National Aeronautics and Space Administration

NASA Advisory Council

HEO/Science Committees Joint Public Meeting

Kathryn Lueders
Associate Administrator
Human Exploration and Operations Mission Directorate

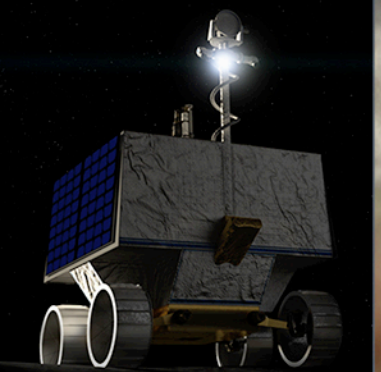
January 14, 2021

Updates

- ARTEMIS I launch scheduled for this year
- Space Launch System (SLS) Hot Fire – final test cued up
- Mobile Launcher-2 (ML-2) – Exploration Ground Systems working closely with SLS program on ML-2/Exploration Upper Stage (EUS) integration
- EUS plus associated capabilities; development well underway
- Docking capabilities for Orion; more complex flights for future Artemis missions

NEAR TERM EXPLORATION PLANS

COMMERCIAL LUNAR PAYLOAD SERVICES
Small Payload Deliveries to the Moon



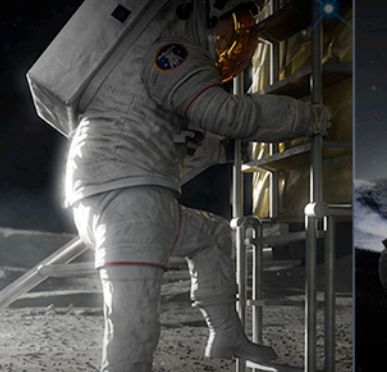
ARTEMIS I
Space Launch System (SLS)/Orion Uncrewed Test Flight

ARTEMIS II
Crewed Mission to Lunar Orbit Aboard SLS/Orion

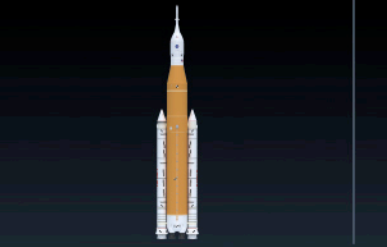
GATEWAY:
Power Propulsion Element/Habitation & Logistics Outpost
First Gateway Elements Integrated for Launch; Science Operations Begin

INITIAL HUMAN LANDING SYSTEM
Delivered to Lunar Orbit

ARTEMIS III
Crewed Mission to the Lunar Surface



SURFACE MOBILITY
Lunar Terrain Vehicle to the Lunar Surface



Conducting science missions on Mars in preparation for human exploration

ARTEMIS FIRSTS

2021

First CLPS Mission

In 2021, the first Commercial Lunar Payload Services deliveries will begin with two companies delivering 16 instruments to the lunar surface that will pave the way for human explorers.

VIPER

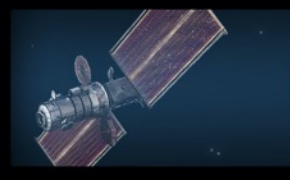
This golf-cart-sized rover will be the first to investigate lunar polar soil samples to characterize the distribution and concentrations of volatiles, including water, across a large region on the Moon.

CAPSTONE CubeSat

This small satellite will be the first spacecraft to enter the lunar Near Rectilinear Halo Orbit—the future home of the Gateway. There it will test new navigation techniques to validate predictive models, reducing uncertainties about the orbit.

Artemis I

The uncrewed, maiden flight of the integrated Space Launch System rocket and Orion spacecraft will verify spacecraft performance and test Orion's heat shield during its high-speed Earth reentry at nearly 5,000 degrees Fahrenheit.



PPE & HALO Launch

The Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO) are the first pieces of the Gateway. On-board science investigations from NASA and the European Space Agency will conduct early characterization of the deep space environment.

