# ARCHIVED REPORT

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# Ares V (Cargo Launch Vehicle)

## Outlook

- Ares I-X launched in October 2009
- FY 2011 NASA budget request proposed terminating the Constellation program, and with it, the Ares V launch vehicle
- NASA proposal to cancel Constellation program met with stiff resistance in Congress
- NASA will study technologies for a future heavy-lift launch vehicle with the goal of beginning development in 2015

## Orientation

**Description.** Ares V is the next-generation U.S. heavy-lift unmanned cargo launch vehicle.

**Sponsor.** The Exploration Launch Projects Office at NASA's Marshall Space Flight Center, Huntsville, Alabama, manages efforts on the Ares V. Marshall reports to the Constellation Program Office at Johnson Space Center, Houston, Texas.

**Status.** Development of the Ares V has been cancelled. NASA hopes to begin development of a heavy-lift launch vehicle by 2015.

**Total Produced.** None

**Application.** The Ares V is the unmanned heavy-lift Cargo Launch Vehicle (CaLV), which was to be used for NASA's Constellation Program. The Constellation Program, which was cancelled in 2010, intended to send humans to the Moon, Mars, and beyond. The rocket was being designed to lift an estimated 188 metric tons to low-Earth orbit. The upper stage of the Ares V is the Earth Departure Stage (EDS), which will house a Lunar Surface Access Module (LSAM). The EDS will rendezvous with Orion (the Crew Exploration Vehicle) in orbit and will take the craft out of Earth orbit.

**Price Range.** Some estimates put the cost of an Ares V launch between $300 and $400 million.

## Contractors

### Prime

| | |
|---|---|
| **Marshall Space Flight Center, MSFC** | http://www.msfc.nasa.gov, Bldg 4200, Rm 120, Huntsville, AL 35812 United States, Tel: + 1 (205) 544-2121, Fax: + 1 (205) 544-5852, Prime |

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## Subcontractor

| | |
|---|---|
| **Alliant Techsystems - Aerospace Systems, Aerospace Structures** | http://www.atk.com, 1700 North Research Park Way, Logan, UT 84341 United States, Tel: + 1 (435) 753-8565 (RS-68 Nozzle) |
| **Alliant Techsystems - Armament Systems** | http://www.atk.com, 938 University Park Blvd, Clearfield, UT 84015 United States, Tel: + 1 (763) 712-7700, Email: businessdevelopment@atk.com (Five Segment SRBs) |
| **Pratt & Whitney Rocketdyne** | http://www.pratt-whitney.com, 6633 Canoga Ave, Canoga Park, CA 91309 United States, Tel: + 1 (818) 586-3829, Fax: + 1 (818) 586-6155 (J-2X Upper Stage Engine; RS-68 Engine) |

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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

# Technical Data

**Design Features.** Ares V was planned to be the most capable heavy-lift launch vehicle ever created. The design was intended to incorporate updated technology from the Saturn V rocket, as well as components derived from the Space Shuttle fleet. The new launch vehicle, a vertically stacked two-stage rocket, will more closely resemble the 364-foot Saturn V than the aging Space Shuttle. Standing approximately 360 feet tall, Ares V will lift more than 414,000 pounds into low-Earth orbit, compared with the Space Shuttle's payload capacity of 53,800 pounds.

Ares V design features six RS-68 engines and two five-and-a-half-segment SRBs, enabling the Ares V to be able to send 71 metric tons to the Moon. The Pratt & Whitney Rocketdyne RS-68 engines are currently used on the Delta IV to power its main stage. The use of six of these engines would have made Ares V the largest and most powerful liquid oxygen/liquid hydrogen rocket stage ever developed. Modifications to the Ares V engines included regeneratively cooled nozzles, LH2 propellant densification, and a number of other changes that will increase the thrust and specific impulse (Isp) of the engines while reducing overall cost. RS-68 engines have a simplified design and use fewer parts than engines of equivalent size and performance. Though the RS-68 requires more propellant than the Space Shuttle Main Engine (SSME), it produces 650,000 pounds of thrust at sea level, an increase of more than 50 percent compared with the SSME.

Attached to the main stage will be two reusable five-and a-half segment solid rocket boosters (SRBs), which are based on the four-segment SRBs used on the Space Shuttle. The solid propellant will be shaped differently from the Space Shuttle's boosters in order to provide the optimum thrust characteristics for the Ares V missions. The Ares V SRBs were similar in configuration to the single SRB that will serve as the first stage of the Ares I crew launch vehicle.

