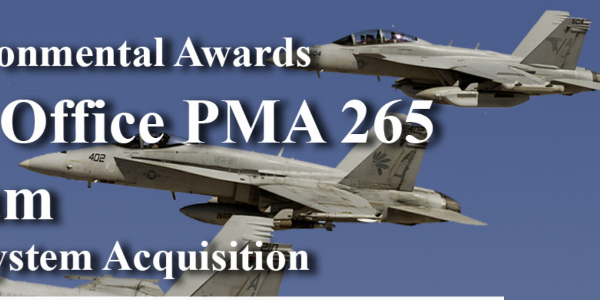

FY2011 Chief of Naval Operations Environmental Awards

F/A-18E/F & EA-18G Program Office PMA 265 Green Hornet Team

Environmental Excellence in Weapons System Acquisition

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 "Growler." 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 and NAS Oceana, Virginia.

Figure 1: Supersonic Flight Test of the F/A-18 Super Hornet Strike Fighter Jet powered by a 50/50 biofuel blend.

The EA-18G (Figure 2) achieved initial operational capability in Fiscal Year (FY) 2010. Currently, EA-18Gs are deployed at NAS Whidbey Island, Washington. The first Growler operational deployment was announced on 17 February 2011. 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) continues for both the F/A-18 and EA-18G at several United States (U.S.) Navy facilities and ranges, as PMA265 continues to upgrade the capability of these aircraft platforms.

Figure 2: EA-18G Growler

The multi-disciplined Green Hornet Team (GHT) manages and monitors all environment, safety, and occupational health (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 and 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 GHT Lead communicates directly with PMA265 specific platform acquisition managers (PMs) and is a key member of PM weekly meetings with senior leadership. These meetings include reports on key efforts, schedules, budgets, top degraders, and risks. The PMA265 GHT Lead maintains close working relationships with Naval Air Systems Command (NAVAIR), Chief of Naval Operations (CNO), Office of Naval Research (ONR), and Fleet/user communities. PMA265 coordinates regularly with the NAVAIR Sustainability Office to address environmental planning and National Environmental Policy Act (NEPA)/Executive Order (EO) 12114 requirements associated with T&E at NAVAIR ranges.

PMA265 ESOH MANAGEMENT STRATEGY

- Develop and validate ESOH requirements and criteria
- Identify ESOH hazards/issues, assign risk levels (probability and severity), and develop mitigations to include plan of action and milestones for resolution of the hazard
- Prioritize ESOH initiatives and integrate with systems engineering
- Monitor ESOH initiatives
- Track identified hazards and formal management acceptance of the ESOH risks

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 and Secretary of Navy (SECNAV) Instruction 5000.2E, PMA265 continues ESOH initiatives and risks management even though the F/A-18E/F and EA-18G are in operation and sustainment. The GHT seeks to apply these efforts to production, T&E, operation, maintenance, and disposal of the aircraft. The GHT's proactive ESOH management practices ensure Federal and State regulatory directives are addressed for the life-cycle of the aircraft. Original Equipment Manufacturers (OEMs), system integrators, and sub-system contractors are required to address ESOH considerations and risk management as part of systems engineering, logistics support/sustainment, and maintenance processes for the aircraft. System contracts incorporate ESOH requisites, including prohibited and restricted hazardous materials (HAZMAT) considerations and pollution prevention (P2). OEMs identified the type and quantity of HAZMAT delivered with and used for maintenance of the aircraft, as part of their HAZMAT Management Program Reports, and whether any materials contain hazardous constituents on NAVAIR's Chemical of Concern List (CoCL) (such as Class I and II ODS, hexavalent chromium, and emerging contaminants).

