National Aeronautics and
Space Administration

Orion Flight Test

Exploration Flight Test-1

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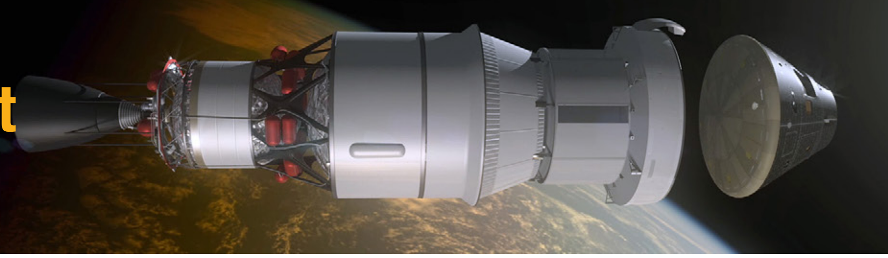

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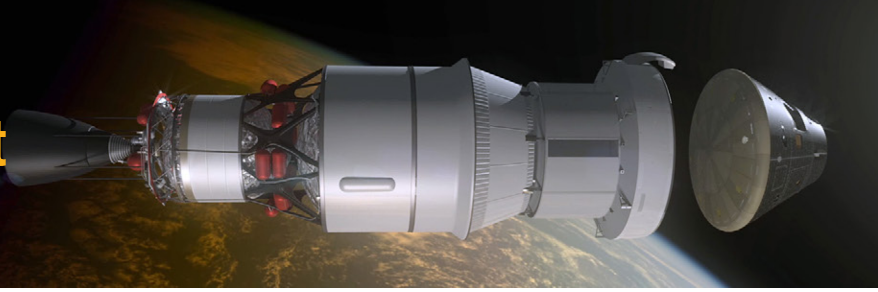


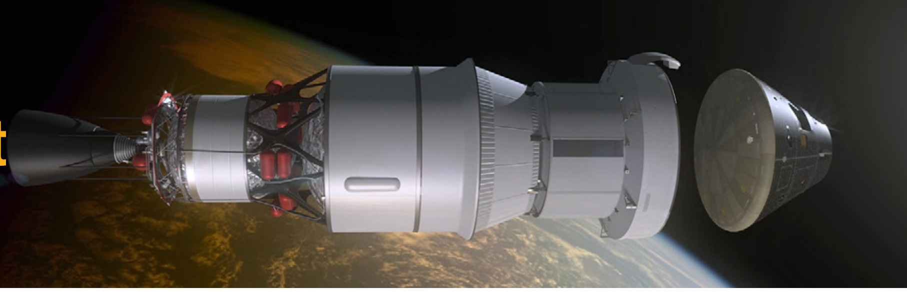
Flight Overview

Orion is NASA's new spacecraft built to carry humans, designed to allow us to journey to destinations never before visited by humans, including an asteroid and Mars. On this uncrewed test flight, Exploration Flight Test-1, Orion will test systems critical to crew safety as it travels farther into space than any spacecraft built for humans has traveled in more than 40 years.

During the 4.5-hour flight, Orion will orbit Earth twice, covering more than 60,000 miles (96,600 kilometers) and reaching an altitude of 3,600 miles (5,800 kilometers) on the second orbit. (The International Space Station orbits Earth at an altitude of approximately 260 miles, or 420 kilometers.) That altitude will allow the spacecraft to return through the atmosphere at a speed of 20,000 mph (32,000 kph), which will generate temperatures near 4,000 degrees Fahrenheit (2,200 degrees Celsius) on Orion's heat shield. Those temperatures – about 80 percent as hot as Orion would experience returning from lunar orbit – will provide the most challenging test currently possible.

The flight test will also validate systems such as Orion's parachutes, avionics and attitude control, and demonstrate major separation events such as the launch abort system jettison and the service module fairing separation. All of these systems must perform flawlessly to guarantee safe, successful missions in the future. Although they have been tested extensively on the ground, the space environment cannot be replicated completely on Earth, and Exploration Flight Test-1 will provide critical data that will enable engineers to improve Orion's design and reduce risk for the astronauts it will carry as NASA continues to move forward on its human journey to Mars.

Although Orion is a NASA program, Exploration Flight Test-1 is managed and led by Orion prime contractor Lockheed Martin and will launch on a United Launch Alliance Delta IV Heavy rocket.



Timeline Overview

Preflight:

L-8 hours 15 minutes –
Mobile Service Tower First Motion

- The gantry used to access the vehicle as it was being readied for launch begins to move away from the rocket.

L-4 hours 35 minutes –
Fueling Readiness Polls

- United Launch Alliance launch team will poll its members to decide whether to begin fueling the rocket with liquid hydrogen and liquid oxygen.

L-4 hours 30 minutes –
Delta IV Heavy Fueling Begins

- The Delta IV Heavy boosters begin to be filled with liquid hydrogen and liquid oxygen.

L-3 hours 30 minutes –
Flight Control Team on Console in Mission Control, Houston

- The NASA flight control team overseeing Orion's flight from Houston takes over from the pre-launch flight control team that has been making preparations for launch.

L-2 hours 35 minutes –
NASA TV Coverage Begins

L-1 hour 55 minutes –
Landing Weather Briefing

- The National Oceanic and Atmospheric Administration's Space Flight Meteorology Group in Mission Control, Houston, briefs the Flight Control Team on weather conditions at the splashdown point in the Pacific Ocean.

L-0 hours 30 minutes –
Launch Weather Briefing

- The 45th Space Wing Operations Group Weather Squadron at Cape Canaveral Air Force Station briefs the United Launch Alliance's Delta Launch Team on weather conditions at the launch site.

L-0 hours 19 minutes –
Terminal Countdown Hold

- The Orion launch countdown enters a 15-minute hold at the T-4 minute mark, during which time the final go or no-go polls are conducted.

L-0 hours 16 minutes –
Orion Go or No-go Poll for Launch

- The Lockheed Martin mission manager polls the Mission Management Team for a final go or no-go for Orion's launch.

L-0 hours 8 minutes –
Orion on Internal Power

- Orion begins using power from its own batteries rather than external power.

L-0 hours 8 minutes –
Delta Go or No-go Poll for Launch

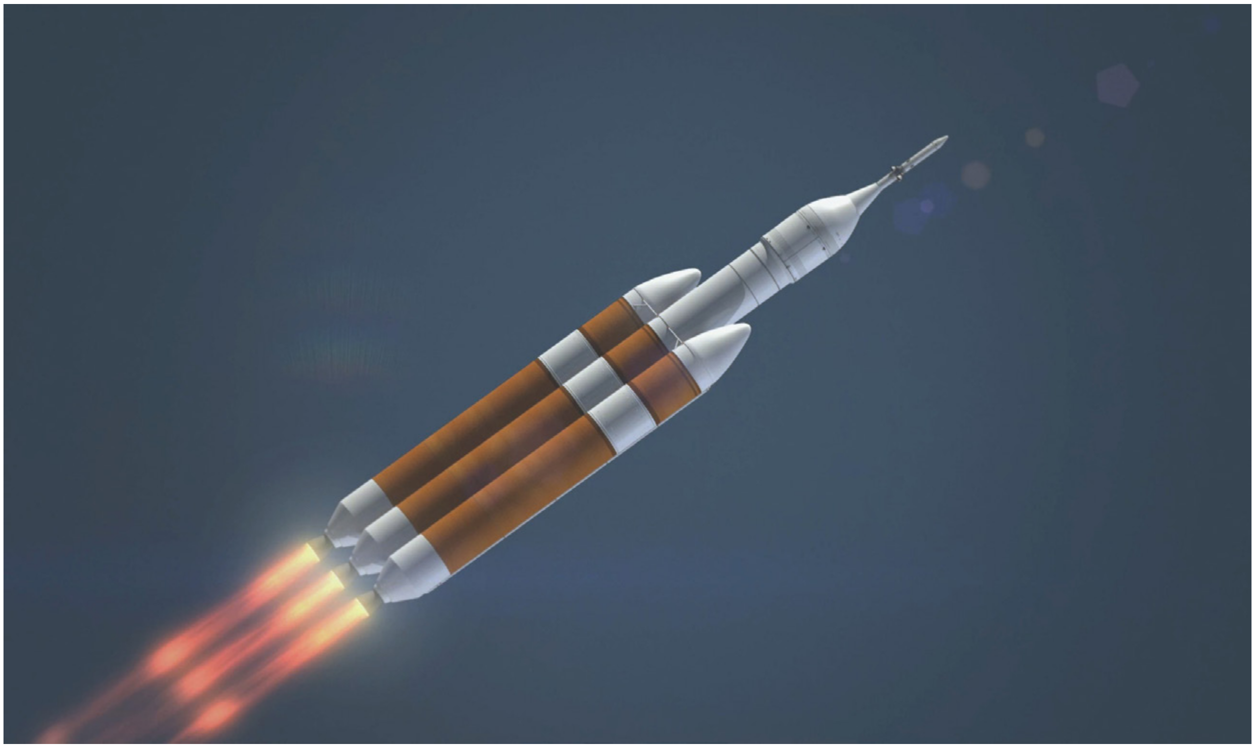
- The United Launch Alliance launch conductor polls the Delta Launch Team for a final go or no-go for launch of the Delta IV Heavy that will carry Orion into space.

