Introduction and Background

Orion is the NASA spacecraft that will carry astronauts to the Moon on the upcoming Artemis missions. It will launch on NASA's new heavy-lift rocket, the Space Launch System (SLS). Orion will serve as the vehicle that will take astronauts to space, provide emergency abort capability, sustain the crew during their missions, and provide safe reentry velocities from deep space as astronauts return to Earth.

To protect astronauts on these long-duration missions and return them safely to Earth, Orion engineers have woven innovative technology, advanced systems, and state-of-the-art thermal protection into the fabric of the spacecraft. The team behind Orion has built upon the past 50 years of space exploration experience in human space flight, launch operations, robotic precursor missions, in-space construction, and mission management.

Recovery of the Orion test module in the Pacific Ocean. (NASA)

Artemis Missions

Artemis was the twin sister of Apollo and the goddess of the Moon in Greek mythology; she was also referred to as the "torch bringer." Artemis now personifies NASA's path to the Moon. As part of the broader Moon to Mars exploration objective, this program name is the umbrella under which NASA's lunar plans will be branded. By 2024, the third Artemis mission will land the first woman and the next man on the Moon.

Artemis I

Artemis I is the first integrated flight test of NASA's Orion spacecraft and the SLS rocket. This uncrewed mission will be the first in a planned series of exploration missions in the vicinity of the Moon and will travel 64,000 km (40,000 miles) beyond the lunar surface. This first exploration mission will allow NASA

Artemis Mission Logo.

to use the area of space near the Moon as a proving ground to test technologies farther from Earth and demonstrate that Orion can get to a stable orbit in the lunar vicinity to support sending humans to deep space.

Artemis II

The second flight will take crew on a slightly different trajectory and test Orion's critical systems with humans on board. The SLS will evolve from an initial configuration capable of sending a minimum of 70 metric tons to the Moon to a new and more powerful configuration that can deliver at least 105 metric tons. Future exploration missions will include visits to the Gateway, a space habitat in orbit around the Moon. NASA and its partners will use the Gateway to create a permanent presence in cislunar space that will drive activity with commercial and international partners, help explore the Moon and its resources, and leverage that experience toward human missions to Mars.

Artemis III

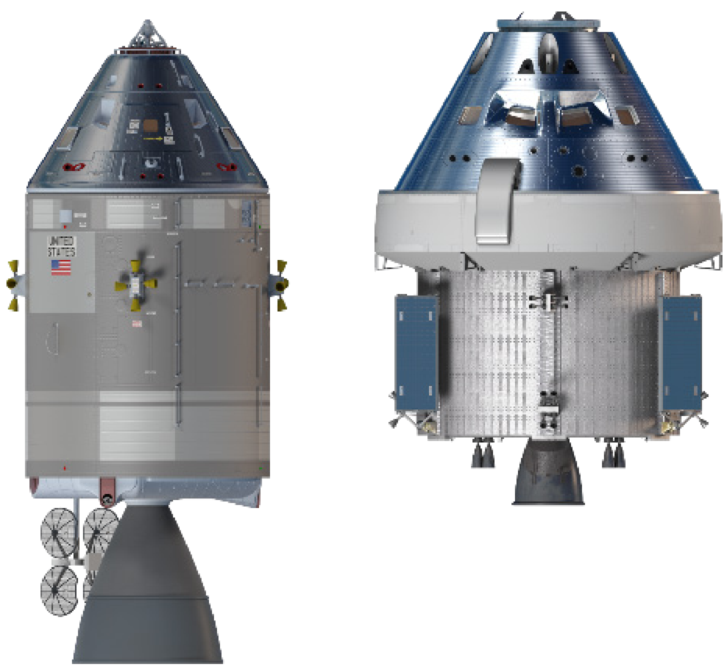
The third flight will deliver the first crew to the surface of the Moon since 1972. This flight will take the crew to the Moon's south pole via a human landing system departing from the Gateway in lunar orbit.

Orion: Learning From the Past With Apollo

Orion will use an improved, larger, blunt-body module, much like the shape of the Apollo capsule. With a diameter of 16.5 ft (5 m), the Orion crew module will have 1.5 times the habitable volume of the Apollo capsule. With a habitable volume of approximately 217.9 ft^3 (6.17 m^3), the Apollo could carry a three-member crew. The Orion crew module has a habitable volume of 316 ft^3 (9 m^3) and will be able to carry a four-member crew. During Orion's planning process, NASA studied several different kinds of entry vehicles and rockets. Although Apollo-era researchers were consulted, NASA did not set out to make the Orion spacecraft identical to the Apollo spacecraft. Ultimately, the chosen module design met NASA's mission requirements while being the safest and most effective.

