

The Agency requires the unique capabilities of the Space Launch System (SLS) vehicles to make possible a new era of human exploration of the Moon, as well as the ability to send more capable robotic probes deep into the solar system. A new deep space exploration system, comprised of the SLS rocket, the Orion crew spacecraft and the Exploration Ground Systems (EGS) Program at Kennedy Space Center (KSC), will provide the United States with a capability to send both astronauts and large cargo payloads to lunar orbit. As the Agency’s deep space exploration plans mature – human exploration of the Red Planet remains a horizon goal – SLS is designed to evolve into increasingly more powerful and capable variants. Its design will support a variety of missions to a variety of destinations and provide benefits commercial vehicles cannot.

1B vehicle. The ability of SLS to launch co-manifested (and possibly secondary) payloads along with the Orion crew capsule will maximize use of launch resources.

2. SPACE LAUNCH SYSTEM OVERVIEW

SLS will provide the United States with assured access to deep space while lifting more mass and volume with greater energy to make new exploration missions possible. Three block variants – Blocks 1, 1B and 2 – are currently planned, each progressively more powerful in terms of payload mass to TLI (see Figure 2). Each block variant will be available in crew and cargo configurations, with larger fairings providing more volume for robust payloads, whether habitats, landers or other infrastructure.

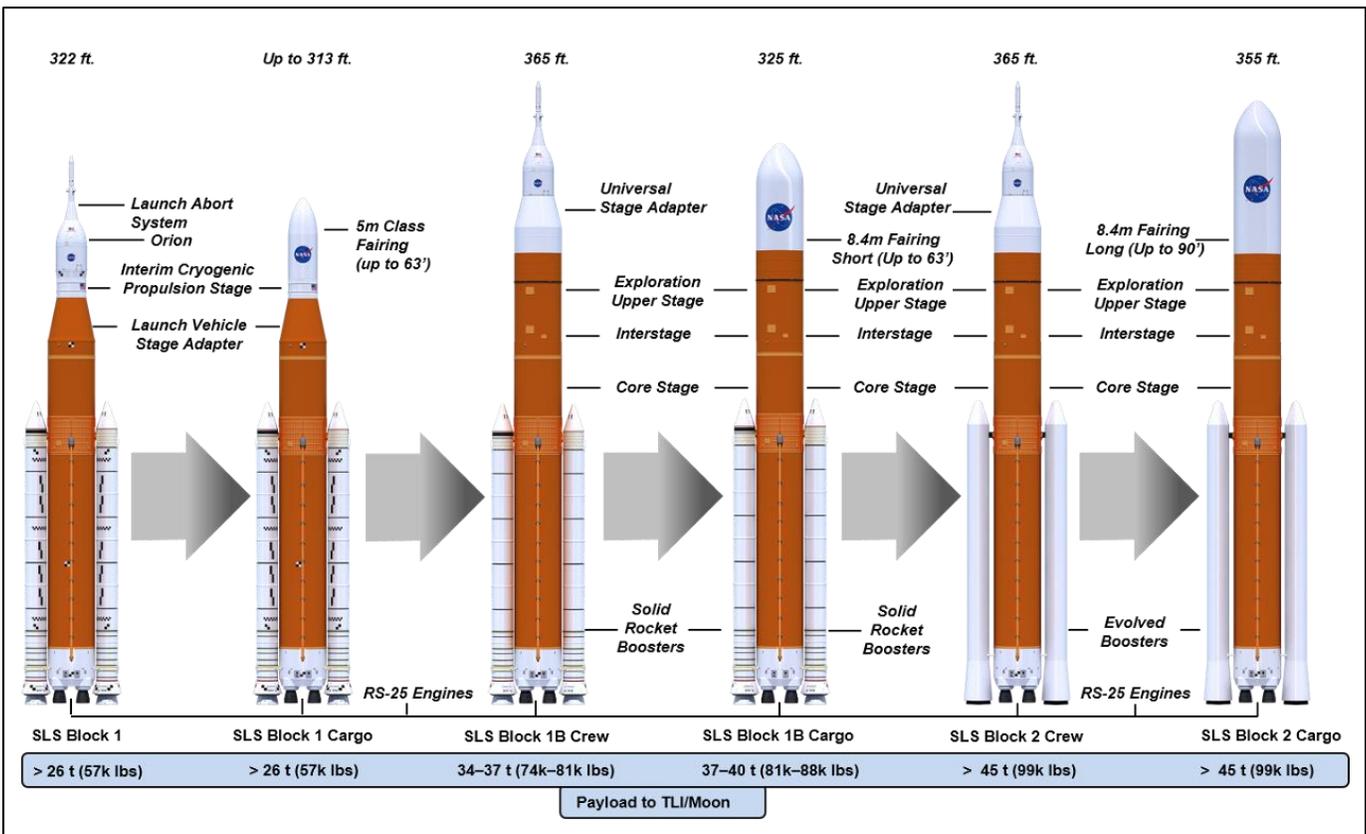


Figure 2. The SLS series of progressively more powerful launch vehicles

NASA plans to spur lunar exploration with construction of an orbiting outpost, known as the Gateway, in a Near-Rectilinear Halo Orbit (NRHO) [2]. Plans are still maturing, but the Gateway is expected to provide 125 m³ of pressurized volume and habitation for up to four crew members for stays up to 90 days. The Gateway will provide access to the lunar surface for both humans and robotic probes, with the ability to adjust orbits as necessary to accommodate various science objectives. NASA’s cadence of missions will begin with a test flight known as Exploration Mission-1 (EM-1), using the Block 1 crew vehicle, followed by crewed missions. Use of SLS to support buildup of the lunar Gateway will commence with the fourth SLS flight and the initial flight of the Block

