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Ares I First Stage

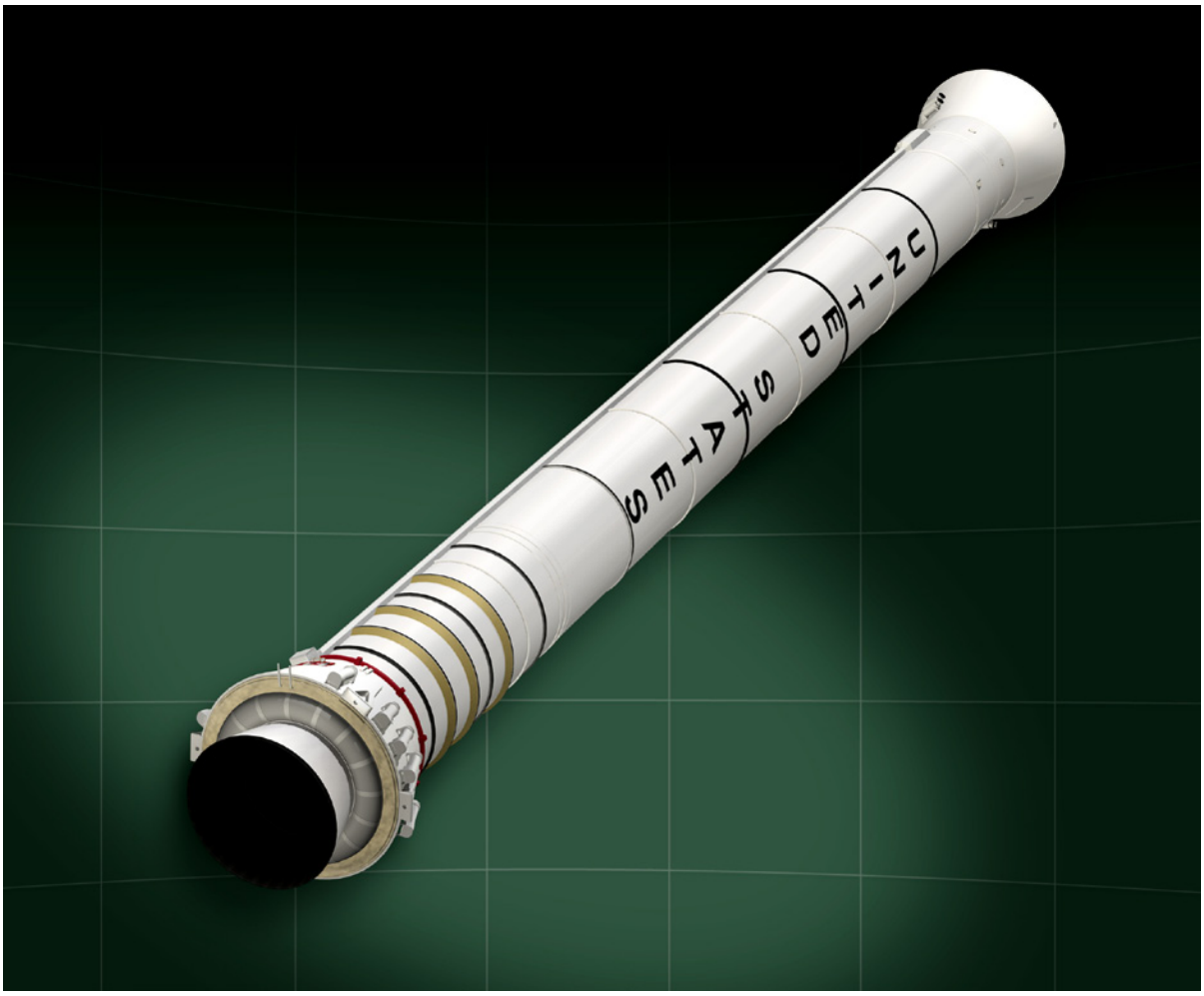
Powering NASA's newest rocket

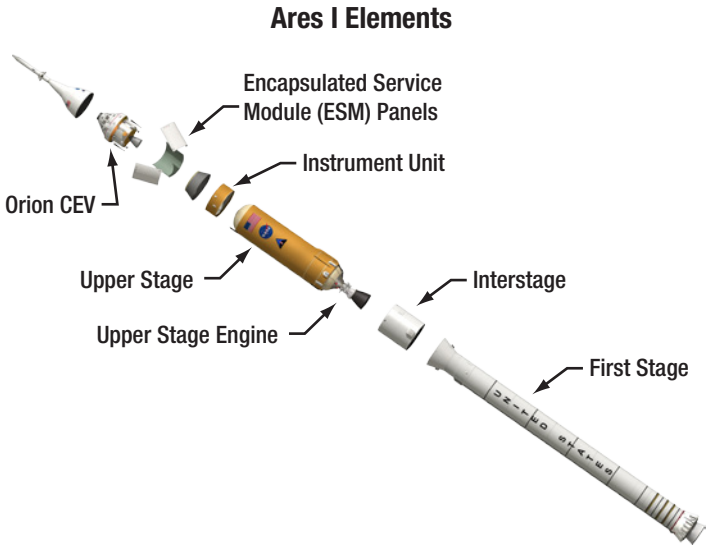
NASA's Ares I rocket is the flagship of America's next-generation space transportation system designed to deliver explorers to Earth orbit – supporting NASA's exploration goals for crewed missions back to the moon and beyond.

Starting in 2015, Ares I will carry the Orion crew exploration vehicle and its crew of four to six astronauts, or small cargo payloads, to the International Space Station.

Powering the launch vehicle – an in-line, two-stage rocket configuration – is the Ares I first stage element. The backbone of the integrated launch vehicle system, the first stage provides the main thrust or propulsion component, enabling liftoff from Earth.

Part of NASA's Constellation Program, the development of the Ares I first stage is led by the Ares Projects team at NASA's Marshall Space Flight Center in Huntsville, Ala., responsible for the design and development of the Ares launch vehicles. The Constellation Program is responsible for overall development of the crew capsule, launch vehicles and related systems needed to further humanity's reach throughout the solar system.





First Stage Components

The Ares I first stage is approximately 173 feet in length and is responsible for lifting the entire Ares I launch and crew vehicle stack – over two million pounds – off the ground toward Earth orbit.

The first stage element comprises a five-segment solid rocket booster. It includes a parachute recovery system, deployed for safe recovery of the booster and motor components for post flight evaluation and reuse. It has an aluminum aft skirt, which provides structural support for the vehicle. A forward skirt contains the avionics system and the forward skirt extension contains the main parachutes. The frustum, which is made of a composite material, interfaces with the upper stage and contains the aeroshell, which houses the pilot and drogue parachutes.

Five-Segment Solid Rocket Booster