Resource

Orion Fact Sheet: https://www.nasa.gov/sites/default/files/fs-2014-08-004-jsc-orion_quickfacts-web.pdf



Apollo capsule (left) and Orion module (right).

Orion: Expanded View

Launch Abort System

The Launch Abort System, positioned on a tower atop the crew module, can activate within milliseconds to propel the vehicle to safety and position the crew module for a safe landing. This was demonstrated during the Ascent Abort–2 (AA–2) Flight Test.

Crew Module

The crew module is capable of transporting four crewmembers beyond the Moon, providing a safe habitat from launch through landing and recovery. Inside the familiar deep-space capsule shape are advances in life support, avionics, power systems, and advanced manufacturing techniques.

Service Module

The service module provides support to the crew module from launch through separation prior to reentry. It provides in-space propulsion for orbital transfer, power and thermal control, attitude control, and high-altitude ascent aborts. While mated with the crew module, it also provides water and air to support the crew.

The Process of Creating the Orion Crew Module

The Orion crew module, or pressure vessel, is the primary structure that creates the atmosphere astronauts will breathe and work in while in the vacuum of deep space. Orion is specifically designed to withstand the harsh and demanding environment of deep space travel while keeping the crew safe and comfortable.

The main structure of the pressure vessel is composed of seven large, machined aluminum alloy pieces that are welded together to produce an airtight module that is strong yet lightweight. The module is welded together by a state-of-the-art process called friction stir welding. Friction stir welding produces an extremely strong bond of the two aluminum components with a uniform welded joint.

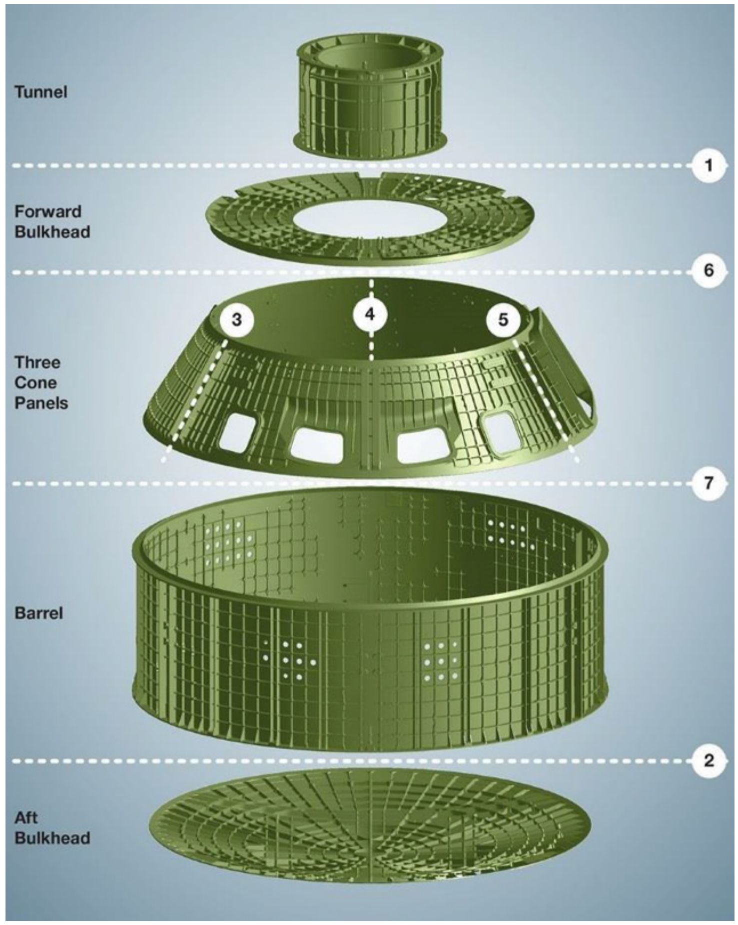


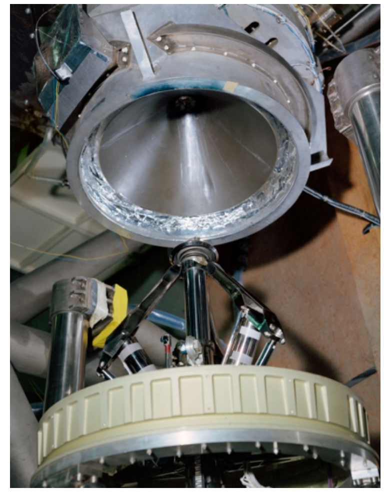
Diagram showing the seven components of Orion's primary structure and the order in which they are welded together. (NASA)

How Does Friction Stir Welding Work?

