Replacement Tanker for USAF – ESOH Protection Using Systems Engineering

John Stallings
AFLCMC/WKC

U.S. AIR FORCE

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

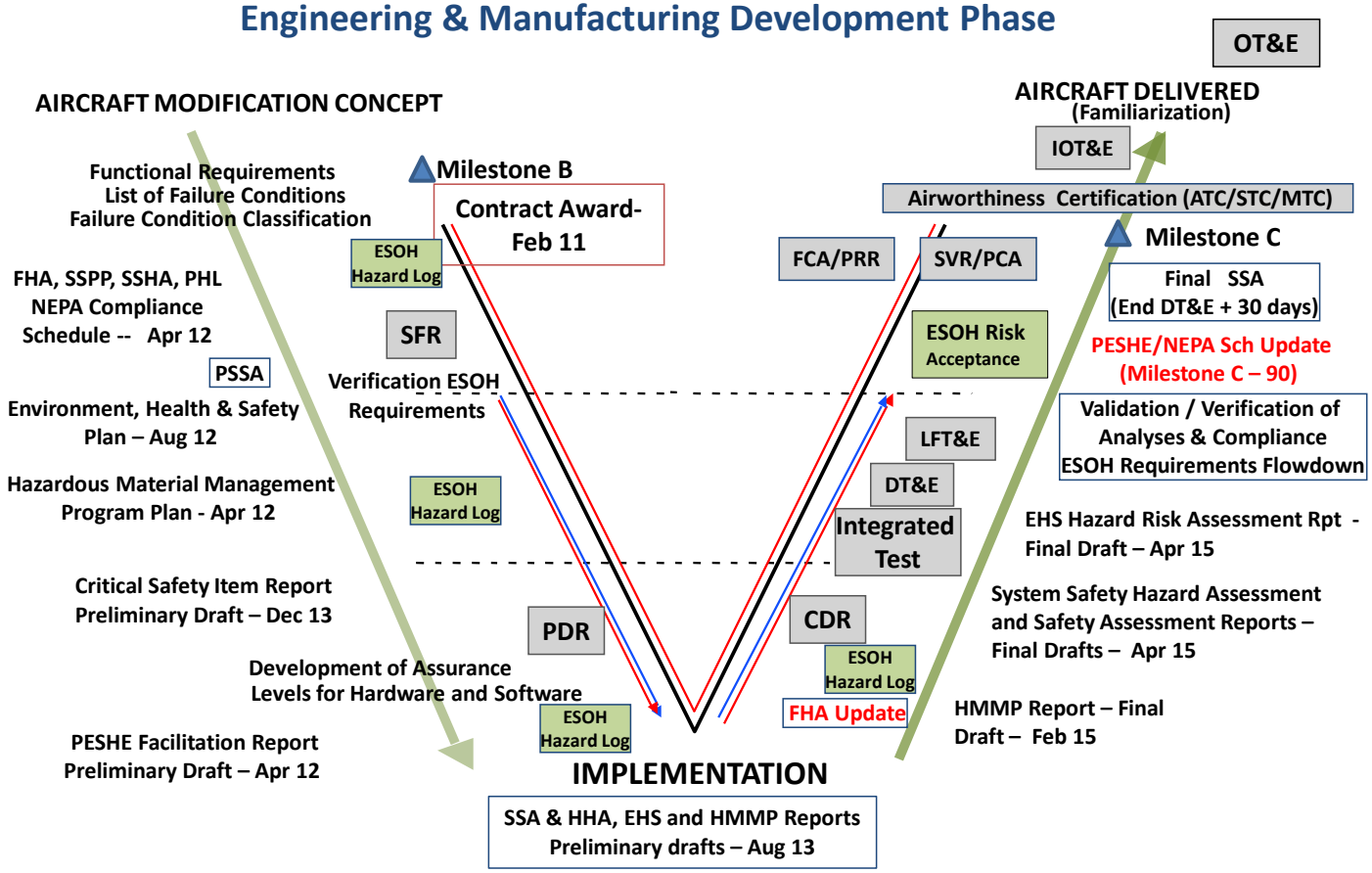
ESOH Systems Engineering Process

- 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



7 May 15

Program of Record

AFLCMC… Providing the Warfighter's Edge

- **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

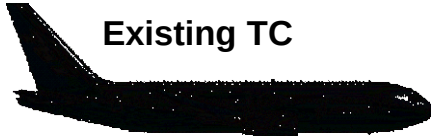
Delivering an advanced, multi-mission tanker on-time, on-cost … ready for war on day one!