Artemis II

On this 10-day crewed test flight, NASA astronauts will set the record for the farthest human travel from Earth. They will validate deep space communication and navigation systems and ensure that life support systems keep them healthy and safe.

2024

Artemis III

With confidence gained through Artemis I and Artemis II, Orion and its crew will once again travel to the Moon, this time boarding the Human Landing System that will bring the first woman and next man to the lunar surface.

SLS Status


SLS Core Stage on the B-2 Test Stand at NASA Stennis

ARTEMIS I

✓	**JAN 2020**	Core Stage 1 delivered to Stennis Space Center
✓	**JUN 2020**	Booster motor segment processing complete, shipped to Kennedy Space Center
✓	**AUG 2020**	Launch Vehicle Stage Adapter complete, delivered to Exploration Ground Systems
✓	**OCT 2020**	Green Run Simulation Launch Countdown (TC #6) Complete
✓	**NOV 2020**	Artemis I booster stacking begins at Vehicle Assembly Building
✓	**DEC 2020**	Wet Dress Rehearsal Test (TC #7) complete
	JAN 2021	Green Run Hot Fire Test (TC #8) complete
	FEB 2021	Core Stage 1 ship to Kennedy Space Center

ARTEMIS II: Space Launch System (SLS) solid motor segments completed and stored in Promontory, UT; Interim Cryogenic Propulsion Stage 2 manufacturing in work; RS-25 engines complete; RL-10 engine complete; Core Stage 2 manufacturing in work

ARTEMIS III and beyond: Core Stage 3 manufacturing in work; Artemis III Launch Vehicle Stage Adaptor and Orion Stage Adapter manufacturing in work; Exploration Upper Stage Critical Design Review complete; Flight Set 1 Hot Fire Test complete

Orion Status


Orion Adapter installation for Artemis I underway

ARTEMIS I

✓	**MAR 2020**	Artemis I Spacecraft Environmental Testing complete
✓	**AUG 2020**	Crew and Service Module testing complete
✓	**AUG 2020**	Spacecraft Adapter Install
✓	**NOV 2020**	Solar Array Wings/Solar Adapter Jettison Fairing Install
✓	**NOV 2020**	Forward Bay Cover/Final Installs
	JAN 2021	Orion delivery to Exploration Ground Systems
	FEB 2021	Start of Orion fueling operations by Exploration Ground Systems

ARTEMIS II: Launch Abort System Motors shipped to Kennedy Space Center; Artemis II Crew Module and heat shield in work at Kennedy Space Center; European Service Module II in work in Bremen, Germany; Orion astronaut training simulator shipped to Johnson Space Center

ARTEMIS III and beyond: Artemis III Orion Crew Module manufacturing underway at Michoud Assembly Facility; Artemis III European Service Module in work in Bremen, Germany

Exploration Ground Systems Status

SLS rocket booster stacking on the Mobile Launcher underway in the VAB

ARTEMIS I

✓	**MAR 2020**	Underway Recovery Test 8 Complete
✓	**SEP 2020**	Terminal Countdown Simulation
✓	**SEP 2020**	Booster Stacking Demo complete
✓	**OCT 2020**	Mobile launcher rollout to Pad 39B
✓	**NOV 2020**	Cryogenic Loading Simulation Countdown
	JAN 2021	Orion delivery to Exploration Ground Systems
	FEB 2021	Core Stage delivery to Exploration Ground Systems

ARTEMIS II & III: Crew Emergency Egress System in work; 1.4Mgal LH2 Sphere in work; VAB Environmental Control System upgrade in work

