FY 2016 Secretary of Defense

Environmental Awards

Environmental Excellence in Weapon System Acquisition–Large Program
KC-46A Program Environment, Safety, and Occupational Health Team

Introduction

The KC-46A, which achieved first flight on 25 September 2015, will replace the U.S. Air Force's aging tanker fleet. This Acquisition Category I program is converting the commercial Boeing 767-200 Federal Aviation Administration (FAA) certified passenger and freighter aircraft to an aerial refueling aircraft with passenger/cargo/aeromedical evacuation capabilities.

The program's Environment, Safety, and Occupational Health (ESOH) integration effort is the responsibility of the KC-46A Program ESOH Team; a cross-functional, government-contractor team composed of engineers, program managers, maintenance specialists, and user representatives from the KC-46A Program Office, Air Force Research Laboratory, Air Mobility Command, and from the Prime Contractor, The Boeing Company.

Primary KC-46A Program Environment, Safety, and Occupational Health Team Members

- Mr. Nick Shouse, Chief of Systems Engineering, Development Integrated Product Team (IPT) (U.S. Air Force)
- Maj Matt Obenchain, Deputy Chief of Systems Engineering (U.S. Air Force)
- SMSgt Brian Cantrell, Maintenance Superintendent (U.S. Air Force)
- Mr. Bill Hunt, System Safety Manager (U.S. Air Force)
- Mr. Don Jackson, System Safety Manager (U.S. Air Force)
- Dr. Kevin Kendig, AFRL Materials & Manufacturing Engineer (U.S. Air Force)
- Mr. John Stallings, Environmental Engineer (U.S. Air Force)
- Mr. Darren Veneman, Logistics Manager (U.S. Air Force)
- Mr. Luis Diaz-Rodriguez, Aircraft Structural Integrity Manager (U.S. Air Force)

Background and Program Description

The U.S. Air Force's new aerial refueling aircraft, the KC-46A Pegasus, is a commercial derivative aircraft, based on the Boeing 767-200. With more refueling capacity than the KC-135, improved efficiency and increased capabilities for cargo and aeromedical evacuation, the KC-46A will provide aerial refueling support to the U.S. Air Force, U.S. Navy, and U.S. Marine Corps as well as allied nation coalition force aircraft. For most of the last 15 years, this new multi-role tanker has been the Air Force's #1 mobility aircraft acquisition priority. The cur-rent contract, valued at $52B, will deliver 179 aircraft by 2027.

Beginning with the early planning and

Primary Government Members of the KC-46A Program ESOH Team
Mr. Hunt, Mr. Shouse, Dr. Kendig, SMSgt Cantrell, Mr. Jackson, Mr. Veneman, Mr. Stallings, Maj Obenchain, and Mr. Diaz-Rodriguez. Air Mobility Command and Boeing members of the team are not in the picture.

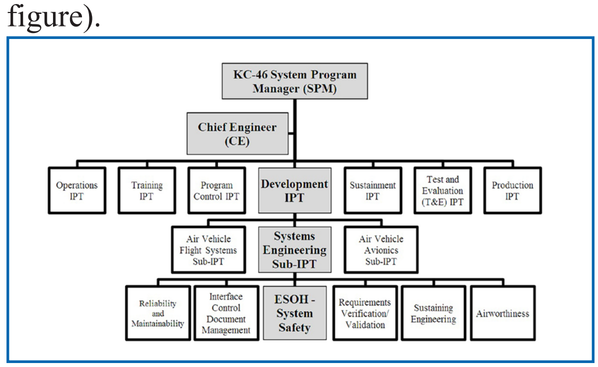
engineering that supported the pre-award competition (the "KC-X Program"), extending to the setting of user capability requirements and contract specifications, and continuing through ongoing developmental engineering efforts, the KC-46A Program has implemented a comprehensive integrated ESOH effort into its system design and sustainment planning activities. The KC-46A is implementing processes across the life cycle that meet and exceed the expectations set by Department of Defense (DoD) and Air Force Acquisition and ESOH policy and guidance, including system safety-ESOH risk assessment and acceptance, noise reduction, hexavalent chromium (Cr6+) minimization, halon replacement, and hazardous materials (HAZMAT) minimization and tracking. This exemplary ESOH effort was accomplished on a commercial derivative system acquisition program, an acquisition approach that often discourages additional ESOH "improvements" beyond the baseline established by the underlying commercial system.

