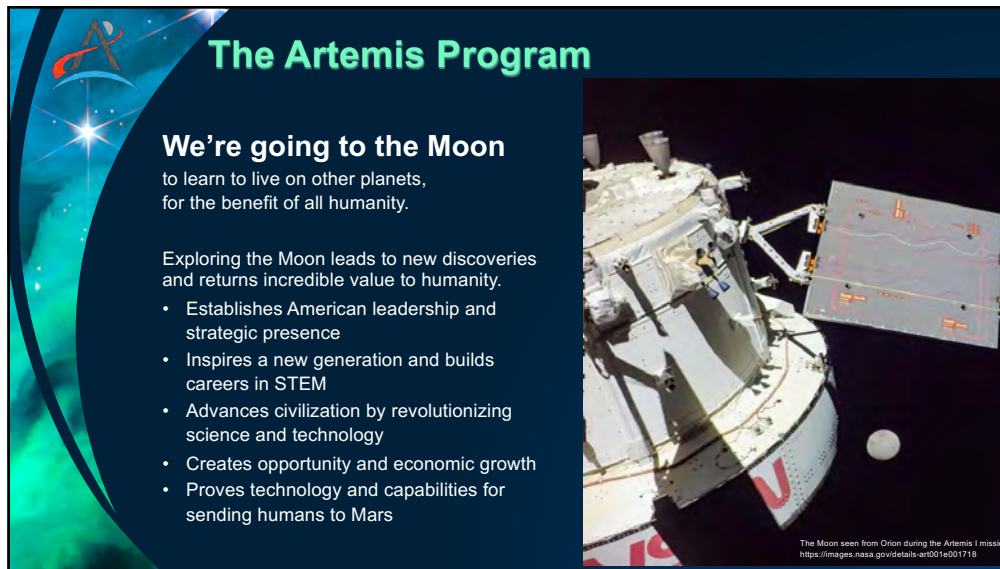



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Artemis Science Objectives

- 1) Understanding Planetary Processes
- 2) Understanding the Character and Origin of Lunar Volatiles
- 3) Interpreting the Impact History of the Earth-Moon system
- 4) Revealing the Record of the Ancient Sun and Our Astronomical Environment
- 5) Observing the Universe and the Local Space Environment from a Unique Location
- 6) Conducting Experimental Science in the Lunar Environment
- 7) Investigating and Mitigating Exploration Risks

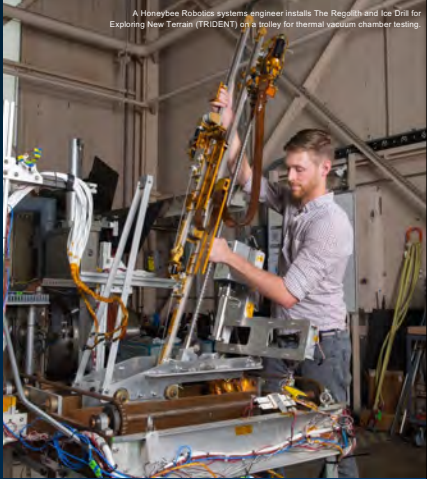


Apollo 12 Lunar Module

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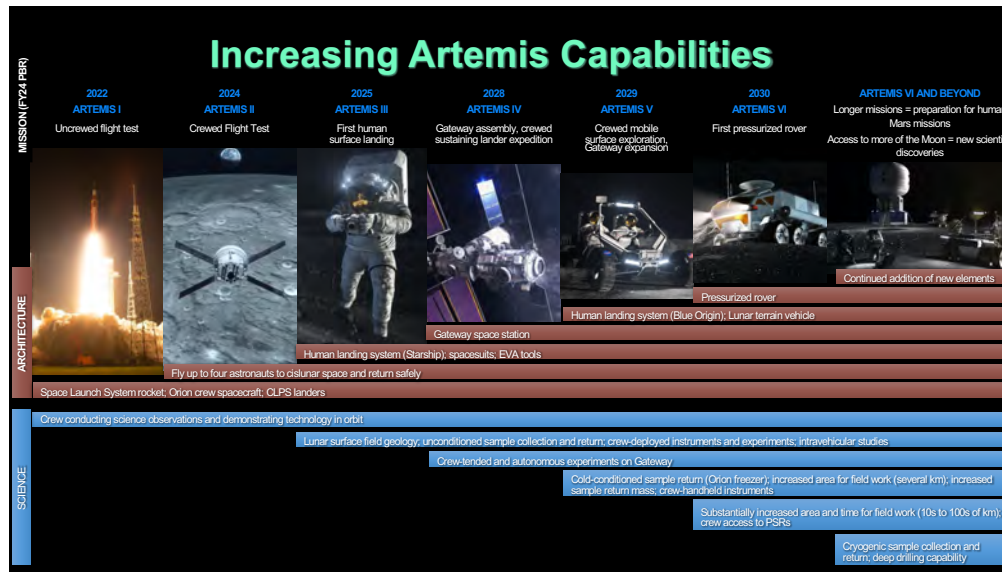
Artemis Technology Objectives

