KC-46 Program ESOH Team Wins SECDEF Environmental Excellence in Weapon Systems in Acquisition Award

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KC-46 First Flight – 25 Sep 15

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KC-46 is implementing ESOH and engineering processes across the life cycle that meet or exceed requirements set by DoD and AF guidance including Cr6+ minimization, halon replacement, noise reduction, emissions reduction, and HAZMAT minimization, tracking, demilitarization, disposal planning

Areas Covered

- Background and program description
- Early KC-X: Systems Engineering Integration
- Incorporating ESOH Integration into Systems Engineering
  - Using JCIDS for early identification of user ESOH requirements
  - ESOH requirements in solicitation, contract and planning documents
  - Establishing energy efficiency requirements
  - Supporting NEPA Analyses
- ESOH risk management
- HAZMAT management and pollution prevention
  - Comprehensive life cycle HAZMAT Identification and tracking
  - P2 successes
- Internal execution and documentation
- External coordination of ESOH risk management
- Summary of accomplishments

Background and Program Description

- KC-46 Pegasus is starting replacement of aging tanker fleet
- Commercial derivative aircraft based on Boeing 767-200
  - First 18 tankers by 2018
  - $52B contract delivers 179 tankers by 2027
- Missions
  - Air refueling for AF, Navy and Marine Corp
  - Cargo/passenger transport
  - Aeromedical evacuation
- ESOH included early in KC-X Systems Engineering
  - Safety and environmental engineer assigned in Jan 06
  - Worked directly with chief engineer prior to source selection
  - Provided ESOH guidance for CDD, (SRD), and RFP
  - Set Framework for ESOH risk minimization effort

ESOH Risk Management Approach

- Early KC-X system engineering integration efforts
  - Safety and environmental engineers were assigned to sys eng IPT
  - Worked directly with KC-X Chief Engineer beginning in Jan 2006
  - Provided input to CDD, SRD and RFP
  - Set framework for current ESOH risk minimization effort
- Current KC-46A EXOH Risk Management Approach
  - Contract was awarded to Boeing Defense Systems in Feb 2011
  - ESOH and system safety located in system engineering in Development IPT
  - KC-46A Program office established cross functional government/contractor ESOH WG
    - Meets weekly
    - Face-to-face meetings two to four times/yr
    - Groups work identified ESOH hazards, risk assessments and minimization of HAZMATs

KC-46A Program Office IPT Organization Chart

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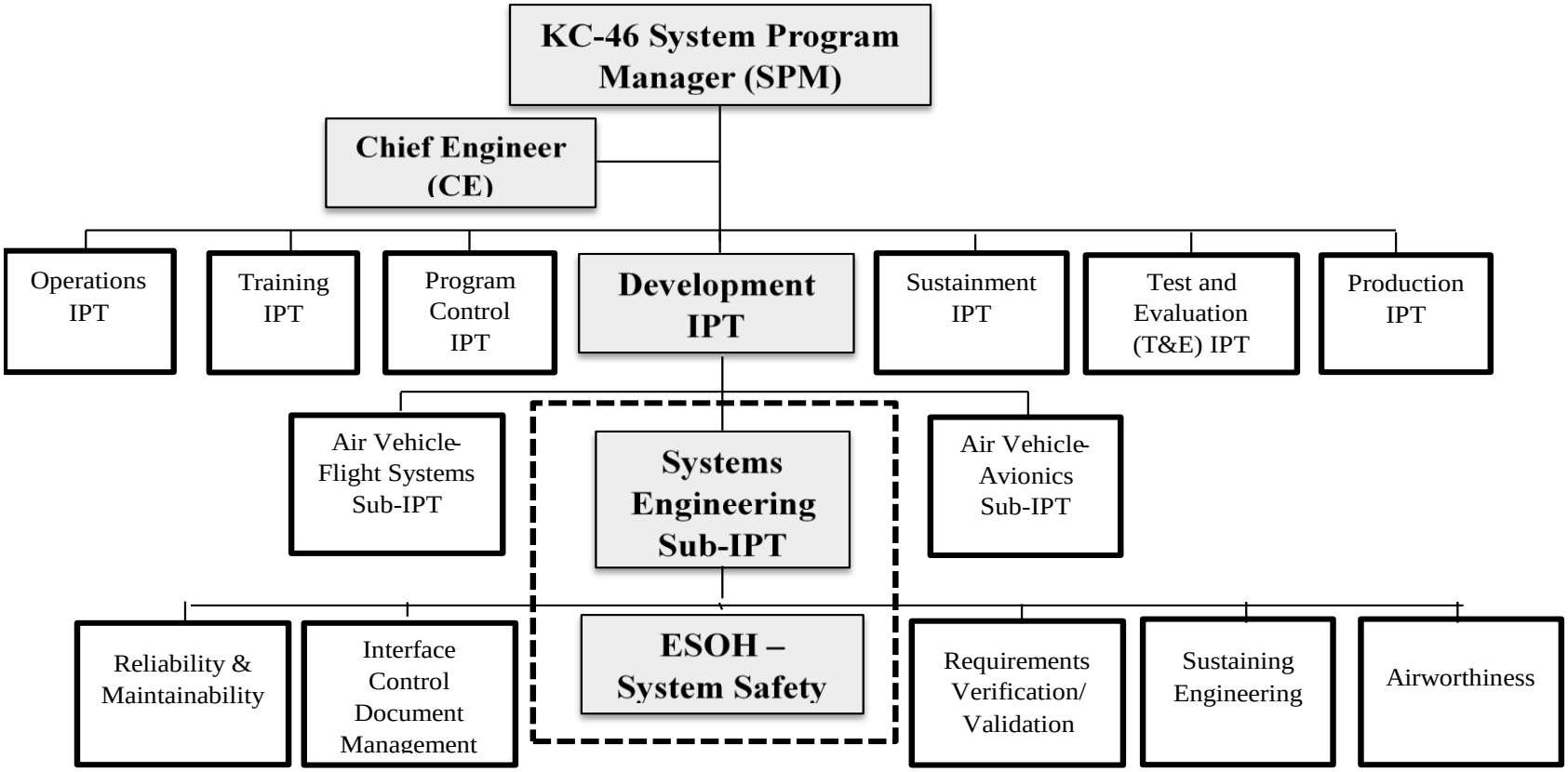
ESOH Integration into KC-46 Program Organization Structure