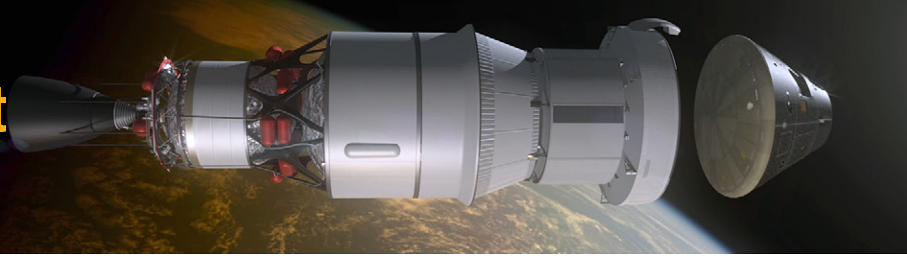
L-0 hours 4 minutes –
Terminal Countdown Begins

- The final built-in hold ends, and the clock begins counting down the final minutes before launch.

L-0 hours 0 minutes –
Liftoff!

- Orion launches into space on its first flight test!





Flight:

L+1 minute 23 seconds –
Max Q

- Orion and the Delta IV Heavy experience the maximum dynamic pressure during ascent.

L+1 minute 25 seconds –
Mach 1

- Orion and the Delta IV Heavy reach the speed of sound.

L+3 minutes 56 seconds –
Port and Starboard Common Booster Cores Jettisoned

- The boosters on either side of the rocket are released after their engines cut off at the 3 minute, 56 second mark.

L+5 minutes 30 seconds –
Core Common Booster Core MECO

- The main engines cut off on the remaining booster core.

L+5 minutes 33 seconds –
Stage 1 Separation

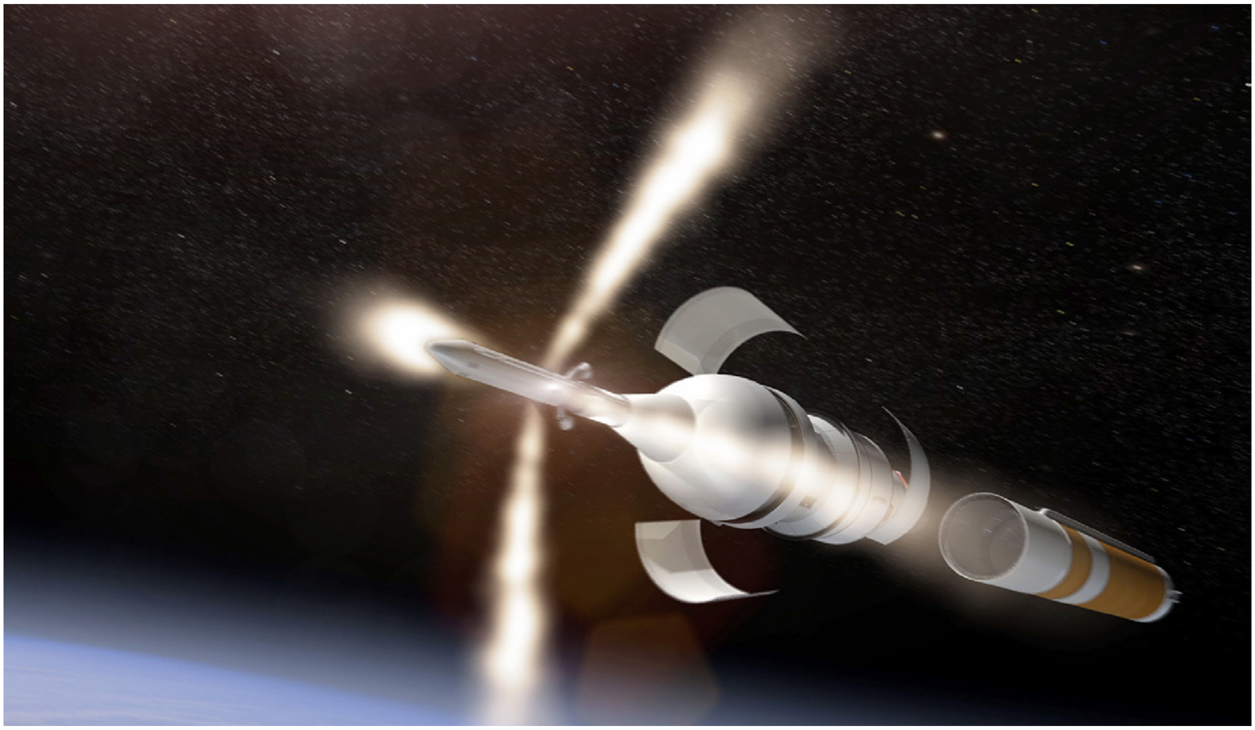
- The first stage of the Delta IV Heavy separates from the rest of the vehicle, while the second stage continues on with Orion.

L+5 minutes 49 seconds –
Second Stage Ignition #1

- The second stage of the Delta IV Heavy begins an 11-minute, 50-second engine burn to continue Orion's ascent.

L+6 minutes 15 seconds –
Service Module Fairing Separation

- The three 13x14-ft. fairing panels that have provided structural support and protected the service module through the first minutes of flight are pushed away from the vehicle to reduce Orion's weight.



L+6 minutes 20 seconds –
Launch Abort System Jettison

- The system that would be used to pull future Orion crews away from their rocket during an emergency is jettisoned once Orion is safely through the most dynamic portion of its launch.

L+17 minutes 39 seconds –
Secondary Engine Cutoff (SECO) #1

- The Delta IV Heavy second stage engine shuts down as Orion arrives at its initial orbit, 115 x 552 miles (185 by 888 kilometers) above Earth.

L+1 hour 55 minutes 26 seconds –
Second Stage Ignition #2

- The second stage of the Delta IV Heavy begins a 4-minute, 45-second engine burn to push Orion farther into orbit.

L+2 hours 0 minutes 09 seconds –
SECO #2

- The Delta IV Heavy second stage completes its engine burn, sending Orion on its way to its peak altitude of 3,600 miles (5,800 kilometers).

L+2 hours 05 minutes –
Entering First High Radiation Period

- Orion enters the first of two periods of intense radiation in the lower Van Allen Belt. Its cameras are turned off during this period to protect them from damage.

L+2 hours 20 minutes –
Leaving High Radiation Period

- Orion rises above the most intense area of radiation it will travel through. Its cameras are turned back on.

L+2 hours 40 minutes –
Reaction Control System Activation

- The engines that will steer Orion once it has separated from the Delta IV Heavy second stage are activated.

L+3 hours 05 minutes –
Peak Altitude

- Orion reaches its highest altitude of the flight, 3,600 miles (5,800 kilometers) above Earth and farther than any vehicle built for humans has been in more than 40 years.

L+3 hours 09 minutes –
Maneuver to Crew Module/Service Module Separation Attitude

- Orion moves into position for the separation of its service module and the Delta IV Heavy second stage.

L+3 hours 23 minutes 41 seconds –
Crew Module/Service Module Separation

- The Orion crew module separates from its service module and the Delta IV Heavy in preparation for its return to Earth.

L+3 hours 30 minutes –
Entering Second High Radiation Period

- Orion re-enters the area of intense radiation in the lower Van Allen Belt, this time going down instead of up. Its cameras will again be turned off for protection.

L+3 hours 57 minutes 11 seconds –
Crew Module Translation Burn

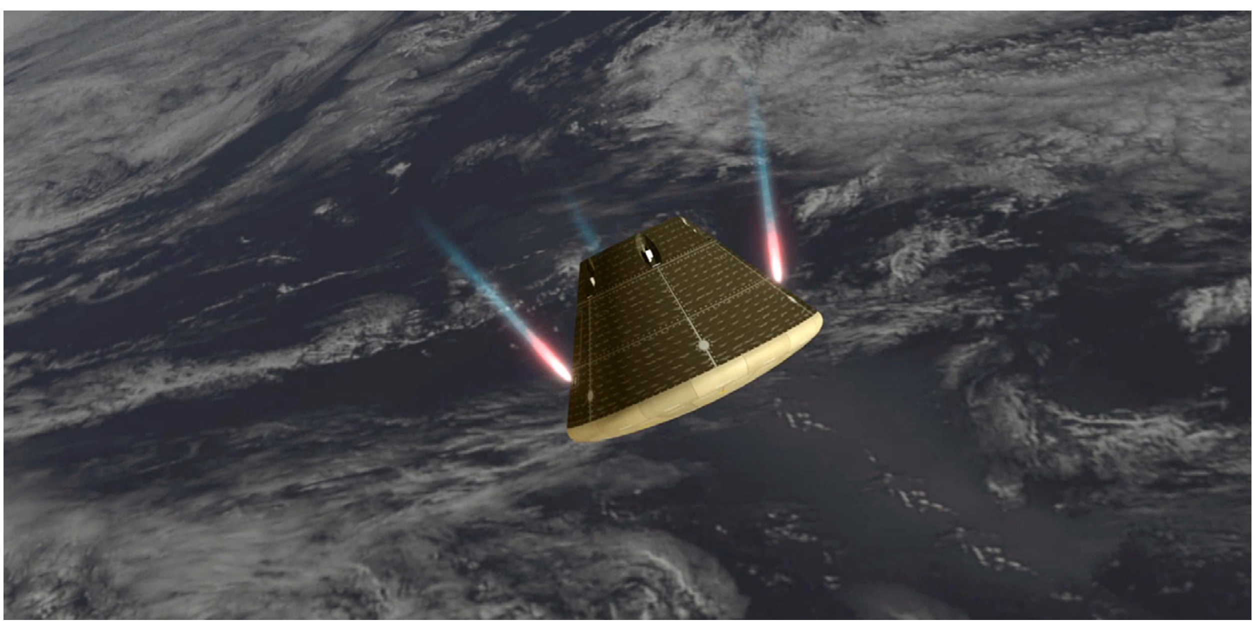
- Orion's reaction control system engines fire for 10 seconds to initiate its return to Earth.

