Exploration Systems Development Update

Tom Whitmeyer, Acting Deputy Associate Administrator for
Exploration Systems Development

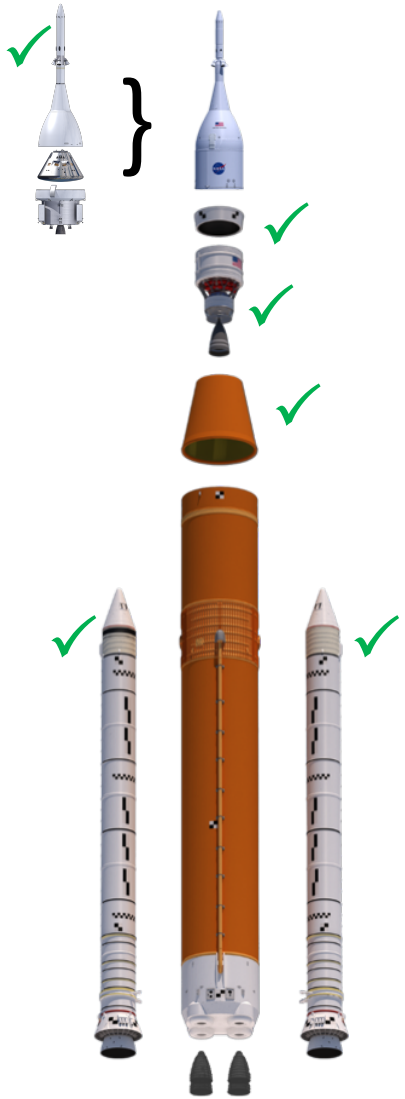
NASA Advisory Council (NAC)
October 30, 2019

Artemis I Status

- European Service Module Critical Design Review
- Crew Module Pressure Proof Test
- Booster Qualification Motor 2 Test
- Crew Module Propellant Pressure Proof Test
- VAB Verification & Validation Complete
- RS-25 Flight Engines Complete
- ICPS Delivered to KSC
- Crew Module Initial Power On
- VAB High Bay Construction Complete
- Multi-Payload Processing Facility Construction
- LVSA Manufacturing Complete
- Mobile Launcher (ML) Umbilicals Installed
- VAC Welding Complete on Core Stage
- Launch Pad Flame Trench Construction Complete
- Parachute Tests Complete
- European Service Module Delivered to KSC
- Crew Module and Service Module Mate
  - All Orion Splash-down Recovery Tests Complete*
  - Core Stage Integration
  - ML Ground Support Equipment Installation Complete
  - Core Stage Green Run Hot Fire Test
  - Crew and Service Module Delivery to EGS
  - Ground Flight Application Software Complete
  - Booster Stacking in VAB
  - Core Stage Arrival at KSC
  - Core Stage Stacking with Boosters in VAB
  - CM/SM Mating with Launch Abort System
  - Orion Mating with SLS in VAB
  - Wet Dress Rehearsal at Launch Pad
  - Roll-out for Launch

*Known as Underway Recovery Tests – NASA and the U.S. Navy are conducting Underway Recovery Tests to verify and validate procedures and hardware that will be used to recover the Orion spacecraft after it splashes down in the Pacific Ocean following deep space exploration missions.

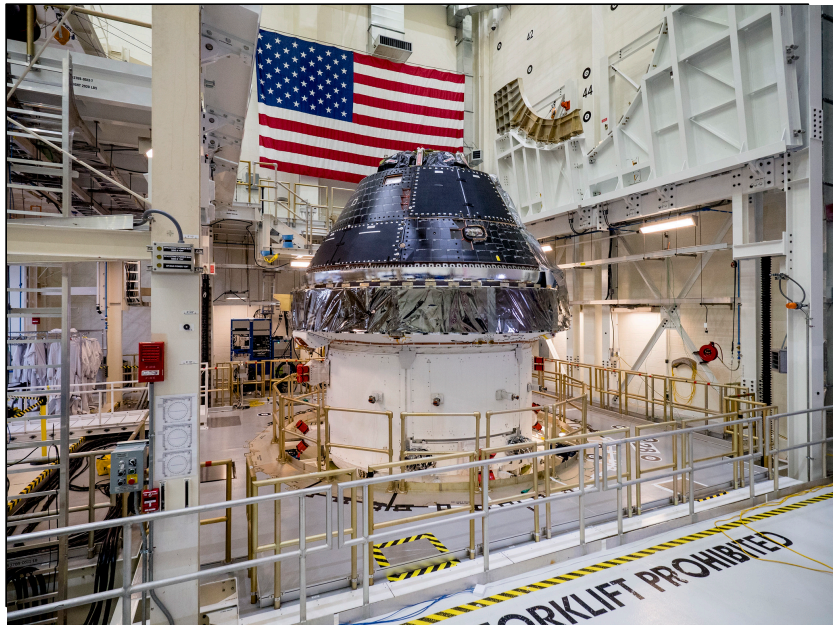
Building to Artemis I



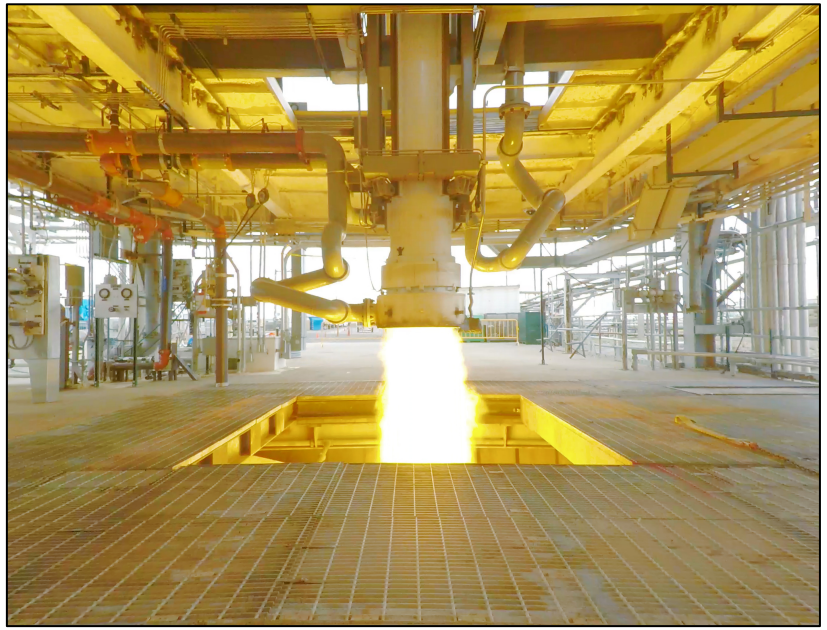
✓ 4 Artemis I Engines

National Aeronautics and
Space Administration

Orion Spacecraft



Completed Orion Crew Vehicle for Artemis I flight in the Operations & Checkout Building at NASA's Kennedy Space Center in Florida.



