Exploration Systems Development Update

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Bill Hill, Deputy Associate Administrator Exploration Systems Development





For comments contact mark.e.ogles@nasa.gov



ESD HQ Milestones – June – October 2016

IMMS Month	Program	IMMS Program Milestone	Comment
Jul-16	Orion	FSW 26a Release	Complete
	SLS	Flight Intertank Panels to MAF	Complete, originally planned for May 2016
	GSDO	SCCS 3.3/3.4 Verification	Complete
Aug-16	SLS	LOX STA Test Fac. Complete	Completed in September 2016
Sep-16	Orion	CMA Aft Walls Installed	Completed in October 2016
	Orion	CMA Clean Room Operations Start	Under Review, ECD Nov 2016
	ESD	Build to Sync Exit Board	Complete with outbriefs in progress
	SLS	VAC Welding Complete	Under Review, ECD TBD, Root cause analysis team outbrief planned 11-16-16
	Orion	1 st Propellant Tank for FM-1 Delivery	Under Review, ECD Nov 2016, Due to weld quality issues
Oct-16	Orion	Flight S/W Release 26B	Complete. Patch required with that release planned in Nov 2016
	GSDO	SCCS 3.5 Valid. Complete	Complete, 9-23-2016



EM-1 Secondary Payloads

Cubesat to Study Solar Particles (CuSP)



- Objective: Observations of Interplanetary Space environment to gain insight into space weather
- Destination: Heliocentric Trajectory



- LUNAr polar Hydrogen Mapper (LunaH-Map)
 - Payload Developer: Arizona State University (ASU)
 - Objective: Perform neutron spectroscopy of lunar surface to determine H abundance
 - Mission Destination: Lunar Orbit



- Lunar Flashlight
 - Payload Developer: Jet Propulsion Laboratory
 - Objective: Search for lunar surface ice deposits using near-IR band lasers
 - Mission Destination: Lunar Orbit
- Near Earth Asteroid Scout (NEA Scout)



- Payload Developer: Marshall Space Flight Center
- Objective: Perform target detection, reconnaissance and close proximity imaging of a NEA
- Mission Destination: a Near Earth Asteroid (within ~1.0 AU distance from Earth)



- BioSentinel
 - Payload Developer: Ames Research Center
 - Objective: Quantify DNA damage from space radiation environment
 - Destination: Heliocentric Trajectory



- Lunar IceCube
 - Payload Developer: Moorehead State University
 - Objective: Prospect for water (ice, liquid & vapor) & other lunar volatiles using IR spectrometer
 - Mission Destination: Lunar Orbit
- SkyFire
 - Payload Developer: Lockheed Martin Space Systems
 - Objective: Collect IR imaging of Lunar Surface
 - Mission Destination: Heliocentric via Lunar Flyby
- ArgoMoon
 - Payload Developer: ASI
 - Objective: Provide photography of EM-1 Mission, detailed imagery of ICPS as well as demonstrate image system operability
 - Mission Destination: Elliptical Earth Orbit (ICPS proximity)
- Outstanding Moon exploration TEchnologies demonstrated by NAno Semi-Hard Impactor (OMOTENASHI)
 - Payload Developer: JAXA
 - Objective: Develop worlds smallest lunar lander and observe lunar radiation environment
 - Mission Destination: Lunar Surface
 - EQUULEUS



- Payload Developer: JAXA
- Objective: Characterize radiation environment in geospace by imaging the Earth's plasmasphere
- Mission Destination: Earth-Moon L2

EM-1 Secondary Payload Candidates

- The three final secondary payloads will be selected via the STMD Centennial Challenges
 - Final selection from the 6 candidates below will be made Feb 2017
 - MIT KitCube



- Payload Developer: Massachusetts Institute of Technology
- Objective: Compete in Lunar Derby for the Achieve Lunar Orbit, Best Burst Data Rate, Largest aggregate Data Volume Sustained over time and Spacecraft Longevity prizes
- Mission Destination: Lunar Orbit
- Team Miles
 - Payload Developer: Fluid & Reason, LLC