A reliable, proven propulsion system, consisting of solid rocket boosters, RS-25 liquid main engines and a liquid-propellant upper stage serve as foundational elements for all block configurations. The first variant, Block 1, is slated for the first three flights, with two flights utilizing the Block 1 crew vehicle and one flight using the Block 1 cargo vehicle, with a 5 m-diameter fairing. The Block 1 vehicle, with the solid rocket boosters and four RS-25 main engines supplying 8.8 million pounds of liftoff thrust, will lift at least 26 metric tons (t) of payload system mass (PSM) to trans-lunar injection (TLI). The Block 1 vehicles will launch from a newly refurbished Mobile Launcher (ML) at KSC’s launch pad 39B.

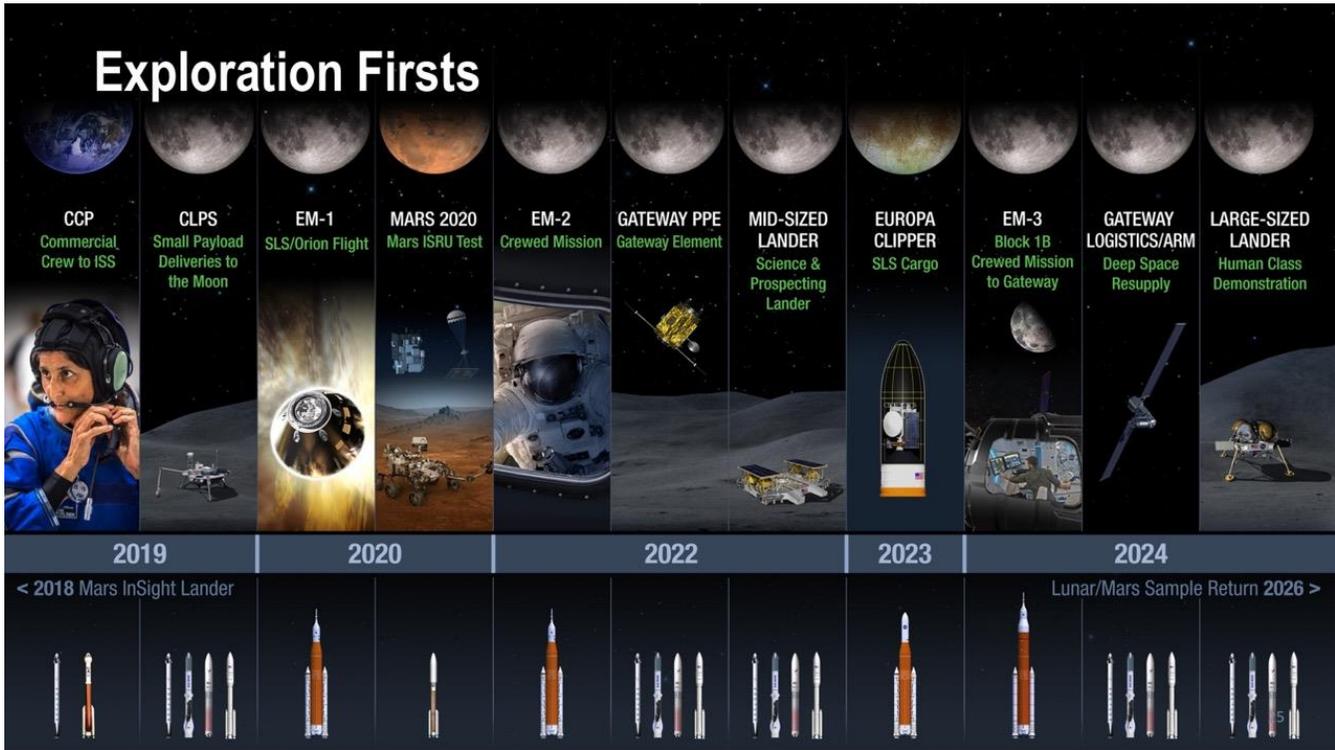


Figure 3. SLS enables new deep space missions to the Moon and beyond

Following the Block 1 flights, the more powerful Block 1B variant is scheduled for availability. A new upper stage, termed the Exploration Upper Stage (EUS), will increase Block 1B’s PSM capabilities to TLI. The Block 1B crew vehicle will lift 34 to 37 t to TLI and be able to accommodate a co-manifested payload in the 8 to 10 t range in its Universal Stage Adapter (USA). The usable payload volume in the USA is expected to be 286 m³ – roughly equivalent to an industry-standard 5 m-diameter fairing. The Agency expects to utilize the USA volume to launch elements of the lunar Gateway simultaneous with crewed Orion missions.

The Block 1B cargo variant will be able to accommodate an 8.4 m-diameter fairing in varying lengths (see Figure 4). Vehicle designers are studying both an 8.4 m “short” (19.1 m) concept and an 8.4 m “long” (27.4 m) concept, which would be able to accommodate a variety of transformative science missions to provide capabilities to launch large habitat modules. Lift capabilities for the Block 1B cargo vehicle are expected to be in the 37 t to 40 t range to TLI. The EGS Program recently received funding to construct a second ML to launch the Block 1B vehicles. Engineers are currently finalizing

design requirements for that critical infrastructure.

