SE) and acquisition process. The GHT's strategy is to participate in system design, SE, and logistics processes. With ESOH requirements crossing over multiple PMA265 functional/Integrated Product Teams (IPTs), the GHT actively engages with PMA265 product managers in weekly/monthly meetings to plan cost-effective ESOH efforts, discuss ESOH initiatives, and mitigate constraints/risks. This process occurs as a matter of standard operating procedure even though the F/A-18E/F and EA-18G and most of the subsystems are in the Operations and Support (O&S) phase of the Department of Defense (DoD) acquisition process. Post-production planning as it pertains to demilitarization/ disposal efforts are underway with ESOH staffing efforts estimated at ~ 1.85 man-years over the next eight years. System upgrades are required to maintain the F/A-18 and EA-18G platforms as a critical component of Naval Aviation (e.g., Conformal Fuel Tank-[CFT]), which are subject to ESOH integration requirements.

GHT ESOH Integration Strategy Summary

- ESOH criteria in performance specifications, contractual documents, Systems Engineering Plans (SEPs), Life Cycle Sustainment Plans (LCSPs), post production planning, and demilitarization/disposal planning.
- National Environmental Policy Act (NEPA)/Executive Order (EO) 12114 analyses including NEPA/EO 12114 Compliance Schedule
- Hazardous Materials identification and alternative material technology evaluations
- ESOH risk management and communication to the test, user, and maintenance communities

ESOH Risk Management

PMA265's risk assessment process (Figure 2) is based on the methodology and risk definitions of Military-Standard (MIL-STD)-882E. The GHT's mission is to minimize potential ESOH impacts/risks throughout the acquisition process in a manner that balances cost, schedule, and system performance considerations over the system's life cycle.

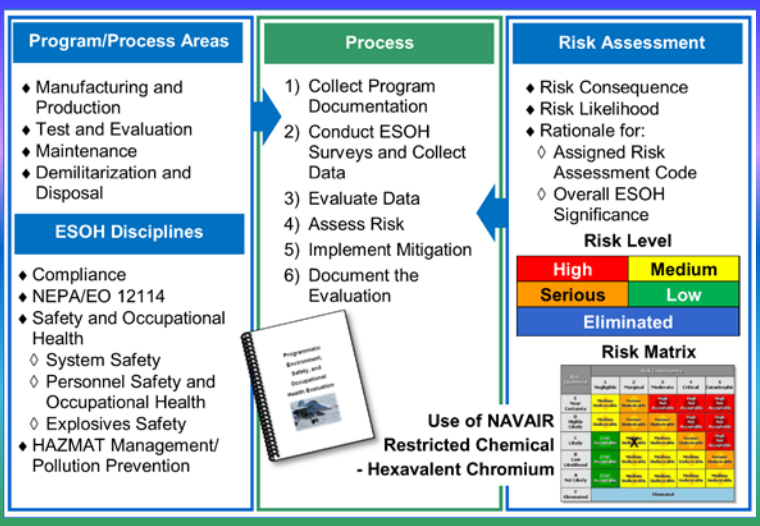

Figure 2: PMA265's ESOH Risk Assessment Process

Hazards and mitigation measures for the risks are managed via the Risk Assessment Module (RAM) of NAVAIR's Programmatic ESOH Evaluation (PESHE) Document Authoring Tool (DAT) and the F/A-18 and EA-18G System Safety Hazard Tracking System (HTS). High and serious risks are evaluated for inclusion in the PMA265 risk database and reported on at the Program Risk Assessment Board. The Technical Risk Report generated by the RAM is used during varied reviews to communicate and support formal risk acceptance by program management and user representatives.

PMA265's commitment to safety throughout the acquisition process is achieved by a proactive system safety team comprised of PMA265, Boeing, Northrop Grumman Corporation (NGC), General Electric (GE) Aviation, and the Fleet Support Team. Prompt communication between NAVAIR, PMA265, and the Fleet promotes active management and reduction of risks associated with thousands of safety hazards. The ESOH strategies employed by the GHT, in collaboration with PMA265 IPTs and other organizations, advances PMA265's ability to provide the user mission critical systems with fewer ESOH compliance constraints. A key component of ESOH is "Occupational Health" and fulfilling our responsibility to provide the Fleet with effective and safe systems. Aircraft noise is recognized, based on MIL-STD-882E, as a significant occupational health hazard, and it is also a problem in communities adjacent to naval air stations.