- In-situ resource utilization (ISRU)
- Surface power
- Dust mitigation
- Extreme environment
- Extreme access
- Excavation and construction

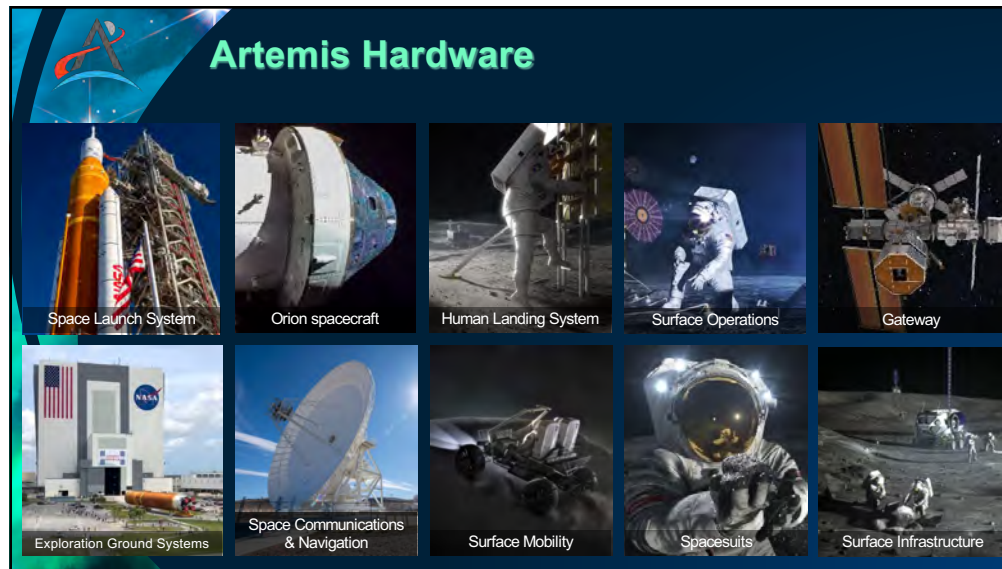


A Honeybee Robotics systems engineer installs The Repolith and Ice Drill for Exploring New Terrain (TRIDENT) on a trolley for thermal vacuum chamber testing.

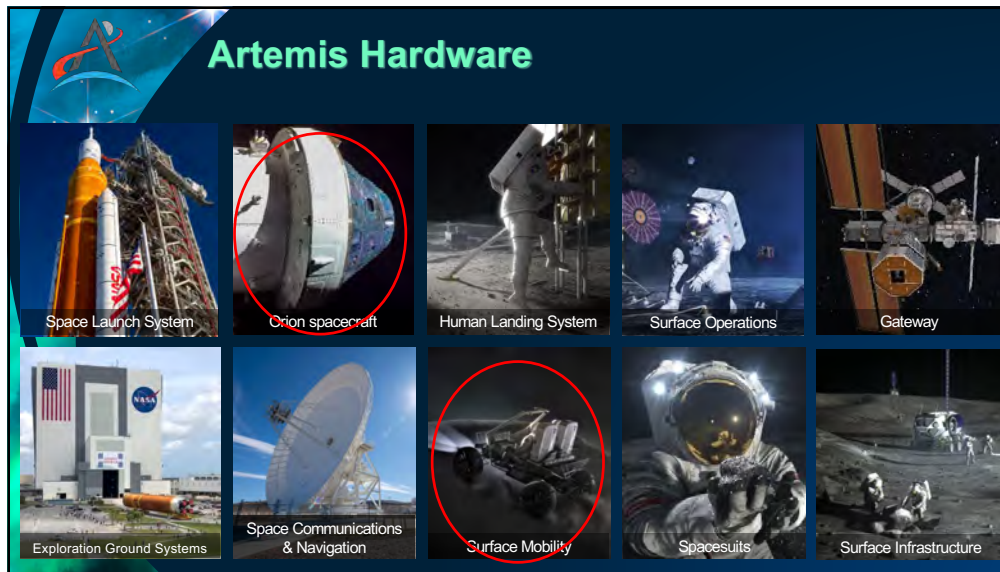
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Space Launch System