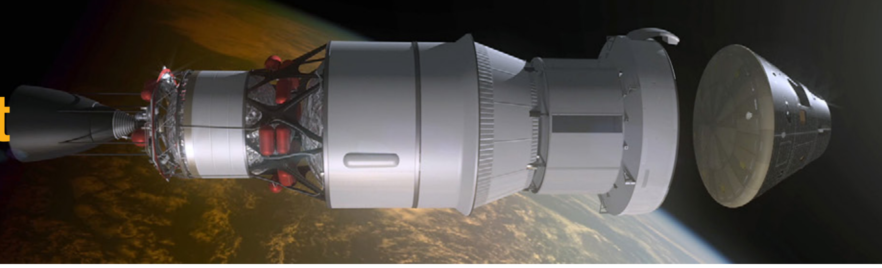
L+4 hours 05 minutes –
Leaving High Radiation Period

- Orion falls below the most intense area of radiation it will travel through. Its cameras are turned back on.

L+4 hours 13 minutes 35 seconds –
Entry Interface

- Orion reaches the upper limits of Earth atmosphere, which generates heat as Orion passes through it at about 20,000 mph (32,000 kph).





L+4 hours 13 minutes 41 seconds – Blackout

- The flight control team in Mission Control loses contact with Orion for approximately 2.5 minutes as a superheated plasma forms around the capsule, blocking signals in and out.

L+4 hours 15 minutes 03 seconds – Peak Heating

- Orion experiences the hottest period of its return through Earth's atmosphere, with its heat shield experiencing temperatures near 4,000 degrees Fahrenheit (2,200 degrees Celsius).

L+4 hours 19 minutes 29 seconds – Forward Bay Cover Jettison

- The forward bay cover, with its tiles that have protected Orion through the heat of re-entry, is jettisoned to expose its parachutes. The forward bay cover has three parachutes of its own that will lower it to the Pacific Ocean.

L+4 hours 19 minutes 31 seconds – Drogues Deployed

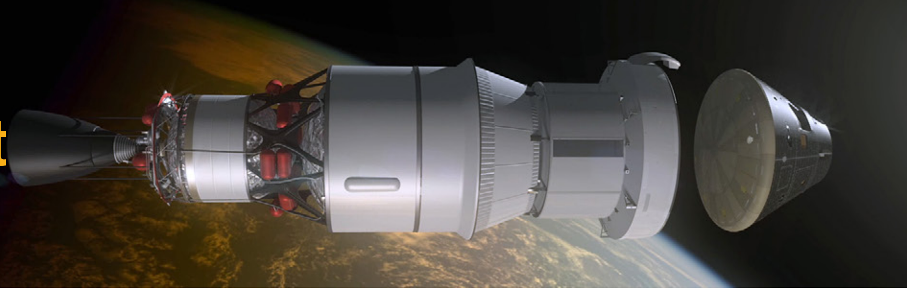
- The first two parachutes of the eight that will slow Orion for splashdown deploy while Orion is traveling about 300 mph (480 kph).

L+4 hours 20 minutes 40 seconds – Main Parachutes Deployed

- Three pilot parachutes are used to pull the three massive main parachutes out after the drogue parachutes are released. The main parachutes, which together would cover almost an entire football field, slow the vehicle from about 100 mph (160 kph) to less than 20 mph (30 kph).

L+4 hours 23 minutes 29 seconds – Splashdown

- Orion lands in the Pacific Ocean, approximately 600 miles off the coast of Baja California. It will be recovered by a combined NASA and U.S. Navy team that will attach Orion to cables that will pull it into the flooded well deck of the USS Anchorage.



Flight Profile

Launch

Launch vehicle: United Launch Alliance Delta IV Heavy

Launch site: Space Launch Complex 37 at Cape Canaveral, Florida

Launch date: Dec. 4, 2014

Launch time: 7:05 a.m. EST

Launch window: 2 hours, 39 minutes

Altitude: 115 x 552 miles initial orbit; -23 x 3,609 miles final orbit

Inclination: 28.8 degrees

Duration: 4 hours, 24 minutes

Vehicle Data

Orion/Delta combined liftoff weight: 1,630,000 pounds (740,000 kilograms)

Orion liftoff weight (including service module and launch abort system): 46,000 pounds (21,000 kilograms)

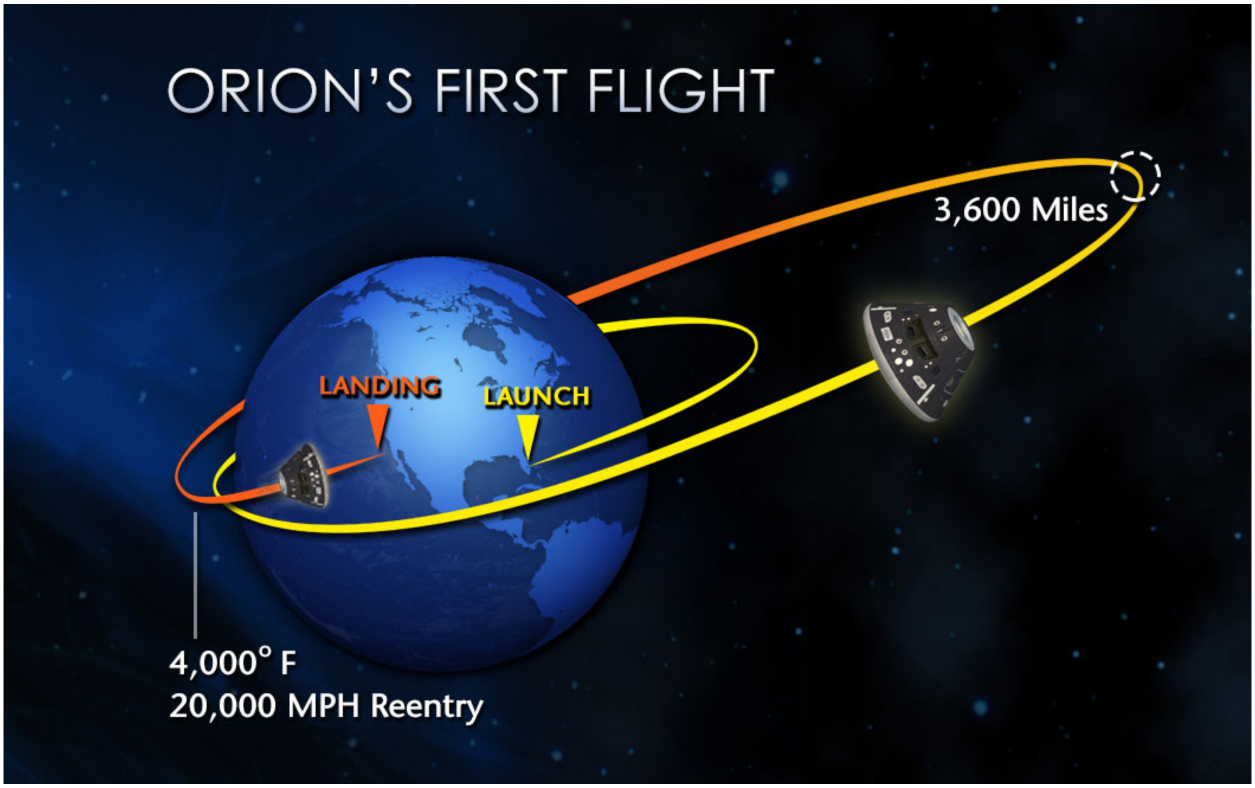
Orion landing weight (crew module only): 19,000 pounds (8,600 kilograms)

Landing

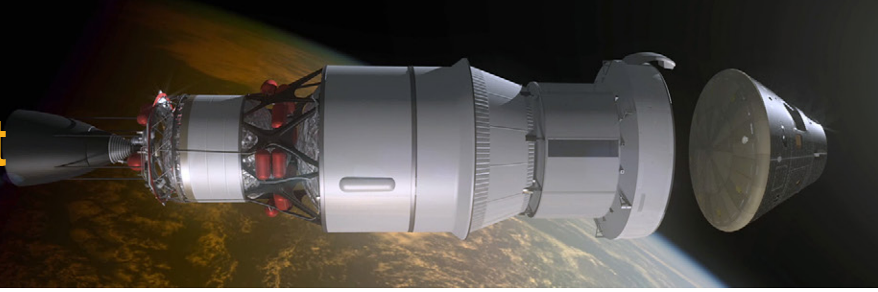
Splashdown date: Dec. 4, 2014

Splashdown time: 8:29 a.m. PST (assumes an on-time launch)

Targeted splashdown site: the Pacific Ocean, 600 miles (1,000 kilometers) west of Baja California



Orion Flight Test



For its first flight, Orion will launch into space on a United Launch Alliance Delta IV Heavy rocket, the largest rocket currently available until NASA's Space Launch System rocket is completed. The Delta IV Heavy is powerful enough to boost Orion 3,600 miles in altitude above Earth – high enough to require the spacecraft to return to Earth at speeds that will result in its heat shield experiencing temperatures approximately 80 percent of what the vehicle would endure on a return from lunar orbit.

Atop the Delta IV Heavy, it will take Orion 17 minutes to reach orbit. During that time, several portions of both the rocket and Orion will be jettisoned.