Jet Noise Reduction; A Case Study in ESOH Risk Management

PMA265 was the first U.S. Navy tactical aircraft acquisition program to formally coordinate and document with the user, Commander Naval Air Forces (CNAF), that jet engine noise (Figure 3) poses a serious risk to sailors. PMA265's robust research and development noise reduction efforts are driven by CNAF's acknowledgement of the noise risks and the direction of Program Executive Officer for Tactical Air to PMA265 to assess annually "*…the viability of incorporating proven technologies into the F/A-18E/F and EA-18G*." Case in point is PMA265's and the GHT's research initiatives and engagement with the Office of Naval Research (ONR), U.S. Navy, and DoD committees to demonstrate viable jet noise emission solutions to minimize personnel exposure risks. Recently, in the DoD Fiscal Year (FY) 2018 Appropriations Act, Congress directed the Secretary of the Navy to "*…carry out a jet noise reduction program to study the physics of, and reduce, jet noise produced by high-performance military aircraft*." PMA265's efforts to date and continuing jet noise reduction demonstrations are indicative of the commitment to protecting sailors and addressing the congressional directive in the FY18 appropriations.

Figure 3: Personnel Exposure to Jet Noise

PMA265's jet noise reduction research, development, test, and evaluation have shown that installing uniquely shaped extensions of the jet engine nozzles (Variable Exhaust Nozzle [VEN] Chevrons) provide a potential solution for noise reduction (Figure 4). PMA265, collaborating with ONR and GE Aviation, demonstrated that significant noise reduction without measured loss of thrust can be achievable with VEN Chevrons. The reduction of sound pressure levels by 3 Decibels (dB) A-weighted over much of the frequency range represents a 50 percent reduction in sound pressure levels. Moreover, noise reduction of up to 7 dB is possible in the 3 Kilo Hertz (kHz) to 6 kHz frequency, which is the most likely to cause Noise Induced Hearing Loss (NIHL) (Figure 5). Additional development and testing is required to finalize the VEN Chevron design to achieve the desired noise reduction at all power levels.

Figure 4: Chevrons - The Search for a Solution

HOW DO CHEVRONS WORK?

- Generate vorticity, which mixes the jet plume streams faster to reduce noise
- Lessens peak velocity faster and reduces noise
- Alters shock cell structure to reduce broadband shock noise in the turbulent airflow of the jet plume

This effort is a useful case example of what a proactive, dedicated acquisition program office and their ESOH Team can accomplish, even with the development and delivery of this technology to the Fleet in process. ESOH goals may often take a back seat to higher priority military performance objectives. In this instance, a serious safety and occupational health problem (NIHL) was identified; a commitment was made to investigate solutions; an achievable design that showed promise identified; and resources committed to demonstrate and validate the proposed solution.

"Frequencies identified as most susceptible to hazardous noise exposure are 3000Hz-6000Hz."

–CAPT L Sims, MSC, USN-NMCPHC

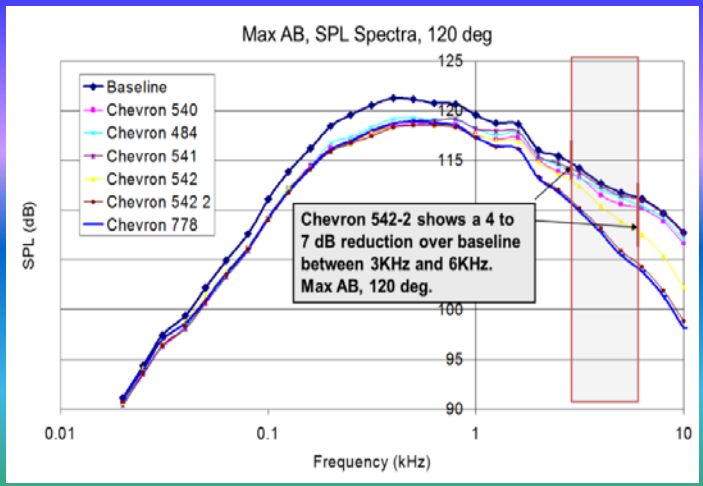

Figure 5: F/A-18 Jet Noise Reduction - Chevron Nozzle Static F404 Engine Test

Note that Congress, in the DoD FY18 Appropriations Act, requires the U.S. Navy to: "*(1) identify material and non-material solutions to reduce jet noise; (2) develop and transition such solutions to the Fleet; (3) communicate relevant discoveries to the civilian aviation community; and (4) support the development of theoretical noise models, computational prediction tools, noise control strategies, diagnostic tools, and enhanced source localization.*" Development of this technology, consonance with congressional direction, required program leadership, dedication by a government/acquisition/industry team, and hard work by SE personnel. The eventual retrofit of the VEN Chevrons into the aircraft would be the first engineering noise reduction design solution integrated into any DoD high-performance tactical aircraft.