Aug. 5 Propulsion Qualification Test - a successful, continuous 12-minute firing of Orion's propulsion system.

Launch of NASA's Ascent Abort-2 successfully demonstrated the Launch Abort System on July 2, 2019.

Artemis I Launch Abort System (LAS) (Lockheed)

✓LAS assembly and integration complete

- System Acceptance Review (SAR) and Design Certification Review (DCR) – mid-November 2019
- LAS DD250 - November 2019

Orion Launch Abort System

Ascent Abort (AA)-2 Test Findings/Results

- 38 Total AA-2 Flight Test Objectives (FTOs) were assessed at an Engineering Review Board (ERB) on August 21, 2019
- Preliminary assessments of FTOs are positive
- AA-2 flight test results scheduled to be finalized on November 20, 2019

Expect AA-2 Flight Test will be deemed fully successful

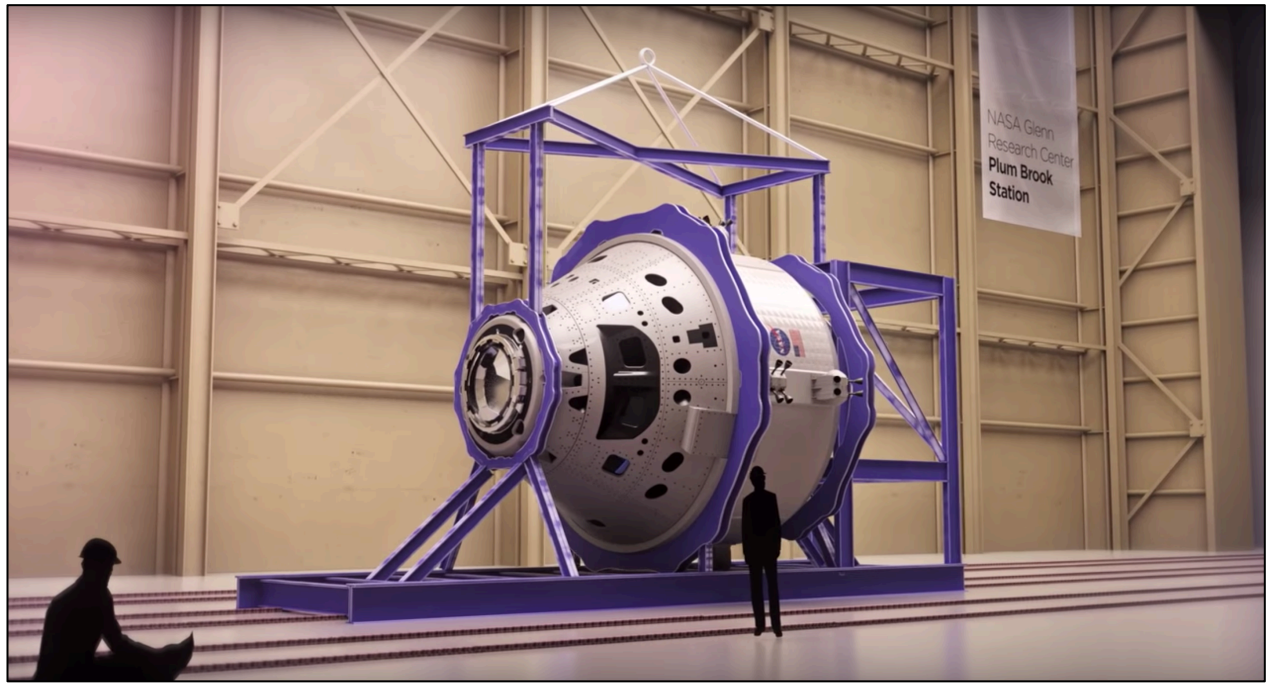
Artemis I Crew and Service Module (CSM) (KSC O&C Building)

- ✓ CM/SM Mate to form CSM - July 2019
- ✓ CSM Final Assembly and System Testing (FAST) Cell Operations - July – October 2019
  - ✓ CSM Initial Power Up
  - ✓ CSM Subsystem Integration
  - ✓ CSM Integration Spacecraft Testing
  - ✓ Complete CSM Assembly
- – CSM Transport to Plum Brook – November 2019

Drogue Mortar being installed
Side Hatch TPS Panel Installed

Artemis I CSM Environmental Testing (Plum Brook Station (PBS)

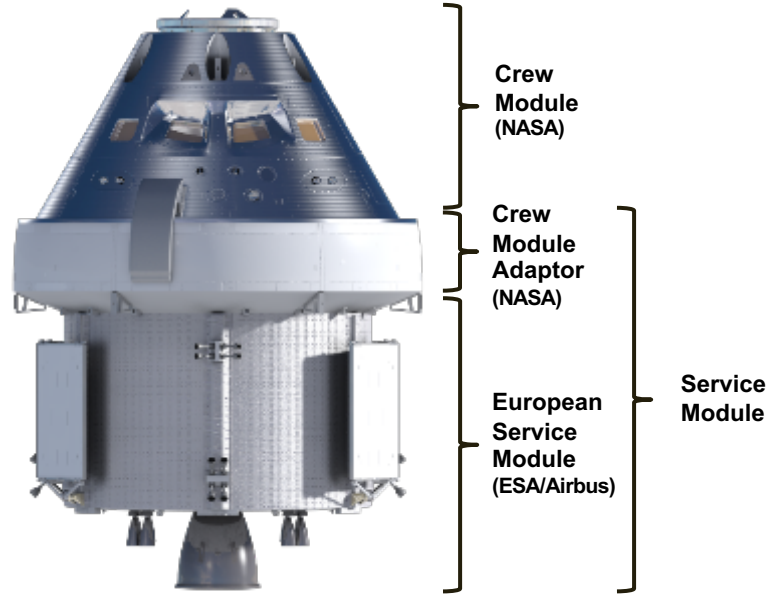
- CSM Received at PBS– November 2019
- CSM Thermal Balance Test complete – January 2020
- CSM Thermal Vacuum Test complete – February 2020
- CSM Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC) Test complete – March 2020
- CSM Transport to KSC – March 2020