ARTEMIS IV and beyond: Mobile Launcher 2 design in work

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

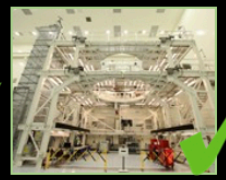

SERVICE MODULE PROPULSION TESTING


ROTATION PROCESSING & SURGE FACILITY ACCEPTANCE AND READINESS


MOBILE LAUNCHER CONTRUCTION


HEAT SHIELD INSTALL ON CREW MODULE


VAB HIGH BAY 3 CONSTRUCTION

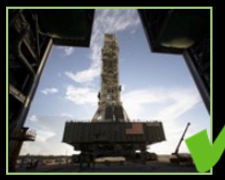

MPPF 1ST HAZARDOUS OPERATIONS

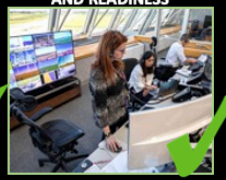

EUROPEAN SERVICE MODULE SHIPPED TO KSC


SLS BOOSTER QUAL TESTING

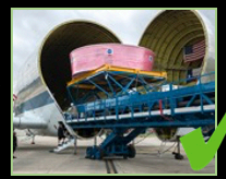

C3 READY FOR HAZARDOUS OPERATIONS


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

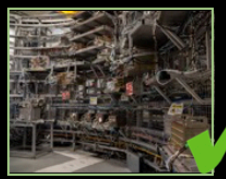

ORION ENVIRONMENTAL TESTING

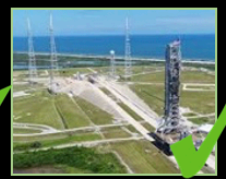

SLS STRUCTURAL TESTING


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

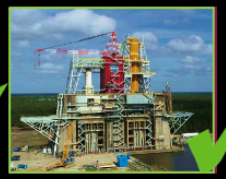

GREEN RUN TESTING BEGINS


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

START OF BOOSTER STACKING ON MOBILE LAUNCHER

HANDOVER OF CREW & SERVICE MODULE TO EXPLORATION GROUND SYSTEMS

GREEN RUN HOT FIRE

LAUNCH VEHICLE STAGE ADAPTER/ INTERIM CRYOGENIC PROPULSION STAGE INTEGRATION

CORE STAGE INTEGRATION

SLS/ORION INTEGRATION WITH LAUNCH VEHICLE

UNDERWAY RECOVERY TEST END-TO-END REHEARSAL

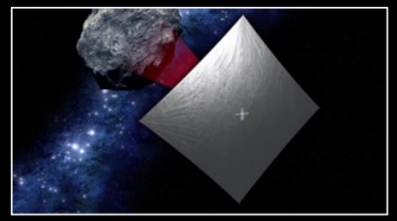
VEHICLE MODAL TESTING

ROLL OUT FOR LAUNCH

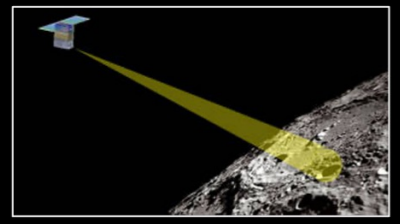
ARTEMIS I Secondary Payloads

Science and technology investigations and demonstrations paving the way for future, deep space human exploration

ArgoMoon
Developer: Argotec
Sponsor: Agenzia Spaziale Italiana (ASI)
Destination: Geocentric orbit with high eccentricity and apogee close to the Moon
Mission: Photograph the ICPS, CubeSat deployment, the Earth and Moon using HD cameras and advanced imaging software.

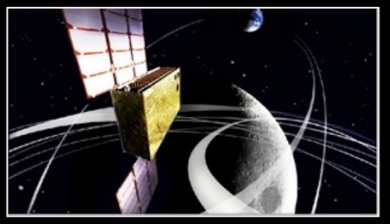


Near-Earth Asteroid Scout (NEA Scout)
Developer: NASA MSFC
Sponsor: NASA AES
Destination: Near-Earth asteroid (within ~1 AU of Earth)
Mission: Detect target NEA, perform reconnaissance and close proximity imaging.