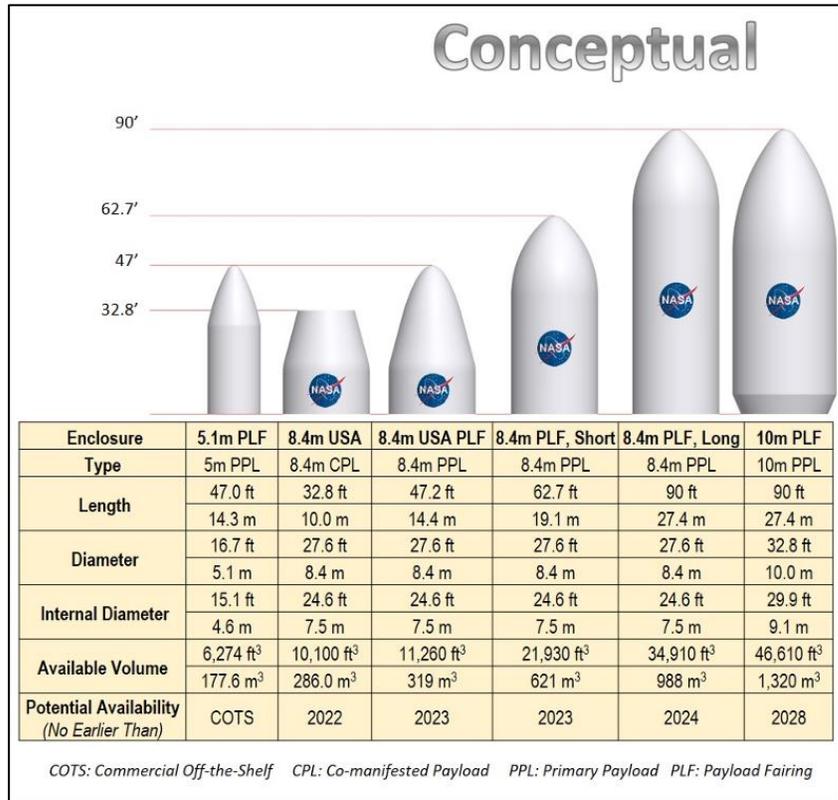


Figure 4. Several fairing concepts are being studied for Block 1B and Block 2 vehicles that will provide maximum volume for payloads

For its ultimate capability, SLS will evolve to a Block 2 variant, able to lift at least 45 t to TLI in crew and cargo configurations. Still under development, the Block 2 vehicle will be needed to achieve the Agency’s goal of human exploration of Mars. New boosters are expected to help achieve sea level thrust levels exceeding 11 million pounds and fairings larger than 8.4 m in diameter are also being studied. The SLS Program regularly engages with the science community to better understand the demand for launch vehicle performance and volume capacity to enable next-generation missions. Because the system is based on a flexible architecture – multiple off-the-shelf upper stages are even possible – it can be configured to launch a wide variety of science missions to destinations deep in the solar system.

In addition to launching primary and co-manifested payloads in the various SLS block configurations, small secondary payloads can be accommodated on flights where mass and volume margins are available. The Block 1 crew vehicle has space available in the Orion Stage Adapter (OSA), which sits near the top of the vehicle, just below Orion’s spacecraft adapter. Up to 17 berths are available in the OSA. For the Block 1B crew and cargo vehicles, up to 21 berths for smallsats may be available on a payload adapter. For EM-1, 13 6U CubeSats are manifested (see Table 1). Future flights may accommodate 6U, 12U and possibly larger payloads. The Program provides a Secondary Payload Deployment System (SPDS) — as well as the extraordinary opportunity for smallsats to deploy in deep space along the upper stage disposal trajectory (see Figure 6).

In addition to the SLS launch vehicles NASA is building to enable sustained exploration of the Moon, the SLS Program, managed at Marshall Space Flight Center (MSFC) in Huntsville, Alabama, has also invested in factory tooling and upgrades, ground support equipment and transportation, and full-scale testing of hardware elements to meet NASA human safety requirements (see Figure 5). SLS is not designed to be a point solution. It’s designed to enable a generation of missions to cislunar space and beyond, with crewed launches, deployment of large-scale infrastructure and even ridesharing services to CubeSat-class payloads. Beyond the Earth-Moon system, SLS utilization opportunities for the science community range from sending robotic probes on direct trajectories to the outer planets or sending larger payloads to the outer reaches of the solar system (see Section 3, SLS Utilization). The SLS Program’s Spacecraft Payload Integration & Evolution (SPIE) Office welcomes dialog with the larger payload community. Interested parties may download the *SLS Mission Planner’s Guide* [3] for a more detailed understanding of the SLS system of launch vehicles, their capabilities and the services the Program provides. Or, email the SPIE Office directly: NASA-slspayloads@mail.nasa.gov.

3. SLS UTILIZATION

As mentioned earlier, three Block 1 flights are currently planned. The first two exploration missions will utilize the

crew configuration; for Science Mission-1 (SM-1), the Block 1 cargo vehicle will potentially send the Europa Clipper probe on a direct trajectory to the icy Jovian moon. For the first Block 1B flight, Exploration Mission-3 (EM-3), NASA will send a co-manifested payload consisting of elements of the Gateway to lunar orbit, along with a crewed Orion spacecraft. The planned SLS missions as well as other possible missions are discussed below.