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.

JCIDS - Early ID of User ESOH Requirements

- Integration of ESOH started with capability requirements documents
- Generated by Joint Capabilities Integration and Development System (JCIDS)
- Air Mobility Command 2006 CDD identified specific ESOH risk reduction requirements
  - Eliminate halon in commercial aircraft fire suppression system
  - Meet most restrictive commercial aircraft noise std - FAA Part 36 Stage 4
  - Obtained maximum fuel efficiency with current aviation technology
  - No additional requirements for HAZMATS or/hazardous waste disposal
- KC-X Systems Engineering - ESOH management translated CDD into SRD included in RFP and KC-46A contract specifications
  - Halon elimination, noise, and HAZMAT management requirements are specifically included in contract specifications
  - Also included in contract were requirements for use of MIL-STD-882 and NAS 411
  - Specifications also required elimination of Cr6+ coating on OML
  - Minimize use of Cr6+ wherever possible

Integrating ESOH into Systems Engineering Planning Documents

- KC-46A Systems Engineering (SE) Plan - key technical planning document
- Strategy for integration of ESOH into the SE process using MIL-STD-882 methodology is answered by ESOH Team
  - AF PESHE and Boeing System Safety Program Plan define and prescribed strategy for successful ESOH integration into SE process
  - Documents is current and connected (production contract revisions)
- Energy Efficiency Requirements
  - Fuel efficiency requirements included in CDD
  - Converted in specifications - Performance targets (fuel offload vs radius requirements)
  - Targets reduced the amount of fuel required to achieve mission
- NEPA Compliance
  - NEPA Compliance Schedule maintained in the PESHE
  - Part of Milestone C Integrated Master Schedule reviews
  - Data required for NEPA EIS and EAs provided by contract deliverables

ESOH Risk Management

- **KC-46 ESO Team implemented an ESOH MIL-STD-882 compliant process**

(ESOH risk, identification, assessment, mitigation, acceptance and management process)

- **Contract clearly specifies how data, assessments, and reports are provided to support the ESOH risk management process**
- **Weekly tag-up, monthly virtual meetings, semi-annual formal meeting**
  - **Members include users, AF, AFMC and AFLCMC Safety and Environment Home Offices**
  - **Members participate in both system engineering technical reviews**
  - **Program management reviews**
- **Hold separate cross-functional, senior management level SS**
  - **Chaired by KC-46 Program Manager**
  - **Deep-dives into status of ESOH risk and risk acceptance**

Life Cycle Cost Savings

- KC-46 Selected Advanced Performance Coating (APC) topcoat
  - Painting/depainting early identified with significant cost and ESOH risks
  - Multipronged approach used to reduce cost and risk areas
  - Coatings with Cr6+ alternatives with long paint cycles were specified
  - APC topcoat use doubles coating life–cutting coatings and waste by ½
  - Reduces hazardous material use/waste disposal - Cr6+, VOCs
- HAZMAT Management and pollution prevention
  - HAZMAT identified embedded in system and used in O and M
  - Uses P2 principles to guide product substitution and process engineering to reduce HAZMAT use
- Boeing uses Project Chemical Profiling System to "mine" for HAZMATs
  - Used for Boeing Commercial and Military Aircraft (P-8)
  - Database contain 3.2M rows of HAZMAT data on KC-46A and support equipment
  - Maintenance Manuals - mined for sustainment hazardous consumables

