What Comes Next

An entire generation has grown up with the space shuttle. Under development for most of the 1970s, the space shuttle *Columbia* made its maiden flight on April 12, 1981. Since then, the shuttle has flown more than 120 missions and carried more astronauts into space than all other rockets combined. It has deployed satellites, sent space probes throughout the solar system, and lofted science laboratories and many of the major components of the ISS.

The space shuttle is a complex and versatile space launch system, but its flights will end when the ISS is fully assembled. What comes next?

In the decades of exploration that followed its creation in 1958, NASA expanded our perspective of the universe and humanity's place within it. Many important lessons have been learned, some of them the hard way. As we move into the second century of human flight, it is time to improve our ability to travel and live in space. For its second 50 years, NASA will pursue a new era of space exploration.

Ares I and V, to Earth orbit, the Moon, and Mars.

Human Space Flight Objectives for the Second Fifty Years:

- Implement a sustainable and affordable human and robotic exploration program throughout the solar system and beyond.
- Build a permanent outpost on the Moon and prepare for human exploration of Mars.
- Develop the innovative technologies, knowledge base, and infrastructure needed to support and sustain human exploration.
- Promote international and commercial participation leading to furthering U. S. scientific, security, and economic interests.

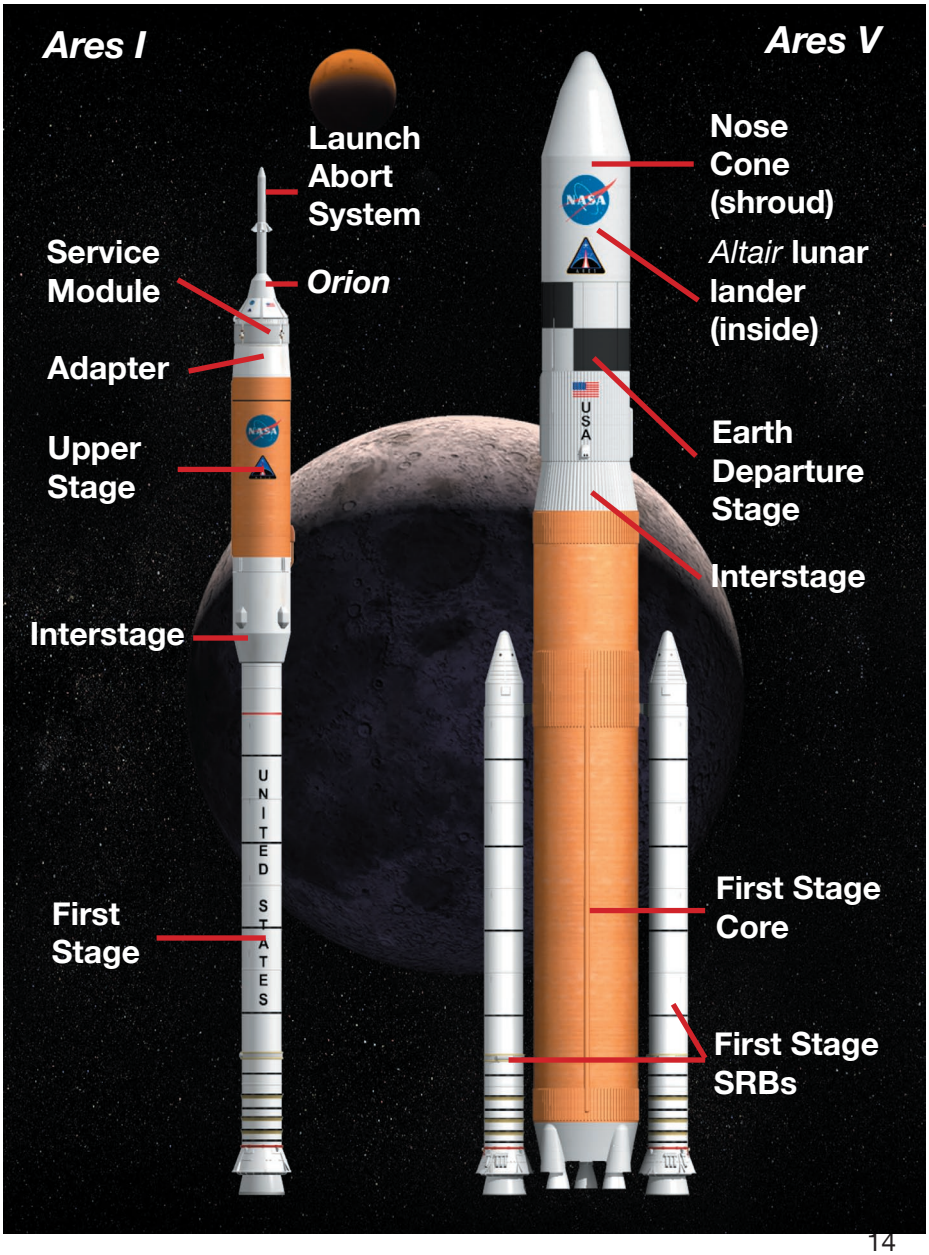
Essential to NASA's plans is a new and versatile space launch system to replace the space shuttle. Capitalizing on NASA's multi-decade experience, the new system will combine the best of the past with the best of the present and future. It is called the Constellation program and will consist of two launch vehicles, each with different configurations to meet varying mission and cost requirements.