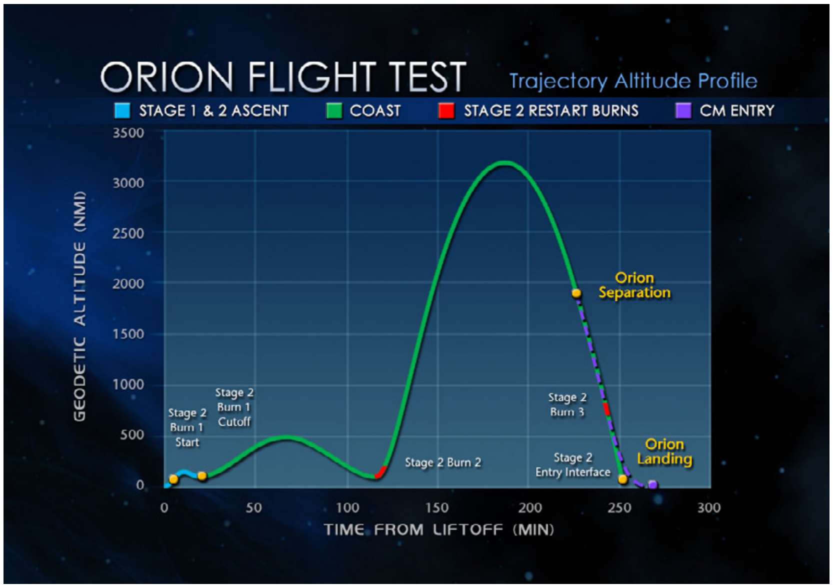
The first things to go are the rocket's port and starboard liquid-fueled rocket boosters, which are jettisoned about four minutes after launch. The center booster stays with the vehicle for another minute and a half before it, too, has fulfilled its purpose and separates from the second stage of the rocket and the Orion spacecraft.

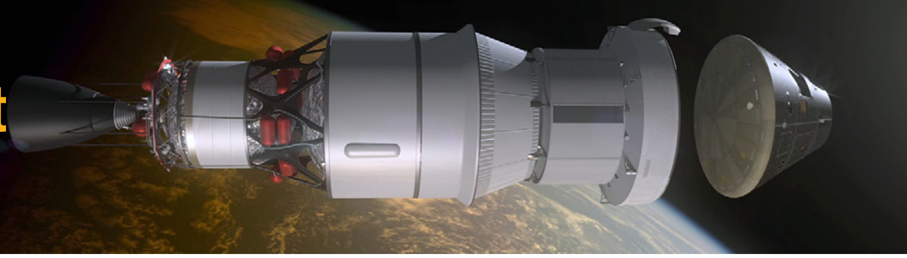
Six minutes into the flight, Orion jettisons the three service module fairing panels that protect the service module and provide structural support for the crew module and launch abort system during the heaviest loads of launch and ascent. The launch abort system itself follows seconds later.

The second stage of the Delta IV Heavy will provide all of the attitude control and propulsion for Orion while it remains with the vehicle. Its engine cuts off for the first time when Orion reaches its initial 115- by 552-mile (185- by 888-kilometer) orbit, 17 minutes after launch. It ignites again as the first of Orion's two orbits ends, pushing the spacecraft to its peak altitude. After firing for 4 minutes and 45 seconds, Orion's orbit will change from roughly circular to extremely oval, with an apogee – or high point – of 3,609 miles (5,808 kilometers) and a perigee that would actually dip below Earth surface, if the flight weren't ending at splashdown.

Orion will reach that peak altitude three hours into the flight. At 3,600 miles in altitude, Earth should fill 60 percent of the field of view through Orion's window.

At that point, the rocket's second stage will perform its final task as part of Orion's flight test, by maneuvering the spacecraft into position for separation. At 3 hours and 23 minutes, the Orion crew module will separate from both the Delta IV second stage and the Orion service module. The second stage, with the service module still attached, will fire its engines one more time to drop itself into Earth's atmosphere and burn up.





The Orion crew module will continue on the flight by itself, providing its own attitude control and propulsion. It will go from peak altitude to splashdown in just an hour and a half. Just before completing its fourth hour of flight, Orion will use its reaction control system for 10 seconds to perform its re-entry demonstration burn. About 15 minutes later, the spacecraft will begin experiencing Earth's atmosphere again, at an altitude of 400,000 feet (122,000 meters).

Orion will be traveling just under 20,000 mph (32,000 kph) at this time. It will take it only 10 minutes from that point to reach the Pacific Ocean for splashdown. By comparison, the space shuttles took 40 minutes to descend for landing.

The hottest temperatures Orion's heat shield will see occur less than 10 minutes before landing, 4 hours and 15 minutes into the flight. As its heat shield is put to the test, Earth's atmosphere will begin to slow the spacecraft down. Within five minutes, it will reach a speed of about 300 mph (480 kph) and have passed the extreme heating phase of the flight. This will allow the forward bay cover, which protects the capsule and its parachutes, to jettison, making way for the first two of the eight parachutes that further slow Orion's descent.

Orion's two drogue parachutes deploy first, at 22,000 feet (6,700 meters), and within a minute slow Orion to about 100 mph (160 kph) before being released. They are followed by three pilot parachutes that pull out the three massive main parachutes when Orion is still 6,500 feet (2,000 meters) above the Pacific Ocean. They finish the job and lower Orion to the ocean's surface at less than 17 mph (27 kph).

Recovery Operations

Before Orion launches on its flight test from Cape Canaveral Air Force Station in Flroida, the integrated team will embark aboard two ships, the U.S. Navy's amphibious ship, the USS Anchorage, and the Navy's salvage ship, the USNS Salvor, on the West Coast to prepare for Orion's recovery. The team is made up of U.S. Navy amphibious specialists, engineers and technicians from NASA's Ground Systems Development and Operations (GSDO) program at the agency's Kennedy Space Center in Florida, Johnson Space Center in Houston, and Lockheed Martin Space Operations.

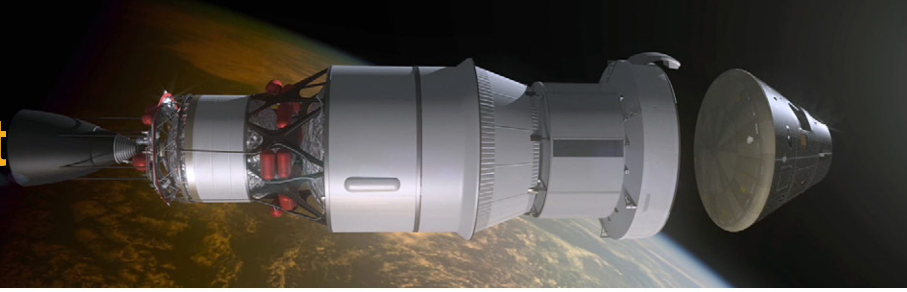
While the team waits for Orion to take flight, it will launch weather balloons from the deck of the Anchorage and monitor sea conditions. Before Orion's splashdown in the Pacific Ocean, helicopters will take off from the Anchorage'sdeck and fly out to help locate Orion as it makes its descent toward the ocean. After Orion's splashdown, the team will recover the crew module and attempt to recover hardware that was jettisoned, including the forward bay cover and parachutes.

Minutes after Orion splashes down, the crew module uprighting system will inflate to help rotate the spacecraft into a heads-up position, if needed.

U.S. Navy divers in Zodiac boats will check for any hazards around Orion. Then they will attach a sea anchor, load-distributing collar and tether lines to the crew module, and work to guide it to the ship's well deck.

The crew module will be winched into the flooded well deck of the USS Anchorage and placed on rubber shock absorbers. Water will be drained from the well deck, leaving Orion secure and dry. Once the ship starts the journey back to shore and reaches calm waters, the crew module then will be placed into its recovery cradle and readied for offloading.

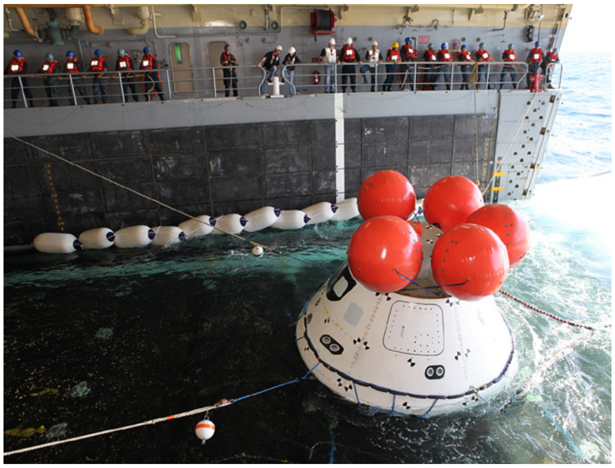
The USNS Salvor and rigid-hull inflatable boats will be used to secure and recover



Orion's forward bay cover and parachutes. The Salvor's cranes will be used to lift the forward bay cover and parachutes onto the ship deck. The crew module and jettisoned hardware will be transported from the landing site to a pier at the U.S. Naval Base San Diego. After the crew module is secured in the recovery transportation fixture, nicknamed the Armadillo, the Orion crew module and hardware will be transported by truck to Kennedy, where the crew module will be prepared for use in Orion's Ascent Abort-2 test.

The team also is prepared to use an alternative crew module recovery method in case Orion cannot be recovered using the USS Anchorage's well deck. At sea, a sling would be placed around Orion, and the stationary crane on the USNS Salvor would be used to lift the crew module up and onto the deck where it will be secured. In case of very turbulent sea conditions, the USNS Salvor could tow Orion along until calmer seas are reached, and it could be recovered.

