A Brief History of the Ares Projects
2003 to 2008

2003
Examining America's Commitment to Human Space Exploration

After seven months of investigations, the Columbia Accident Investigation Board (CAIB) issued Volume 1 of the CAIB Report in August 2003. This investigation addressed the causes of the February 2003 accident and examined the culture and goals of American's space program. On page 6, the report said, "We sought to discover the conditions that produced the tragic outcome and to share those lessons in such a way that the nation's space program will be stronger and more sure-footed. If those lessons are truly learned, then Columbia's crew will have made an indelible contribution to the endeavor each one valued so greatly."

The board emphasized that a public debate was needed to decide the future of human space exploration. The report stated, "The loss of Columbia and her crew represents a turning point, calling for a renewed public policy debate and commitment regarding human space exploration. One of our goals has been to set forth the terms of that debate." The CAIB report and related documents can be downloaded at http://www.nasa.gov/columbia/caib/html/start.html

2004
Setting a New Path for Space Exploration

In January 2004, President George W. Bush addressed the CAIB findings on the vision for human space exploration with a new U.S. Space Exploration Policy. This policy directed NASA to return astronauts to the Moon by 2020 in preparation for eventual human exploration of Mars. Other goals included

- finish building the International Space Station
- retire the Space Shuttle in 2010
- build and fly a new crew exploration vehicle no later than 2014.

Although the policy included target dates, it stressed space exploration should be a journey, not a race. The policy called *A Renewed Spirit of Discovery, the President's Vision for U.S. Space Exploration* said, "The fundamental goal of this

vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program."

This vision and the possibilities it suggested energized the NASA workforce. Employees at Marshall Space Flight Center could be heard to say it was their generation's time to contribute new vehicles and technologies for space exploration. Many had worked on advanced transportation concepts and technologies throughout the 1990s. Much of what they had learned could be applied to the new efforts. They had also learned what would not work or would be too costly to develop under NASA's planned budgets.

2005
Developing a Space Exploration Architecture

Based on the successes and failures of past programs, NASA reorganized to implement these new goals and objectives. The agency formed the Exploration Systems Mission Directorate (ESMD) and the Constellation Program. These groups set out to develop the architecture, or plan, for space exploration and a strategy for meeting the plan's goals. ESMD funded definition studies to determine what vehicles and technologies could best accomplish the new policy goals.

In 2005, Congress endorsed the new U.S. Space Exploration Policy. They also approved funding in the 2005 NASA Authorization Bill, giving the program an even greater foundation of support. That year, Congress confirmed a new NASA Administrator, Dr. Michael Griffin, who had an extensive background in both commercial and governmental aerospace endeavors. He commissioned the Exploration Systems Architecture Study (ESAS), which built on numerous prior studies. A team of experts from across NASA analyzed thousands of potential vehicles including Shuttle-derived launch vehicles and expendable launch vehicles. Subsequently, they recommended an approach for delivering human-rated systems within the target timeline and budget guidelines. The ESAS study can be downloaded at
http://www.nasa.gov/directorates/esmd/news/ESAS_report.html

Steve Cook from the Marshall Center was the ESAS Deputy Study Manager. In 2005 after the study, NASA selected Cook as the project manager for NASA's Exploration Launch Projects, which later became the Ares Projects. This organization is developing the Ares I crew launch vehicle and the Ares V cargo launch vehicle. These vehicles are based on the concepts recommended by the ESAS study.

The Ares Projects are part of the Constellation Program, which is developing technologies and a fleet of vehicles, including the Orion crew exploration vehicle and the Altair lunar lander. These space vehicles will enable America to extend its exploration to the Moon and beyond. Jeff Hanley, another ESAS team member, leads the Constellation Program. Both Constellation and Orion are managed by the Johnson Space Center in Houston, Texas.