ESOH CONTRACT COMPLIANCE REQUIREMENTS

- Military Standard (MIL-STD)-882D
- HAZMAT Management/P2
- National Aerospace Standard 411
- EO 13423 and 13514
- Montreal Convention Banning Ozone Depleting Substances (ODS)
- Radioactive Materials
- Occupational Safety and Health Act
- Material Safety Data Sheets

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

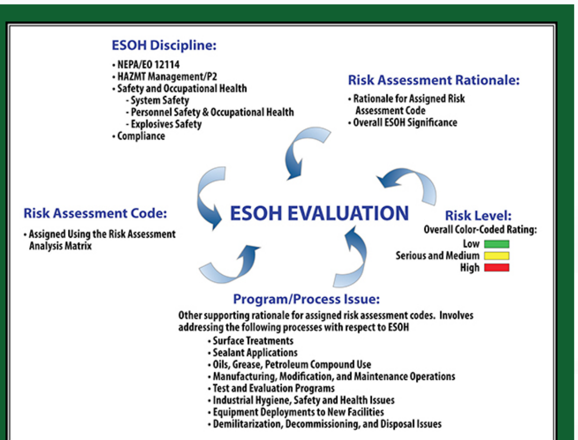

Figure 3: ESOH Evaluation Process

Energy availability costs and security are at the forefront of the challenges faced by our Nation, DoD, and the Navy. SECNAV Ray Mabus stated that "*America and the Navy rely too much on fossil fuels…. In the Navy last fall, I put out five goals for the Navy, the most ambitious of which, and one which I am absolutely confident that we can reach, is that within 10 years, the United States Navy will get one half of all its energy needs, both afloat and ashore, from non-fossil fuel sources.*" To further his goals, PMA265 collaborated with the Navy's Task Force Energy, NAVAIR Propulsion & Power, and General Electric Aviation (F414 manufacturer) to research and develop alternative sources of energy, specifically an acceptable biofuel substitute for JP-5. The Green Hornet successfully flight tested this fuel (a 50/50 blend of camelina-based fuel and conventional based JP-5 jet fuel) on Earth Day, April 2010. As Secretary Mabus tells the story…"*We flew an F-18 Hornet on camelina. It's a small, little seed, member of the mustard family. It's not edible. And it can be used in rotation with other crops, so you don't have the problem that you do with corn ethanol, for example, or the first generation of biofuels. The plane flew at Mach 1.2—almost 1,000 miles an hour. The plane didn't notice the difference…we named it the Green Hornet.*" This test flight and others are steps toward the U.S. Navy's goal of sailing the Great Green Fleet by 2016, supported by aircraft using biofuel.

The Green Hornet flew to Andrews Air Force Base and was used as a backdrop for President Obama's Major Policy Address

Green Hornet – The Lead in Fleet Testing

- F/A-18E/F Super Hornet
  - ◊ Serves as the U.S. Navy's premier fighter aircraft
  - ◊ Wide Operating Envelope
  - ◊ Large Fuel User
- Component Testing
  - ◊ Auxiliary Power Unit (APU) Atomizer, Combustor, Engine Fuel Control
- Engine Testing
  - ◊ GE F414 Turbojet, Honeywell 36-200 APU
- Flight Testing
  - ◊ Completed 16 flight tests for 17+ hours
  - ◊ First-ever supersonic flight powered by a renewable jet fuel

No Impacts to Performance or Operability

on Energy Security on 31 March 2010 (Figure 4). Testing with the Green Hornet (Figure 5) reduced the biofuel test requirements in other aircraft (MH-60S, MV-22B, T-45A, EA-6B, AV-8B, and MQ-8B), and led the way for use of biofuel during the Blue Angels' performance at NAS Patuxent River's Labor Day Weekend 2011 Airshow. The camelina biofuel blend (Figure 6) was successfully demonstrated in the Blue Angels' high performance maneuvers, tight formations, and close tolerances with no changes in performance. Additional testing with the Green Hornet will continue in 2011-2012, including a carrier trial in summer 2012.

Figure 4: President Obama with The Green Hornet

Figure 5: Biofuel Testing

Figure 6: Blue Angels in Flight

ESOH Risk Management

Communication of 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 to advise them 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. The GHT Lead tracks the identified ESOH risks and ensures that these risks are communicated appropriately with aircraft PMs, Integrated Product Team representatives, test and user communities, and other organizations. High and serious ESOH risks (and medium risks as necessary) are elevated, incorporated into the overall PMA265 risk database, and presented at 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.

The risk of Noise Induced Hearing Loss (NIHL) to personnel from exposure to U.S. Navy jet aircraft

ESOH Hazard and Risk - Exposure to Flight Line/Deck Noise

Noise is a long standing issue with jet aircraft. Current hearing protection devices do not adequately prevent noise exposure that personnel may experience when working around aircraft.