For maximum crew safety, the Constellation program separates human crews and payloads. The crew launch vehicle is called the *Ares I* and it is capped with the *Orion* crew exploration vehicle. The heavy-lift unmanned payload vehicle is the *Ares V*.

Ares I Crew Launch Vehicle

The *Ares* rockets take their name from the Greek word for the planet Mars. *Ares I* is an in-line, two-stage rocket with a crew capsule on top. The first stage is derived from the space shuttle's solid rocket boosters. The space shuttle uses two boosters, each consisting of four segments joined end-to-end. The *Ares I* first stage is a single booster with five segments. Like the space shuttle's boosters, it will be recoverable from the ocean for reuse.

Resting on top of the first stage will be a interstage with mechanisms and small rocket motors used for separating the first and upper stages. The upper stage, resembling the external tank of the space shuttle, is a new vehicle with a liquid hydrogen liquid oxygen J-2X engine at its base. Derived from the Saturn rockets of the *Apollo* era, the J-2X engine is an upgraded version of the J-2 engines used for the second and third stages of the Saturn V. The J-2X will consume liquid hydrogen and liquid oxygen propellants contained in large tanks within the upper stage.

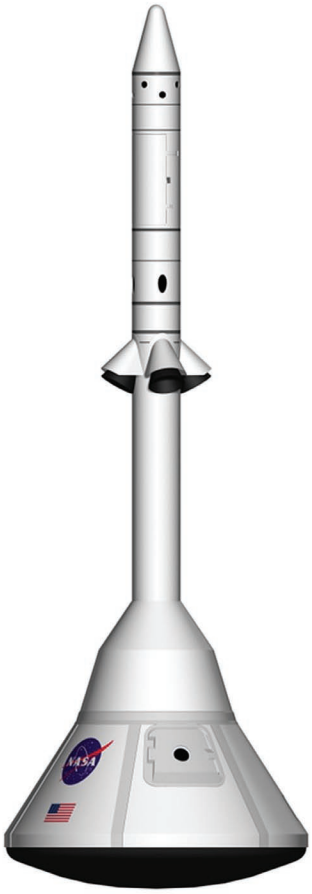


.On top of the second stage will be an instrumented adapter ring that will connect to the *Orion* crew exploration vehicle.

Orion will consist of two modules, similar to but larger than the crew modules used for *Apollo*. A service module, containing propellants for a single rocket engine and power systems for the crew module, will perch directly on top of the upper stage adapter. The crew module, a cone-shaped capsule, will be mounted on top of the service module. It will be large enough to carry six astronauts to the ISS or four astronauts to the Moon. On lunar missions, the crew of *Orion* will rendezvous with a lunar landing craft launched into Earth orbit by Constellation's cargo vehicle, *Ares V*.