- Objective: Compete in the Deep Space Derby for Furthest Communication Distance from Earth prize
- Mission Destination: Deep Space
- Cislunar Explorers
 - Payload Developer: Cornell University
 - Objective: Compete in the Lunar Derby for Achieving Lunar Orbit and Spacecraft Longevity prizes
 - Mission Destination: Lunar Orbit



- Heimdallr
 - Payload Developer: Ragnarok Industries
 - Objective: Compete in the Lunar Derby for the Achieve Lunar Orbit, Best Burst Data Rate, Largest aggregate Data Volume Sustained over time and Spacecraft Longevity prizes
 - Mission Destination: Lunar Orbit
- CU-E3
 - Payload Developer: University of Colorado
 - Objective: Compete in the Deep Space Derby for Best Burst Data Rate, Largest Aggregate Data Volume Sustained over time, Spacecraft Longevity and Furthest Communication Distance from Earth prizes
 - Mission Destination: Deep Space
 - SEDS Triteria
 - Payload Developer: University of California San Diego



- Objective: Compete in the Lunar Derby for the Achieve Lunar Orbit and Spacecraft Longevity prizes
- Mission Destination: Lunar Orbit

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Exploration Systems Development Top Concerns

Concern	Current Status
Integrated avionics and software verification and validation (V&V): Integrated Test Lab capacity, software delivery status, agile software development process productively metrics and cross-program interdependencies for emulators and design functionality.	Cross-program dependencies are mapped and content migration is being monitored as both Orion and SLS have deferred some content to subsequent builds. ITL impacts due to late ESM avionics box delivery also being evaluated.
Verification and validation (V&V): Plan involves distributed multi-site activities such as structural dynamics testing, environmental test, and functional check out leading to design and integrated flight certification traceable to requirements closure and certification of flight readiness (CoFR) with sufficient resources and testing.	Enterprise V&V Team (EVVT) Focus Planning In Work, T&V resources are a watch item. Build to Sync (BTS) complete with limited open issues. Continuing to work with engineering and others on V&V and IV&V opportunities. Successful loads analysis TIM conducted.
Budget : Out-year funding uncertainty impacts to EM-2 (EUS) mission definition and content, interdependencies management, ground infrastructure, and efficiency of program planning and implementation.	Indeterminate length of FY2017 continuing resolution impacts the ability of GSDO and Orion to fund required work. Out-year funding uncertainty remains a watch item.
GSDO: Mobile Launcher (ML) outfitting and V&V including ground system control software/Ground Flight Application Software (GFAS) and Spaceport Command and Control System (SCCS) necessary to support offline processing at MPPF and integrated processing in VAB. Dependencies on cross-program flight/ground hardware interfaces and software. Ground processing first flight learning curve.	GFAS and SCCS are watch items; closely managing interdependencies and flight software release functionality which are impacted by changes in SLS and Orion software delivery. ML government furnished equipment delivery improving. Umbilical build and test is a watch item.
Orion: ESM CDR completion and FM-1 delivery to KSC. Crew Module (CM)/ESM structural analysis and environmental T&V planning and resource availability for parallel work at KSC Operations and Checkout (O&C) and GRC, preparations for CM and CM Adaptor (CMA) outfitting at O&C (parts availability).	ESA post CDR check point complete with agreed to forward work to prepare for EM-1 and EM-2. ESM is now been outfitting in Bremen clean room. Shaker testing at Plum Brook complete now doing pyro shock. ESM delivery in April 2017 is the critical path.
SLS : Vertical Assembly Center (VAC) welding operations, TPS spray operations and core stage integrated assembly at MAF through green run test. RS-25 controller status. Outfitting of core stage engine section this fall.	Review of low pull strength of .625" welds in work, LO2 tank on hold for VAC welding until resolved. LH2 tank preparing for proof test. RS- 25 controller delivery a watch item. Progress of engine section and inter-tank outfitting are watch items
Long-Term Sustainability : Productions and operations (P&O) sustainability at the rate of one flight per year after EM-3 by reducing cost.	RFI is being prepared for release to identify opportunities to lower P&O, and in parallel a P&O working group has been established to implement P&O study results.
EM-2: Test flight, first crewed flight risk and related mission planning, including co- manifested payload and docking systems capability determination.	Decision memo for EM-2 mission profile is in review. Mission planning guidelines are in work. EM-2 co-manifested payload RFI closed 11/7; review in work.





