

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

**Matthew C. Bielozer**

**NASA Glenn Research Center**

Joint Propulsion Conference, July 28-30th, Cleveland, Ohio



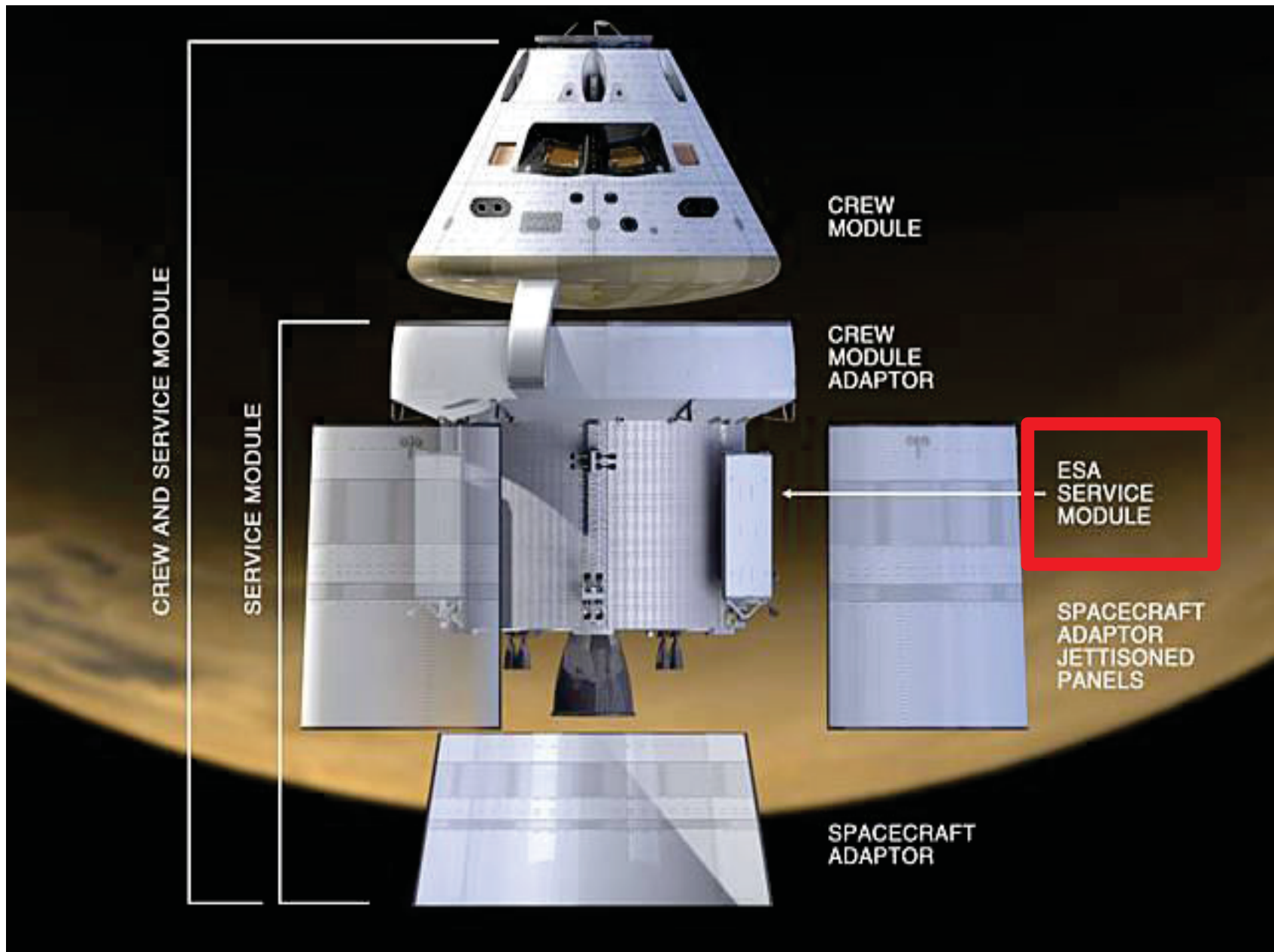
# Overview

- 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



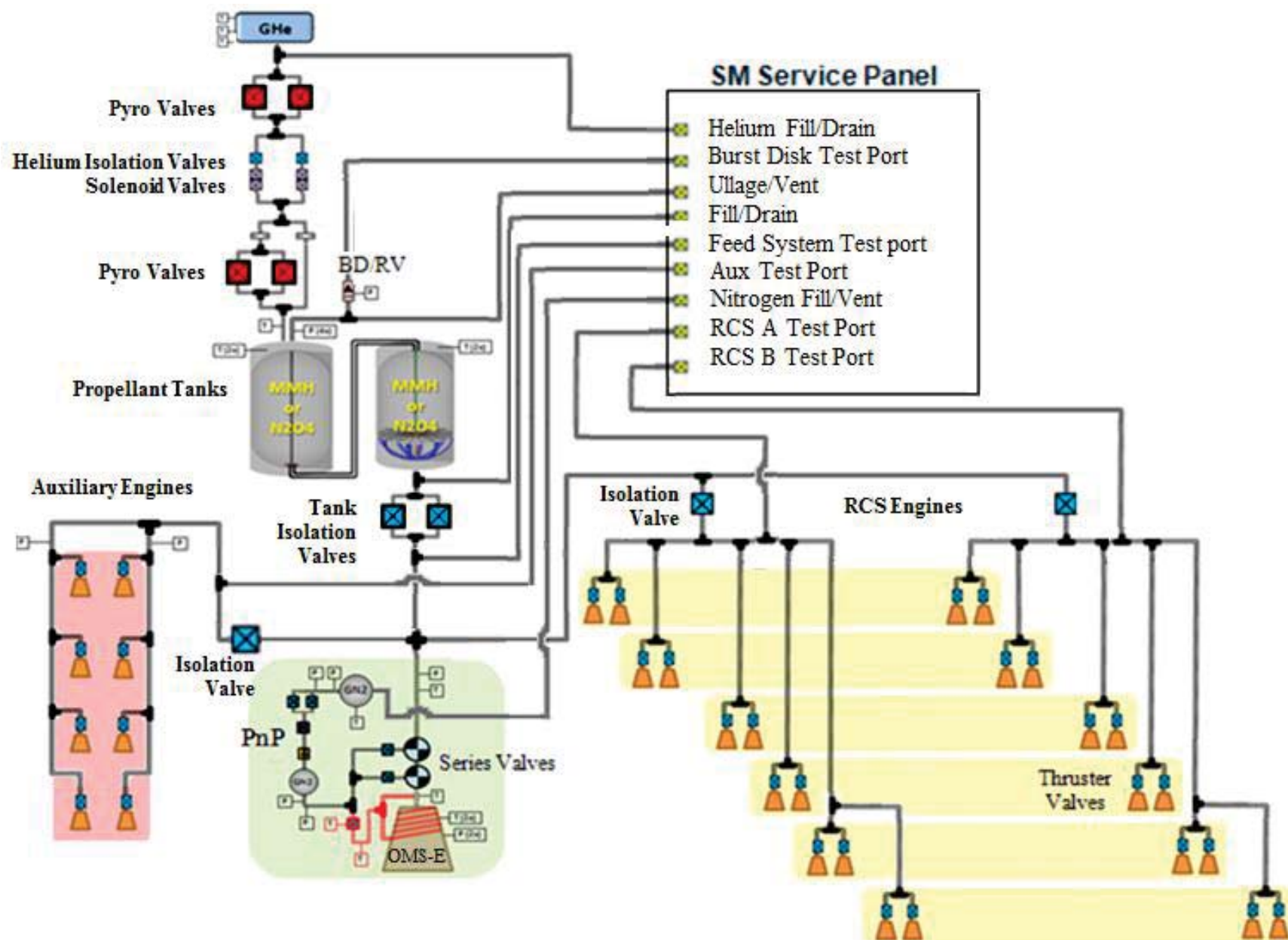
- Under the Constellation Program, Orion was to be designed and manufactured completely by Lockheed Martin
- With the Implementing Agreement signed, ESA and Airbus Space and Defense is responsible for designing, fabricating and qualifying the ESM
- Flight Model-1 will be delivered to NASA for integration 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

