



DEEP SPACE EXPLORATION SYSTEMS



NASA Advisory Council

Bill Hill, Deputy Associate Administrator
Exploration Systems Development

March 29, 2017

Exploration Systems Development

Top Concerns



Concern

Integrated avionics and software verification and validation (V&V): Progressing from flight software build phase to integrated test phase. Continue to monitor test facility capacity and prioritization. Continuing to monitor Orion and SLS software release dates and associated functionality versus need dates at GSDO.

Verification and validation (V&V): Progressing from V&V planning phase, and test site preparation phase, to test implementation phase. Continuing to monitor test hardware availability against test schedule to ensure resource support and scheduling consistent with structural design certification need dates. Continuing to monitor structural analysis resource availability with concurrent certification (Block 1) and development (Block 1-B).

Budget: Indeterminate length of CR and out-year funding uncertainty impacts to EM-1 and EM-2 (EUS) mission definition and content, interdependencies management, ground infrastructure, and efficiency of program planning and implementation.

GSDO: ML, VAB, and Pad making good individual progress with some first time build delays causing re-sync of integrated scheduling and sequencing. Continuing to evaluate Orion and SLS delivery date status in terms of integrated flow at KSC. Continuing to monitor GFAS and SCCS software development against cross program commitments. LCC/OMRS requirements being developed and progress being monitored against need dates.

Orion: EM-1 CM and CMA production at O&C making good progress with hybrid circuit board production issues as a watch item. ESM delivery continues to be a significant concern with impacts to start date for ESM/CM/CMA integration, ITL SW development and testing, and related cross-program deliverables. Schedule study team analysis mitigates some but not all issues.

SLS: Tornado damages assessment and recovery operations. Vertical Assembly Center (VAC) weld strength anomaly resolution and disposition of hardware. TPS spray development. First time build manufacturing efficiencies for core stage integrated assembly at MAF leading to green run test at SSC.

Long-Term Sustainability: Productions and operations (P&O) sustainability at the rate of one flight per year after EM-3 by reducing cost.

EM-2: Test flight, first crewed flight risk and related mission planning, including co-manifested payload and docking systems capability determination.

Current Status

Cross-program dependencies are mapped and content migration is being monitored as both Orion and SLS have deferred functional content to subsequent releases. ITL impacts and re-planning due to late ESM avionics box late delivery is in work.

ESM STA testing at Plum Brook complete. Propellant Qualification Model (PQM) testing at WSTF to start shortly. ICPS/LVSA testing at MSFC starting. B2 test stand complete. MSFC stages STA test stands are complete and ready for testing. CS structural testing will begin this summer. Monitoring test schedule versus STA hardware delivery in light of weld issue resolution and MAF tornado damage impacts. LETF testing continues to make progress.

Ongoing FY2017 continuing resolution is impacting the ability of GSDO and Orion to fund required work. Out-year funding uncertainty and potential for program planning updates remains a watch item.

VAB platforms installation complete and platform outfitting is in work. Umbilical deliveries to ML from LETF recently passed 50% complete. 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. LCC/OMRS burn-down metrics in place.

ESM coordination on AI&T improving however ESA delivery date continues to erode and now is fall 2017. Propulsion Qualification Module (PQM) delivered to WSTF. CM/CMA progress re-baselined in light of ESM status. ESM delivery is in the Orion critical path and secondary enterprise critical path. Related Software delivery is tertiary. EM-2 PV production has already started.

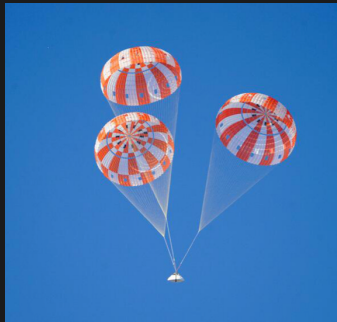
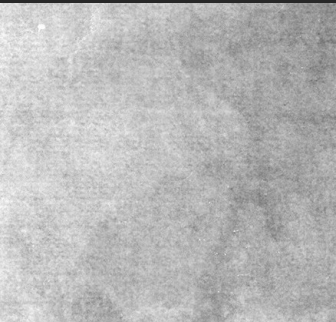
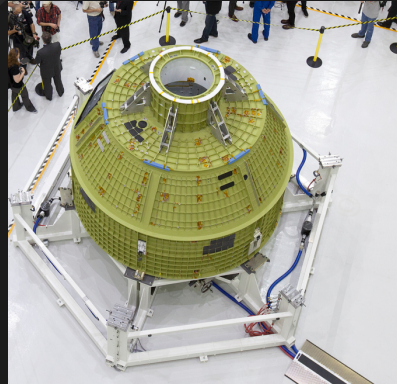
Review of new .625" confidence welds in work. VAC welding of LO2 confidence article pending. LH2 tank in proof test. Evaluating tornado damage cost and schedule impacts. Manufacturing efficiency initiative to improve Core Stage engine section and inter-tank outfitting being implemented.

P&O working group established to implement study results. Industry affordability RFI responses being evaluated for implementation.

Initial Mission planning guidelines for Phase 1 activities being refined. EM-2 co-manifested payload options being evaluated.