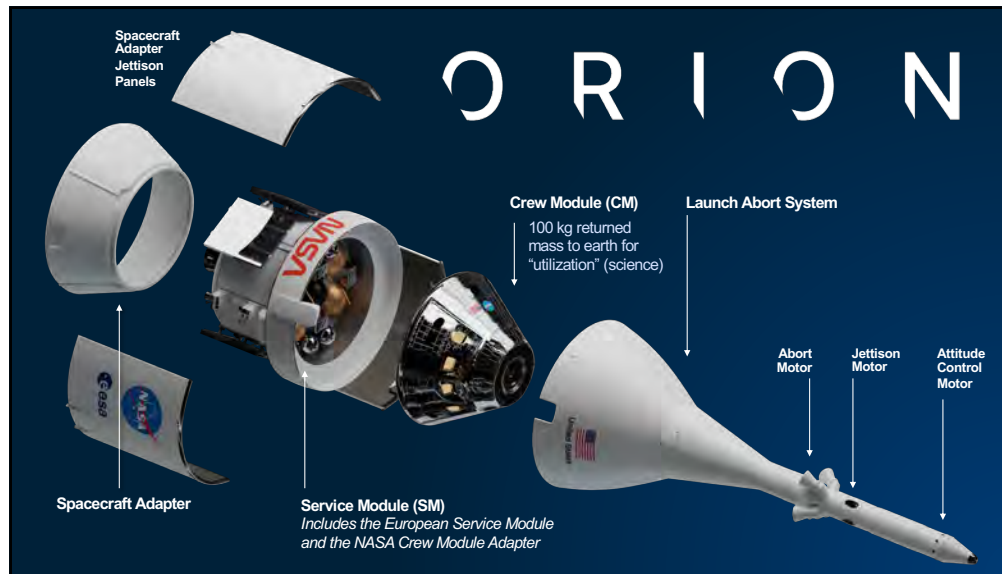
S L S

Core stage: hydrogen and oxygen propellant tanks and the avionics, four RS-25 engines

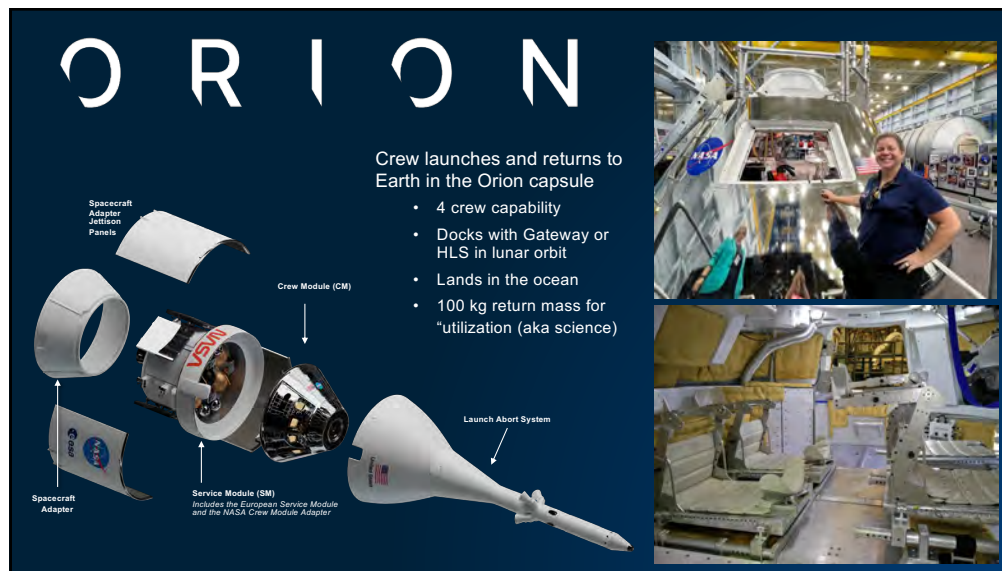
Boosters: Two boosters provide more than 75 percent of the total SLS thrust for two minutes at launch

Upper stage: in-space propulsion with one RL10 engine

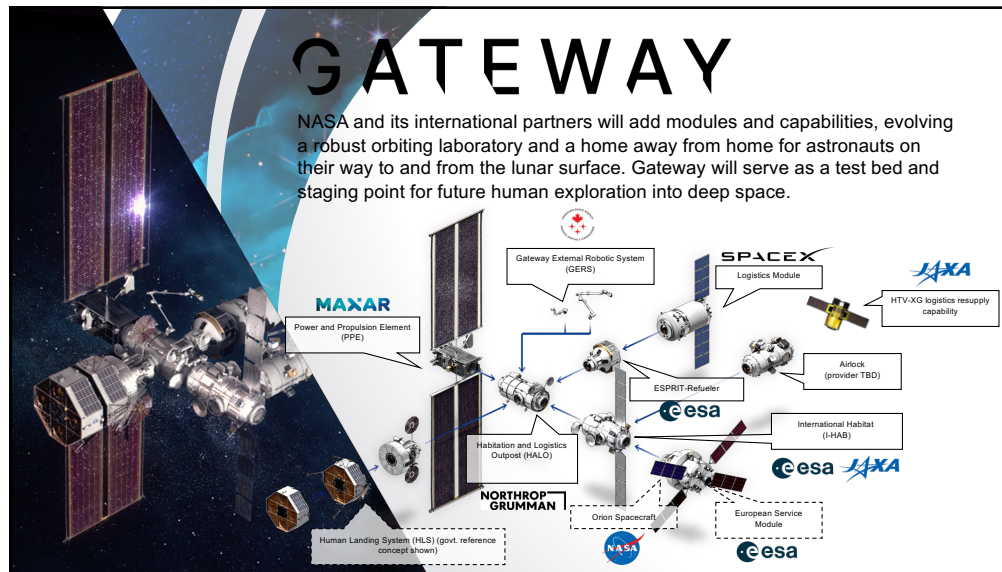
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11

Human Landing System (HLS) STARSHIP

NASA awarded SpaceX contracts to develop its HLS Starship for use on Artemis III and IV. Each contract includes two surface missions.

