ENVIRONMENTAL EXCELLENCE IN WEAPON SYSTEM ACQUISITION, LARGE PROGRAM: AFLCMC F-35 ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH SUPPORT TEAM, WRIGHT-PATTERSON AIR FORCE BASE

PROGRAM MANAGEMENT

Introduction

In fiscal year (FY) 2012 and 2013, the Air Force Life Cycle Management Center (AFLCMC) F-35 Environment, Safety and Occupational Health (ESOH) support team continued to implement the program's approach to comprehensive ESOH risk management, reviewing contractor ESOH deliverables, ensuring compliance with the National Environmental Policy Act (NEPA), and providing contractual language for solicitations to properly identify and manage ESOH risk. These actions provide the framework for the F-35 Joint Program Office to successfully identify and track hazards and their mitigation status throughout the life cycle of the program.

Historically, aircraft in the Air Force inventory rely heavily on coating systems that contain hazardous materials to prevent airframe corrosion. These coating systems also emit large amounts of Volatile Organic Compounds (VOCs) and Hazardous Air Pollutants (HAPs) during the painting process. As a result, during depot maintenance operations, workers are required to wear personal protective equipment (PPE) to paint and de-paint the aircraft.

Per Military Standard (MIL-STD)-882E, "When a hazard cannot be eliminated, the associated risk should be reduced to the lowest acceptable level within the constraints of cost, schedule, and performance by applying the system safety design order of precedence." The system safety design order of precedence (Figure 1), includes eliminate hazards through design selection, reduce risk through design alteration, incorporate engineered features or devices, provide warning devices, and (least effective) incorporate signage, procedures, training, and PPE. Unfortunately, in the past, aircraft platforms have relied too heavily on PPE as their primary method of mitigating system safety risk.

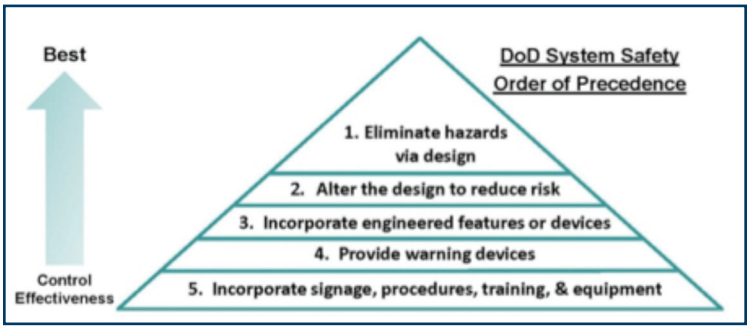


Figure 1 – System Safety Design Order of Precedence

To reduce reliance on PPE and lessen the impact to the environment, among other initiatives, the AFLCMC F-35 ESOH support team spearheaded the successful evaluation of an Alternative Outer Mold Line (AOML) coating system for the F-35 Joint Strike Fighter. This novel all-in-one corrosion-resistant coating, which contains no hexavalent chromium, replaces the traditional coating system's top two layers. The unique AOML coating system significantly decreases aircraft final finish weight and increases durability over the traditional coating system.

AOML Field Service Evaluation

The Field Service Evaluation (FSE) Program of the AOML coating system culminated in a side-by-side evaluation of the AOML coating and a traditional aircraft topcoat (MIL-PRF-85285) applied on a Lockheed Martin product support F-16 aircraft, which proved the technical and economic viability of the AOML coating system. The FSE is currently at 44 months with no significant degradation in the AOML coating condition. The FSE has been deemed by the F-35 Joint Program Office to be highly successful, resulting in a proven, durable coating with established environmental and economic benefits.

Shown above is a head on view of the F-16 used for the AOML FSE. The AOML coating system was applied to the pilot's right side of the F-16. The tradition aircraft coating system was applied to the pilot's left half of the aircraft.

AOML Cost Savings and Mission Benefits

The elimination of one layer from the F-35 aircraft coating system results in a significant overall aircraft weight reduction, which translates to reduced fuel consumption and lower aircraft emissions during flight. Additionally, compared to the traditional coating system, the AOML coating system eliminates 17 pounds of VOCs and 21 pounds of HAPs emissions per aircraft during the paint process, while maintaining required coating corrosion resistance properties.