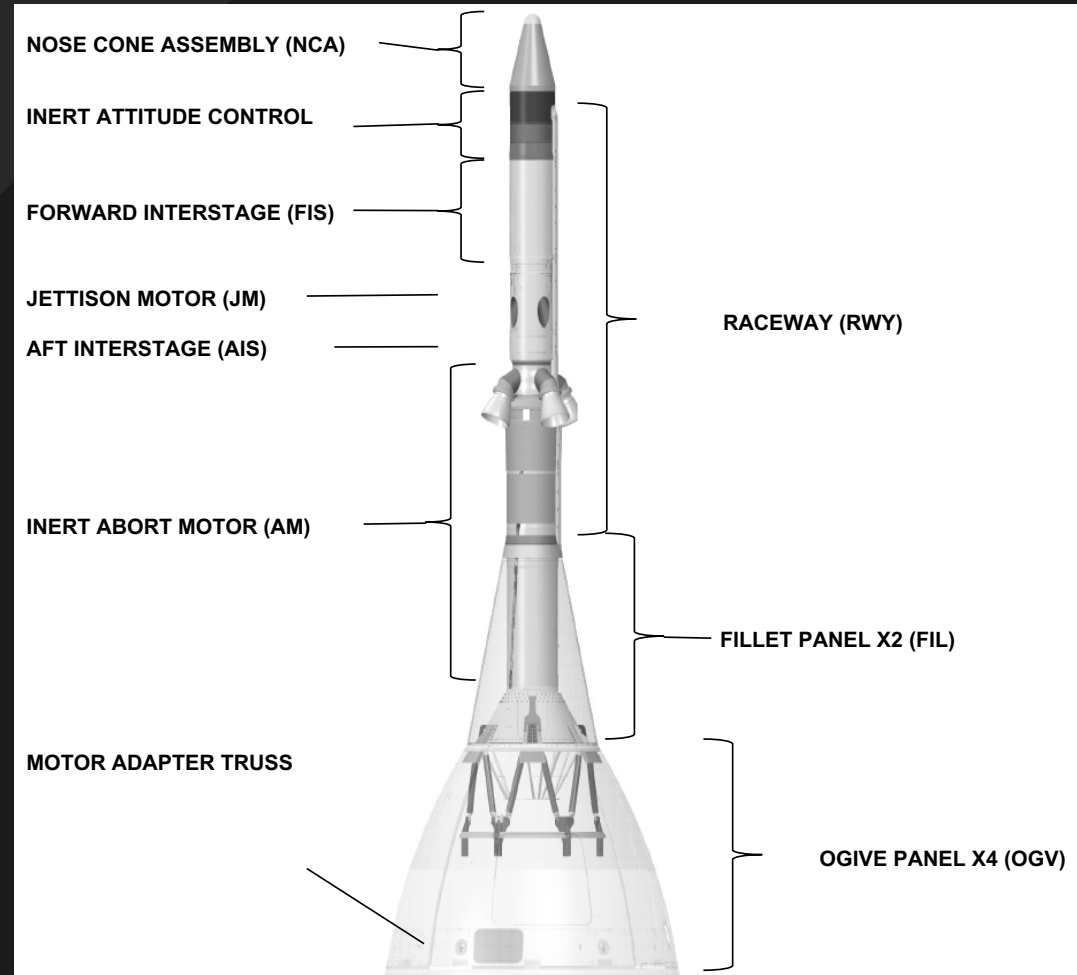
orion



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 complete
- ✓ STA Abort Motor Delivery Nov 2016
- ✓ Attitude Control Motor (ACM) HT-11 casting Nov 2016
- ✓ ACM Assembly Delivery Mar 17, 2017
- ACM hot fire test (HT-11) Apr 2017
- JM Delivery to KSC Jan 2018
- Ogive Deliver to KSC March 2018



☒ Ogive Production Start

☒ EM-1 Jettison Motor Build Start

☒ Ogive Panel Fabrication Complete

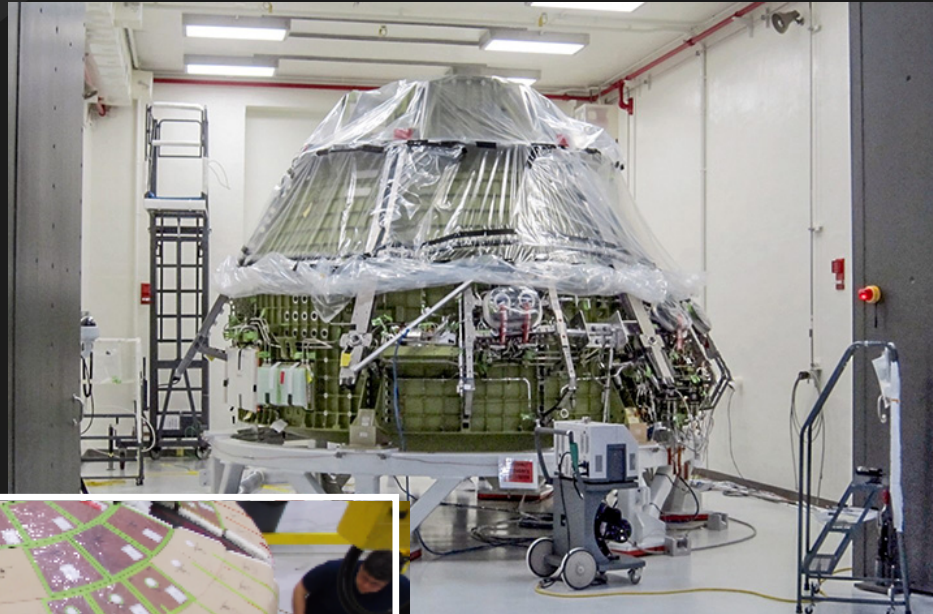
☐ Jettison Motor Deliver to KSC

☐ Ogive Deliver to KSC

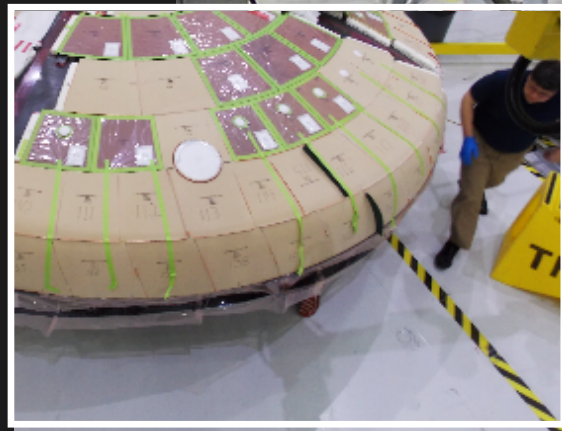
EM-1 Crew Module (KSC O&C Building)



- ✓ 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
- ✓ 112 flight blocks fabricated; 69 installed of 186 blocks
- Clean room operations complete April 2017
- Initial power-on Summer 2017
- Power Distribution Unit (PDU) Functional Tests Complete Oct 2017
- Heat Shield install Nov 2017