A pin tool is rotated at between 180 to 300 revolutions (circular movements) per minute, depending on the thickness of the material. The pin tip of the dowel is forced into the material under pressure. The pin continues rotating and, as it rotates, friction heats the surrounding material and rapidly produces a softened area around the pin, which can be described as plasticized. This process under pressure creates a bond between the two pieces of material without melting the material. This results in a uniform bond between the two pieces of metal that creates a strong joint and increases safety. Using a process called nondestructive ultrasonic inspection, scientists can then evaluate the joint weld to make sure the weld is stable and capable of withstanding the dynamic forces of launch.

Orion's bulkhead and nose cone are joined using friction stir welding at NASA's Michoud Assembly Facility. (NASA)

Orion Docking Capabilities



Docking system with probe (bottom) and cone-shaped drogue (top). (NASA)

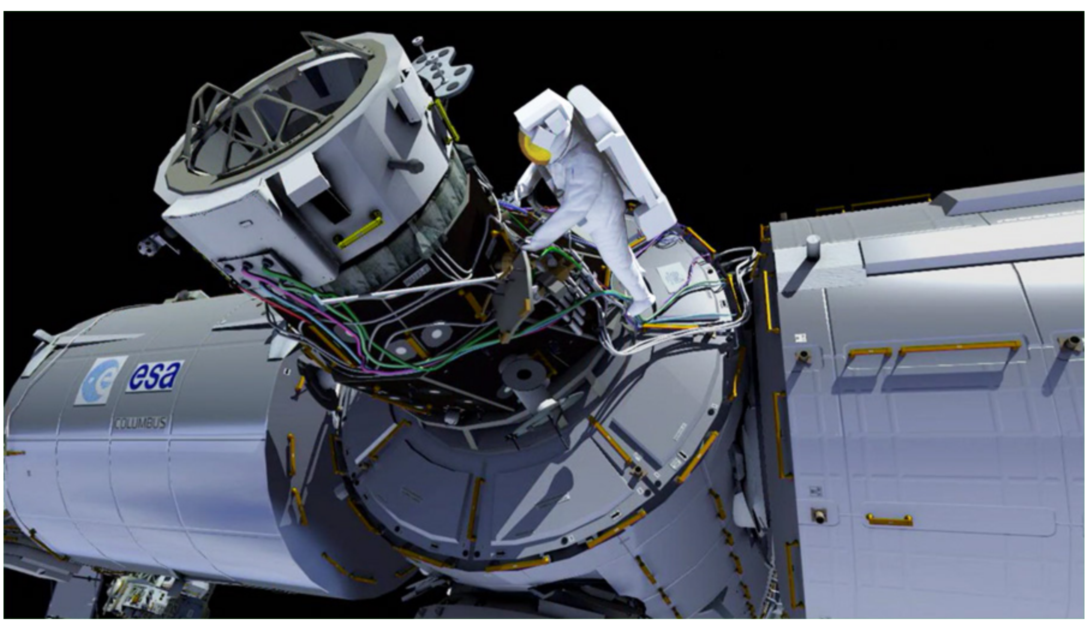
Even before the first successful space flight, scientists and engineers envisioned spacecraft docking with space stations and other spacecraft to transfer people and supplies. This was first successfully accomplished in 1966, when American astronaut Neil Armstrong piloted NASA's Gemini VIII spacecraft and docked with an Agena target vehicle. This important test showed that two spacecraft could be joined in space, an important step in the race to put a man on the Moon. (Three years later, Neil Armstrong would be that man!)

Early docking systems had limitations, however. They used a system called probe and drogue. One spacecraft had a long rod (the probe), which would be inserted into a funnel (the drogue) on the target spacecraft. This system worked fine for two spacecraft designed to go together—one with a probe and the other with a drogue. However, if both spacecraft had probes, or both had drogues, they would not be able to dock with each other.

Engineers then designed docking systems that were androgynous, meaning that the two identical docking systems could dock with each other. This made spacecraft, resupply vehicles, and space station docking more versatile. But with different countries' space agencies and private companies using different systems, many craft were still unable to dock with each other without the addition of heavy and expensive adapters.

Increasing cooperation among international space agencies and private companies led to the design of the International Docking System Standard (IDSS). Any craft that uses this new system will be able to dock with any other craft with the same system. The two craft will also be able to share air, water, power, communications, and even fuel. NASA has adopted this system, and its IDSS-compatible docking adapters are called the NASA Docking System (NDS). Two NDS adapters have already been installed on the International Space Station.

NASA's newest spacecraft, Orion, incorporates an NDS as part of its design. Orion will have to dock with many different types of spacecraft in order to fulfill its many roles, such as docking with the planned Gateway platform in orbit around the Moon, docking with landers and other support craft, and even docking with a larger habitat craft for a mission to Mars.



This computer rendering depicts an astronaut from the International Space Station performing a spacewalk to install the International Docking Adapter. (NASA Johnson YouTube)