



June 2024 | Space Studies Board

# Exploration Systems Development Mission Directorate and Artemis Update

**Catherine Koerner**

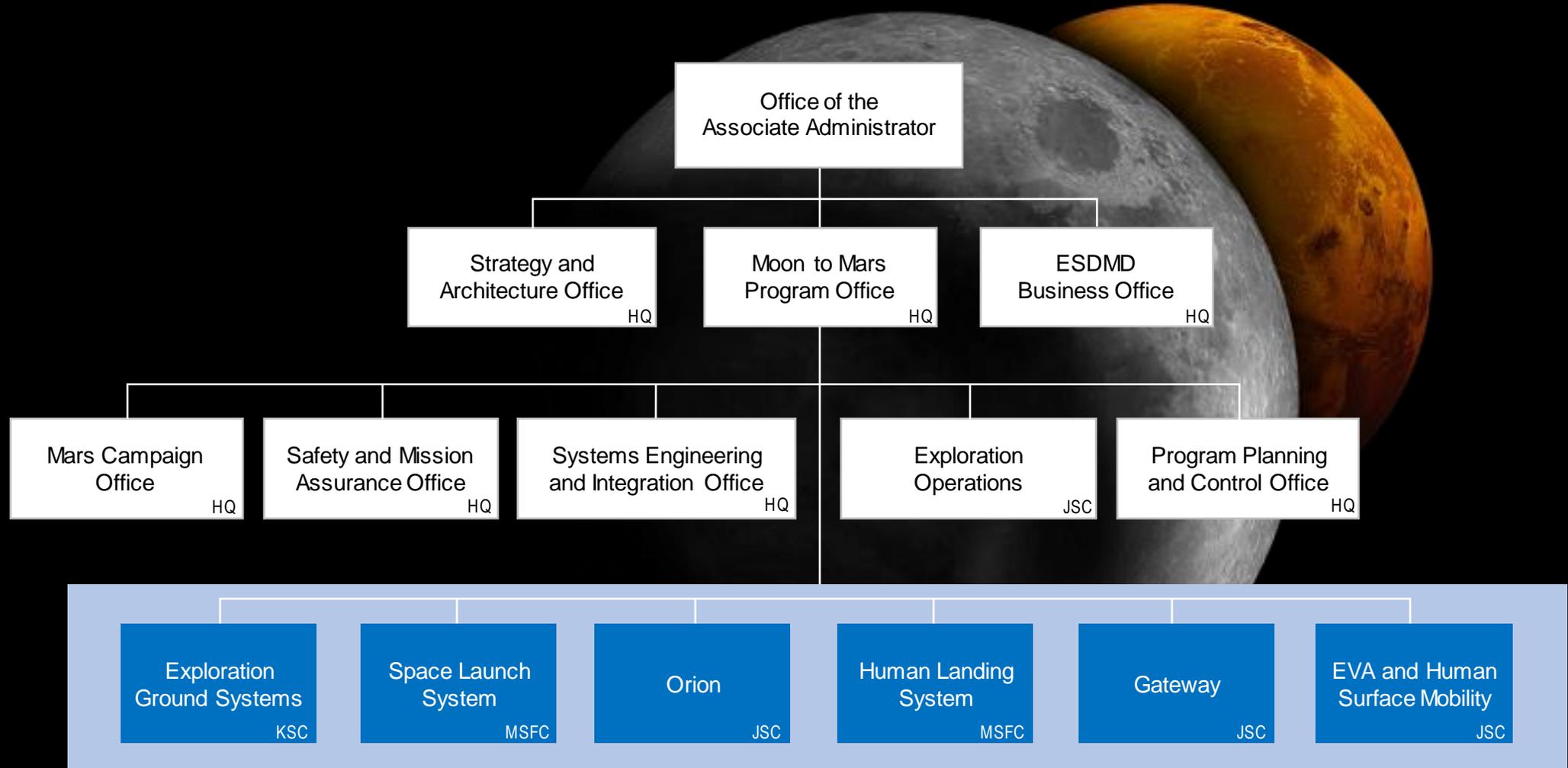
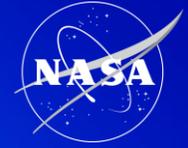
Associate Administrator  
Exploration Systems Development

# Exploration Systems Development Mission Directorate (ESDMD)



- Defines and manages systems development for programs critical to NASA's Artemis campaign and planning for NASA's Moon to Mars exploration approach
- Manages the human exploration system development for lunar orbital, lunar surface, and Mars exploration

# ESDMD Organization Chart



# Exploration Systems Development Mission Directorate (ESDMD) Goals



Note: Mission Safety and Success are not listed as a goal because they are an inherent mandate

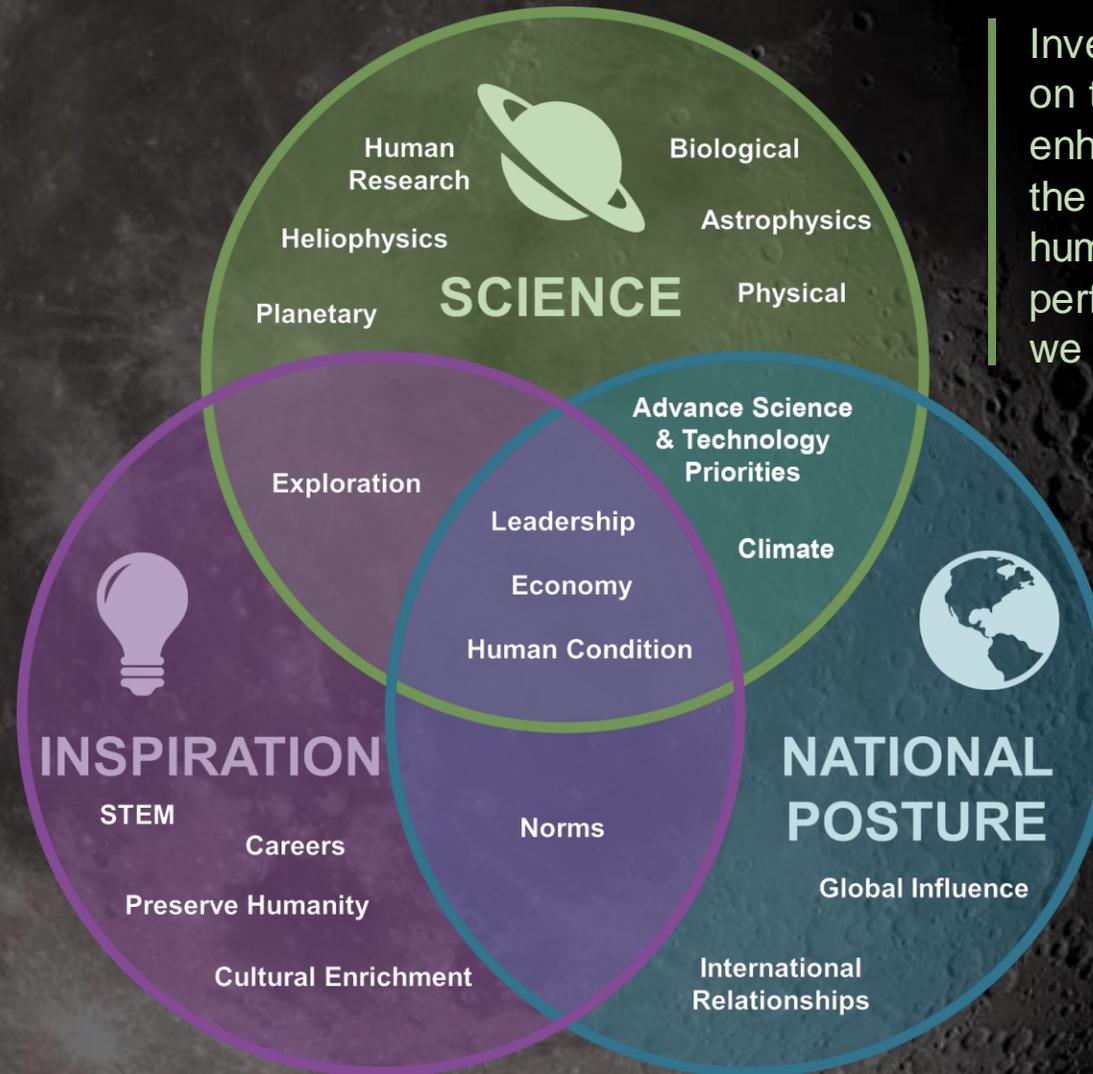
## ESDMD Goals 2024-2025

- Execute NASA's Artemis missions
- Evolve a sustainable architecture to meet Moon to Mars objectives
- Enable a national deep space transportation capability
- Enhance affordability of all exploration systems
- Expedite toward a yearly mission cadence