- SpaceX Uncrewed Lunar Demo-A
- SpaceX Crewed Lunar Demo-A – Artemis III
- SpaceX Crewed Lunar Demo-B – Artemis IV

HLS is a service contract. Contractor provides end-to-end services from development and delivery to the lunar surface to execution of operations.

Image Credit: SpaceX

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Human Landing System (HLS) **BLUE MOON LANDER**

NASA awarded Blue Origin a contract to develop a human landing system built to meet NASA's plans for regularly occurring, long-term access to the lunar surface.

The contract includes one uncrewed demonstration mission and one crewed demonstration mission.

HLS is a service contract. Contractor provides end-to-end services from development and delivery to the lunar surface to execution of operations.



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Lunar Terrain Vehicle **L T V**

Transport a crew of two astronauts on the surface of the Moon

- Traverse from one landing zone to another and increase exploration range beyond the maximum suited walking distance
- Reusable and rechargeable for approximate 10-year service life
- Remote operation from Human Landing System, the Gateway, Earth
- Interface with science instruments and payloads for semi-autonomous operations, including collecting samples and performing analyses with remote operators
- Pre-deployment of assets



LTV is a service contract. Contractor provides end-to-end services from development and delivery to the lunar surface to execution of operations.

Request for Proposal (RFP) was published on May 26; July 10 deadline for LTV proposals.

14

Pressurized Rover



Provides pressurized mobile habitation to enable long-range surface exploration in shirtsleeve environment and access to surface for exploration.

- Habitation for 30 days for 2 crew
- Allows astronauts to explore outside the vehicle in their spacesuits
- Provides volume for spares and logistics
- Power generation and energy storage for lunar environment
- Dust and radiation protection
- Interfaces with instruments and experiments [TBD]
- Reuse for multiple missions of 10-year lifetime
- Capability also identified in current concepts for first human mission to Mars

PR *may* be an international contribution, akin to the international ISS nodes.

15

Artemis Science Payloads

- **PRISM / CLPS** – robotic explorers on the lunar surface
 - Payloads and Research Investigations on the Surface of the Moon (PRISM) – each year
 - Future CLPS capabilities evolution (night survival, sample return, orbiters)
- **Gateway Experiments** – extended views of the Earth, Sun, Moon, and space
 - Heliophysics Environmental and Radiation Measurement Experiment Suite (HERMES; GSFC) - low energy solar particles including the solar wind
 - European Radiation Sensors Array (ERSA; ESA) - radiation at higher energies with a focus on space weather
 - The Internal Dosimeter Array (IDA; ESA / JAXA) - inside the HALO to study of radiation shielding effects and improve radiation physics models
 - *More to be solicited*
- **Deployed Instruments** – autonomous instrument packages installed on the lunar surface by astronauts during EVAs
 - Artemis III call out now!
 - Artemis IV call out in 2024 ROSES
- **Mobility packages** – autonomous instrument packages installed on mobility assets for crew and/or autonomous use
 - LTV – coming soon
 - PR – under development




Alan Bean carrying ALSEP AS12-46-8807

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Artemis Samples

- The primary goal of Artemis EVA science is to explore, document, and gain understanding of the field site. This activity enables real-time confirmation or refutation of hypotheses formed on the ground, which in turn guides science activities such as imaging, sampling, and instrument deployment.
- A **thoughtfully-planned, skillfully-collected, carefully-returned, and meticulously-curated** set of samples from each Artemis mission will be crucial for addressing Decadal-level and Artemis III Science Definition Team (SDT)-prioritized science goals in the lunar south polar region.
- Sample Integrity and Sample Contamination Control / Contamination Knowledge (CC/CK) planning are integral to sample return success.



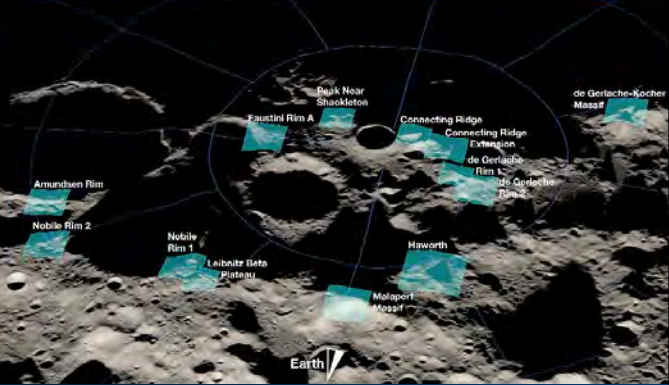
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Artemis Landing Regions

- 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.