Exploration Mission-1 (EM-1)—The first mission, EM-1, will be an uncrewed test flight of both new hardware and operations. Over a 25.5-day mission timeline, EM-1 will demonstrate the capabilities needed to launch astronauts to the Moon for the first time since the Apollo Program. SLS will launch Orion to a distant lunar retrograde orbit for a thorough checkout of systems and procedures. Primary mission objectives include:

- Validation of thermal protection, control and data systems
- Testing deep space maneuvers, communications and tracking
- Demonstrating landing and recovery operations
- Testing motion imagery systems
- Deploying secondary payloads after upper stage separation from Orion



Figure 5. The SLS Program has upgraded tooling at Michoud Assembly Facility to produce SLS core stages

At liftoff, the four RS-25 liquid hydrogen (LH2)/liquid oxygen (LOX) engines will ignite, followed by the two five-segment solid rocket boosters — the largest and most

propellant, take one more set of readings, downlink them and shut down. The ICPS will no longer be able to maintain attitude control and it will eventually decay into a flat spin.

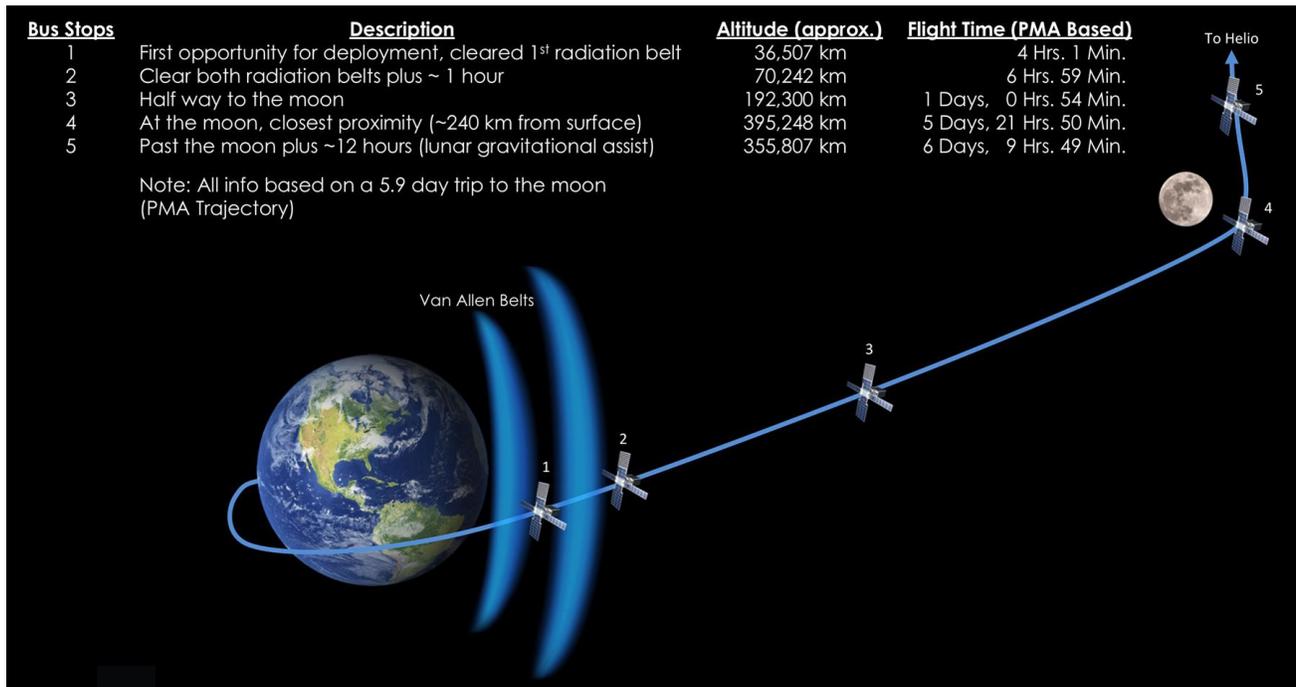


Figure 6. Secondary payloads will be deployed along the upper stage disposal trajectory

powerful ever built for spaceflight. Similar to shuttle-era boosters, the SLS boosters will burn 5.5 tons of propellant per second for about two minutes, providing more than 75 percent of thrust off the pad. After the boosters are jettisoned (following a throttle-down at maximum dynamic pressure on the vehicle), the Orion Service Module fairing is jettisoned at three minutes into flight. Forty seconds later, Orion’s Launch Abort System (LAS) is also discarded. The RS-25s burn for approximately six additional minutes. Once the vehicle reaches escape velocity, the main engines shut down and the core separates from the Interim Cryogenic Propulsion Stage (ICPS) and Orion. Using thrust from the ICPS, the system performs a perigee raise maneuver to reach Earth orbit. Once the raise maneuver is complete, all systems are checked prior to the TLI burn. About 90 minutes into the mission, the ICPS performs the TLI burn that will send Orion to the Moon. The approximately 20-minute burn increases the spacecraft’s velocity to more than 9,000 feet per second. Following the TLI burn, the ICPS separates from Orion and continues on a heliocentric disposal trajectory.

Following conclusion of most of the ICPS disposal maneuvers, the upper stage will activate the SPDS and put itself into a 1 rpm roll and be pointed at a 55° beta angle to the sun to give the payloads the best possible thermal conditions. The ICPS will deplete any remaining hydrazine

The 13 6U CubeSats manifested on EM-1 are listed in Table 1. The SPDS includes mounting brackets, cable harnesses and the avionics unit. Pre-loaded scripts control deployment of the payloads based on flight time to the Moon (see Figure 6). Payload developers are responsible for the payload, the specified commercial off-the-shelf (COTS) dispenser, vibration isolation system and thermal protection.