KC-46A Fuel Transfer to Navy F-18 Aircraft

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All KC-46A aircraft, including this first aircraft are coated with Advanced Performance Topcoat. Coating provides increased resistance to weathering and cracking resulting in a cost reduction of up to $44M over the fleet service life

HAZMAT Data and P2 Successes

- HAZMAT databases are maintained for manufacturing, sustainment and SE
  - System based on National Aerospace Standard 411, *"Hazardous Material Management"*
  - Data is available to all users and will be maintained for aircraft life
  - Deactivation, Demilitarization and Disposal (D3) Plan prepared
    - Draft prepared for EMD contract with final version in production contract
    - D3 plan provides current tabulation of HAZMAT with safety warnings
- P2 Successes – Halon (Class I ODS) Elimination
  - KC-46A is first commercial aircraft passenger/transport-based aircraft in world to be delivered with FAA-certified non-halon fire control systems
  - Halon has been out of production in much of world since 1993
  - KC-46 ESOH team assessed halon dependence as significant ESOH risk
  - Established halon elimination as a priority at beginning of program
  - Very forward leaning initiative for commercial derivative aircraft
  - Halon elimination required 5 years of intensive work by Boeing and AF

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

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The KC-46A will be the first airliner/ transport-type airframe delivered with an FAA-certified non-halon engine and APU fire suppression system.

P2 Continued

- Minimizing use of Hexavalent Chromium ($Cr6^+$)
- KC46 ESOH team early during SRD review in 2006 KC-46 assessed $Cr6^+$ dependence
- Hazard was assessed as catastrophic even though risk could be mitigated to medium (engineering controls and PPE)
- Therefore $Cr6^+$ elimination minimization was as a priority at beginning of program
- DoD published 8 Apr 09 policy, *Minimizing the use of $Cr6^+$*
- KC-46A contract (24 Feb 11) established multiple requirements for $Cr6^+$
  - Eliminate $Cr6^+$ in Outer Moldline of aircraft (not fully achieved)
  - Minimize/eliminate $Cr6^+$ throughout remainder of KC-46
- Forward-leaning initiative for commercial-derivative aircraft
- Continuing outdoor exposure testing of 7 non-$Cr6^+$ with high potential to meet OML coating standard
- High potential for integration on full rate production aircraft.

Outdoor Exposure Test for KC-46A Non-Cr6+ Coating Systems

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Shown above are outdoor exposure test coupons for seven non-Cr6+ external surface paint systems set for long exposure tests. Tests are conducted under high humidity, rainfall, and salt conditions in Daytona, FL.

Design for Environment, Internal Execution and Documentation

- **Boeing *Design for Environment* practices as part of the HMMP Plan are embedded across the aircraft lifecycle**
  - **Includes efforts to evaluate consumable replacements used in manufacturing and maintenance**
  - **Includes both the 767and KC-46A**
  - **Special emphasis on toxic chemicals, $Cr6^{+}$, and cadmium reduction**
- **Internal Execution**
- **ESOH effort is comprehensively integrated into KC-46A program documentation from requirements, contract documents to deliverables**
- **Boeing shares data with AF using a Integrated Digital Environment (IDE)**
- **Contract required Hazard Tracking System (HTS) is part of the IDE**
- **HTS is key enabler of the ESOH risk management as repository for assessments, mitigation, elimination, verification and acceptance status**
- **ESOH Team manages and tracks 460 ESOH risks including areas of HAZMAT, occupational health and airworthiness**

External Coordination of ESOH Risk Management

- **KC-46A ESOH coordinates its ESOH risk management activities and outcomes with external stakeholders**
  - **KC-46A users are integral part of ESOH risk management process**
  - **FAA Fire Safety Branch and US AFRL Coatings Technology Office were key external technical collaborators**
  - **Lessons learned from FAA certification of first transport-type non-halon fire suppression systems are unique and potentially transferable to other commercial aircraft**
  - **The use of requirement for non-$Cr6^{+}$ coating system using APC has been presented at various aviation industry , coatings technology and ESOH forum**
- **KC-10 and KC-135 plan to use the APC and non-$Cr6^{+}$ external coating system when fully qualified**