Concept imagery of Orion Crew and Service Module testing at Plum Brook Station

Artemis I CSM Final Assembly and Test (KSC O&C Building)

- CSM Return to KSC – March 2020
- CSM Final Assembly and Test – March 2020 – May 2020
- CSM Complete – May 2020
- CSM Turnover to EGS – May 2020



Flight Software/Integrated Test Lab (Lockheed Martin/Denver)

Software Development
Artemis I

- ✓ Flight Software load 28E released 9/24/18 (Guidance, Navigation and Control, Fault Detection Isolation and Recovery, Safe Mode, Backup Flight System, and Redundancy Management)
- ✓ Flight Software Load 28E-Patch 1 release 10/25/18
- ✓ Flight Software Load 28E–Patch 2 release 12/17/18
- ✓ Flight Software Load 28E – Patch 3 release - 2/28/19
- ✓ Flight Software Load 28E – Patch 4 release – 4/28/19
- ✓ Flight Software Load 28E – Patch 5 release - 6/30/19
- - Flight Software Load 28E – Patch 6 release – 12/12/19
- - Flight Software Load 28E – Patch 7 release – April 2020

Software Development
Artemis II

- – Software Build 201 Formal Software Release – March 2020
- – Software Build 202 Formal Software Release – July 2020
- – Software Build 203 Formal Software Release – October 2020

☑ 28E Patch 1 Release ☑ 28E Patch 2 Release ☑ 28E Patch 3 Release ☑ 28E Patch 4 Release ☑ 28E Patch 5 Release ☐ 28E Patch 6 Release ☐ 28E Patch 6 Release ☐ Artemis II Release 201 ☐ Artemis II Release 202

Integrated Test Lab (ITL)

- ✓ Assembly, Test, and Launch Operations mission & CSM 28E Functional testing complete – July 2019
- ✓ ITL Verification Test Campaign complete for Artemis I– September 2019
- - Reconfigure ITL to support both Artemis I and Artemis II testing – November 2019

☑ ATLO mission & CSM 28E Functional testing complete ☑ ITL Verif Test Campaign complete – Artemis I ☐ ITL Reconfig to support Artemis I & II

Build up of Artemis II Crew Module (CM) (Kennedy Space Center Operations & Checkout (O&C) Building)

- ✓ CM Pressure Vessels Arrives at O&C – August 2018
- ✓ CM Primary Structure – Bird Cage Complete – January 2019
- ✓ CM Proof Pressure Test – February 2019
- ✓ Heatshield/Lower Backshell Prefit –July 2019
- – ECLSS Wall Drilling, Secondary Structure, ECLSS, Prop, & Component Installation – November 2019
- – CM ECLSS/Prop Proof Pressure Leak Test –
  - – Phase 1 - April 2020
  - – Phase 2 – August 2020
- – Artemis II Core Avionics Delivered – August 2020
- – CM Subsystem Installations – January - August 2020
- – CM Functional Tests – February 2021
- – Heatshield Installation – January 2021
- – CM Back Shell, Forward Bay Cover and Avionics Installation – April 2021
- – CM ready to mate – April 2021

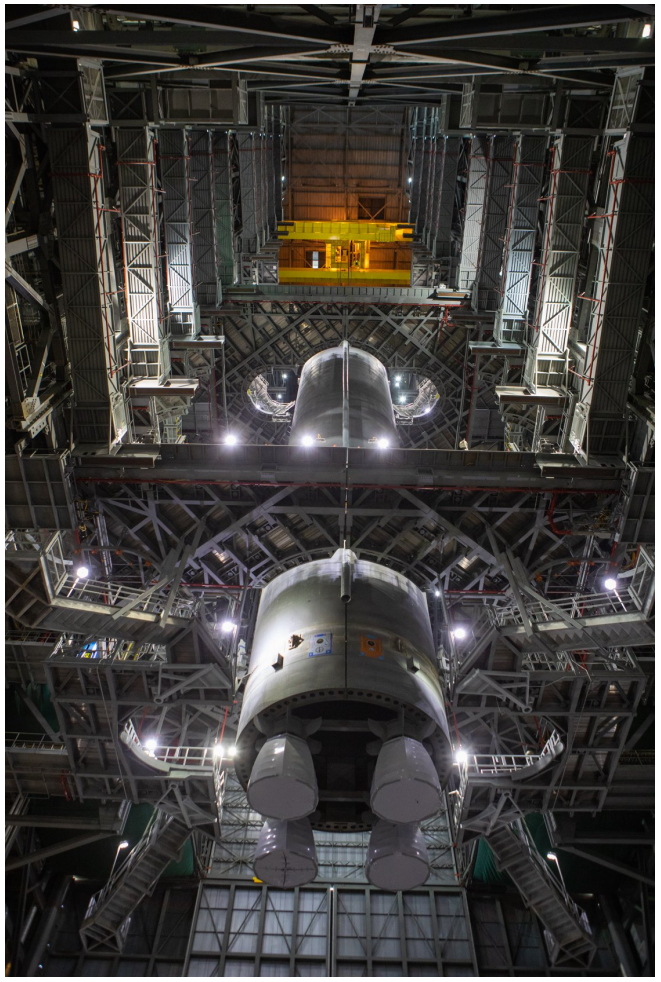
Artemis II Crew Module at the O&C

✓ CM Bird *Cage Complete* | ✓ CM Proof Pressure Test | ✓ Heatshield/ Lower Backshell Prefit | ☐ ECLSS Installation | ☐ ECLSS/ Prop Proof Pressure Test | ☐ Subsystem Installation | ☐ Functional Tests | ☐ Heatshield installation | ☐ CM Back Shell, FW Bay Cover, Avionics Installation | ☐ CM ready to mate

Artemis II Crew Module Adapter (CMA) (KSC O&C Building)

✓CMA Structural Assembly – October 2019
- CMA Secondary Structure and Clean Room Ops – January 2020
- CMA Leak/Proof Tests – February 2020
- CMA Subsystem Installation – March 2020
- Complete Functional Test – May 2020
- Ready to Mate with the European Service Module - May 2020