The traditional aircraft coating system could require scuff sanding and repaint after 2-3 years of use. The AOML coating is projected to extend the refresh cycle to approximately every 6-8 years, which cuts the paint/de-paint waste stream by over 50 percent and is expected to result in vastly reduced hazardous waste, VOCs and HAPs, maintenance crew labor hours, and aircraft down time over the aircraft's life cycle.

Seen here, the F-16 used for the AOML FSE during take-off. The FSE is currently at 44 months with no significant degradation in the AOML coating condition. The FSE has been deemed successful by the F-35 Joint Program Office.

The F-35 Joint Program Office has estimated that the AOML coating system will result in a $435 million reduction in production costs and a savings of $1.07 billion in operations and sustainment costs over the life cycle of the Joint Strike Fighter program (total savings of $1.505 billion). The huge impact to their program was recognized by the Director of Engineering, F-35 Joint Program Office, in a letter of appreciation, received in July 2013, touting the F-35 ESOH support team's dedication and teamwork in implementing the AOML FSE program. The total AFLCMC pollution prevention investment cost for this effort was $1.05 million.

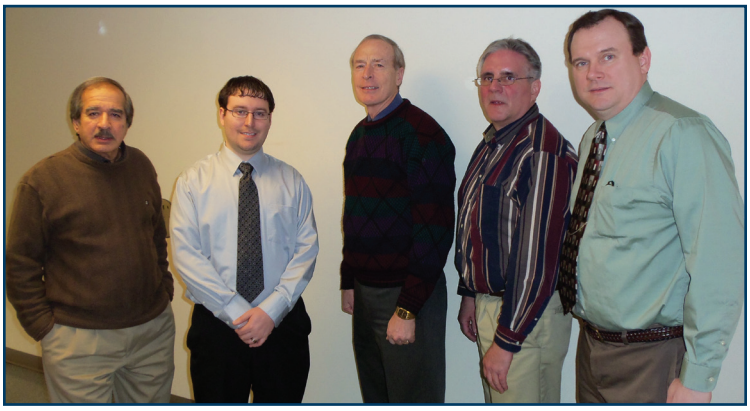
AOML Background

Interest in the AOML originated in 2004, when lowering the weight of the F-35 aircraft became a programmatic priority. In January 2005, a formal trade study was performed to evaluate an AOML coating. Compared to the paint system used on legacy airframes, the alternate coating system incorporated a different filler material to provide corrosion resistance properties. This change in filler allowed for the elimination of the top two stack layers (the flexible primer and topcoat), which resulted in significant weight savings and reduction of VOC and HAP emissions. The trade study showed that by using the AOML, the amount of time required for an F-35 to pass through the manufacturing process could be cut by four days and that a significant reduction in Unit Recurring Flyaway costs and the capital costs could be achieved. Although these benefits were estimated specifically for the F-35 program, other programs that implement the AOML concept could realize similar benefits.

Team Description

The mission of AFLCMC is to acquire and support war-winning capabilities. AFLCMC's objectives are to deliver cost effective acquisition solutions, deliver affordable and effective product support, launch high confidence sustainable programs, standardize and continuously improve the AFLCMC processes, develop and place the right person at the right time, and assure a safe, secure, and quality work environment. All of these objectives are supported by AFLCMC's foundational goal to deliver to commitments. AFLCMC is subdivided into ten Program Executive Office (PEO) directorates and sixteen program, support, and execution directorates.

The AFLCMC F-35 ESOH support team, based at Wright-Patterson Air Force Base (AFB), Ohio, is comprised of members of the AFLCMC's Agile Combat Support Directorate, Acquisition Environmental & Health Risk Management Branch (AFLCMC/WNVV). This branch provides ESOH support, manages pollution prevention material substitution efforts, and helps integrate ESOH considerations into weapon system engineering activities and outputs, including the F-35 Joint Program Office, which is responsible for the F-35 program design engineering and materiel acquisition process. Although the F-35 ESOH support team members are part of the Agile Combat Support Directorate, this AFLCMC ESOH home office supports all ten AFLCMC PEO directorates and several of the support directorates. The Acquisition Environmental and Health Risk Management Branch's mission is to reduce the ESOH burden of the systems acquisition process: 1) by promoting effective ESOH risk management processes and 2) by identifying innovative pollution prevention processes and business practices to mitigate hazards and reduce life cycle costs.