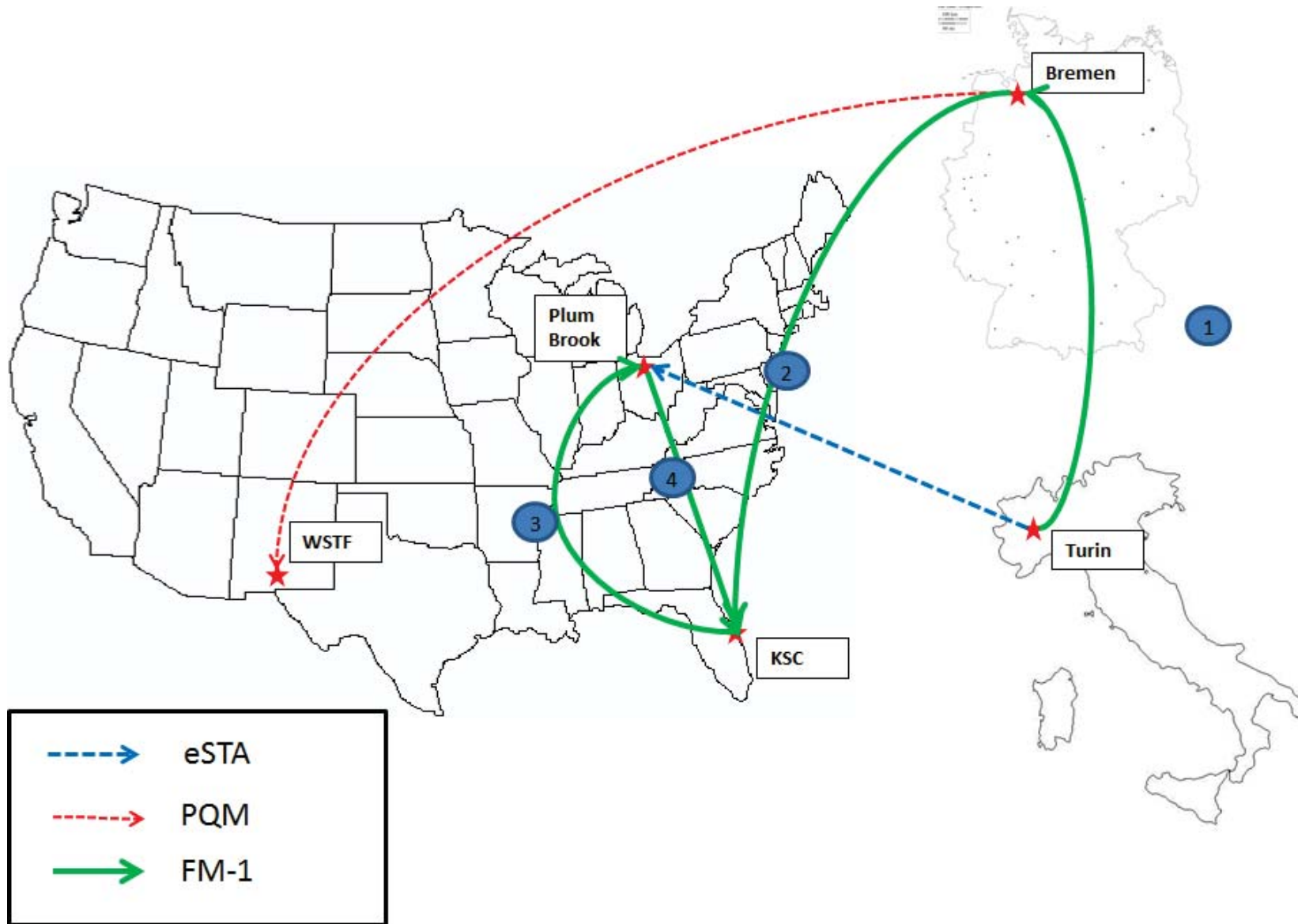
- ESM Structure is partially manufactured and assembled in Italy
- After shipping to Bremen, Germany the final assembly integration and functional testing of the ESM will occur
- ESM structure is separated into a lower and upper platform for parallel processing
  - Propulsion components on the lower 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