Aircraft Development with FAA

U.S. AIR FORCE

AFLCMC… Providing the Warfighter's Edge

Existing TC



767-200ER Baseline
(767-200 TCDS)

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

-300F Wing
-300F Landing Gear
-400ER Sect 48
-400ER APU
Revise Doors
Add Cargo Features
Provision for Body Tanks

767-2C Provisioned Freighter
Structural Capability

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

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

Military Type Certification (MTC)

ATC

767-2C Provisioned Freighter

+

STC / non-FAA MTC

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

=

KC-46A Tanker

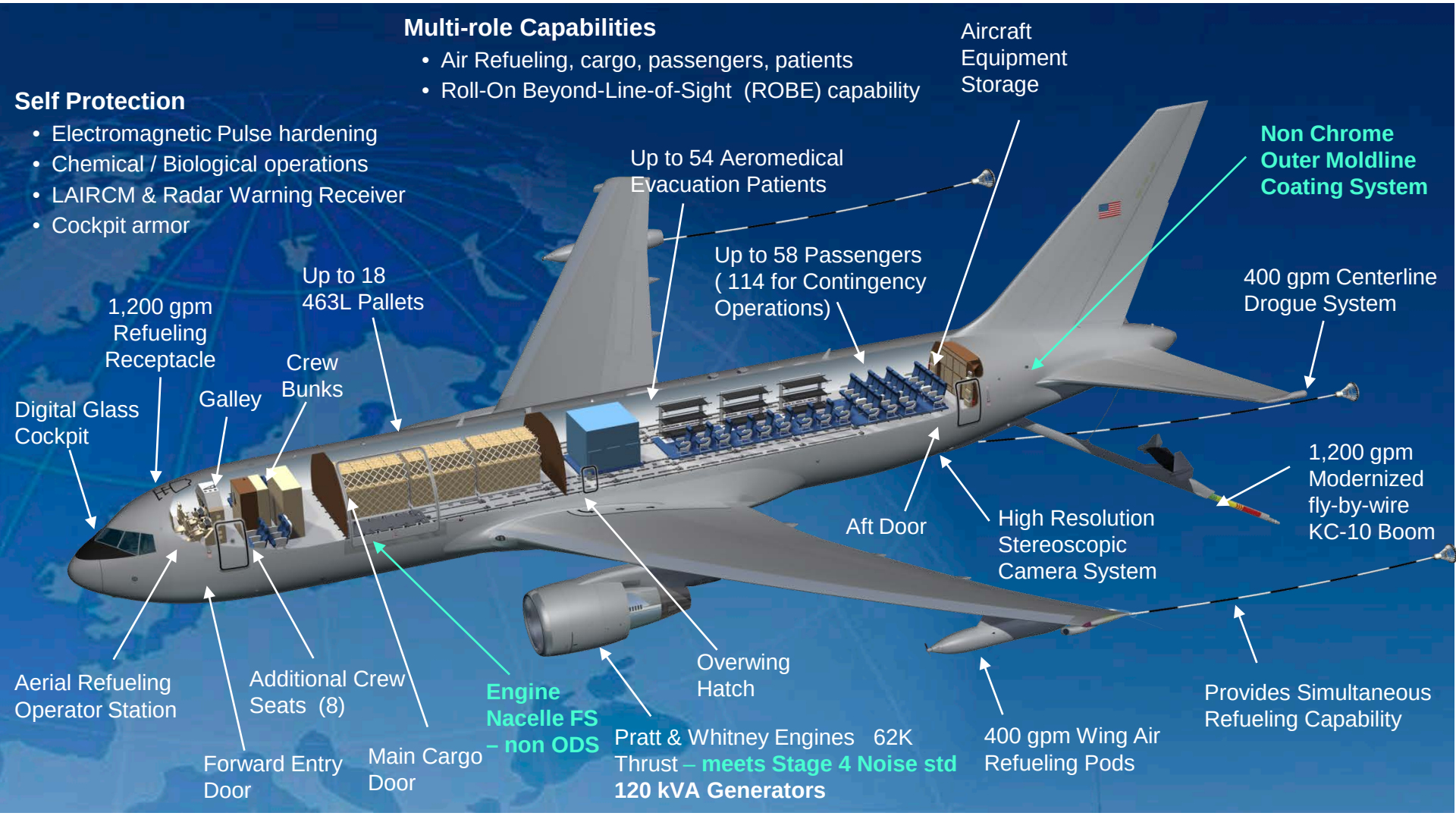
Delivery to USAF

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

U.S. AIR FORCE

Key Capabilities

AFLCMC… Providing the Warfighter's Edge



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

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

U.S. AIR FORCE

AFLCMC… Providing the Warfighter's Edge

Mishap Severity ▪ Airworthiness ▪ MIL-STD-882D (Dollar figures modified by DoDI 6055.07)	▪ 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 days(s), loss exceeding $100K but less than $1M, or mitigatible 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	▪ Slight reduction in safety margins