The upper stage of an Ares V, also referred to as the Earth Departure Stage (EDS), would have housed the Lunar Surface Access Module (LSAM). The LSAM, based on the Apollo Lunar Module, was the planned lunar landing vehicle of the Constellation Program, and was planned to carry the entire four-man Orion crew to the surface of the Moon. The EDS was to be powered by a single Pratt & Whitney Rocketdyne J-2X engine, an updated version of two historic engines: the J-2 used on the Saturn V upper stage during the Apollo Moon missions in the 1960s and 1970s, and the J-2S, a simplified version of the J-2 developed and tested in the early 1970s but never flown. The J-2X featured a channel-walled main combustion chamber, and it is currently being examined for possible upgrades to improve performance.

A typical manned lunar mission would require separate launches of the Ares I and Ares V. An Ares V would be the first to launch, placing the EDS into low-Earth orbit. An Ares I would launch the Orion spacecraft within a few weeks to meet up with and dock to the orbiting EDS. Once together, the EDS would fire its J-2X engine to achieve escape velocity. Following the burn, the EDS would be jettisoned, leaving the crew on its way to the Moon.

Missions to Mars would have the same structure, though the details have yet to be worked out. The missions would require multiple Ares V launches to lift the required hardware for such an extensive mission. One proposed theory would consist of cargo being delivered directly to Mars prior to crew departure. Another envisions an EDS refueling from an in-orbit refueling station, where it would become a Mars transit vehicle.

Ares V (Cargo Launch Vehicle)

| | Metric | U.S. |
|---|---|---|
| **Dimensions** | | |
| Total rocket length | 109 m | 358 ft |
| Core stage diameter | 10 m | 33 ft |
| **Weight** | | |
| Gross liftoff weight | 3.35 million kg | 7.4 million lb |
| **Performance** | | |
| Payload to LEO | 188,181 kg | 414,000 lb |
| Payload to lunar orbit | 71,363 kg | 157,000 lb |

**Propulsion**

| | | |
|---|---|---|
| Stage 1 | (2) | Five-and-a-half segment reusable SRBs |
| | (6) | Modified RS-68 engines |
| Stage 2 | (1) | J-2X engine |

Artist's Depiction of the Ares V

Source: NASA

# Variants/Upgrades

**Ares I.** Also known as the Crew Launch Vehicle (see separate Ares I report in this tab).

# Program Review

**Background.** In January 2004, U.S. President George W. Bush announced the Vision for Space Exploration (VSE), which outlined a plan to return humans to the Moon, and eventually to travel to Mars and beyond. These ambitious goals called for the development of a replacement for the aging Space Shuttle, which is limited to low-Earth orbit missions.

In response to this plan, NASA launched an Exploration Systems Architecture Study (ESAS), which lasted from

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May to July 2005. The purpose of the agency-wide study included the following:

- assess plans regarding development of a new Crew Exploration Vehicle (CEV) to replace the Space Shuttle and provide access to the International Space Station (ISS)
- define requirements and configurations for crew and cargo launch systems for missions to the Moon and Mars
- develop a conceptual exploration architecture for sustained human and robotic lunar operations
- identify key technologies and investment strategies to support and improve such an architecture

A finalized report with NASA's findings was published in November 2005, outlining NASA's implementation of the VSE. A roadmap was created for the Constellation Program that would allow for the completion of the International Space Station, accelerated lunar missions, and eventual voyages to Mars. The new family of spacecraft for Constellation would include a new Crew Exploration Vehicle to replace the shuttle, a Crew Launch Vehicle (CLV) to launch the CEV into orbit, and a Cargo Launch Vehicle (CaLV) to carry up the tremendous payloads needed for trips beyond Earth orbit. When looking at potential spacecraft to use for the program, NASA tried to adhere to the slogan, "Safe, simple, soon." Each principle would be essential to allow for manned missions to continue soon after the retirement of the shuttle in 2010.