The Ares I first stage element is derived from the space shuttle's solid rocket boosters. It uses a single five-segment solid rocket booster, compared to the shuttle which uses two, four-segment reusable solid rocket boosters.

The addition of a fifth booster segment on Ares I allows the launch vehicle to lift more weight and reach a higher altitude before the first stage separates from the upper stage, which ignites in mid-flight to propel the Orion spacecraft to Earth orbit.

The Ares I solid rocket motor burns a specially formulated propellant, polybutadiene acrylonitrile, or PBAN, which is poured into a shuttle derived steel case.

Similar in operation to the shuttle boosters and motors, the thrust or power needed to lift the launch vehicle off the ground is achieved by igniting the highly-configured propellant grain. The internal propellant configuration is created by pouring the propellant into an insulated and lined segment containing grain core tooling – like pouring cake batter into a mold, allowing it to solidify and then removing it. The final consistency of the cured propellant is similar to that of a pencil eraser. The propellant fins in the forward segment provide surface area to burn with a precisely controlled release of energy, or thrust. The added fifth segment on the Ares I solid rocket booster provides additional propellant mass and surface area to burn, providing even more thrust. This additional performance allows the launch vehicle to lift more weight, or more payload, and fly higher.

To accommodate the additional fifth segment, certain features of the shuttle reusable solid rocket motor will be modified to suit the Ares I first stage design. The motor's nozzle throat, for example, is three inches wider in diameter. The nozzle will be manufactured using similar metallic materials and will perform the same functions, such as gimballing – a pivoting or swiveling mount – to move the motor nozzle, allowing the motor to point in different directions to control the vehicle's flight path. The bigger nozzle throat allows the motor to handle the additional thrust from the five-segment booster, and meets NASA requirements to stay within the pressure capacity of the existing steel cases.