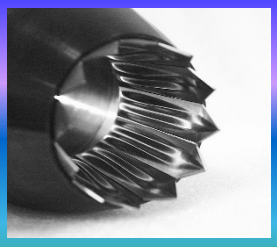

Figure 6: Corrugated VEN Seals

In another collaboration initiative, PMA265 is funding (to date $6.25M) the University of Mississippi National Center for Physical Acoustics (NCPA) to develop another promising noise reduction technology—corrugations on VEN seals (Figure 6). Currently, NCPA is performing Research and Development (R&D) to complete the design and scale model testing of a nozzle system for the F/A-18E/F aircraft with a F414-400 engine that optimizes both performance and noise reduction; this design is a realizable, retrofit noise reduction solution for the engine. The goal is to achieve design optimization and laboratory test of the full-scale nozzle system. The R&D effort will build on a previous PMA265 funded noise reduction effort, which demonstrated promising noise reduction with performance enhancement.

Optimization of chevrons, Contoured Inserts (Figure 7), and hybrid designs for the nozzle seals will be evaluated with the goal of producing a usable design to meet mid-term jet noise reduction goals.

Figure 7: Contoured Inserts

Hazardous Materials Management and Pollution Prevention

PMA265 and the GHT remain committed to Hazardous Materials (HAZMAT) elimination and/or reduction, even with the F/A-18, EA-18G, and their subsystems in the O&S phase. PMA265's customized HAZMAT database in Microsoft Access allows for robust review of HAZMAT data from the Original Equipment Manufacturers (OEMs) and reporting capability based on the process in Figure 8. The Excel spreadsheet used by the OEMs in providing HAZMAT data for an acquisition system streamlines the reporting process.

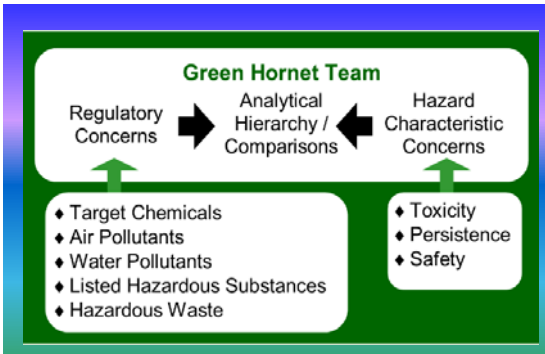

Figure 8: HAZMAT Evaluation Concept

HAZMAT Lists (HMLs) for operation and maintenance of PMA265 systems are coordinated with the NAVAIR Environmental Logistics Lead to validate against those materials approved on the Aviation and Shipboard HMLs. If a material is not on these lists, then either an alternative is identified or PMA265 works with NAVAIR Environmental Logistics and Naval Support to obtain material approval. The following reflect other PMA265's HAZMAT efforts:

- Testing Class N Primer Composite/Aluminum Project on the F/A-18E/F and EA-18G—Four non-chrome primers were tested using chromated primer on metallic part composite panels. Based on NAVAIR Materials' evaluation of test results, MIL-PRF-23377 Type I Class N is approved for use on composite moldline parts (both outside and inside). Using Class N primers would save approximately 12 pounds of hexavalent chromium per aircraft, which amounts to a savings of approximately 144 pounds of hexavalent chromium per year (based on FY 2016 aircraft production). In 2016–2017, Boeing changed the F/A-18 Finish Specification to allow the use of Class N primers on the composite moldline parts. The Finish Specification has been released and Boeing is assessing how to transition the change to all the suppliers. One of the suppliers already expressed interest in converting to the use of this primer.
- Boric Sulfuric Acid Anodize (BSAA)—In September 2015, the Chromium National Emissions Standards for Hazardous Air Pollutants eliminated the use of Perfluorooctane Sulfonic Acid (PFOS)-based fume suppressants used in the Chromic Acid Anodize (CAA) process. Boeing investigated other methods to reduce hexavalent chrome fumes during the anodize process. Boeing Commercial has been using a BSAA process for many years (which meets MIL-A-8625 Type IC). In review of the few drawings that call out CAA for use on the F/A-18 (Note: Most anodize on the aircraft is sulfuric acid anodize), a determination was made that the small subset of parts can use BSAA. A revision to the Boeing Finish Specification is currently awaiting NAVAIR approval. Once approved, Boeing will release the specifications, drawing changes will be made, and notification of the change will be sent to suppliers.

