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

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JPC, July 28-30 2014, Cleveland, OH
Multi-Purpose Crew Vehicle (MPCV)

Agenda

- NASA propulsion hardware obligations for ESM
- Hardware Overview
- Design Description and Interface Document
- Implementation
- Current Status
- Conclusion
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
Design Description and Interface Document (DDID) Overview
Design Description and Interface Document

- 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)
Multi-Purpose Crew Vehicle (MPCV)

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 assess 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.