Risk Likelihood	Risk Consequence				
	I Negligible	II Marginal	III Moderate	IV Critical	V Catastrophic
E Near Certainty	Medium Undesirable	Serious Undesirable	High Not Acceptable	High Not Acceptable	High Not Acceptable
D Highly Likely	Medium Undesirable	Serious Undesirable	Serious Undesirable	High Not Acceptable	High Not Acceptable
C Likely	Low Acceptable	Medium Undesirable	Medium Undesirable	X Serious Undesirable	High Not Acceptable
B Low Likelihood	Low Acceptable	Medium Undesirable	Medium Undesirable	Medium Undesirable	Serious Undesirable
A Not Likely	Low Acceptable	Medium Undesirable	Medium Undesirable	Medium Undesirable	Medium Undesirable

Risk Matrix

PMA265 and Chief of Naval Air Forces are seeking technical solutions for this hazard. Even with viable jet engine noise suppression technologies, the use of improved hearing protective devices and flight deck procedures/training will still be required to protect personnel.

noise, especially in an aircraft carrier flight deck environment, is a long-standing problem and requires formal risk acceptance procedures. Additionally, encroachment constraints continue to affect DoD and U.S. Navy installations and occupational safety. 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, ONR, and OEMs to research and develop technical solutions that reduce community noise levels and minimize personnel exposure to jet noise levels. PMA265 embarked on a robust engine noise reduction program using mechanical chevrons on the F414 jet engine nozzle (Figure 7). In partnership with ONR and General Electric (GE) Aviation, PMA265 is implementing a Rapid Technology Transfer project for variable exhaust nozzle (VEN) chevrons, a promising and viable solution to reducing jet engine noise in the F414/F404 engine and other DoD tactical aircraft.

Figure 7: VEN Chevrons

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 generate noise through their interaction with turbulent airflow. GE successfully developed chevrons for the commercial aircraft engines, CFM56-5B and CF34, currently in revenue service.

NAVAIR Propulsion & Power/GE Aviation tested this technology at Naval Air Warfare Center Lakehurst, New Jersey and demonstrated an approximate reduction of 2.5 to 3 decibels (dB) over much of the frequency range. In the 3 to 6 KHz frequency range (identified as most susceptible to hazardous noise exposure), they demonstrated reductions up to 7 dB. Figure 8 displays encouraging noise reductions with 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 secured $2 million in research and development funding from ONR; an additional $3.3 million of PMA265 funds are committed to complete the design, engineering, testing, and manufacturing development phase. Flight testing that culminates with a flight clearance is expected to be complete in FY12. With today's austere funding climate, a forced retrofit of the F/A-18E/F inventory is unrealistic. PMA265 is working with NAVAIR 4.4 and Commander Naval Air Forces to gradually introduce the nozzle with chevron configuration as a cost-neutral, preferred spare into the Fleet. This nozzle will be the first installation of jet noise reduction technology on any DoD high performance tactical aircraft.

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

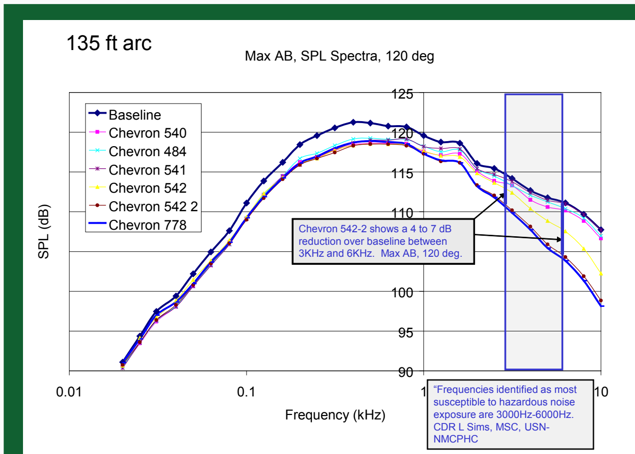

Figure 8: FY09 Sound Pressure Level Spectra Comparison for the Mechanical Chevron Nozzle

PMA265 secured funding for and contracted with the University of Mississippi National Center for Physical Acoustics (NCPA) to research and develop an alternative technology—corrugations on VEN seals, which differs from the chevron technology in that the corrugations are on the interior of the seals vice an extension. The corrugated seal concept is a product of prior ONR research. Previous tests were not conducted at any level of afterburner function. PMA265 requires the test, demonstration, and qualification of up to three corrugation configurations on an F414 engine. Testing will evaluate performance in all flight regimes, including afterburner. The objective of this effort is to determine whether other technologies show improved jet noise reduction.