Earth

18


18

Artemis Data and Software Systems


Digitizing EVA Procedure Authoring and Execution



Putting Mission Data into Mission Context



Enabling spatiotemporal awareness for EVA Procedure Authoring and Execution




See for More Detail: Miller, M.J., Charney, D., Feist, B., Pittman, C., Rynearson, D., Vu, J., Montalvo, Heinemann, K., Davis, T., Lin, S., Baig, O., (2023) Supporting Exploration Missions by Enabling Exploration Mission System Software, 52nd International Conference on Environmental Systems ICES-2023-242, 16-20 July 2023, Calgary, Canada

- Developing new software systems via the EVA Mission System Software (EMSS) Effort for the Artemis era
 - Near-term: Mission support systems development that unite spatial and temporal data to enable both mission personnel and the broader scientific public
 - Future: Advanced informatics such as spacesuit augmented reality for crewed EVAs
- Software systems development is integrated with the EVA Human and Surface Mobility Program (EHP) testing program
 - Using analog and testing opportunities, like JETT-5 to refine needs and improve software tools to meet science needs
- Artemis Geospatial Data Team was formulated in 2022 and is directly integrated with site selection, mission planning, and EVA development
 - Developing and verifying products, such as hazard maps, as input to the site selection process

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How do I get involved in Artemis?



Read!

- NASA's Moon to Mars Objective, Strategy & Architecture <https://go.nasa.gov/3BUkHGL>
- Artemis III Science Definition Team Report: <https://www.nasa.gov/sites/default/files/atoms/files/artemis-iii-science-definition-report-12042020c.pdf>

Attend!

- Lunar Surface Science Workshops (LSSW), LEAG meetings
- Artemis Town Halls, updates, and Q&A at meetings like the NESF, LPSC, AGU

Propose!

- Artemis-specific science and instrument calls
- Basic research, instrument development, and flight programs

Volunteer!

- Review panels, AG membership and Special Action Teams (SATs)

Interact!

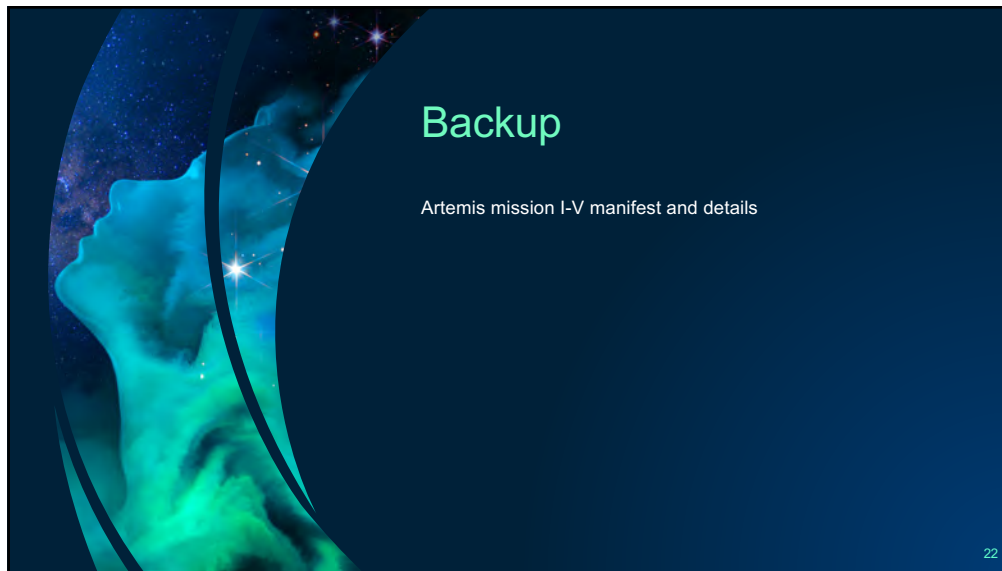
- International Observe the Moon Night, eclipse opportunities

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Artemis I

MISSION COMPLETE:

The Artemis I mission launched on November 16, 2022, and the Orion spacecraft successfully splashed down on December 11, 2022.

