FY 2013 Chief of Naval Operations Environmental Awards Program
Environmental Excellence in Weapon System Acquisition - Large Program

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

PROGRAM DESCRIPTION

The F/A-18E/F is a twin engine, mid-wing, multi-mission tactical aircraft currently in sustainment at Naval Air Station (NAS) Lemoore, California and NAS Oceana, Virginia. The F/A-18E/F Super Hornet (Figure 1) has been the United States (U.S.) Navy aircraft platform of choice for various energy and environmental initiatives. The EA-18G retains many of the F/A-18F capabilities combined with Airborne Electronic Attack systems (e.g., tactical receivers and jamming pods). The EA-18G (Figure 2) is in operation at NAS Whidbey Island, Washington. Follow-on Test and Evaluation (FOT&E) at several U.S. Navy facilities/ ranges continues on both platforms and their associated subsystems to enhance mission capabilities.

Figure 1: President Obama and the Green Hornet

Figure 2: EA-18G Landing at Whidbey Island

The Green Hornet Team (GHT) manages the environment, safety, and occupational health (ESOH) program for the F/A-18E/F "Super Hornet" (and earlier variants) and the EA-18G "Growler," as well as their associated subsystems for Program Manager Air (PMA)265 within the Naval Air Systems Command (NAVAIR). The GHT's mission is to ensure environmental excellence in systems acquisition by incorporating ESOH compliance during the design and systems engineering (SE) process. This enables PMA265 to deliver systems meeting fleet operational needs with reduced ESOH constraints.

The GHT's proactive ESOH integration strategy, as follows, accounts for the consistently high level of compliance and achievements:

- Validating ESOH criteria into performance specifications, contractual documents, and Systems Engineering Plans (SEPs)
- Identifying ESOH hazards/risks/issues to include mitigation measures
- Planning and executing ESOH analyses throughout the system's life-cycle, ESOH risk management, and National Environmental Policy Act (NEPA)/ Executive Order (EO) 12114 Compliance Schedule requirements

ESOH requirements cross over into multiple PMA265 functional/integrated product teams. The GHT directly engages with team representatives to plan and execute cost-effective ESOH efforts.

The GHT Lead actively participates with PMA265 product managers in weekly/ monthly meetings to report on the status of ESOH efforts, risks, and constraints with respect to cost, schedule, and performance. The GHT Lead and members interact with other organizations and communities to share ESOH related information, identify solutions, and influence policy.

GHT INTERACTION WITH OTHERS

- North Atlantic Treaty Organization Science & Technology Organization, Task Group-198 Noise Reduction Technologies
- Defense Safety Oversight Council High Noise Source Reduction Initiative
- Department of Navy Hazardous Noise Exposure Mitigation Working Group
- Office of Naval Research
- NAVAIR 1.6 Environment and Energy Programs Department
- NAVAIR 6.7.1.4 Environmental Logistics
- NAVAIR 5.2.2.F Range Sustainability Office
- NAVAIR Fuels Branch

Close coordination with the NAVAIR 1.6 and 5.2.2.F assures that FOT&E of the F/A-18E/F and EA-18G is conducted in an environmentally compliant manner to include NEPA/EO 12114 requirements. PMA265 was the first tactical aircraft acquisition

program within the U.S. Navy, if not Department of Defense (DoD), to formally coordinate and document with the user, Commander Naval Air Forces (CNAF), that jet engine noise poses a serious risk to sailors. This acknowledgement remains the driver of PMA265's noise reduction efforts during the past two years. The GHT's engagement with Office of Naval Research (ONR), U.S. Navy, DoD, and North Atlantic Treaty Organization (NATO) committees and research initiatives supports PMA265's efforts to find and demonstrate viable solutions to jet noise [i.e., Variable Exhaust Nozzle (VEN) Chevrons].

Incorporating Risk Management into the Acquisition Process

Even though the F/A-18E/F and EA-18G, as well as many of their core subsystems, are in the operation and sustainment phase, the GHT continues to address ESOH risk management. Proactive ESOH management practices ensure regulatory directives are addressed for the life-cycle of the systems. Contractual requirements imposed on the Original Equipment Manufacturers (OEMs), system integrators, and subsystem contractors incorporate ESOH requisites, including prohibited/restricted hazardous materials (HAZMAT) based on NAVAIR's Chemical of Concern (CoCL) List. ESOH requirements are also included in varied acquisition documents [i.e., SEP and Life-Cycle Sustainment Plan (LCSP)].