Orion crew module in proof cell



EM-1 heat shield Block installation

✓ Pressure Vessel Ship to KSC

✓ Pressure Vessel Proof Pressure Test

✓ Clean Room Ops Start



Clean Room Ops Complete



Initial Power On

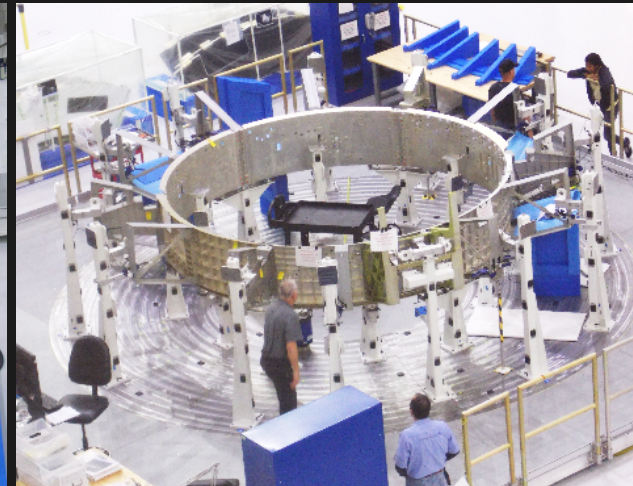
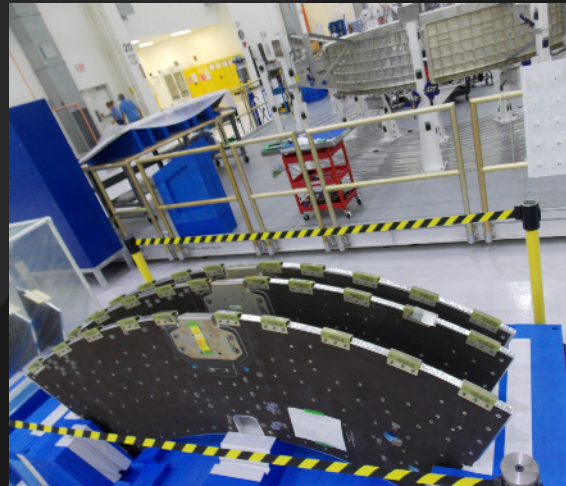
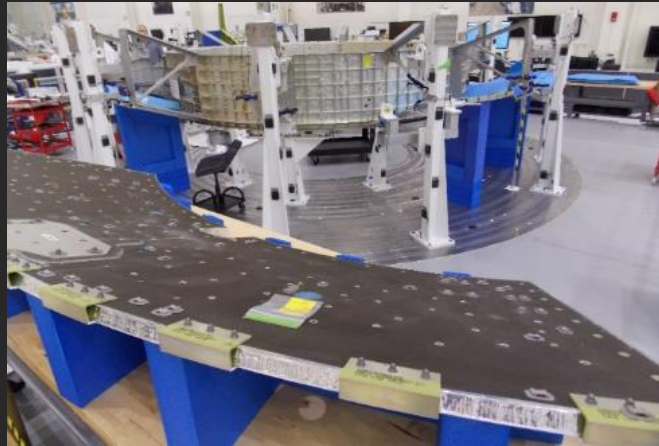


PDU Functional Tests Complete



Heat Shield Install

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



- ✓ CMA Aft Walls installed
- ✓ CMA FWD Walls in process
- ✓ Clean Room Ops Start Nov 2016
- ✓ Propellant/ECLSS line proof and leak test February 2017
 - Initial Power On Summer 2017
 - ESM Mate (Under Review)



CMA Inner
Walls
Delivered
to KSC



CMA Aft
Walls
Delivered
to KSC



Clean Room
Ops Start



Prop/ECLSS
Pressure
Proof Test



Initial
Power On



ESM
Mate

EM-1 Service Module (*Bremen, Germany*)



- ✓ Primary Structure to Bremen 2016
- ✓ Entered Bremen cleanroom in July 2016
- ✓ CDR 2 Closure TIM Complete
- ✓ CDR 2 Board complete Oct 2016 with forward work
- ✓ Start Prop & Cooling line welding
- ✓ Start Harness install
- Thermal Control Unit Install June 2017
- N2 Tank Install July 2017 (U/R)
- Aux Engine Install August 2017 (U/R)
- RCS Thruster Install Sept 2017 (U/R)
- Prop Tanks Install Sept 2017 (U/R)
- OMS-E Integration Oct 2017 (U/R)
- Functional Tests Oct-Nov 2017 (U/R)
- On Dock at KSC (U/R)



**Primary Structure
to Bremen**



**Clean Room
Ops Start**



**Prop Tanks
Installed**



**Functional
Tests**



**On Dock
At KSC**

Crew Module Structural Test Article



- ✓ Pressure Vessel 2 (PV2) weld (Cone to Forward Bulkhead)
- ✓ Layup of the STA heatshield
- ✓ Pressure Vessel 3 (PV3) weld (Barrel to Cone)
- ✓ Ship to KSC O&C Nov 18
 - Mate with ESA SM STA
 - STA Pressure Proof Test April 2017
 - Ship to Denver Spring 2017



☒ Start CM STA Fabrication

☒ PV2 & PV3 Weld

☒ CM STA Ship to O&C

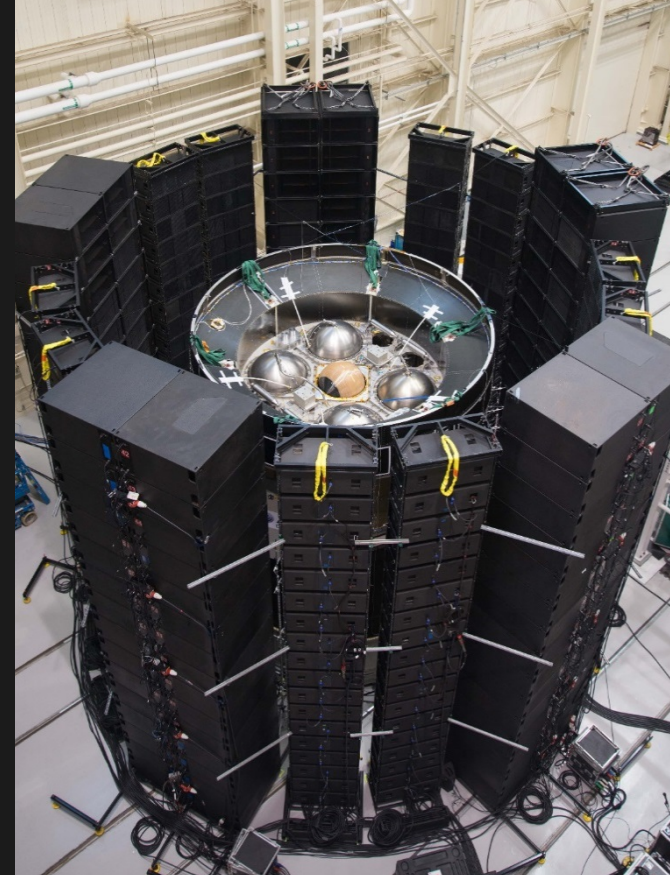
☐ CM STA Pressure Proof Test

☐ STA Testing Complete

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 - Feb 2-7, 2017
- ✓ Ship to KSC (March 6, 2017)
- Mate to CMA STA and Ship to Denver Summer 2017



