



October 31, 2022

NASA Advisory Council (NAC)

ARTEMIS

Artemis I – IV Mission Overview / Status

Amit Kshatriya, ADAA,
Common Exploration Systems Development

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Artemis Campaign Development

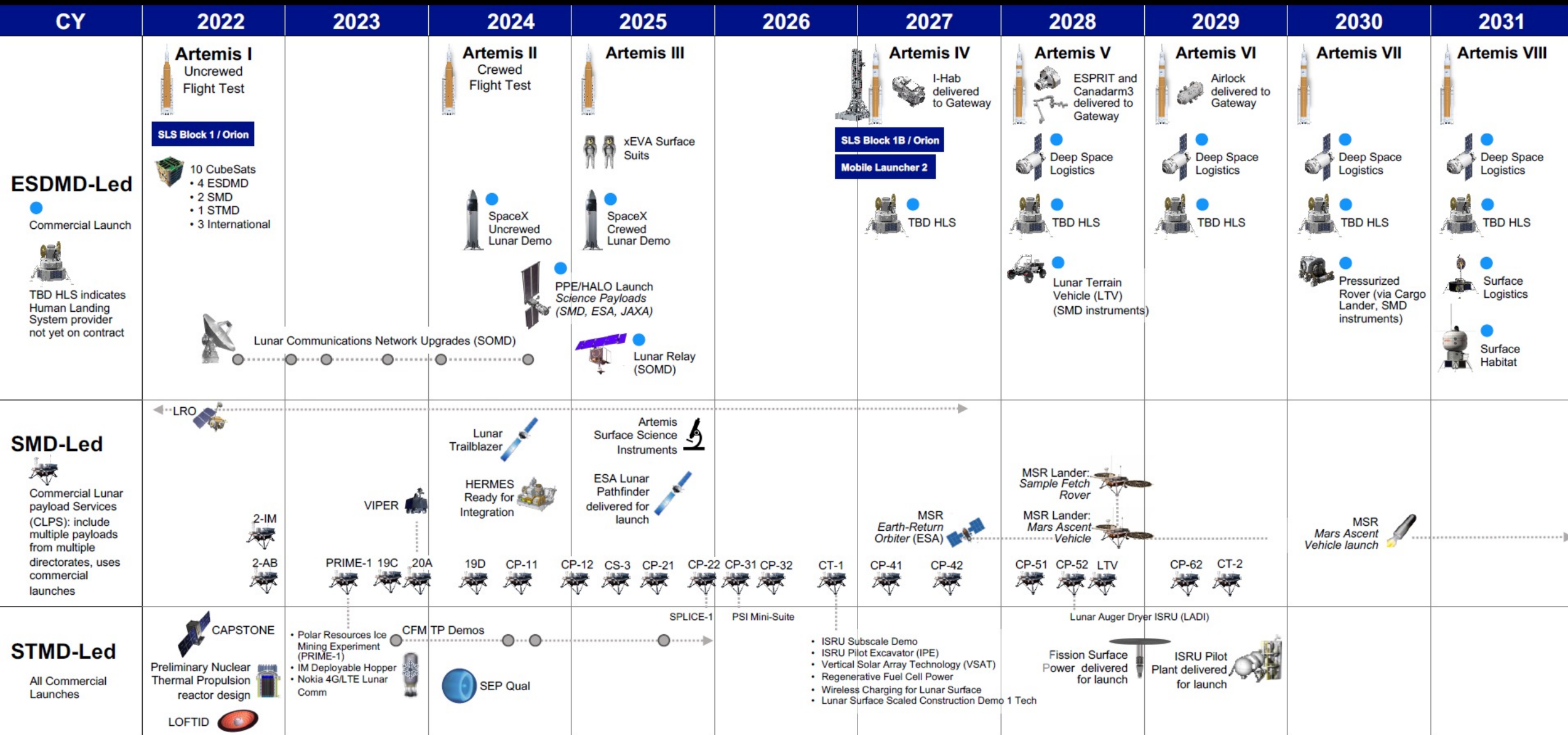


Outline



- Artemis Planning Manifest
- Artemis I
- Artemis II
- Artemis III
- Artemis IV

Artemis Planning Manifest



Icons represent the calendar year in which the launch occurs. | Based on FY23 Presidents budget request. | Does not include impact from FY22 appropriations. | Selected Mars forward elements in SMD and STMD included for context.



ARTEMIS

Artemis I Mission Status

MAJOR MILESTONES FOR ARTEMIS I

									
EXPLORATION FLIGHT TEST-1	UPGRADES AT PAD 39B	SLS WIND TUNNEL TESTING	PRESSURE VESSEL COMPLETE	CORE STAGE PRODUCTION BEGINS	ORION PRESSURE VESSEL TESTING	CRAWLER TRANSPORTER-2 UPGRADES & MODS	RS-25 ENGINE TESTING COMPLETE	SERVICE MODULE PROPULSION TESTING	ROTATION PROCESSING & SURGE FACILITY ACCEPTANCE AND READINESS
									
MOBILE LAUNCHER CONSTRUCTION	HEAT SHIELD INSTALL ON CREW MODULE	VAB HIGH BAY 3 CONSTRUCTION	MPPF 1ST HAZARDOUS OPERATIONS	EUROPEAN SERVICE MODULE SHIPPED TO KSC	SLS BOOSTER QUAL TESTING	C3 READY FOR HAZARDOUS OPERATIONS	ASCENT ABORT-2 FLIGHT TEST	MOBILE LAUNCHER/VAB MULTI-ELEMENT VERIFICATION & VALIDATION	LCC TEAM TRAINING START
									
CREW MODULE/SERVICE MODULE MATE	ORION STAGE ADAPTER DELIVERED	CORE STAGE ASSEMBLY	ORION ENVIRONMENTAL TESTING	SLS STRUCTURAL TESTING	INTEGRATED TEST LAB VERIFICATION TESTING	CORE STAGE INTEGRATION	ORION STRUCTURAL TESTING	SLS AVIONICS TESTING	MOBILE LAUNCHER/PAD MULTI-ELEMENT VERIFICATION & VALIDATION
									
MISSION CONTROL CENTER TEAM TRAINING START	LAUNCH ABORT SYSTEM HANDOVER TO EGS	INTERIM CRYOGENIC PROPULSION STAGE DELIVERED	GREEN RUN TESTING BEGINS	LAUNCH VEHICLE STAGE ADAPTER DELIVERED TO KSC	MOTOR SEGMENTS DELIVERED TO KSC	UNDERWAY RECOVERY TEST 8	BOOSTER & AFT SKIRT MATE	WET DRESS REHEARSAL	BOOSTER AFT SEGMENT POSITIONED ON MOBILE LAUNCHER
					<div style="border: 2px solid red; padding: 10px; text-align: center;"> <p>See Next Chart for KSC Flow</p> </div>				
START OF BOOSTER STACKING ON MOBILE LAUNCHER	HANDOVER OF CREW & SERVICE MODULE TO EXPLORATION GROUND SYSTEMS	GREEN RUN HOT FIRE	CORE STAGE INTEGRATION	LAUNCH VEHICLE STAGE ADAPTER/ INTERIM CRYOGENIC PROPULSION STAGE INTEGRATION					

MAJOR MILESTONES FOR ARTEMIS I KSC FLOW

Status – October 7, 2022



START OF CORE STAGE MATE



START INSTALL OF INTERNAL PLATFORMS



START OF LVSA MATE



STACK ICPS



ORION TO LASF



CORE STAGE POWER UP



STACK ORION STAGE ADAPTER STRUCTURAL TEST ARTICLE



STACK MASS SIMULATOR FOR ORION



COMPLETE SLS PREVALUE CLUTCH CHANGEOUT



MODAL TAP TEST



FIRST INTEGRATED POWER UP



UMBILICAL CONNECTS COMPLETE



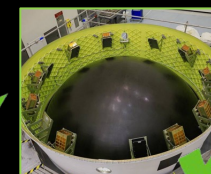
START OF UMBILICAL RELEASE AND RETRACT TEST (URRT)



INTEGRATED MODAL TEST (IMT) COMPLETED



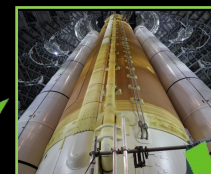
DESTACK MASS SIMULATOR FOR ORION



ORION STAGE ADAPTER TO VAB HIGH BAY 4



DESTACK ORION STAGE ADAPTER STRUCTURAL TEST ARTICLE



ESTABLISH CORE STAGE ACCESS COMPLETED



STACK OSA



ORION TO VAB HIGH BAY 4



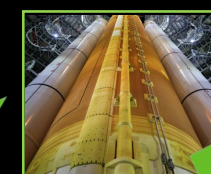
STACK ORION TO SLS



UMBILICAL REMATES



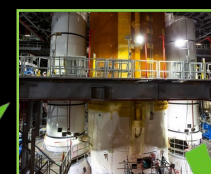
INTEGRATED VEHICLE INTERFACE VERIFICATION TEST (IVT) PT 1



COMM END-TO-END (LIVE) COMPLETE



COUNTDOWN SEQUENCE TEST (CST) PT 1



CORE STAGE PROGRAM SPECIFIC ENGINEERING TESTING (PSET) COMPLETE



CORE STAGE FLIGHT BLANKET INSTALL



FLIGHT TERMINATION SYSTEM TEST PART 1



VEHICLE CLOSEOUT AND PREP FOR ROLL



ROLL TO PAD B FOR WET DRESS REHEARSAL (WDR)



Vehicle Initial Power On at Pad

LC-39/LCC Activated in Launch Mode
Initial Cryo Loading
System Interfaces Verified

