Replacement Tanker for USAF – ESOH Protection Using Systems Engineering

John Stallings
AFLCMC/WKC
Acquisition Process Beginnings

- The KC-135 Recapitalization Program was Impacted by AoA
- Evaluation included the Use of Commercial Derivative Aircraft
- Capabilities Based on KC-135
- Initiated at Acquisition Stage B rather than A
- Incorporated FAA requirements into SRD
  - Flight Safety Standards
  - Air Contaminant Emission Standards
  - Far Field/Community Noise Limits
- Also included DoD requirements
  - No Class I ODS
  - Elimination/Reduction of Cr6+
- Fixed Price Incentive Firm
ESOH Systems Engineering Process

- Acquisition Program Initiated in ASC (AFLCMC)
- Developed SRD based on CDD from MAJCOM (AMC)
  - Chief Engineer led team preparing SRD
  - System Engineering concepts were keys (SS, Environmental Eng, RM & MOSA)
  - Requirements coordinated with AMC
- RFP included Instructions to Offerors for Sys Eng & ESOH
  - Provide SEP incorporating detailed ESOH plan
  - Airworthiness Certification incorporated FAA requirements
  - SRD, example SOO and CDRLs
- ESOH in System Engineering requirements
  - Included in IMP
  - Included in PDR, CDR, TRR
ESOH in IMP

ESOH in Integrated Master Plan
Engineering & Manufacturing Development Phase

AIRCRAFT MODIFICATION CONCEPT

Functional Requirements
List of Failure Conditions
Failure Condition Classification

FHA, SSPP, SSHA, PHL
NEPA Compliance
Schedule -- Apr 12

Environment, Health & Safety
Plan -- Aug 12

Hazardous Material Management
Program Plan - Apr 12

Critical Safety Item Report
Preliminary Draft – Dec 13

Development of Assurance
Levels for Hardware and Software

PESHE Facilitation Report
Preliminary Draft – Apr 12

Milestone B
Contract Award - Feb 11

Verification ESOH Requirements

ESOH Hazard Log

SFR

ESOH Hazard Log

PDR

ESOH Hazard Log

CDR

ESOH Hazard Log

FHA Update

AIRCRAFT DELIVERED
(Familiarization)

IOT&E

Airworthiness Certification (ATC/STC/MTC)

Final SSA
(End DT&E + 30 days)

PESHE/NEPA Sch Update
(Milestone C – 90)

Validation / Verification of
Analyses & Compliance
ESOH Requirements Flowdown

EHS Hazard Risk Assessment Rpt -
Final Draft – Apr 15

System Safety Hazard Assessment
and Safety Assessment Reports –
Final Drafts – Apr 15

HMMP Report – Final
Draft – Feb 15

IMPLEMENTATION

SSA & HHA, EHS and HMMP Reports
Preliminary drafts – Aug 13

ESOH Risk Acceptance

LFT&E

DT&E

SVR/PCA

FCA/PRR

Milestone C

ESOH Risk Acceptance

Final Draft – Apr 15

ESOH Hazard Log

PESHE/NEPA Sch Update
(Milestone C – 90)

7 May 15

Delivering an advanced, multi-mission tanker on-time, on-cost ... ready for war on day one!
Program of Record

KC-46 begins replacement of aging tanker fleet
- Acquires 179 aircraft; delivery of first 18 tankers by 2017
- Production ramps up to 15 tankers per year through 2027

Missions
- Air refueling
- Cargo/passenger transport
- Aeromedical evacuation

Implements Better Buying Power concepts
- Fixed Price Incentive Firm contract awarded 24 Feb 11
- Success depends on stable funding and requirements

KC-46 Program Team
- KC-46 built in the Boeing Everett WA factory and modified in the Puget Sound Area
- Boeing Program Office also located at Everett WA factory site
- Air Force Program Office located at WPAFB, OH

Numerous teammates, including:
- AMC
- AETC
- FAA Military Certification Office (MCO)
- DCMA
- AF Sustainment Center
- 412 TW, Edwards—Responsible Test Organization (RTO)
- AFOTEC, Kirtland AFB—Operational Test Agency (OTA)
- USN
- United Kingdom

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Aircraft Development with FAA

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Existing TC

767-200ER Baseline (767-200 TCDS)

- Design Weights (lbs):
  - MTW = 396,000
  - MTOW = 395,000
  - MLW = 300,000
  - MZFW = 260,000