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



**SAW
Deploy 1**



**Acoustic
Testing
Complete**



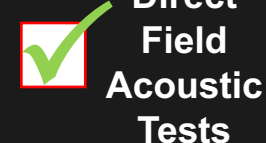
**Sine Vibe
Testing
Complete**



**Pyro/
Shock
Testing**



**SAW
Deploy 2**



**Direct
Field
Acoustic
Tests**



**Ship to
KSC**

FSW/Integrated Test Lab (LM /Denver)









Software Development

- ✓ Flight Software load 26A released on 7/22/16 (Orbit Navigation, ESM Reaction Control System (RCS) & Thrust Vector Control (TVC), CM and ESM Active Thermal Control System (ATCS))
- ✓ Flight Software load 26B released on 10/12/16 (Nominal Ascent thru Post ICPS Sep, Preliminary Entry, Descent, and Landing (EDL))
- ✓ FSW load 27A released on 1/26/17 (Nominal Ascent Mission Sequencing, Final EDL, Orbit Attitude Control with ESM RCS)
- FSW load 27B on schedule for 4/27/17 (Pre-launch sequencing, Initial CM Fault Detection Isolation & Recovery (FDIR))
- FSW load 28A on schedule for 7/20/17 (Nominal On-Orbit, Final CM FDIR, Safe Mode)
- FSW load 28B on schedule for 10/05/17 (Entry Dynamic Backup Flight Software, Optical Nav, ESM FDIR)

	26A FSW Release		26B FSW Release		27A FSW Release		27B FSW Release		28A FSW Release		28B FSW Release
--	----------------------------	---	----------------------------	---	----------------------------	--	----------------------------	---	----------------------------	---	----------------------------

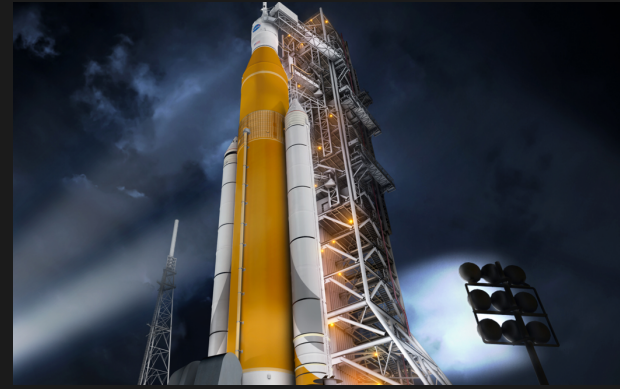
Integrated Test Lab (ITL)

- ITL-03A May 2017
 - ✓ Successful run with Global Positioning System Receiver (GPSR) and Barometric Altimeter (BALT) hardware
- ITL-SM Aug 2017 U/R
- ITL-03B CSM Feb 2018 U/R
 - ESM ITL schedule milestones are under review pending ESM ITL delivery schedule review

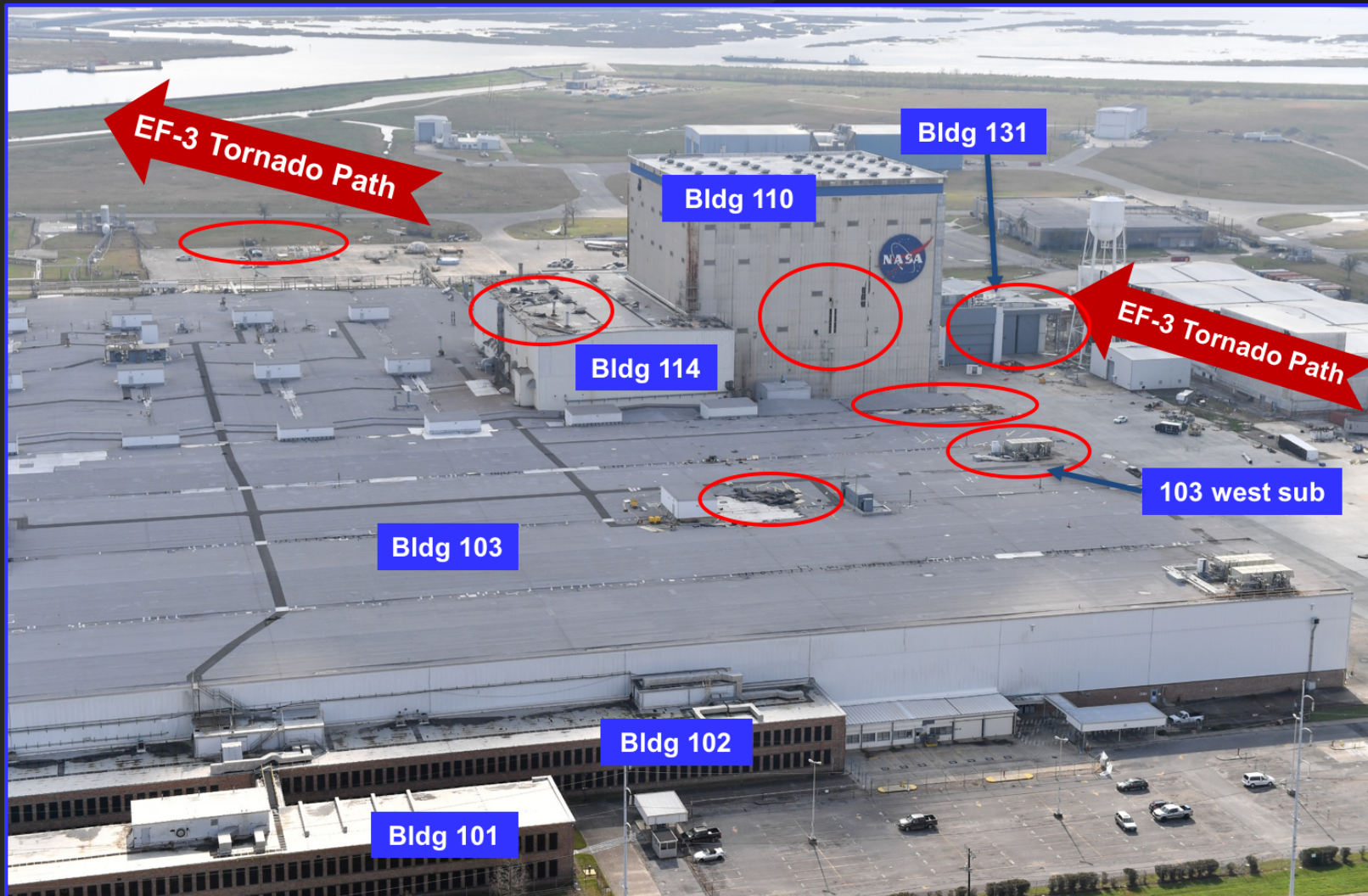
	ITL-01 Single String		ITL-02 Dual String		ITL-03A CM		ITL-SM		ITL-03B CSM		ITL Test Campaign
--	---------------------------------	---	-------------------------------	---	-----------------------	---	---------------	---	------------------------	---	------------------------------



sls



MAF Tornado Path Damage



EF-3 = Enhanced Fujita 3: The Enhanced F-scale is a set of tornado wind estimates (not measurements) based on damage. Wind speed estimates are representative of a three second gust. An EF-3 has estimated 3 second gusts of 136 to 165 mph.