EM-1 Launch Abort System (Lockheed)

- ✓ EM-1 Jettison Motor build started February 2016
- ✓ JM STA inert delivery 09/19/2016
- ✓ Abort Motor (AM) completed casting EM-1 flight motor on October 24
- ✓ Jettison Motor DM-3 hot fire test completed
- STA Abort Motor and ACM Assembly Complete Nov 2016
- ACM HT-11 casting Nov 2016
- Attitude Control Motor (ACM) hot fire test (HT-11) Jan 2017
- JM Deliver to KSC Nov 2017
- Ogive Deliver to KSC Nov 2017

Start



Ogive Production



EM-1 Jettison **Motor Build** Start



Ogive Panel Fabrication Complete

Jettison Motor Deliver to KSC Ogive

Deliver to

KSC



EM-1 Crew Module (KSC O&C Building)

- Shipped pressure vessel to KSC to begin spacecraft assembly February 2016
- ✓ Proof pressure test in April 2016
- Clean room operations in work, on vehicle and off-vehicle welds being performed
- ✓ Fabricated all Avcoat [™] qual blocks & first flight blocks
- Clean room operations complete
- Initial power-on February 2017
- PDU Functional Tests Complete May 2017

Pressure Vessel

Proof Pressure

Test

- Heat Shield install June 2017

Pressure

Vessel

Ship to KSC





Clean Room

Ops Start

Clean Room

Ops

Complete

Orion crew module is undergoing assembly in the clean room

PDU

Functional

Tests

Complete

Heat

Shield

Install

9

Initial

Power On

EM-1 Heatshield structure



EM-1 Crew Module Adapter (KSC O&C Building)





- ✓ CMA Aft Walls installed
- ✓ FWD Walls in process
- Clean Room Ops Start Nov 2016
- Propellant/ECLSS line proof and leak test December 2016
- Initial Power On Feb/March 2017
- ESM Mate Oct 2017





EM-1 Service Module (Bremen, Germany)

- ✓ Primary Structure to Bremen 2016
- \checkmark Entered Bremen cleanroom in July 2016
- ✓ CDR 2 Closure TIM Complete
- ✓ CDR 2 Board complete Oct 2016 with forward work
- Prop Tanks Install Feb 2017
- Functional Tests April 2017
- On Dock at KSC April 2017





Primary Structure to Bremen



Pro Ir

Prop Tanks Installed Functional Tests





Crew Module Structural Test Article (MAF)

- ✓ Pressure Vessel 2 (PV2) weld (Cone to Forward Bulkhead)
- ✓ Layup of the STA heatshield
- ✓ PV3 weld (Barrel to Cone)
- Ship to KSC O&C Nov 18
- STA Pressure Proof Test Feb 2017
- STA Testing June 2017







ESA Service Module Structural Test Article (Plum Brook)

- ✓ Delivered to Plum Brook Station and integrated with Crew Module Adaptor (CMA) in November 2015
- ✓ SAW Deploy 1 Feb 2016
- ✓ Acoustic testing successfully completed in May 2016
- Vibration testing began in June 2016
- ✓ Pyro/Shock Test Nov 2016
- SAW Deploy 2 Nov 29 Dec 2
 2016
- Direct Field Acoustics Test Dec 12 – Feb 2, 2017



European Service Module structural test article vibration testing is underway at Glenn Research Center's Plum Brook Station





Integrated Test Lab (LM /Denver)

Software Development

- ✓ Flight Software deliver 26A released on 7/22/16
- ✓ Flight Software load 26B released on 10/12/16
 - 85% of EM-1 FSW complete after 26B release
 - 26B patch on schedule for 11/23/16 for IPO & CM functional testing
- FSW load 27A on schedule for 1/18/17
- FSW load 27B on schedule for 4/12/17



Integrated Test Lab (ITL)

- ITL-03A March 2017
 - ✓ Multiple Checkpoint entry runs
 - ✓ Successful run with GPSR and BALT hardware
- ITL-SM Aug 2017
- ITL-03B CSM Feb 2018







EM-1 Integrated Spacecraft / Payload Element (MSFC/ULA-Decatur)