2006 to 2008
Building on History to Develop the Nation's New Launch Vehicles

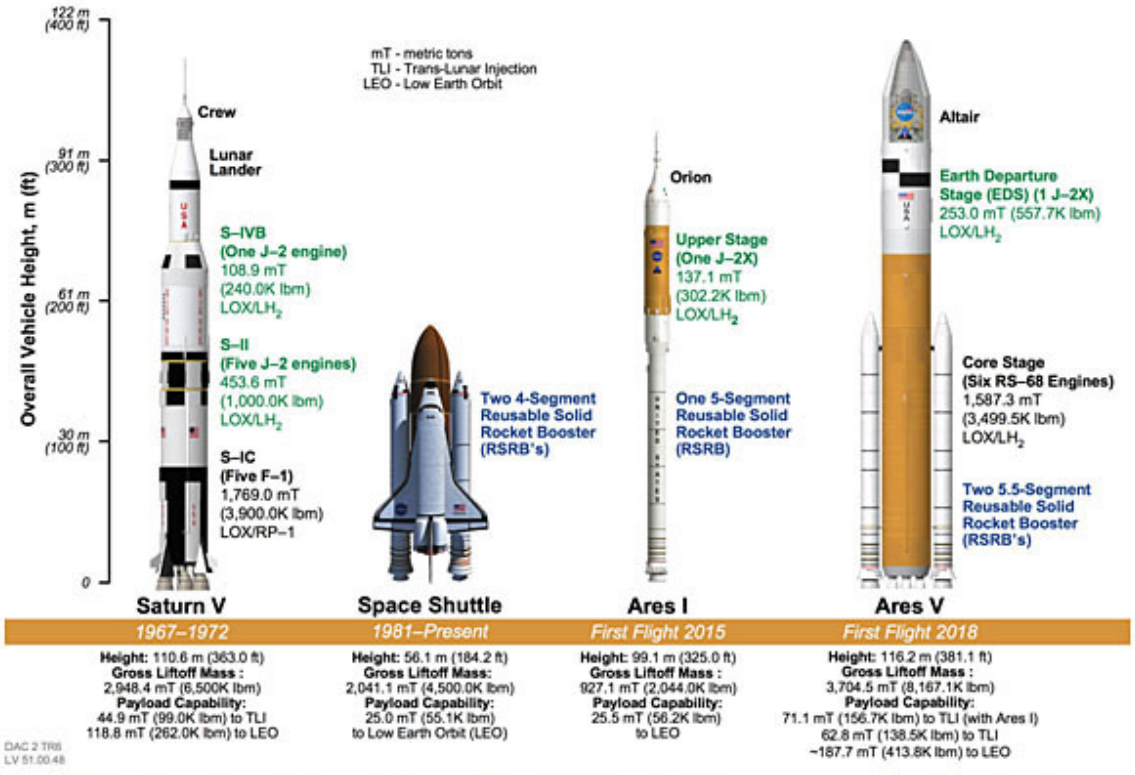
The Ares Projects team at the Marshall Center leads a multi-Center and nationwide partnership to design, develop, test, and evaluate both the Ares I and Ares V launch vehicles. Other NASA Centers involved with this work include the Ames Research Center, Glenn Research Center, Johnson Space Center, Kennedy Space Center, Langley Research Center, and Stennis Space Center. Marshall manages the Michoud Assembly Facility in New Orleans where the Ares I upper stage and the Orion crew exploration vehicle will be built.

By the end of 2007, NASA had awarded all four major Ares I prime contracts, as well as the Orion prime contract. By 2008, hundreds of small businesses joined the effort as subcontractors, vendors, and suppliers. For a complete listing of team members and locations, see the interactive map at: http://www.nasa.gov/mission_pages/constellation/ares/workmap/index.html

The Marshall Center's expertise in integrating large, complex space systems ties all the Ares Project elements together. In this second generation of lunar exploration, Marshall engineers are designing and developing the structures and propulsion systems for the Ares rockets. It is also integrating the vehicle stacks. This is a change from the Space Shuttle program management style. It is a return to Wernher von Braun's "arsenal" concept of design, where NASA keeps the design and vehicle integration to maintain the Agency's in-house expertise. Marshall engineers are enjoying this "getting-your-hands-dirty" approach of rocket design and development.