The strength of PMA265's commitment to the "Safety" aspect of ESOH integration into all aspects of the acquisition process is further evident this year during the 35th anniversary of the Hornet program. The legacy F/A-18A-D flew 110,514 flight hours in fiscal year (FY) 2013 without a Class A mishap. It takes an aircraft with safety designed into it and superb risk management to be able to accomplish this feat of Class A mishap-free operations over an entire fiscal year. It is unprecedented for a TACAIR platform to achieve its safest year ever in its 4th decade of service. This is only the second time that any TACAIR, carrier-based aircraft program has accomplished this feat while flying over 100,000 flight hours; the Super Hornet accomplished this in FY 2007 (107,128 flight hours). Such accomplishments are achieved only by:

- Daily application of sound operational risk management principles
- Free flow of safety information between NAVAIR, Hornet Commands, Wing Safety Officers, Navy Safety Center, and Fleet Support Teams (FSTs)—North Island and Jacksonville
- Early identification of hazards and planned mitigations in infancy stages rather than after a mishap is realized
- Accurate and up-to-date Naval Air Training and Operating Procedures Standardization

The core system safety team of PMA265, Boeing, Northrop Grumman Corporation (NGC), General Electric (GE) Aviation, the FST, and others have implemented risk mitigation actions for thousands of safety hazards with prompt, ongoing communication to NAVAIR and user leadership.

Initiatives in energy-efficiency and alternative fuels continued to be promoted by the GHT, PMA265, and NAVAIR 4.4 Fuels Branch. Their alternative aviation fuel qualifications in FY 2013 resulted in issuance of the revised JP-5 fuel specification to use 50/50 blends of either Fisher Tropsch or Hydroprocessed Ester and Fatty Acid alternative processes. The next focus is lab and hardware testing of the alcohol-to-jet process. Another effort is PMA265's ongoing partnership with National Aeronautics and Space Administration (NASA) Dryden Flight Research Center on a real-time Trim-Optimizing Flight Control application to enhance optimized performance with reduced fuel consumption. This system was able to

Infrared Search and Track Program ESOH Requirements for Deployment

- Low Rate Initial Production
  - Execute ESOH program to include updated hazard analyses and regulatory compliance assessments
  - Eliminate/minimize use of materials on CoCL; Update HAZMAT List
  - Update demilitarization (demil)/disposal ESOH considerations
  - Continue ESOH risk identification/ tracking
- LCSP/ Logistics Management Information
  - No significant/serious hazard and impacts
  - ESOH handling and disposal considerations for HAZMAT identified
  - Demil codes assigned
  - Warning/caution notes for Organizational-Level maintenance and demil tasks based on HAZMAT usage (e.g., Corrosion Resistant Alodine Touch-Up, Aviation Turbine Fuel, Loctite Sealing Compound)

optimize the aircraft's trim configuration across a variety of flight conditions. F/A-18A fuel consumption was reduced by up to 2.9 percent without negatively impacting transient performance based on six test flights from September 2012 to January 2013.

Potential Results of Application

3 percent fuel burn reduction for the F/A-18E/F and EA-18G = Fuel savings of approximately 6 million gallons per year

ESOH Risk Management

PMA265's risk assessment process (See Figure 3) is based on the combined methodology and risk definitions of NAVAIR Instruction 5090.21B and MIL-STD-882E. The GHT's charter is to minimize potential ESOH impacts/ risks throughout a system's life-cycle. Management of hazards and the plan of action and milestones for mitigation actions are conducted via the Risk Assessment Module (RAM) of NAVAIR's Programmatic ESOH Evaluation (PESHE) Document Authoring Tool and the F/A-18 and EA-18G system safety hazard tracking system. These tools support proactive ESOH risk mitigation to alleviate issues before a PMA265 system transitions to the fleet. This management ultimately helps to alleviate ESOH regulatory burdens and reduces system total ownership costs. High and serious risks are elevated for inclusion in the PMA265 risk database and reported on at program risk assessment boards. The Technical Risk Report generated by RAM is used during varied reviews to communicate and support formal risk acceptance by program management and user representatives.