### *NASA Reviews Multiple Launcher Designs*

A number of CaLV design options were considered in the ESAS. The study required that any mission beyond Earth orbit would require a maximum of four launches, meaning the CaLV would have to be capable of lifting a minimum of 70 metric tons. A 1.5- or 2-launch scenario would require 100- to 125+-metric-ton capacity. One option the study examined was the Evolved Expendable Launch Vehicle (EELV) powered by RD-180 or RS-68 engines, with core diameters of 5.4 and 8 meters. It was determined that RS-68 powered EELVs would require the development of a new upper stage, as well as the use of a new liquid strap-on booster or shuttle reusable SRBs. The cost and complexity of development was deemed too high, eliminating the RS-68 powered EELV from the race. An RD-180-powered vehicle would be more feasible and would be capable of lifting the necessary loads to LEO. However, such a vehicle would have restricted Earth-escape performance due to a low liftoff thrust-to-weight ratio.

The ESAS also looked at two Shuttle-Derived Launch Vehicles (SDLVs) in hopes that shuttle technology would speed up development and reduce the overall cost. One option looked similar to today's shuttle, with the Orbiter being replaced by a side-mounted expendable cargo vehicle. It was determined that this side-mounted variation would require more than four launches for a lunar mission and would be unsuitable for the much larger payloads needed for future Mars missions.

The second SDLV NASA considered was an in-line rocket, similar in design to the historic Saturn V. Three engine configurations were proposed: the smallest using four-segment SRBs and three SSMEs, which would require three launches for a lunar mission; an upgraded configuration using five-segment SRBs and four SSMEs; and the largest configuration equipped with five-segment SRBs and five SSMEs.

### *NASA Selects a New Rocket*

NASA decided to pursue the in-line launch vehicle. It was estimated that design, development, testing, and evaluation (DDT&E) costs for the in-line option would be higher than the side-mounted vehicle, but that per-flight costs would be reduced. This made the in-line SDL more cost effective overall. The largest engine configuration for the rocket was recommended, because it could provide stage-and-a-half cargo lift capability for lunar missions.

The original design for the CaLV incorporated the same 27.5-foot-diameter propellant tank used by the shuttle, with two five-segment SRBs on each side. The SRBs would be a similar configuration as those used on the shuttle, with an extra segment inserted in the center of the booster. The SSMEs in the core stage were RS-25s. The Earth Departure Stage (EDS) was planned to use two J-2S+ engines encompassed in a 27.5-foot-diameter housing.

### *NASA Changes Ares Design*

In May 2006, NASA announced that it would no longer be using the SSME for the CaLV. Instead, the rocket would be equipped with five modified RS-68 engines, which were currently being used on the Delta IV. The RS-68 is a much simpler design than the RS-25, and it can produce up to 55 percent more thrust. What sealed the deal for NASA was that a single RS-68 has a cost of approximately $20 million compared with the $80 million for the SSME. The larger RS-68 engines would require more propellant than the SSMEs, leading NASA to increase the diameter of the core propulsion stage tank from 27.5 feet to 33 feet.

Second Stage Design Change. The core stage engine change required subsequent alterations to the EDS engine configuration. The two J-2S+ engines previously planned would be replaced with a single

J-2X, which would be the same engine used in the CLV upper stage. Following the announcement of the new design in May 2006, NASA began a five-month series of tests on the J-2X at the Marshall Space Flight Center. Tests took place on subscale main injector hardware, producing approximately one-thirteenth the thrust level of a full-scale J-2 engine. The injector was fired from a horizontal position with a number of fuel temperatures and propellant mixture ratios. Each test lasted between 10-20 seconds and produced 20,000 pounds of thrust. The A-1 test stand at NASA's Stennis Space Center in Mississippi is expected to be modified to support future tests of the J-2X.

Pratt & Whitney also announced in August 2006 that a new program office was being formed to carry out all development activities associated with the new engine.

New Rockets Named. The new Constellation launch vehicles did not receive their official names until June 2006. From its immense list of potential titles, NASA eventually designated the CaLV as Ares V and the CLV as Ares I. Those names have special meaning for NASA. Ares, another name for Mars, represents the launch vehicles' overarching goal of launching humans to the Red Planet. The Roman numerals I and V were used in honor of the Saturn I and Saturn V rockets, the first rockets designed and developed specifically for human spaceflight. The names represent a combination of old and new, which is the basis for the design of the rockets themselves.