Lastly, a thick, pencil-shaped launch abort system attaches directly to the apex of the crew module. The abort system has a cluster of small rocket engines angled outward from the capsule below. The abort system enhances crew safety during the launch phase. In the event of an emergency, its rockets will pull the *Orion* away from the *Ares I* stack so that the capsule can parachute safely into the ocean. When *Orion* is successfully launched, the launch abort system will be jettisoned. Another significant safety improvement of the *Orion* design is the placement of the capsule above the *Ares I* upper stage. *Orion* will be out of harm's way from colliding with any ice or insulation material that might vibrate loose and fall during launch.

Ares I on the launch pad.



Ares V Cargo Launch Vehicle

Ares V will become NASA's primary heavy-lift cargo launch vehicle. Like *Ares I*, it will be derived from earlier launch systems and will consist of two stages. The first stage will be assembled around a cylindrical core vehicle containing liquid hydrogen and liquid oxygen. The core design is based on proven technology for the Saturn V rocket. At the base of the core stage will be five RS-68 engines upgraded from engines currently used in the Delta IV rocket. Flanking the core will be two five-segment solid rocket boosters.

For lunar missions, an Earth departure stage (EDS) will be mounted on top of the core stage adapter rings. The EDS, propelled by liquid hydrogen and oxygen, will employ a J-2X engine.

Above the EDS and covered by a nose cone shroud will be the *Altair* lunar lander. The shroud will be jettisoned once the lander is in orbit, exposing the lander and its docking adapter to space.

Ares V ready for flight.

Orion approaching the International Space Station.

ISS Missions

For missions to the ISS, only the *Ares I* rocket will be flown. Up to six astronauts will ride in the *Orion* capsule. The *Ares I* launch will be carefully timed to make sure *Orion* arrives in orbit in a favorable position to rendezvous with the station. Using the engine on the service module, the crew will approach the station. Small clusters of attitude control rockets, along the outside of the service module, will permit minor velocity changes and adjustments in the direction (attitude) *Orion* points. Slowly moving forward, the docking adapter mounted in the apex of the *Orion* cone is pushed onto and locked to the matching adapter on the station. Airlock doors open, and the crew transfers into the station along with supplies.

Orion will have the ability to remain docked to the ISS for six months at a time. It will serve as a "lifeboat" for emergency evacuation of station crews. *Orion* will also be able to deliver large quantities of supplies to the station in an automatic, unpiloted flight mode.

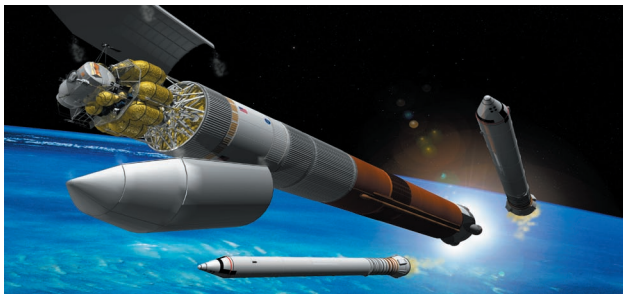
To The Moon

For missions to the Moon, both *Ares I* and *Ares V* will be deployed. In orbit, the crew of *Orion* will begin maneuvers for rendezvous. *Orion* docks with the *Altair* lunar lander mounted on the forward end of the EDS. Once a hard dock is achieved, an interconnecting airlock door is opened, and the crew can pass from *Orion* into the lander and back again.