New insulation and rubber liner materials also are being used. These materials are more environmentally friendly and provide the thermal protection required for the steel case hardware.

ATK technicians inspect the new Ares I first stage forward casting core for the five-segment booster after delivery to ATK Space Systems in March 2008.

Avionics Systems

The first-stage avionics system comprises electronic components necessary to interface with the upper stage, communicate with ground operations and control other first stage booster functions. The system provides commands to various first-stage components, such as signaling for motor firing, recovery functions, separation firings, control of the thrust vector control system, and pre-launch test

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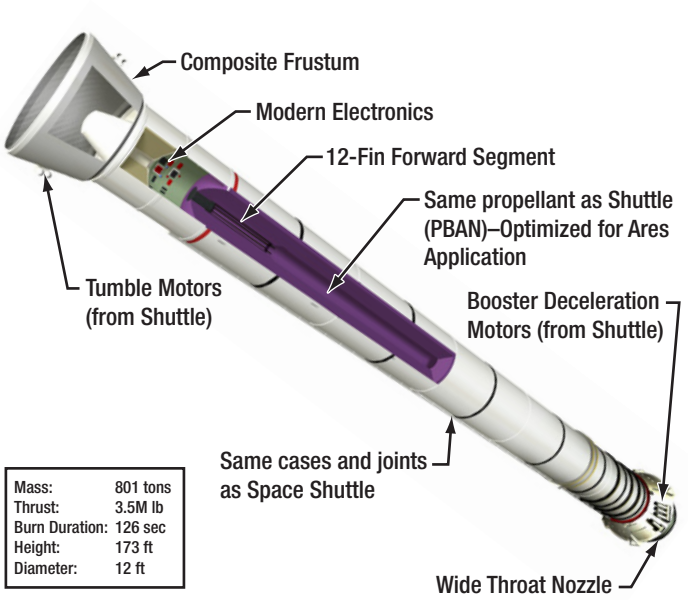


functions. The avionics also transmit flight-critical data, such as vehicle trajectory information, to the Ares I upper stage element. Ares I will incorporate a new avionics system that will use state-of-the-art technology and meet today's industry standards.

The first-stage avionics system will be similar to the shuttle booster electrical system in terms of function, meaning the system will perform the same kinds of tasks in a similar order. This includes such commands as those to initiate the booster separation sequence and parachute recovery system deployment sequence and for auxiliary power unit speed control. However, several key differences will be evident in the design and location of these systems.

The thrust vector control servo valve commands, which maneuver the motor nozzle to steer the rocket, are located in the forward section of the first stage. These same functions are found on the space shuttle orbiter.

All first-stage power will be provided by batteries located in the forward section of the booster. The aft skirt will include only one electrical function: the auxiliary power unit speed controller. The auxiliary power unit provides hydraulic power that enables the reusable solid rocket motor to gimbal – or fluidly point in different directions – to control the rocket's flight path. The controller monitors the hydraulic fluid supply for appropriate levels, pressure, flow and temperature, and regulates the speed of the power unit's pumps.

Ares I first-stage avionics also include a flight termination system, which allows for emergency destruction of an errant rocket to protect the public and ground facilities. The system design will use shuttle components but will extend the full length of the motor. Activation of the flight termination system would also be required in the event of an Ares I launch abort system initiation, which separates the Orion crew module from the launch vehicle and carries the astronaut crew to safety.

Launch Profile

The Ares I first stage launch sequence begins with engineers sending a signal commanding the thrust vector control startup and nozzle gimbal checkout. Ignition commands from the vehicle flight computers commit the vehicle to flight as electrical energy is routed from the first stage avionics to the motor igniter. The igniter then initiates the burn of the five-segment motor. As the motor burns, it builds up combustion along the surface of the propellant, which is then expelled out the nozzle, creating the thrust needed for liftoff. The vehicle's control system continuously monitors trajectory performance and issues guidance commands through the first stage avionics to the thrust vector control system to adjust nozzle vector angle.