Early KC-X ESOH-Systems Engineering Integration Efforts

Safety and environmental engineers were assigned to the KC-X Systems Engineering IPT and worked directly with the Chief Engineer beginning in January 2006, at the early plan-ning, pre-source selection stages of the pro-gram. These engineers provided critical input to the user's Capability Development Document (CDD), the System Requirements Document, and the KC-X Request for Proposals (RFP). The expert dedicated ESOH support and manage-ment focus in the early KC-X ESOH integration efforts provided the critical groundwork and set the framework for the Program's ESOH risk minimization effort that continues to this day.

The Current KC-46A ESOH Risk Management Approach

In 2011, after the selection of the Boeing proposal and contract award, the KC-X became the KC-46A Program. ESOH and system safety management are integrated into the U.S. Air Force program office systems engineering effort under the Development IPT (see figure).



KC-46A Program Office IPT Organization Chart
The organization chart highlights the integration of the ESOH Team under the Development IPT and the Systems Engineering sub-IPT, as well as the relationship of ESOH to other design considerations.

The Program Office established the KC-46A Program ESOH Team, a cross-functional, gov-ernment-contractor group that coordinates the program's ESOH effort. The Team has ESOH and System Safety Working Groups that meet virtually on at least a monthly basis and have face-to-face meetings two to four times per year. These groups work on identified hazards, risk assessments, the Hazard Tracking System (HTS), and other ESOH deliverables.

Incorporating ESOH Integration into Systems Engineering

The KC-46A Program has thoroughly integrated ESOH into systems engineering planning and execution starting with the capability requirements documents (generated by the Joint Capabilities Integration and Development System – JCIDS), through contract requirements, and extending into program documentation.

Using JCIDS for the Early Identification of User ESOH Requirements

The Air Mobility Command 2006 CDD identified specific ESOH risk reduction requirements. This has been critical to establishing ESOH priorities from the beginning of the program. The requirements included:

- Eliminating halon in the underlying commercial aircraft's fire suppression systems.
- Meeting Federal Aviation Regulation Part 36 Stage 4 noise requirements – the most restrictive FAA community noise limit for commercial aircraft.
- Operating with maximum fuel efficiency within current aviation technology, without any degradation to mission/aircraft performance.
- Incorporating no additional requirements for HAZMAT/ hazardous waste disposal over those in the underlying commercial aircraft.

Incorporating ESOH Requirements into the Solicitation and Contract

The KC-X Systems Engineering – ESOH management effort successfully translated these CDD requirements into specific requirements that were included in the KC-X RFP and KC-46A contract documents. Halon elimination, noise, and HAZMAT management requirements were specifically called out in contract documents. MIL-STD-882, *DoD Standard Practice for System Safety*, and National Aerospace Standard 411, *Hazardous Materials Management Program*, and specific requirements from DoD and Air Force policy were also specified. In addition, contract specifications required the aircraft to eliminate the use of Cr6+ in the Outer Moldline (OML) paint system for the air-craft and eliminate or reduce the use of Cr6+ wherever possible.

Integrating ESOH into Program Systems Engineering Planning Documents

The Systems Engineering (SE) Plan, the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE), and the contractor's System Safety Program Plan comprehensively define and prescribe the program's strategy for successful integration of ESOH into the SE process using MIL-STD-882 methodology. The KC-46A ESOH Team ensures that these program planning documents stay up-to-date and connected. The PESHE also contains the Program's schedule for supporting National Environmental Policy Act (NEPA) and Executive Order (EO) 12114, *Environmental effects abroad of major Federal actions*, compliance (32 U.S.C. 4321-4370d). This schedule was incorporated into the Program's Integrated Master Schedule (IMS) after contract award.