Current plans call for the SPDS to deploy seven CubeSats at the first “bus stop,” between the Van Allen radiation belts, about four hours post-launch. Payloads deployed at this time include the two JAXA missions, OMOTENASHI and EQUULEUS; Lunar Flashlight; BioSentinel; ArgoMoon; Cislunar Explorers and Lunar IceCube. About 90 minutes after the ICPS clears the first Van Allen Belt, NEA Scout will be released and begin its journey to an asteroid. After the ICPS has cleared both radiation belts, the LunaH-Map payload will be deployed. About one hour after clearing the radiation belts, the LunIR spacecraft will be deployed. About 12 hours after the ICPS passes the Moon and uses its gravity to enter heliocentric orbit, the final three smallsats will be released: CuSP, Team Miles and CU-E³. During the release periods where multiple payloads are to be deployed, payloads will be dispensed at one-minute intervals to ensure there is no recontact.

Table 1. Summary of 6U Payloads Manifested on EM-1

Payload	Developer(s)	Sponsor	Destination	Mission
ArgoMoon	Argotec	Agenzia Spaziale Italiana (ASI)	Geocentric orbit with high eccentricity and apogee close to the Moon	Photograph the ICPS, CubeSat deployment, the Earth and Moon using HD cameras and advanced imaging software
Biosentinel	NASA Ames, NASA Johnson, Loma Linda University Medical Center, University of Saskatchewan	NASA Advanced Exploration Systems (AES)	Heliocentric orbit via lunar flyby	Use yeast as a biosensor to evaluate the effects of ambient space radiation on DNA
Cislunar Explorers	Cornell University	NASA Cube Quest Challenge, sponsored by NASA's Science Technology Mission Directorate (STMD) Centennial Challenges	Lunar orbit	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)	Southwest Research Institute, NASA Goddard	NASA Science Mission Directorate (SMD)	Deep space	Study the sources and acceleration mechanisms of solar and interplanetary particles in near-Earth orbit
EQUilibrUm Lunar-Earth point 6U Spacecraft (EQUULEUS)	University of Tokyo	Japanese Aerospace Exploration Agency (JAXA)	Earth-Moon L2 point	Demonstrate trajectory control techniques within the Sun-Earth-Moon region and image Earth's plasmasphere
Lunar IceCube	Morehead State University, NASA JPL, NASA Goddard, BUSEK	NASA Next Space Technologies for Exploration Partnerships (NextSTEP)	Lunar orbit	Search for water (and other volatiles) in ice, liquid and vapor states using infrared spectrometer
Lunar Flashlight	NASA JPL	NASA AES	Lunar orbit	Search for ice deposits using near-infrared band lasers
Lunar-Polar Hydrogen Mapper (LunaH-Map)	Arizona State University	NASA SMD	Lunar orbit	Perform neutron spectroscopy to characterize abundance of hydrogen in permanently shaded craters
LunIR	Lockheed Martin Space Systems	NASA NextSTEP	Heliocentric orbit via lunar flyby	Use a miniature high-temperature Mid-Wave Infrared (MWIR) sensor to characterize the lunar surface
Near Earth Asteroid (NEA) Scout	NASA Marshall	NASA AES	NEA within ~1.0 AU of Earth	Detect target NEA, perform reconnaissance and close proximity imaging
Outstanding MOon exploration Technologies demonstrated by Nano Semi-Hard Impactor (OMOTENASHI)	Institute of Space and Astronautical Science (ISAS)/JAXA	JAXA	Lunar surface	Develop world's smallest lunar lander and observe lunar radiation environment
Team Miles	Miles Space, LLC	NASA Cube Quest Challenge, sponsored by STMD Centennial Challenges	Deep space	Demonstrate propulsion using plasma thrusters; compete in NASA's Deep Space Derby
University of Colorado-Earth Escape Explorer (CU-E ³)	University of Colorado in Boulder	NASA Cube Quest Challenge, sponsored by STMD Centennial Challenges	Deep space	Demonstrate use of solar radiation pressure for propulsion; compete in NASA's Deep Space Derby

Exploration Mission-2 (EM-2)—With EM-1 providing a rigorous test of the new Agency’s new deep space exploration system and many of the challenges of building a launch vehicle for the first time resolved, the second SLS Block 1 crew vehicle will launch astronauts to cislunar space. EM-2

mass margins permit accommodation of CubeSats during this mission, a combination of 6U and 12U smallsats may be manifested. Payloads may be deployed anywhere along the ICPS disposal trajectory. With the return of astronauts to cislunar space, EM-2 will be a landmark achievement. The