- Completed LVSA Fwd to Aft Cone Weld Mar
- ✓ Completed LOX Tank Proof Testing Apr
- ✓ Completed vertical welds & NDE of EM-1 Orion Stage Adaptor – May
- ✓ Delivered ICPS Structural Test Article (STA) to MSFC – Jun
- ✓ Flight ICPS LH2 Tank / Intertank / LOX Tank Integration – Oct
- ✓ Flight ICPS RL-10 Engine Mating Oct 2016
- EM-1 ICPS Production Complete Feb 2017
- EM-1 OSA Production Complete Aug 2017
- EM-1 LVSA Production Complete Dec 2017



ICPS in Assembly at ULA-Decatur



OSA on 7-axis Milling Machine

* Acronyms: OSA - Orion Stage Adapter; ICPS - Interim Cryogenic Propulsion Stage; LVSA - Launch Vehicle Stage Adapter





EM-1 Stages (Boeing - MAF)

VORK COMPLETE

LH2 CS1

ES WC

ON HOLD

H2 WCA

- ✓ LH2 Tank WCA VAC Welds Complete Jan
- ✓ Started LOX Tank WCA VAC Welds Feb
- ✓ Completed Engine Section Structural Test Article (STA) Weld on VAC – Mar
- Completed Engine Section Flight Unit Weld on VAC – Apr
- CS-1 Forward Skirt Vertical Welds Complete Jun
- ✓ CS-1 LH2 Tank VAC Welding Complete Sep
- Flight Intertank panels loaded into assembly jig – Sep
- CS-1 Engine Section (ES) VAC Welding Complete – April
- CS-1 Forward Skirt VAC Welding Complete Nov 2016
- Engine Section STA Assembly complete Dec 2016
- LH2 Qual Tank Pneumatic Proof Test Dec 2016 (TBD)
- CS-1 LOX Flight Tank Welding Complete TBD
- Completion of all STA and EM-1 flight article VAC welding operations TBD



ES QUAL



SLS Structural Test Article Testing (MSFC)

- ✓ Official Start of SSC B2 Activation Jan 2016
- ✓ Test Stand 4693 (LH2 Tank) Topping Out event Apr
- ✓ Test Stand 4697 (LOX Tank) CoF Complete Oct
- Engine Section Structural Test Facility Ready Nov 2016
- CoF Complete for LH2 Test Stand (4693) Dec 2016
- Intertank Test Facility ready Dec 2016
- Start ISPE Integrated Structural Test (IST) Jan 2017
- Complete ISPE Integrated Structural Test Mar 2017



LOX Tank STA Stand



Intertank STA Stand



LH2 Tank STA Stand



Engine Section STA Stand





LVSA being loaded into Test Stand 4699





EM-1 Boosters (ATK - Utah)

EM-1

First Segment

Cast

- M-1 Left & Right Hand Booster Production progressing
 - EM-1A (left) forward, aft and center-forward completed casting
 - EM-1B (right) aft and centerforward segment has completed casting
 - EM-1B (right) forward segment casting Nov
- Started EM-1 Aft Skirt refurbishment Feb
- ✓ Completed QM-2 Test Firing June 28
- Booster Battery Qual Testing Begins Aug
- EM-1 Motor Segments Casting Complete – Apr 2017

QM-1

est

EM-1 Segments Delivered – Sept 2017

QM-2

Test



Qualification Motor-2 (QM-2) was successfully testfired in June, paving the way for flight certification.



EM-1 All

Segments

Cast

EM-1

Segments

Delivered



EM-1 Engines (AJR - SSC)

- Flight Engine Control Unit (ECU)
 Production began Jan
- ✓ Completed Engine 2059 RS-25 Test Mar
- ✓ Held RS-25 Production Re-start IBR May
- ✓ Completed two RS-25 Engine Tests (E0528) – Jul & Aug
- ECU Qualification Unit, Flight Model 1 (FM1), Assembly Complete – Oct
- ECU FM1 ATP complete Dec '2016
- Next Engine Test: Begin ECU FM Green Run Testing – Jan 2017
- All EM-1 ECUs Delivered March 2017
- Engines Delivered to MAF Apr 2017
- FM1 Qual Testing Complete May 2017



The SLS Program hot fire-tested RS-25 Development Engine 0528 with a new flight controller three times this summer at Stennis Space Center.