MAF Damage Assessment – Current Status



- **B103 – Main Manufacturing Areas (1 week critical path impact)**
 - Significant roof damage; critical path impacts if not repaired quickly
 - No damage to SLS Program equipment in B103 identified to date
 - Temporary power due to substation damage
- **B103 – West End (no known critical path impact to date)**
 - Significant damage to roof and sub station, condition of doors unknown to date
 - Final Assembly and Area 6 without power (restricted access)
- **B110 – VAC, Stacking (A & D), Clean (E) & Hydrostatic (F) (minimum 2 month impact to critical path)**
 - Significant damage to siding and electrical sub-station 20a
 - SLS facility/hardware status
 - No visible damage to VAC
 - Concrete debris in Cell E, minor damage to Cell D
 - Full assessment to be complete when power and full access restored
- **B131/Area 86/Cells Q & G – TPS (minimum 2 month impact to critical path)**
 - B131 (Cells M, N, & P) - Significant roof & door damage. Temp shelter and debris netting installed in Cell M to secure the Pot Room
 - Area 86 (TPS Component shop) Roof damage, significant water leak, currently no power (sub-station 20a), B103 identified for temp pour foam activities
 - Cells Q & G - Roof repairs underway. No immediate impact,
 - No damage to SLS Program equipment identified to date
- **Dynamic Demonstration Unit blown off stand; will require component rebuilds**

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



- ✓ Vertical welds & NDE of EM-1 OSA Complete – May 2016
- ✓ ICPS Structural Test Article (STA) Deliver to MSFC – Jun 2016
- ✓ EM-1 ICPS Production Complete – Feb 2017
- ✓ EM-1 OSA Diaphragm Proof testing complete – Feb 2017
- ✓ EM-1 LVSA Forward Cone and C1 weld complete – Feb 2017.
- ✓ Secondary Payload Deployment Avionics and cables complete qual environmental testing – Feb 2017
- ✓ EM-1 ICPS ship to United Launch Alliance at Cape Canaveral Air Force Station for final outfitting
- EM-1 ICPS Delivery to NASA – July 2017 (store in SSPF)
- EM-1 OSA Production Complete – Aug 2017
- EM-1 LVSA Production Complete – Feb 2018

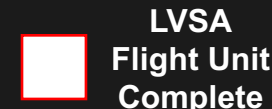
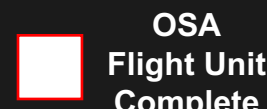


Completed EM-1 ICPS shipment to Delta Operations Center (DOC)



OSA Diaphragm Proof Testing

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





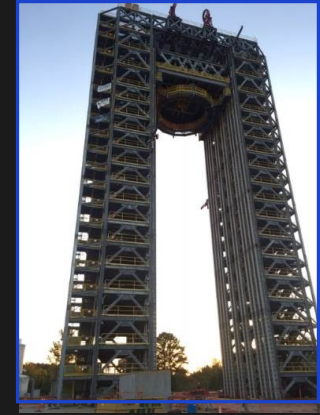
SLS Structural Test Article Testing (MSFC)



- ✓ Official Start of SSC B2 Activation – Jan 2016
- ✓ Test Stand 4697 (LOX Tank) CoF Complete – Oct
- ✓ Engine Section Structural Test Facility Ready – Nov
- ✓ Test Stand 4693 (LH2 Tank) CoF Complete – Dec
- ✓ Start ICPS/LVSA Integrated Structural Test (IST) – Feb 2017
- IT Test Facility ready – May 2017
- Complete ISPE Integrated Structural Test – May 2017
- ES Structural Test Article (STA) ready to ship – April 2017
- LH2 STA ready to ship – Aug 2017
- LOX STA ready to ship – Oct 2017
- IT STA ready to ship – Sept 2017



ISPE STA & Stand - Testing Started



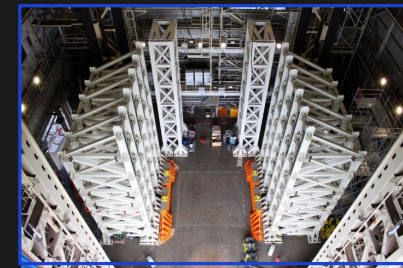
LH2 Tank STA Stand



Engine Section STA Stand



LOX Tank STA Stand



Intertank STA Stand

IT= Intertank
ES = Engine Section
ISPE = ICPS/LVSA
LVSA = Launch Vehicle Stage Adapter

Stands:



ICPS/LVSA
Stand Ready



ES STA
Stand Ready



LH2 Stand
CoF
complete



LOX Stand
CoF
Complete



Intertank
STA Stand
Ready



ICPS/LVSA
STA
Complete



Start
ICPS/LVA
Testing



ES STA
Complete



LH2 STA
Complete



LOX STA
Complete



IT STA
Complete

STAs and Testing:

1

EM-1 Boosters (ATK - Utah)



- ✓ All Booster Separation Motors are cast and finalized.
- ✓ EM-1 Left & Right Hand Booster Production progressing
 - ✓ EM-1A (left) forward, center-forward, center-aft, and aft casting complete
 - ✓ EM-1B (right) forward, center-forward, and aft segment casting complete casting
 - ✓ EM-1B (right) center-center segment casting - Mar
- ✓ Both Aft skirts structural refurbishment complete
- EM-1 Motor Segments Casting Complete – May 2017
- EM-1 Segments Delivered – Sept & Oct 2017



Qualification Motor-2 (QM-2) was successfully test-fired in June 2016, paving the way for flight certification.