## To accomplish these goals, we will continue to:

- Foster high standards of program and project management
- Balance funding profile, mission dates, and risks
- Lead international and commercial exploration partnerships
- Collaborate with centers to maintain highly skilled workforce and capabilities
- Communicate clear status and plans for all stakeholders

# Artemis—Why we Explore

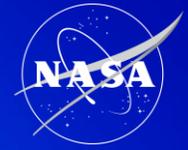


Investigations in deep space, on the Moon, and on Mars will enhance our understanding of the solar system, Earth, the human body, and how to perform new operations while we are out there exploring.

Accepting audacious challenges and succeeding through perseverance and tenacity in the face of adversity motivates current and future generations to dare mighty things.

What we choose to do, how we do those things, and who we do them with greatly impacts our place in the world today, our quality of life, and our possibilities for the future.

# Artemis: A Foundation for Deep Space Exploration



Space Launch System



Orion Spacecraft



Human Landing System



Surface Operations



Gateway



Exploration Ground Systems



Space Communications & Navigation



Surface Mobility



Spacesuits



Surface Infrastructure



# Artemis II

## ARTEMIS FIRSTS:

- Crewed integrated flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at KSC
- Active Orion Launch Abort System (LAS)
- Demonstration of Orion life support systems
- Proximity operations demonstrations
- Human data collection in transit to and from the Moon, in lunar orbit, and through reentry and splashdown
- Conducting new science and technology demonstrations in orbit

## NEW ELEMENTS:

- Orion life support systems
- Launch Complex 39B emergency egress system for crew and new liquid hydrogen system

## COMMON ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1

**ENSURING CREW SAFETY IS OUR TOP PRIORITY!**

# Artemis II Human Research



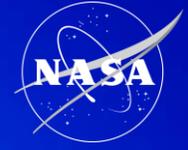
## Artemis Research for Crew Health & Readiness (ARChER):

- Wearable device to study crew sleep-wake patterns and activity levels
- Will collect performance data on crew and team operational tasks
- Audio and video between operations teams will also be collected for analysis after the mission

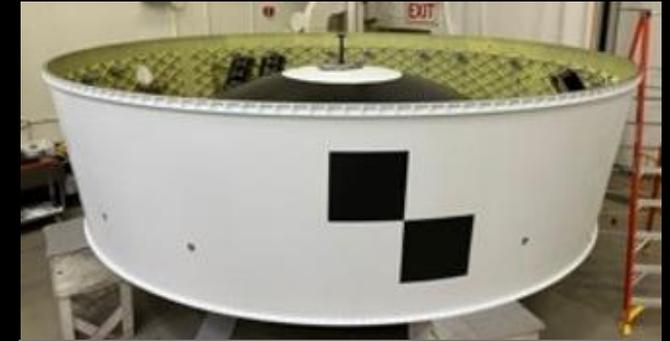
## Immune Biomarkers:

- Samples of crew saliva will be collected and studied to determine how space travel affects the immune system

# Artemis II Progress



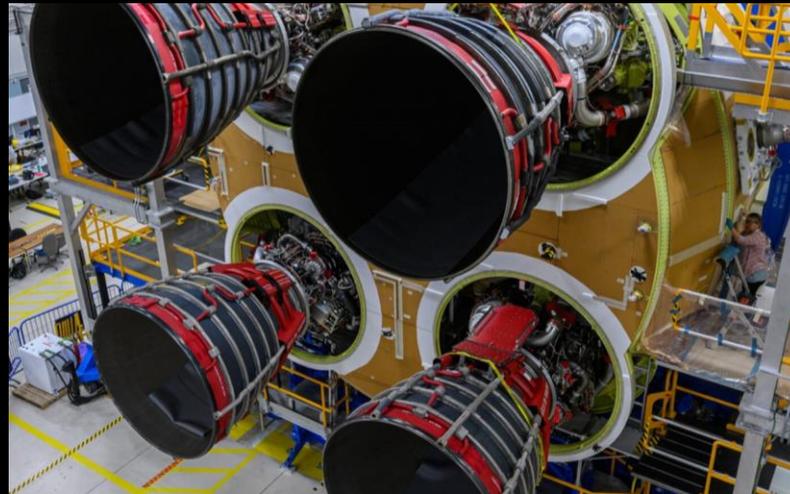
The Artemis II crew stand on the crew access arm of the mobile launcher at Launch Pad 39B as part of an integrated ground systems test



Artemis II Orion stage adapter with docking target and diaphragm installed



In preparation for the Artemis II crewed mission, EGS teams begin installation of four emergency egress baskets at Launch Complex 39B

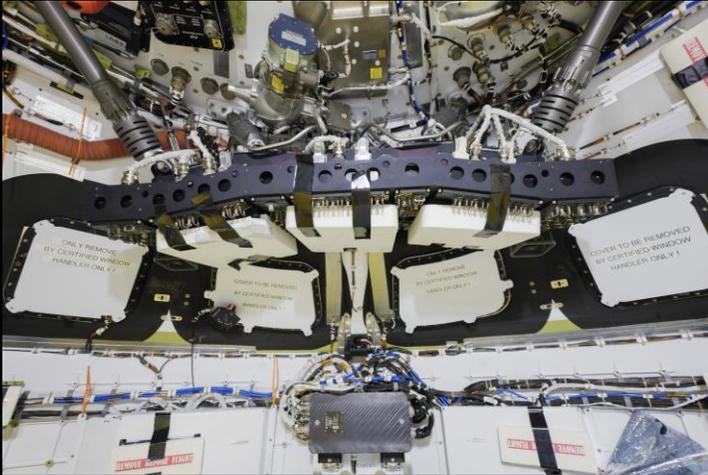
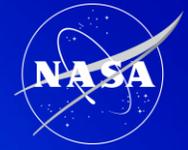


Artemis II core stage with installed engines undergoing final outfitting



Artemis II booster motor segments receive "worm" logotype in the Rotation, Processing and Surge Facility at Kennedy Space Center

# Artemis II Progress



Artemis II Orion Crew Module Interior



Integration of Crew and Service Modules for the Artemis II Orion Spacecraft



Artemis II Orion Spacecraft inside the altitude chamber at NASA's Kennedy Space Center for testing



Artemis II Service Module

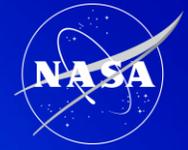


Artemis II Orion Spacecraft is lifted into an altitude chamber at NASA's Kennedy Space Center for electromagnetic interference/compatibility testing



Orion environmental test article being prepared for vibro-acoustic testing at NASA's Neil Armstrong Test Facility

# Artemis II Progress



Artemis II crew members Reid Wiseman (foreground) and Jeremy Hansen participate in training in the Orion simulator



U.S. Navy personnel grab onto a mockup of the Orion spacecraft during a practice procedure of the Underway Recovery Test 11 (URT-11)



Teams conducted a cryogenic simulation for the Artemis II mission inside Launch Control Center Firing Room 1 at Kennedy Space Center. During this operation, the launch team practiced loading the super-cool liquid propellant on the SLS.



