Systems Engineering to Ensure Aircraft Airworthiness

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Sustainment Environment

727th Aircraft Sustainment Wing

Col. Paul Waugh
Commander

Mr. Bob Valdez
Deputy Director

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PROVIDING EFFECTIVE & EFFICIENT WEAPON SYSTEM SUPPORT
327th ASW Responsibilities

- 1503 Aircraft Mgd (357 Inactive)
- 28,000+ Engines Mgd 51 types
- 1382 Air Traffic Control & Landing Sys Mgd
- 62 Weapon Systems 33 ATCALS
- 153 Program Depot Maintenance Completed
- FY07 $3.3B Obligation Authority
- FY07 24 Commands
- $14.8B Contracts Managed In FY07
- 212 USAF Bases 41 FMS Nations
- 327 ASW

- 327th ASW Responsibilities

- FY07
- 153 Program
- Depot Maintenance Completed

- FY07
- $3.3B Obligation Authority

- $14.8B Contracts Managed In FY07

- 212 USAF Bases
- 41 FMS Nations

- 327 ASW
- 327th ASW Responsibilities

- 327th ASW

So What is the Airworthiness Problem?

- Airworthiness is a requirement for all aircraft, whether FAA or DoD
- Tinker AFB manages 20-plus different types of CDA
  - Aircraft use a mixture of FAA and Air Force criteria and methods of compliance to verify airworthiness when modifying the aircraft
- Modifying a CDA by a process that combines both FAA Certification and Air Force Certification could result in a hybrid safety standard.
  - Such a standard is unproven by either the FAA or the DoD, and could therefore put the aircraft and crew at risk
- No planning and implementation process to ensure comprehensive and complete airworthiness of all designs and parts
- No tracking the organization’s progress regarding airworthiness for upper management in a fleet of over 400 aircraft throughout the entire lifecycle of the CDA
Airworthiness Project Overview

• Problem Statement
  – Current practices do not ensure 100% of CDA modification design/parts are correctly certified for airworthiness.

• Project Definition and Scope
  – 727 ACSG aircraft (CDA) sustained by Boeing
  – Airworthiness certification to cover various (FAA & Military) compliance methods
  – Review and “Walk” the entire process in both orgs
  – Define Responsibility Accountability Authority (RAA) for any process decision pts
  – Ensure certification means supports lifecycle sustainment
  – Must include metrics for upper management visibility
**Airworthiness certification requirements and RAA’s not well defined by FAA, Government or Contractor**

**No comprehensive airworthiness certification plan**

**No control mechanisms in place to measure airworthiness**
GAPS

• Government does not clearly state airworthiness requirement to contractors
• Responsibility, Accountability and Authority (RAA) not well defined by FAA, Government or Contractor
• No comprehensive airworthiness certification plan
  – Plan not done early in modification process
  – Plan not coordinated between Government, FAA and Contractor
• No control mechanisms in place to measure airworthiness
Gap #1: Requirements Not Clear

- Airworthiness very briefly mentioned
- Rarely states what type airworthiness certification required
- Rarely addresses parts
- Rarely addresses life cycle cost/sustainment aspects
- Does not address who/when airworthiness decisions will be made
- Examples....
Airworthiness SOW Language Examples

- “The contractor shall obtain FAA approval for this modification…”
- “Any equipment installed as part of this modification not covered with full FAA certification must be…”
- “Obtain FAA approval for engineering drawings…”
- “This SOW directs the contractor to provide an FAA approved modification…”
- “Contractor shall obtain FAA approval where applicable…”
- “Contractor shall obtain FAA where practical…”
Gap #2: RAA Not Well Defined

- Responsibility, Accountability and Authority (RAA) not well defined by FAA, Government or Contractor
- Neither Gov’t nor Contractor have policy in place defining who makes airworthiness decisions throughout process
  - Design: Not clear who decides which of design cert will be followed
  - Parts: Decisions made at various levels, part “pedigree” often assumed, or not given consideration to life cycle cost
GAP #3: No Certification Plan

- MIL-HDBK-516B describes criteria, but not implementation and planning
- Currently no certification plan required for modification
- No plan provided up-front regarding all designs and all parts
- Government usually does not find out until end what the certification is
GAP #4: No Control Measures

- How much FAA certified and how much Military certified?
- Which design certification methods used?
- What are the pedigrees of all the parts?
- Does the actual delivered modification match the planned?
- How can you keep your SPM and Chief Engineer informed of this important topic before the signing of the DD Form 250?
So What Are Doing About It?