To make the Ares vehicles affordable and available for flight in a reasonable amount of time, NASA is developing the rockets with proven technology. Many Ares elements are based on hardware from the Space Shuttle and Saturn vehicles. The Ares I and Ares V also share common elements. Although heritage hardware increases NASA's confidence in the safety and reliability of hardware, the hardware is still being used in a new configuration. In

most cases, modern technology and materials have been introduced. This requires the launch vehicle to undergo rigorous review, testing, and evaluation.



The Ares I and Ares V launch vehicles build on proven technologies. The blue and green labels show hardware evolution and commonality.

Ares I Crew Launch Vehicle

Ares I is a two-stage vehicle designed to carry Orion and four to six crew members. Ares I can send Orion to Earth orbit for missions to the International Space Station or to rendezvous with the Ares V for missions to the Moon. The Ares I first stage is a single five-segment solid rocket booster. This larger booster is derived from the existing four-segment Space Shuttle booster.

An in-house NASA team is designing the new Ares I upper stage. The design builds on years of experience with Saturn V stages and Space Shuttle external tanks. This Ares I upper stage is powered by a single J-2X engine. The J-2X upper stage engine design is based upon the J-2 engine used for the Saturn upper stages.

A NASA team also leads the vehicle integration effort. The vehicle integration team ensures all Ares I elements work together as an integrated system. The team works closely with the Orion crew vehicle team so that both vehicles meet the Constellation Program's goals to explore the Moon, Mars, and beyond.

Ares I will carry the Orion crew exploration vehicle to orbit. The Launch Abort System on top of the capsule is a crew safety feature that allows the crew to escape if there is a problem during launch.

Ares V Cargo Launch Vehicle

The Ares V cargo launch vehicle will launch the Altair lunar lander to Earth orbit. There, it can dock with the Orion crew spacecraft. From Earth orbit, Ares V can send Orion and Altair to the Moon. It also can carry launch automated landers and other heavy cargos to the Moon. For other types of missions, Ares V can carry other large payloads, such as telescopes or planetary probes, to destinations throughout the solar system. The Ares V first stage lifts off with the power of two Shuttle-derived five-and-a-half-segment solid rocket boosters. They are similar to the Ares I first stage and the Shuttle solid rocket boosters.

To launch, Ares V needs six RS-68B engines. These engines are based on the RS-68A engine developed for the Air Force Delta IV unmanned launch vehicle. The Ares V core stage will be the largest rocket stage ever built. It delivers liquid oxygen and liquid hydrogen to fuel the RS-68B engines.

The Ares V upper stage is known as the Earth departure stage. Its primary job is to send humans and cargo beyond Earth orbit to other destinations. This stage provides fuel for a single J-2X engine similar to the Ares I upper stage engine. The Ares V J-2X must fire twice: once to get the Earth departure stage in orbit and a second time to send people and payloads to the Moon or other places. The Earth departure stage is topped with a composite payload shroud that will be the largest faring structure ever built. The shroud encloses and protects payloads, such as the Altair lunar lander.

Ares V will send missions to the Moon by 2020.