WDR RUN #1



WDR RUN #2

LOX Load Adjusted for Thermal Conditions
Helium Purge Pressure Resolved



WDR RUN #3

LOX Load Technique Demonstrated
LH2 Load Process Developed
LH2 Leak (Ground Side) Discovered



WDR RUN #4

Full LOX & LH2 Cryo Load
Transition from GLS to ALS



ROLL TO VAB

Final Closeouts for Launch
Flight Safety System Tests



ROLL TO PAD B FOR LAUNCH



LAUNCH ATTEMPT 1 (Scrub: Eng Bleed Pressure)



LAUNCH ATTEMPT 2 (Scrub: Hydrogen Leak)



CRYO DEMONSTRATION TEST



ROLL TO VAB (Hurricane Ian; Limited Life Items)

ROLL TO PAD B (Planned Nov 4)

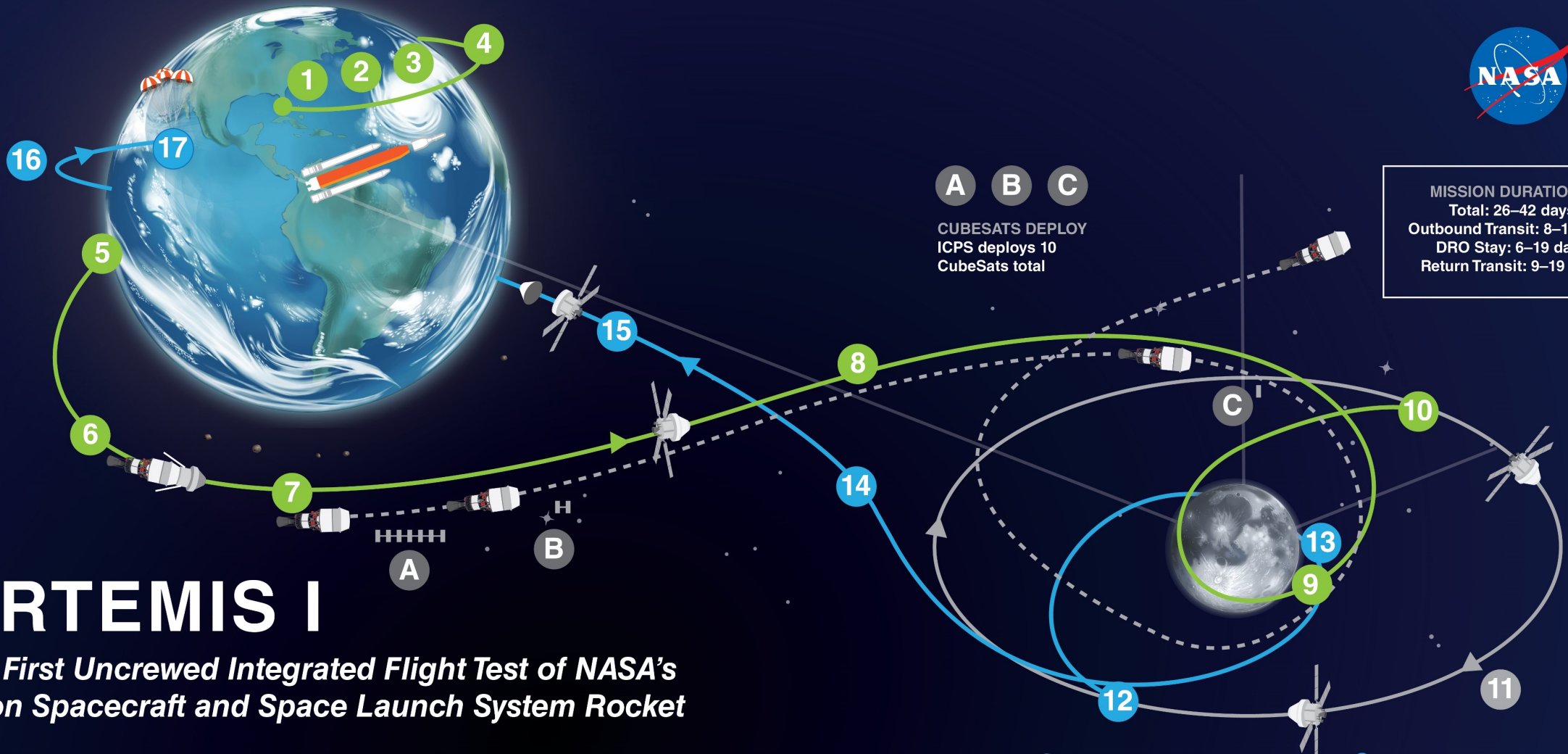
PAD OPS AND LAUNCH COUNTDOWN

ARTEMIS I LAUNCH (Planned Nov 14)

RECOVERY OPS COMPLETED



ARTEMIS I



A B C
 CUBESATS DEPLOY
 ICPS deploys 10
 CubeSats total

MISSION DURATIONS:
 Total: 26–42 days
 Outbound Transit: 8–14 days
 DRO Stay: 6–19 days
 Return Transit: 9–19 days

ARTEMIS I

The First Uncrewed Integrated Flight Test of NASA's Orion Spacecraft and Space Launch System Rocket

- 1 LAUNCH**
SLS and Orion lift off from pad 39B at Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**
With separation.
- 4 PERIGEE RAISE MANEUVER**
- 5 EARTH ORBIT**
Systems check with solar panel adjustments.
- 6 TRANS LUNAR INJECTION (TLI) BURN**
Maneuver lasts for approximately 20 minutes.
- 7 INTERIM CRYOGENIC PROPULSION STAGE (ICPS) SEPARATION AND DISPOSAL**
ICPS commits Orion to moon at TLI.
- 8 OUTBOUND TRAJECTORY CORRECTION (OTC) BURNS**
As necessary adjust trajectory for lunar flyby to Distant Retrograde Orbit (DRO).
- 9 OUTBOUND POWERED FLYBY (OPF)**
60 nmi from the Moon; targets DRO insertion.
- 10 LUNAR ORBIT INSERTION**
Enter Distant Retrograde Orbit.
- 11 DISTANT RETROGRADE ORBIT**
Perform half or one and a half revolutions in the orbit period 38,000 nmi from the surface of the Moon.
- 12 DRO DEPARTURE**
Leave DRO and start return to Earth.
- 13 RETURN POWERED FLYBY (RPF)**
RPF burn prep and return coast to Earth initiated.
- 14 RETURN TRANSIT**
Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere.
- 15 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 16 ENTRY INTERFACE (EI)**
Enter Earth's atmosphere.
- 17 SPLASHDOWN**
Pacific Ocean landing within view of the U.S. Navy recovery ship.

ARTEMIS I

- Launch attempt 1 on August 27, 2022 was scrubbed due to an inability to confirm proper engine conditioning. Also had small but manageable hydrogen leaks
- Launch attempt 2 on September 3, 2022 was scrubbed due to a large hydrogen leak
- Stayed at pad and replaced seals within umbilical
- Successful tanking test was completed on September 21, 2022
- Set up for launch attempt on September 27, 2022 but had to roll back to the VAB due to Hurricane Ian
- Teams will use roll back as an opportunity to replace Flight Termination System batteries, and assess Limited Operational Life Items that may need replacement or servicing
- Agency will prepare for November launch attempt on Nov. 14.