Establishing Energy Efficiency Requirements

To meet the fuel efficiency requirements called-out in the CDD, the KC-46A has established performance targets related to the amount of fuel that the aircraft can carry certain distances (known as "fuel offload versus radius" requirements). These targets drive close monitoring of fuel usage rates and aircraft operational empty weight because, in general, every pound of excess weight equates to a corresponding reduction in the amount of fuel the aircraft can carry to accomplish its mission.

Supporting NEPA Analyses

In addition to integrating the NEPA/EO 12114 Compliance Schedule into the PESHE and the program's IMS, the KC-46A ESOH Team has ensured that Program Office processes and the KC-46A contract itself collect, analyze, and report data to support NEPA analyses by KC-46A test, training, depot maintenance, and operating installations

ESOH Risk Management

The KC-46A ESOH Team has implemented an ESOH risk, identification, assessment,

First Flight, 25 September 2015
The KC-46A is implementing ESOH and engineering processes across the life cycle that meet or exceed the requirements set by DoD and Air Force guidance, including system safety-ESOH risk assessment and acceptance, hexavalent chromium minimization, halon replacement, noise reduction, emissions reduction, hazardous materials minimization and tracking, and demilitarization and disposal planning.

mitigation, assessment, acceptance, and management process that utilizes the methodology in MIL-STD-882, in compliance with DoDI 5000.02, *Operation of the Defense Acquisition System*. The program has specified in the contract how Boeing will provide data, assessments, and reports to the program's risk management process. As discussed above, the cross-functional, multi-stakeholder KC-46A ESOH Team, through its working groups, meets at least monthly to review ESOH risk management, plan mitigation measures, and prepare for risk acceptance by the proper risk acceptance authority. Since user representatives are an integral part of the KC-46A ESOH Team, they participate in the risk management and acceptance process throughout. The KC-46A ESOH Team has integrated the reporting of ESOH risk status with the program's primary systems engineering technical reviews and appropriate program management reviews. In addition to integrating ESOH risk reviews with the overall technical risk management, at least annually the KC-46A Program also holds a separate cross-functional, senior-management-level System Safety Group meeting, chaired by the KC-46A Program Manager, that deep-dives into the status of ESOH risks and risk acceptance.

Life Cycle Cost Savings

One example of the KC-46A ESOH risk and cost reduction process in action is the selection of the Advanced Performance Coating (APC) topcoat. The KC-46A ESOH risk management process has long identified the hazards associated with depainting and painting the aircraft as collectively one of the most significant ESOH cost and risk areas being managed. The KC-46A ESOH Team has taken a multi-pronged approach to mitigating these costs and risks. In addition to Cr6+ alternatives, the Team has sought ways to lengthen the painting cycle, reducing the number of times the aircraft will need to be repainted during its service life. The use of APC polyurethane topcoats increases by two times the cycle between repaints compared with the U.S. Air Force standard polyurethane topcoat. In addition to reducing the discharge of volatile organic compounds, this mitigation is estimated to save at least $44M over the life cycle of the initial fleet of aircraft procured by the U.S. Air Force.

HAZMAT Management and Pollution Prevention

The KC-46A ESOH Team has implemented a comprehensive HAZMAT management program (HMMP) that identifies HAZMAT embedded in the system and used in operations and maintenance. In addition to HAZMAT identification, the team utilizes Pollution Prevention (P2) principles to guide product substitution and process re-engineering efforts to reduce the use of HAZMAT. The team is pursuing high-impact HAZMAT eliminations during system development, and establishing the groundwork that will enable hazard communication and continued risk reduction throughout the life cycle via demilitarization and disposal.

Comprehensive Life Cycle HAZMAT Identification and Tracking

The KC-46A HMMP approach follows the requirements of NAS 411. It requires the identification of prohibited, restricted, and tracked HAZMAT based on Environmental Protection Agency, Air Force, and European Union lists of HAZMAT. Boeing meets this requirement using their Project Chemical Profiling System. This system "mines" HAZMAT data for both Boeing commercial and military aircraft. It includes 3.2M rows of specific information about the HAZMAT contained on the KC-46A and its support equipment. Additional HAZMAT data was derived by "mining" the KC-46A aircraft maintenance manuals.