HAZMAT Efforts for Active Electronically Scanned Array

- Beryllium Oxide eliminated in Transmit/Receive Module, Array Drive Module
- Aluminum heat sink used in processor cards instead of Aluminum-Beryllium metal
- Beryllium Copper spring replaced with steel spring
- Toluene Diisocyanate-containing urethane adhesives replaced with Polysulfide adhesives
- Volatile Organic Compound reduction:
  - Parylene Conformal Coating
  - Acetone for solvent cleaning operations instead of isopropyl alcohol and methyl ethyl ketone
  - Paint/primer/chemical film removed from bus bars and lower rack shelf (also hexavalent chromium reduction)

- Paint Stripping Alternatives—Chemical-based paint strippers, such as Methylene Chloride (MeCl), pose health and environmental hazards and hazardous waste disposal issues. PMA265's system contractors have been exploring over the last couple of years viable alternatives to depainting methods. The challenges in finding viable alternatives, besides cost constraints, are the thin aluminum, composites and other nonmetallic surfaces on the F/A-18E/F and EA-18G. Research to date has identified potentially viable alternatives that the GHT will continue to explore—Plastic Media Blasting (PMB), Laser Ablation (Figure 9), and EFS2500. PMB is a mature, well understood technology. Bell Boeing Philadelphia and U.S. Air Force (USAF) are using PMB in depainting processes, and NAVAIR North Island Fleet Readiness Center Southwest is using PMB successfully on the legacy Hornets. Because the aircraft must be masked extensively to keep the media out of the inside areas of the aircraft, the PMB depainting process is labor intensive (up to seven days). Facility requirements to capture the PMB is also extensive; and, if any chromated paint chips end up in the media, it must be disposed of as hazardous waste (e.g., USAF Hill Air Force Base [AFB] estimates 2,000 pounds of hazardous waste per F-16 using PMB). Laser Ablation is in use by some of our suppliers (Cobham/Meggett), at USAF Hill AFB, and U.S. Marine Corps Air Station Cherry Point. The compelling advantages of this technology is waste reduction and labor savings. Laser Ablation produces no more hazardous waste than the paint removed and is much less labor intensive since pre-masking of the aircraft is not needed. Hill AFB estimates the cycle time for this system is 60–70 hours per F-16 aircraft (vice seven days for PMB) and labor savings of 200–300 man-hours per aircraft. Initial installation costs, though, are high for this technology. Cobham/Meggitt and NGC have identified an alternative stripper for MeCl - EFS2500. Studies demonstrated the material to be extremely effective and the base substrate material proved to tolerate long-term exposure to EFS2500.

Figure 9. Laser Depainting

As the Infrared Search and Track (IRST) Program proceeds towards a full-rate production decision, the Logistics Team and GHT review technical publications to assure inclusion of ESOH procedures and protective measures. The Logistic Support Analysis Record, *Task Analysis Summary for current O-level maintenance (LSA-019*), addresses HAZMAT usage and other ESOH-related precautions. Initial HAZMAT considerations for demilitarization/disposal planning are addressed in the *IRST System AN/ASG-34 (v)1, ACAT II, LCSP Supporting MS C and the P&D Phase*. The initial demilitarization/disposal evaluation identifies the primary HAZMAT used in each of the IRST system components and HAZMAT/ hazardous waste disposal considerations (Figure 10).