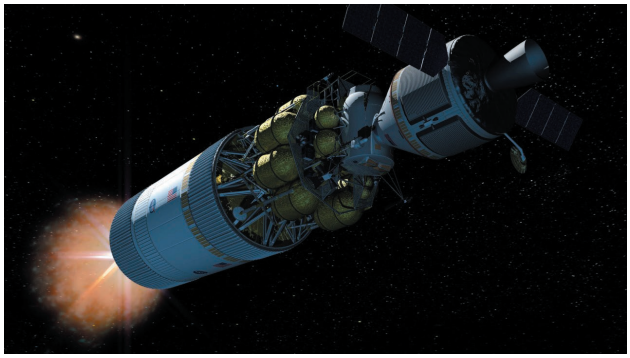
When ready, the EDS fires its engine and sends Orion and the lander towards the Moon. At this point, the EDS will have completed its mission. It will leave Orion and the lander and propel itself out of the way into a long-period solar orbit.

For the next three days, *Orion* and lander will coast to the Moon. The crew will rotate the combined vehicle so that the engine of the lander is aimed in the direction of the Moon.

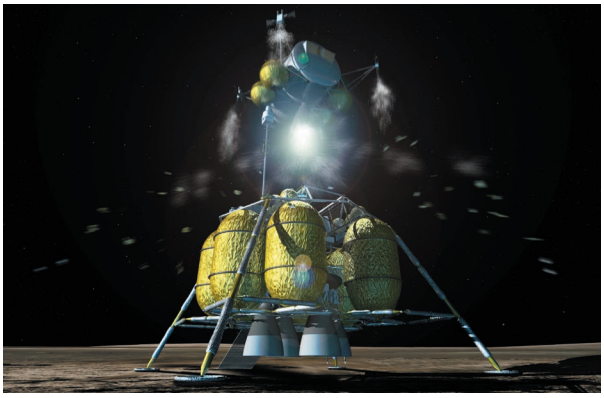
The *Altair* lunar lander will be functionally similar to the landing vehicles used for the Apollo Moon landings. It will consist of two stages. The descent stage has four landing pod legs that will unfold and a large landing



Ares V lifts the Earth departure stage and *Altair* lunar lander to orbit.



The EDS propels *Orion* and the *Altair* lunar lander to the Moon.

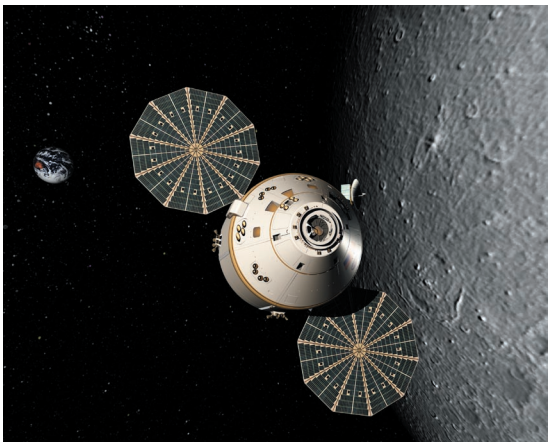


The surface crew returns to orbit in the ascent stage of *Altair.*

engine. The four crew members enter *Altair* for the trip to the lunar surface. *Orion* will remain in orbit, functioning in automatic mode.

The engine fires in a retrograde direction (reverse to the direction it is moving) to slow for landing. During the descent, clusters of small rocket engines on the ascent module fire as needed for attitude control.

Following surface operations (sample collections, automatic experiment deployment,



Orion in lunar orbit while the landing crew explores the Moon's surface below.