The four Artemis II astronauts practiced procedures to exit the Orion spacecraft in an emergency



NASA Artemis II crew members are assisted by U.S. Navy personnel as they exit a mockup of the Orion spacecraft in the Pacific Ocean during URT-11



# Artemis III

## ARTEMIS FIRSTS:

- Human landing in South Pole region and return
- Orion to human landing system direct mission including crew docking activity
- Use of Near Rectilinear Halo Orbit (NRHO)
- Four astronauts to lunar orbit
- Two astronauts to lunar surface to collect scientific samples and data
- Conducting new science and technology demonstrations

## NEW ELEMENTS:

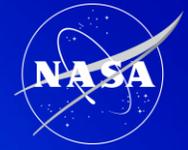
- Orion full up rendezvous, proximity operations, and docking systems
- Starship human landing system
- Advanced spacesuits and tools to explore the surface and collect samples

## COMMON ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1



# Starship Human Landing System Progress



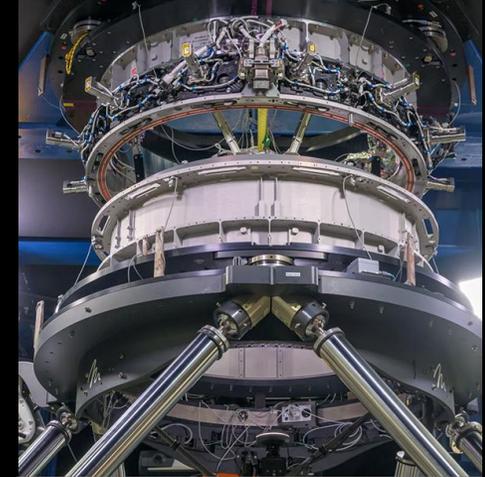
March 14, 2024—Starship third integrated test flight.  
Credit: SpaceX



March 14, 2024—For the second time, all 33 Raptor engines on the Super Heavy Booster started up successfully and completed a full-duration burn during ascent. Credit: SpaceX



March 14, 2024—Starship third integrated test flight.  
Credit: SpaceX

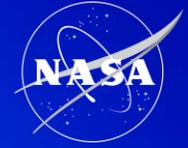


Starship Human Landing System docking system qualification test

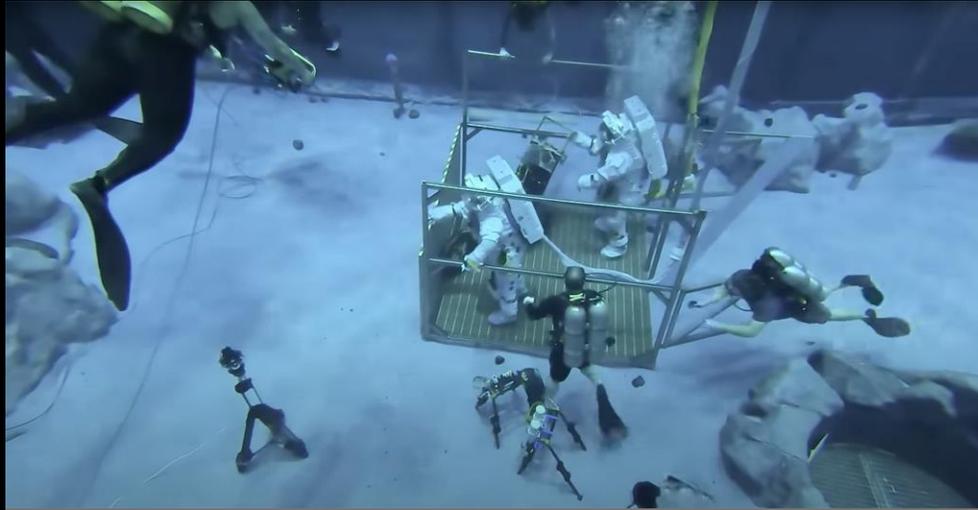


Starship Human Landing System elevator astronaut testing

# Artemis III Progress



AxEMU spacesuit during testing



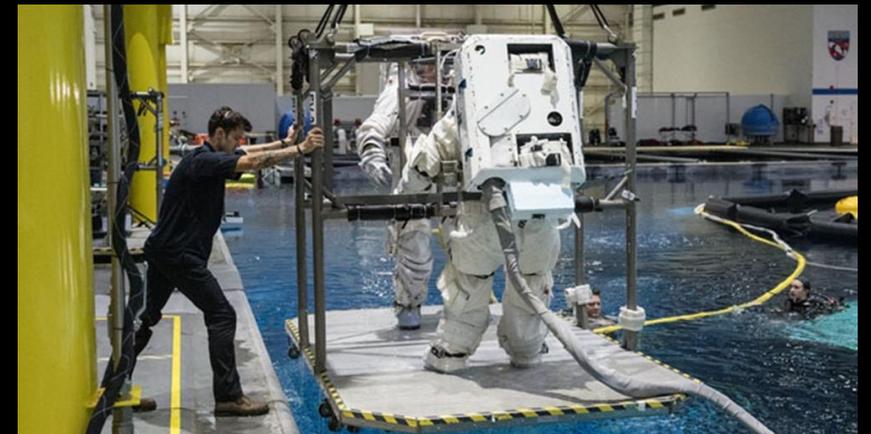
Astronauts Victor Glover and Christina Koch practice runs on a Starship elevator mockup in the Neutral Buoyancy Laboratory



Spacesuit and hardware tests on the simulated lunar terrain on the Neutral Buoyancy Laboratory (NBL) pool floor

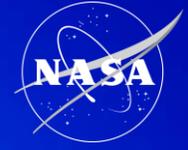


The Joint Extravehicular Activity and Human Surface Mobility Program Test Team (JETT) 5 w as a fully integrated Artemis III mission test in AZ with simulated moonwalks, advanced technology runs, a science evaluation room, and a flight control team.



Spacesuit and EVA hardware testing in the NBL

# Artemis III Progress



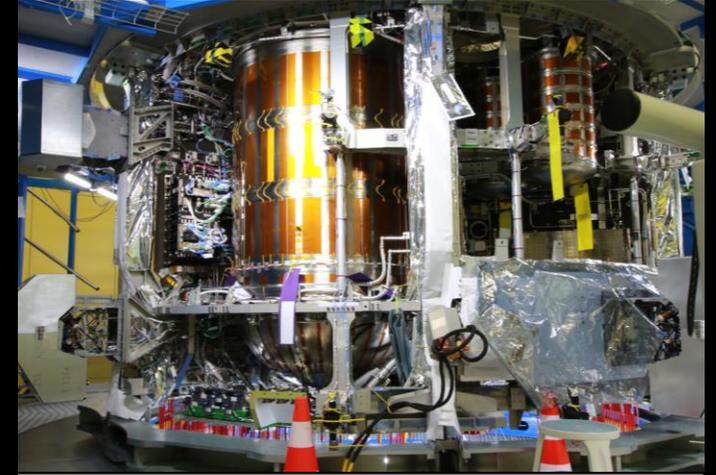
All Artemis III booster motor segments complete