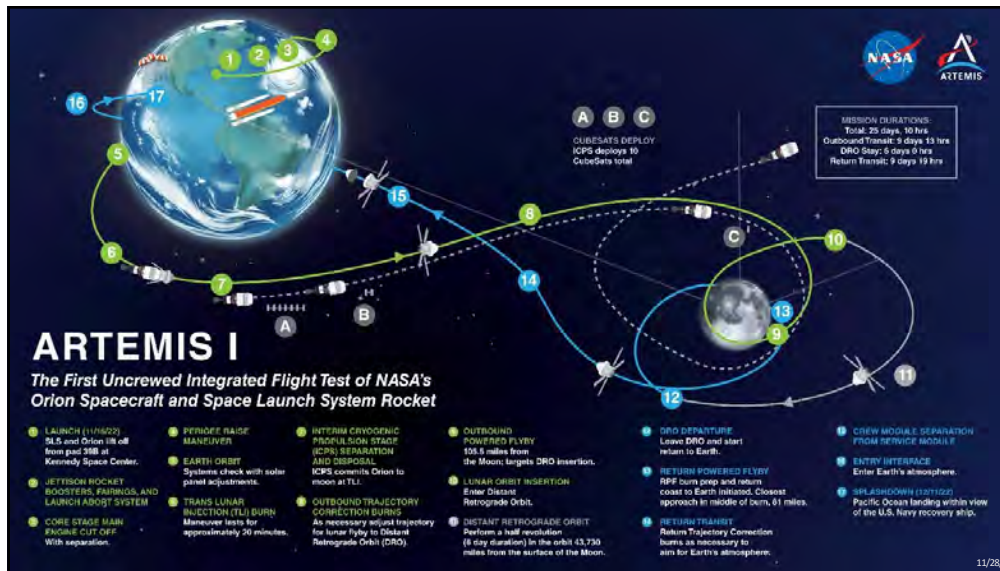
ARTEMIS FIRSTS:

- Integrated uncrewed flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at Kennedy Space Center
- Demonstration of Orion heatshield at lunar re-entry conditions
- Science activities via payloads in Orion and CubeSats deployed from SLS

NEW ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems

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ARTEMIS I

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

- 1 LAUNCH (11:00Z) SLS and Orion lift off from pad 39B at Kennedy Space Center.
- 2 JEFFERSON ROCKET BOOSTERS, FAIRINGS, AND LAUNCH ASSIST SYSTEM
- 3 CORE STAGE MAIN ENGINE CUT OFF. With separation.
- 4 PERIPHERY RAISE MANEUVER
- 5 EARTH ORBIT Systems check with solar panel adjustments.
- 6 TRANS LUNAR INJECTION (TLI) BURN Maneuver lasts for approximately 30 minutes.
- 7 INTERIM CRYOGENIC PRODUCTION STAGE (ICPS) SEPARATION AND DISPOSAL ICPS commits Orion to moon at TLI.
- 8 OUTBOUND TRAJECTORY CORRECTION BURNS An necessary mid-course trajectory for lunar flyby to Distant Retrograde Orbit (DRO).
- 9 OUTBOUND POWERED FLYBY 105.5 miles from the Moon; targets DRO insertion.
- 10 LUNAR ORBIT INSERTION Enter Distant Retrograde Orbit.
- 11 DISTANT RETROGRADE ORBIT Perform a half revolution (8 day duration) in the orbit 63,730 miles from the surface of the Moon.
- 12 DRO DEPARTURE Leave DRO and start return to Earth.
- 13 RETURN POWERED FLYBY RPF burn prep and return coast to Earth initiated. Closest approach in middle of burn, 61 miles.
- 14 RETURN TRAJECTORY Correction burns as necessary to aim for Earth's atmosphere.
- 15 CREW MODULE SEPARATION FROM SERVICE MODULE
- 16 ENTRY INTERFERENCE Enter Earth's atmosphere.
- 17 SPLASHDOWN (13:01:02Z) Pacific Ocean landing within view of the U.S. Navy recovery ship.

11/28/22

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Artemis II

NASA ARTEMIS

ARTEMIS FIRSTS:

- Crewed integrated flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at Kennedy Space Center
- Demonstration of Orion life support systems
- Human data collection in transit to and from the Moon, in lunar orbit, and through reentry and splashdown

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 and upgraded ground systems
- Conducting science and demonstrating technology in orbit

Artist's Concept

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ARTEMIS II

First Crewed Test Flight to the Moon Since Apollo

NASA ARTEMIS

- LAUNCH: Astronauts lift off from pad 39B at Kennedy Space Center.
- PERIGEE RAISE MANEUVER: ARTEMIS RAISE BURN TO HIGH EARTH ORBIT: Begin 33.5 hour checkout of spacecraft.
- ORION SEPARATION FROM INTERIM PROPELLION STAGE (ICPS) FOLLOWED BY PROX OPS DEMO: Post-main-test handling, facilities assessments for up to 2 hours.
- ORION UPPER STAGE SEPARATION TEST BURN: Begins high Earth orbit checkout. Life support, avionics, and habitation equipment evaluations.
- PERIGEE RAISE BURN: TRANS-LUNAR INJECTION (TLI) BY ORION'S MAIN ENGINE: Lunar free return trajectory initiated with European service module.
- OUTBOUND TRANSIT TO MOON: Outbound Trajectory Correction (OTC) burns as necessary for lunar free return trajectory; travel time approximately 4 days.
- LUNAR FLYBY: 6,679 miles / 10,727 km (mean) lunar far-side altitude.
- TRANS-EARTH RETURN: Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere; travel time approximately 4 days.
- CREW MODULE SEPARATION FROM SERVICE MODULE: ENTRY INTERFACE (EI): Enter Earth's atmosphere.
- SPLASHDOWN: Ship recovers astronauts and capsule.
- ICPS Earth disposal
- PROX OPS Demonstration

