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# **C-130J Block 7.0 Software Design Acceptance**

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## Overview

- The C-130J
- The C-130J Block Upgrade Program
- The Block 6.1 Upgrade... news flash
- The Block 7.0 Upgrade
- Block 7.0 Software Design Acceptance Activities
  - Scope of ADF involvement in a multinational environment
  - Planning for the activities
  - Software Development Audit





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## The C-130J

- Four engine, turbo-prop, medium airlifter
- 12 aircraft in RAAF fleet
- Roles – Inter and Intra theatre Logistics Support, Airborne Operations, Aeromedical Evacuation, Search and Rescue, Special Operations, Training







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## C-130J Block Upgrade Program

- Established by C-130J owner nations – currently includes United States, United Kingdom, Australia, Italy, Denmark, Canada and Norway
- Provides regular, rolling updates throughout the life of the aircraft, addressing equipment obsolescence and new capability requirements
- Prime Contractor is Lockheed Martin Aeronautics – the OEM
- Establishes a common set of functional and performance requirements
- Each nation can add their own ‘national unique’ requirements as desired
- Common costs are shared proportionally to the user’s fleet size – ie Australia pays about 6% of the common core bill



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## What's Block 6.1

- Common effort between United Kingdom, Denmark, Italy and Australia
- Built from the United States Block 6.0 Build
- Hardware Changes include:
  - New Mission Computer
  - Upgrade IFF for Enhanced Mode S
  - Terrain Awareness Warning System (TAWS)
  - Upgrade to Intercom Central Switching Unit for TAWS messages
  - Upgrade to Auxiliary Hydraulic Pumps for High Altitude Cargo Ramp Door operations
  - Firearm Safe
  - Removal of OLMU (RAAF unique)



## What's Block 6.1 (cont)

- Software Changes include:
  - Migrate TOLD calculations from CNI to MC
  - Ground Collision Avoidance System OFP modification
  - MC update to Advisory, Cautions and Warning System
  - MC update to Electronic Circuit Breaker data tables
  - MC updates to diagnostic and maintenance software
  - MC update for Propeller data capture
  - MC update for Missile Laser Warning System
  - CNI Processor OFP to common multinational build
  - CNI Track Offset
  - CNI update to CARP, Chute and Ballistics data



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## Block 6.1 News flash

- Design Acceptance Strategy based upon RPA from USAF for Block 6.0 and RAF for Block 6.1, and a targeted compliance finding of the RAAF unique software
- Delays with RAF certification effort
- ALSPO had not completed compliance finding activities on RAAF unique
- Uncertainty in software assurance resulted in a 'High' AVRMM risk
- Dec 09 AwB deferred the decision for STC/SR
- AwB rescheduled to Nov/Dec 10





## Block 6.1 News flash

- Found that
  - 84% of RAAF software packages common to USAF (1243)
  - 5% of RAAF software packages common to RAF (74)
  - 7% of RAAF software packages unique to RAAF Block 6.1 (103)
  - 4% of RAAF software packages unique to RAAF (Block 5.4 and other)
- RAF highlighted a number of deficiencies resulting in significant procedural workarounds and limitations:
  - Weight and Balance data transfer
  - TAWS functionality
  - IPRA functionality
  - CNI driftdown and HARP
  - MC derived loading area calculations



## Block 6.1 News flash

- ALSPO compliance finding done in three phases:
  - Phase 1: Determine configuration differences between USAF, RAF and RAAF builds
  - Phase 2: Examine controls and data flow linkages
  - Phase 3: Conduct detailed assessment of evidence against each RAAF unique package against relevant objectives in RTCA/DO-178B
- Risk down from 'High' to 'Medium'
- Options
  - 1: Don't retain risk
  - 2: Wait until compliance findings finalised
  - 3: Retain risk



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## What's Block 7.0

- Block 7.0 is being developed by LM Aero under contract to the 657th AESS International Project Office (IPO) on behalf of all C-130J Joint User Group (JUG).
- The customers include
  - United States Government (USG),
  - Royal Air Force (RAF), Royal Australian Air Force (RAAF),
  - Royal Danish Air Force (RDAF), Aeronautica Militare Italiano (AMI), Canadian Forces (CF), and the Royal Norwegian Air Force (RNoAF)



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## What's Block 7.0

- Changes include:
  - replacement Flight Management System (FMS) including both modified and new software developed by LM Aero and General Electric
  - integration of a Civil Certified Global Positioning System (GPS)
  - re-architecture of the MC to include a Real Time Operating System (RTOS)
  - additions/modifications to functionality of the MC software
  - integration of Tactical Data Link (Link 16)
  - upgrade of the Data Transfer and Diagnostic System (DTADS), and associated impacts of the MC