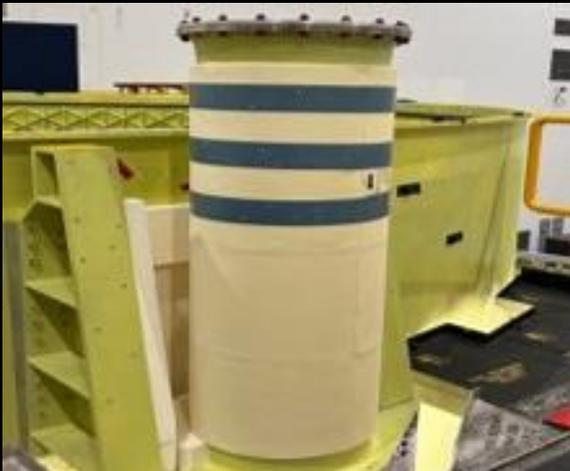
Artemis III launch vehicle stage adapter has completed frangible joint assembly



Artemis III SLS core stage liquid oxygen tank moved to Cell D at Michoud



European Service Module 3 integration in Bremen cleanroom



Artemis III SLS engine section at Kennedy Space Center

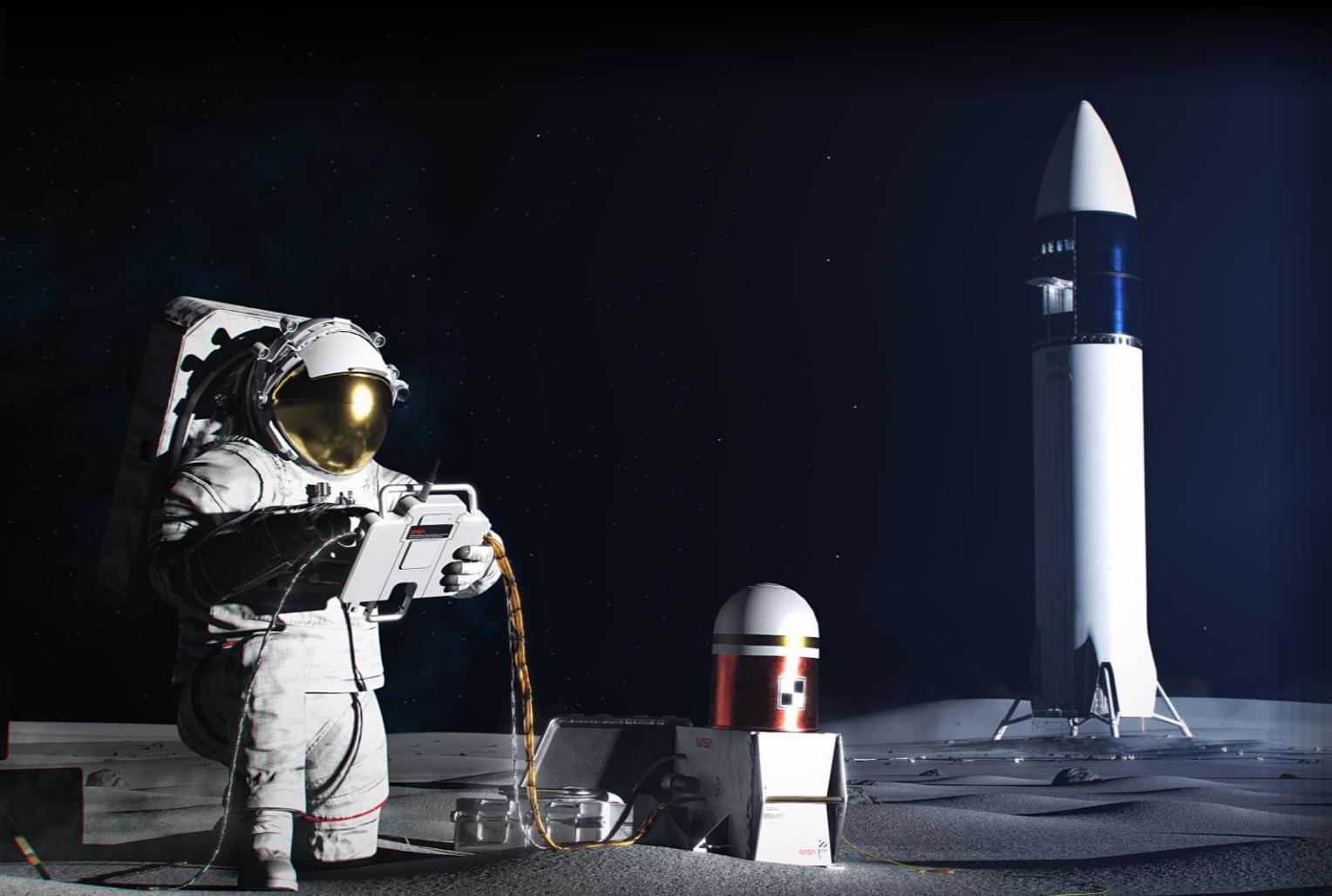


Artemis III interim cryogenic propulsion stage in Delta Operations Center



Artemis III crew module integration

# Artemis III Science Instruments to be Deployed by Astronauts



**Three instruments selected, with final manifesting decisions to be determined later**

- Lunar Environment Monitoring Station (LEMS)
- Lunar Effects on Agricultural Flora (LEAF)
- Lunar Dielectric Analyzer (LDA)

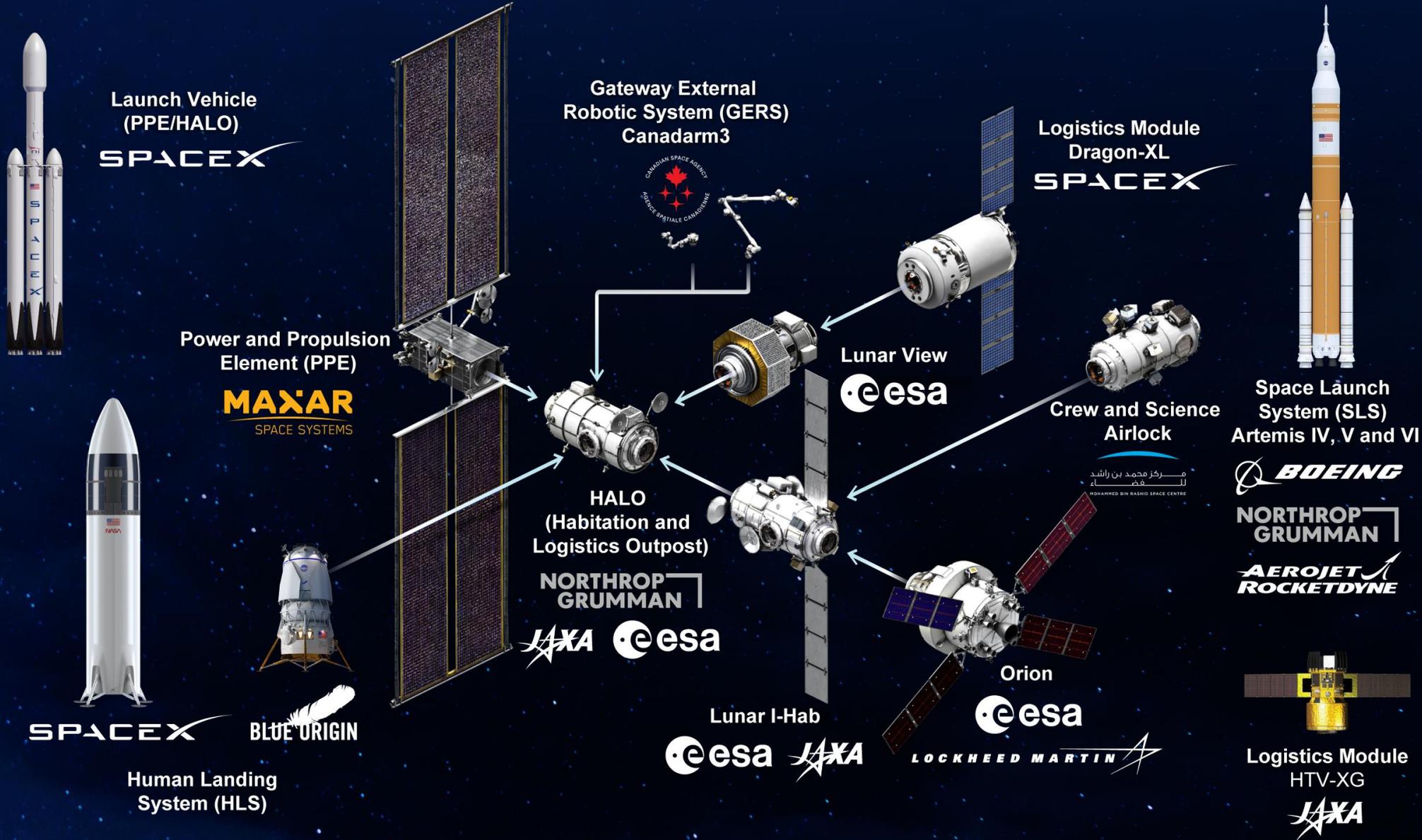
**Three Artemis science objectives to be addressed:**