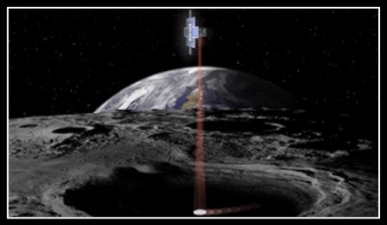


LunIR
Developer: Lockheed Martin Space Systems
Sponsor: NASA NextSTEP
Destination: Heliocentric orbit via lunar flyby
Mission: Use a miniature high-temperature Mid-Wave Infrared (MWIR) sensor to characterize the lunar surface.

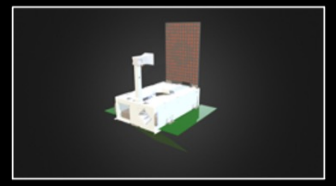
LunaH-Map
Developer: Arizona State University
Sponsor: NASA SMD
Destination: Lunar orbit
Mission: Perform neutron spectroscopy to characterize abundance of hydrogen in permanently shaded craters.



EQUULEUS
Developer: University of Tokyo
Sponsor: JAXA
Destination: Earth-Moon L2 point
Mission: Demonstrate trajectory control techniques within the Sun-Earth-Moon region and image Earth's plasmasphere.

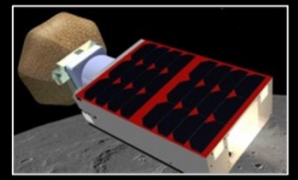


Lunar Flashlight
Developer: NASA JPL
Sponsor: NASA AES
Destination: Lunar orbit
Mission: Search for ice deposits using near-infrared band lasers.

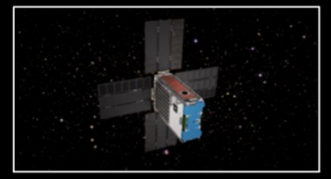


University of Colorado-Earth Escape Explorer (CU-E3)
Developer: University of Colorado Boulder
Sponsor: NASA Cube Quest Challenge
Destination: Deep space
Mission: Demonstrate use of solar radiation pressure for propulsion; compete in NASA's Deep Space Derby.

Team Miles
Developer: Miles Space, LLC
Sponsor: NASA Cube Quest Challenge
Destination: Deep space
Mission: Demonstrate propulsion using plasma thrusters; compete in NASA's Deep Space Derby.

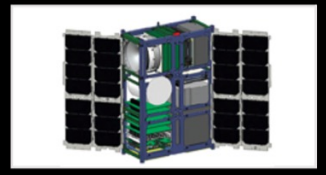


OMOTENASHI
Developer: Institute of Space and Astronautical Science (ISAS)/JAXA
Sponsor: JAXA
Destination: Lunar surface
Mission: Develop world's smallest lunar lander and observe lunar radiation environment.

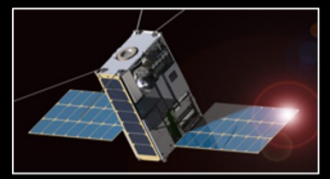


Biosentinel
Developers: NASA Ames, NASA Johnson, Loma Linda University Medical Center, University of Saskatchewan
Sponsor: NASA AES
Destination: Heliocentric orbit via lunar flyby
Mission: Use yeast as a biosensor to evaluate the effects of ambient space radiation on DNA.

Cislunar Explorers
Developers: Cornell University
Sponsor: NASA STMD
Destination: Lunar orbit
Mission: Demonstrate use of an inert water-based propulsion system for lunar gravity assists and capture in lunar orbit; compete in NASA's Deep Space Derby.