FM1 Engine Control Unit in assembly showing Channels A and B.





Software Test Lab (MSFC)

Software

- Stages Redundant Inertial Navigation Unit (RINU) Development Test data delivered to support validation & verification – Jan 2016
- ✓ Began Release 13 Sprint 3 Mar 2016
- Deliver Flight Software Release 13 Dec 2016
- Deliver Flight Software Release 14 Mar 2018



SITF

Qual Test -

Ph 2 Comp

SITF – Q Testing

SITF

Development

- ✓ Complete Phase 1 (Pwr Quality & Verif)– May 2016
- ✓ Complete Phase 2 (C&DH & FSS Dry Run) Oct 2016
- Complete Phase 3 (Flt Ctrl & TLM Dry Run) Feb 2017
- Complete Phase 4 (Final Avionics Verif) Mar '17

SITF

Qual Test

Ph 1 Comp



SITF

Qual Test

Complete

SITF

Qual Test -

Ph 3 Comp





Umbilical Production and LETF Testing (LETF - KSC)

The LETF is testing 6 day per week / 2 shift per day schedule for CSFSU, ICPSU, ASEU, and CSITU testing. 2nd shift was implemented in mid-September

- ✓ Orion Service Module Umbilical (OSMU) testing completed Sep 2016
- ✓ Core Stage Forward Skirt Umbilical (CSFSU) testing completed Nov 2016
- Aft Skirt Electrical Umbilical (ASEU) testing complete Nov 2016
- Interim Cryogenic Propulsion Stage Umbilical (ICPSU) testing complete Feb 2017
- Core Stage Inter-tank Umbilical (CSITU) testing complete Feb 2017
- LH2 and LO2 Tail Service Mast Umbilical (TSMU) testing complete May 2017





Mobile Launcher Outfitting and Check Out (KSC)

- Schedule under review by GSDO and contractor
- Preparing for delivery of umbilicals from LETF beginning in November
- Beginning Crawlerway analysis and conditioning
 - ✓ Contract for first four phases awarded to JEA -POP 8/3/16 - 7/10/17
 - First round of bore samples complete Awaiting results
 - ✓ MLP-1 design awarded to RS&H
 ✓ Pre-design meeting on Oct 12
- CT-2 Ready to rcll ML to VAB 11/30/2016
- ML Ready, GSE and Umbilicals Complete Jun 2017
- ML/Pad Multi-element V & V Dec 2017



Mobile Launcher



VAB and Pad 39B Construction (KSC)



Pad 39B

Ignition

Overpressure

Sound Suppression

 Launch Pad EIT kicked off the year-long LH2 upgrade design effort with the selected contractor

Flame

Trench

Deflector

ECS

- Hurricane clean up continues

Chillers



LH2 Tank

Fill



Ground Software (KSC)

GFAST

- ✓ Drop 8 completed with 20,280 GCUs delivered and 3771 Remote SW hours
- Drop 9 began 10/1/16
 - Currently, 10,592 GCUs are Ready to Work and in-progress
 - GFAST continues to work dependencies to address additional ~19K constrained GCUs



SCCS

<u>SCCS 3.6</u>

✓ Validation complete 10/27/2016.

<u>SCCS 4.0</u>

 Due to technical challenges and Hurricane Matthew impacts, Development Complete date has moved to 12/7/2016

SCCS 4.1

- Completed Plan to Launch Team (PLT) assessment and follow-up SEI&O recommendations to identify the essential SCCS 4.1 development content
- Impacts from Hurricane Matthew, SCCS 4.0 delay, and PLT / SEI&O recommendations have moved the SCCS 4.1 Development Complete date to 05/26/2017



Cross-Program Systems Development Update



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CSI Technical Performance and Accomplishments