This data is maintained by the KC-46A ESOH Team in the program's HAZMAT databases. The HAZMAT data is available to all KC-46A users and will be maintained for the life of the system. The KC-46A Program has drafted a Deactivation, Demilitarization, and Disposal Plan, and populated it with data from the HAZMAT databases on embedded HAZMAT, safety precautions, and other ESOH considerations.

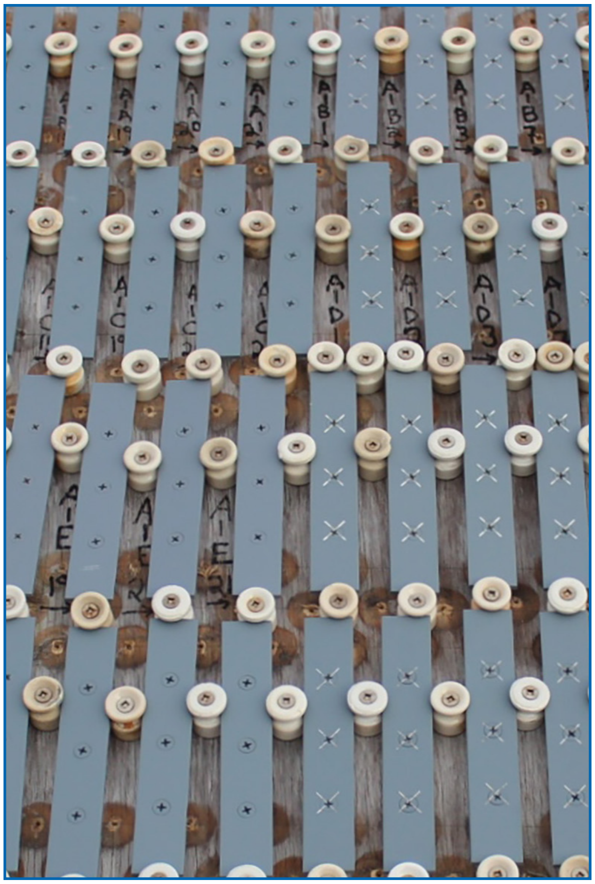
P2 Successes

Two significant achievements of the KC-46A ESOH Team's HAZMAT reduction/P2 efforts are halon elimination and Cr6+ reduction.

The KC-46A will be the first commercial airline and transport-based aircraft in the world to be delivered with an FAA-certified non-halon fire suppression system. Under the *Montreal Protocol on Substances that Deplete the Ozone Layer*, halon has been out of production in much of the world since 1993. Nevertheless, all commercial airline and transport aircraft manufactured around the world today are still delivered to customers with halon fire suppression systems. The KC-46A ESOH Team assessed halon dependence to be a significant ESOH and life cycle sustainment risk for the Air Force, and established halon elimination as a prior-ity at the beginning of the program. This was a particularly *forward-leaning* initiative for a commercial derivative system like the KC-46A.

KC-46A Non-Halon Auxiliary Power Unit (APU) Fire Bottle

The KC-46A will be the first airliner and transport-type air-frame in the world delivered with an FAA-certified non-halon engine and APU fire suppression system. The prec-edent-setting KC-46A halon replacement initiative has given industry and FAA valuable testing and certifica-tion experience that will support the gradual transition to non-halon systems in commercial fleets in coming years.



Outdoor Exposure Test for KC-46A Non-Chrome Coating Systems
Shown above are outdoor exposure test coupons for seven non-Cr6+ external surface paint systems set up for long exposure tests. Tests are conducted under high humidity, rainfall, and salt conditions in Daytona, Florida.

Eliminating halon has required five years of intensive work by Boeing and the ESOH Team, leveraging halon replacement breakthroughs from previous DoD military-unique aircraft and collaborating closely with the FAA.