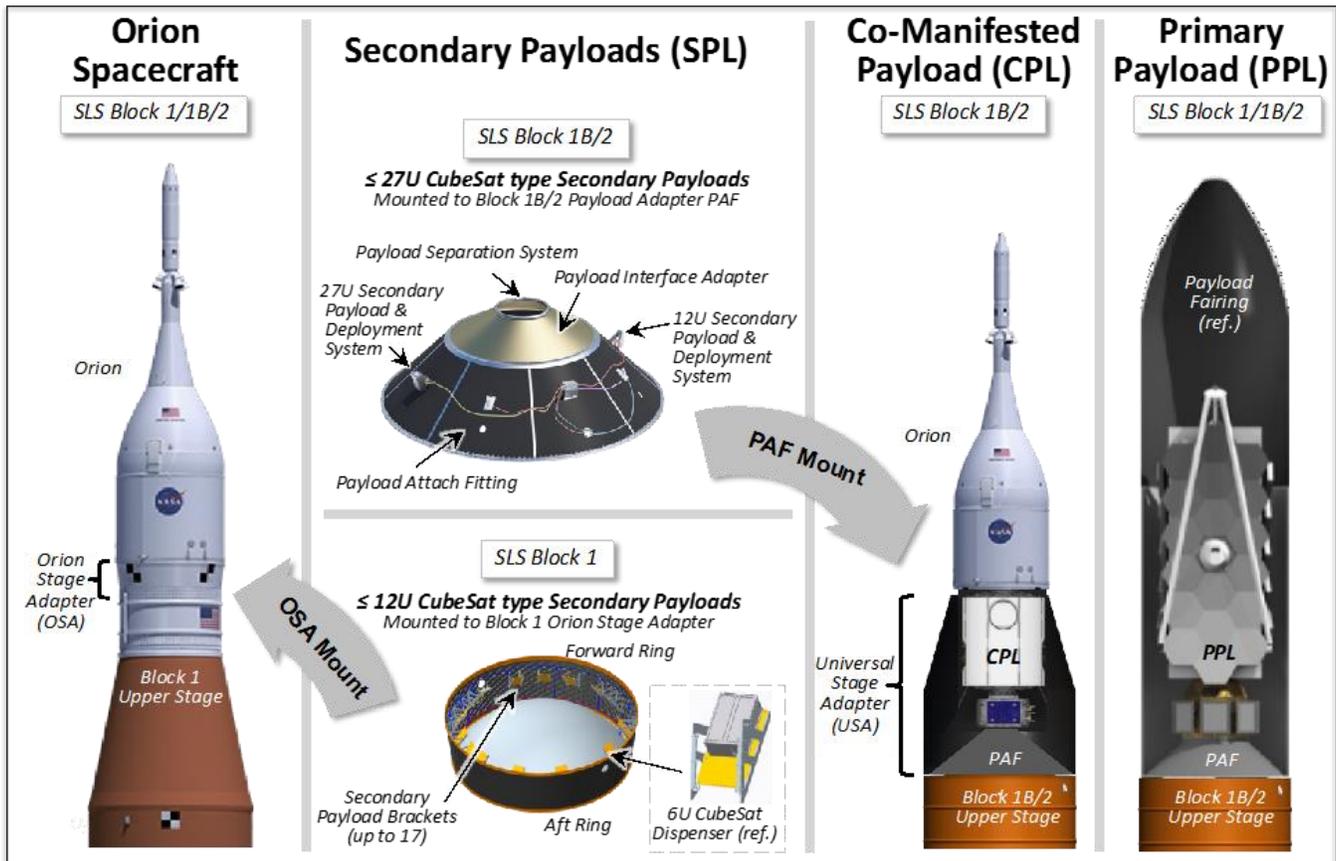


Figure 7. Payload accommodation concepts in the Block 1B and Block 2 vehicles

is expected to be an approximately nine-day mission with a crew of four. Following separation from the core stage, the ICPS will perform a perigee raise maneuver to insert the vehicle into a 22 x 975 nautical mile (nmi), 28.5° inclination orbit. The next burn the ICPS will complete is an apogee raise burn to high Earth orbit (100 x 975 nmi), where the upper stage and crew vehicle will loiter for 24 hours to enable a systems checkout. Following the loiter phase, the ICPS will separate from Orion and the crew vehicle’s service module’s Orbital Maneuvering System (OMS) engine will perform a TLI burn to send the Orion vehicle on a lunar flyby 4,800 nmi past the Moon. This trajectory will make the EM-2 crew the world record holders for farthest distance humans have traveled from Earth. Total distance traveled by the crew during the mission will be about 677,493 miles (1,090,320 km). Orion will make its way back to Earth via free return trajectory.

After separating from Orion, the ICPS will continue on a heliocentric disposal trajectory. At the time of writing, status of secondary payloads of on the EM-2 is under evaluation. If

completion of the first two exploration missions of the Agency’s new deep space exploration system, will lay the foundation for a new era of lunar exploration.

Science Mission-1 (SM-1)—The first dedicated SLS science mission would use the Block 1 cargo vehicle with a 5 m fairing to send the Europa Clipper probe on a direct trajectory to the icy Jovian moon. The Europa Clipper mission on a Block 1 cargo vehicle provides a case study in utilization of SLS’s superior departure energy. Although the mission could fly on a commercial vehicle (United Launch Alliance’s Delta IV Heavy is the only vehicle with the performance and track record to meet mission requirements), it would require a trajectory with three gravity assists (Venus-Earth-Earth) and a cruise time of seven to eight years. SLS will directly inject the probe into a Jovian space, shortening outbound transit to less than three years.

Exploration Mission-3 (EM-3)—Following the first three flights, the Block 1B vehicle is scheduled for availability for the next series of deep space exploration missions. Exploration Mission-3 (EM-3) is scheduled to utilize the Block 1B crew configuration to launch astronauts in the Orion spacecraft and a co-manifested payload in the USA to lunar orbit. The new Gateway lunar outpost will have a flexible architecture, making it suitable as a platform for missions to the lunar surface, science and technology experiments and demonstrations, and as a staging point for destinations deeper into space. Its location will enable it to receive incoming flights from commercial vehicles as well as SLS. Initial functionality will comprise a Power and Propulsion Element (PPE); habitation; an airlock to enable docking and extra-vehicular activity (EVA); and logistics for cargo delivery, science utilization, technology