### *GAO Unhappy with NASA's Constellation Business Plan*

In a report published in July 2006, the Government Accountability Office (GAO) expressed concern over the true benefits of human space exploration, citing the loss of life, unsuccessful missions, and unforeseen cost overruns in recent history. The GAO's most urgent concern was the contract for CEV – given the name Orion in August 2006 – which was to be awarded in September to either Lockheed Martin or a team made up of Northrop Grumman Corp and The Boeing Co. The GAO recommended modification of the CEV acquisition strategy and a reassessment of NASA's business plan regarding the CEV and the implementation of the VSE. NASA was confident in its direction, however, and awarded the CEV contract to Lockheed Martin in August 2006.

The decision to award the Orion contract demonstrates NASA's sincere interest in the timing and success of the Constellation Program. NASA's hope for Ares I is to launch humans into space no later than 2014, with a manned Moon landing using Ares V no later than 2020.

In its proposed Fiscal Year 2011 budget submitted to Congress in February 2010, the Obama administration is terminating the Constellation Program. As part of the Constellation, the Ares V will be cancelled as well.

## Funding

Funding for the Ares V (CaLV) Project falls under the Constellation Systems Program, which is located in the Constellation Systems Theme. The Constellation Systems Theme is part of the Exploration Systems Mission Directorate.

Beginning in FY11, there is no funding line for Ares V (Cargo Launch Vehicle). According to NASA's FY11 budget request, funding in the Constellation Program provides for transition and closeout activities. NASA has allocated $2.5 billion between FY11 and FY12 for Constellation Transition costs.

## Timetable

| Month | Year | Major Development |
|---|---|---|
| Jan | 2004 | President George W. Bush announces VSE |
| Nov | 2005 | ESAS final report published; outlines initial launch vehicle goals |
| Jan | 2007 | Ares I System Requirements Review |
| Apr | 2008 | Ares I Preliminary Design Review |
| Oct | 2009 | Ares I-X test flight |
| Feb | 2010 | FY11 NASA budget proposes Constellation termination |

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# Forecast Rationale

NASA announced it would develop a new strategy to develop deep space with the release of the FY11 budget request in February 2010. The Ares V, which was to be the heavy lift launch vehicle of the future will have no place in the new plans. Instead, NASA will rely on commercial companies to transport humans into low earth orbit. The agency will also investigate a broad scope of R&D activities to support next-generation space launch propulsion technologies and heavy-lift launch vehicles, rather than focusing its resources on developing a single vehicle.

Based on a 2005 analysis by the Congressional Research Service (CRS), the cost of developing and flying the new Crew Exploration Vehicle (CEV) to the Moon would total $24 billion. A companion craft that could set down on the Moon by 2020 would cost an additional $40 billion. The figures include the cost of developing rocket boosters to launch both. NASA has already spent an estimated $9 billion on development of the Constellation.

In 2009, the Review of U.S. Human Spaceflight Plans Committee released its final report. The report said that plans at the time were unsustainable at then-current funding levels. In addition, the committee estimated that delays in the Orion program will mean the CEV will not be ready to transport humans to the space station until the station has already ceased operations.

Budget constraints, along with the findings of the Human Spaceflight Committee, forced NASA to reconsider the Constellation program, and with it, the Ares V launch vehicle. Instead, NASA will contract private companies to send humans into low earth orbit. These missions will not require a heavy lift vehicle, such as the Ares V. NASA officials say they have not abandoned exploration of deep space, and will require a heavy-lift launch vehicle in the future. However, for the time being, the agency will focus on a wide range of R&D activities as well as more foundational research, such as basic propulsion research.

NASA's new plan has met with strong resistance from many members of Congress, who are opposed to giving up an "in-house" manned space program. They site the loss of jobs and U.S. international leadership in space activities as major reasons to maintain the Constellation program. The White House has promised its opponents that NASA will begin development of a new heavy-lift launch vehicle by 2015, minimizing as much as possible the amount of time the U.S. will go without a government-owned human transport and deep-space exploration capability. To begin the process of researching new technologies, NASA issued a Broad Agency Announcement in June 2010, seeking proposals and industry input on future heavy-lift launch vehicles and propulsion technologies. Companies that submit proposals could be awarded contracts worth up to $625,000 to begin studies.

No Ares V launch vehicles are forecast to be produced during the next 10 years. The debate between Congress and the White House over NASA's budget is still to be determined, but the outlook for the Ares V is not good. NASA has promised to begin work on a heavy-lift launch vehicle, but it will not be the Ares V.

# Ten-Year Outlook

No Ares Vs are expected to be produced during the next 10 years.

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