- Recent Major Cross-Program Accomplishments (August October)
 - Underway Recovery Test 5 commenced (Oct)
 - Submitted ESD Decision Memo (13028) for signature: EM-2 MTLI Mission Profile (Oct)
 - Held NESC/JLTT Face to Face and follow-on discussion with OCE resulting in decision to not perform FRF Test Firing (Memo in work)
 - Held EVVT Face to Face at KSC focused on verification planning and closure (Oct)
 - Held IAS Face to Face at MSFC focus on SW testing plans (Oct)
 - Updated Loss of Crew/Loss of Mission Technical Performance Measurements (Oct)
 - Enterprise Verification & Validation process presented to GAO (Oct)
 - Completed ASAP deep dive into ESD CoFR process (Oct)
 - Completed VAC1 loads for assessment
 - Developing Flight Rules Control Board charter (Oct)
 - Baselined OMRS and LCC charters. Continuing to approve OMRS, baselined initial 3 LCCs (Sept/Oct)
 - Updated trace of ESD Flight Test Objectives and HEO MD objectives (Sept)
 - Completed OMRS mapping to ITCO test plans phase 1 (Sept)
 - Updated Joint Interface Verification Plans
 - Supported SPIE Block 1B SRR (Aug)



CSI Technical Performance and Accomplishments

• Near-term forward work

- Update EM-2 Ground Rules and Assumptions and perform MTLI-Free Trajectory Trades, analyze crew sleep shifts, scheduling constraints and abort analysis for trajectory analysis
- Initiate EM-3 analysis with sizing considerations for power and conops, RPOD and mission unique additions
- Update Cross Program FMEA Integration Summary Report
- Update EM-1 launch, entry descent/landing, and recovery lighting requirements in Mission Definition Baseline
- Baseline Mobile Launcher only modal test
- Develop EM-1 Abort Trigger Flight Rule
- Initiate EM-2 Block 1B Integrated Design Cycle
- Update Block 1 B ICDs for SLS to MS and MPCV to SLS
- Baseline of SLS Block 1B SLS-to-GSDO Interface Control Documents Volume 10: Core Stage
- Update EM-1 Mission Definition Baseline to include Cross Program Groundrules and Constraints Annex
- Develop Mission Definition Baseline for EM-2
- Update Communications Network and Tracking Architecture Document
- Update ESD 10015 ESI System Safety Analysis Report to Rev A. (Nov)
- Updated Cross-Program Orbital Debris Assessment Report (ODAR) (Nov)
- Update ESD 20002-RPT-006 EM-1 XPRA LOOV Report to Rev 2 (Nov)
- Baseline Cross Program Integrated Communications and Network (ICAN) Test Plan (Dec)
- Support EUS PDR (Dec)



- TBX burndown in Orion-GSDO ICDs, Volume 1 (Hardware)
 - MPCV-IRN0006-X released on 4/21/16 closes 9/16 of the TBXs.
 - Remaining major technical issues resolved by JICB/JPCB in March, including Ground Cooling System design closure and rollout purge
 - MPCV-IRN0006 approved at JPCB on 6/23/16, remaining work: TBX:7; FWD:2
 - Only remaining technical issue for resolution is the purge outage, which will be tracked as a separate issue
 - Issue Closed

• VSS Timing

- Current VSS clearance analysis shows positive clearance; however, there is a concern that the VSS may bind if worst on worst timing conditions are assumed to be credible
- JICB reviewed results of GSDO-led early release feasibility study on 6/1. JICB determined additional assessments were required by GSDO, S&MA, LEO, Vehicle Management & JLTT for a JICB decision
- JLTT updating loads looking at early release of 250 and 500 ms. Running Monte Carlo analysis for baseline release doing Monte Carlo of 0 to 220 ms late. 220 ms is worst case hangup case.
- GSDO/SLS working on final pitch to bring forward to JICB. ECD Mid November.



- GSDO Ground to Flight Applications Software (GFAST)
 - GFAST development is highly dependent on agreements for products (CUI, OMRS, LCC, XTCE) to be delivered by other programs
 - GSDO has completed an update of the GFAST plan for delivering all required EM-1 ground processing/launch control application software
 - GSDO, Orion and SLS are negotiating OMRS RCN BDEALS to meet GFAST needs
 - Challenge is on time delivery of ESM products
 - 98% of Orion CUIs will be delivered to GSDO by 3/1/2017 per GSDO need and remaining to be delivered by 6/1/2017.