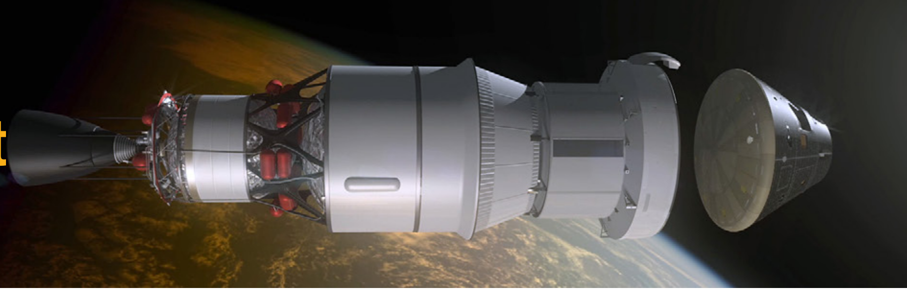
During future crewed Orion exploration missions propelled by NASA's Space Launch System rocket, the recovery procedures will be adjusted to allow for extraction of the crew members. NASA astronauts will remain inside Orion after splashdown and be removed once the craft is secured inside the well deck of the Navy ship. There, a platform will be moved into place after the water has drained from the deck, allowing the astronauts to climb out. They will undergo a thorough medical evaluation on the ship.



Several of the unique pieces of Orion recovery hardware were designed and developed by NASA and Lockheed Martin engineers and technicians at Kennedy. Lockheed Martin designed the cradle Orion will sit on inside the well deck. It will be used to secure Orion in the recovery ship and move it out of the ship after returning to port.

Building on 50 years of experience in spacecraft recovery operations, NASA's GSDO Program at Kennedy is helping the agency prepare for future human deep space exploration, and will play a key role in Orion recovery operations.

During NASA's Apollo Program, Launch Services Program rocket launches and all 135 space shuttle launches, NASA's expertise included deploying and leading complex integrated teams at off-site locations throughout the world, working hand-in-hand with military personnel (both foreign and domestic), developing and coordinating search and rescue efforts with the Department of Defense, and creating and implementing a recovery operations concept that is compatible with the unique spacecraft, payload hazards and requirements.



Vehicle Components

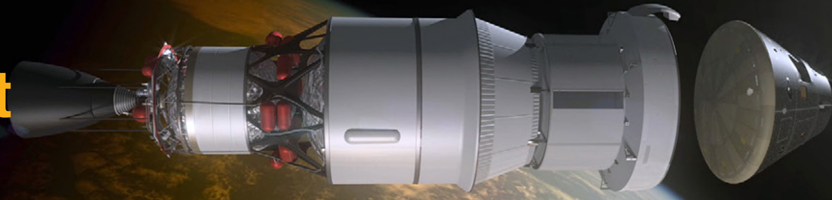
The Orion spacecraft is made up of four primary parts: the crew module, the service module, the launch abort system and the Orion-to-stage adapter. Each of those components is being tested on Orion's flight test. Overall, 55 percent of the Orion systems that will be required for the spacecraft's first crewed mission are being demonstrated for the first time in space on Exploration Flight Test-1.

Crew Module

Orion's crew module will protect future crews during launch, provide them an area in which to live and work in space, and return them safely to Earth at the mission's conclusion. It was built to support a crew of four for up to 21 days in space, but could also house a smaller crew for a longer period and up to six astronauts for either a shorter period or with the addition of a habitat module for extended missions.

The crew module is the only portion of Orion that returns to Earth at the end of the flight.

Its primary structure is made of aluminum and aluminum-lithium, with a friction-stir-welded pressure vessel covered in 970 tiles that make



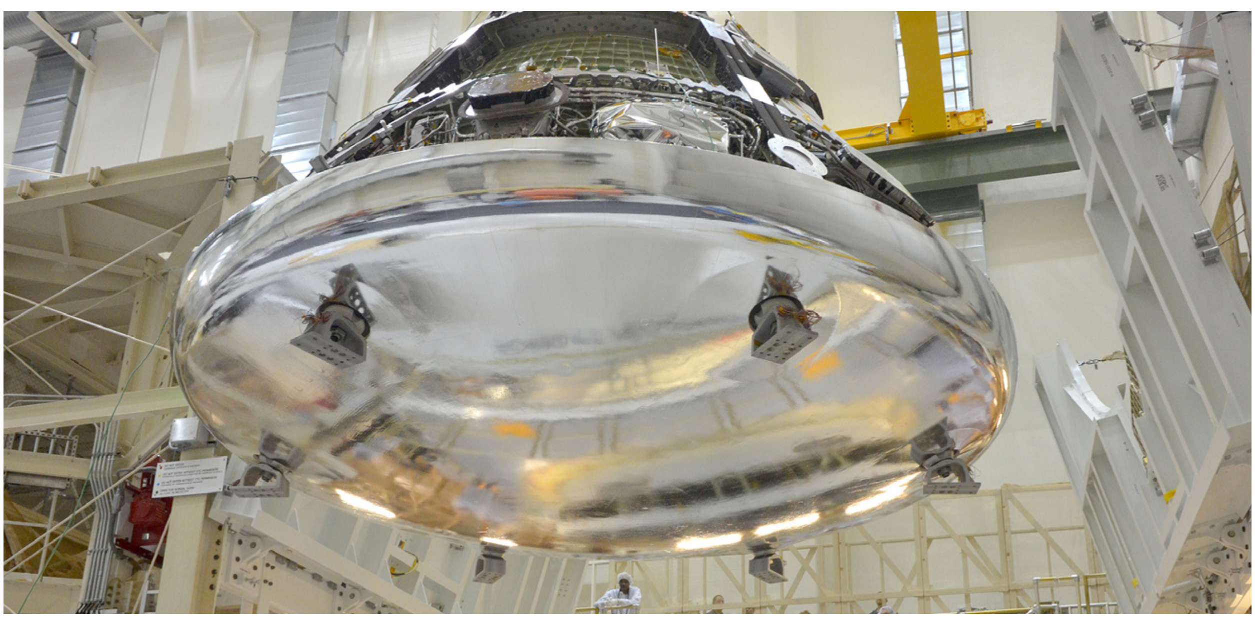
up Orion's back shell. The back shell tiles are almost identical to the tiles that protected the bellies of the space shuttle orbiters as they returned from space. Made of a low-density, high-purity silica fiber made rigid by ceramic bonding, the tiles will be called upon to protect the sides of Orion from temperatures up to 3,150 degrees Fahrenheit (1,732 degrees Celsius) on this test.

Temperatures will climb even higher at the bottom of the Orion capsule, which will be pointed into the heat as Orion returns to Earth. Protecting the spacecraft from those temperatures requires the largest, most advanced heat shield ever built.

The 16.5-foot (5-meter) diameter heat shield is built around a titanium skeleton and carbon fiber skin that give the shield its shape and provide structural support for the crew module during descent and splashdown. A fiberglass-phenolic honeycomb structure fits over the skin, and each of its 320,000 cells are filled with a material called Avcoat. Avcoat is designed to burn away, or ablate, as the material heats up, rather than transfer the heat back into the crew module. At its thickest, the heat shield is 1.6 inches (4 centimeters) thick, and about 20 percent of the Avcoat will erode as Orion travels through Earth's atmosphere.

On this first flight, Orion will face temperatures near 4,000 degrees Fahrenheit (2,200 degrees Celsius) during its return to Earth. That's about 80 percent of the peak heating it would see during a return from lunar orbit, in which temperatures could reach 5,000 degrees Fahrenheit (2,800 degrees Celsius), and enough to give engineers on the ground confidence in the heat shield design for future missions.

Once the heat shield has done its job, Orion's parachute system takes center stage. Throughout the flight, the forward bay cover on top of the crew module cone protects the parachutes from any damage in orbit and the heat of re-entry. After the spacecraft has safely made it through that heat, it is jettisoned to expose the parachutes, which begin deploying almost immediately. Including



the three parachutes that pull the forward bay cover away from the rest of the vehicle, 11 parachutes make up Orion's parachute system.

Once the forward bay cover and its parachutes are out of the way, two 23-foot (7-meter) parachutes called drogues deploy to stabilize and slow down the spacecraft. They unfurl at approximately 25,000 feet (760 meters), while the spacecraft is traveling more than 300 mph (480 kph), and are cut away after approximately 30 seconds, when the vehicle is still about 8,000 feet above the ground. They're followed by three pilot chutes that pull out the three, 116-foot (35-meter) main parachutes, which slow the vehicle down from 100 mph (160 kph) to less than 20 mph (30 kph) for splashdown.

For more stability, the main and drogue parachutes inflate in stages, with what are called "reefs" keeping the canopy of the parachutes bound until the proper time. This prevents the parachute system from putting too much stress on Orion by slowing it down too abruptly.

Almost all of the systems that will be a part of the crew module on a crewed flight are included in the Exploration Flight Test-1 crew module. In addition to the systems already mentioned, this first crew module includes electrical power storage and distribution; thermal control; cabin pressure control; command and data handling; communications and tracking; guidance, navigation and control; reaction control system propulsion and flight software and computers. The only crew module systems that will not fly on this vehicle are the environmental control and life support system; and the crew support systems such as displays, seats and crew-operable hatches.

Service Module

Orion's service module is designed to be the powerhouse that fuels and propels the Orion spacecraft in space. Located directly below the crew module, on future flights it will contain the in-space propulsion capability for orbital transfer, attitude control and high-altitude ascent aborts. It will also generate power using solar arrays and store it, and provide thermal control, water and air for the astronauts until just before their return to Earth, when it will separate from the crew module.