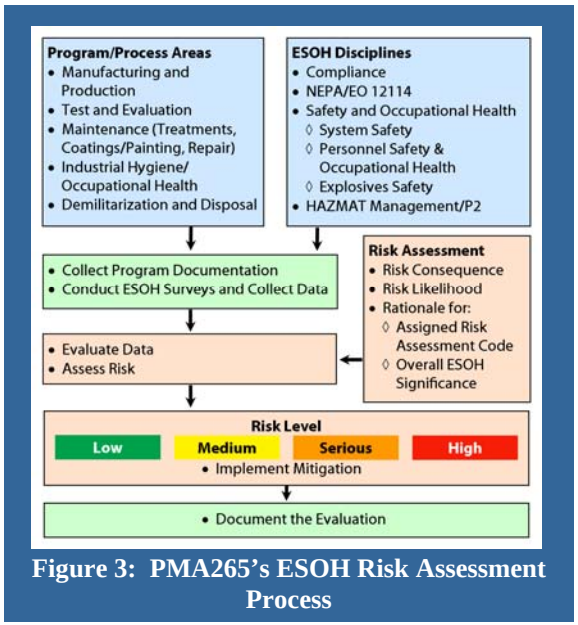

Figure 3: PMA265's ESOH Risk Assessment Process

PMA265 and the GHT actively pursue engineering design and process change initiatives during sustainment to mitigate system-related ESOH risks. Foremost are those initiatives that PMA265 and CNAF committed to in pursuit of viable solutions to reduce flight line/deck jet noise. PMA265's progressive efforts, in partnership with ONR and GE Aviation, continued on the robust Rapid Technology Transfer project—Chevrons on the VEN. Tests over the last two years confirm that integration of VEN Chevrons (depicted in Figure 4) onto the F414/ F404 engine can reduce noise. Accelerated service mission endurance testing was completed in November 2012. The first ground-based test with a full-scale, installed engine was conducted in December 2012, leveraging the new American National Standards Institute S12.75-2012 Jet Noise Measurements Standard to assess near-field noise levels (personnel exposure to noise). Tests demonstrated upwards of a 3-decibel (dB) reduction over much of the frequency range [including 3 to 6 kilohertz, identified as the range most likely to cause Noise Induced Hearing Loss (NIHL)] can be achieved with VEN Chevrons. Results also show that this chevron configuration does not impact thrust through maximum afterburner engine settings, a critical criteria for fleet acceptance to ultimately allow integration of this noise reduction technology solution into the F/A-18E/F inventory. Planning continues for the next ground-based and in-flight noise measurement test events in FY 2014 of an F/A-18E with and without chevrons. Over the last two years, PMA265 invested $5.6 million and an additional $1.4 million is required to complete this project. The eventual retrofit of the VEN Chevrons into the aircraft will be the first engineering design solution integrated into any DoD high-performance tactical aircraft.

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

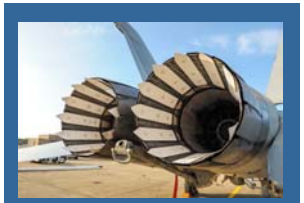

Figure 4: VEN Chevrons Installed on Engine

PMA265 continues to fund basic engine nozzle research at the University of Mississippi National Center for Physical Acoustics (NCPA) to develop another promising technology to address jet engine noise: corrugations on VEN seals (see Figure 5). Objectives for this project are both a minimum of 2.5 dB reduction in peak noise (with a goal of 3 dB) and no measurable negative impact on thrust. Aero-Shapes for testing were generated with the operating parameters and conditions of the nozzle at all operating conditions for a flight (cruise, afterburner, military power settings), calculated for a Conic Nozzle and a Method of Characteristics Nozzle. Model-scale thrust and acoustic preliminary testing shows that is possible to create corrugated shapes to reduce noise. Integration with the GE Chevron design is another goal of this research (Figure 6). Test results in 2013 of a combined chevron/lobe seal were promising with fabrication of an optimized model and additional tests proceeding forward.