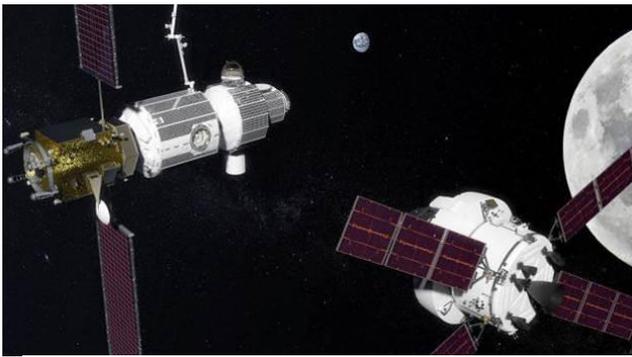


Figure 8. Artist's depiction of NASA's Gateway lunar outpost

demonstrations and potential commercial operations. Following launch of the PPE on a commercial vehicle, the Block 1B crew vehicle will carry a European Space Agency (ESA)-provided European System Providing Refueling Infrastructure and Telecommunications (ESPRIT) module and a U.S.-developed utilization module as a co-manifested payload to help establish the Gateway. The utilization payload will consist of a small habitat and logistics module while the ESPRIT module will provide a science airlock, additional communications and refueling for the PPE. The USA in the Block 1B crew vehicle will provide as much volume for payloads as the space shuttle payload bay. Co-manifested payloads will typically separate from the EUS five to eight hours after launch. After Orion separates and reaches a safe distance, the USA will separate in a “canister” fashion rather than a “sector” separation, as was used during the Apollo Program. Co-manifested payloads may be extracted from the stage by Orion or may separate autonomously, depending on mission requirements. Similar to evolved expendable launch vehicles (EELVs), the mechanical interface between the SLS Block 1B launch vehicle and a co-manifested payload is a payload adapter consisting of up to three components: a payload attach fitting, a payload separation system and a payload interface adapter. Choice of a particular payload adapter depends on mission needs.

For possible secondary payloads in the Block 1B crew configuration, rideshare opportunities for up to 21 smallsats up to 27U in size may be offered on the USA payload adapter. The SLS Program is also evaluating user demand for payload accommodations in a propulsive EELV Secondary Payload Adapter (ESPA)-class ring configuration.

Utilization beyond lunar exploration—The ultimate SLS Block 2 capability, with the cargo variant potentially utilizing fairings in the 10 m-diameter range, will make human exploration of Mars possible. Landers and other infrastructure will require the large payload volume and launch vehicle performance that SLS provides. Looking farther into the solar system, scientists could utilize the unique capabilities of SLS to send probes to the giant ice worlds of Uranus and Neptune to investigate the atmospheric and magnetic properties and conduct flybys of larger satellites. SLS can send spacecraft on direct trajectories to these systems also, opening new opportunities for exploration with faster data return for investigators. In the field of astrophysics, the unmatched payload volume in SLS fairings, whether 8.4 m or a potentially larger-diameter fairing, facilitates launch of large-aperture telescopes that could put a view of early formative events in the universe or life on exoplanets within our reach. The payload volume of SLS could be used to deploy a telescope larger than the James Webb Space Telescope to be stationed at a Sun-Earth Libration Point to investigate hundreds of galaxies and uncover the secrets of dark matter. SLS could be used to send a probe beyond the heliosphere to explore the interstellar medium. Mission concepts include investigation of the interstellar medium and its influence on the solar system, and the characterization of interstellar gas, low-energy cosmic rays, dust and magnetic fields. SLS provides a new capability for a new era of scientific missions, as well as the basis for returning human exploration to the Moon.

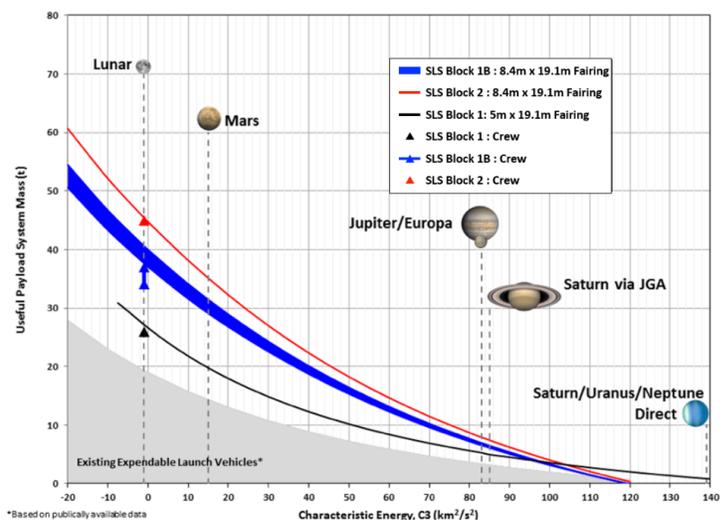


Figure 9. SLS vehicles can deliver a range of useful payload mass, shown here in the form of a C3 curve

4. PROGRESS TOWARD EM-1

The first build of the SLS Block 1 vehicle, for the EM-1 test flight, is nearing completion. Several elements have been delivered to the EGS Program at KSC. The SLS Program is working toward finishing the core stage and shipping it to Stennis Space Center (SSC) for the “Green Run” hot-fire test as well as modal tests of the stage. Following is a summary of progress on the vehicle.

Solid Rocket Boosters—Boosters prime contractor Northrop Grumman has completed all 10 propellant segments for the EM-1 flight set. The motors are based on the space shuttle’s solid rocket boosters, but are larger and more powerful, with



Figure 10. All propellant segments of the five-segment solid rocket motors for EM-1 are complete

an additional propellant segment. In addition to the fifth segment, each booster has new asbestos-free insulation, a new grain design and new avionics. The aft skirts contain the thrust vector control (TVC) system and technicians at KSC have recently finished installing that system in each skirt. The forward assemblies are in final processing for flight. The motors will be shipped from Northrop Grumman facilities in Utah to KSC where the boosters will be assembled and integrated for flight.