Shown here are members of the AFLCMC F-35 ESOH support team. From left to right, team members are: Mr. Andy Ghazee, Mr. Arnold Godsey, Mr. Thomas McDonald, Mr. David Walker and Mr. Jeff McCann. Absent from the picture are Mr. Thomas Lorman & Mr. Jim Ryckman.

Individual participation varied throughout the two-year award period, so the combined efforts of the AFLCMC F-35 ESOH support team members will be used herein for brevity. The team members are (alphabetically):

- Mr. Andy Ghazee, AFLCMC/WNVV Branch Chief
- Mr. Arnold Godsey, Environmental Manager
- Mr. Thomas Lorman, Environmental Engineer
- Mr. Jeffrey McCann, Environmental Engineer
- Mr. Thomas McDonald, ESOH Program Manager
- Mr. Jim Ryckman, Environmental Engineer
- Mr. David Walker, Occupational Health Manager

TECHNICAL MERIT

The AFLCMC/WNVV staff emphasizes incorporating ESOH into systems engineering as an essential step to significantly reducing ESOH risk in weapon systems. AFLCMC/WNVV reviews each weapon system program (including Acquisition Category I, II, and III programs) to ensure a solid ESOH strategy is in place that will deliver a product or service within cost, schedule, and performance goals. AFLCMC/WNVV addresses ESOH considerations at the beginning of the acquisition process – when changes are cost effective and easiest to implement – facilitating more successful mitigation of life cycle ESOH risks through the systems engineering process.

The primary focus of the F-35 program is quality and ESOH risk management is no exception to that rule. Through multiple interactions with F-35 weapon system engineers, sustainment process engineers, and other stakeholders, the F-35 ESOH support team collected and analyzed weapon system specific engineering challenges that pose ESOH risks. The resulting engineering requirements were reviewed by the AFLCMC/WNVV staff, by the F-35 ESOH support team, and the F-35 Program Manager. While it is the AFLCMC/WNVV mission to integrate ESOH requirements early in the weapon system procurement life cycle, projects are also reviewed for potential cross-platform benefit which often results in risk and cost reductions for other weapon systems regardless of their life cycle phase. The staff is continuing to work on chromium and cadmium reductions on related coatings and sealants.

The AFLCMC F-35 ESOH support team reviewed and improved the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) for the F-35 program that was developed in support of Acquisition Milestone C. The PESHE is a program document that establishes the overarching ESOH guidelines for the program, how the program's ESOH considerations will be identified and monitored, and documents the hazards and risks identified in implementing the ESOH risk management approach. The PESHE is a living document that will be updated and maintained throughout the life cycle of the program, including disposal and demilitarization.

ORIENTATION TO MISSION

The F-35 Lightning II Weapon System is the Department of Defense's (DoD's) focal point for defining an affordable next generation strike aircraft weapon system to meet an advanced threat, while improving lethality, survivability, and supportability. The F-35 will be operated by the United States Air Force, Navy, and Marine Corps, and the United Kingdom Royal Air Force and Royal Navy. Additional international partners include Australia, Canada, Denmark, Italy, the Netherlands, Norway, and Turkey.

The 100th production F-35 Lightning II Strike Fighter was unveiled during a ceremony at Air Force Plant 4 on Dec 16, 2013. The F-35 Joint Program Office has estimated that the AOML coating system will result in a $435 million reduction in production costs. It will also result in a savings of $1.07 billion in Operations and Sustainment costs over the life cycle of the Joint Strike Fighter program.

Throughout the F-35 acquisition process, ESOH is a critical aspect of the program's success. Because this weapon system will be based in and sold to European Union (EU) nations, in addition to addressing United States laws, regulations, Executive Orders, and DoD policies, the weapon system program office needed to consider Registration, Evaluation, Authorization & Restrictions of Chemical Substances (REACH) restrictions. REACH is an effort to register and control the chemicals used in the EU. The goal of REACH is to ensure appropriate safety and toxicity data is obtained for chemicals in the EU, which includes about 30,000 chemicals.