Space Launch System (SLS) Rocket

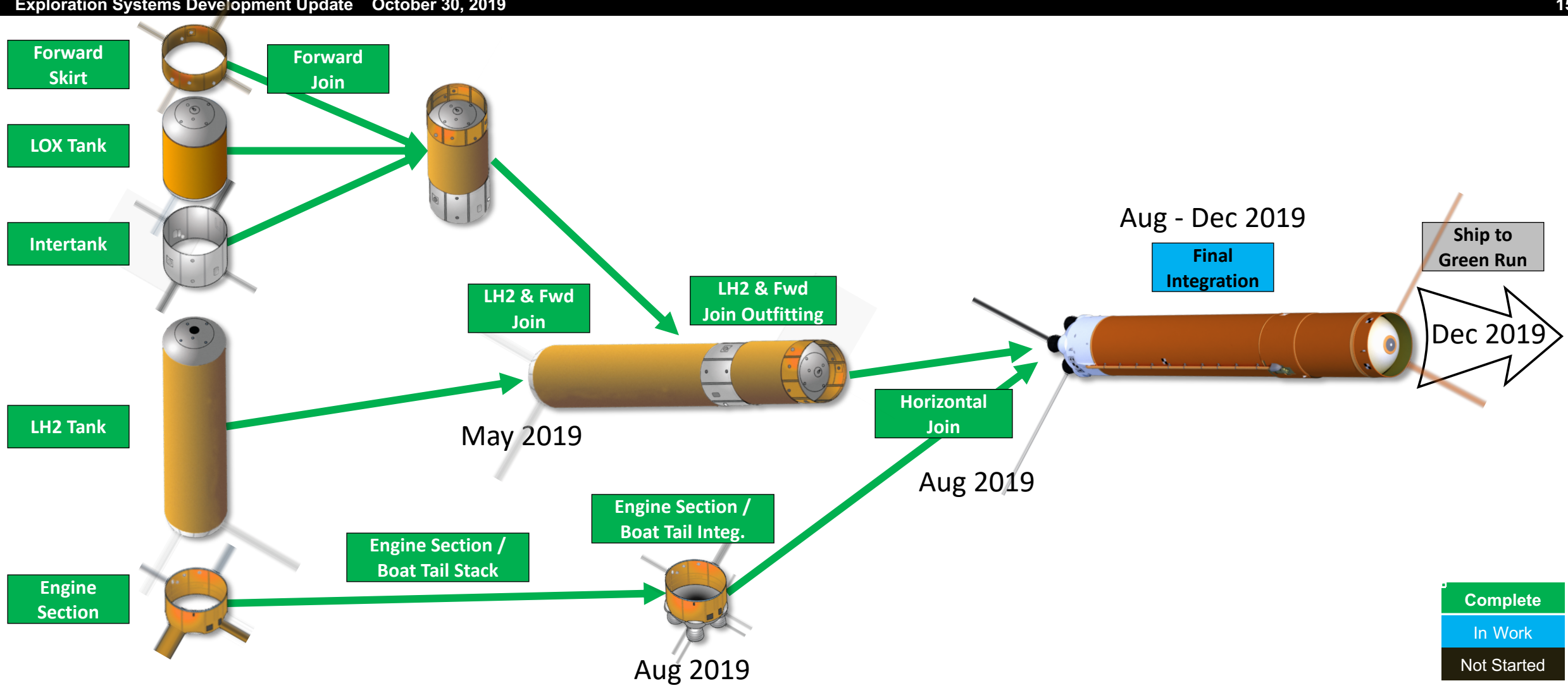


VAB crane lowers the SLS Core Stage Pathfinder into High Bay 3

The first of four RS-25 engines has been attached to the core stage

Liquid oxygen tank structural test article placed into Test Stand 4697 at NASA's Marshall Space Flight Center.

Artemis I Stages (Boeing - MAF)

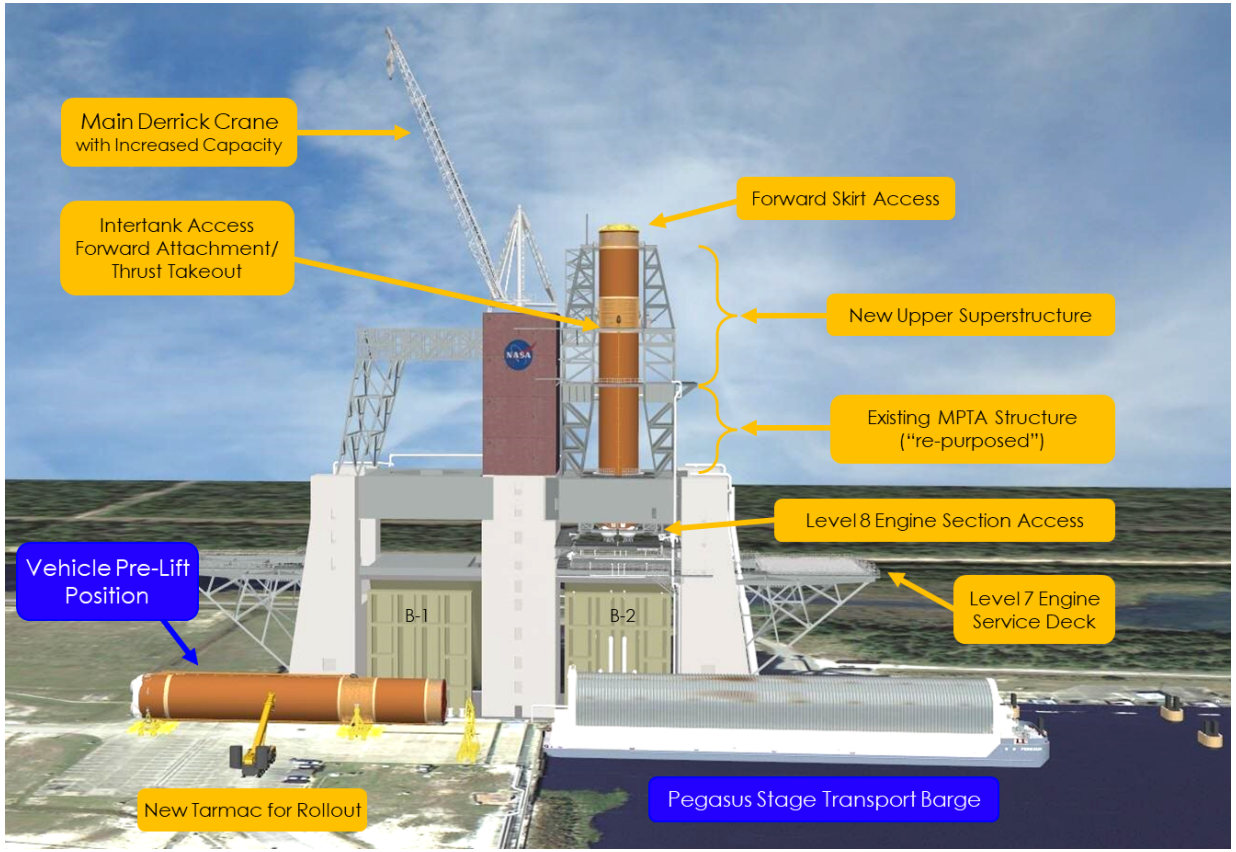


Weld Confidence Articles	All CS 1 VAC Complete	FS Complete	IT Complete	LOX Tank Complete	Forward Join	LH2 Tank Complete	ES Complete	Horiz. Join	Final Integration	Ship to Green Run
✓	✓	✓	✓	✓	✓	✓	✓	✓	☐	☐