PROXOPS OPERATIONS DEMONSTRATION REQUIREMENTS

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
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| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

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Artist's Concept

Artemis III



ARTEMIS FIRSTS:

- Human landing in South Pole region
- 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

NEW ELEMENTS:

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

COMMON ELEMENTS:


- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems
- Conducting science and demonstrating technology in orbit and on the surface

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Artemis III: Starship HLS Fueling and Pre-staging



MISSION SUMMARY:
In preparation for the launch of the Artemis III crew aboard Orion on SLS, SpaceX will fuel their Starship Human Landing System (HLS) in low-Earth orbit and send it to the selected Near Rectilinear Halo Orbit (NRHO).

ARTEMIS FIRSTS:

- Fueling of a commercially owned and designed lunar lander in low-Earth orbit
- Lunar lander pre-staged for crew in NRHO


NEW ELEMENTS:

- SpaceX Starship human landing system
- SpaceX Starship fuel depot
- SpaceX Starship tanker

Artist's Concept

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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

NEW ELEMENTS:

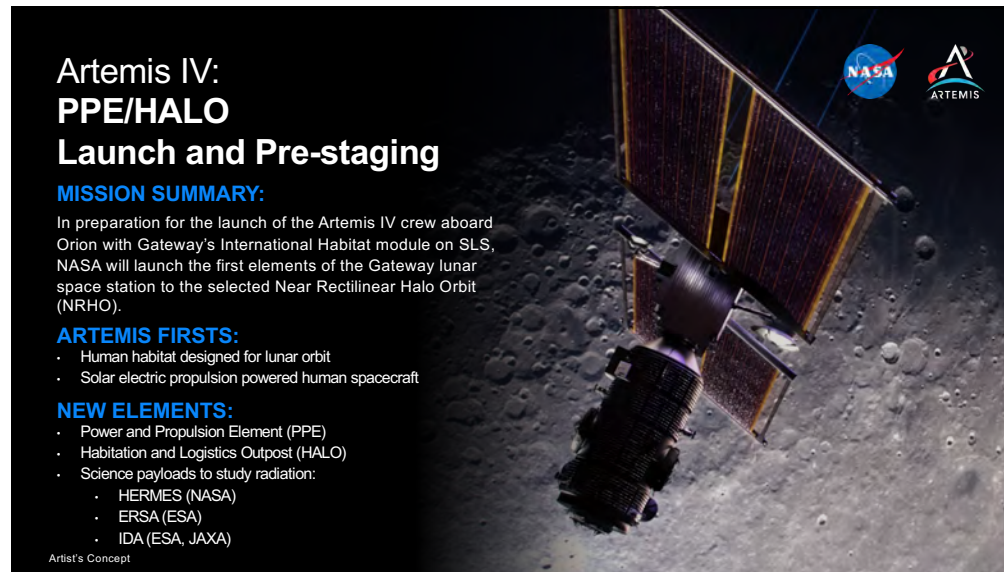
- Space Launch System rocket Block 1B configuration Mobile Launcher 2 with supporting ground systems
- SpaceX Sustaining Starship HLS
- Gateway modules: Power and Propulsion Element and Habitation and Logistics Outpost (pre-staged in orbit); International Habitat (launched on SLS Block 1B alongside the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

COMMON ELEMENTS:

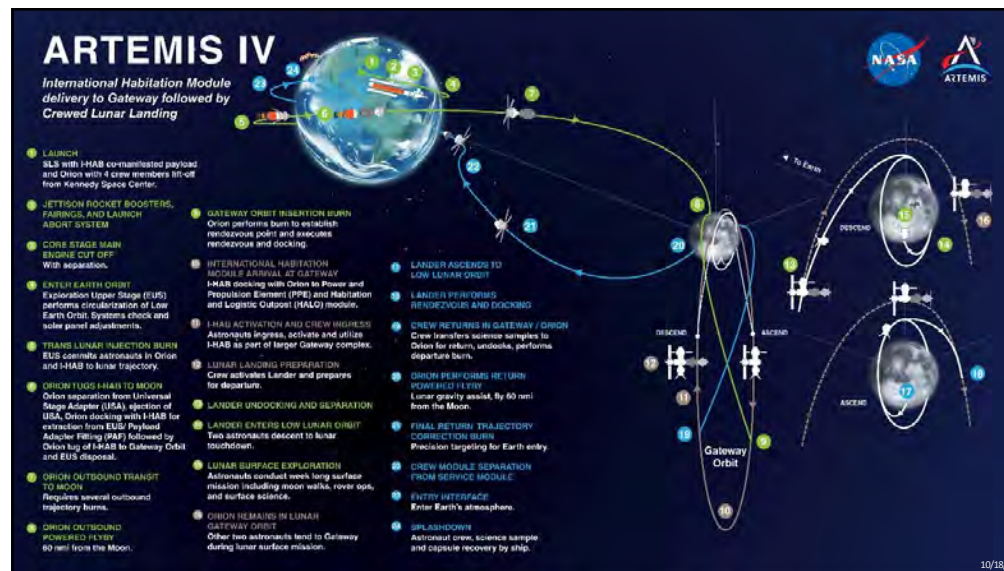
- Common SLS elements
- Orion crew spacecraft
- Spacesuits and support systems
- Conducting science and demonstrating technology in orbit and on the surface