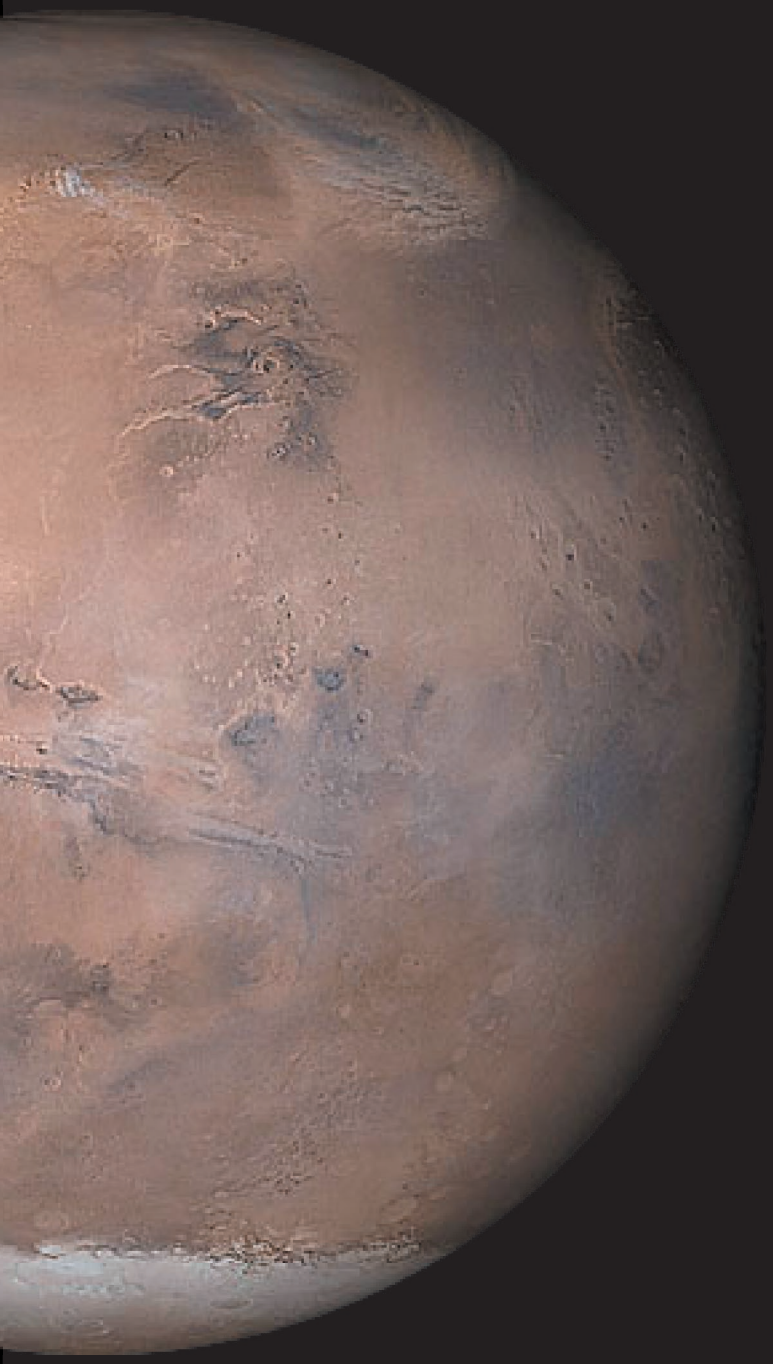
exploration, etc.), the surface crew will board the ascent stage and fire its engine to return to lunar orbit. The descent stage will be left behind. Following docking with *Orion* and crew transfer, the ascent stage will be jettisoned to crash on the Moon.

Using the engine of the *Orion* service module, the crew will begin the voyage home. Near Earth, the service module will be jettisoned, and the blunt heat shield side of the *Orion* capsule will be aimed towards Earth's atmosphere. Following intense heating of the shield, small drogue parachutes will be

Orion reenters Earth's atmosphere.

deployed from the capsule to stabilize its fall. Three main parachutes will then open, and the capsule will make a water landing.

Orion's main chutes bring the capsule down for a soft landing.



Mars and Beyond

The Constellation program will support NASA's exploration programs for decades to come. The first flights of *Ares I* will take place around 2015, and the first return missions to the Moon will take place after 2020. Later, missions to the planet Mars will be mounted. The *Ares V* will make several flights to bring components of the Martian spacecraft up to orbit for assembly. The Mars crew will ride an *Orion* capsule to rendezvous with the completed spacecraft. Upon return from Mars two years later, an *Orion* capsule will be waiting in orbit to carry the crew back to Earth.