Artemis I Green Run

- Core Stage Ship to SSC - December 2019
- Core Stage Load into B-2 Test Stand
- Modal Test Complete
- Vehicle Power-on Checks Complete
- Main Propulsion System (MPS) & Engine Leak / Functional Checks Complete
- Hydraulics and Thrust Vector Control (TVC) Checks Complete
- Safing Checks for Wet Dress Rehearsal Complete
- Simulation Countdown Complete
- Wet Dress Rehearsal Complete
- Hot-Fire Test Complete
- Post Hot-Fire Refurbishment
- Post Green Run Final Health and Status Check −

Core Stage Ship to KSC



Core Stage Arrive at SSC | Core Stage Load into B 2 Test Stand | Modal Test Complete | Vehicle Power On Checks | MPS & Engine Leak/Functional Checks | Hydraulics and TVC Checks | Safing Checks | Simulation Countdown | Wet Dress Rehearsal | Hot Fire Test | Refurbish and Final Check | Ship to KSC

Artemis I Boosters (Northrop Grumman - Utah)

- ✓ All Booster Separation Motors are cast and finalized
- ✓ All Artemis I Segment Casting complete (10 out of 10 Artemis I segments cast)
- ✓ Both Aft skirts structural refurbishment complete
- ✓ Both Artemis I Nozzle assemblies and Aft Exit Cones complete
- ✓ Avionics Qualification Testing Complete
- ✓ Artemis I Left Hand aft skirt TVC lower frame installation complete
- ✓ All 10 Artemis I Segments Finalized and in Storage
- ✓ Propellant-liner-insulation (PLI) flight rationale complete - November 2018
- ✓ Artemis I PLI Waiver signed – May 2019
- − Artemis I Segments Ready to Ship – Plan to ship by March 2020 (warmer weather to ship from Utah)
- − Booster stacking

Final Artemis 1 segment to storage

Engineers remove the core after casting the booster case with propellant

Artemis I & II Engines (Aerojet Rocketdyne – MAF & SSC)

- ✓ Held RS-25 Production Re-start Integrated Baseline Review (IBR) - May 2016
- ✓ Engine 0528 RS-25 (LOX Pump Pressure) Complete - February 2017
- ✓ Engine Control Unit (ECU) Flight Model (FM) -1 to 3 Authority To Proceed (ATP) Complete - April 2017
- ✓ Engine 0528 ECU Green Run Testing Complete
- ✓ Artemis I RS-25 Engines Deliver in Place - October 2017

  The Artemis I Flight Engines are Engine 2045, Engine 2056, Engine 2058, and Engine 2060
- ✓ RS-25 Development Test Campaign (First Hot Isostatic Pressure bonded Main Combustion Chamber and Controller Green Runs) - August 2018 through April 2019
- Artemis II (Artemis I contingency engines) Engines Complete
  - ✓ E2059
  - ✓ E2047
  - – E2063
  - – E2062
- – Engine Installation into Core Stage 1 – CURRENTLY IN PROGRESS @ MAF

Final Engine Adaptation / Software Cert Hot-fire Test

Artemis I Engine #2 Installation

Software Test Lab (Marshall Space Flight Center)

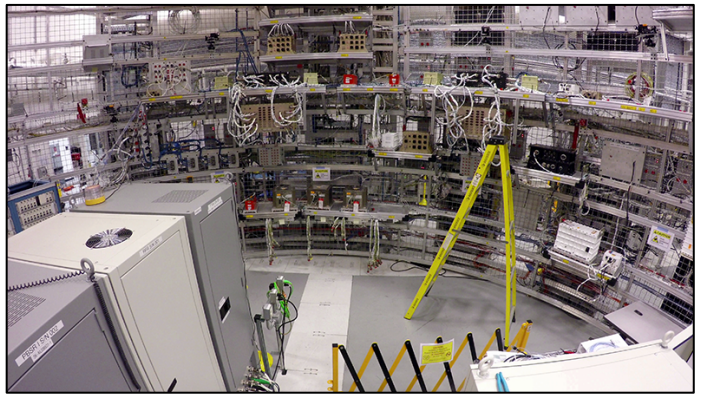
Software

✓Deliver Flight Software Release 13 - December 2016
✓Complete Sprint 5 Flight Software Release 14 - March 2017
✓Complete Sprint 6 (final sprint) Flight Software Release 14 - May 2017
✓Complete Release 14 Green Run Application Software (GRAS) - June 2018
✓Complete GRAS Regression Testing – January 2019
✓Complete Release 14 Flight Control Application Software (FCAS) - July 2019

✓ FSW 11 Release (Engineering) | ✓ FSW 12 Release (Engineering) | ✓ FSW 13 Release | ✓ FSW 14 Release (GRAS) | ✓ FSW 14 Release (FCAS)

Software Integration Test Facility (SITF) - Qualification Testing

✓Complete Phase 1 (Pwr Quality & Verif) - May 2016
✓ Complete Phase 2 (Command and Data Handling (C&DH) & Flight Safety System (FSS) Dry Run) - October 2016
✓Complete Phase 3 (Flt Ctrl & Telemetry (TLM) Dry Run) - June 2017
✓Complete Avionics Subsystem Qualification Testing - May 2019
− Complete Phase 4 (Final Avionics Verif) - November 2019 – IN PROGRESS



SITF Qualification Testing

✓ SITF Development | ✓ SITF Qual Test Ph 1 Comp | ✓ SITF Qual Test – Ph 2 Comp | ✓ SITF Qual Test – Ph 3 Comp | ✓ SITF Qual Test – Avionics Test Comp | ☐ SITF Qual Test Complete

Artemis II SLS Progress

- ✓ All (10 out of 10) Artemis II Segment Casting complete
- ✓ All 10 Artemis II Segments Finalized and in Storage in Utah
- − Artemis II (Artemis I contingency engines) Engines Complete
- Forward Skirt Complete
- Intertank Complete
- LOX Tank Complete
- Forward Join
- LH2 Tank Complete
- Engine Section Complete
- Horizontal Join
- Engines Installed

Artemis II LVSA OSA Panels

Artemis II Boosters Segments Cast

Artemis II Engine Section

Artemis II LH2 Tank in VAC @ MAF

Exploration Ground Systems

Completed the Rotation Processing and Surge Facility (RPSF) System Acceptance Review / Operational Readiness Review. The RPSF will receive the booster segments for the SLS rocket.