Artist's Concept


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Artist's Concept

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

NEW ELEMENTS:

- Blue Moon human landing system
- LTV unpressurized rover with scientific instruments
- Gateway modules: ESPRIT (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
- Gateway space station and Deep Space Logistics
- Conducting science and demonstrating technology in orbit and on the surface

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Artist's Concept

Artemis V: Blue Moon HLS Fueling and Pre-staging




MISSION SUMMARY:

In preparation for the launch of the Artemis V crew aboard Orion on SLS, Blue Origin will launch its Blue Moon Human Landing System (HLS) and fuel it in the selected Near Rectilinear Halo Orbit (NRHO).

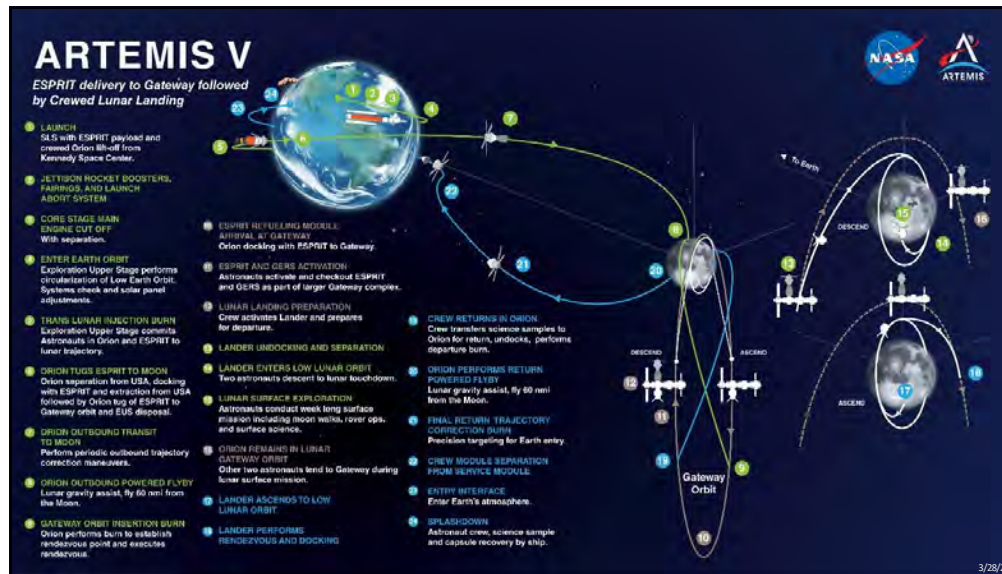
ARTEMIS FIRSTS:

- Crewed demonstration of the Blue Moon lander
- Lunar lander fueled in NRHO for a crewed mission

NEW ELEMENTS:

- Blue Moon lander
- Cislunar transporter

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Artemis VI

Artist's Concept

ARTEMIS FIRSTS:

- Gateway assembly complete

NEW ELEMENTS:

- Human landing system via services contract
- Gateway module: airlock

COMMON ELEMENTS:

- Space Launch System rocket Block 1B configuration
- Orion crew spacecraft
- Mobile Launcher 2 with supporting ground systems
- Spacesuits and support systems
- Gateway space station and Deep Space Logistics
- Lunar Terrain Vehicle (LTV)
- Conducting science and demonstrating technology in orbit and on the surface

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Artist's Concept

Artemis VII



ARTEMIS FIRSTS:

- Use of a pressurized rover by crew to access more of the lunar surface and collect diverse scientific samples

NEW ELEMENTS:

- Pressurized rover

COMMON ELEMENTS:

- Space Launch System rocket Block 1B configuration
- Orion crew spacecraft
- Mobile Launcher 2 with supporting ground systems
- Spacesuits and support systems
- Gateway space station and Deep Space Logistics
- Lunar Terrain Vehicle (LTV)
- Conducting science and demonstrating technology in orbit and on the surface