However, because Orion's first test flight lasts only 4.5 hours and does not include crew members, those functions are not needed in the first service module. Instead the service module flying on Exploration Flight Test-1, which was built by Lockheed Martin, will primarily provide a structural representation of the full service module. The full service module will be provided by the European Space Agency on Orion's first mission atop the Space Launch System, Exploration Mission-1.

This service module for the flight test will include ground cooling components, mass simulators and development flight instrumentation, as well as the separation mechanism needed to release the service module from the crew module before the crew module returns to Earth.

In addition, the service module on this and all future flights will be required to support the load of the crew module and launch abort system during the extreme stress of launch. The crew module and launch abort system together weigh more than 37,000 pounds (17,000 kilograms) at liftoff, and that load is multiplied by the forces exerted on the spacecraft during ascent. To support the weight and protect the service module from the heat, wind and acoustics it will experience during launch, three 14-foot by 13-foot panels (4-meter by 4.3-meter) – called fairings – surround the inner structure of the service module.

The fairings' job is done six minutes after launch, and each of those panels weighs more than 1,000 pounds (450 kilograms). So rather than carry them along for the rest of the flight, Orion jettisons them after reaching an altitude of about 560,000 feet (171,000 meters). To make that possible, six breakable joints and six explosive separation bolts are used to connect the fairing panels to the service module and each other. In a carefully timed sequence, the joints are fired apart, followed shortly by the bolts. Once all of the pyrotechnics have detonated, six spring assemblies push the three panels away, leaving the service module exposed as it travels on into space.

The service module fairing separation is one of 17 separations or jettisons that have to happen exactly as planned for Orion's first flight test to be successful.

Launch Abort System

Orion's launch abort system will make it the safest spacecraft ever built for humans. Positioned atop the crew module, it is designed to protect the capsule during ascent and pull it – with astronauts inside – away from a failing rocket on the launch pad or during the first few minutes of launch. On crewed missions, it will be able to activate within milliseconds to pull the capsule away and position it for landing.

The launch abort system can be divided into two parts: the fairing assembly, which is a

shell composed of a lightweight composite material that protects the capsule from the heat, wind and acoustics of the launch environment; and the launch abort tower, which includes the system's three motors.

Each of the three solid propellant rocket motors serves a different function:

- The abort motor would provide the force to pull the crew module away from the rocket in the event of an emergency. It is capable of producing about 400,000 pounds (181,000 kilograms) of thrust to propel the vehicle away from the launch pad. The 7,636-pound (3,464-kilogram) motor has enough force to lift 26 elephants off the ground.
- The attitude control motor uses a solid propellant gas generator with eight proportional valves equally spaced around its 3-foot (1-meter) diameter to steer the vehicle as it moves away from the launch pad. The 1,680-pound (760-kilogram) motor can exert up to 7,000 pounds (3,200 kilograms) of steering force in any direction.
- The jettison motor is the only motor on the launch abort system that will be used in every Orion launch, including Exploration Flight Test-1. Six minutes into a nominal flight, when Orion has made it through the most dangerous period of ascent, the 904-pound (410-kilogram) motor will ignite and pull the launch abort system – the fairing assembly and the launch abort tower – 300,000 feet (91,000 meters) away, allowing the crew and service module to continue on with the flight. In an emergency, it would fire once the crew capsule was safely away from the rocket, making way for Orion's parachutes to deploy and lower the spacecraft and crew to the ground.

Because there is no crew aboard Orion on this first flight, the jettison motor is the only one of the three that will be active. However, all three motors were tested during the Pad Abort-1 Test in 2010 and will be tested again during the Ascent Abort-2 test, set for 2018. During that test, the crew module built for Exploration Flight Test-1 will be reused on a first stage booster from a Peacekeeper missile modified by Orbital Sciences Corporation to demonstrate an abort under the highest aerodynamic loads it will experience during flight.

Orion-to-Stage Adapter

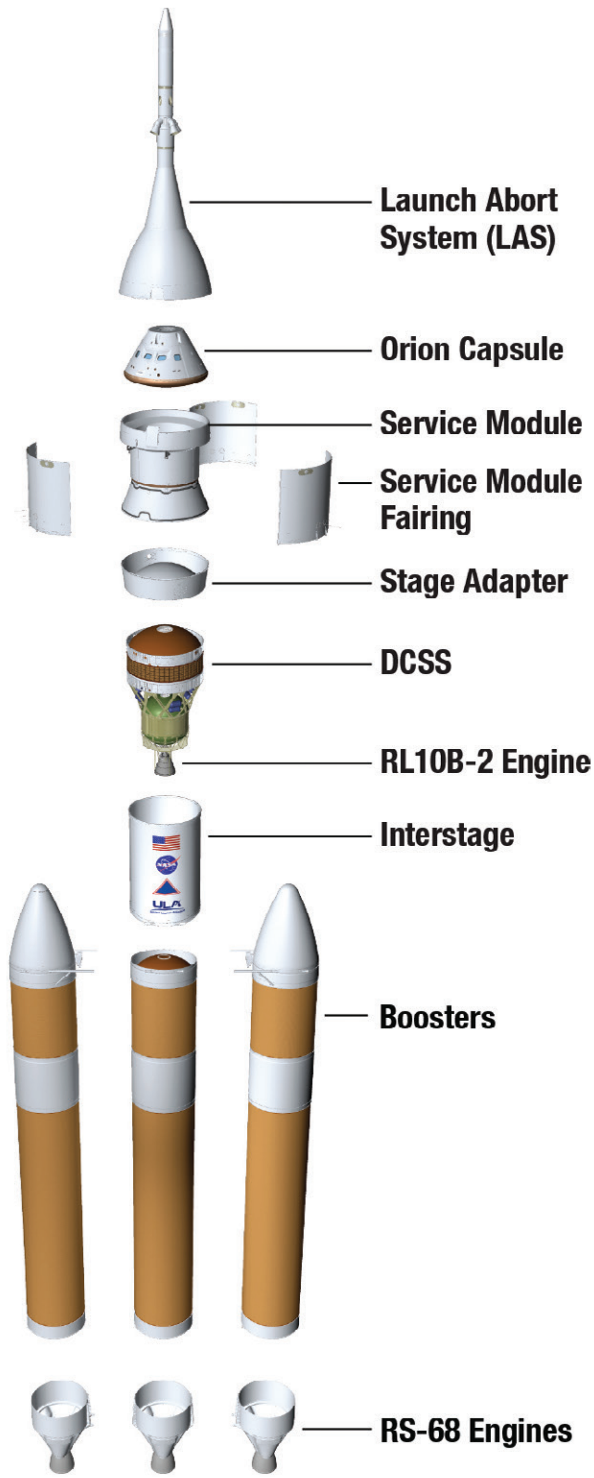
The Orion-to-stage adapter connects Orion's service module to the rocket below. In this case that is the Delta IV Heavy rocket, but in the future, the same design will connect Orion to the Space Launch System. The adapter provides structural support to Orion and electrical interfaces between the spacecraft and the rocket.

Delta IV Heavy Rocket

The Delta IV family of launch vehicles combines design simplicity, manufacturing efficiency, and streamlined mission and vehicle integration to meet customer requirements to launch high-priority U.S. Air Force, National Reconnaissance Office, NASA, and commercial payloads to orbit.

The Delta IV launch system is available in five configurations: the Delta IV Medium, three variants of the Delta IV Medium-Plus, and the Delta IV Heavy. For Orion's flight test, United Launch Alliance is providing a Delta IV Heavy.

Each configuration is comprised of a common booster core (CBC) and a cryogenic second stage. The Delta IV Heavy employs two additional CBCs to augment the first-stage CBC.

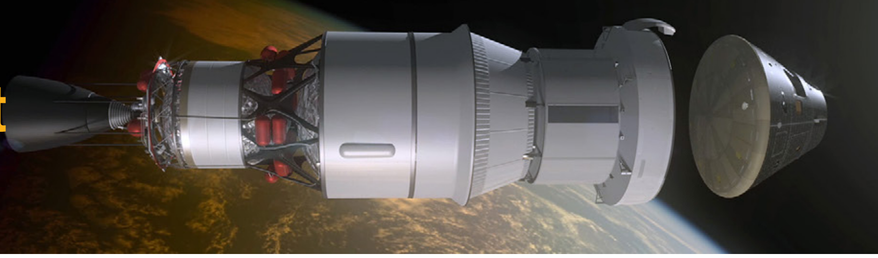


Delta Cryogenic Second Stage (DCSS)

The DCSS stage propellant tanks are structurally rigid and constructed of isogrid aluminum ring forgings and spun-formed aluminum domes. It is a cryogenic liquid hydrogen/liquid oxygen-fueled vehicle, and uses a single RL10B-2 engine that produces 24,750 pounds of thrust. The DCSS cryogenic tanks are insulated with a combination of spray-on and bond-on insulation, and helium-purged insulation blankets. An equipment shelf attached to the aft dome of the DCSS liquid oxygen tank provides the structural mountings for vehicle electronics.

Boosters

The Delta IV booster tanks are structurally rigid and constructed of isogrid aluminum barrels, spun-formed aluminum domes and machined aluminum tank skirts. Delta IV booster propulsion is provided by the RS-68 engine system, which burns cryogenic liquid hydrogen and liquid oxygen, delivering 663,000 pounds (301,000 kilograms) of thrust at sea level. Booster cryogenic tanks are insulated with a combination of spray-on and bond-on insulation and helium-purged insulation blankets. The boosters are controlled by the DCSS avionics system, which provides guidance and flight control.