Software Functional DAL (DO-178B) *Hardware Functional DAL (DO-254)*			Level A	Level B	Level C	Level D	Level E
FAA (AC 25.1309-1B draft)			**A** Catastrophic	**B** Hazardous	**C** Major	**D** Minor	**E** No Effect
	FAA (AC 25.1309-1A)		Catastrophic	Major		Minor	
		KC-46 Program	Catastrophic **I**	Critical **II**	Marginal **III**	Negligible **IV**	Designed Out **V**
No Probability Requirement	Probable 1	**A** Frequent 1 Continuously experienced	1	3	7	13	21
Probable 10^{-3}		**B** Probable 1 Will occur frequently	2	5	9	16	22
Remote 10^{-5}	Improbable 10^{-5}	**C** Occasional 10^{-5} Will occur several times	4	6	11	18	23
Extremely Remote 10^{-7}		**D** Remote 10^{-5} Unlikely, but can reasonably be expected to occur	8	10	14	19	24
Extremely Improbable 10^{-9}	Extremely Improbable 10^{-9}	**E** Improbable 10^{-9} Unlikely to occur, but possible	12	15	17	20	25

ESOH HRI Matrix (R1.0 PC12)
KC-46 NewGen Tanker

FAA ■ Acceptable ■ Unacceptable

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

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	Catastrophic (I)	Critical (II)	Marginal (III)	Negligible (IV)
Effect on Personnel	Death, permanent total disability	Permanent partial disability or occupation illness that may result in hospitalization of at least three personnel	Injury or occupational illness resulting in one or more lost work days	Injury or illness not resulting in a lost work day
Effect on Environment	Irreversible severe environmental damage that violates law or regulation	Reversible environmental damage causing a violation of law or regulation	Mitigatible environmental damage without violation of law or regulation where restoration activities can be accomplished	Minimal environmental damage not violating law or regulation
Monetary Damages	Damage exceeding $10M	Loss exceeding $1M but less than $10M	Loss exceeding $100K but less than $1M	Loss less than $100K
EHS PROBABILITY	**Catastrophic I**	**Critical II**	**Marginal III**	**Negligible IV**
A Frequent Occurs at least once a month	**I A**	**II A**	**III A**	**IV A**
B Probable Occurs no more than once a month	**I B**	**II B**	**III B**	**IV B**
C Occasional Occurs no more than 4 times a year	**I C)**	**II C**	**III C**	**1IV C**
D Remote Occurs not more than once a year	**I D**	**II D**	**III D**	**IV D**
E Improbable Occurs no more than once in 5 years	**I E**	**II E**	**III E**	**IV E**
F Eliminated Does Not Occur	**IV F**			

1-3	HIGH	Air Force Acquisition Executive Approval Required
4-7	SERIOUS	KC-46 Program Executive Officer Approval Required
8-12	MEDIUM	KC-46 Program Manager Approval Required
13-17	LOW	KC-46 Chief Engineer Approval Required
18-20	NEGLIBILE	KC-46 Chief Systems Engineer Approval Required
21	ELIMINATED	Not Required

Risk Acceptance Management Level

Risk Assessment Value	Risk Category	Risk Acceptance Management Level
I A to II A	High	Air Force Acquisition Executive
I C to II C	Serious	Program Executive Office for Tankers
I D to I E	Medium	KC-46 System Program Manager
IV A to IV E	Low	KC-46 System Program Manager
IV F	Eliminated	Not Required

KC-46 EHS Hazard Risk Assessment Summary

U.S. AIR FORCE

AFLCMC… Providing the Warfighter's Edge

SEVERITY / PROBABILITY	CATASTOPHIC I	CRITICAL II	MARGINAL III	NEGLIGIBLE IV
A FREQENT Occurs at least once a month	(IA) **[0]**	(IIA) **[0]**	(IIIA) **[0]**	(IVA) **[3]**
B PROBABLE Occurs no more than once a month	(IB) **[0]**	(IIB) **[0]**	(IIIB) **[0]**	(IVB) **[4]**
C OCCASIONAL Occurs no more than 4 times a year	(IC) **[0]**	(IIC) **[0]**	(IIIC) **[1]**	(IVC) **[1]**
D REMOTE Occurs not more than once a year	(ID) **[0]**	(IID) **[3]**	(IIID) **[28]**	(IVD) **[1]**
E IMPROBABLE Occurs no more than once in 5 years	(IE) **[23]**	(IIE) **[15]**	(IIIE) **[27]**	(IVE) **[1]**
F ELIMINATED Does not occur	(IV) **[11]**			

EHS Hazard Risk by Category

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

*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 Airwothiness 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

John H. Stallings

(937) 255-5944

Air Force Life Cycle Management Center

Tanker Directorate

KC-46 Program

john.stallings@us.af.mil

QUESTIONS?