767-2C Provisioned Freighter Structural Capability

- 300F Wing
- 300F Landing Gear
- 400ER Sect 48
- 400ER APU

Install:
- A/R Provisions (less Boom, WARP, and Centerline Drogue System)
- Body Tanks
- OBIGGS
- Oxygen Bottles
- NVIS
- Ballistic Protection
- Air Crew Member Compartment
- Hazardous Cargo Venting
- Non-Military Avionics

Design Weights (lbs):
- MTW = 416,000
- MTOW = 415,000
- MLW = 310,000
- MZFW = 273,000

Military Type Certification (MTC)

ATC

767-2C Provisioned Freighter

+ STC / non-FAA MTC

Installed into Provisioned Aircraft:
- A/R Boom
- WARP
- Centerline Drogue System
- Defensive Systems
- Military Avionics
- Palletized Equipment

KC-46A Tanker

Delivery to USAF

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

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Self Protection
- Electromagnetic Pulse hardening
- Chemical / Biological operations
- LAIRCM & Radar Warning Receiver
- Cockpit armor

Multi-role Capabilities
- Air Refueling, cargo, passengers, patients
- Roll-On Beyond-Line-of-Sight (ROBE) capability

Aerial Refueling Operator Station
Digital Glass Cockpit
Galley
Crew Bunks
Aft Door
Overwing Hatch
Engine Nacelle FS – non ODS
Pratt & Whitney Engines 62K Thrust – meets Stage 4 Noise std
120 kVA Generators

1,200 gpm Modernized KC-10 Boom
Non Chrome Outer Moldline Coating System

400 gpm Centerline Drogue System
1,200 gpm Refueling Receptacle
Up to 18 463L Pallets
Up to 54 Aeromedical Evacuation Patients
Up to 58 Passengers (114 for Contingency Operations)

400 gpm Wing Air Refueling Pods
Aircraft Equipment Storage

1,200 gpm Refueling
Receptacle

Up to 54 Aeromedical Evacuation Patients
Up to 58 Passengers (114 for Contingency Operations)

1,200 gpm Refueling
Receptacle

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SS Hazard Risk Acceptance Process

MIL-STD-882E
• Systematic Hazard Analysis Process
• Severity category and probability level are determined across all systems
• Risks expressed as combination of a severity level and a probability level (RAC)
• Risks are eliminated or reduced by verifiable mitigation processes
• Catastrophic Severity - ≤ 1X 10-6 for Improbable Frequency – Medium Risk

FAA AC 25-1309-1A
• Depending on Probability Hazard risks are either acceptable or unacceptable (Flight Safety)
• Extremely Improbable - ≤ 1X10-9
• Catastrophic Severity – Acceptable (meet Flight Safety Standard)
• Residual Risks not accepted

KC-46 requires equivalent probability of FAA standard for MTC.
# KC-46 ESOH Hazard Risk Matrix

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## KC-46 Program

<table>
<thead>
<tr>
<th>FAA (AC 25.1309-1A)</th>
<th>Catastrophic</th>
<th>Critical</th>
<th>Marginal</th>
<th>Negligible</th>
<th>Designed Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>KC-46 Program</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>9</td>
<td>16</td>
<td>22</td>
</tr>
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<td></td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>18</td>
<td>23</td>
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<tr>
<td></td>
<td>8</td>
<td>10</td>
<td>14</td>
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<td>24</td>
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<td></td>
<td>12</td>
<td>15</td>
<td>17</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESOF HRI Matrix (R1.0 PC12)</th>
<th>FAA Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
</table>

**Mishap Severity**
- Airworthiness
- MIL-STD-882D

(Correction figures modified by DoDI 8056.07)

- All failure conditions which preclude the continued safe flight and landing of the aircraft
- Could result in death, permanent total disability, loss exceeding $10M, or irreversible severe environmental damage that violates law or regulation

- Physical distress or excessive workload such that the flightcrew cannot be relied upon to perform their tasks accurately or completely; or
- Serious or fatal injuries to a relatively small number of persons other than the flightcrew
- Could result in permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, loss exceeding $1M but less than $10M, or reversible environmental damage causing a violation of law or regulation

- Significant increase in flightcrew workload or in conditions impairing flightcrew efficiency, or
- Physical distress to passengers or cabin crew, possibly including injuries
- Could result in injury or occupational illness resulting in one or more lost work day(s), loss exceeding $100K but less than $1M, or mitigable environmental damage without violation of law or regulation where restoration activities can be accomplished

- Slight reduction in safety margins or functional capabilities
- Slight increase in flightcrew workload, such as routine flight plan changes; or
- Some physical discomfort to passengers or cabin crew
- Could result in injury or illness not resulting in a lost work day, loss exceeding $2K but less than $100K, or minimal environmental damage not violating law or regulation