The F-35 ESOH support team assists program offices with reviewing alternatives to hazardous materials use, and mitigations to occupational health risks are considered for all aspects of the program life cycle. The required approach to identifying hazards is documented and updated in the PESHE and includes the NEPA Compliance Schedule. ESOH risk management is conducted based on criteria established in the PESHE and the Systems Engineering Plan by the ESOH support team and others. This benefits the F-35 program by identifying, qualifying, quantifying, and mitigating, where practicable, the ESOH risks associated with the program. By addressing ESOH risks, value can be added through risk mitigation (i.e., an ESOH-compliant and safe product) and cost savings can be realized where ESOH risks can be accepted within existing funding constraints.

The PESHE for the F-35 program identifies the overall risk management approach (strategy, processes, and procedures) for the integration of ESOH considerations in systems engineering processes and contract solicitation with respect to the government's specific ESOH requirements for the program in the system requirements document, the statement of work, and the contract data requirements list. Regular System Safety Working Group meetings throughout the acquisition process are held to assess hazards and mitigate the associated risks to acceptable levels; these meetings are led by the System Safety Engineer, thus ensuring continuity of purpose and a centralized focal point for ESOH data management.

Pictured above is an F-35 Lightning II robotic painting work cell. The AOML coating system eliminates one layer when compared to the tradition paint system. This results in an overall aircraft weight reduction.

TRANSFERABILITY

Although the AOML coating system was developed specifically for the F-35 program, similar benefits could be realized by other weapon systems. The F-16 program is currently in the process of implementing a similar coating system on their aircraft that is based on the results of the AOML coating system.

During FY 2012, F-35 ESOH team members were instrumental in the formation of an AFLCMC ESOH Council which focuses on cross cutting acquisition-ESOH matters and includes the Director of Engineering from each of the AFLCMC Program Executive Office directorates. Successes, like the AOML coating system are briefed during Council meetings. The first AFLCMC ESOH Council meeting was held on 23 Jan 13.

Also in FY 2012, the branch formed a Weapon System Pollution Prevention (WSP2) Working Group to identify and prioritize projects. The working group includes representatives from the Air Force Research Laboratory, Air Force Sustainment Center, HQ AFMC Directorate of Logistics, Air Force Civil Engineer Center, and the Secretary of Air Force Acquisition Integration Division (SAF/AQX). These meetings and interactions improve communication among organizations and avoid duplication in research efforts. Within the past two years, the team managed five WSP2 projects specifically to reduce hexavalent chromium risks/costs for a range of aircraft, both during production at Air Force plants and during sustainment/maintenance at the Air Logistics Complexes. Results of completed WSP2 projects are documented in the DoD Advanced Surface Engineering Technologies for a Sustainable Defense (ASETSDefense) Defense database.

STAKEHOLDER INTERACTION

Throughout the AOML coating system project, the AFLCMC F-35 ESOH support team worked closely with the F-35 Joint Program Office and the F-35 manufacturer, Lockheed Martin, to keep up to date on the status of the FSE program for the AOML coating system. Results of the FSE were also shared with the F-16 program, who early on in the project expressed their potential interest in the coating system.

As part of the systems engineering process, the team highlighted critical deficiencies in two versions of the draft F-35 program PESHE update (dated December 2011 and March 2012) that were developed in support of Acquisition Milestone C, which occurs prior to the start of the Production and Deployment phase. Between the December 2011 and March 2012 draft versions of the PESHE, the AFLCMC PESHE Checklist/ Scorecard, which was developed by WNVV staff and gauges compliance with DoD and Air Force requirements, increased from 53 percent to 71 percent, a 40 percent improvement. The revised PESHE update had a greater emphasis on ESOH concerns. The team recommended that far field noise hazard

be documented in the PESHE as a serious or high risk. Far field noise was subsequently identified in the revised PESHE update as a serious risk, requiring mitigation and acceptance of the residual risk by the appropriate decision authority. The team also identified needed improvements to the NEPA compliance schedule.

A newly painted F-35 sits inside a paint booth at Air Force Plant 4. The AOML coating is projected to more than double the coating system refresh cycle. This results in over a 50 percent reduction in the paint/de-paint waste stream.