Despite the fact that requirements establishment and program planning had been underway for several years before DoD published its 8 April 2009 policy, Minimizing the Use of Cr6+, the Air Force had already established Cr6+ as an ESOH risk that required mitigation. The 24 February 2011 KC-46A contract established multiple requirements for Cr6+ reduction and the specific requirement for the KC-46A aircraft to eliminate Cr6+ in the OML paint system for the aircraft. Like halon elimination, this was a particularly *forward-leaning* initiative for a commercial derivative system like the KC-46A. The KC-46A program is continuing outdoor exposure testing of seven non-Cr6+ systems that have a high potential to meet performance standards for potential integration on the remaining 168 aircraft to be delivered by Boeing.

In addition to these singular achievements, Boeing and the KC-46A ESOH Team have embedded *Design for Environment* practices across the lifecycle. Specifically this effort includes continual improvement activities that evaluate replacements for consumables used in both manufacturing and maintenance operations for the 767/KC-46A, with special emphasis on toxic chemicals, Cr6+, and cadmium reductions.

Internal Execution and Documentation

The KC-46A's ESOH effort is comprehensively integrated into the program's documentation from requirements, through program planning, to contract documents, and dozens of deliver-ables and data products. The HTS is part of the Program's Integrated Digital Environment which Boeing is providing as a source of shared data between the Air Force KC-46A Program Office and the Boeing KC-46A program staff.

The HTS is a key enabler of all aspects of life cycle ESOH risk management including assessments, mitigations, verifications, and acceptance status. The KC-46A ESOH Team is currently managing and tracking about 460 ESOH risks across various categories, including HAZMAT, occupational health, and airworthiness. The KC-46A's ESOH working group performed detailed reviews and coordination on 118 non-airworthiness risks, assessing 28 as medium and 79 as low. Eleven risks were eliminated through source eliminations or process changes. Formal acceptance for all risks is obtained at the appro-priate management levels per DoDI 5000.02 requirements.

External Coordination of ESOH Risk Management

KC-46A Fuel Transfer to Navy F-18 Aircraft
All KC-46A aircraft including this first aircraft are coated with an Advance Performance Topcoat. The Topcoat provides increased resistance to weathering and cracking, resulting in a cost reduction of up to $44M over the fleet service life.

The KC-46A ESOH Team coordinates its ESOH risk management activities and outcomes with external stakeholders to obtain technical advice, ensure buy-in, and to cross-feed lessons-learned and successes. As discussed above, the U.S. Air Force system user is an integral part of the KC-46A ESOH risk management effort. The FAA Fire Safety Branch and the U.S. Air Force Research Laboratory Coatings Technology Integration Office have been key external tech-nical collaborators. Lessons learned from the FAA's certification of the first airliner and transport-type non-halon fire suppression system on the APC and Cr6+ elimination have been trans-ferred to other aircraft programs across the Air Force Life Cycle Management Center and have been presented at various aviation industry, coatings technology, and ESOH forums. The KC-10 and KC-135 aircraft in particular plan to transition to the APC-non-Cr6+ external paint system once it is fully qualified

Summary of Accomplishments

The KC-46A ESOH Team has successfully integrated comprehensive ESOH risk reduction and management processes into the systems engineering, design development, life cycle management efforts of the KC-46A Pegasus. The Team's innovative efforts have ensured that this program:

- Delivers the first commercial airliner/transport-based aircraft in the world with an FAA-certified non-halon fire suppression system. The precedent-setting KC-46A halon replacement initiative gives industry and FAA valuable testing and certification experience that will support the gradual transition to non-halon systems for commercial aircraft in coming years.
- Meets FAA Part 36, Stage 4 Far Field Noise Limits – the most restrictive level set for commercial aircraft and quieter than the C-17.
- Meets FAA Part 34 requirements for commercial aircraft air contaminant emissions – the most restrictive limits were required.
- Incorporates Cr6+ reduction as a top priority for the system – including the contractual requirement for a non-Cr6+ paint system for the external surfaces of the aircraft, the primary source for Cr6+ generation during sustainment.
- Has comprehensive data on HAZMAT embedded in the system and required for sustainment that can provide a basis for ESOH risk management throughout the life cycle and ensure that the system is safely demilitarized at end-of-life.