- Understanding planetary processes,
- Understanding the character and origin of lunar polar volatiles, and
- Investigating and mitigating exploration risks

**Payload teams will become members of NASA's Artemis III science team**

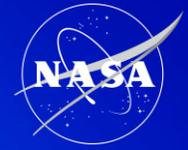
# GATEWAY

## Artemis Mission Elements

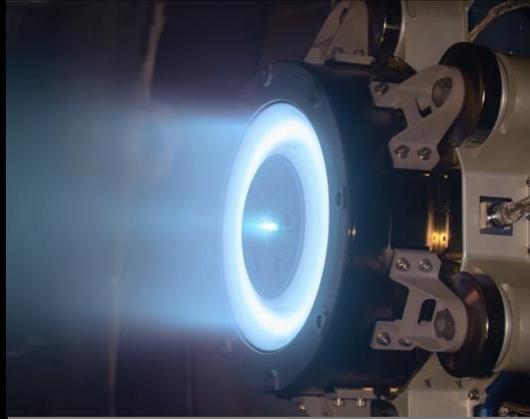


\*Artemis mission elements are not to scale.

# Gateway Initial Capability Progress



PPE Roll Out Solar Array (ROSA) Boom



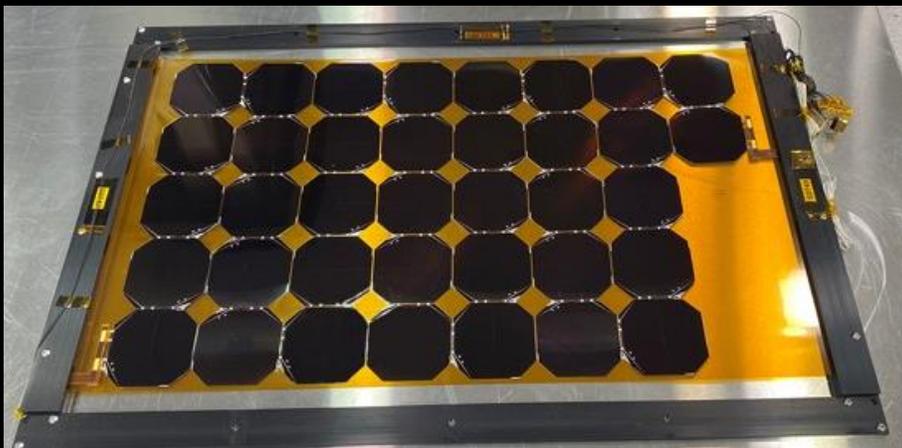
Power and Propulsion Element 12-kilowatt Solar Electric Propulsion Test



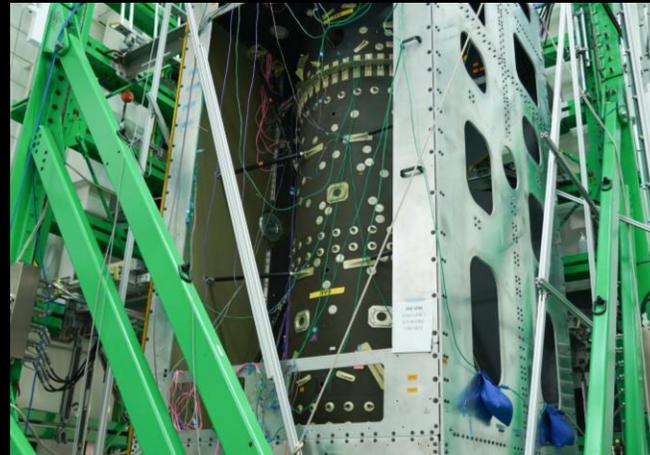
Gateway advanced electric propulsion system qualification thruster



Engineers at Thales Alenia Space Italia gently guide HALO from its welding platform to an integration test stand.



Power and Propulsion Element (PPE) Solar Array Power Module



Power and Propulsion Element central cylinder testing at Maxar



Habitation and Logistics Outpost after completion of final welds in Turin, Italy



# Artemis IV

## ARTEMIS FIRSTS:

- Crewed mission to Gateway space station
- Launch, delivery, and integration of a space station module in lunar orbit
- Crew transfer from Orion to human landing system (HLS) via Gateway
- Deep Space Logistics flight to Gateway
- Conducting science and demonstrating technology in orbit and on the surface

## NEW ELEMENTS:

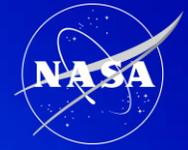
- Space Launch System rocket Block 1B configuration  
Mobile Launcher 2 with supporting ground systems
- SpaceX Sustaining Starship HLS
- Gateway modules: Power and Propulsion Element and Habitation and Logistics Outpost (pre-staged in orbit); International Habitat (launched on SLS Block 1B alongside the crew aboard Orion); Deep Space Logistics

## COMMON ELEMENTS:

- Common SLS elements
- Orion crew spacecraft
- Spacesuits and support systems



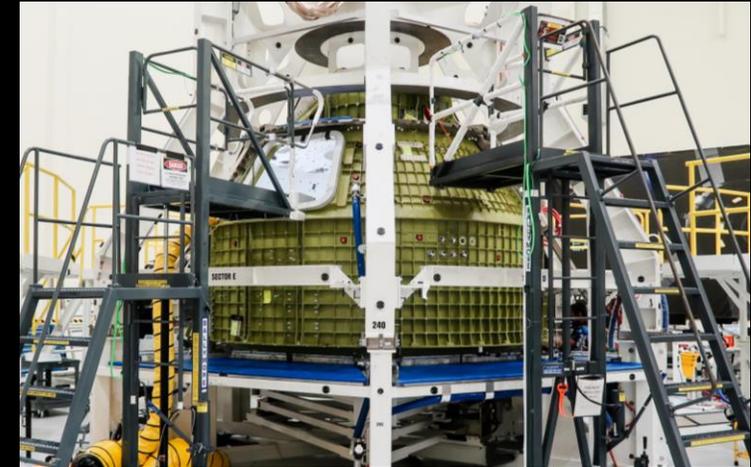
# Artemis IV Progress



ML-2 truss work



Artemis IV payload adapter engineering development unit ready for evaluation



Artemis IV Crew Module Pressure Vessel at Kennedy Space Center



ML-2 tower module



Artemis IV universal stage adapter development test article at Marshall for testing