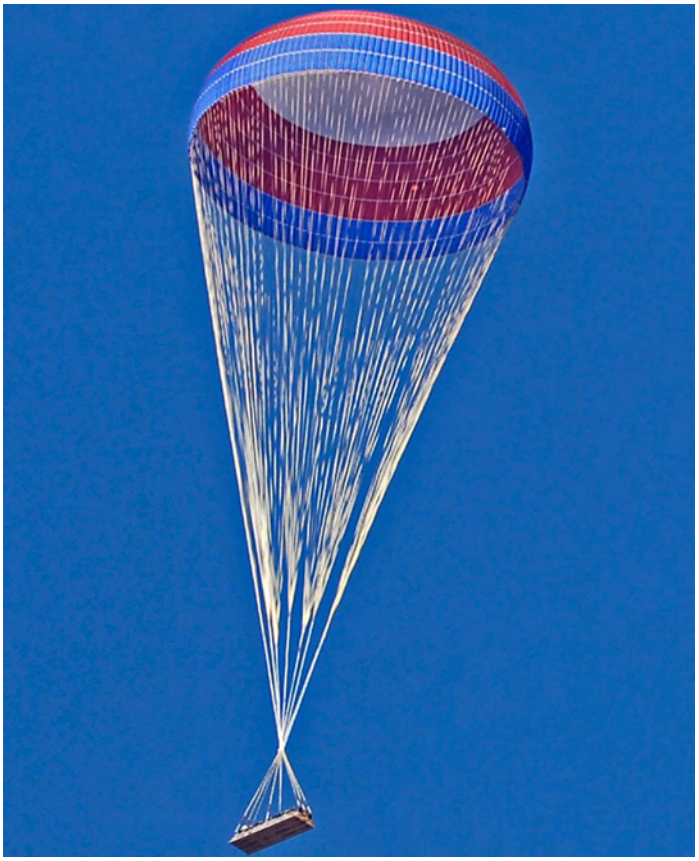
A space shuttle reusable solid rocket motor billows smoke and fire during a two-minute static test Nov. 1, 2007, at a Utah test facility. Image Credit: ATK

The first stage burns for approximately 126 seconds before separating from the launch vehicle's upper stage at an elevation of about 188,500 feet (36 miles). The upper stage's J-2X engine then ignites in mid-flight, propelling the launch vehicle to Earth orbit.

After separation, the first stage free falls back toward Earth. At approximately 15,000 feet, the booster's aeroshell, a protective heat shield, is ejected. This begins the parachute recovery system deployment sequence. The system – including pilot, drogue and main parachutes designed and developed by NASA – will deliver

the first stage booster and motor to water splashdown and recovery.

Because of the heavier weight and higher speed of the Ares I booster as well as its drop from a higher altitude, the launch vehicle's parachutes are much larger and stronger than those used for the space shuttle boosters. The first parachute to be deployed in the three-stage recovery system is the pilot parachute, measuring approximately 11.5 feet in diameter. As the pilot parachute deploys, it automatically releases the 68-foot-diameter drogue parachute, which is used to maneuver the booster into a vertical position and further slow its descent. Once the booster is slowed, a cluster of three main parachutes, each 150 feet in diameter, is deployed. The main parachutes continue to slow the booster prior to splashdown in the ocean.



NASA and industry engineers successfully completed the first drop test of the main parachute that will help recover the first stage of the Ares I crew launch vehicle.

Ares V Application

The Ares V heavy cargo launch vehicle, which will have its first launch late in the next decade, will launch the Earth departure stage and Altair lunar lander into orbit. At liftoff, Ares V will use two solid rocket boosters attached to a core stage powered by six RS-68B liquid-fuel engines.

The two five and a half segment solid rocket boosters will help propel the 8.2 million-pound Ares V into orbit. When the boosters' PBAN propellant is expended, they will be jettisoned into the ocean and recovered, like the Ares I first stage.

Summary

The Ares Projects are managed by the Marshall Center for NASA's Exploration Systems Mission Directorate in Washington. The projects office answers directly to the Constellation Program Office, located at NASA's Johnson Space Center, Houston.

The Ares I effort incorporates project teams, hardware development, evolution of proven technologies and component and system testing at NASA centers and contract organizations around the nation.

ATK Launch Systems of Brigham City, Utah, is the prime contractor for Ares I first stage.

For more information on the Web about the Ares I launch vehicle and the Ares V cargo launch vehicle, visit:
www.nasa.gov/ares

For more information on the Web about the Constellation Program, visit:
www.nasa.gov/constellation

For more information on the Web about NASA programs and projects, visit:
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