Figure 5: Style C^{m} Corrugation Seal (Scale Model)

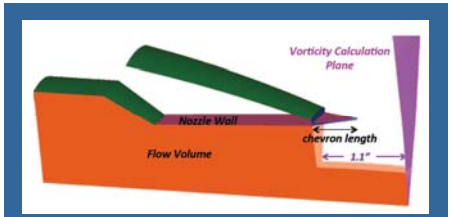

Figure 6: Illustration of the Chevron Extension to the Faceted Nozzle

The Navy Small Business Innovative Research Phase II study—Flight Profile Optimizer Enhancements: Aircraft Engine Emissions and Fuel Consumption Models (proposed and managed by PMA265's GHT Lead over the last 2 years) concluded in September 2013. This software model is an effective near-term, low-cost solution for finding ways to alleviate noise impacts around military airfields by analyzing aircraft operational flight profiles and trajectories. Phase II enhanced the Flight Profile Optimizer through integration of other environmental factors (noise metrics/ measures including speech interference, fuel flow and air emissions for military aircraft/engines in service, and aircraft engine emissions and fuel consumption models for flight operations) within the context of aircraft operational requirements (e.g., flight routes, fuel consumption, time in flight, etc.). The model incorporates approximately 56 aircraft/engine combinations. Optimization of flight profiles can now be performed based on any combination of weightings for noise, fuel burn, and air emissions. The upgraded Flight Profile Optimizer was used successfully in environmental studies for NAS Oceana and NAS Patuxent River.

Flight Profile Optimizer Modeling Approach

- Nominal flight profile of a single aircraft initiated
- Parameters defining the track and/or vertical profile varied to produce multiple profiles for the aircraft
- Defined constraints applied to each generated profile
- Environmental impacts determined through analysis of profiles; computations of noise, air emissions, and fuel consumption for each flight profile
- Resulting profiles and environmental parameters rank ordered based on defined cost function

Another design effort is the use of nanotechnology to address the safety hazard of F/A-18E/F and EA-18G aircrew experiencing hypoxia-like symptoms at less than 10,000 feet. Design improvements to the On-Board Oxygen Operating System are in process to close out this hazard.

Hazardous Materials Management and Pollution Prevention

PMA265 and the GHT remain committed to HAZMAT elimination and/or reduction, readily providing assets in support of research and development initiatives even with the F/A-18 and EA-18G in the operation and sustainment phases of the DoD acquisition process. Twelve F/A-18A-D aircraft were selected in 2012–2013 by PMA265, CNAF, and Fleet Readiness Center South West (FRCSW) F/A-18 Production, in conjunction with Materials Engineering North Island, to serve as the platform for the field evaluation of the U.S. Navy's Environmental Sustainability Development to Integration Project #458: Advanced Non-Chromate Primers & Coatings. The following mature primers are being used:

- Deft 02-GN-084 (MIL-PRF-23377N, Type I)
- Hentzen 17176KEP/16709CEH (MIL-PRF-23377N, Type II)

Aircraft will carrier deploy soon after repainting at FRCSW North Island or FRC South East (FRCSE) Jacksonville (Figure 7). The F/A-18s will be carrier deployed at least two

Figure 7: F/A-18 Being Painted for the Advanced Non-Chromate Primers & Coatings Project

times during the project. The first F/A-18 was painted in October 2013 with Deft 02-GN -084 (direct to metal) at FRCSE Jacksonville. The final primer will be Hentzen 17176KEP. Another F/A-18 is scheduled to receive the non-chromate primer stack-up at FRCSE Jacksonville in the latter part of 2013. FRCSW North Island will paint their first aircraft in the spring of 2014. The objective is to qualify and implement this alternative material to offset the use of chromated-based corrosion preventative materials, including hexavalent chromium. Corrosion maintenance, prevention, and repair costs are estimated at $3 billion per year, including an estimated disposal of 2.3 million pounds of waste related to aircraft coating systems.

Another effort is the Class N Primer Composite/Aluminum Project on the F/A-18E/F and EA-18G. The test plan was finalized in 2013 for the following materials:

- Hentzen 16708TEP Primer (MIL-PRF-23377 Ty I, Class N)
- Deft 02GN084 (MIL-PRF-23377 Type I Class N)
- Deft 44GN098 (MIL-PRF-85285 Type I Class N)
- PPG CA7233 Primer (Control – Water-Borne Epoxy)

With NGC's assistance, composite substrates were acquired from their scrap production materials resulting in a $50 thousand material cost savings for this project. Use of paints and primers already available on site resulted in an additional $5 thousand in cost savings. Specimens were assembled to closely represent the F/A-18 structure including the use of F/A-18 unique coatings (e.g., conductive sealant). Test specimens entered the salt fog chamber in April 2013 in accordance with American Society for Testing and Materials B117 and G85.A4. The specimens were removed in September 2013 and are under evaluation by NAVAIR Materials Engineering.