MAJOR PASS/FAIL CRITERIA FOR VEN SEALS WITH CORRUGATIONS APPLIED TO THE F414

- Reduction in near field sound pressure levels by a minimum of 2.5 dBA with a goal of 3 dBA in the audible spectrum
- Impact to engine performance in all flight regimes will be nominal and acceptable
- Modified configuration – VEN seals with corrugations – will be as durable as the current VEN seals installed on the F414 engine

Figures 9 and 10 show promising, preliminary results obtained for the Mach number inside a 12-lobe nozzle following initial attempts at optimization. NCPA is working to better define the optimization process. Specifically, the corrugation is being defined more clearly in terms of a small number of geometrical constraints, including axial starting location, axial ending location (for truncating inside the nozzle), profile curvature, cross-sectional profile, and width-to-height ratio.

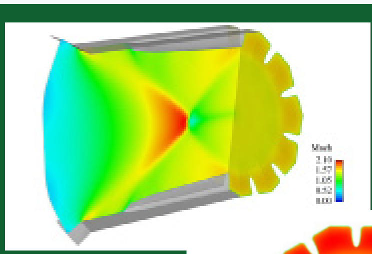

Figure 9: Cross-Section Mach Contour for 12-Lobe Corrugation Nozzle Design

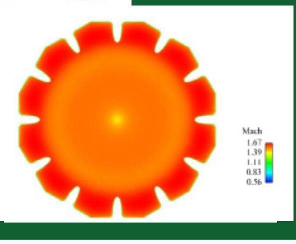

Figure 10: Cross-Section Mach Contour for 12-Lobe Corrugation Nozzle Design

PMA265 proposed and is managing a Navy Small Business Innovative Research Phase I Feasibility Study to optimize modeling of operational flight profiles to help alleviate noise impacts around military airfields. Modeling 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 (i.e., population annoyance, sleep disturbance, and speech interference). Results of the Phase I study demonstrated that 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 now in 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 military installations on safe flight procedures and routes that minimize community noise impacts, and (3) to optimize flight profiles for reduced fuel consumption, a key goal and challenge expressed by the SECNAV.

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 and EA-18G is on the DoD Emerging Contaminants Action List (e.g., Hexavalent Chromium [Cr6+], Perfluorooctanoic Acid, and Beryllium). The GHT continues to engage with NAVAIR Material and Corrosion Branches to investigate viable alternatives to Cr6+ and proceed to address requirements in DoD Memorandum for Secretaries of the Military Departments, Minimizing the Use of Hexavalent Chromium (Cr6+), of April 8, 2009.

PMA265 OEMs proactively pursue methods to reduce pollution and to green the environment . GHT initiatives include in-process, alternative material analyses. Boeing, prime contractor for the F/A-18E airframe, evaluated a non-chrome primer to meet the Type II (Low Infrared) primer requirements for mold line painting of the F/A-18. They evaluated a Non-Chrome Tie Coat Primer to use as final paint over the chromated primer. The alternative is a low-risk application for corrosion concerns of an aircraft used in severe corrosion environments. Use of non-chrome primer also eliminates the use of a highly volatile organic compound Koroflex flexible primer, no longer needed due to reduction of conductive paint. Boeing and NAVAIR Materials selected the Hentzen 17176KEP/16709CEH as the alternative to evaluate. Two F/A-18 product support aircraft were painted in February and March 2011 at St. Louis Boeing facility (Figure 11). The aircraft were monitored

Figure 11: Non-Chrome Tie Coat Primer Application on F/A-18Comparison for the Mechanical Chevron Nozzle

for several months and no anomalies were found. Approval to change over to Hentzen MIL-PRF-23377 Type II Class N Primer as a tie coat on the F/A-18 is in process; incorporation is expected by the end of 2011.