A flow test of the Ignition Overpressure Protection and Sound Suppression water deluge system on the mobile launcher. The mobile launcher is undergoing final testing and checkouts at Launch Pad 39B

Core Stage Pathfinder moved into the VAB for training operations

Mobile Launcher (ML) (KSC)

Artemis I Progress

- ✓ ML Roll to VAB – September 2018
- ✓ ML Roll to Pad – June 2019
- ✓ ML Pneumatics Functional Testing Completed – September 2019
- ✓ ML Simultaneous Retract Completed – October 2019
- ✓ ML End To End (ETE) Electrical V&V Completed – October 2019
- ML/Pad LO2/LH2 Systems Verification and Validation (V&V) Complete – November 2019
- ML/Pad Multi-Element (ME) V&V Complete – November 2019
- ML ETE Fluid V&V Complete – December 2019

Future Mission Development

- ✓ ML-2 Contract Award (Artemis IV) – June 2019
- ✓ ML-1 Crewed Modifications Design Award (Artemis II) – August 2019
- ✓ ML-2 Charrettes & Studies Completed (Artemis IV) – October 2019
- ML-2 Construction Start (Artemis IV) – November 2019

ML at Pad 39B for ME V&V

Vehicle Assembly Building (VAB) (KSC)

Artemis I Progress

✓ Testing on the Environmental Control System (ECS) for Artemis I Completed – September 2018

✓VAB Handling & Access Design Certification Review (DCR) Completed – May 2019

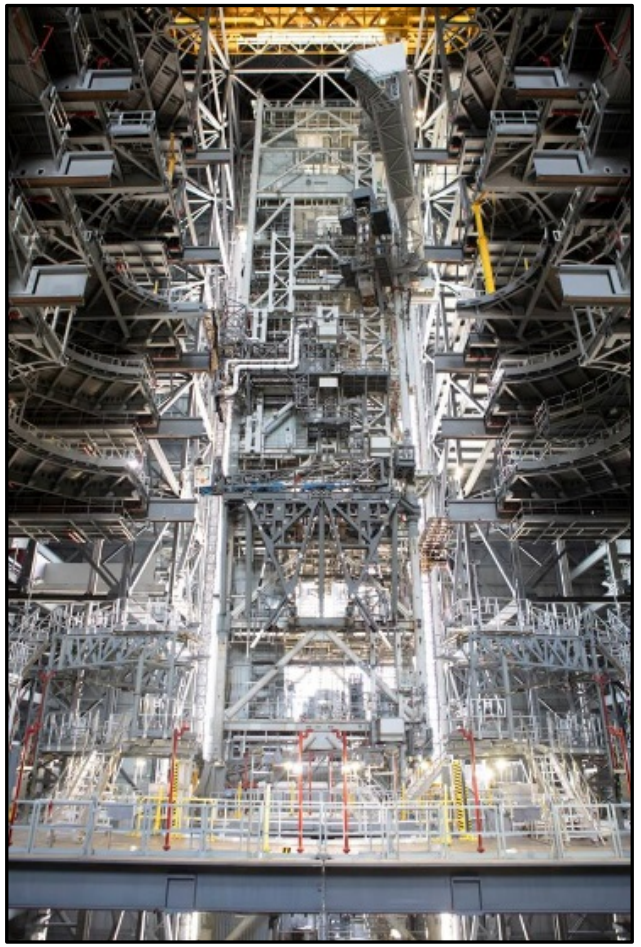
- VAB Integrated Platform Demonstrations – November 2019
- VAB Platforms DCR – November 2019
- VAB Subsystem Transitions – November 2019

Future Mission Development

✓ VAB High Bay (HB) 3 Platform Design Completed (Artemis IV) – March 2019

✓VAB ECS Construction Started (Artemis II) - April 2019

- VAB HB3 Platforms Construction Start (Artemis IV) – TBD



VAB HB3 Platforms surrounding ML

Pad 39B (KSC)

Artemis I Progress

- ✓ Flame Trench/Flame Deflector Completed – September 2018
- ✓ Pad B ECS Test Readiness Review (TRR) Completed – October 2018
- ✓ Pad B ECS Testing Completed – December 2018
- ✓ Pad B Extensible Columns Fabrication Completed – April 2019
- ✓ Pad B Ready for ML – June 2019
- ✓ Pad B Extensible Columns Testing Completed – October 2019
- ML/Pad Multi-Element V&V Complete – November 2019
- ML/Pad ECS V&V Testing Complete – November 2019

Extensible Columns integrated with Side Flame Deflector

Future Mission Development

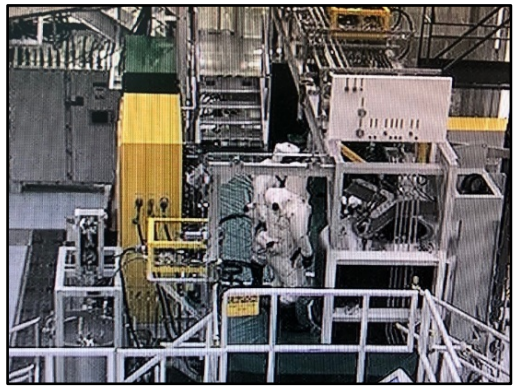
- ✓ Emergency Egress System (EES) Concept study extension to evaluate ML-1 and ML-2 interchangeability (Artemis II) - Completed
- ✓ LH2 Sphere Dewer Support Columns Installed (Artemis IV) – July 2019
- ✓ LH2 Sphere Outer Equator Plate Installation Completed (Artemis IV) – September 2019
- ✓ Pad LN2 Heat Exchanger GSE 60% Design Review (RL10 Chilldown) (Artemis IV) – Sept. 2019
- ✓ Pad B Emergency Egress System Design Started (Artemis II) – April 2019
- ✓Pad B Environmental Control System Design Started (Artemis IV) – April 2019
- Converter Compressor Facility design complete, construction start (Artemis III) – June