COMPONENT	MATERIALS	DEMIL/DISPOSAL	HAZARD DATA	EXPLOSIVE DATA	SPECIAL FEATURES
Processor Chassis Assembly	Aluminum, beryllium chassis, and nickel plated connectors, plus Filter Assembly	Destroy by melting, cutting, tearing, crushing, and/or breaking	Solder, Nickel Plated Connectors and Chromate Nickel Chromate	None	None
Roll Gimbal Assembly	Aluminum chassis and nickel plated	Remove and/or demilitarize by melting,	Beryllium, Solder, Nickel	None	None

Material	Handling	Considerations	Disposal
Helium	Use a pressure reducing regulator to prevent a sudden release	Oxygen deficient atmosphere can result from release in a confined space	Vent outdoors
Be and Be Alloys (e.g., Be Cu, Be-Aluminum)	Remove from assemblies in a manner minimizing any surface damage and without any type of	Any sort of machining or disturbance of oxide powders will release inhalable Be particles	Double bag material and return to manufacturer

Figure 10: Example of ESOH-Related Data for Demilitarization/Disposal Planning for IRST HAZMAT

Internal Execution and Documentation

Communicating acquisition ESOH requirements and responsibilities to leadership and key personnel is a fundamental role of the GHT. ESOH requirements and integration practices are included as part of PMA265's new hire orientation briefing. Additionally, when another Program Office's system is slated for integration onto the F/A-18 and EA-18G, the GHT works with staff in that Program Office to assure cohesive integration of ESOH requirements and risk management in system design, engineering, test, and logistics.

As part of the ESOH risk assessment process (Figure 2), GHT functions include:

- Addressing ESOH requirements in varied acquisition documents.
- Monitoring and assessing impacts of regulatory and policy changes. Naval Facilities Engineering and Expeditionary Warfare Center's Weekly Federal Regulatory Summary is one tool the GHT uses to monitor ESOH regulatory actions.
- Maintaining the NEPA/EO 12114 Compliance Schedules using NAVAIR's PESHE DAT, even though most of PMA265's acquisition system programs are in the O&S phase. The focus is on assuring NEPA/EO 12114 is addressed for PMA265 specific Follow-on Test and Evaluation (FOT&E) of the aircraft and subsystems, and overall Fleet NEPA/EO 12114 efforts.
- Including prohibited/restricted HAZMAT, based on NAVAIR's Chemicals of Concern List (CoCL) and National Aerospace Standard 411-1, which are imposed in performance specifications and contractual requirements for OEMs, system integrators, and subsystem contractors (program examples are the 480-gallon external fuel tank, Lot 40 production contract, Distributed Target Processor - Networked, CFT)
- Assessing potential concerns, constraints, or risks in the areas of ESOH Compliance, NEPA/EO 12114, Safety and Occupational Health, and HAZMAT Management/Pollution Prevention (Figure 11)
- Tracking hazards and risks using the NAVAIR PESHE DAT RAM, OEM/system contractor-Government system safety HTS, and Excel-based HTS.
- Supporting post production and demilitarization/disposal planning by identifying ESOH requirements and costs.

REPRESENTATIVE REGULATORY/POLICY/NEPA-EO 12114 ASSESSMENT REVIEWS CONDUCTED BY GHT IN 2015–2017

- Offshore Oil-Gas Designations Impacts
- Addendum to F/A-18 & EA-18G Follow-On Test and Evaluation at Naval Air Station Oceana
- F/A-18C/D Joint Air to Surface Standoff Missile Flight Loads, December 2015
- MK 62/63 Captive Carriage and Separation F/A-18E/F, December 2015
- System Configuration Test, March 2016
- F/A-18E/F Flying Qualification and Flight Certification Evaluation, March 2016
- Flight Control Computer Operational Flight Program, March 2016
- F/A-18E/F Captive Carriage & Weapons Separation of ACM-84D, April 2016
- OBOGS Monitoring in F/A-18 & EA-18G, December 2015 and September 2017

Technical Risk	Risk Level	Target Risk Level
Personnel Exposure to HAZMAT	Medium	Medium
Degraded Lightning Protection	Medium	Medium
Beryllium Usage	Medium	Medium
Cadmium Usage	Medium	Medium
Hexavalent Chromium Usage	Medium	Medium
Thorium Fluoride Usage	Medium	Medium

Mitigation Actions

#	Event	Description	Scheduled Date	Actual Date
1	Lightning Strike Test	A lightning strike test of the IRST FTA is planned for late 2014. The test will be conducted at Boeing Seattle. This test is designed to assess the top safety concern of degraded ability to provide lightning protection.	Late 2014	