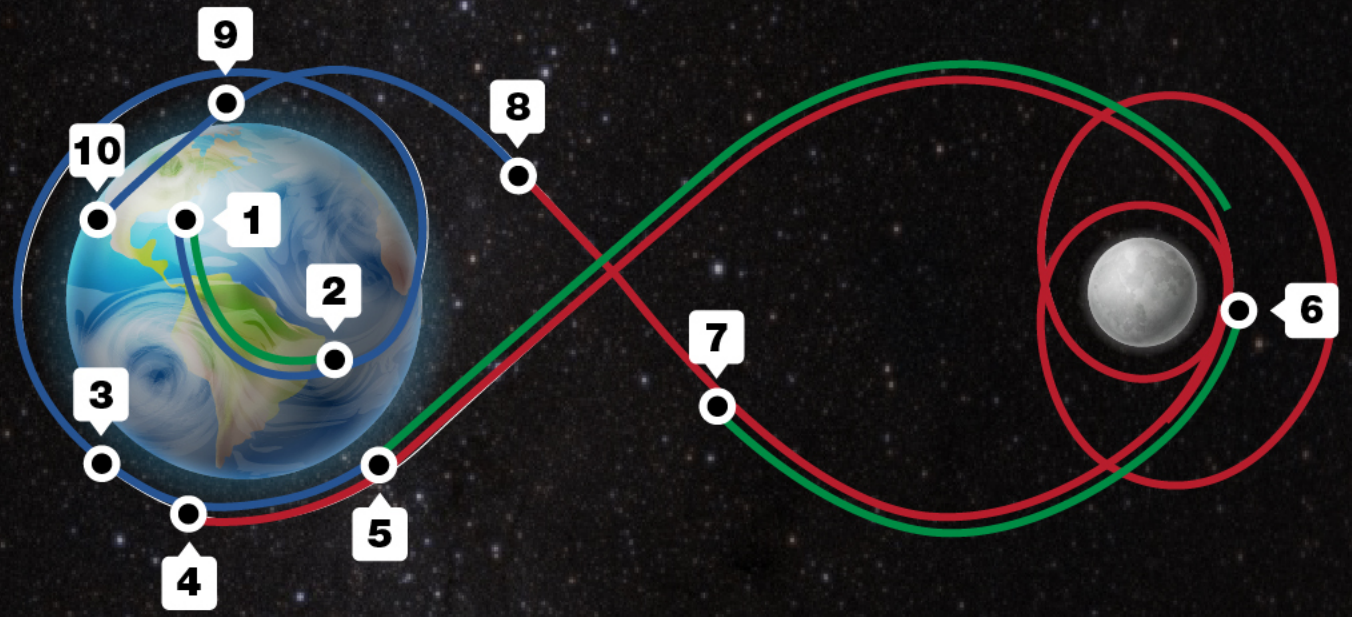
CubeSat to Study Solar Particles (CuSP)
Developers: Southwest Research Institute, NASA Goddard
Sponsor: NASA SMD
Destination: Deep space
Mission: Measure incoming radiation that can create a wide variety of effects on Earth.



Lunar IceCube
Developers: Morehead State University, NASA JPL, NASA Goddard, BUSEK
Sponsor: NASA NextSTEP
Destination: Lunar orbit
Mission: Search for water (and other volatiles) in ice, liquid and vapor states using infrared spectrometer.

ARTEMIS I

SPACE COMMUNICATIONS & NAVIGATION MILESTONES



NSN DTE / NSN TDRS 1 Launch

Both the Launch Communications Segment and the Space Network's constellation of Tracking and Data Relay Satellites will maintain communication between the Space Launch System and Orion.

NSN TDRS 2 Low-Earth Orbit

In low-Earth orbit, NASA's Near Space Network TDRS will maintain continuous communications with Orion and the Interim Cryogenic Propulsion Stage (ICPS), which will accelerate Orion fast enough to overcome the pull of Earth's gravity and set it on a precise trajectory to the Moon.

NSN TDRS 3 ICPS Separation

Once Orion no longer needs the ICPS, the Near Space Network will monitor telemetry from the ICPS until it is out of range. The ICPS will continue towards the Moon on a heliocentric trajectory, deploying small satellites that provide additional science in translunar orbit.

NSN TDRS / DSN 4 Handover to DSN

As Orion prepares to leave the area of near-Earth space covered by the Near Space Network, network engineers will pass communications services to the Deep Space Network.

DSN / NSN DTE 5 Journey to the Moon

En route to the Moon, the Deep Space Network will be the primary method of communication with Earth, with Near Space Network ground stations providing supplementary tracking and navigation data.