LH2 Upgrade Construction – The outer shell "equator" panels being assembled

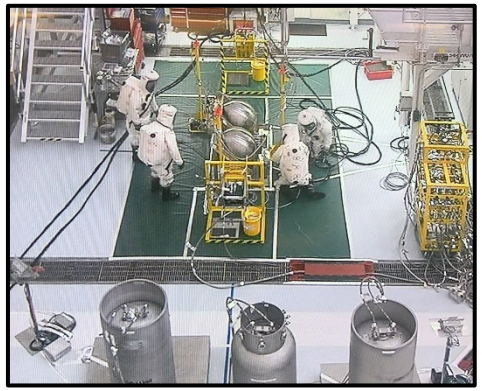
Multi-Payload Processing Facility (MPPF) (KSC)

MPPF standalone V&V activities

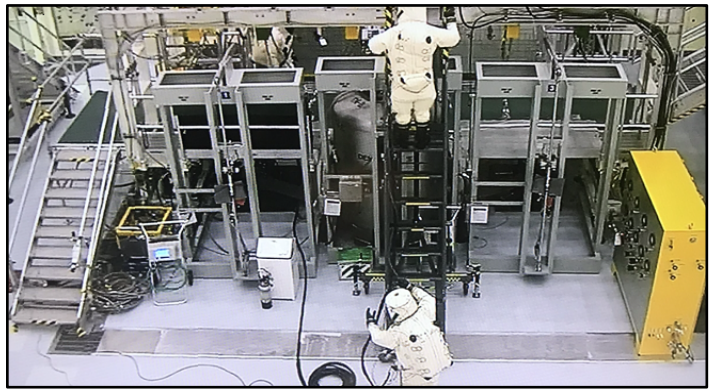
- ✓ Hypergol Servicing/Deservicing V&V testing being split for Fuel and Ox Testing
  - ✓ Hyper-Fuel-Hot Flow V&V Completed – October 2018
  - ✓ Hyper-Oxidizer Hot Flow V&V Completed – September 2019
- ✓ MPPF ICPS Cold Flow Demonstration Completed – April 2019
- ✓ MPPF Hyper V&V Completed – September 2019
- ✓ MPPF Subsystem Standalone/Integrated V&V Completed – September 2019
- – Spacecraft Offline System Acceptance Review / Operational Readiness Review – December 2019



Service Module Fuel Hot Flow



Crew Module Hot Flow De-servicing

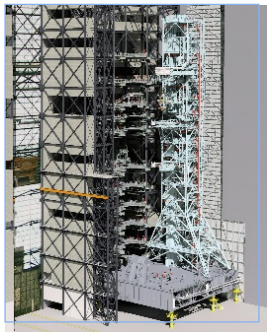


Oxidizer Hot Flow

Spaceport Command & Control System (SCCS)

- SCCS 6.0 – GFAS V&V
- SCCS 6.1 – GFAS Regression, Orion Flight Vehicle Processing, & ITCO
- SCCS 6.2 – GFAS Regression, WDR and Artemis I Launch

MPPF Hazardous Testing



MEVV @ VAB

MEVV @ Pad

- ✓SCCS 6.0 Development Comp. – June 2019
- ✓SCCS 5.0 Delta Sys S/W H/W Val Complete F1R (F1R Offline) – July 2019
- SCCS 6.0 V&V Comp. – December 2019
- SCCS 6.1 V&V Comp. – January 2020

✓ SCCS 5.0 Engineering Release	✓ SCCS 5.0 Validated Release	✓ SCCS 6.0 Development Complete	☐ SCCS 6.0 System Test Complete	☐ SCCS 6.0 Validated Release

Ground Flight Application Software (GFAS)

Integrated Orion Power-Up in Firing Room 3

- ✓ ITL Run-for-Record 2 testing ECLSS, Avionics, GLS, Flight Communications, Navigation and Tracking, and Electrical Power System – September 2019
- Houston Orion Test Hardware (HOTH) test runs ECLSS, Avionics, Communication, Ground Launch Sequencer (GLS) – September thru October 2019
- ITL Run-for-Record 3 testing – December 2019 (post ITL blackout period)
- Cross Program initiatives are increasing, yielding positive results (FSW integration, Operations and Maintenance Requirements and Specifications (OMRS) scripting & pre test, Launch Commit Criteria / GLS algorithms, Green Run / Launch Countdown)

✓ GFAS Drop 17	✓ GFAS Ready for ML/Pad ME V&V	☐ GFAS Hoth Test Runs	☐ GFAS ITL Test Runs	☐ GFAS ITCO Ready (SAR)

Exploration Systems Development:
Systems Engineering & Integration

Wayne Jermstad

Acting Director, Cross-Program Systems Integration, Exploration Systems Development

SE&I Accomplishments This Quarter

- Developed ESD Internal Planning Manifest for Artemis I through Artemis IX (Sept)
- Baselined ESD 10045, ESD Architecture Configuration and Design Constraints (ACDC) (Sept)
- Held Integrated System and Mission Certification (ISMC) Dry Run #1 (Oct)
- Held Artemis II Sync Point #1 (Sept)
- Updated ESD 10030, Enterprise Functional Operational Capabilities (FOC) and Validation Expectations to Revision B (Sept)
- Updated ESD 10020, ESD CoFR Plan to Revision C to incorporate ESD Integration Review and ISMC (Sept)
- Completed EGS Validation testing Run for Record Test #1 in HOTH (HOTH-RFR-1) (Sept)
- Completed EGS Validation testing Run for Record Test #2 in ITL (ITL-RFR-2) (Oct)
- Completed EGS Integration Test #6 in SIL (Oct)
- ICAN Test 51b (Oct)
- ICAN Test 28b (Sept)

SE&I Schedule Assessment Teams

- Core Stage Assembly, Integration and Test (AI&T)
- Green Run Testing
- Vehicle Assembly, Integration and Test (AI&T)
- Integrated Loads and Guidance, Navigation and Control (GN&C)
- Integrated Trajectories
- Integrated Software
- Enterprise Verification and Validation

SE&I Issue Resolution Teams

- Range Safety (new)
- Pad Access/Con Ops
- Ignition Overpressure Sound Suppression (IOPSS) Water Flow Rate
- IT Security
- Block 1B Acoustics
- Block 1B Loads
- Imagery

Prep for FRR: ISMC Dry Run #1

- Purpose:
  - Assess and track the current state of flight readiness of the Enterprise from an integrated system and mission integration perspective
- Objectives:
  - Review the status of technical integration work necessary for Enterprise integration at the ESD Pre-FRR
  - Identify gaps in technical integration to allow appropriate time to address them
  - Identify technical integration issues that need to be addressed
  - Ensure integration issues have adequate plans for closure
  - Determine if any changes warranted to the agenda/content/presenters