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EHS Hazard Risk Reviews

- Environment, Occupational Health, and Occupational Safety (EHS)
  - (Hazard Assessment Categories)
    - Environment – Water, Air, Noise, D3, HM spills, HW clean up
    - OH - Chemical Safety, Heat/Cold, Radiation, Confined Space, Ergonomics, Hazard Communication, Hearing Protection
    - OS - Fall Protection, Ordinance, Haz Energy, PPE, GSE

- KC-46 Commodity Listings
  - Aircraft decomposed into “commodity groups”
  - A group is a new capability for 767 or significant impact to baseline 767 – 52 identified (example – centerline drogue)
  - Reviews lead by Boeing EHS and included MQE and HSI representatives.
  - Ranked from 1 - EHS unmitigated hazard to 5 - No EHS issues (118 hazards identified)
EHS Risk Acceptance Process

- MIL-STD-882E methodology used to identify EHS hazards and mitigate risks with Systems Engineering process

- EHS hazard analyses include human responses to processes and mitigations applied to reduce impacts dominated by human error causal factors compared with quantitative hazard risk analyses based on functional failure conditions for hardware and software performance

- Hazard analysis review and technical agreement of mitigated risk begins with the ESOH Working Group with final coordination by SSG prior to PM Acceptance

- Hazard categories are grouped into final acceptance packages
  - Include quad chart summarizing hazards, risks and mitigations
  - Detailed briefings for each hazard risk
  - Basis for frequency estimates
## EHS Matrix

### EHS SEVERITY

<table>
<thead>
<tr>
<th>EHS SEVERITY</th>
<th>Catastrophic (I)</th>
<th>Critical (II)</th>
<th>Marginal (III)</th>
<th>Negligible (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect on Personnel</td>
<td>Death, permanent total disability</td>
<td>Permanent partial disability or occupation illness that may result in hospitalization of at least three personnel</td>
<td>Injury or occupational illness resulting in one or more lost work days</td>
<td>Injury or illness not resulting in a lost work day</td>
</tr>
<tr>
<td>Effect on Environment</td>
<td>Irreversible severe environmental damage that violates law or regulation</td>
<td>Reversible environmental damage causing a violation of law or regulation</td>
<td>Mitigatable environmental damage without violation of law or regulation where restoration activities can be accomplished</td>
<td>Minimal environmental damage not violating law or regulation</td>
</tr>
<tr>
<td>Monetary Damages</td>
<td>Damage exceeding $10M but less than $10M</td>
<td>Loss exceeding $1M but less than $1M</td>
<td>Loss exceeding $100K but less than $1M</td>
<td>Loss less than $100K</td>
</tr>
</tbody>
</table>

### EHS PROBABILITY

<table>
<thead>
<tr>
<th>A Frequent</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurs at least once a month</td>
<td>I A</td>
<td>II A</td>
<td>III A</td>
<td>IV A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B Probable</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurs no more than once a month</td>
<td>I B</td>
<td>II B</td>
<td>III B</td>
<td>IV B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C Occasional</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurs no more than 4 times a year</td>
<td>I C)</td>
<td>II C</td>
<td>III C</td>
<td>1IV C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D Remote</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurs not more than once a year</td>
<td>I D</td>
<td>II D</td>
<td>III D</td>
<td>IV D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E Improbable</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurs no more than once in 5 years</td>
<td>I E</td>
<td>II E</td>
<td>III E</td>
<td>IV E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F Eliminated</th>
<th>Catastrophic I</th>
<th>Critical II</th>
<th>Marginal III</th>
<th>Negligible IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does Not Occur</td>
<td>IV F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

- **1.3** HIGH: Air Force Acquisition Executive Approval Required
- **4.7** SERIOUS: KC-46 Program Executive Officer Approval Required
- **6.12** MEDIUM: KC-46 Program Manager Approval Required
- **13.17** LOW: KC-46 Chief Engineer Approval Required
- **18.20** NEGLIGIBLE: KC-46 Chief Systems Engineer Approval Required
- **21** ELIMINATED: Not Required

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Risk Acceptance Management Level