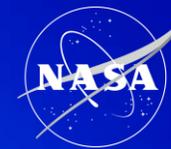


Artemis IV engine section in progress



Artemis IV European Service Module in Bremen, Germany

# Artemis IV Progress



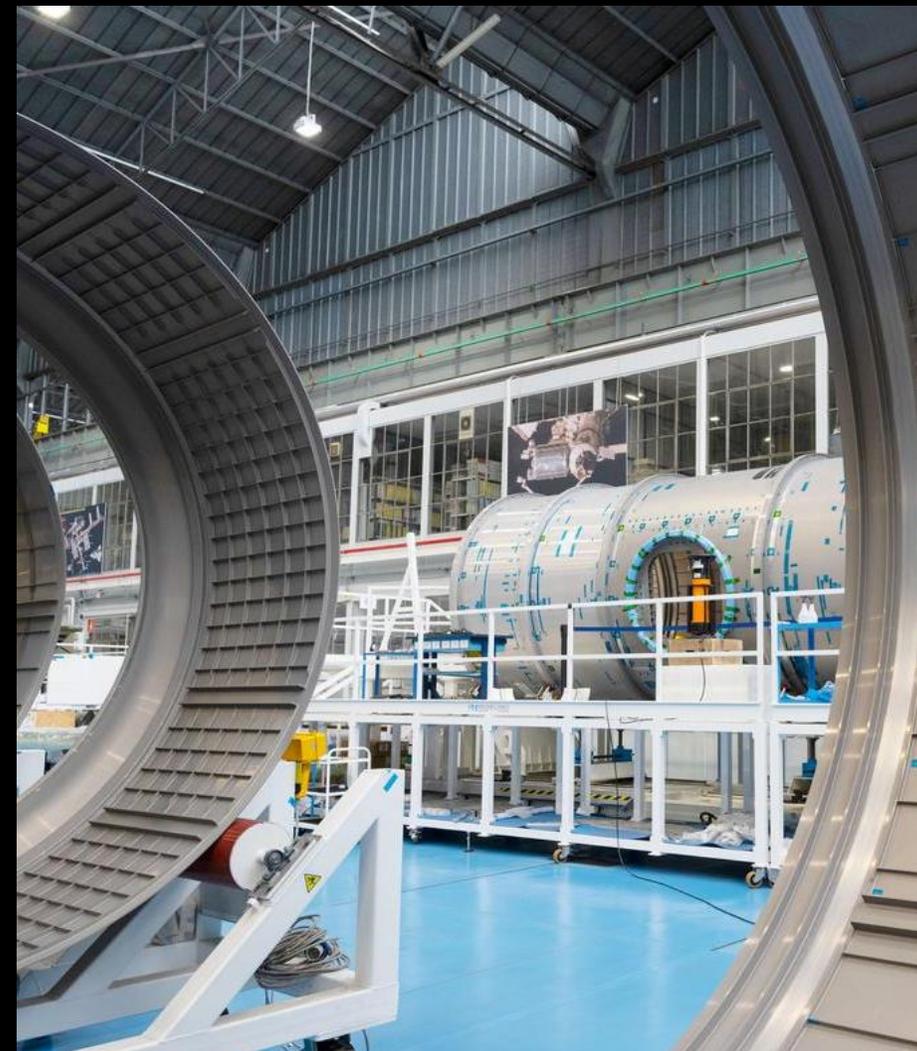
Early hardware for Lunar I-Hab



Early hardware for Lunar I-Hab that will be delivered to Gateway on Artemis IV



Early hardware for Lunar I-Hab



Pieces of Lunar I-Hab with HALO module visible in center, back of image



# Artemis V

## ARTEMIS FIRSTS:

- Use of the lunar terrain vehicle (LTV) rover by crew to access more of the lunar surface and collect diverse scientific samples
- Use of second lunar lander design
- Use of new RS-25 engines
- Conducting new science and demonstrating technology in orbit and on the surface

## NEW ELEMENTS:

- Blue Moon human landing system
- LTV unpressurized rover with scientific instruments
- Gateway modules: ESPRIT Refueling Module (European System Providing Refueling Infrastructure and Telecommunications), Canadarm3 robotic arm

## COMMON ELEMENTS:

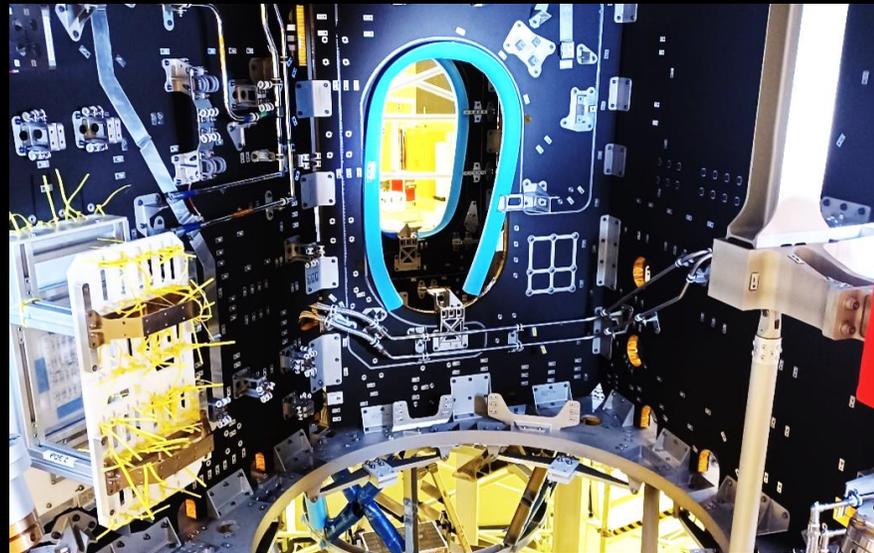
- Space Launch System rocket Block 1B configuration
- Orion crew spacecraft
- Mobile Launcher 2 with supporting ground systems
- Spacesuits and support systems



# Artemis V Progress



Artemis V Y-ring manufactured at Michoud Assembly Facility



European Service Module-5 at the Airbus Integration Hall in Bremen, Germany



Certification testing for production of new RS-25 Retrofit 3b engines to power the SLS rocket, beginning with Artemis V, completed early April 2024



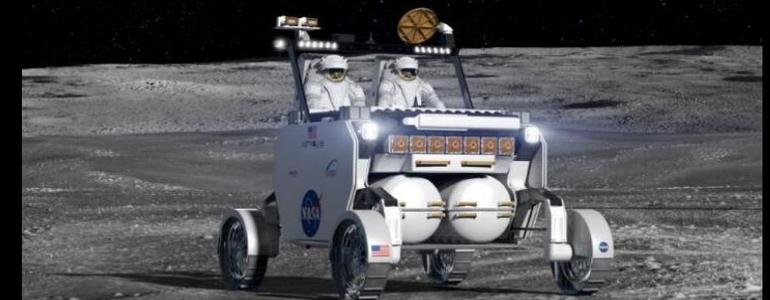
Orion crew module pressure vessel welding has begun at NASA's Michoud Assembly Facility



Artist's concept of Intuitive Machines' Moon RACER lunar terrain vehicle. Credit: Intuitive Machines



Artist's concept of Lunar Outpost's Lunar Dawn lunar terrain vehicle. Credit: Lunar Outpost



Artist's concept of Venturi Astrolab's FLEX lunar terrain vehicle. Credit: Astrolab

# Blue Moon Human Landing System Progress



A Blue Origin technician conducts a vacuum chamber fit check for a fuel cell at Blue Origin's facility in West Texas.