# Software Design Acceptance Activities

- C-130J Block 7.0 Project Design Acceptance Strategy (PDAS) and Certification Basis Description (CBD) identifies the requirement for a software compliance finding against an appropriate software assurance benchmark.
- The Software Compliance Finding Plan (SCFP) describes those activities forming the Commonwealth software compliance finding for the C-130J Block 7.0 Upgrade Program.
- The purpose is to provide the Commonwealth assurance that the software added or modified as part of C-130J Block 7.0 is acceptably safe for the RAAF C-130J configuration, role and environment.
- The impact of failing to properly execute the SCFP is as follows:
  - limited ADF support to the International Program Office (IPO) software certification resulting in a degraded IPO software certification program
  - limitations in the extent to which an RPA argument can be made for C-130J Block 7.0 software due to potentially implicit retained risk by the USAF; and
  - limited insight into the safety assurance of C-130J Block 7.0 software resulting in potentially high to very high risks being referred to the OAA.



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# Software Design Acceptance Activities

- The USG's software assurance requirements for Block 7.0 are
  - flowed down through the contractual arrangements with LM Aero, and
  - are levered from LM Aero's established software development and verification practices, in conjunction with a substantial USAF test and evaluation program.
- For partner nations, there have been historically different approaches....
- For several of the C-130J partner Nations the use of RTCA/DO-178B has become the basis of acceptance for aircraft avionics software due to its wide international acceptance by civil international certification authorities.
  - Canadian Forces
  - Australian Defence Force (ADF)
  - UK MoD
- Agreement on a current standard across a number of partner Nations will
  - ease past issues related to software acceptance and
  - gives opportunities for Nations to increase their insight and influence as well as maximise the use of consolidated resources and activities.



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# Software Design Acceptance Activities

- Appreciation for the multinational schedule
- Understand the scope of the ADF involvement
- Plan for this in terms of cost, resources and schedule



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# Software Development Audit

- C-130J Block 7.0 Common Core Aircraft Software Audit plan as prepared by the Defense Contract Management Agency (DCMA) and the 657<sup>th</sup> AESS (IPO).
  - proposes software certification be achieved through a series of phased audits of LM Aero and GE developed software for C-130J Block 7.0 against the RTCA/DO-178B benchmark.
    - SOI#1 Planning Audit
    - SOI#2 Development Audit
    - SOI#3 Verification Audit
  - examine key product and process evidence articles to establish that the objectives of RTCA/DO-178B have been achieved.
  - draw specialist support from technical specialists within the UK Defence Science and Technical Laboratories (DSTL) and QinetiQ, and from the RAAF.



# Software Development Audit - Overview

- SOI#2 Development audit was conducted in May 10
- Purpose was to explore LM Aero's equivalence claims against the development objectives set in RTCA/DO-178B Level A
  - the audit team also examined the extensiveness of evidence produced by LM Aero with respect to the safety of software added or modified as part of the C-130J Block 7.0.
  - underpins a broader argument as to if the product could be acceptably safe.
  - inform the IPO and Partner Nations judgements on the safety and robustness.
- To provide an assessment of Block 7.0 software assurance of design development aspects, the audit used:
  - the objectives of RTCA/DO-178B
  - RTCA/DO-248 Final Report for Clarification of DO-178B - Software Considerations in Airborne Software Systems Certification and Equipment Certification of 12 Oct 2001
  - FAA Order 8110.49 Software Approval Guidelines of 03 Jun 2003
  - FAA Job Aid – Conducting Software Audit Review



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## Software Development Audit - Aims

- Identify compliance and shortfalls against satisfaction of the applicable software assurance objectives for the design development lifecycle phase;
- Identify product features and shortfalls with respect to the software architecture, including fault tolerance mechanisms, and functional requirements underpinning safety or robustness objectives;
- Propose an assessment of the impact of the compliance/shortfalls on safety objectives;
- Propose potential resolution strategies for any shortfalls for consideration by LM Aero;
- Inform the customer certification on Block 7.0 software; and
- Provide LM-Aero the opportunity to resolve any identified shortfalls at a phase of the lifecycle which results in the least cost and schedule impact.