6 of 10 EM-1 Booster Segments Cast



QM-1
Test



QM-2
Test



EM-1
First Segment
Cast



EM-1 All
Segments
Cast



EM-1
Segments
Delivered

EM-1 Engine Control Unit (ECU)/ Engines (AR - SSC)



- ✓ Held RS-25 Production Re-start IBR – May 2016
- ✓ Latest Engine 0528 RS-25 (LOX Pump Pressure) Complete - Feb 2017
- ✓ Engine Control Unit (ECU) Flight Model (FM) - 1 ATP Complete - Feb 2017
- ✓ ECU FM2 ATP Complete - Feb 2017
- Engine 0528 ECU Green Run Testing:
 - ECU FM2: Mar 2017
 - ECU FM3: Apr 2017
 - ECU FM4: May 2017
 - ECU FM5: Date to be determined
- EM-1 RS-25 Engines Delivered to MAF – Jun 2017

The EM-1 Flight Engines are Engine 2045, Engine 2056, Engine 2058, and Engine 2060



The SLS Program successfully completed a 380 second test of RS-25 Development Engine 0528 at Stennis Space Center 2/22/17.



FM1 ECU has completed ATP



ECU
Dev
Testing



ECU FM1
ATP
Complete



ECU Green
Run Testing
Begins



ECU Green
Run Testing
Complete



EM-1 RS-25
Engines
Delivered to MAF

Software Test Lab (MSFC)



Software

- ✓ Deliver Flight Software Release 13 – Dec 2016
- ✓ Complete Sprint 5 (final sprint) Flight Software Release 14 – Mar 2017
- Complete Release 14 Green Run Application Software (GRAS) – Oct 2017
- Complete Release 14 Flight Control Application Software (FCAS) – Mar 2018

 **FSW 11
Release
(Engineering)**

 **FSW 12
Release
(Engineering)**

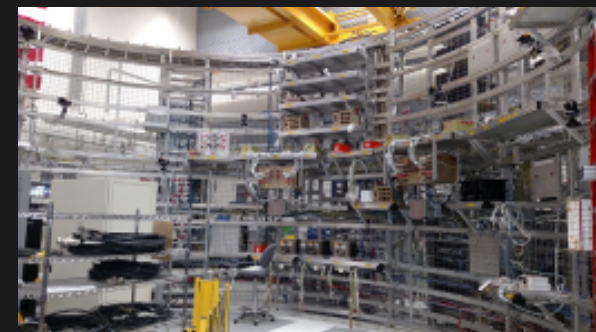
 **FSW 13
Release**

 **FSW 14
Release
(GRAS)**

 **FSW 14
Release
(FCAS)**


Software Integration Test Facility – Qualification (SITF-Q) Testing


- ✓ 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) – Apr 2017
- Complete Phase 4 (Final Avionics Verif) – Mar 2017





SITF-Q Facility Testing

 **SITF
Development**

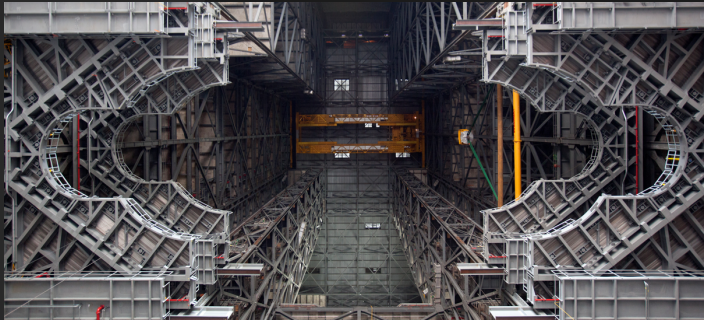
 **SITF
Qual Test
Ph 1 Comp**

 **SITF
Qual Test –
Ph 2 Comp**

 **SITF
Qual Test –
Ph 3 Comp**

 **SITF
Qual Test
Ph 4 Comp**

gsdo



Umbilical Production and Launch Equipment Test Facility (LETF) Testing (*LETF - KSC*)



The LETF is testing 6 day per week / 2 shift per day schedule for CSFSU, ICPSU, ASEU, and CSITU testing. LETF Testing and Mobile Launcher (ML) ground support equipment & umbilical installation remain the primary critical path driver with negative margin prior to the start of Integrated Operations.

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



Core Stage Inter-tank Umbilical (CSITU)

<input checked="" type="checkbox"/>	Orion Service Module Umbilical (OSMU)	<input checked="" type="checkbox"/>	Core Stage Forward Skirt Umbilical (CSFSU)	<input checked="" type="checkbox"/>	Aft Skirt Electrical Umbilical (ASEU)	<input type="checkbox"/>	Core Stage Inter-tank Umbilical (CSITU)	<input type="checkbox"/>	Interim Cryo Propulsion Stage Umbilical (ICPSU)	<input type="checkbox"/>	LH2 and LO2 Tail Service Mast Umbilical (TSMU)
-------------------------------------	---------------------------------------	-------------------------------------	--	-------------------------------------	---------------------------------------	--------------------------	---	--------------------------	---	--------------------------	--

Mobile Launcher (ML) Outfitting and Check Out (KSC)



- ML V&V Re-plan is being incorporated into Program schedule, due to delays on ground support equipment installation phase
 - Cable installations are well underway
 - Cryo pipe installation is started – critical path
 - ECS bracket installations are in-work – duct work to follow in Spring
- ✓ Delivery of umbilicals from Launch Equipment Test Facility began 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
- ML OSMU & ASEU installation complete Mar 2017
- ML Aft Skirt Pneumatic Umbilical (ASPU) installation complete Apr 2017
- ML Move to VAB Sept 2017
- ML/Pad Multi-element V&V Dec 2017



Mobile Launcher (ML)



**Design
Complete**



**Start
Outfitting**



**CT-2 Ready to
roll ML to VAB**

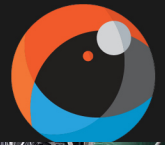


**ML Move to
VAB**



**ML/Pad
multi
element
V&V**

VAB and Pad 39B Construction (KSC)



VAB

High Bay-3 Platforms

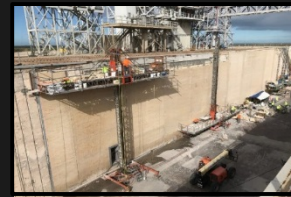
- ✓ All platforms have been installed
- Platform outfitting underway
 - Platforms Functional Testing/Turnover to Ops – all levels
 - Elevators 13 and 14 refurb work
 - Fire Suppression Water Supply – work complete, close-out process
 - Thrust Vector Control Hydraulic Servicing System (THSS) Platform/Hydraulic line Installations - ~50% complete
 - Tower F Level 32 Substation replacement - <10% complete



☐ Platform F ☒ Platform E ☒ Platform D ☒ Platform C ☒ Platform B ☒ Platform A

Pad 39B

- Flame Trench Project Status
 - Overall 50%+ complete
 - Bricks: 75%+ complete
- Prep for Flame Deflector installation is in-work
- Environmental Control System (ECS)
 - Refurbishment 90% complete (duct, chilled water piping, insulation, control wiring installation, instrumentation waiting final inspection; stub tower framework erection complete; pre-functional tests continuing).