RS-25 engines—The RS-25 engines for EM-1 are complete and ready for integration with the core stage. The engines have been upgraded with state-of-the-art engine controller units that have been hot-fire tested on development engines at SSC. The four RS-25 engines, located in the base of the rocket, each supply 512,000 pounds of vacuum thrust at 109 percent rated power. NASA selected the RS-25 engine, manufactured by Aerojet Rocketdyne, based on its power and reliability. The engine performed successfully in 135 space shuttle missions and has more than a million seconds of ground and flight operating time. It’s been adapted to meet SLS mission requirements with new nozzle insulation and other improvements in addition to the computerized controllers. Sixteen engines from the Space Shuttle Program are available to power the first four SLS missions. NASA has contracted with Aerojet Rocketdyne to restart production on

the RS-25 to supply engines for the fifth flight and beyond. To improve affordability of the engine, several “smart manufacturing” improvements, such as 3D-printed parts, are being incorporated into the new manufacturing process. Using these technological improvements, the Program aims to improve affordability of the new engines by 30 percent.

Integrated Spacecraft/Payload Element—Above the core stage and below Orion’s spacecraft adapter, the Integrated Spacecraft/Payload Element (ISPE) comprises the in-space stage and two adapters in the Block 1 crew vehicle. The in-space stage, the ICPS, is a modified United Launch Alliance (ULA) Delta Cryogenic Second Stage (DCSS) that uses one LH2/LOX-fueled RL-10 engine to perform the burn that sends Orion on a trajectory toward the Moon. The EM-1 ICPS was completed and delivered to EGS in 2017. To meet SLS requirements, engineers lengthened the LH2 tank, added hydrazine bottles for attitude control and implemented some minor avionics changes. As mentioned earlier, the OSA provides the payload accommodations for the 13 6U



Figure 11. The complete Interim Cryogenic Propulsion Stage (ICPS) for EM-1

CubeSats manifested for EM-1 (see Table 1). The OSA was completed and delivered to EGS in 2018. The other adapter, the LVSA, is in final processing. The LVSA, managed by prime contractor Teledyne Brown Engineering, was manufactured in MSFC’s Advanced Weld Facility using robotic and vertical friction-stir welding tools. The adapter, 27.5 feet tall and 27.5 wide at its base, tapers to 16.4 feet at the top and partially encloses the ICPS. The LVSA was recently sprayed with thermal protection in the largest manually acreage application of TPS that MSFC technicians have ever completed. Major work left to complete on the LVSA includes mating the adapter with the frangible joint assembly and installation of the pneumatic actuation system.

Core Stage—Major work to be completed for EM-1 centers on the core stage. The 212-foot stage, being built by Boeing at Michoud Assembly Facility near New Orleans, Louisiana, will be the largest rocket stage ever constructed. The core stage includes five major sections:



Figure 12. The completed forward skirt of the SLS core stage

- Forward skirt, where the flight computers and other avionics are located
- LOX tank
- Intertank, which connects the two propellant tanks and has the forward attach points for solid rocket boosters
- LH2 tank
- Engine section, where the four RS-25 engines are housed

The forward skirt is complete and technicians at Michoud will soon begin the “forward join” by mating the intertank with the LOX tank and then joining that assembly with the forward skirt. The aft join will follow, with the engine section joined to the LH2 tank. The forward and aft sections will then be mated and, finally, the RS-25s will be integrated into the engine section before shipment to SSC for green run testing. Following the green run test series, the core stage will ship to



Figure 13. The avionics in the EM-1 intertank were recently tested

KSC, where stacking and integration of the vehicle will commence in the Vehicle Assembly Building.

5. SUMMARY

The nation’s investment in NASA’s new deep space exploration system, of which SLS is a key component, represents a paradigm shift from human operations in LEO to a partnership of activities on the Moon and in lunar orbit. The launch of the EM-1 mission is the first step in sustained operations in cislunar space. The Block 1 vehicle for EM-1 is nearing completion, with the Program moving toward a Green Run test of the core stage. The unmatched performance and volume for payloads that SLS provides will enable the return of human missions to the Moon and beyond. Following EM-1, the Block 1 crew configuration will be used for EM-2, the first mission to return astronauts to cislunar space since the Apollo Program. Later, progressively more powerful variants of the vehicle will be used to support buildup of the lunar Gateway. Mission planners hope to offer CubeSats in 6U, 12U or even larger sizes, rideshare opportunities on any missions with mass margins available. The Block 1 vehicle, with a 5 m fairing, will launch the Europa Clipper probe directly to the Jovian moon, eliminating several years of gravity assists. The Block 1B cargo vehicle can accommodate an 8.4 m-diameter fairing in two lengths, opening new opportunities for the science community to launch more mass and utilize the powerful EUS to give payloads the energy to reach distant destinations. NASA is focused on establishing a sustained presence in cislunar space, leading a diverse coalition of international and commercial partners to achieve this next great leap in exploration. The unique capabilities of the SLS vehicle are a critical component to making this bold vision of exploration a reality.

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BIOGRAPHY



Steve Creech received a B.S. in Industrial Engineering from Mississippi State University and currently serves as the manager of the Spacecraft / Payload Integration and Evolution (SPIE) Office of the Space Launch System (SLS) Program, located at NASA's Marshall Space Flight Center in Huntsville, Alabama. In that role, he oversees development of

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