DSN 6 Distant Retrograde Orbit

When Orion arrives at the Moon, it will enter a distant retrograde orbit, a highly stable orbit in which Orion travels opposite the direction the Moon travels around Earth. There, NASA will continue to test and demonstrate Orion's capabilities.

DSN / NSN DTE 7 Return Transit

Returning from the Moon, the Deep Space Network will be the primary method of communication with Earth, with Near Space Network ground stations providing supplementary tracking and navigation data.

DSN / NSN TDRS 8 Return Trajectory Correction Burn

During the final engine burn that places Orion on target to safely enter Earth's atmosphere, the Near Space Network will join the Deep Space Network, ultimately taking over communications for the remainder of the mission.

NSN TDRS 9 Re-entry

During re-entry, the enormous heat generated as Orion encounters the atmosphere turns the air surrounding the capsule into plasma. Until it dissipates, this can disrupt communications with the spacecraft.

NSN TDRS 10 Splashdown and Recovery

The Near Space Network maintains communications through the unfurling of parachutes, splashdown in the Pacific Ocean, and recovery of the capsule by military and NASA professionals.

NSN NEAR SPACE NETWORK — NSN DTE — NSN TDRS — **DSN** DEEP SPACE NETWORK

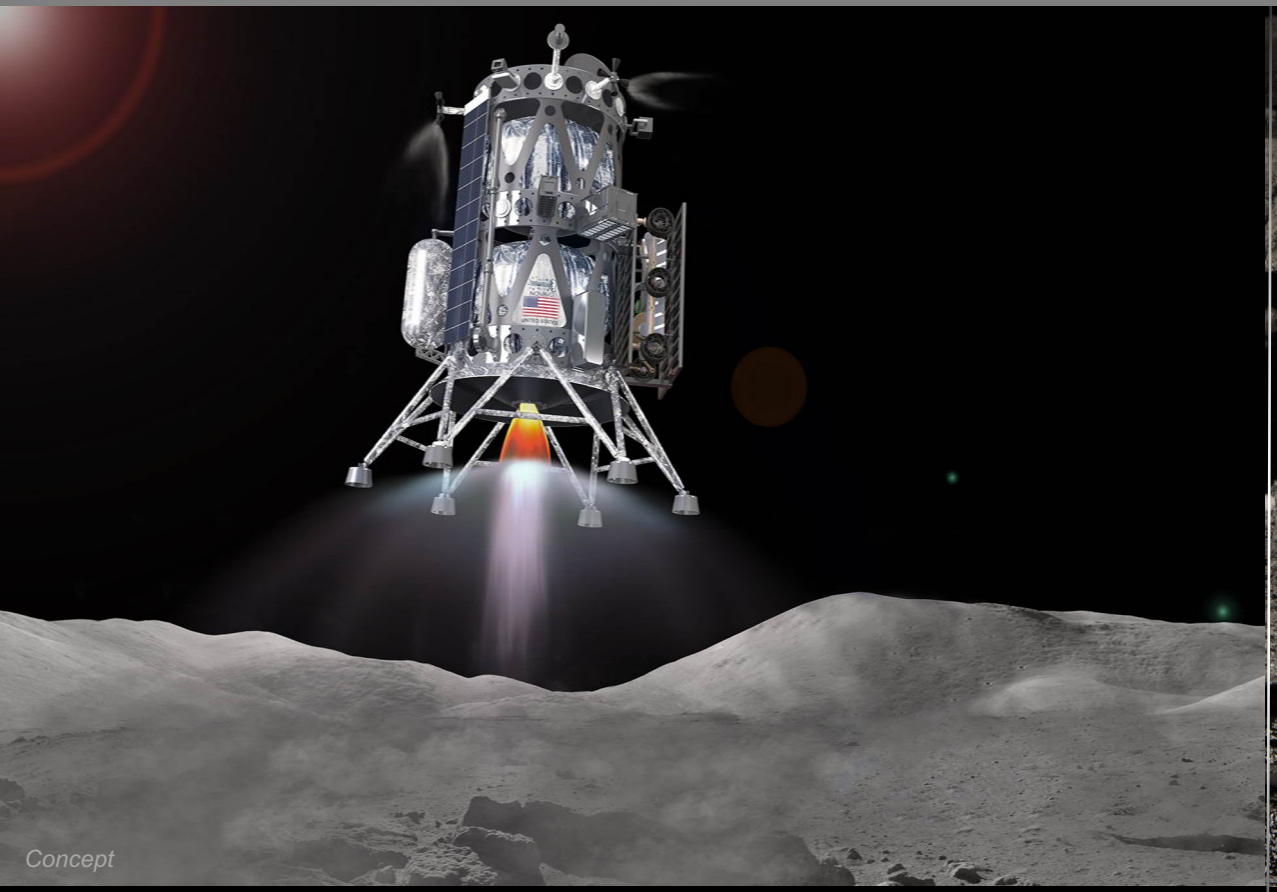
Gateway Status

AUG 2019	✓	Gateway External Robotic Interfaces contract awarded by Canadian Space Agency (CSA) to MDA
MAR 2020	✓	Gateway Logistics Services contract awarded to SpaceX
	✓	First two Gateway science payloads selected
JUN 2020	✓	Habitation and Logistics Outpost (HALO) contract awarded to Northrop Grumman
SEP 2020	✓	I-HAB contract awarded by European Space Agency (ESA) to Thales Alenia Space (Italy)
OCT 2020	✓	HALO Preliminary Design Review (PDR) Kick-Off
	✓	Memorandum of Understanding (MOU) with ESA signed