Flight Objectives

NASA and Lockheed Martin established the following objectives for Orion's flight test:

1. Successfully launch and deliver Orion into the planned 115 by 552 mile orbit.
2. Demonstrate critical separation events during ascent and deorbit:

   a. service module fairing separation

   b. launch abort system jettison

   c. crew module/service module separation

   d. forward bay cover jettison
3. Demonstrate thermal protection system performance during a high-energy return, when Orion will travel near 20,000 mph (32,000 kph), generating 4,000 degrees Fahrenheit (2,200 degrees Celsius) on its heat shield and 3,150 degrees Fahrenheit (1,730 degrees Celsius) on its backshell.
4. Demonstrate descent, landing and recovery. A series of eight parachutes will slow Orion from about 300 mph (480 kph) to less than 20 mph (30 kph) when it will splash down in the Pacific Ocean and be recovered by a combined team of NASA, U.S. Navy and Lockheed Martin personnel.

Flight Personnel

Mission Operations

Mission Director/Mission Management Team Chair: Bryan Austin, Lockheed Martin

Flight Director: Mike Sarafin, NASA

Launch Conductor: Scott Barney, United Launch Alliance

Recovery Director: Jeremy Graeber, NASA

Program Management

NASA Orion Program Manager: Mark Geyer

Lockheed Martin Orion Program Manager: Mike Hawes

NASA Television Commentators

Host: Brandi Dean

Pre-launch commentator: Michael Curie

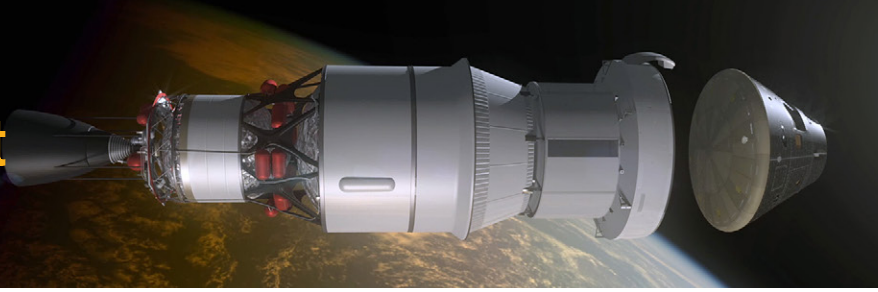
Flight commentator: Rob Navias

United Launch Alliance Delta commentator: Steve Agid

Orion's flight test is unique. Although Orion is a NASA program, the flight is managed and led by Orion prime contractor Lockheed Martin, and launched on a United Launch Alliance Delta IV Heavy rocket. Because of this, several teams of personnel will be involved in the minute-to-minute operation of Orion and differ from the personnel that will be involved in Orion's missions atop NASA's Space Launch System.

Mission Management Team

The Mission Management Team, chaired by Lockheed Martin's Mission Manager Bryan Austin, will provide oversight of Orion operations during the flight test. It is made up of program and operations managers from NASA and Lockheed Martin who provide expertise in various areas and will advise Austin during real-time decisions. If circumstances during the flight go beyond the scope of established launch commit criteria



or flight rules, the mission management team will decide how to respond.

In addition to Austin, the members of the Mission Management Team include the NASA and Lockheed Orion program managers; the NASA and Lockheed Martin safety officers; the NASA and Lockheed Martin chief Orion engineers; a flight test management officer; a Ground System Development and Operations Program officer for landing and recovery operations insight; a NASA flight operations assistant director; a Lockheed Martin mission success manager; a liaison to the Federal Aviation Administration Office of Commercial Space Transportation; and the Orion Director, a Lockheed Martin representative to the United Launch Alliance Delta Launch Team.

With the exception of the Orion Director and the flight operations director, the members of the Mission Management Team will be located inside the Mission Director's Center in Hangar AE at Cape Canaveral Air Force Station.

United Launch Alliance (ULA) Team

Led by Launch Conductor Scott Barney, the United Launch Alliance Team is responsible for activating and configuring the Delta IV Heavy rocket for launch. They will also lead the integrated countdown operations for the launch and are responsible for all powered phases of the flight, through the Orion crew module's separation from its service module and the Delta IV Heavy second stage. The Orion Director on the Mission Management Team will be NASA and Lockheed Martin's representative on the Delta Launch Team, reporting for Orion in the go/no-go polls the launch conductor will lead. ULA will make the final go or no-go decision for launch.

The ULA Team will be stationed in the Mission Director's Center and the Launch Control Center of the Delta IV Operations Center at Cape Canaveral.

Flight Control Team

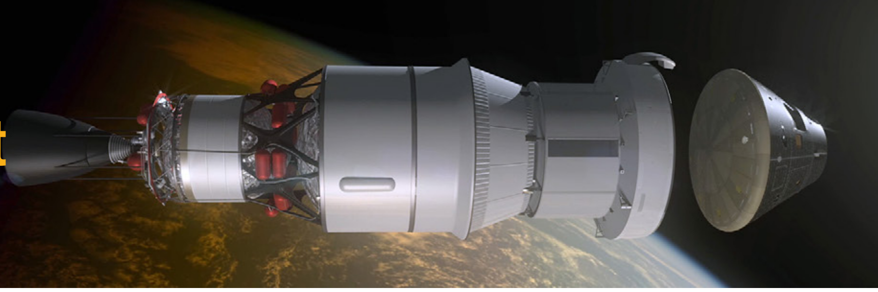
Responsible for monitoring Orion's flight performance, overseeing its real-time operations and sending commands to the spacecraft, the Flight Control Team, located at NASA's Johnson Space Center, will be led by NASA Flight Director Mike Sarafin. He will be the responsible authority for the spacecraft between liftoff and the post-splashdown handover to the Orion recovery team. Based on input from his 14-member team and on the landing weather forecast, Sarafin will provide a go or no-go decision for Orion's launch to the Mission Management Team and provide recommendations on operations outside the flight rules as needed.

Positions on the Flight Control Team include:

- Flight Dynamics Officer (FDO): responsible for the pre-launch heading alignment update and orbit and entry trajectory predictions
- Electrical Power System Officer (EPS): responsible for spacecraft electrical and mechanical systems
- Emergency, Environmental and Consumables Manager (EECOM): responsible for spacecraft pressure control and active thermal control systems
- Command and Data Handling (C&DH): responsible for the command and data handling system, including the flight control module, the on-board storage module, the Orion data network and portions of the power and data units

- Propulsion Officer (PROP): responsible for the propulsion system hardware and software
- Guidance Navigation and Control Officer (GNC): responsible for operations of the navigation hardware, including inertial measurement units, barometric altimeters and the GPS receiver and antennas
- Guidance Officer (GUIDANCE): responsible for the onboard navigation performance; launch vehicle and onboard navigation state vector quality assessments; guidance performance monitoring and associated flight test objectives evaluations; ground navigation processing and best state vector source determination; and the Mission Control Center contingency state vector update command
- Instrumentation and Communications Officer (INCO): responsible for Orion's communication systems, development flight instrumentation systems, video systems and recovery beacon; INCO will send all nominal and contingency commands to Orion
- Ground Control Officer (GC): responsible for ground data systems and data flows that interface with the Mission Control Center
- Weather Officer (WEATHER): responsible for providing landing and contingency weather forecasts, as well as sea state information; located in a supporting room in the Mission Control Center
- Landing Support Officer (LSO): responsible for relaying mission status and milestones to external interfaces, such as the State Department, the Department of Defense, the recovery team, NASA Headquarters and others as required

The Flight Control Team will operate from the Blue Flight Control Room in Johnson's Mission Control Houston, a room previously used for International Space Station operations.



Next Steps for NASA

NASA's missions, programs and projects are ensuring the United States will remain the world's leader in space exploration and scientific discovery for years to come, while making critical advances in aerospace, technology development and aeronautics. Here is what's next for NASA.

Exploration

NASA is designing and building capabilities to send humans farther into the solar system than ever before, including to an asteroid and Mars. On this Journey to Mars, NASA is developing the most advanced rocket and spacecraft ever designed. NASA's Orion spacecraft will carry four astronauts on missions beyond the moon, launched from Florida aboard the Space Launch System (SLS) — an advanced heavy-lift rocket that will provide an entirely new national capability for human exploration beyond Earth's orbit.

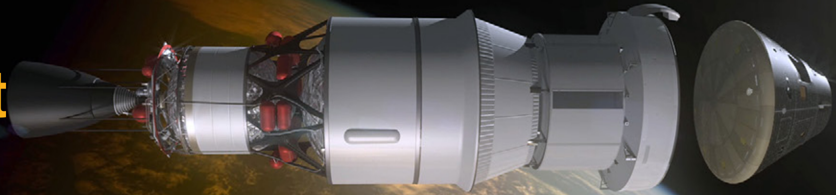
To help test other spaceflight capabilities to meet the goal of sending humans to Mars, including advanced propulsion and spacesuits, NASA is developing the Asteroid Redirect Mission – the first-ever mission to identify, capture and redirect a near-Earth asteroid to a stable orbit around the moon, where astronauts will explore it in the 2020s, returning with samples.