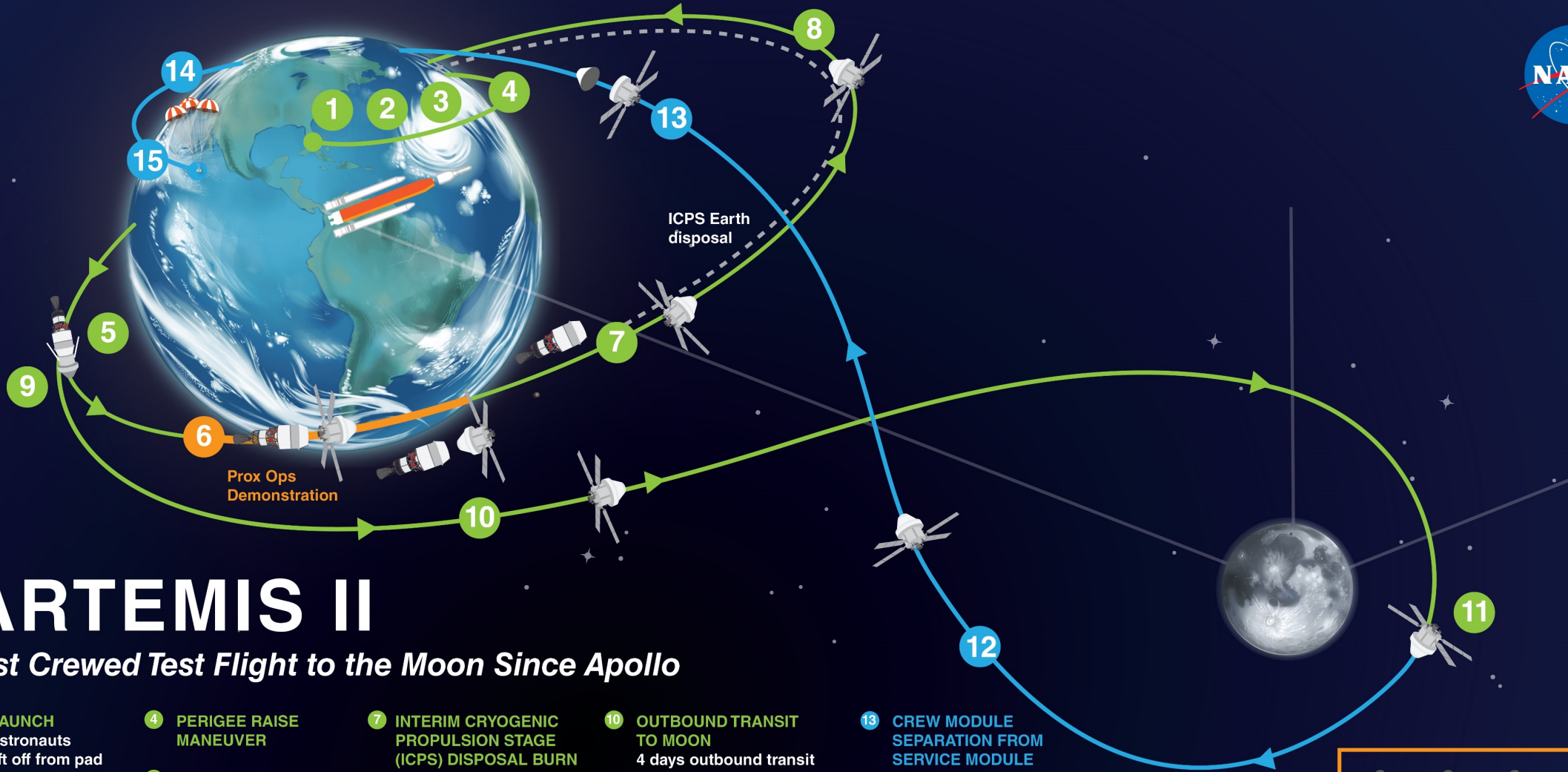
ARTEMIS

Artemis II Mission Status

Rev H, Updated
as of 8/22/2022

MAJOR MILESTONES FOR ARTEMIS II

													
PARACHUTES QUALIFIED FOR FLIGHT	*CREW EGRESS TRAINING AT NBL	ORION PRESSURE VESSEL ELEMENTS MACHINED	*HAND CONTROLLER EVAL	*DOCKING HATCH EVAL	ORION WATER IMPACT TESTING	*CREW EMERGENCY EGRESS TESTS	*CREW AT SEA TEST	*CREW MODULE UPRIGHT SYSTEM TEST	ORION ENVIRONMENTAL TESTS	HEAT SHIELD BLOCK INSTALL COMPLETE	SLS BOOSTER MOTOR SEGMENTS CAST	RS-25 ENGINES PROCESSED	SLS CORE STAGE PROOFING AND WELDING
													
*HUMAN-IN-THE-LOOP TESTS	*DIVER RECOVERY TRAINING	ORION MISSION CONTROL SIMULATIONS	*VACUUM PRESSURE CREW TEST	PRESSURE VESSEL COMPLETE	PRESSURE VESSEL ARRIVES AT KSC	*DISPLAY AND CONTROL EVAL	ASSEMBLY, INTEGRATION, AND TESTING AT KSC	JETTISON MOTOR QUALIFIED	ATTITUDE CONTROL MOTOR QUALIFIED	SLS RL10 ENGINE COMPLETION	CREW MODULE TRAINING ARTICLE TRANSPORTED TO LETF	*EES MOCKUP EVALUATION	*PAD EMERGENCY EGRESS SYSTEM 60% DESIGN REVIEW
													
*EMERGENCY EGRESS SYSTEM BASKET PROTOTYPE	LH2 SPHERE	*MOBILE LAUNCHER 1 60% DESIGN REVIEW	ENVIRONMENTAL CONTROL SYSTEM CHILLERS INSTALLED	ENVIRONMENTAL CONTROL SYSTEM INFRASTRUCTURE INSTALLED	EUROPEAN SERVICE MODULE ASSEMBLY AT AIRBUS	HEAT SHIELD INSTALL ON CREW MODULE	EUROPEAN SERVICE MODULE SHIPS TO KSC	CREW MODULE ADAPTER/ EUROPEAN SERVICE MODULE MATE	CORE STAGE 2 FORWARD JOIN	CORE STAGE 2 4/5ths JOIN	CORE STAGE 2 ENGINE SECTION INTEGRATION COMPLETE	SLS LAUNCH VEHICLE STAGE ADAPTER COMPLETION	ORION CREW MODULE PART 1 COMPLETE
													
EGS CRYO SYSTEM V&V COMPLETE	*MOBILE LAUNCHER 1 CREWED MODS COMPLETE	SLS INTERIM CRYOGENIC PROPULSION STAGE (ICPS) COMPLETION	CORE STAGE 2 READY FOR SHIPMENT TO KSC	BOOSTERS ARRIVE AT KSC	CREW MODULE COMPLETE	CREW AND SERVICE MODULE MATE	*PAD UPGRADES COMPLETE	VAB ECS UPGRADES COMPLETE	*MOBILE LAUNCHER 1 MULTI-ELEMENT V&V COMPLETE	EGS BOOSTER OFFLINE PROCESSING START	EGS OPERATIONAL READINESS CHECKPOINT	ORION HANDOVER TO EGS	EGS ORION OFFLINE PROCESSING START
													
BOOSTER STACKING COMPLETE	SLS CORE STAGE, ICPS, & ADAPTERS INTEGRATION AT KSC	ORION MASS SIMULATOR MATE	ROLL TO PAD FOR TANKING TEST	ARTEMIS II TANKING TEST	ROLL TO VAB FOLLOWING TANKING TEST	ORION TO VAB	ORION INTEGRATION TO SLS	CONDUCT FINAL INTEGRATED TESTING	ROLL TO PAD FOR LAUNCH	ARTEMIS II LAUNCH	<div style="display: flex; align-items: center;"> <div style="border: 1px solid blue; width: 15px; height: 15px; margin-right: 5px;"></div> <p>Unique aspect of Artemis II (* unique for crew config.)</p> </div> <p>For Artemis II:</p> <ul style="list-style-type: none"> No core stage hot-fire at SSC or post hot-fire refurbishment required at KSC No modal test required Bleed line re-sizing and Pre-Valve clutch R&R are not anticipated 		

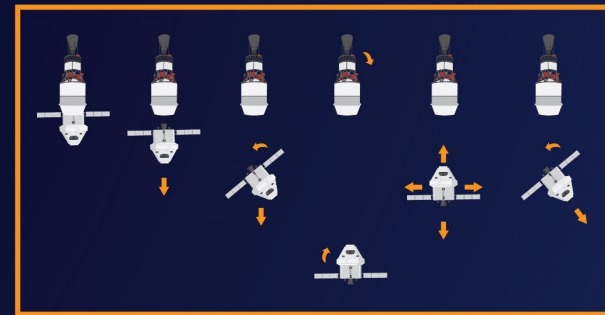


ARTEMIS II

First Crewed Test Flight to the Moon Since Apollo

- 1 LAUNCH**
Astronauts lift off from pad 39B at Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**
With separation.
- 4 PERIGEE RAISE MANEUVER**
- 5 APOGEE RAISE BURN TO HIGH EARTH ORBIT**
Begin 24 hour checkout of spacecraft.
- 6 PROX OPS DEMONSTRATION**
Orion proximity operations demonstration and manual handling qualities assessment for up to 2 hours.
- 7 INTERIM CRYOGENIC PROPULSION STAGE (ICPS) DISPOSAL BURN**
- 8 HIGH EARTH ORBIT CHECKOUT**
Life support, exercise, and habitation equipment evaluations.
- 9 TRANS-LUNAR INJECTION (TLI) BY ORION'S MAIN ENGINE**
Lunar free return trajectory initiated with European service module.
- 10 OUTBOUND TRANSIT TO MOON**
4 days outbound transit along free return trajectory.
- 11 LUNAR FLYBY**
4,000 nmi (mean) lunar farside altitude.
- 12 TRANS-EARTH RETURN**
Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere; travel time approximately 4 days.
- 13 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 14 ENTRY INTERFACE (EI)**
Enter Earth's atmosphere.
- 15 SPLASHDOWN**
Ship recovers astronauts and capsule.

PROXIMITY OPERATIONS DEMONSTRATION SEQUENCE



Artemis II Mission Status



Four Artemis II engines in their shipping containers and the RS-25 “pathfinder” engine



LH2 Tank at KSC

Orion

- ~70% of all Crew Module hardware has been installed
- Service Module initial power up successfully completed and functional testing is underway

SLS

- Artemis II Core Stage progress at Michoud Assembly Facility (MAF) is on plan to complete by March 2023
- All four Core Stage Engines were delivered to MAF and engine installation is planned for December
- All solid rocket motor segments for Artemis II have been cast and are in storage in Utah
- Artemis II Interim Cryogenic Propulsion Stage has been manufactured and is at ULA’s facilities at Cape Canaveral in Florida

EGS

- New 1.4Mgal LH2 Sphere at Pad 39B is essentially complete (remaining work after Artemis I Launch)



ARTEMIS

Artemis III Mission Status



Artemis III Baseline

FIRSTS:

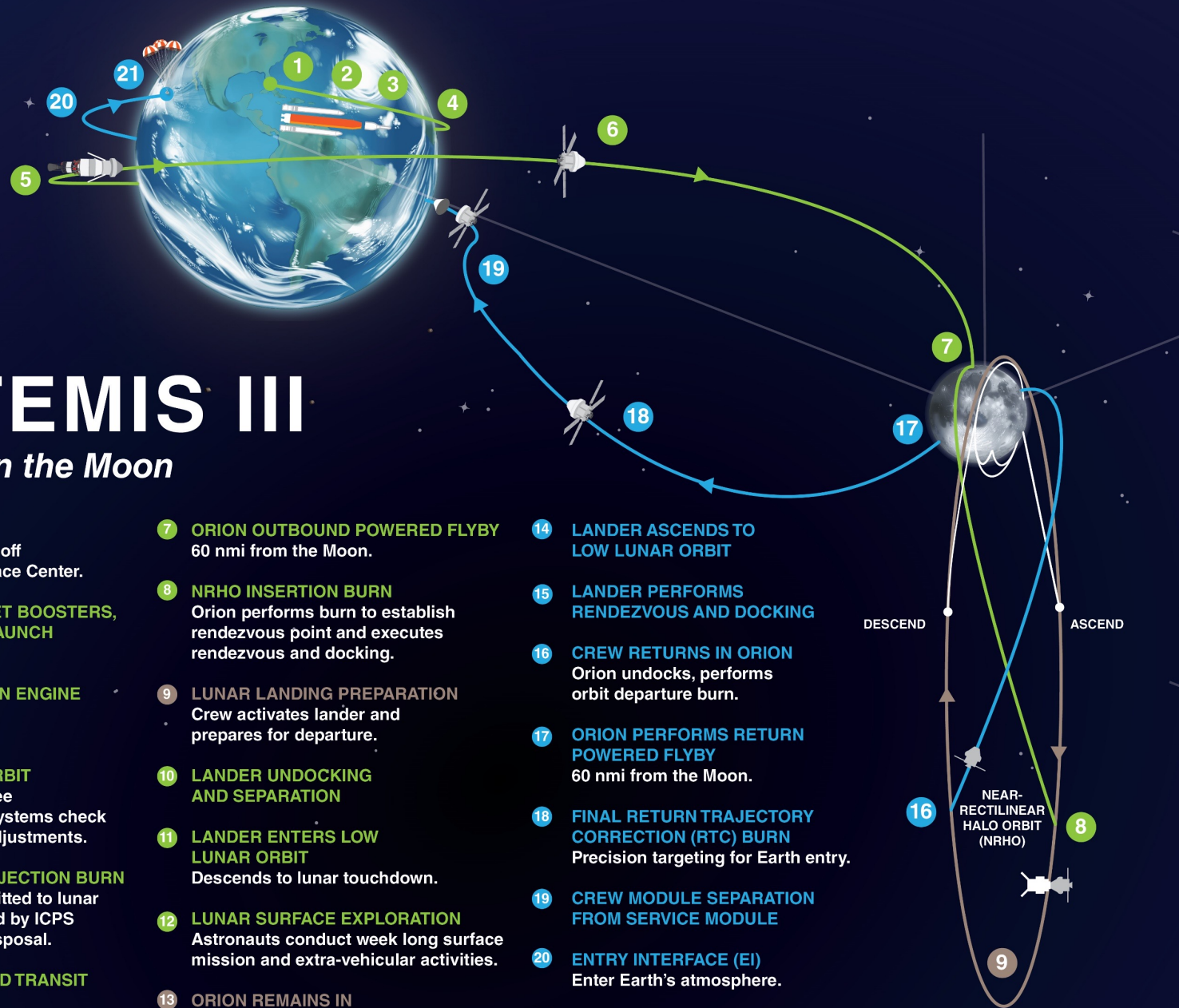
- Human landing in south pole region
- Orion to Human Landing System direct mission
- Near Rectilinear Halo Orbit
- 4 crew to lunar orbit (2 to surface)

NEW ELEMENTS:

- Human Landing System (Starship)
- xEVA Suits and tools (Axiom)
- Orion full up Rendezvous, Prox Ops, and Docking systems

COMMON ELEMENTS:

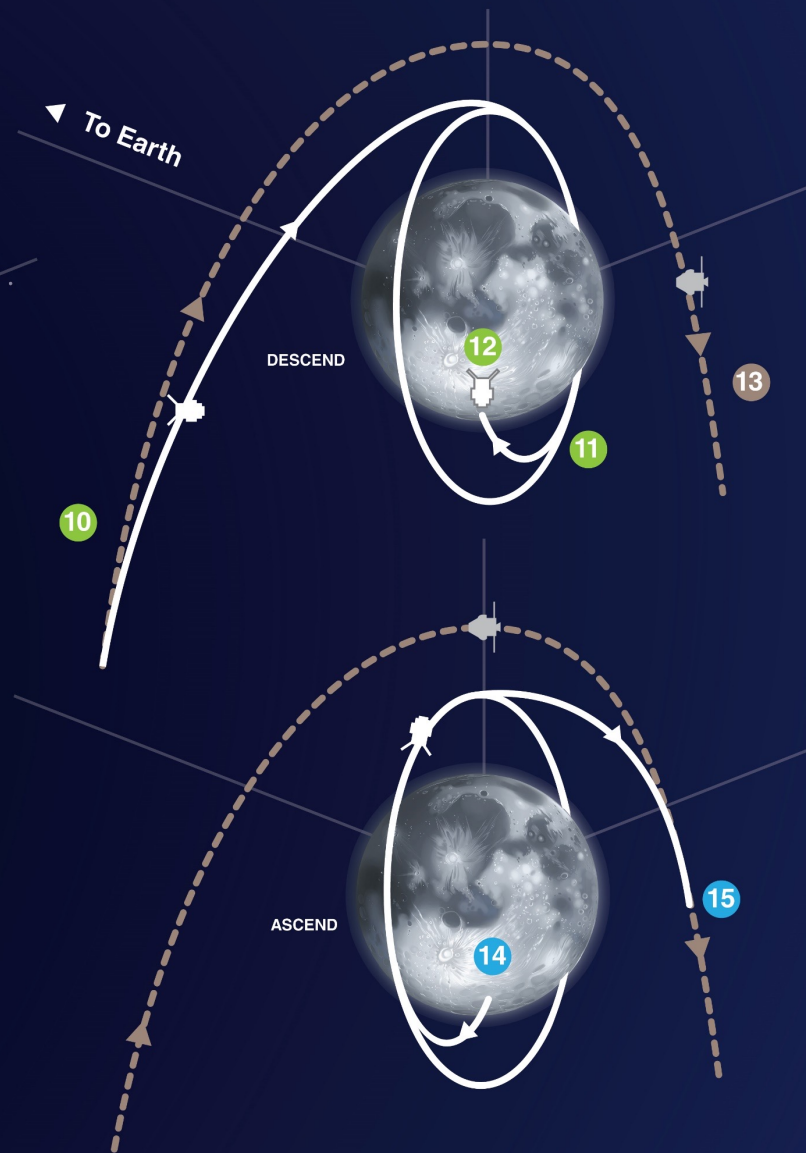
- Crewed Orion on Block 1 SLS with Interim Cryogenic Propulsion Stage
- Enhanced ESA Service Module
- Mobile Launcher 1



ARTEMIS III

Landing on the Moon

- 1 LAUNCH**
SLS and Orion lift off from Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**
With separation.
- 4 ENTER EARTH ORBIT**
Perform the perigee raise maneuver. Systems check and solar panel adjustments.
- 5 TRANS LUNAR INJECTION BURN**
Astronauts committed to lunar trajectory, followed by ICPS separation and disposal.
- 6 ORION OUTBOUND TRANSIT TO MOON**
Requires several outbound trajectory burns.
- 7 ORION OUTBOUND POWERED FLYBY**
60 nmi from the Moon.
- 8 NRHO INSERTION BURN**
Orion performs burn to establish rendezvous point and executes rendezvous and docking.
- 9 LUNAR LANDING PREPARATION**
Crew activates lander and prepares for departure.
- 10 LANDER UNDOCKING AND SEPARATION**
- 11 LANDER ENTERS LOW LUNAR ORBIT**
Descends to lunar touchdown.
- 12 LUNAR SURFACE EXPLORATION**
Astronauts conduct week long surface mission and extra-vehicular activities.
- 13 ORION REMAINS IN NRHO ORBIT**
During lunar surface mission.
- 14 LANDER ASCENDS TO LOW LUNAR ORBIT**
- 15 LANDER PERFORMS RENDEZVOUS AND DOCKING**
- 16 CREW RETURNS IN ORION**
Orion undocks, performs orbit departure burn.
- 17 ORION PERFORMS RETURN POWERED FLYBY**
60 nmi from the Moon.
- 18 FINAL RETURN TRAJECTORY CORRECTION (RTC) BURN**
Precision targeting for Earth entry.
- 19 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 20 ENTRY INTERFACE (EI)**
Enter Earth's atmosphere.
- 21 SPLASHDOWN**
Ship recovers astronauts and capsule