The F/A-18A-D is a test platform for the Navy's Environmental Sustainability Development to Integration Project #458: Advanced Non-Chromate Primers & Coatings. The mature primers, Deft 02-GN-084 (MIL-PRF-23377N, Type I) and Hentzen 17176KEP/16709CEH (MIL-PRF-23377N, Type II), were chosen for the demonstration. PMA-265, F/A-18A-D TYCOM, and FRCSW F/A-18 Production, in conjunction with Materials Engineering North Island, will select twelve aircraft for field evaluation. Criteria for aircraft selection include carrier deployment soon after repainting at FRCSW North Island and aircraft to be carrier deployed at least twice within the next four years. Aircraft are already at FRCSW or are scheduled for Depot maintenance in the very near future.

Another effort is the Class N Primer on F/A-18 Composite/Aluminum Interfaces (Figure 12). The test plan is in development to test the following materials:

- PRC-DeSoto 825X480 (Chromated Ty II Koroflex)
- PRC-DeSoto EWAE118 Primer (MIL-PRF-85582 Ty II, Class N)
- Hentzen 17176KEP/16709CEH Primer (MIL-PRF-23377 Ty II, Class N)
- Deft 02GN084 (MIL-PRF-23377 Type I Class N)
- Deft 44-GN-72 Primer (CONTROL) (water-borne, epoxy)
- Deft 02BK036 Primer (high-solids, epoxy)

Test substrates are being acquired, and paints and primers are already on-site. Test specimens will be evaluated in accordance to ASTM B117 and ASTM G85.A4.

Boeing-St Louis' initiative in Sustainable Manufacturing Zero Waste Program targeted the F/A-18E/F outer wing assembly cell line to document the current environmental footprint of that product, including energy [materials (supplier), fabrication (supplier), transportation, plant equipment, and factory infrastructure] , HAZMAT, and factory waste. Boeing used modified lean tools, value stream mapping, and dial charts to document the current environmental footprint (e.g., define nomenclature, units of measure, normalize environmental impact by product revenue), generate approach for achieving a neutral environmental footprint, and generate short-term/long actionable implementation plan.

ZERO WASTE PROGRAM OBJECTIVES

- Understand the environmental footprint of typical military aircraft structural assembly line
- Apply lean techniques to sustainability

Accomplishments achieved for HAZMAT/waste were recycling of sealant tubes, right sizing of HAZMAT containers, conduct of compressed air leak survey and repair, and minimization of waste. The pilot study identified sealant tubes as a significant portion of aircraft assembly solid waste stream. Boeing Winnipeg currently recycles empty sealant tubes and identified 278,000 St. Louis Sealant tubes to recycle. Boeing uses a Small Disadvantaged Business to remove the cured sealant and send the tubes for recycling. The resultant cured sealant that is extracted is sent to a cement kiln to be used as fuel (energy recovery). The energy considerations included outer wing part suppliers (e.g., energy used to produce raw materials for fabricated parts, during part fabrication, and during transportation of parts from supplier to Boeing) and outer wing assembly lines (e.g., lighting, heating, ventilation, air conditioning, miscellaneous equipment, compressed air, and vacuum). Energy estimated for supply chain transportation used the Green House Gas Protocol Initiative Transportation