NOV 2020	✓	Maxar-led Power and Propulsion Element (PPE) Delta System Requirements and System Definition Reviews initiated to ensure requirement alignment for PDR
	✓	MOU with CSA signed
DEC 2020	✓	ESPRIT contract awarded by ESA to Thales Alenia Space (France)
	✓	Canadarm3 contract awarded by CSA to MDA
	✓	MOU with JAXA signed
MAR 2021		HALO PDR Close-Out
		Gateway Sync Review

NASA REFERENCE DESIGN

NASA Science and Technology Payloads on the Lunar Surface in 2021

NASA has finalized the first 16 science experiments and technology demonstrations to be delivered to the surface of the Moon with the agency's Commercial Lunar Payload Services (CLPS) initiative



Intuitive Machines will launch the Nova-C lander on a SpaceX Falcon 9 rocket and will carry 5 payloads

Astrobotic will launch the Peregrine lander on a ULA Vulcan Centaur rocket and will carry 11 payloads

2021 HEOMD Milestones

Quarter 1	Quarter 2	Quarter 3	Quarter 4
• Land SpaceX CRS-21 • Handover Orion to EGS for processing • Launch Boeing OFT-2 • Launch SpaceX Crew-2 (date under review) • Launch Northrop Grumman (NG) CRS-15 • Ship Artemis I Core Stage to KSC • Launch Laser Communications Relay Demonstration • Select companies developing Artemis III human lander(s)	• Commercial LEO Development Program announcement • Artemis II ESM delivered to NASA • Launch Soyuz 64S • Land Soyuz 63S • Launch/land SpaceX CRS-22 • Launch Boeing CFT • Land Boeing OFT-2 • Land SpaceX Crew-1	• Launch Dart • Launch Landsat-9 • Astrobotic Peregrine launch; 1st CLPS flight & lunar landing • Launch NG CRS-16 • Launch Soyuz 65S • Launch SpaceX Crew-3 (date under review) • Land SpaceX Crew-2	• Intuitive Machines Nova-C launch; 1st CLPS flight & lunar landing • Artemis I launch (~3-week mission) through Orion splashdown • Starliner-1 (date under review) • NASA announces new class of astronaut candidates • Launch Lucy • Launch IXPE • Launch GOES-T • 2 Science mission launches with LSP in Advisory Role (JWST & NiSAR)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