Artemis III Candidate Landing Regions



KEY LANDING REGION CHARACTERISTICS

Close proximity to the geographic South Pole

Gentle slope for landing and moonwalks

Constant view to Earth for communications

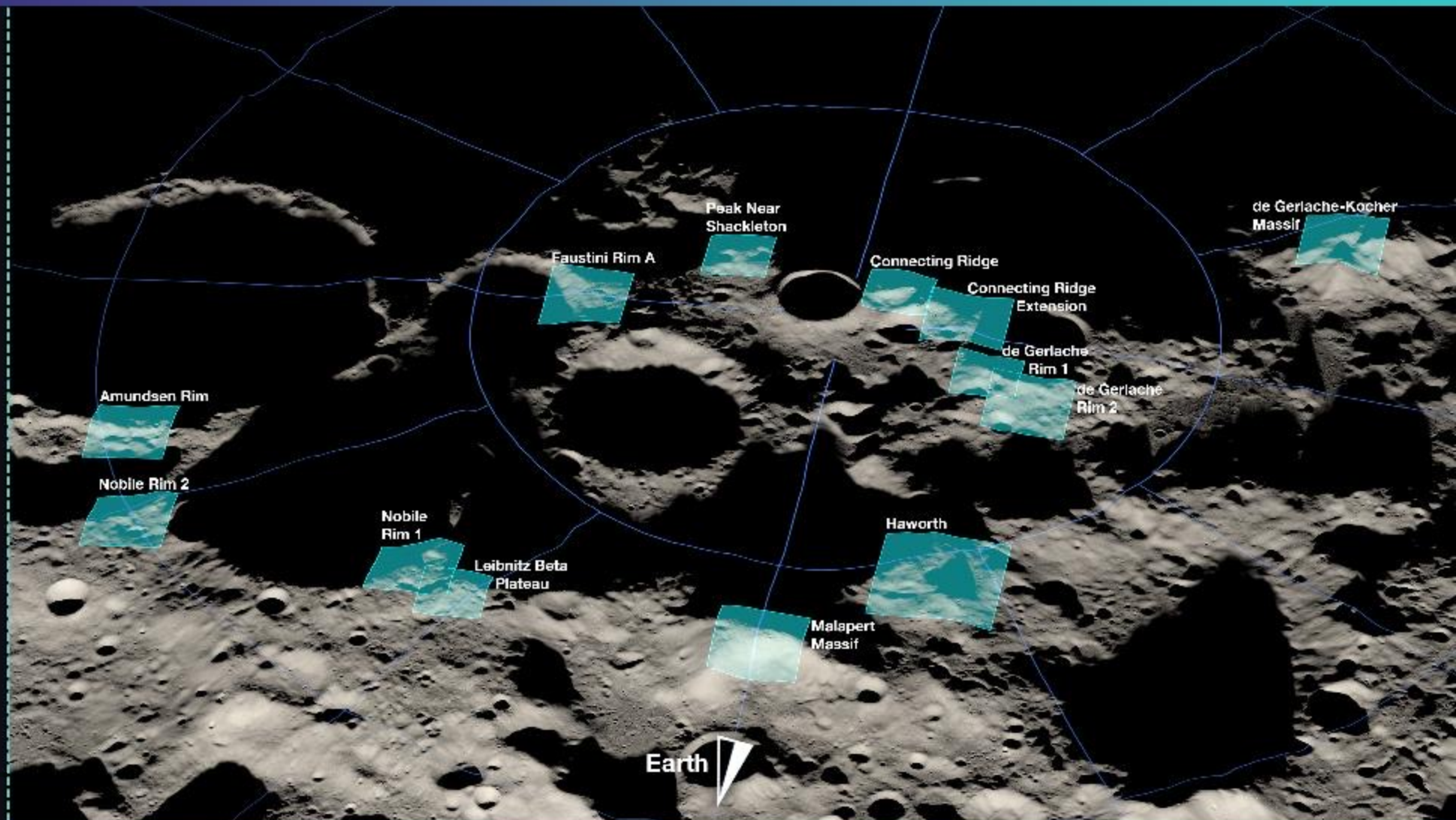
Continuous sunlight throughout the surface expedition of about 6.5 days

Landing Accuracy

Surface data resolution

Combined mission vehicle capabilities: Space Launch System, Orion spacecraft, Starship Human Landing System

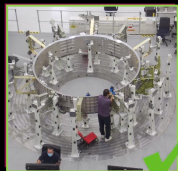
A landing *region* is approximately 15 km². Each landing region includes multiple potential landing sites.



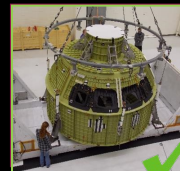
MAJOR CESD MILESTONES FOR ARTEMIS III



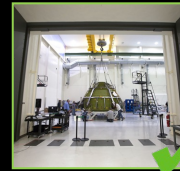
ICPS-3 ENGINE
DELIVERY TO ULA



CREW MODULE
ADAPTER INNER
WALL DELIVERED
TO O&C



CREW MODULE
PRESSURE VESSEL
DELIVERED TO O&C



CREW MODULE
PRESSURE VESSEL
PROOF TEST
COMPLETED



MOTOR
SEGMENTS
COMPLETE



ENGINES READY
FOR DELIVERY
TO MAF

CORE STAGE 3
FWD SKIRT
COMPLETE

CORE STAGE 3
INTERTANK
COMPLETE

CORE STAGE 3
LOX TANK
COMPLETE

CORE STAGE 3
LH2 TANK
COMPLETE

ORION CREW
MODULE
ADAPTER
COMPLETE

EUROPEAN
SERVICE
MODULE
DELIVERY TO
O&C

CORE STAGE 3
ES/BT READY
FOR JOIN

START CORE
STAGE 3 FINAL
ASSEMBLY AND
INTEGRATION

SLS INTEGRATED
CRYOGENIC
PROPULSION
SYSTEM
COMPLETE

CORE STAGE 3
READY FOR SHIP
TO KSC

SLS LAUNCH
VEHICLE STAGE
ADAPTER
COMPLETE

ORION STAGE
ADAPTER
COMPLETE

ORION SERVICE
MODULE
COMPLETE

BOOSTER
FORWARD
ASSEMBLY
COMPLETE

CREW MODULE
READY FOR
MATE

CREW AND
SERVICE
MODULE (CSM)
MATE

LAS ASSEMBLY
AND TEST
COMPLETE

BOOSTER AFT
SKIRTS
COMPLETE

CSM DELIVERY
TO EGS

BOOSTER STACKING
COMPLETE

CORE STAGE
MATE

LAUNCH
VEHICLE STAGE
ADAPTER
INTEGRATION

ICPS
INTEGRATION

UMBILICAL
CONNECTS

ORION MPPF
PROCESSING
COMPLETE

ORION TO VAB

ORION STAGE
ADAPTER
INTEGRATION

ORION
INTEGRATION
TO SLS
COMPLETE

ORION SPECIFIC
TESTING

CREW MODULE
STOW

FINAL CLOSEOUTS
FOR LAUNCH & FSS

ROLL TO PAD FOR
LAUNCH

EGS READY FOR
ARTEMIS III
LAUNCH



ARTEMIS III

Initial Human Landing System

HLS

NASA will use the HLS Starship for use on Artemis III, the mission that will put the next two Americans on the surface of the Moon.

The SpaceX Option A contract includes two lunar surface missions:

- SpaceX Uncrewed Lunar Demo-A
- SpaceX Crewed Lunar Demo-A



Image Credit: SpaceX

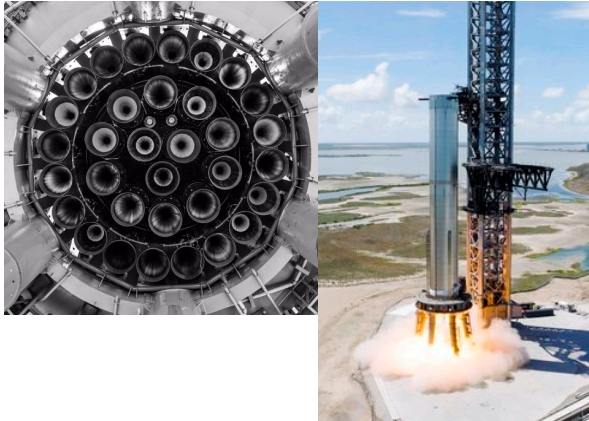


HLS Program Status



-
- Initial HLS for Artemis III (SpaceX)
 - Completed SpaceX Option A contract milestones in CY22 including:
 - Landing Software and Sensor Demo
 - Software Architecture Review
 - Sea-level Raptor Engine Cold Start Demo
 - Advancing lander system design maturity; examples include:
 - Raptor development/build: demonstrated production of 7 engines in one week
 - Cryo Fluid Management: Plan in-space Propellant Transfer and Long Duration Flight Tests
 - Prep for first Starship orbital flight
 - Sustaining HLS for Artemis IV+
 - Conducting Sustaining HLS studies and risk reduction tasks (“Appendix N” contracts)
 - Sustaining HLS Acquisitions
 - Impending SpaceX Option B contract mod
 - Issued HLS Sustaining Lunar Development “Appendix P” solicitation
-

Booster 7



7-Engine Static Fire

Starship 24



6-Engine Static Fire

Booster 7

- Completed 1-engine, 3-engine, and 7-engine static fire tests
- Completed 33-engine spin prime tests after incorporating repairs and corrective actions from July 11 high-energy event

Starship 24

- Completed 2-engine and 6-engine static fire tests

Stacked Vehicle

- Conducted LOX & LCH4 single species prop system test and de-stacked

Remaining Path to Flight (dates TBD)

- Booster 7 / Starship 24 re-stacking
- Additional single-species prop system testing
- Additional de-stacked static fire tests (including Booster 7 33-engine test)
- Wet dress rehearsals
- FAA license processing in work

Stacked vehicle (S24 atop B7) at Boca Chica



Artemis III EVA System Overview

Advanced suits

- Portable Life Support Subsystem; Oxygen, cooling, power, CO₂ removal
- Pressure Garment Subsystem