The AFLCMC/WNVV staff developed numerous tools to assist all Acquisition Category programs with their ESOH requirements during the acquisition process. These tools provide guidance/templates/best practices for writing PESHEs; developing NEPA compliance schedules; and preparing contract documents. The tools are accessible to all weapon system programs on the AFLCMC ESOH Central SharePoint website. The tools offer a quick start to authoring the respective documents while also explaining the purpose of each section and sub-section within those documents. The development and deployment of several checklists and circulars (e.g., NEPA circular, PESHE Checklist, and ESOH circular) has also served as an integral part of transferring ESOH knowledge to acquisition program office personnel responsible for ESOH considerations. The documents provide guidance and support to ESOH managers by incorporating the most current information from regulations, instructions, and policies.

Other methods the AFLCMC F-35 ESOH support team used in FY 2012 and FY 2013 to transfer ESOH knowledge to acquisition program office personnel include the following:

- The team taught multiple quarterly AFLCMC Focus Week courses, including Introduction to Acquisition Environmental Management, Developing the PESHE, ESOH Risk Management for Program Managers, Hazardous Material (HAZMAT) Management in Acquisition, and Introduction to Nano Material ESOH.
- In cooperation with Air Force Institute of Technology (AFIT) staff, team members developed a six hour web-based AFIT course, designated SYS198, Integrating ESOH into Systems Engineering, A Practitioner's Guide, Part 2, which went live on 11 July 2012. This course details the use of the DoD Standard Practice to integrate ESOH criteria into systems engineering for the Engineering & Manufacturing Development, Production & Deployment, and Operations & Support phases of the Defense Acquisition, Technology, and Logistics Life Cycle Management Framework. This course is a follow-on to SYS197, Integrating ESOH into Systems Engineering, A Practitioner's Guide, Part 1 (developed by the team in 2010), which details the integration of ESOH principles into the systems engineering process using MIL-STD-882 for the Materiel Solution Analysis and Technology Development phases.
- During FY 2012, the ESOH support team developed three AFLCMC technical process guides on ESOH Risk Management, the Weapon System Pollution Prevention Program, and the AFLCMC ESOH Council. These process guides, while not mandatory, are used to reduce ESOH risk and promote greater standardization across the AFLCMC. The ESOH Risk Management process guide is intended to help program managers identify and manage ESOH risks over a system's life cycle by integrating ESOH into the program management and systems engineering processes. This guide specifically addresses developing and coordinating the PESHE, developing the NEPA compliance schedule, establishing a hazardous material management program plan and report, and complying with statutory and regulatory ESOH requirements.

PROJECT IMPACT/OUTCOMES

The ESOH support team is already working with the F-35 program office and Lockheed Martin on developing and testing an extended life version of the AOML coating. The next step is to develop a hexavalent chromium free conversion coating that is compatible with the AOML coating, which would result in a totally non-chrome coating system for the F-35. The ESOH support team has recently funded a project to identify non-chromated fuel tank coatings suitable for substitution of current materials used on the F-35, F-16, F-22, and C-130 weapon systems, using an F-16 as a test bed for demonstration and validation.

ESOH considerations will continue to be addressed by the program office through the PESHE planning requirements, the contractor-developed Hazardous Material Management Program plan, and relevant sections of other program plans. Should a new hazard be identified, the contractor, with Air Force oversight, will conduct the requisite impact analyses and

health assessments to determine required mitigations and/or control mechanisms, in accordance with MIL-STD-882, the DoD System Safety Standard Practice.

AFLCMC guidance, templates, best practices, and success stories developed by the ESOH support team will continue to be available to all AFLCMC weapon system programs on the AFLCMC ESOH Central SharePoint website to promote and foster the transfer of ESOH knowledge to acquisition program office personnel responsible for ESOH considerations.

CONCLUSION

Over the past two fiscal years the AFLCMC F-35 ESOH support team provided many acquisition program offices, including the F-35 Joint Program Office, a single cohesive focal point for acquisition ESOH support. The team consistently supplied superior technical and management support to all AFLCMC weapon systems and reduced or eliminated a significant amount of HAZMAT in the manufacturing, operation, sustainment and disposal processes. The team's achievements fully incorporated the spirit and intent of Executive Orders and Air Force policy and used the federal, state, and local regulatory requirements as a framework to accomplish these goals.