- Instigated a step-by-step Operating Instruction to implement air worthiness management throughout the organization
- Implemented tangible approach that is:
  - Aimed at the working level
  - Applies to both contractor and Air Force
  - Applicable throughout entire organization
  - Accounts for status/progress through metrics
  - Always starts with requirements
4 Solution Recommendations

- Improve SOW wording (Requirements)
- Complete airworthiness approach/certification plan for both design and parts early
- Clearly define decision making authority for each airworthiness condition
- Establish control measures to verify 100% certification of designs and parts and keep upper management informed
Sol’n #1: Improved SOW Words

- OI contains decision tree which will drive appropriate level of airworthiness requirements
- Airworthiness certification requirements expanded and clarified to contractor
- OI contains “cut-and-paste” template SOW language for modification contracts
- Templates available for:
  - FAA Airworthiness Certification
  - Non-FAA Airworthiness Certification
  - Airworthiness Sustainment Requirements (Parts)
  - Airworthiness Documentation
Sol’n #2: Airworthiness Cert. Plan

• The Airworthiness Certification Plan Must:
  – Be delivered NLT System Requirements Review
  – Cover 100% of planned design
  – Cover 100% of planned parts
    • Instructions for Continued Airworthiness (ICA)
    • Sustainment plan to ensure availability of airworthy parts throughout life cycle
  – For all non-FAA parts or design, must have SPM or Chief Engineer approval
  – Account for life cycle maintenance
  – Deliver applicable airworthiness certification documentation
  – Include specific control measures (metrics) to track health
Sol’n #3: Decisions at Right Level

• Clearly define decision making authority for each airworthiness condition
  • OI contains detailed matrix for each certification method, part certification and documentation requirement
  • OI clearly defines for each condition what level has approval authority
    – Chief Engineer or Single Manager
    – Engineering Flight Director
    – Lead engineer or program manager
  • Boeing make similar changes to their internal processes
Sol’n Gap #4: Developed Metrics

- Establish control measures to track the following:
  - Design/part certification method
  - Design certification breakout
  - Part certification breakout

- Start tracking at beginning and continue through delivery
  - Brief to Upper Management Quarterly
  - Metrics must have ability to roll-up
  - For a collection of modifications
  - For entire aircraft
  - For entire organization
Design/Part Certification Method

**DESIGN**
- FAA: 40%
- Military: 60%

**PARTS**
- FAA: 15%
- Military: 85%

**NOTIONAL DATA**
- FAA represents fully commercial compliant
- Military is anything but fully commercial compliant
Design Certification Breakout

Total Mods

NOTIONAL DATA
Part Certification Breakout

[Bar chart showing NOTIONAL DATA for Total Parts distribution across different categories: FAA Appr Part, Replaced by 155 station, TCSTC Part, FAA Distributor, AIC Unique Part, MIl Qual Part, COC, TBD for SRR]
New Process to Ensure Airworthiness

Fixed Gaps

**Strengthened SOW language, defined intent and established clear RAA**

**Ensured cert approach in place before SRR**

**Implemented control measures (metrics) to verify both designs and parts**

- **Input/Output**
- **Task**
- **Decision**
- **Connector**
- **Record**
- **Control Point**
Summary

- Focuses on airworthiness certification planning and implementation rather than establishment of airworthiness certification criteria
- Provides a standardized proactive airworthiness certification management process consistent with Air Force policy
- Provides a process to ensure airworthiness certification requirements are an integral part of program management—contractor and DoD
- Ensures “the right” airworthiness certification requirements, for both design and parts, are identified, implemented, monitored, controlled, and reported.
## Parking Lot Gaps