Tools and equipment

- Geology sampling tools
- Maintenance tools
- Handrails and umbilicals



Portable Life Support Subsystem





xEVAS Project Status



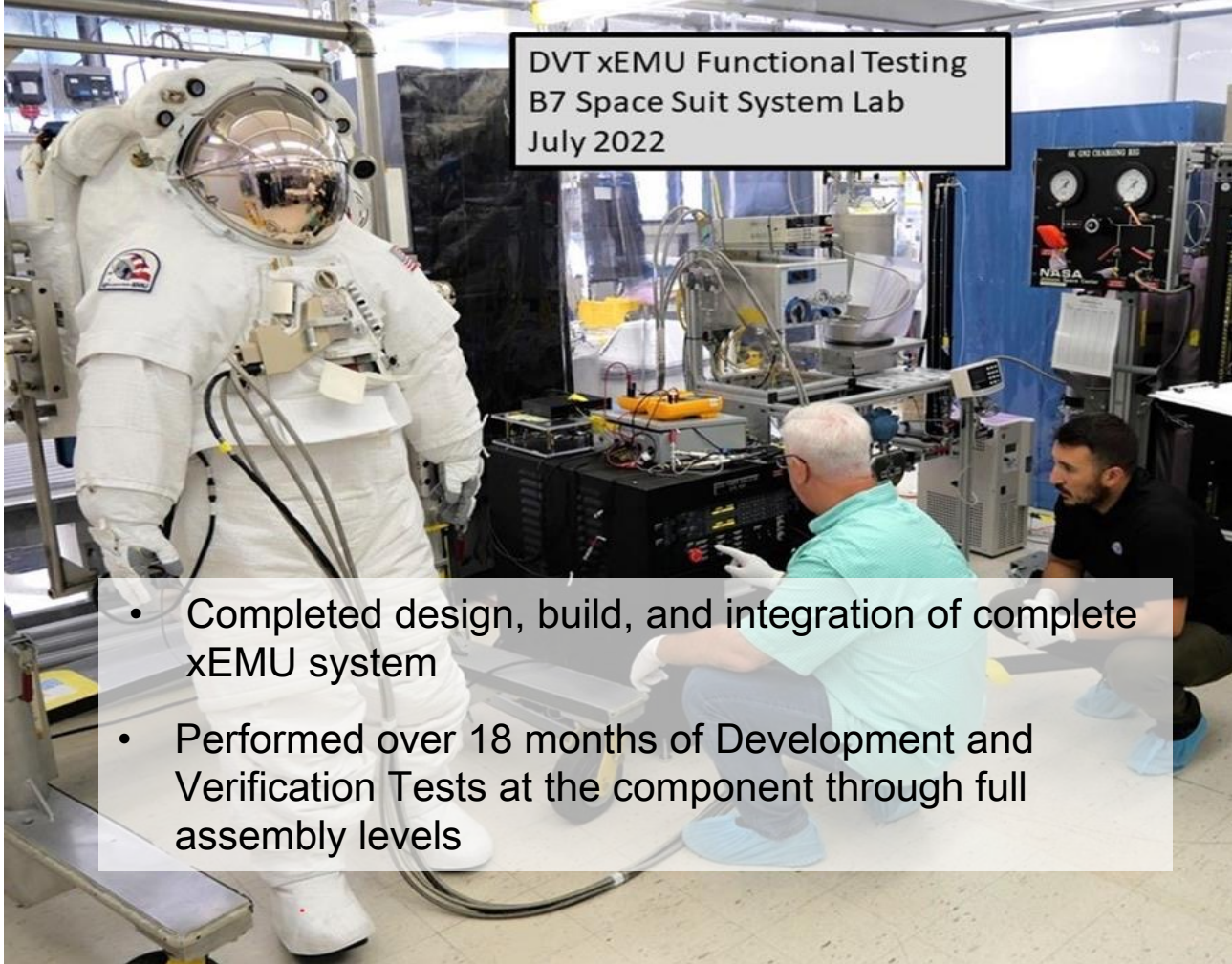
- **Axiom Space** and **Collins Aerospace** selected to compete for task orders to demonstrate an EVA System and certify the system to support NASA programs
 - Task order for Artemis development and demonstration on Artemis III awarded to Axiom Space
 - Task order for ISS development and demonstration award planned for the near future
- Developed government reference design (DVT) EVA system (xEMU) to validate requirements and reduce development risks
 - All xEMU technical details and test results provided to suit vendors for potential incorporation into provider EVA systems designs
- New, government reference design thermal control system, the ISS SERFE Payload, was demonstrated for ~2 years on ISS including 25 simulated EVAs
- Initiated EVA testing in the Iceland Highlands, the Suit System Lab, ARGOS, the Desert RATS, and the NBL

Investment buys down risk for Artemis III EVA system design

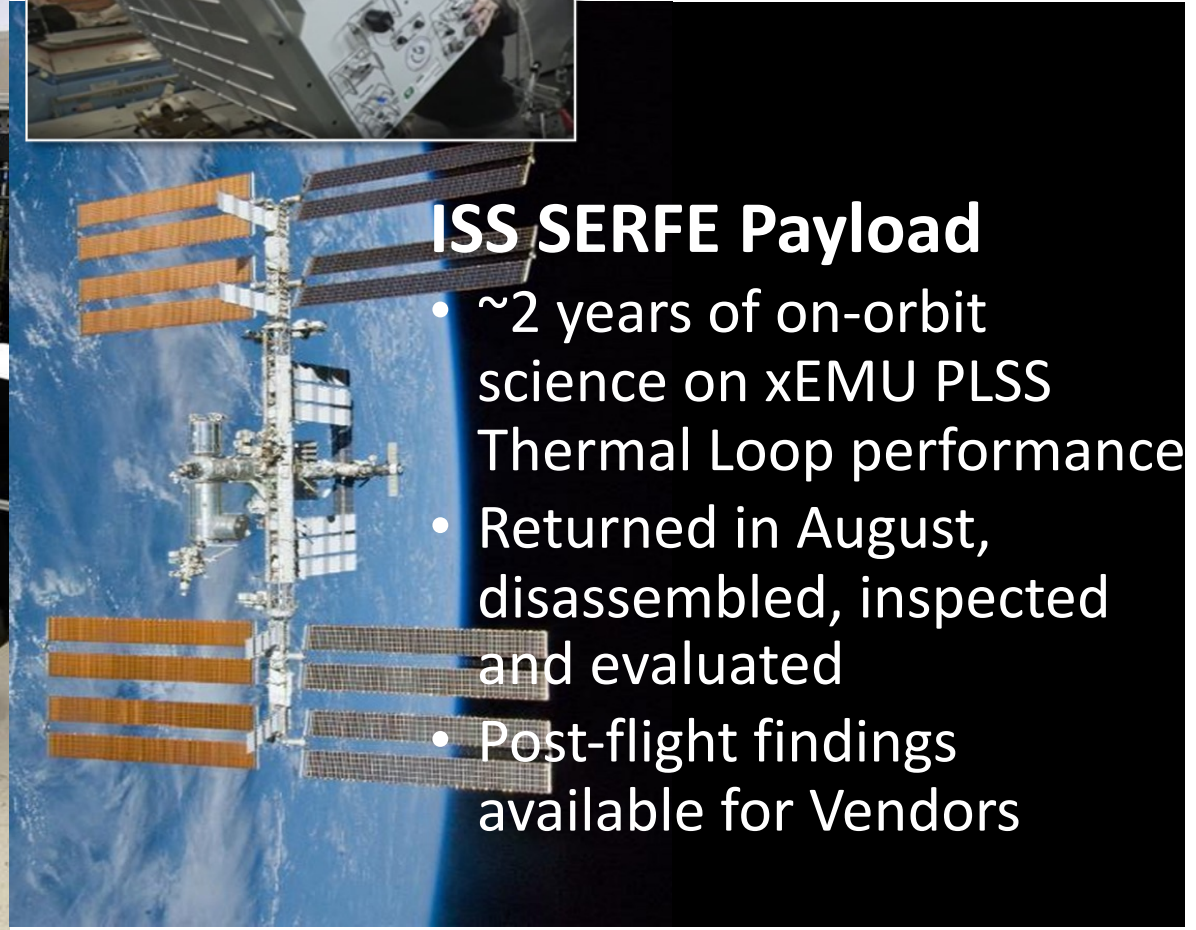
EHP EVA Development Achievements



DVT xEMU Functional Testing
B7 Space Suit System Lab
July 2022

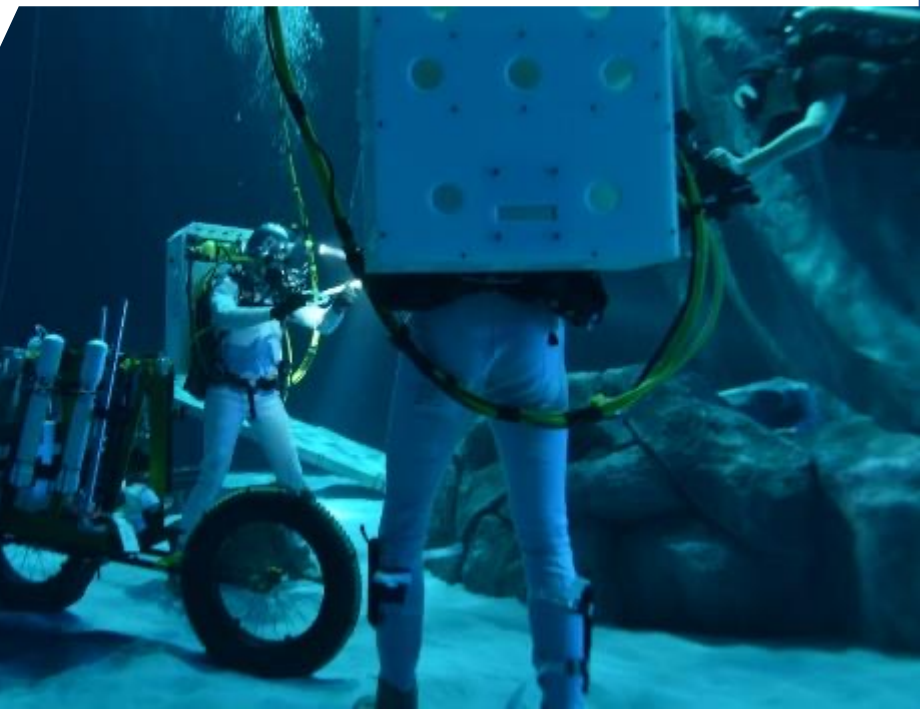
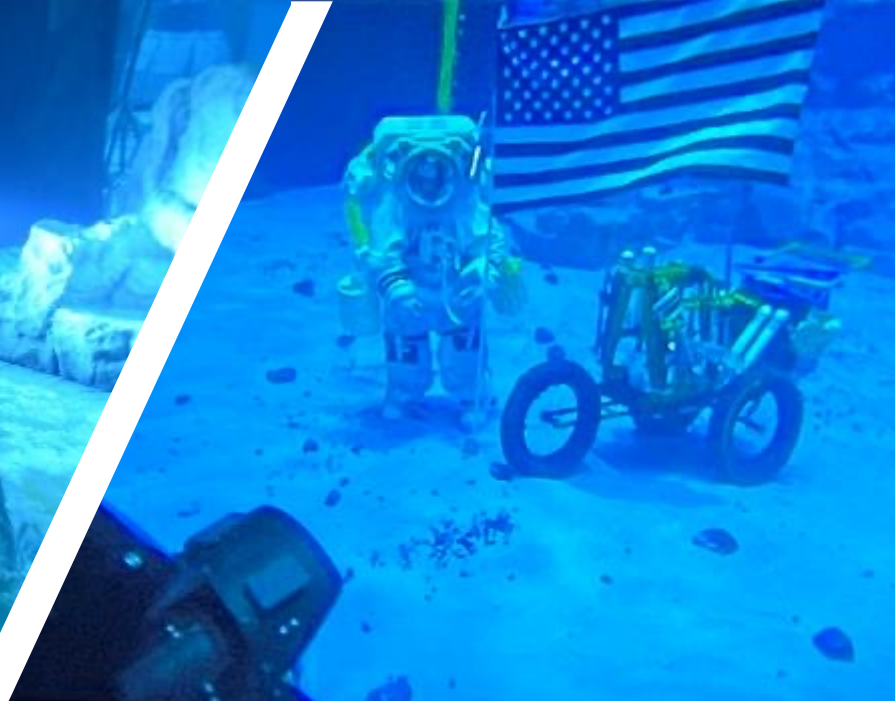