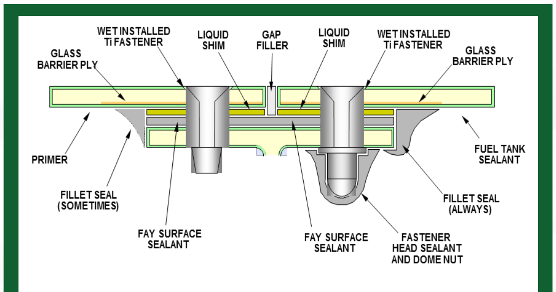

Figure 12: Class N Composite/Aluminum Project

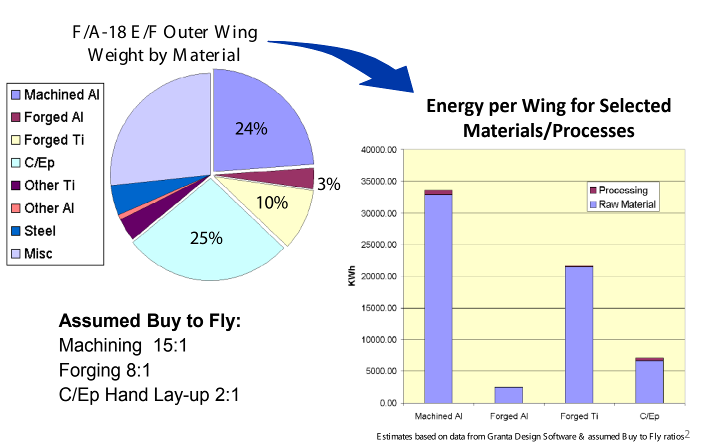

Figure 13: Energy Estimate for F/A-18E/F Outer Wing Supply Chain Part Fabrication

Tool. Data from the Granta Design Software Tool and the University of Illinois Energy Calculation Tool was used to estimate energy for raw material production and part fabrication. The majority of packaging materials (100% cardboard and plastic) are recycled. Figure 13 shows results of the energy estimates. Boeing installed sensors in automated drilling equipment to monitor actual energy usage in the outer wing line. Instrumentation and energy consumption visibility is necessary to quantify and drive continuous improvement—the first step toward maturing a transformational approach for factory power optimization. Overall, the study demonstrated that value stream mapping is a useful approach for measuring sustainability progress on the shop floor, and that raw material production is a significant energy contributor in aircraft production.

Finally, efforts continue to replace the industry standard high-temperature composite material, PMR-15, in the F/A-18E/F & EA-18G engine, the F414 Outer Bypass Duct (OBD) (Figure 14). Uncured PMR-15 is a known Occupational Safety and Health Administration issue; restrictions during its use are due to the presence of Methylenedianiline (MDA), a liver toxin. To mitigate ESOH risks, GE Aviation and Maverick identified an environmentally friendly replacement material, MVK-14 FreeForm™, which has the same mechanical properties and temperature capability as the current OBD PMR-15 material. Preliminary estimates for replacement of PMR-15 with MVK-14 FreeForm™ predict a potential reduction in HAZMAT usage of 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 14: F414 OBD

External Coordination

The GHT maintains situational awareness of Federal, State, and international legal and regulatory developments. Program Office Leadership is apprised of any issues that impact F/A-18E/F and EA-18G Programs. Examples of external coordination are:

- GHT Lead participated in the March 2011 Symposium: Adapting to Climate and Energy Challenges: Options for U.S. Maritime Forces at the John Hopkins University Applied Physics Laboratory.
- PMA265 is at the forefront of tactical aircraft program acquisition programs worldwide to support the international scientific and engineering community in seeking jet noise mitigation solutions. Our GHT Lead was recently selected as the U.S. Chair of the North Atlantic Treaty Organization Research and Technology Organization, Advanced Vehicle Technology Task Group 198 - Recent Development in Noise Reduction Technologies.
- The GHT assists international environmental requirements with foreign military sales of PMA265 systems. GHT provided the Royal Australian Air Force with information about specific health monitoring of personnel involved in maintenance activities, especially with regard to Cr6+ and precautions regarding the potential for Beryllium Copper (BeCu) dust from the use of the gun (due to the BeCu liner in the gun blast diffuser) and when sanding/grinding BeCu bushings.

In the area of community outreach, the GHT Lead, Mike Rudy, is President of the Board of Trustees for Cove Point Natural Heritage Trust, Inc (CPNHT). CPNHT is a Southern Maryland environmental and educational organization, which promotes preservation and protection of Chesapeake Bay and the surrounding area. Mr. Rudy set aside $250,000 in the CPNHT endowment to fund annual scholarships in environmental studies at Southern Maryland higher education institutions.

AVT TG 198 CONSIDERATIONS

- Recent developments in aircraft noise reduction at the combustion source and at the exhaust jet.
- Improvement of noise measurement and modeling of military noise
- Management of community noise surrounding military facilities
- Noise Induced Hearing Loss; its early diagnosis and prevention
- Ongoing research on hearing protection devices and the physiological aspects of noise impact on humans