<table>
<thead>
<tr>
<th>Gap</th>
<th>727 ACSG</th>
<th>Boeing</th>
<th>ASC/FAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(G1) MACC’s not being prepared for each modification</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(G1a) Cert plans that are generated by contractor are not coordinated with Government</td>
<td></td>
<td>X</td>
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<tr>
<td>(G2) No approach in 727 ACSG for military certification path</td>
<td>X</td>
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<tr>
<td>(G2a) Contractor processes do not support military certification path or have firm understanding of military airworthiness requirements (i.e. AFPD 62-6, AFPD 62-4, AFPD 62-5, MIL-HDBK 516B)</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>(G3) User and contractual requirements provide insufficient details to ensure airworthiness certification for 100% of designs/parts</td>
<td>X</td>
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<tr>
<td>(G3a) Definitive definition of correct level of certification has not been provided by FAA</td>
<td></td>
<td>X</td>
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<tr>
<td>(G3b) Definitive definition of correct level of certification has not been provided by ASC/EN</td>
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<td>X</td>
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<tr>
<td>(G3c) Contractor processes do not support different methods of airworthiness certification or incorporate FAA order 8110</td>
<td></td>
<td>X</td>
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<tr>
<td>(G4) Responsibility, Accountability, Authority (RAA) is not defined or documented on Government or contractor side resulting in Program Managers, Equipment Specialists making airworthiness decisions on designs/parts</td>
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<tr>
<td>(G4a) Contractor does not have defined and documented RAA’s for airworthiness decisions</td>
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<td>X</td>
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<tr>
<td>(G4b) FAA has not defined and documented RAA’s for airworthiness decisions</td>
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<td>X</td>
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<tr>
<td>(G4c) ASC/EN has not defined and documented RAA’s what airworthiness decisions should be made at what level for the different methods of certification</td>
<td></td>
<td>X</td>
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<tr>
<td>(G5) Airworthiness certification for entire provisions only installation not attained</td>
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<tr>
<td>(G6) Methods of maintaining continued airworthiness not fully understood</td>
<td>X</td>
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<tr>
<td>(G6b) Sustainment and modification teams on ASC/EN team not integrated</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(G6a) Sustainment and modification teams on contractor team not integrated</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(G7) Contract requirements impact on existing airworthiness decisions not understood</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>(G8) Sustainment (parts or services procurement and repair) not necessarily in accord with design/certification basis</td>
<td>X</td>
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<tr>
<td>(G8a) Contractor sustainment teams are not involved with new mod development</td>
<td></td>
<td>X</td>
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<tr>
<td>(G9) FAA certification of COTS do not play well together</td>
<td>X</td>
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<tr>
<td>(G9a) Air Force customer mission requirements and airworthiness requirements do not support each other</td>
<td>X</td>
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</table>
## RCM Template

<table>
<thead>
<tr>
<th>Event</th>
<th>Requirement</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Effort kickoff or major review/change</td>
<td>• Identify scope of modification, including functions/ capabilities affected/incorporated, major hardware elements and LRUs, areas of a/c affected, and system or systems involved.</td>
<td></td>
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</tr>
</tbody>
</table>
| 1 Overall Certification | • R1 – Prepare an integrated airworthiness certification plan to accomplish comprehensive design certification.  
• R2 – Provide Instructions for Continued Airworthiness to permit aircraft sustainment in accordance with certified design  
• R22 – Provide control measures (metrics) to track design/part certification method, part certification breakout and design certification breakout on or before SRR with updates to metrics throughout modification program  
• R23 – Provide delivery dates for metrics and supporting data in program integrated master schedule. | Step 1 | Step 2 | | |
| 2 Are there portions of the modification which can/should be fully FAA certified? That is elements (A) which are:  
• Similar/identical to widespread commercial requirements  
• Similar to private initiatives in effects on airworthiness, flight characteristics, operational characteristics, or pilot technique  
• Are similar to private initiatives in aircraft usage or implementation of mission or interior accommodations  
• Can meet all applicable FAA regulations and the same requirements for a commercial modification. | • R3 – Obtain FAA approval/certification for (A) equipment/ capability implementation in accordance with requirements applicable to aircraft operating under FAR Part (91, 121, etc. as applicable). | Step 3 | | Step 5 |
| 3 Are there adaptations or alterations of commercial aviation equipment required to suit military or mission requirements? | • R4 – Modify (E) to provide capabilities (Z)  
• R5 – Obtain FAA certification for (E), as modified | Step 3a | | |
| 3 Will existing STCs (S) be partially changed as a result of this modification? | • R18 – Obtain FAA approval of changes to (S)  
 Gov’t note: Military a/c primarily don’t maintain the airworthiness certificate (from the strict FAA stance). Recommend that a technical risk. | Step 3a | | |
## RCM Template

### Event | Requirement
--- | ---
5 | **Are there elements of the modification which cannot be approved for carriage by the FAA (B)?**
   Examples include:
   - Hazardous materials or equipment
   - Equipment which cannot be demonstrated to be safe even when not operating

6 | **Will military qualified equipment (C) be needed/used in the modification?**
   - **R7** – Obtain FAA installation certification/approval for (C) using military qualification and operational data.
   - **R8** – Perform necessary analysis to support FAA certification/approval for (C)
   - **R9** – Perform additional testing required to support FAA certification/approval for (C)

7 | **Will the modification use/apply non-aviation commercial- or consumer-grade equipment**
   - **R10** – Perform safety analyses covering use and operation of (L)
   - **R11** – Obtain FAA certification/approval for (J)
   - **R 12** – Identify any equipment in (L) which is unsafe or hazardous when applied to this modification (H)

8 | **Is there hazardous commercial/consumer equipment?**
   - **R13** – Design enclosures and/or accommodations to control hazards posed by (H)
   - **R14** – Obtain FAA certification/approval for enclosures and/or accommodations for (H)

9 | **Is there doubt that sustainment parts and repairs can be readily obtained for FAA certified design, throughout the life of the modification?**
   - **R15** – Develop a sustainment plan to ensure availability of FAA parts repair capability throughout the life of the modification
   - **R16** – Develop a sustainment plan to ensure availability of FAA replacement parts throughout the life of the modification
   - **Gov’t note**: Requires a Logistics Support Analysis to determine right path FAA or not – don’t assume pure FAA is the right approach.