Blue Origin's BE-7 team conducted a successful Thrust Chamber Assembly test at NASA Marshall Space Flight Center.



The first and second stages of New Glenn's test vehicle mated for the first time enabled Blue Origin to exercise their tooling and stage interfaces in preparation for the first launch.



Dual Tank Cryo Fluid Management Test Article. Credit: Blue Origin



Blue Origin conducted a drop test of the Blue Moon MK1 cargo lander leg to provide engineers with data to correlate design models for dynamic loads analysis.



Hardware for Blue Origin's New Glenn second stage, which will refuel the cislunar transporter as part of Blue Origin's Artemis V architecture, is being manufactured at Blue Origin's production facility in Cape Canaveral, FL.



Blue Origin's New Glenn rocket upended on its launch pad for the first time. The rocket's first stage underwent three tanking tests in preparation for its first launch.



New Glenn test article on Blue Origin's launch pad at LC-36

# Beyond Artemis V Progress



NASA Administrator Bill Nelson, left, and Japan's Minister of Education, Culture, Sports, Science and Technology Masahito Moriyama, hold signed copies of an historic agreement between the U.S. and Japan. Under the agreement, Japan will design, develop, and operate a pressurized rover for crewed and uncrewed exploration on the Moon. NASA will provide the launch and delivery of the rover to the Moon as well as two Japanese astronaut missions to the lunar surface.



The European Service Module 6 structure ahead of shipment to the Airbus Integration Hall in Bremen, Germany



BOLE DM-1 Booster Segment complete for Artemis IX



Early conceptual renderings of cargo variants of human lunar landing systems from NASA's providers SpaceX, left, and Blue Origin, right. Both industry teams have been given authority to begin design work to provide large cargo landers capable of offloading 15 metric tons of cargo, such as a pressurized rover, on the Moon's surface. (SpaceX and Blue Origin)



## Pressurized Rover

- Japan will design, develop, and operate the enclosed and pressurized rover
- NASA will provide launch and delivery to the Moon
- Will be able to accommodate two astronauts for up to 30 days, as soon as Artemis VII
- Mobile laboratory for exploration activities during both crewed and uncrewed missions

# International Collaboration



## PEOPLE



For Artemis II, which will be the first to send crew around the Moon, one of the four astronauts will be Canadian.



50 attendees representing 18 countries attended the Moon to Mars Architecture Workshop on Feb. 20, 2024.

## HARDWARE

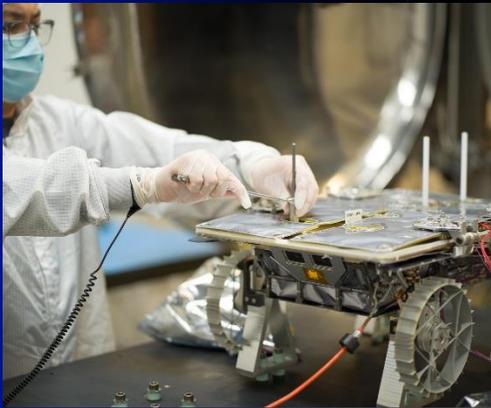


Artist's concept of Gateway.



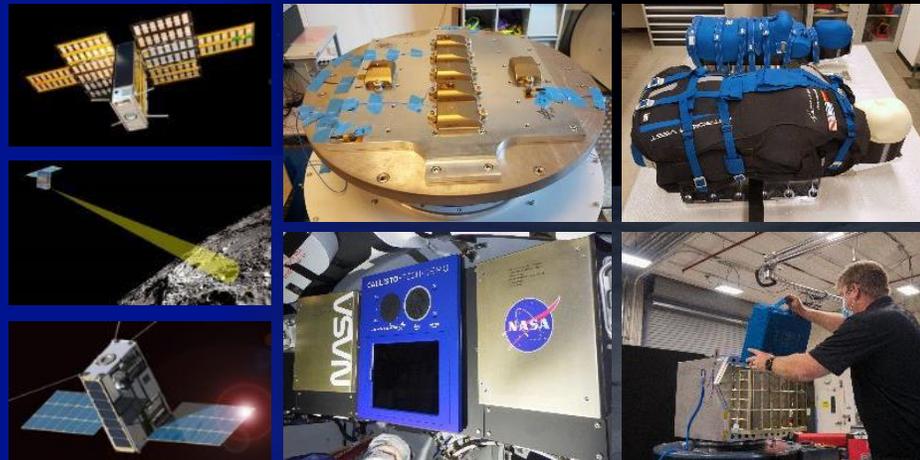
European Service Module for the Orion spacecraft, provided by the European Space Agency.

## LUNAR SCIENCE



An engineer prepares a small rover—part of NASA's CADRE (Cooperative Autonomous Distributed Robotic Exploration) technology demonstration that will be headed to the Moon.

## PAYLOADS



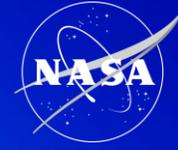
Artemis I: Several international partners provided payloads to research key knowledge gaps for deep space exploration.

## SPACE COMMUNICATIONS AND NAVIGATION



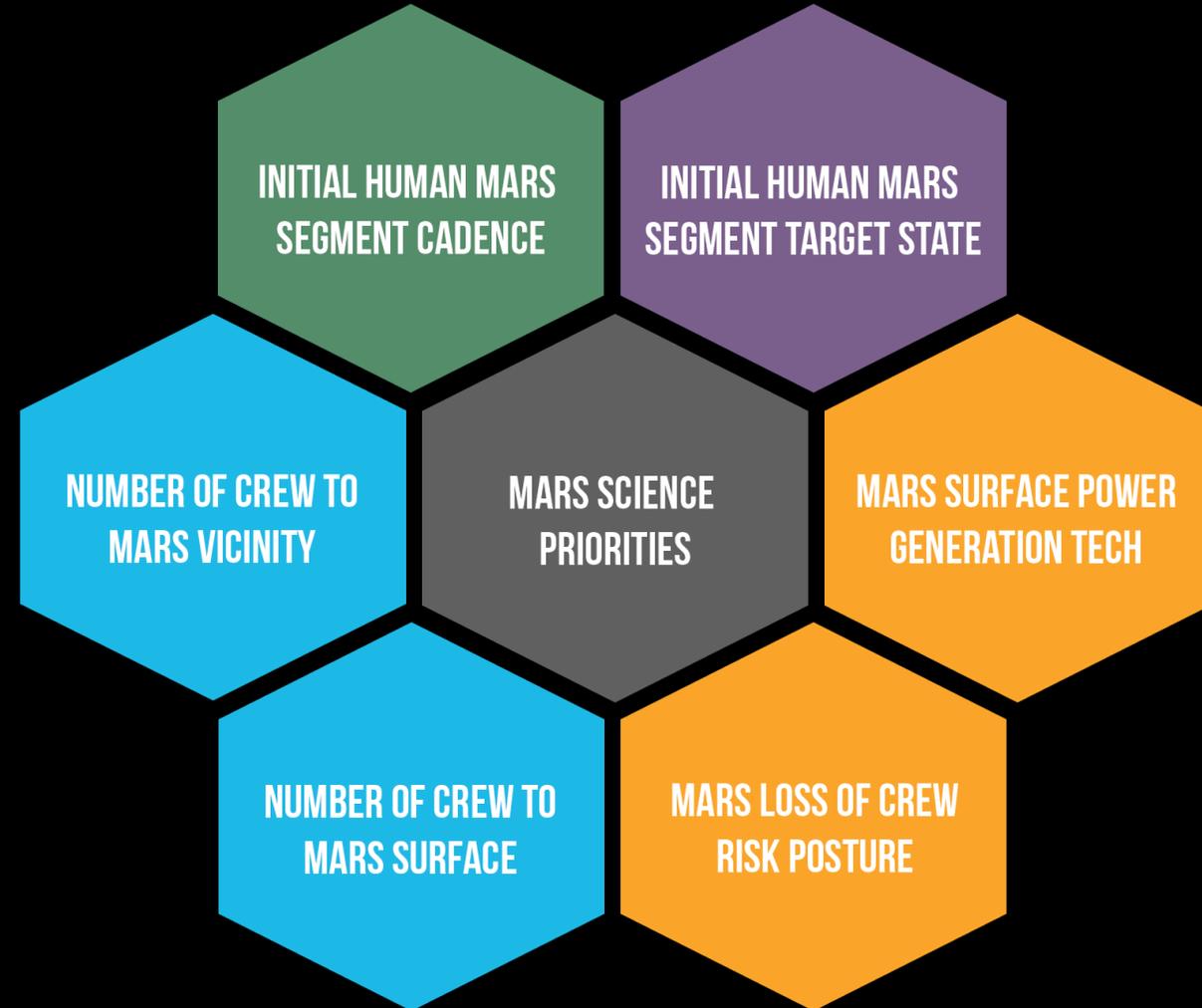
Deep Space Station 53 is a new waveguide antenna that went online in February 2022 at NASA's Deep Space Network's ground station in Madrid.