**Day 1**

Time	Topic	Required Personnel
0900-0930	Introductions/Familiarisation/Tour	
0930-1030	Audit Opening Brief	Audit Team, LM Aero Software Engineering Manager
1030-1200	MC Software Architecture / System Overview Critical System Requirements -functional requirements -allocation to software and hardware	Audit Team, LM Aero Systems and Software Engineers
1200-1300	LUNCH	
1300-1400	Identify CSCIs -assess software safety analysis, and CSCI to software level assignment -identification of software teams, processes, and tools applicable to each CSCI	Audit Team, LM Aero Systems Engineers
1400-1630	Software Reuse -assess proportion of software reuse/new development in specific terms (functions, s/w architecture, etc) for each significant CSCI -CSCI ancestry (requirements, functions, s/w architecture, processes applied) -configuration management (including historical) -problem reporting history -development environment	Audit Team, LM Aero Software Engineers
1630-1700	Audit Team Consolidation and Documentation	Audit Team

**Day 2**

Time	Topic	Required Personnel
0830-0900	Clarification on Previous Day's Findings	Audit Team
0900 - 1000	Software System Safety -system safety analysis -software safety analysis	Audit Team, LM Aero System Safety Rep and relevant Software Engineers
1000 - 1200	Software Requirements -requirements management -requirements traceability -derived requirements -software safety requirements -requirements reviews and inspections -requirements analyses	Audit Team, LM Aero Software Eng Manager and Engineers
1200-1300	LUNCH	
1300-1630	System and Software Design -requirements to design traceability -software architecture -derived design requirements -design analysis -design review and approval	Audit Team, LM Aero Software Eng Manager and Engineers
1630-1700	Audit Team Consolidation and Documentation	Audit Team

**Day 3**

Time	Topic	Required Personnel
0830-0900	Clarification on Previous Day's Findings	Audit Team
0900-1200	Software Coding -requirements to design and implementation traceability -coding standard -code reviews and inspection	Audit Team, LM Aero Software Engineers, LM Aero Software Developers/Coders
1200-1300	LUNCH	
1300-1400	Software Coding cont...	Audit Team, LM Aero Software Developers
1400-1500	Software Testing -overall proposed strategy -requirements versus implementation testing -black box versus white box testing -requirements and design traceability	Audit Team, LM Aero Software Test Engineers
1500-1630	Software Testing Results -unit testing and development integration testing – completed so far	Audit Team, LM Aero Software Test Engineers
1630-1700	Audit Team Consolidation and Documentation	Audit Team

**Day 4**

Time	Topic	Required Personnel
0830-0900	Clarification on Previous Day's Findings	Audit Team
0900-1200	Software Tools -requirements, design, code, test, CM, QA -qualification	Audit Team, LM Aero Software Eng Manager and Engineers, LM Aero Software Developers/Coders
1200-1300	LUNCH	
1300-1500	Configuration Management	Audit Team, LM Aero CM
1500-1630	Software Quality Assurance	Audit Team, QA Representatives
1630-1700	Audit Team Consolidation and Documentation	Audit Team

**Day 5**

Time	Topic	Required Personnel
0830-0900	Clarification on Previous Day's Findings	Audit Team
0900-1200	Revisit Issues as Required	TBA
1200-1300	LUNCH	
1300-1500	Audit Brief Preparation	Audit Team
1500-1700	Audit Closing Brief	Audit Team, LM Aero



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## Audit outcomes

- Positive
  - development of high and low level functional requirements documented in CoRE tables and/or T-VEC models
  - software change management and configuration control
  - software reviews and inspections
  - coding practices and the use of SPARK
  - software quality assurance
  - test team independence
  - software lifecycle environment
  - software level assignment



# Audit Outcomes

- Negative
  - evidence of system safety and software safety influence on the MC software requirements and design;
  - development of high and low level requirements on RTOS integration, software architecture including template behaviours and infrastructure coding, and error management
  - evidence of schedulability
  - robustness testing of high and low level requirements
  - the use of test coverage of software structure as a mechanism for establishing the extensive of requirements based verification activities
  - MC/DC equivalence



## Where to for Block 7.0?

- Findings have been tabled to the USG, partner Nations and LM Aero
  - LM Aero response is expected to be forthcoming
  - IPO to take ownership of the recommendations
  - Where USG is not successful, then the Partner Nations to address under individual certification programs
  - Informs the ADF certification on current certification and operational risks
- What's it mean for the product?
  - MC's functionality was likely to be dependable when the system is exposed to 'expected' data from sensors and integrated systems.
  - MC's response to 'unexpected' data from sensors and integrated systems, or failures of these systems lead the audit team to conclude that the MC would likely not be dependable under these conditions.
- SOI#3 Verification Audit to go ahead in the latter part of 2010 / early 2011
- Related audit activities on the FMS are progressing in parallel



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# Questions?