- Completed design, build, and integration of complete xEMU system
- Performed over 18 months of Development and Verification Tests at the component through full assembly levels



- ## ISS SERFE Payload
- ~2 years of on-orbit science on xEMU PLSS Thermal Loop performance
 - Returned in August, disassembled, inspected and evaluated
 - Post-flight findings available for Vendors

Joint Test Team NBL Runs with new facility capabilities, EVA Tools, xEMU DVT





ARTEMIS

Artemis IV Mission Status

Artemis IV Baseline

FIRSTS:

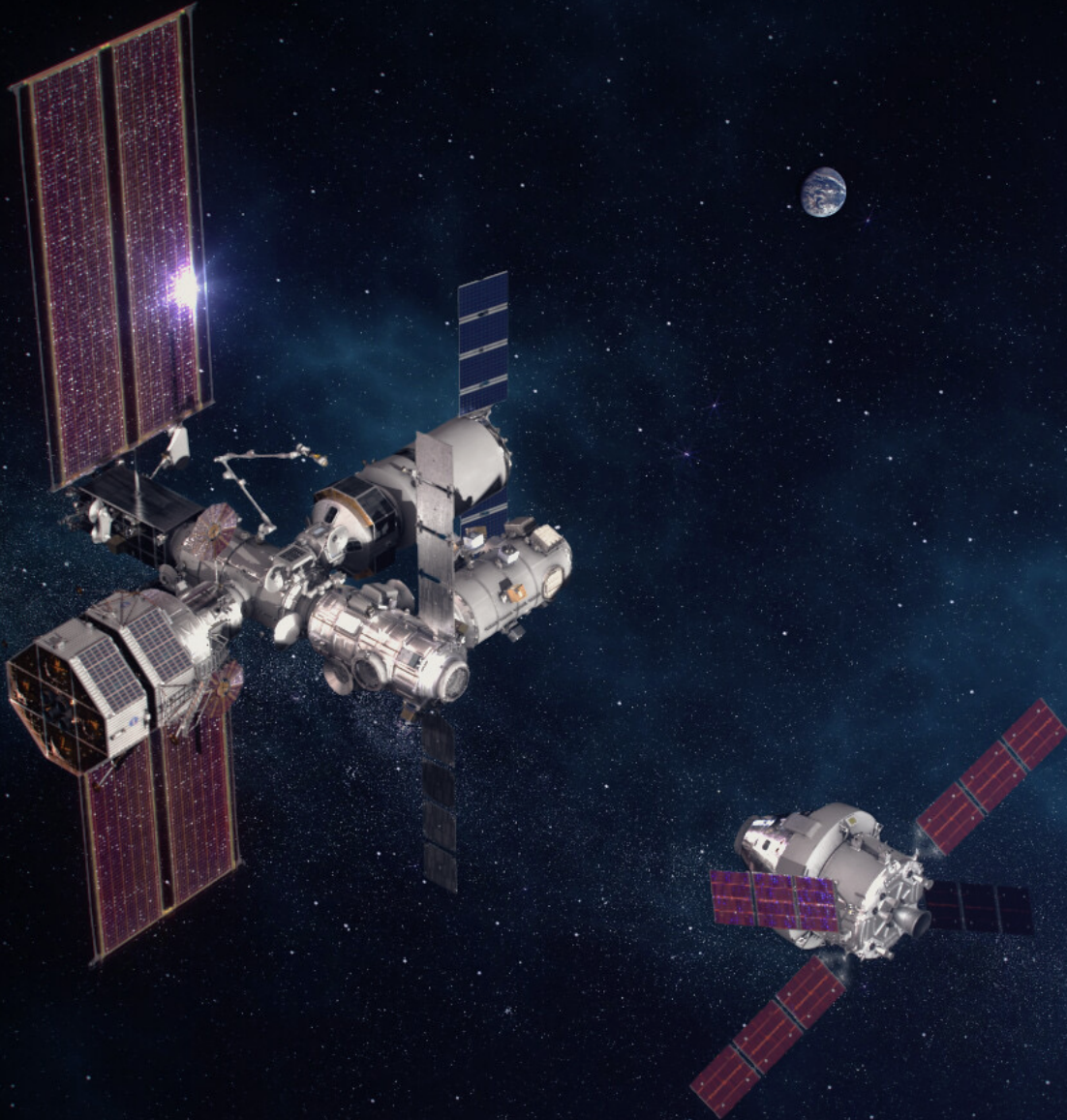
- SLS Block 1B Flight with Exploration Upper Stage (EUS)
- Launch from ML-2
- Orion/SLS Co-Manifested Payload (I-HAB); Orion to deliver to Gateway
- Gateway Initial Operational Capability (IOC) with PPE+HALO
- Orion and HLS Docking at Gateway

NEW ELEMENTS:

- SLS Block 1B with EUS, Universal Stage Adapter, Payload Adapter Fitting
- ML-2 with supporting EGS physical and comms upgrades
- Sustaining Human Landing System
- Gateway IOC (PPE + HALO), I-HAB

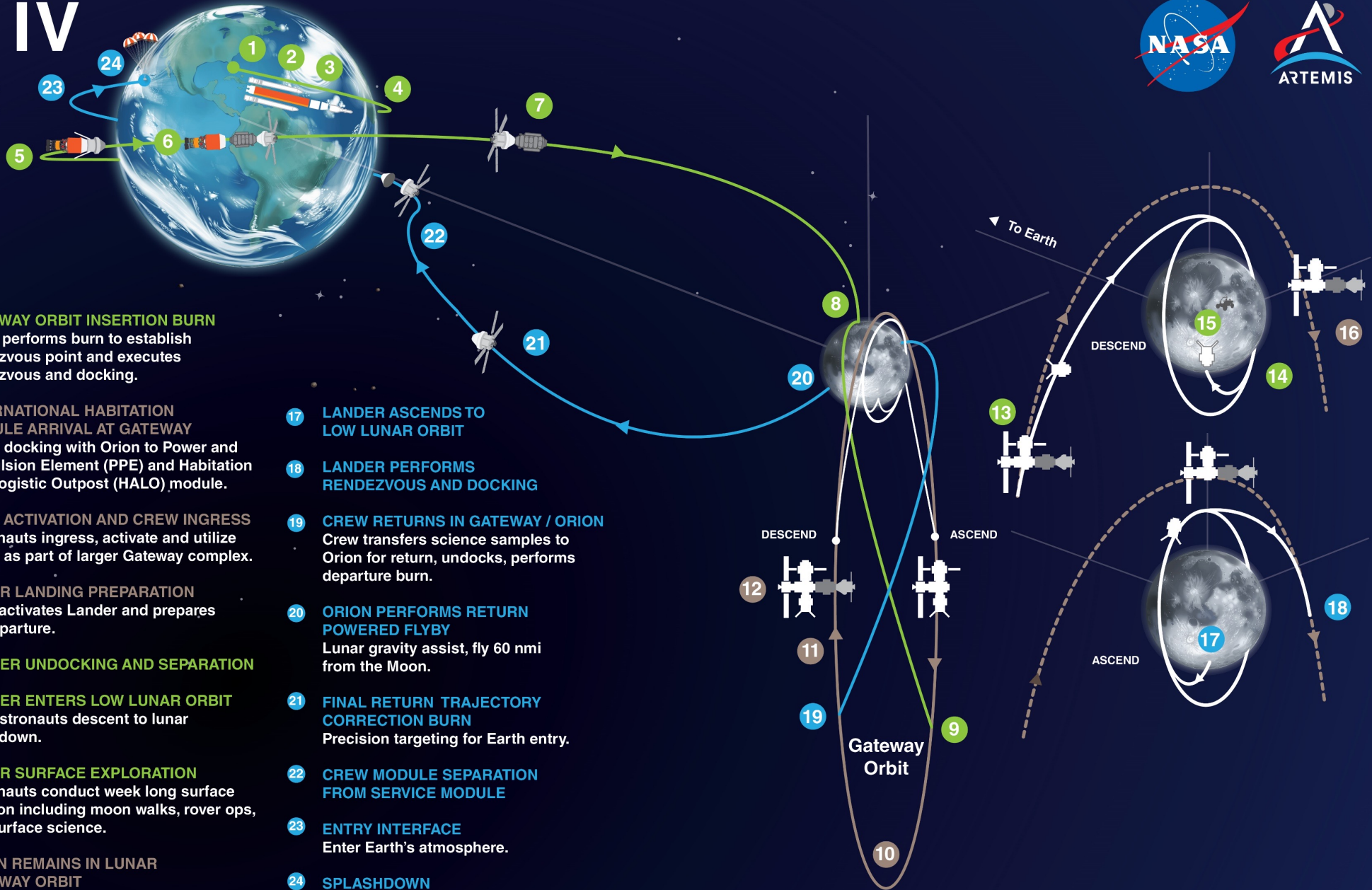
COMMON ELEMENTS:

- Crewed Orion with docking capability
- Common Block1 / Block 1B SLS Elements
- xEVA Suits and tools



ARTEMIS IV

International Habitation Module delivery to Gateway followed by Crewed Lunar Landing



- 1 LAUNCH**
SLS with I-HAB co-manifested payload and Orion with 4 crew members lift-off from Kennedy Space Center.
- 2 JETTISON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ABORT SYSTEM**
- 3 CORE STAGE MAIN ENGINE CUT OFF**
With separation.
- 4 ENTER EARTH ORBIT**
Exploration Upper Stage (EUS) performs circularization of Low Earth Orbit. Systems check and solar panel adjustments.
- 5 TRANS LUNAR INJECTION BURN**
EUS commits astronauts in Orion and I-HAB to lunar trajectory.
- 6 ORION TUGS I-HAB TO MOON**
Orion separation from Universal Stage Adapter (USA), ejection of USA, Orion docking with I-HAB for extraction from EUS/ Payload Adapter Fitting (PAF) followed by Orion tug of I-HAB to Gateway Orbit and EUS disposal.
- 7 ORION OUTBOUND TRANSIT TO MOON**
Requires several outbound trajectory burns.
- 8 ORION OUTBOUND POWERED FLYBY**
60 nmi from the Moon.
- 9 GATEWAY ORBIT INSERTION BURN**
Orion performs burn to establish rendezvous point and executes rendezvous and docking.
- 10 INTERNATIONAL HABITATION MODULE ARRIVAL AT GATEWAY**
I-HAB docking with Orion to Power and Propulsion Element (PPE) and Habitation and Logistic Outpost (HALO) module.
- 11 I-HAB ACTIVATION AND CREW INGRESS**
Astronauts ingress, activate and utilize I-HAB as part of larger Gateway complex.
- 12 LUNAR LANDING PREPARATION**
Crew activates Lander and prepares for departure.
- 13 LANDER UNDOCKING AND SEPARATION**
- 14 LANDER ENTERS LOW LUNAR ORBIT**
Two astronauts descent to lunar touchdown.
- 15 LUNAR SURFACE EXPLORATION**
Astronauts conduct week long surface mission including moon walks, rover ops, and surface science.
- 16 ORION REMAINS IN LUNAR GATEWAY ORBIT**
Other two astronauts tend to Gateway during lunar surface mission.

- 17 LANDER ASCENDS TO LOW LUNAR ORBIT**
- 18 LANDER PERFORMS RENDEZVOUS AND DOCKING**
- 19 CREW RETURNS IN GATEWAY / ORION**
Crew transfers science samples to Orion for return, undocks, performs departure burn.
- 20 ORION PERFORMS RETURN POWERED FLYBY**
Lunar gravity assist, fly 60 nmi from the Moon.
- 21 FINAL RETURN TRAJECTORY CORRECTION BURN**
Precision targeting for Earth entry.
- 22 CREW MODULE SEPARATION FROM SERVICE MODULE**
- 23 ENTRY INTERFACE**
Enter Earth's atmosphere.
- 24 SPLASHDOWN**
Astronaut crew, science sample and capsule recovery by ship.

Status: EGS Mobile Launcher 2 (ML-2)



- NASA's Exploration Ground Systems program is working with contractor Bechtel National Inc. to build a second mobile launcher (ML2) for NASA's Space Launch System (SLS) Block 1B and Block 2 configurations
- The ML2 project is a key component for future exploration, providing the assembly and launch platform for the Artemis IV mission and beyond that enable the power Block 1B SLS operations.
- Significant progress has been made with the design with 90% design completion over the next few months
- However, the project has experienced development and production issues:
 - Completion of steel fabrication drawings has also been delayed by revisions to reduce overall weight
 - Steel supply chain issues have caused delays of both steel fabrication and delivery on the completed design
- Significant improvements have been made in the design to accommodate weight, changes in management approach to improve performance, and additional work is being performed to address supply base issues.



GATEWAY



Artemis IV – Initial Capability

The two foundational elements of Gateway will launch together, prior to Artemis IV establishing a platform where astronauts can live and work in lunar orbit

Power and Propulsion Element (PPE)

- High-power solar electric propulsion used to transfer PPE/HALO to lunar orbit
- Provides power for the Gateway
- Maintains the Gateway's orbit

Habitation and Logistics Outpost (HALO)

- Houses up to 4 crew for up to 30 days (with Orion)
- Provides high-rate lunar communication relay to support lunar surface activities and command and control systems for Gateway
- Docking port for visiting spacecraft and future modules

PPE and HALO are launched together as a Co-Manifested Vehicle (CMV) on a SpaceX Falcon 9 Heavy





Gateway Initial Capability Status

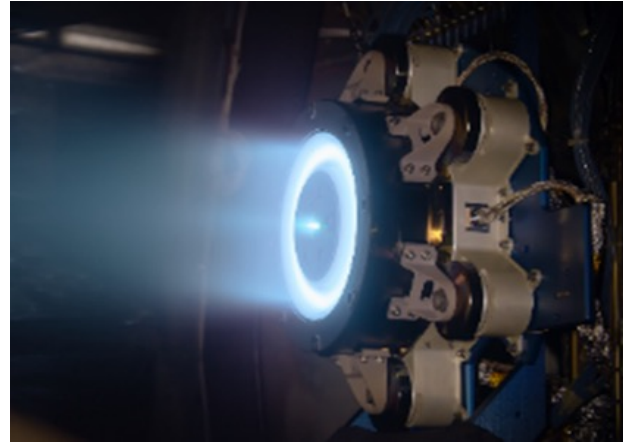


- Conducted the Program PDR-informed Sync Review in May. Targeting PDR-informed Sync Review technical closeout for December.
 - Finalizing updates to the Maxar PPE contract to incorporate major changes for CMV, risk mitigation, and 15-yr life. This is the last major contract change, all other IOC elements under contract to flight.
 - HALO and PPE manufacturing underway.
 - Completed HALO Habitable Element Longitudinal Welds. Circumferential welds in progress.
 - PPE central cylinder manufacturing and assembly complete.
-

Gateway Hardware Progress

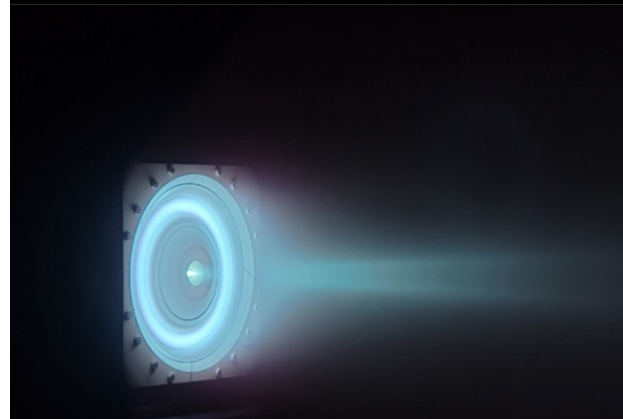


PPE Central Cylinder Assy Complete



Completed 12kw thruster end-to-end string Phase 1 testing

Completed 6kw thruster end-to-end string Phase 3 testing



HALO Habitable Element (HE) Longitudinal Welds Completed

GATEWAY



Artemis IV – I-HAB and Logistics

- **International Habitation Module (I-HAB)**

- Enhances Gateway capabilities for scientific research, life support systems and crew living quarters and imagery components
- Enables longer crewed mission durations
- Includes additional docking ports
- Will be launched with Orion on SLS as co-manifested payload on Artemis IV

- **Logistics**

- SpaceX was selected under the Gateway Logistics Services contract to deliver cargo, experiments and other supplies to the Gateway in lunar orbit
- 5.4 – 6.0 MT delivered cargo capability
- Automated docking/undocking
- Independent power and thermal





ARTEMIS

Backup



Glossary



Acronym	Definition	Acronym	Definition
VAB	Vehicle Assembly Building	PLSS	Portable Life-Support System
MAF	Michoud Assembly Facility	ML2	Mobile Launch 2
LH2	Liquid Hydrogen	EUS	Exploration Upper Stage
KSC	Kennedy Space Center	I-HAB	International Habitat
xEVA	Exploration EVA	HALO	Habitation and Logistics Outpost
ESA	European Space Agency	NRHO	Near Rectilinear Halo Orbit
SLS	Space Launch System	TLI	Translunar Injection
HLS	Human Landing System	CDR	Critical Design Review
LOX	Liquid Oxygen	PPE	Power and Propulsion Element
LCH4	Liquid Methane	CMV	Co-Manifested Vehicle
EVA	Extravehicular Activity	PDR	Preliminary Design Review
xEMU	Exploration Extravehicular Mobility Unit	ECP	Engineering Change Package
NBL	Neutral Buoyancy Lab	HALO HE	HALO Habitable Element
SERFE	Spacesuit Evaporation Rejection Flight Experiment	GERS	Gateway External Robotic System
DVT	Development and Verification Tests	ISS	International Space Station

Gateway Integrated Spacecraft