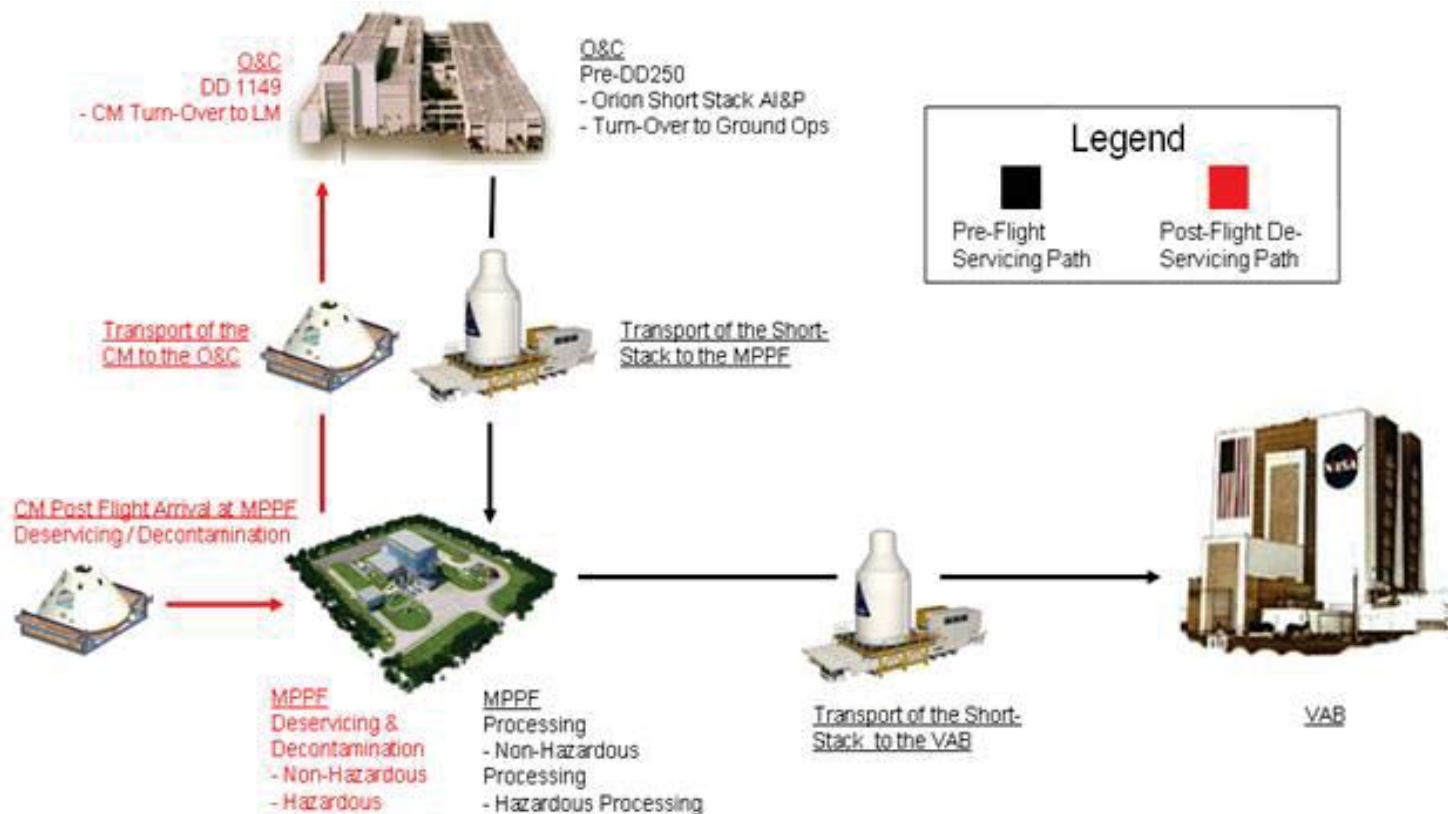
- ESM will arrive at the O&C building at KSC
- Lockheed Martin will perform the majority of the integration and test work in the US
- ESM will be mated with the CMA
- Tubing connections (including propulsion servicing lines) will be made in the clean room area
- OMS Nozzle and SA are attached
- CM and 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 ALT 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