# Moon to Mars Architecture – Priority Mars Decisions



In 2024, NASA has begun analyses needed to allow for informed decision-making by agency leadership, beginning with the seven priority decisions identified.

Decisions for Mars will inform lunar planning, development, and needs to demonstrate and ready systems and operations for eventual Humans to Mars segment missions.



COLOR KEY

**WHY**

WE WILL GO

**WHEN**

WE WILL GO

**WHAT**

WE WILL DO THERE

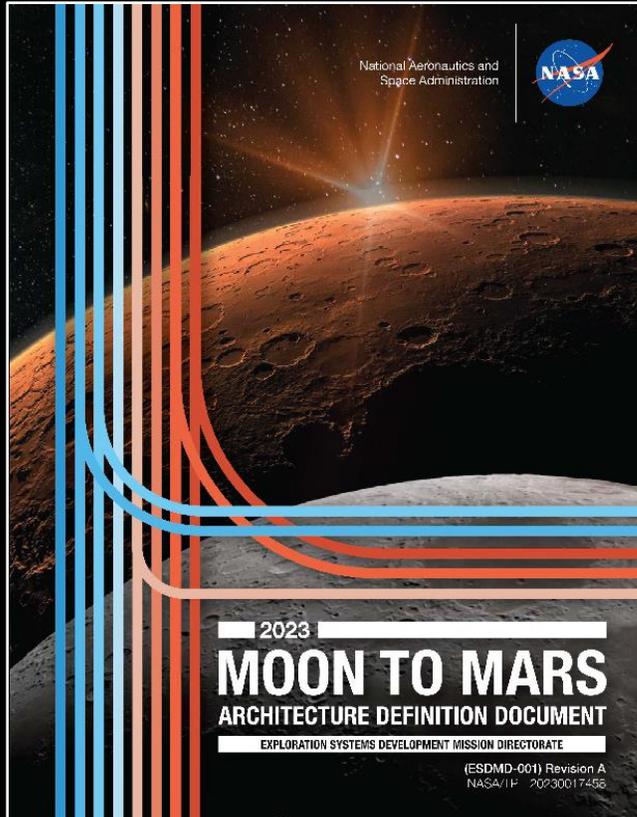
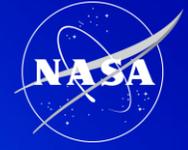
**WHO**

WILL BE INVOLVED

**HOW**

WE WILL GET THERE AND BACK

# Moon to Mars Architecture Updates

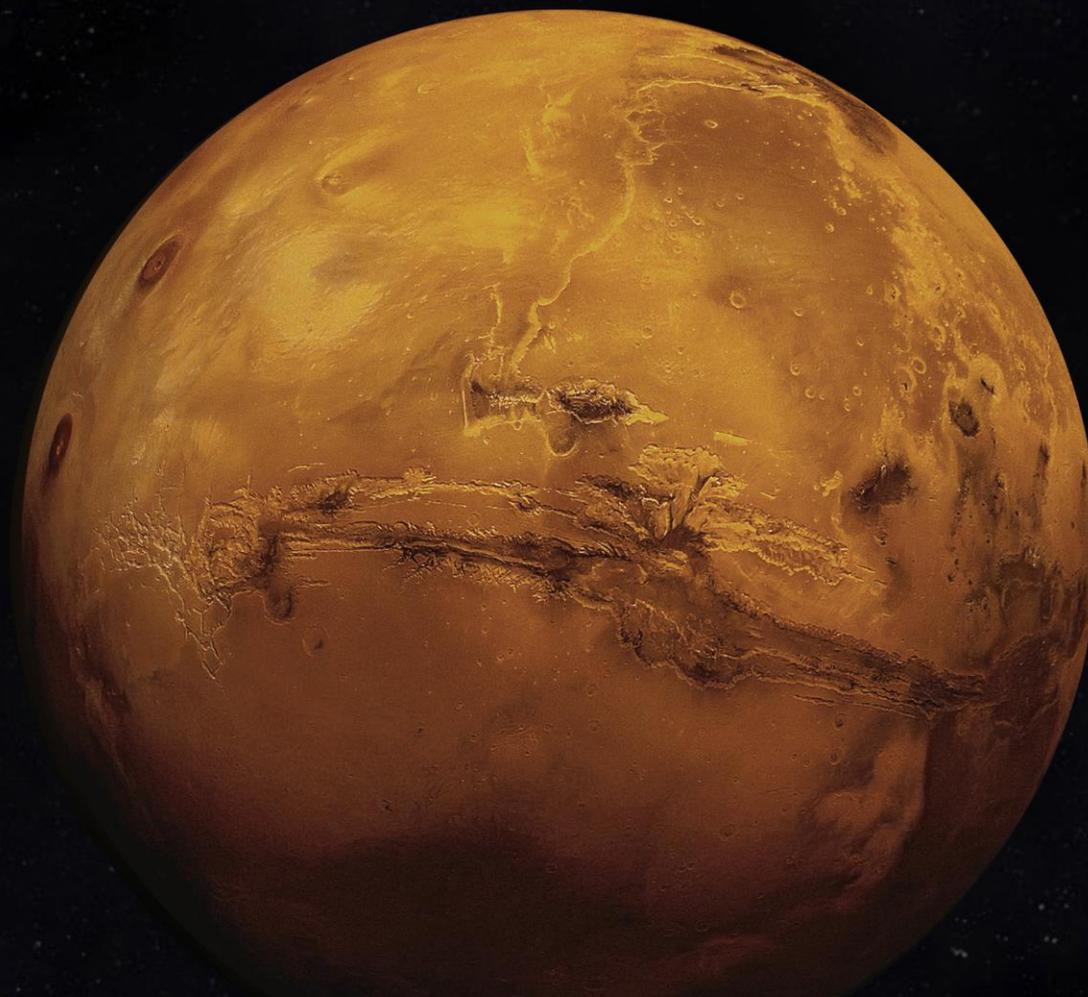


[nasa.gov/architecture](https://nasa.gov/architecture)

# ARTEMIS ACCORDS



United for Peaceful Exploration of Deep Space



**We explore for all humanity.**