<table>
<thead>
<tr>
<th>Risk Assessment Value</th>
<th>Risk Category</th>
<th>Risk Acceptance Management Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>I A to II A</td>
<td>High</td>
<td>Air Force Acquisition Executive</td>
</tr>
<tr>
<td>I C to II C</td>
<td>Serious</td>
<td>Program Executive Office for Tankers</td>
</tr>
<tr>
<td>I D to I E</td>
<td>Medium</td>
<td>KC-46 System Program Manager</td>
</tr>
<tr>
<td>IV A to IV E</td>
<td>Low</td>
<td>KC-46 System Program Manager</td>
</tr>
<tr>
<td>IV F</td>
<td>Eliminated</td>
<td>Not Required</td>
</tr>
</tbody>
</table>
## KC-46 EHS Hazard Risk Assessment Summary

**AFLCMC… Providing the Warfighter’s Edge**

### SEVERITY

<table>
<thead>
<tr>
<th>PROBABILITY</th>
<th>CATASTROPIC I</th>
<th>CRITICAL II</th>
<th>MARGINAL III</th>
<th>NEGLIGIBLE IV</th>
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</thead>
<tbody>
<tr>
<td><strong>A FREQENT</strong>&lt;br&gt;Occurs at least once a month</td>
<td>(IA) [0]</td>
<td>(IIA) [0]</td>
<td>(IIIA) [0]</td>
<td>(IVA) [3]</td>
</tr>
<tr>
<td><strong>B PROBABLE</strong>&lt;br&gt;Occurs no more than once a month</td>
<td>(IB) [0]</td>
<td>(IIB) [0]</td>
<td>(IIIB) [0]</td>
<td>(IVB) [4]</td>
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<tr>
<td><strong>C OCCASIONAL</strong>&lt;br&gt;Occurs no more than 4 times a year</td>
<td>(IC) [0]</td>
<td>(IIC) [0]</td>
<td>(IIIC) [1]</td>
<td>(IVC) [1]</td>
</tr>
<tr>
<td><strong>D REMOTE</strong>&lt;br&gt;Occurs not more than once a year</td>
<td>(ID) [0]</td>
<td>(IID) [3]</td>
<td>(IIID) [28]</td>
<td>(IVD) [1]</td>
</tr>
<tr>
<td><strong>E IMPROBABLE</strong>&lt;br&gt;Occurs no more than once in 5 years</td>
<td>(IE) [23]</td>
<td>(IIE) [15]</td>
<td>(IIIE) [27]</td>
<td>(IVE) [1]</td>
</tr>
<tr>
<td><strong>F ELIMINATED</strong>&lt;br&gt;Does not occur</td>
<td>(IV) [11]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## EHS Hazard Risk by Category

### Risk Level

<table>
<thead>
<tr>
<th>Hazard Category</th>
<th>Medium</th>
<th>Low</th>
<th>Eliminated</th>
<th>Totals</th>
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</thead>
<tbody>
<tr>
<td>Occupational Health - Confined Space</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>7</td>
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<tr>
<td>Occupational Safety - Fall from Elevation</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Occupational Health - Others*</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td>17</td>
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<tr>
<td>Occupational Safety - Hazardous Energy</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>11</td>
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<tr>
<td>Occupational Safety - Ordnance</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Occupational Health - Ergonomics</td>
<td>1</td>
<td>40</td>
<td>4</td>
<td>45</td>
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<tr>
<td>Occupational Safety - Fall on Same Level</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Environment</td>
<td>0</td>
<td>12</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Occupational Safety - Others**</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>27</td>
<td>80</td>
<td>11</td>
<td>118</td>
</tr>
</tbody>
</table>

*Chemical exposure, ionizing and non-ionizing radiation, noise
**Body strike, multiple safety hazards
Value of Systems Engineering Process to ESOH

- Systems Engineering is best fit for ESOH
  - Broad coverage for Weapon System throughout Life Cycle
  - Systems Engineering is Separate Team in KC-46 under Development IPT
  - Tracks Specification Implementation through initial/detailed design to final verification (all report to SE with evaluations)
  - Manages Airworthiness and MFR process for SPM
  - ESOH Capabilities were added early in process
    - Started with SRD preparation (based on AMC developed CDD)
    - RFP preparation (SOO & example CRDLs, Recommendations for Offerors)
    - PESHE
  - Contract Award (start of Milestone activities)
Lessons Learned

- As always, the earlier the better
- Vigilance is required by ESOH acquisition practitioners!
- Input from user on adverse ESOH impact is great!
- If isn’t in the contract it will not happen (difficult to support EIS) if HM, pollutant and noise reduction are not in RFP & contract!
- Templates used to create acquisition documents may not incorporate ESOH (check everything)
- ESOH, HM elimination or reduction requirements and technologies change during acquisition process
Contact

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KC-46 Program
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QUESTIONS?