Summary of ESD SE&I
Statement of Readiness (SoR) / Endorsement

- ✓ *Mission requirements defined and integrated (vertically and horizontally)*
- ✓ *Integrated flight and ground systems will function as designed; constraints identified*
- ✓ *Nonconformances, deviations, waivers, unexplained anomalies, etc. assessed / approved; residual risk acceptable*
- ✓ *Integrated flight and ground systems deemed acceptably safe; design hazard controls and FMEA/CIL rationale implemented*
- ✓ *Top risks address; residual risk acceptable*
- ✓ *Integrated PRA acceptable*
- ✓ *SE&I personnel trained and facilities certified*
- ✓ *External entities personnel, assets, services in place*
- ✓ *Plans and procedures in place to support all mission phases and will operate as designed*
- ✓ *Flight and ground systems environmental factors and constraints will maintain the integrated systems within design limits during all mission phases*
- ✓ *Mishap and contingency plans / procedures in place*
- ✓ *Compliance with NASA governance*

Stay Connected Between Committee Meetings

- Space Launch System Mockup Arrives at Kennedy for Testing
- SLS Rocket Pathfinders Prepare Teams for One-of-a-Kind Hardware
- NASA Commits to Long-term Artemis Mission with Orion Production
- NASA Joins Last of Five Sections for Space Launch System Rocket
- Pad 39B Water Flow Test Comes Through Loud and Clear

Sign up to get Moon to Mars updates from NASA: https://www.nasa.gov/specials/moon2mars/#five

DEEP SPACE EXPLORATION SYSTEMS
PARTNERS & SUPPLIERS IN AMERICA

NASA's Deep Space Systems for human exploration are being built in all 50 states.


NASA

ESD Commonly Used Acronyms and Abbreviations

Acronym	Definition
AA	Ascent Abort
AI&T	Assembly, Integration, and Testing
APU	Auxiliary Power Unit
ASEU	Aft Skirt Electrical Umbilical
ATLO	Assembly, Test, and Launch Operations
ATP	Authority to Proceed
BFS	Backup Flight System
C&DH	Command and Data Handling
CAA	Crew Access Arm
CM	Crew Module
CMA	Crew Module Adapter
CMASS	Crew Module Ammonia Servicing Subsystem
C/O	Check Out
CR	Change Request
CS	Core Stage
CSI	Cross-Program Systems Integration
CSM	Crew and Service Module
CSS	Consumable Storage System
CT	Crawler Transporter
DCR	Design Certification Review
DFAT	Direct Field Acoustics Test
DVO	Detailed Verification Objectives
ECD	Estimated Completion Date
ECLSS	Environmental Control and Life Support System
ECS	Environmental Control System
ECU	Engine Controller Unit
EES	Emergency Egress System
EGS	Exploration Ground Systems
EGSE	Electrical Ground Support Equipment
EMI/EMC	Electromagnetic Interference and Electromagnetic Compatibility
ES	Engine Section
ESA	European Space Agency
ESD	Exploration Systems Development
ETE	End to End
FAST	Final Assembly and System Test
EUS	Exploration Upper Stage
FCAS	Flight Controller Application Software
FCV	Flow Control Valve
FDIR	Fault Detection Isolation& Recovery
FIL	Fillet Panel
FM	Flight Model
FMA	Final Mission Analysis
FRAC	Flight Readiness Analysis Cycle
FRR	Flight Readiness Review
FS	Forward Skirt
FSS	Flight Safety System
FSW	Flight Software
FWD	Forward
GFAS	Ground/Flight Application Software
GFAST	Ground/Flight Application Software Team
GHe	Gaseous Helium
GLS	Ground Launch Sequencer
GN2	Gaseous Nitrogen
GNC	Guidance, Navigation, and Control
GO2	Gaseous Oxygen
GR&A	Ground Rules and Assumptions
GRAS	Green Run Application Software
GRC	Glenn Research Center
GSE	Ground Support Equipment
HB	High Bay
HOTH	Houston Orion Test Hardware
HW	Hardware
ICPS	Interim Cryogenic Propulsion Stage
ICPSU	Interim Cryogenic Propulsion Stage Umbilical
IPO	Initial Power On
IT	Intertank
ITCO	Integrated Test and Checkout
ITL	Integrated Test Laboratory
JICB	Joint Integrated Control Board
JM	Jettison Motor
KCCS	Kennedy Complex Control System
KSC	Kennedy Space Center
LAS	Launch Abort System
LCC	Launch Commit Criteria
LETF	Launch Equipment Test Facility
LH2	Liquid Hydrogen
LN2	Liquid Nitrogen
LO2	Liquid Oxygen
LOX	Liquid Oxygen
LVSA	Launch Vehicle Stage Adapter
MAF	Michoud Assembly Facility
ME	Multi-Element
ML	Mobile Launcher
MPPF	Multi-Payload Processing Facility
MPS	Main Propulsion System
MSFC	Marshall Space Flight Center
NDE	Nondestructive Evaluation
O&C	Operations and Checkout
O/D	On Dock
OGV	Ogive Panel
OMRS	Operations and Maintenance Requirements and Specifications
OMS-E	Orbital Maneuvering System Engine
OSA	Orion Stage Adapter
OTP	Orion Transportation Pallet
PBS	Plum Brook Station
PCDU	Power Control Distribution Unit
PDU	Power Distribution Unit
PLI	Propellant Liner Insulation
PM	Program Manager
PPE	Power and Propulsion Element
PRA	Probabilistic Risk Assessment
QD	Quick Disconnect
QM	Qualification Motor
RCS	Reaction Control System
SAR	System Acceptance Review
SCCS	Spaceport Command and Control System
SCAPE	Self-Contained Atmospheric Protection Ensemble
SE&I	Systems Engineering and Integration
SIL	System Integration Lab
SITF	Software Integration Testing Facility
SLS	Space Launch System
SM	Service Module
SSC	Stennis Space Center
SSPF	Space Station Processing Facility
STA	Structural Test Article
SW	Software
TCU	Thermal Control Unit
TLM	Telemetry
TPS	Thermal Protection System
TRR	Test Readiness Review
TSMU	Tail Service Mast Umbilical
TVC	Thrust Vector Control
ULA	United Launch Alliance
V&V	Verification and Validation
VAB	Vehicle Assembly Building
VAC	Vertical Assembly Center
WDR	Wet Dress Rehearsal
XCS	Extensible Columns