AN OVERVIEW OF THE CONCEPT OF OPERATIONS FOR ASSEMBLY, INTEGRATION, TESTING AND GROUND SERVICING DEVELOPED FOR THE MPCV-ESM PROPULSION SYSTEM

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Overview

• European Service Module (ESM) propulsion system description

• Con-ops for Assembly, Integration, and Testing (AIT)
  – eSTA activities
  – PQM testing at WSTF
  – FM-1 fabrication and testing

• Con-ops for Ground Operations for EM-1 at KSC
The Orion Multi-Purpose Crew Vehicle

- Funding was maintained for Orion MPCV after the Constellation Program was cancelled
- MPCV will fly atop the SLS launch vehicle to support long duration deep space missions
- First flight, EM-1 is unmanned and scheduled for 2017
- EM-2: first manned flight is scheduled for 2021
European Service Module (ESM)
European Roles and Responsibilities

• Under the Constellation Program, Orion was to be designed and manufactured completely by Lockheed Martin

• With the Implementing Agreement signed, ESA and Airbus Space and Defense is responsible for designing, fabricating and qualifying the ESM

• Flight Model-1 will be delivered to NASA for integration into the MPCV for EM-1

• Deliver drawings for the ESM to NASA for reproducibility purposes.
US Roles and Responsibilities

• NASA ESM Integration Office
  – Overall requirements development for EM-1
  – Delivery and Integration OMS-E into the ESM
  – Aux Engines procurement and delivery
  – WSTF Hot-Fire Qualification Testing

• Lockheed Martin
  – Responsible for the CMA, Fairings, and SA
  – Assemble the integrated MPCV at KSC
  – Run the MPCV through qualification testing
  – Deliver the certified vehicle to GSDO

• NASA Ground Systems Development Operations (GSDO)
  – Ground servicing operations for Orion/SLS
  – Stacking, integration, and launch operations
Propulsion System Description
ESM Structural Test Article

- Test article will be first to include propulsion system components
- Built in Italy by an Airbus Subcontractor
- Phase I of Testing: Static Test in Italy
  - Flight-like Propellant Tanks installed as Mass Simulators
  - OMS Qual engine provided to Airbus
    » Mass Simulator
    » Installation Procedures Development
- Phase II of Testing: Dynamic and Pyro Shock Testing at Plum Brook Station
  - LM will add CMA, Fairings, and SA to the ESM test article
  - Propellant tanks will be filled with simulant fluids
  - OMS engine nozzle will be attached
Propulsion System Qualification Testing

- Three distinct propulsion qualification models were planned for PDR
- Hydraulic Models 1&2 will be built and tested in Airbus facilities in Germany
  - HM-1:
    » Breadboard test rig; only fuel side modeled; No PCA or propellant tanks
    » Fluid simulants at pressure provided by facility
    » Feed system isolation valves will be included; flow control valves simulate engines
    » Will conduct basic flow tests to understand feed system pressure drops and transient behaviors like water hammer
    » Testing will validate Airbus mathematical models
  - HM-2
    » PCA and propellant/pressurant tanks will be added (fuel side only)
    » Demonstrate and evaluate system priming
    » Analyze PCA performance
Propulsion Qualification Model (PQM)

• PQM will be built by Airbus in Germany and shipped to WSTF

• The PQM is a self-contained flight representative test article with on-board avionics, propellants, and pressurant gases which will be used for hot fire testing

• Testing will be conducted in the 300 area at WSTF
  – Ambient test stand used to test the Apollo Crew and Service Module propulsion systems
  – Also used during the Shuttle Program

• Modifications to the test stand are currently underway

• Facility engineers will design the test stand to interface with the PQM
PQM Configuration

- Includes both fuel and oxidizer fluidic networks
- Propellant and pressurant tanks
- Pressurization Control Assembly
- Feed system Isolation valves
- OMS-E, 8 auxiliary engines, 12 RCS engines
- Propulsion Drive Electronics (PDE) box

By using the flight like PDE, qualified software and flight like valves, a near end-to-end qualification of the propulsion system is achieved.
Test Objectives

• The priming sequence will be demonstrated.
• System performance during simulated mission profiles will be monitored.
• Pressure drops across all feed line sections will be measured.
• Flow performance will be determined under hot-fire conditions and compared to Airbus mathematical flow models.
• Subsystem hydraulic shocks or water hammer effects will be characterized.
• Opportunities to demonstrate or possibly verify certain ground servicing operation.

The PQM test campaign is the only opportunity to demonstrate the operation of integrated propulsion subsystem with hypergolic propellants.
Flight Model-1 Assembly in Europe

- ESM Structure is partially manufactured and assembled in Italy
- After shipping to Bremen, Germany the final assembly integration and functional testing of the ESM will occur
- ESM structure is separated into a lower and upper platform for parallel processing
  - Propulsion components on the lower platform: auxiliary and RCS engines, feed lines, feed system valves, and the OMS engine
  - On the upper platform: pressurant tanks, the PCA and associated tubing
  - Propellant Tanks and RCS roll thrusters will be installed after the upper and lower platforms are re-assembled
- ESM will be packaged in a special shipping container and shipped to the US
Flight Model-1 Assembly in the US

- ESM will arrive at the O&C building at KSC
- Lockheed Martin will perform the majority of the integration and test work in the US
- ESM will be mated with the CMA
- Tubing connections (including propulsion servicing lines) will be made in the clean room area
- OMS Nozzle and SA are attached
- CM and SM are mated, referred to as the “Short Stack”
- First Orion integrated system tests are performed
- Short Stack transported by air to Plum Brook Station for acoustic and thermal vacuum testing
- Transported back to the O&C for fairing installation and final closeouts
- Final integrated system tests are performed
- Transferred to GSDO
ESM test article and FM-1 Destinations
MPCV Ground Processing Flow

- GSDO assumes responsibility for the SLS/Orion ground operations leading up to launch
- Orion leaves O&C and is transported to the Multi-Purpose Processing Facility (MPPF)
Conclusion

• The concept of operations for AIT and ground operations for the ESM propulsion system has been developed for the PDR

• The SM propulsion system will be designed and qualified through an international partnership between NASA and ESA

• Work has already begun on eSTA, PQM, and FM-1

• eSTA and PQM are scheduled to arrive in the US in 2015 & 2016 respectively

• FM-1 is scheduled to arrive in 2016