Figure 11: Example of ESOH-Related Risks for IRST

The GHT works closely within the Program Office and with NAVAIR Sustainability Office (SO) in the review of test plan summaries (i.e., ~15) to ensure that proposed activities can be achieved in an environmentally compliant manner and with NEPA/EO 12114 coverage. For those tests involving the release of weapons, the GHT works with the NAVAIR SO and VX-23 Strike Squadron to generate a Protective Measures Assessment Protocol Report, which defines the mitigation/precaution measures required for the proposed test to protect marine species. The PMA265 Program Manager approved the Environmental Planning Document reflecting the applicability of a U.S. Navy Categorical Exclusion for planned F/A-18 and EA-18G FOT&E activities from FY 2014–2018. Furthermore, PMA265 is one of the NAVAIR Program Offices participating in the U.S. Navy's environmental planning for military

training, testing, and scientific research activities at sea; this overarching program ensures that all training and testing complies with major Federal laws, especially NEPA/EO 12114. This U.S. Navy-wide effort provides NEPA/EO 12114 compliance and coverage for PMA265 testing requirements over the Atlantic, Gulf of Mexico, Southern California (SOCAL), and Hawaii. PMA265 submitted projected future testing requirements (2019–2023) off the east and west coasts, which will be addressed in the next Atlantic Fleet Training and Testing Environmental Impact Statement (EIS) and Hawaii-SOCAL Training and Testing EIS documents.

External Coordination of ESOH Risks Management

Collaboration with NAVAIR 4.4 and 4.3, PMA265 system contractors, ONR, NCPA, and other organizations furthers technology and material alternative opportunities for the F/A-18 and 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.

Other high-performance military aircraft programs are experiencing the same issues with the risk of personnel jet noise exposure as the F/A-18E/F & EA-18G. To disseminate lessons learned, PMA265 worked with Chief of Naval Operations to produce a cover story in the U.S. Navy's "Currents" magazine (Figure 12). The article, *F/A-18 Program Explores the Use of Exhaust Nozzle Chevrons to Reduce Engine Noise—Innovation Demonstrates Proactive Acquisition Program Management by Fighter Jet Team*, presents a primer of how an acquisition office identifies risk, obtains concurrence by higher authority, and the customer's acceptance of risk. The article also describes a robust R&D program to mitigate jet noise risk.

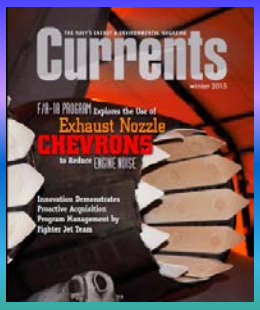

Figure 12: *Currents* Winter 2015 Issue

The GHT Lead and members interact with other organizations and communities, as follows, to share ESOH related information, discuss solutions, and influence/maintain situational awareness of policy:

- DoD Acquisition ESOH IPT
- ONR Joint Noise Reduction Science &Technology Panel
- NAVAIR Sustainability Office
- NAVAIR Environmental Logistics
- NAVAIR Fuels Branch
- NAVAIR Environmental and Energy Programs Department

Summary of Accomplishments

PMA265's multidisciplinary GHT exemplifies commitment in assisting with the delivery of systems that meet user needs while executing a sound, integrated ESOH program throughout DoD acquisition phases. The GHT's superior ESOH execution and risk management is reflected in an aircraft with sustained Class A mishap-free operations, and the first U.S. Navy jet fighter aircraft designated to demonstrate the feasibility of noise reduction technologies without degradation of jet performance. ESOH performance sustained during the reporting period include:

- Collaboration with the scientific research community (both defense and academia) in seeking transferable solutions for DoD-wide common ESOH risks, such as hexavalent chromium and aircraft noise
- Continued commitment to proving that VEN Chevrons jet noise reduction technology—is an engineering solution to NIHL experienced by flight deck personnel
- Continued allocation of funds and aircraft assets for other science and technology solutions to HAZMAT and energy efficiency (e.g., alternative material demonstrations/tests)
- Implementation of alternative materials to hexavalent chromium products (i.e., MIL-PRF-23377 Type I Class N and tri-chrome conversion coatings)

The GHT's mission for achieving integrated ESOH readiness of PMA265 systems is to reduce or eliminate ESOH risks and constraints in systems delivered to the Fleet.