- ICPS Umbilical Loads
 - Initial integrated loads showed that ICPS loads were >200% over hardware design loads.
 - GSDO and SLS/SPIE completed bottoms-up reconciliation of current arm/umbilical plate designs with ADAMS dynamic models and updated integrated model with identified fixes
 - Latest model control run (no vehicle drift, no winds) results show significantly reduced loads at the SLS-GSDO interfaces
 - Residual concerns on Forward Umbilical GH2 Vent QD loads, swing bolt loads and primary pull off load
 - Still need to run primary & secondary release loads with latest model
 - SPIE/GSDO F2F held on 11/2-4 @ KSC to review latest results and agree on path forward for both analytical work and upcoming LETF testing
 - SLS requested that GSDO make available its ground arm design data so that SPIE/Boeing can independently model it in ADAMS and compare results to GSDO-generated loads
 - Model data delivered to SLS/SPIE on 10/21, independent model development in work
 - TRR for ICPSU LETF Config. A testing (Ground side arm, facilities) completed on 9/30/16
 - There will be a delta TRR for mated plate dynamic testing in the mid-December timeframe
 - Testing constraint has been levied on mated plate dynamic separation testing at LETF until SLS/SPIE and GSDO can confirm the resulting GSDO loads will not damage hardware



- OSMU Collet Cup Release
 - Cross-program team examined the collet design and associated scenarios that would result in the need to perform a secondary umbilical release
 - Core Stage Forward Skirt Umbilical (CSFSU) secondary release tests have cup falling off in 3 of 3 tests
 - Decision flow developed defining the inputs & associated decision points
 - Debris team preliminary results via 1-D analysis indicates debris energy does exceed damage threshold for some SLS components
 - Stages/Boeing testing to show minimum 2X margin against bound drive pin ECD 12/14/16
 - If successful, will show probability of having to perform a secondary release to be very low
- OSMU Collet Linkage Engagement Issue
 - Two instances of problems while engaging the collet during OSMU testing at LETF
 - Higher than expected engagement torque on Core Stages Forward Skirt umbilical resulted in an investigative teardown of its collet on 10/18/16
 - While the collet was still functional, teardown did show that the rear linkage pin was bent in this unit
 - Stages/Boeing is working root cause; potential corrective actions include adding bump stop to rear linkage to prevent over rotation of the engagement cam and using stronger material for rear linkage pin



Emerging Cross Program Issues/Concerns

- Modal Tests Instrumentation
 - Dynamic Tests performed at VAB and Pad
 - Implementation of the Dynamic Tests Instrumentation requirement for sensors internal to the CM is challenging
 - The option for adding wires to the SM T-0 harness is costly and has a schedule critical ATP
 - Agreed to pursue using the Wx Data Acquisition System. GSDO-Wx has done a proof of concept test to see if a card could be added to the Wx DAS to send the accelerometers through T0, just like lightning monitoring. Results due next week. No vehicle mods required. LM effort is required to recommend sensor locations, identify sensitive surfaces, etc.
- ML modal testing
 - Joint NESC/JLTT recommendation to perform modal testing to characterize ML prior to stacking.
 - GSDO still evaluating the feasibility and availability of performing a ML modal test prior to stacking with emphasis on trampoline mode. Mid June 2017, after completion of element V&V at parksite, is trending as most likely available timeframe for ML modal testing.
 - JLTT bringing forward options and technical rationale for the test to the JICB on 12/14/16.



Emerging Cross Program Issues/Concerns

- Orion Pad Stay Time
 - SLS and Orion derived differing requirements for pad stay with exposure to winds.
 - SLS has a requirement for 120 days with wind exposure, while Orion has 30 days consistent with CxP heritage.
 - Additional exposure to pad winds causes concern for Orion on the frangible bolts between the CM and SM.
 - Assessing alternate fatigue spectrum for Orion use and will bring forward story to JICB/ECB.
- Use of SLS Engineering Data for OMRS/LCCs
 - GSDO is required to use ED measurements to satisfy existing OMRS and wants to potentially use some of the cryo EFI measurements (via the ED Processor) as a backup verification for LCCs. Some OFI instrumentation deemed as single string.
 - EFI sensors and data acquisition box (grade 4 parts) are rated Crit 3 and to be used for post-data analysis (per SLS documentation).
 - ED processor SW (used for data decom) not classified for this potential use and would require a waiver. (SW is modified heritage SW).
 - JICB action: Carry two separate actions to be worked in parallel: 1) Flight instrumentation assessment on intended use of Engineering data; 2) ED processor gap assessment. An updated GSDO White Paper "MPS EFI Priorities List" is required (joint S&MA, SLS/Stages, GSDO activity) to support these two actions.