### Step
- **Step 6**
- **Step 7**
- **Step 8**
- **Step 9**
- **Step 10**
## RCM Template

<table>
<thead>
<tr>
<th>Event</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Are there elements (M) that will not be FAA certified?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 11    | Are there elements B? | • R18 – Conduct analyses, tests, and demonstrations to qualify (B)  
• R19 – Prepare and submit data to support certification of (B) for airworthiness, including operation in-flight | Step 12 | Step 12 |
| 12    | Are there elements K? | • R20 – Conduct analyses, tests, and demonstrations to demonstrate/develop safe installation and use of (K)  
• R21 – Prepare and submit data to support certification or approval of (K) for installation and use | Step 13 | Step 13 |
| 13    | Military Certification | • R21 - Conduct necessary analyses, test, and demonstrations to support airworthiness and operations approval for (M) |             |
RCM Template Key

- A  Elements of modification which may receive full FAA certification/approval
- B  Military only elements of the modification – those which cannot be approved for installation by FAA and require provisions only approval
- C  Military qualified equipment for which FAA certification may be obtained
- E  Commercial aviation equipment which must be altered or adapted to meet military requirements (subset of A)
- H  Non aviation commercial or consumer equipment which is unsafe or poses hazards which cannot be mitigated (subset of L)
- J  Non aviation commercial or consumer equipment which may be FAA certified (subset of L)
- K  Non aviation commercial or consumer equipment which cannot be FAA certified or for which accommodations cannot be designed to permit certification (subset of L and possibly H)
- L  Non aviation commercial or consumer equipment needed/used as part of modification
- M  Elements requiring military airworthiness certification (Includes B and K)
- S  Existing STCs modified in the course of the current modification
- Z  Capabilities or features for military purposes which must be incorporated into commercial aviation equipment
Basic Systems Engineering Process

INPUTS

Requirements Analysis

Functional Analysis/Allocation

Design Synthesis

Requirements Loop

Verification Loop

Design Loop

OUTPUTS

Analysis & Control
### Major Modification Programs

<table>
<thead>
<tr>
<th>Program Description</th>
<th>ACAT Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>KC-10 AMP – ASC Lead (ACAT II)</td>
<td>$1.03B</td>
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</tr>
<tr>
<td>KC-10 Dual 406 MHz ELT Upgrade (ACAT III)*</td>
<td>$2.4M</td>
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<tr>
<td>KC-10 Iridium Phone (ACAT III)*</td>
<td>$2.7M</td>
<td></td>
</tr>
<tr>
<td>KC-10 UHF SATCOM Antenna (ACAT III)*</td>
<td>$2.6M</td>
<td></td>
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<tr>
<td>VC-25 Forward Lower Lobe (FLL) Cooling (ACAT III)</td>
<td>$14.4M</td>
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<tr>
<td>VC-25 Presidential Data System (PDS) (ACAT III)*</td>
<td>$223.3M</td>
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<tr>
<td>VC-25 CNS/ATM (ACAT III)*</td>
<td>$41.8M</td>
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<tr>
<td>C-20 Gulfstream Test Vehicle (GTV) (ACAT III)*</td>
<td>$8.7M</td>
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<tr>
<td>E-9 Telemetry Sys Upgrade (ACAT III)*</td>
<td>$5.9M</td>
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<tr>
<td>E-4B Mod Block I (ACAT II)</td>
<td>$421.4M</td>
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<tr>
<td>E-4B 256 Kbps High Speed Data via INMARSAT (ACAT III)*</td>
<td>$8.4M</td>
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<tr>
<td>C-12 EFIS (ACAT III)</td>
<td>$77.7M</td>
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<tr>
<td>HFGCS Network Control Station – West (ACAT III)*</td>
<td>$23.2M</td>
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<tr>
<td>HFGCS AFSPC Test Range HF Modernization (ACAT III)*</td>
<td>$3.9M</td>
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<tr>
<td>HFGCS Network Optimization – Spiral II (ACAT III)*</td>
<td>$7.1M</td>
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<tr>
<td>HFGCS Navy Consolidation (ACAT III)*</td>
<td>$6.4M</td>
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<tr>
<td>HFGCS Audit Log Upgrade (ACAT III)*</td>
<td>$189K</td>
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</table>

*Program is fully funded