Summary of Accomplishments

- Delivering the 1st commercial transport based aircraft in world with an FAA-certified non-halon fire suppression system
- Meets FAA Part 36, Stage 4 Far Field Noise Limits – most restrictive commercial limit – quieter than the C-17
- Meets FAA Part 34 commercial aircraft air contaminant emission limits – most restrictive levels
- Incorporates $Cr6^{+}$ reduction as top priority for system – includes contract requirement for non-$Cr6^{+}$ coating system for external surfaces of aircraft (primary source for $Cr6^{+}$ generation during sustainment
- Comprehensive data for HAZMAT embedded in KC-46A aircraft and used for sustainment
  - Provides basis for ESOH risk management through life cycle
  - Ensures safe demilitarization at end of life

Key Capabilities - ESOH

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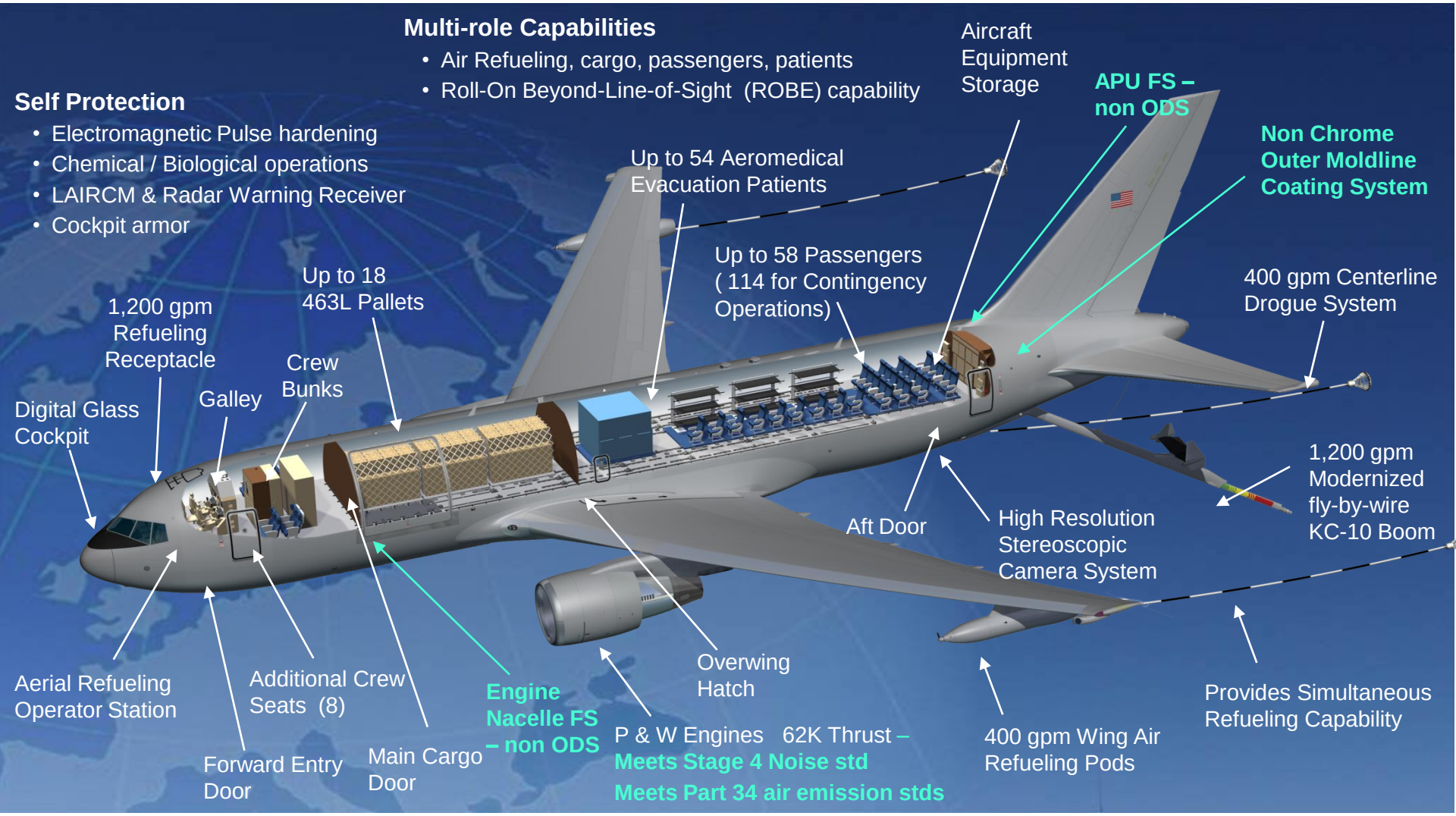

Delivering an advanced, multi-mission tanker on-time, on-cost … ready for war on day one!

END