PMA265 also recently endorsed the Future Naval Capability (FNC) Enabling Capability Candidate – Advanced Top Coating Materials (ATM or "Top Coat") for FY 2016. The fleet has identified significant impacts when applying restorative coatings of current isocyanate-based paints (MIL-PRF-85285 Type IV) aboard ship, resulting in poor paint performance, and HAZMAT storage and personnel exposure restrictions impacting the ability to fully maintain the aircraft for fighter groups. This FNC will develop and prototype useful non-isocyanate resin chemistries for aviation topcoats and a compatible primer.

While improving maintainability, the most significant improvement will be safe ship application and reduced personnel exposure risks to sailors and marines.

Target Capability for FNC Advanced Top Coat Material

- Low volatile organic compound content
- Lower flammability
- High flexibility with equivalent or superior ultra-violet/weathering
- Cleanability
- Solvent and erosion resistance

Internal Execution and Documentation

An institutionalized practice within PMA265 is to include ESOH as part of new hire orientation briefing. The GHT Lead educates new Program Office employees on ESOH policy/drivers and requirements. Specific F/A-18 ESOH examples are included to provide practical realism for those persons in position to influence ESOH considerations for PMA265 acquisition systems. This orientation also introduces the requirements for a PESHE and NEPA/EO 12114 Compliance Schedule.

While the F/A-18 and EA-18G are in the operation and sustainment phases where a formal NEPA/EO 12114 Compliance Schedule is not required, there are still other subsystem programs [i.e., Infrared Search and Track (IRST) Program] where the GHT continues to ensure ongoing ESOH integration with SE and logistics. The Program effectively uses the NAVAIR

PESHE DAT to maintain a current NEPA/EO 12114 Compliance Schedule, and to identify and manage top-level ESOH risks including mitigation measures (Figure 8).

In 2012, PMA265 enhanced their HAZMAT management database, transitioning it from a Microsoft Excel format to Microsoft Access. This new customized database allows for robust review of HAZMAT data by the OEMs and reporting capability based on PMA265's evaluation process (Figure 9). The Excel spreadsheet used by the OEMs to provide HAZMAT data for an acquisition system was simplified, thereby streamlining PMA265's HAZMAT management reporting process. A primary application of the database is to prioritize HAZMAT related hazards of greatest concern for management using metrics and a complex equation of Boolean values for each individual HAZMAT category (such as a carcinogen). Each individual category provides a relative score, which serves as the base score for any chemical of that category. Scores across all entities can be combined into an overall weighted average score based on the score metric weighting scheme. Once HAZMAT use is identified and prioritized, the GHT works together to further assess usage of the material and any related ESOH concerns/risks.

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 8: Overall Technical ESOH Risk Assessment Example for the IRST Program

HAZMAT Inventory Database Elements

Key Entities	*HAZMAT Data Views*
✈ Systems	✈ Chemicals
✈ Materials	✈ Materials
✈ Material Categories	✈ Systems
✈ Chemicals	✈ Year
✈ HAZMAT Categories	✈ Import Data
	✈ Report Data

HAZMAT Lists (HMLs) for acquisition systems are coordinated with the NAVAIR Environmental Logistics Lead to determine whether there are any issues from an operation and maintenance standpoint. The identified HAZMAT are validated 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 to have that material approved for use.

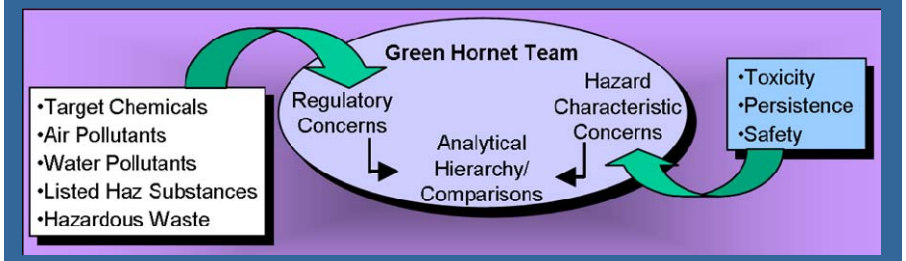

Figure 9: HAZMAT Evaluation Concept

External Coordination of ESOH Risks Management

PMA265 and the GHT maintain situational awareness of ESOH policy and issues through several avenues:

- ✈ Participation in U.S. Navy and DoD organizations (e.g., Joint Noise Reduction Science &Technology Panel Meeting, Defense Safety Oversight Council High Noise Source Reduction Initiative, and Department of Navy Hazardous Noise Exposure Mitigation Working Group), which promote the exchange of information/data in the common goal of minimizing the impacts to personnel who work around jet aircraft.
- ✈ Application of PMA265's sponsored and endorsed noise reduction technologies to other programs; both the Trim-Optimizing Flight Control and Flight Profile Optimizer projects are viable candidates for use by other organizations. For example, PMA265 and NASA believe the algorithm of the Trim-Optimizing Flight Control application has good performance and would perform similarly for different aircraft configurations and flight conditions. It was tested with the F-35B/C in June 2013 demonstrating up to a 1.7 percent efficiency improvement.

- Assistance to FRCSE Jacksonville with ongoing decontamination efforts for the F414 engines and modules exposed to nuclear radiation during the Japan earthquake; the GE Aviation GHT member visited FRCSE Jacksonville in August 2013 to identify potential near- and long-term process improvements for the radiation decontamination efforts. These changes will significantly reduce decontamination/inspection cycle times resulting in an indirect benefit of reducing potential personnel exposure to ESOH hazards.
- Assistance with ESOH-related matters associated with Foreign Military Sales of PMA265 systems; their Royal Australian Air Force (RAAF) customer is highly interested in the results of the non-chrome alternative material initiatives described earlier. If results are successful, the RAAF will be able to leverage these materials into their maintenance efforts, resulting in savings from less regulatory burdens for compliance and personnel protection.
- Engagement in U.S. and international scientific/engineering symposiums. PMA265's GHT Lead, Mike Rudy (Figure 10), who serves as Co-Chair of the NATO Science and Technology Organization (STO) Noise Reduction Technologies Military Vehicles & Platforms (Task Group 198), is uniquely positioned to collaborate with other nations' scientific/technical leaders in promising noise reduction technologies—for the aircraft and personnel protection.

Mr. Rudy is also a leader of environmental stewardship in his PMA265 role as the GHT Lead. He serves as the President of the Board of Trustees for Cove Point Natural Heritage Trust, Inc., which promotes preservation of the Chesapeake Bay through education and environmental initiatives. He sponsored an Eagle Scout project for building a wheelchair accessible duck blind, allowing disabled wounded warrior waterfowl photographers and hunters access to wildlife areas at NAS Patuxent River, Maryland.

Figure 10: GHT Lead, Mike Rudy

Summary of Accomplishments

An Acquisition Program Office must ensure integration of ESOH requirements into the phases of design, engineering, and system sustainment phases. PMA265 established the GHT many years ago, comprised of government and industry leaders in their field of expertise. This multidisciplinary team continues to demonstrate proactive ESOH compliance while fulfilling mission requirements. NEPA/EO 12114 planning/ execution, active technology and HAZMAT initiatives, and ESOH risk management are integral in their efforts. Examples of sustained ESOH performance during the reporting period include:

- Ongoing commitment to scientific research and development in the design, engineering, and logistic integration of jet noise reduction technology—both for flight deck personnel (NIHL) and community noise exposure
- Allocation of funding and assets to HAZMAT/P2 research and development efforts for alternative non-chromate products and other material solutions
- Achievement of 110,514 Class A mishap-free flight hours by the F/A-18A-D, a major achievement in system safety and by working closely with fleet and squadron safety communities
- Collaboration with the scientific research community (both defense and academia) including NATO STO, ONR, Air Force Research Laboratory, and the NCPA in solving DoD-wide common ESOH risks, such as hexavalent chromium and aircraft noise
- Continued validation and integration of biofuels as part of aircraft usage qualification. The F/A-18F "Green Hornet" was the first U.S. military aircraft to fly supersonic using biofuel.

The GHT provides sustained ESOH risk management to acquisition managers and users of their systems. Execution of systems acquisition without ESOH problems is the GHT's goal and mission for achieving ESOH readiness of PMA265 systems.