Flame Trench



Inside ECS Room



ECS Interface to ML

☒ Ignition
Overpressure/
Sound
Suppression ☒ Chillers ☐ Flame
Trench ☐ Deflector ☐ ECS ☐ LH2 Storage
Tank Fill

Ground Software (KSC)







Ground/Flight Application Software Team (GFAST)

- ✓ Drop 8 complete Sept 2016
- Drop 9 & 10 - Dec 2016 & Mar 2017
- Drop 11&12 – June 2017 & Sep 2017
- Drop 13 & 14 – Nov 2017 & Feb 2018
- Drop 15 – May 2018

	GFAST 6 - 8 Delivered (MPPF V&V)		GFAST 9 – 10 (ECLSS/ Hypers)		GFAST 11 & 12 (MPPF)		GFAST 13 & 14 (Spacecraft Offline)		GFAST 15 (Flight)
--	---	---	---	---	---	---	---	---	------------------------------------

Spaceport Command and Control System (SCCS)

- ✓ SCCS 3.6.1 Validation Complete 2/7/17
 - MPPF Haz Ops (1st use of LCS for Haz Ops Testing) scheduled for Q217
 - Validated version ready for use
- SCCS 4.0 Development Complete; Integration in Progress
 - All Launch Vehicles Gateway Interfaces (SLS, ICPS, Orion)
 - Level 5 testing to start March, Validated complete early summer 2017
- SCCS 4.1 Development began Dec '16
 - Performance Improvements
 - Development complete summer '17, Validated complete end CY 2017

	SCCS 3.3/3.4 Verification Complete		SCCS 3.6 Validation Complete		SCCS 4.0 Validation Complete		SCCS 4.1 Validation Complete
---	---	---	---	--	---	---	---



cross-program systems integration



CSI Technical Performance – Recent Major Accomplishments (December-February)



- Released ESD 10012 ESD Concept of Operations Rev E to incorporate EUS architecture baseline and define the capabilities and interfaces needed to implement the Agency's goals (Dec)
- Accepted delivery of Booster OML and lightweight viewable CAD model update for VAC1R/EM-1 (Dec)
- Updated: MPCV to GSDO IRD Rev H (Dec), MPCV to GSDO HW ICD Rev A (Dec), MPCV to GSDO SW ICD Rev C (Dec), MPCV to GSDO RF ICD (Dec) and SLS Real-time Sim to GSDO Real-time Sim ICD baseline (Dec)
- Flight Rules Control Board charter developed and baselined (Dec)
- Approved EM-1 Mission Definition Baseline Rev C (Orion Space Biology Payload) (Dec)
- Baselined ESD 10035 Spectrum Plan as the authority for the integrated stack RF operations plan (Dec)
- RCN processing continues, 337 records have been approved (Dec-Feb)
- LCN processing continues, 39 technical LCC baselined to date (Dec-Feb)
- Mission performance scan completed and defined minimum co-manifested payload performance for EM-2 mission (Jan)
- Launch lighting analysis completed for September through March timeframe. Analysis shows limited launch lighting may be possible at the expense of performance margin for Dec-March launch periods. Tradeoff decisions are forward work (Jan)
- Completion structural modal testing of integrated Block 1 upper stage (LVSA, ICPS & MSA) (Jan)
- Approval by 45th SW of ESD 10114-04 Cross Program Range Safety Requirements Vol. 4 Airborne Flight Safety Systems Design, Test and Documentation Requirements – 8 of 8 volumes approved (Jan)
- Completed Orion Loss of Mission Go/No-Go tables using EM-2 mission profile and LOM Guiding Principles
- Performed independent analysis to compare the 3 DOF in-space preliminary mission analysis flight trajectory data from ULA (Feb)
- Released change request to update the ESD Safety and Mission Assurance Plan to Rev C to include the addition of EM-1 secondary payload safety review process, Probability Risk Assessment Approach for early flight risk assessment and S&MA support to real-time flight operations (Feb)
- Conducted Mission Integration Review (MIR) Readiness Assessment, decision to hold MIR in June (Feb)
- GAHLE delivery and installation at the SIL complete, testing complete (Feb)
- Conducted Human Ratings Summit for overarching discussion of NPR 8705.2b flow down to EUS, manual control and con ops for vehicle control (Feb)

CSI Technical Performance - Near Term Forward Work (March – May)



- Assessments to support mid-June EM-1 Mission Integration Review (March – June)
- Finalize DAC2/VAC-1R Reference Trajectories (Feb-Mar)
- Update ESD 10004 Mishap Preparedness and Contingency Plan with EM-1 Annex (March)
- Baseline ESD 10036-EM1 External Markings Document (March)
- Functional Compliance Report (FCR) Integrated Baseline Coordination; FCR draft (Feb), FCR internal review (March)
- Delivery of process for ESD Requirement (ESD 10002) Closure Status Reporting (March-June)
- Update the ESD CoFR Plan to Revision A (March); Assessment of CoFR Mapped and Compliance products support EM-1 ESD/Agency CoFR reviews and alignment of Program and ESD CoFR Plans (March-June)
- Update ESD Crew Health Operations Concept to Rev A (CR release April)
- Begin update of Integrated Vehicle OML and drawing for VAC1R/EM-1 (April)
- Continue to develop and baseline OMRS to support WADs and Ground and Flight Software (GFAS) development
- ADP package review/acceptance refinement
- Facilitate smooth transition of SLS/Orion provided ground support equipment
- Cross Program coordination of CUI delivery and configuration
- Resolution of GFAS test needs in SIL and ITL assessments
- Baseline ESD 10026-EM2 MDB for EM-2 and 10018-ANX02 Flight Operations Review Plan; Approve ESD 10026-EM1 MDB Rec D launch/landing lighting constraints and –ANX01 Cross Program Ops GR&Cs
- Continue to develop and baseline LCC to support GLS V&V testing
- Outbrief and recommendation to CPIT on EM-2 crew size and HEO size from completed MAIA trades
- Delivery of in-space portion of upper stage (LVSA, ICPS & MSA) test-verified FEM (May)
- Begin URT-6 test plan development, first planning TIM (May)
- EM-2 Mission Duration Trade, pending completion of aborts analysis, mission extension burns, performance (May)
- Release of Version 3 of ESD 20002 EM-1 LOOV XPRA Report (May/June)
- TIM with JAXA on 3-way Doppler support