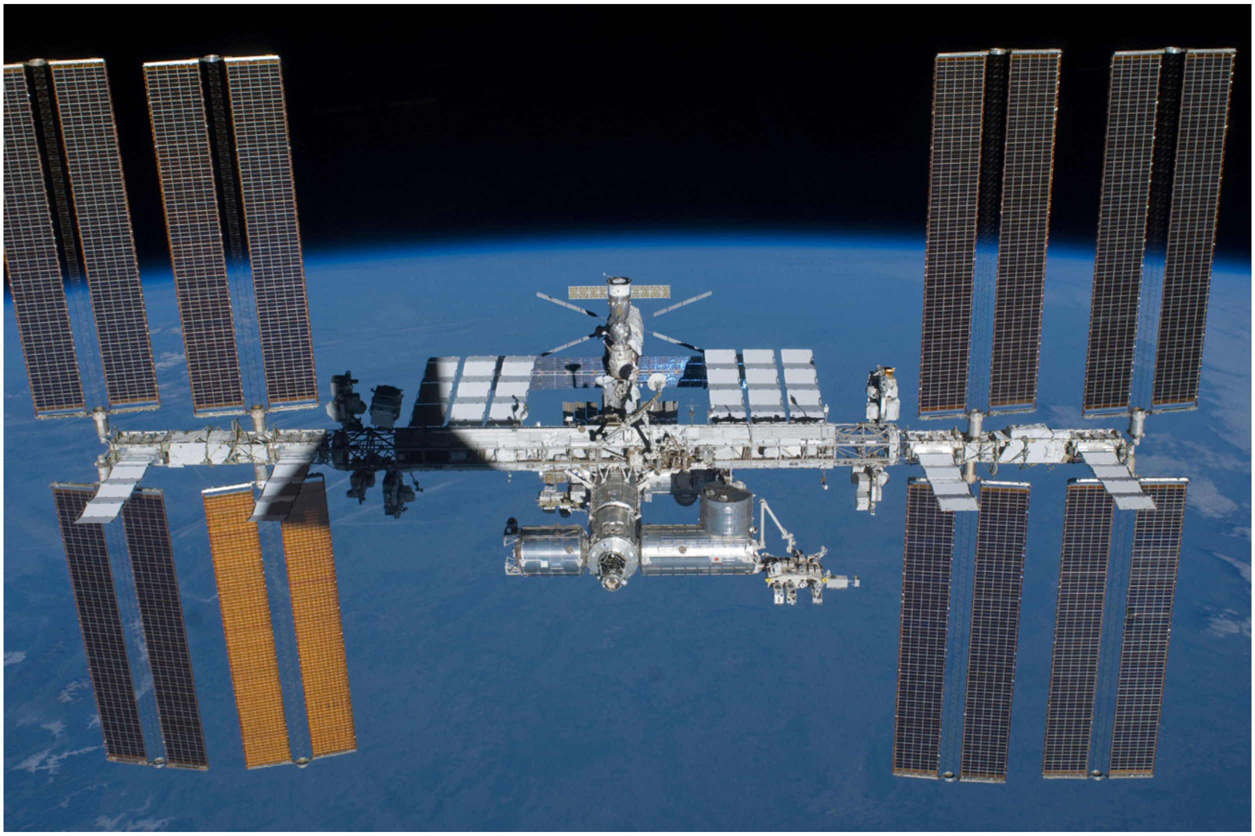
International Space Station

The human spaceflight Journey to Mars begins some 260 miles (420 kilometers) overhead, as astronauts aboard the International Space Station are working off the Earth for the Earth. The space station's microgravity environment makes research possible that can't be achieved on Earth, leading to breakthroughs in understanding Earth, space and physical and biological sciences.

By studying astronauts living in space for six months or more, NASA is learning how future crews can thrive on longer missions into the solar system. The space station also is a test bed for exploration technologies like autonomous refueling of spacecraft, advanced life support systems and human/robotic interfaces.

A portion of the space station has been designated a national laboratory, and NASA is committed to using this unique resource





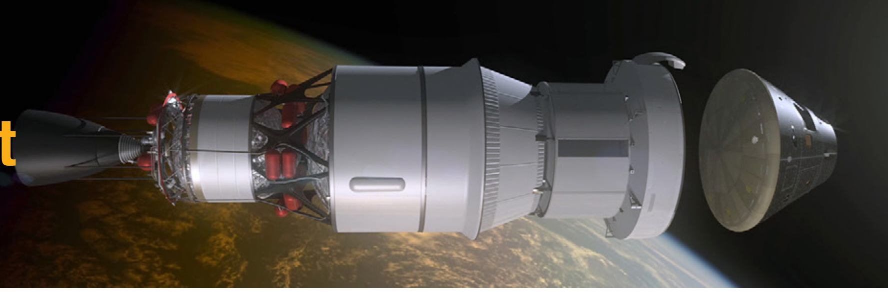
for wide-ranging scientific research. A new generation of U.S. commercial spacecraft and rockets are supplying cargo to the space station and soon will launch astronauts once again from U.S. soil, allowing NASA to expand its focus to build new capabilities for deep space exploration. As a blueprint for international cooperation, the space station enables a U.S.-led multinational partnership and advances shared goals in space exploration.

Aeronautics

NASA is with you when you fly. Every U.S. aircraft and air traffic control tower has NASA-developed technology on board. The agency is helping transform aviation further by dramatically reducing its environmental impact, maintaining safety in more-crowded skies, and paving the way to revolutionary aircraft shapes and propulsion.

NASA's aeronautics research also helps maintain U.S. leadership in aviation, which is a key economic driver for the nation, facilitating $1.5 trillion in economic activity each year, 11.5 million jobs, and transportation of 17.7 billion tons of freight.

From developing new air traffic management tools and designing quieter aircraft that fly at supersonic speeds, to writing innovative problem-solving software that improves aviation safety, NASA's legacy of nearly a century of aviation research continues.



Technology

Technology drives exploration. On Earth and in space, NASA is developing, testing and flying transformative capabilities and cutting-edge technologies for a new future of human and robotic exploration. We take emerging technologies and mature them, delivering innovative solutions that can improve our capabilities to explore, save lives and create economic growth.

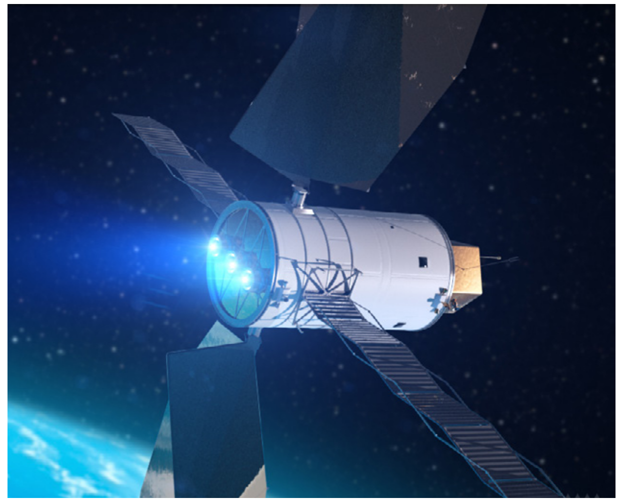
To help humans reach an asteroid and Mars, we'll continue to evolve technologies like advanced solar electric propulsion, large-scale solar sails, new green propellants, and composite cryogenic storage tanks for refueling depots in orbit. These new space technologies will increase our knowledge and spawn new capabilities to sustain our future missions.

Science

NASA is conducting an unprecedented array of missions that will seek new knowledge and understanding of Earth, the solar system and the universe.

We're studying Earth right now through spacecraft currently helping answer critical challenges facing our planet: climate change, sea level rise, freshwater resource depletion and extreme weather events. As an innovation leader in Earth and climate science, NASA is constantly expanding the view of our planet from space, with an exceptional team of experts and decades of innovative scientific and technical research.

The first human footsteps on Mars will follow rover tracks. A fleet of robotic explorers already is on and around Mars, dramatically increasing our knowledge about the Red Planet. The planet once had conditions suitable for life, making it a rich destination

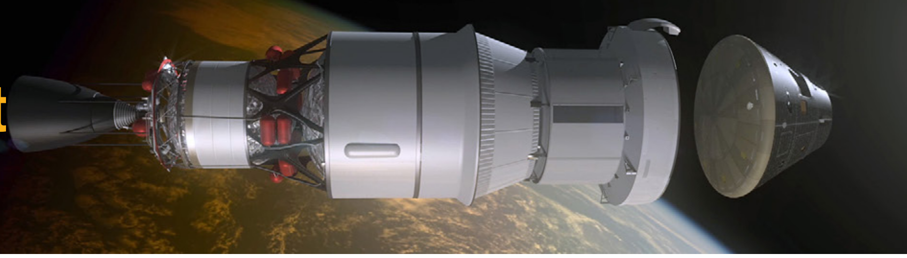


for scientific discovery and robotic and human exploration as we expand our presence into the solar system. The formation of Mars and its evolution are comparable to Earth, helping us learn more about our own planet's history and future. Future exploration could uncover evidence of life on Mars, unraveling one of the fundamental mysteries of the cosmos: Does life exist beyond Earth?

Multiple NASA missions are studying our sun and the solar system, unraveling mysteries about their origin and evolution. By understanding variations of the sun in real time, we can better characterize space weather, which can impact exploration and technology on Earth.

NASA telescopes also are peering into the farthest reaches of the universe and back to its earliest moments of existence, helping us understand the universe's origin, evolution, and destiny.

It's an exciting time at NASA as we reach for new heights to reveal the unknown and benefit humankind. See a list of NASA's current missions and find out what we're launching next!



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Additional Orion Multimedia Materials

More information about Orion and its flight test, including high resolution photo and video, can be found at: http://www.nasa.gov/orion.

The launch will be broadcast live on NASA Television and webcast at: http://www.nasa.gov/nasatv. Prelaunch coverage will begin at 4:30 a.m. EST on Dec. 4.

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