Emerging Cross Program Issues/Concerns

- ITL Test Schedule Risk and Approach
 - ITL test schedule impacts due to ESM delays are a critical path for EM-1 launch date.
 - Orion continues to work the validation testing schedule and is committed to meeting SLS and GSDO testing needs
 - Current schedule is targeted to complete by EM-1 launch and Orion is managing 8 days of negative slack at this time



Emerging Issues

- Orion Purge Outage
 - GSDO needs information on allowable Orion purge outages
 - Purge outage table updates are dependent on completion of the Orion-LM purge analysis, ECD 4/2017.
 - Orion-LM is in the process of assessing mitigations to accommodate a 3 week delay in ESM data delivery, was due 11/1.





EM-2 Co-manifested Payload RFI

- 10/5 ESD released an RFI to assess the available range of Co-manifested Payloads and interest of candidate CPL providers for EM-2
- Information requested for 2 Co-manifested Payload Sizes: large co-manifested payloads up to 6,000 kg and smaller, stackable (ESPA-class) co-manifested payloads approximately up to 300 kg
- RFI closed 11/7, responses are in review





Co-manifested Payload Location

Co-manifested Payload Envelope

CPIT SE&I Schedule Product/Revision Completion Progress





Cross Program Interdependencies Management and Status

- CSI team continues to manage Interdependencies, working with ESD and Program schedulers to ensure Program needs are being met
- Significant process changes to allow for quicker document updates and monthly status briefings to PMs
- Major deliveries last quarter include:
 - SLS and MPCV Software and Emulator updates
 - Continued hardware deliveries for facility readiness, test programs, and LETF testing
 - Model exchanges including detailed CAD models, FEMs, dynamic models associated with Verification Analysis
 - Block 1B initial deliveries for DAC
- Significant upcoming deliveries include:
 - SLS and MPCV Software and Emulator updates
 - Orion M/EGSE and SLS LETF Umbilical Hardware
 - Data needs to continue Verification and Testing activities
- Elevated Item associated with Orion/GSDO agreements for OMRS/RCN delivery, resolved at JICB 11/1

Since 2012, 909 (formerly 867) interdependencies have been identified by the team, with 253 (formerly 274) currently active

Interdependencies Category Definitions

Candidate – An item that has been identified as an interdependency by one program, but formal agreement with the providing program has not been achieved.

Partnered (In Work) – An item has been agreed by the providing program to provide scope on the requested need date, but has yet to be received by the requesting program.

Baselined - An item has been approved in the baselined BSHEALS or BDEALS documents

Under Review (Delivered) – An item/delivery that has been received and is presently under review prior to formal acceptance.

Elevated – An item that has been elevated to the CPIT Leadership, as no resolution has been reached at the ITT/working group level, or need date has passed.

Closed – An item has been received, reviewed, and closed.



Major ESD/CSI Independent Assessments In Progress

- Independent modeling and simulation of separation events
 - Liftoff clearance, booster sep, Orion panel sep, Core Stage/ICPS sep, Core Stage/EUS sep, encompasses Block 1 and Block 1B
- Peer Review of Enterprise Modal Testing
 - Includes testing and analysis, and Development Flight Instrumentation
- Independent Verification of Ascent Abort Loads
 - Tool development complete, analysis in work
- Independent Verification of Pre Launch Loads
 - Validating methodology and loads
- Evaluation of ORDEM 3.0 MMOD environment
 - Using data from available on-orbit assets
- MMOD Pressure Vessel Failure Criteria
 - Hypervelocity Impact Testing on COPVs to validate models
- Enterprise Verification and Validation Assessment
 - Draft findings shared with ESD, expect to complete in November.