CPIT Top Technical Issues



Concern	Current Status
<p>Vertical Stabilization System (VSS) Timing: Current VSS clearance analysis with the integrated stack at launch shows positive clearance; however, there is a concern that the VSS may bind if worst on worst timing conditions are assumed to be credible.</p>	<p>Ran Monte Carlo analysis for baseline release of 0 to 220 ms late showing 220 ms is worst case hangup case. VSS design loads envelope new liftoff loads predictions. Expect that early release will not be required. Will bring to JICB in March.</p>
<p>GSDO Ground to Flight Applications Software (GFAST): GFAST development is highly dependent on agreements for products (Compact Unique Identifier (CUI), Operations and Maintenance Requirements and Specifications (OMRS), Launch Commit Criteria, XML Telemetric & Command Exchange (XTCE)) to be delivered by other programs.</p>	<p>GSDO, Orion and SLS have negotiated and partnered deliveries to meet GFAST needs. SLS CUIs are partnered and will be delivered no later than 7/17/2017. Majority of Orion CUIs delivered to GSDO in March per GSDO need and remaining to be delivered by 6/1/2017. CUI cross program configuration in discussion between Programs with the Integrated Avionics and Software ITT.</p>
<p>Interim Cryo-Propulsion Stage (ICPS) Umbilical Loads: Initial integrated loads showed that ICPS loads were >200% over hardware design loads.</p>	<p>Updated GSDO model showed significantly reduced loads at the SLS-GSDO interfaces; control runs with the independent SLS model agree well with the GSDO model. Full set of results in work with updates based on LETF testing. Model results and static test results will be assessed prior to proceeding with dynamic plate separation testing, which starts NET March 2017.</p>
<p>Orion Service Module Umbilical (OSMU) Collet Cup Release: The cross-program team examined the collet design and associated scenarios that would result in the need to perform a secondary umbilical release; the Core Stage Forward Skirt Umbilical (CSFSU) secondary release tests had cup falling off in 3 of 3 tests.</p>	<p>Debris team preliminary analysis indicates debris energy exceeds damage threshold for some SLS components. Collet release testing halted after exceeded software limit on pull force. Scheduling an Integrated Failure Review Board to assess risks and plan forward.</p>
<p>OSMU Collet Linkage Engagement Issue: Two instances of problems while engaging the collet during OSMU testing at Launch Equipment Testing Facility (LETF)</p>	<p>Stages/Boeing completed designs to resolve issue and provided support for fabrication of modified linkage for Orion development unit to support fit checks. Stages working contract to have supplier deliver updated production collets to Orion with additional design modifications to the collet fingers, cup and drive pin needed to resolve collet binding issue. Scheduling an Integrated Failure Review Board to assess risks and plan forward.</p>
<p>Use of SLS Engineering Data for OMRS/LCCs: GSDO is required to use Engineering Data (ED) measurements to satisfy existing OMRS and wants to potentially use cryo Engineering Flight Instrumentation (EFI) measurements (via the ED Processor) as a backup verification for LCCs because some Operational Flight Instrumentation (OFI) is single string. EFI sensors and data acquisition box (grade 4 parts) are rated Crit 3. ED processor S/W is not classified for this potential use and would require a waiver.</p>	<p>JICB assigned actions to conduct Flight instrumentation assessment on intended use of Engineering data (in process) and to determine if waivers are required for the ED processor S/W. Per GSDO Software Assurance Classification Assessment, waiver will be required; SESC gap analyses now in process and with SLS SESC S/W CMMI organization will make recommendations to SLS Technical Authority whether additional waivers are needed.</p>
<p>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 Constellation Program heritage.</p>	<p>Additional exposure to pad winds causes concern for Orion frangible bolts between the CM and SM. JICB approved an alternate fatigue spectrum with 68 day pad stay duration for Orion to use. Orion to perform fatigue/fracture analysis and come back to JICB in March. Will elevate to ECB for visibility.</p>
<p>Integrated Test Lab (ITL) Test Schedule Risk and Approach: ITL test schedule impacts due to ESM delays are a critical path for EM-1 launch date.</p>	<p>Orion is re-planning the ITL schedule to accommodate the latest ESM delivery schedules and developing a top program risk.</p>
<p>Mobile Launcher (ML) modal testing: Joint NESC/JLTT recommendation to perform modal testing to characterize ML prior to stacking. GSDO evaluated performing a ML modal test prior to stacking with emphasis on trampoline mode.</p>	<p>JICB concurred with technical need for the ML test; forward work to assess sensor quantity/locations and excitation methods/locations. Potential slot for test in late 2017, after completion of element V&V at parksites. Test will be presented to the JPCB in late March for approval.</p>

Major ESD/CSI Independent Assessments In Progress



- Independent modeling and simulation of separation events. Ascent trajectory good comparison with program; Liftoff clearance w/ stuck actuator complete - awaiting report; SM Panel results and recommendations provided; SRB Sep complete – awaiting report
- Peer Review of Enterprise Modal Testing. Correlation effort - Includes testing and analysis, and Development Flight Instrumentation.
- Independent Verification of Ascent Abort Loads. Tool development complete, analysis in work. Preliminary results presented Sept 2016. Update analysis and report expected April, 2017.
- Independent Verification of Pre Launch Loads. Validating methodology and loads. Working to March 2017 completion.
- Evaluation of ORDEM 3.0 MMOD environment. Using data from available on-orbit assets. Final report in work.
- MMOD Pressure Vessel Failure Criteria. Hypervelocity Impact Testing on COPVs to validate models. Small tank testing complete. Arde (ISS High pressure gas) tank testing to begin March.
- Enterprise Verification and Validation Assessment. Presentation of Findings, Observations, Recommendations provided to ESD. Awaiting final report. ESD developing responses and addressing recommendations in anticipation of final report.
- Cross-Program V&V Mapping. Perform interface requirements and compliance gap assessment
- ESD developing a Cross-Program Independent Assessment Summary Matrix. Evaluating SMC-G-63-1202 and NPD 8610.7 approaches and applicability to ESD; Evaluating extent and depth of studies already performed. Reviewing recommendations and follow-up from completed studies.