Implementation of the Orbital Maneuvering System Engine and Thrust Vector Control for the European Service Module

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Agenda

- NASA propulsion hardware obligations for ESM
- Hardware Overview
- Design Description and Interface Document
- Implementation
- Current Status
- Conclusion
Crew and Service Module

Multi-Purpose Crew Vehicle (MPCV)
Hardware Obligations

- Under BHSEALS, NASA is obligated to provide ESA
  - Two (2) OMS-E assemblies for EM-1 and flight spare
  - One (1) OMS-E assembly for propulsion system ground testing
  - One (1) OMS-E assembly for EM-2
  - Two (2) TVC assemblies for EM-1 and flight spare
  - Two (2) TVC assemblies for developmental testing
  - One (1) TVC assembly for EM-2
  - Available OMS-E & TVC GSE
  - One (1) OMS-E mass simulator
  - One (1) OMS-E electrical simulator

- Under BDEALS, NASA is obligated to provide ESA
  - OMS-E & TVC design documentation, drawings, and operational histories
  - Models to support performance, structural, and thermal analysis

BILATERAL HARDWARE and SOFTWARE EXCHANGE AGREEMENTS, LISTS, and SCHEDULES (BHSEALS)

BILATERAL DATA EXCHANGE AGREEMENTS, LISTS and SCHEDULES (BDEALS)
Hardware Overview

- **OMS-E Assembly**
  - Engine Subassembly
    - Pneumatic Pack, TCA, BPV, gimbal ring, service lines, and instrumentation
  - Nozzle Extension
  - Heat Shield Assembly

- **TVC Assembly**
  - Pitch Gimbal Actuator
  - Yaw Gimbal Actuator
  - Active Actuator Controller Unit
  - Standby Actuator Controller Unit
  - Electrical Harnesses

- **GSE**
  - Engine Installation GSE
  - Leak Check/Purge GSE
  - Protective GSE
  - TVC GSE
  - Shop Aides
  - Shipping Containers
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- Design Description and Interface Document (DDID) Overview
Design Definition and Interface Document (DDID) will serve as the single source for the design characteristics and interface requirements for the heritage engine and TVC assemblies.

Complete description of design characteristics
- Product and functional descriptions of subassemblies, components (including GSE)
- Mechanical, thermal, electrical design characteristics
- Performance, life characteristics
- Operational envelopes, operational constraints
- Induced and natural environments
- Logistics characteristics

DDID will provide interface requirements to the vehicle
- DDID requirements will flow to subsystem specifications
- DDID requirements flowed to propulsion system specification will flow to engine and TVC specifications
- DDID will also serve as the verification document for compliant engine and TVC requirements
- Design characteristics and interface requirements/verification will be sourced
  - Traceability back to Rockwell specification for requirements
  - Traceability back to qualification reports and certification requests for verification

- DDID will be peer reviewed within NASA
  - Certify the design and interface characteristics are representative of the heritage hardware design

- If modifications or delta qualifications to the heritage hardware are needed for ESM, they will be documented in the Definition File (DF)
  - DF along with DDID will be implemented as a part of the ESM Verification Compliance Document (VCD)
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- Implementation Overview
Implementation Overview

- **5 Key areas to implement the heritage HW**
  - Areas consists of task that are NASA led, Airbus led, or Joint

- **Secure and Maintain Heritage Hardware**
  - Establish inventory in secured storage, maintain inventory until transfer, provide documentation on design and operational history (NASA)

- **Evaluate Suitability of Heritage Hardware Design for ESM**
  - Establish heritage hardware design characteristics (NASA)
  - Develop technical specification for ESM main engine/TVC (Airbus)
  - Identify areas of heritage hardware design non-compliance with ESM (Joint)
  - Develop and execute plans to resolve non-compliances (Joint)
  - Certify heritage hardware is suitable for ESM application (Joint)

- **Select and Prepare Units for Transfer to ESA**
  - Develop selection criteria for units to be transfer (NASA)
  - Prepare units per ATP’s (Shuttle-era w/ any ESM-specific mods) (NASA)
  - Conduct pre-ship/hardware acceptance reviews before each transfer (Joint)
Implementation Overview

- **Develop Assembly, Integration, and Test Procedures**
  - Provide summarized versions of Shuttle-era AI&T procedures (NASA)
  - Provide descriptions of available heritage GSE (NASA)
  - Develop ESM-specific logistics and installation procedures (Airbus)
  - Identify and develop new, ESM-specific GSE (Airbus)
  - Develop procedures for ground tests (Airbus)

- **Install and Maintain Transferred Units**
  - Install ground test and flight units per developed AI&T procedures (Airbus)
  - Provide engineering support during installation and test activities (NASA)
  - Provide engineering support in response to anomalies during installation and test activities (NASA)
Implementation Overview

- Evaluation tasks to determine the suitability of the GFE can be grouped into several broad areas
  - Mechanical Flight Environments
  - Thermal Flight Environments
  - Radiation Flight Environments
  - SSP vs ESM Interfacing Avionics
  - Engine and TVC Performance
  - Mission Life Capability (Pneumatic Pack Capability)
  - Maximum Design Pressure
  - Shelf Life Evaluation
  - Remaining Operating Life
  - Electromagnetic Compatibility/Electromagnetic Interference
  - Engine Alignment
  - Natural Environments
  - Ground and Transportation Environments
  - Logistics (shipping, packaging, identification, human engineering)
  - Acceptance Test Requirements
Implementation Overview

• New hardware developments, that are needed to implement the heritage hardware into ESM, have already been identified
  – OMS-E EGSE (valve actuation, instrumentation)
  – OMS-E Instrumentation
  – TVC Electrical Harnesses (heritage harnesses have insufficient length)
  – TVC EGSE (gimbal actuation; heritage EGSE not recommended for use)
  – Supporting MGSE (e.g., platform for installation stand)
  – Shipping Containers (TVC components, nozzle, GSE)

• Differences in Shuttle-era and current design and construction standards should be evaluated to understand risks involved in use of heritage hardware for ESM
  – Materials and Processes
  – Mechanical Design
  – Structural Design
  – Pressure System Design
  – Electrical Design
  – Cleanliness

• S&MA support will be needed for OMS-E and TVC
  – FMEA, PRA, Hazards data
  – Support hardware test and integration activities
Current Status

- Initial drafts of engine and TVC specification released
  - System and Subsystem PDR used to incorporate comments and RIDs
- Draft DDID (with ESM subsystem interfaces) released for internal and peer review.
  - Will be revised based on review feedback and baselined for release
- Equipment Qualification Status Review (EQSR) schedule for early fall 2014
  - Review used to asses compliance status of GFE with ESM requirements
  - Board approved all plans to resolve noncompliant requirements
- In parallel suitability of GFE is being evaluated in regards to environments, performance, and life
- Shipping container fabrication and GSE revalidation is being conducted
- TVC Disassembly and Inspection with basics functional checks
- Integration support for all test campaigns associated with the ESM and GFE
Conclusion

- Many challenges associated with reusing heritage hardware
  - Heritage design and history, international cooperation, resources, schedule
- Work required for successful implementation has been identified and mapped to Orion schedule to meet EM-1 launch date.