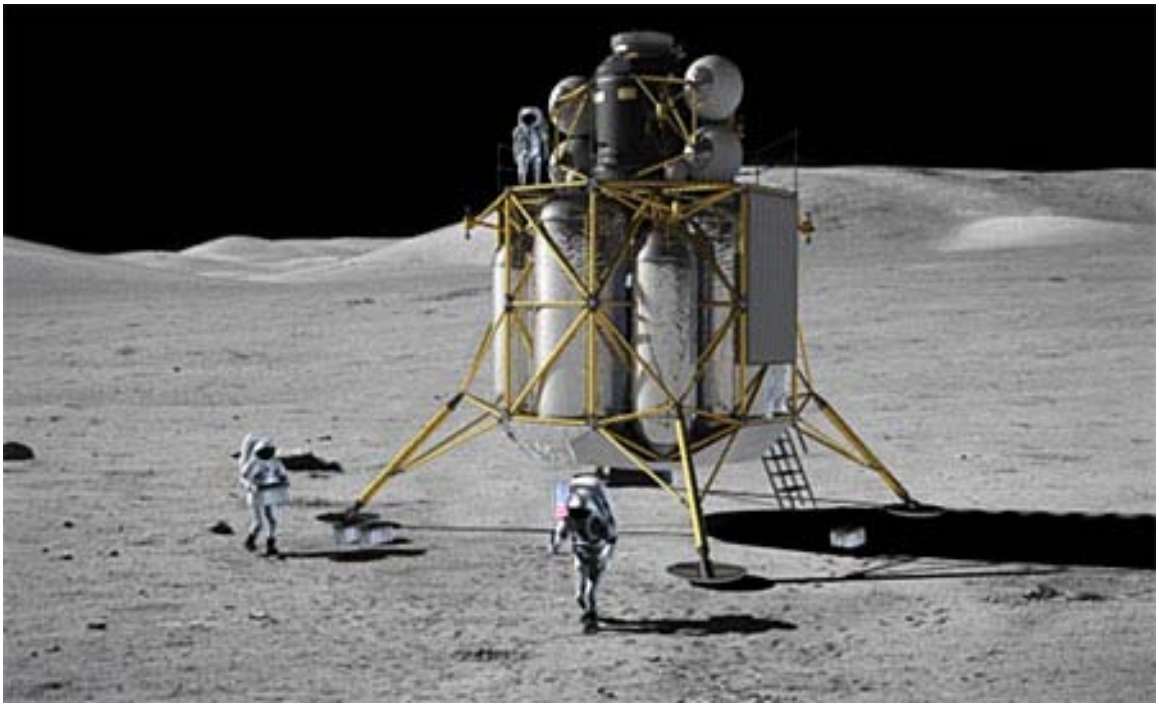
Missions To the Moon

On a typical lunar mission, Ares V will launch the Earth departure stage with the Altair lunar lander. The Earth departure stage will orbit Earth while Ares I launches Orion. In orbit, Orion will rendezvous and dock with Altair. Then, the Earth departure stage will restart its J-2X engine and send Altair and Orion on a trans-lunar injection flight toward the Moon. (For lunar missions, either Ares I or Ares V can be launched first.)

Once the spacecraft achieves lunar orbit, the astronauts will transfer to the lunar lander, which will descend to the Moon. Orion will remain in orbit. At first, astronauts will be able to “camp out” on the Moon for up to a week at a time. Once living quarters are established, they will be able to stay for months.

After completing their mission objectives, the crew will leave the Moon in Altair’s ascent module. Altair will dock with Orion, which will return the crew to Earth. Missions to the Moon are planned for no later than 2020.

The Orion crew exploration vehicle (far right) is docked with the Altair lunar lander and the Ares V Earth departure stage.



Missions to the Moon, only three days away, will prepare Americans for much longer journeys to Mars and other destinations.

Missions to the International Space Station

The first Ares I missions will send Orion and up to six crew members to the International Space Station. In most cases, Orion will bring up new crew members and return to Earth with crew members who have just completed assignments on the Station. Orion can return small equipment, such as film or experiment samples. Missions to the Station are planned for no later than 2015.

Recent Ares Projects Accomplishments

For the first time in 32 years, NASA has completed critical milestone reviews for a human-rated launch vehicle. As of 2008, the Ares team had conducted a critical design review for the J-2X upper stage engine. Preliminary design reviews were completed for the overall Ares I vehicle and for each of the major hardware elements that make up the Ares I rocket. Experienced engineers and project managers who worked on the Saturn and Shuttle programs evaluated the designs and the go-forward plans. This approach allowed NASA to build on its 50 years of launch vehicle development know-how.

In September 2008, the 31-member preliminary design review board voted unanimously to proceed to detailed design on Ares I. The Ares I Critical Design

Review scheduled for 2011 will mark the evolution of the spacecraft from the design phase to the development phase focused on manufacturing and preparation for operations.

Vehicle Integration

The vehicle integration team brings all launch vehicle elements together and examines concerns that affect the entire vehicle. This team works with Marshall's Engineering Directorate and the Ares chief engineer. Together, they organize, plan, and conduct all the major design reviews:

- Systems Requirements Review completed in December 2006
- Systems Definition Review completed in October 2007
- Preliminary Design Review completed in September 2008
- Critical Design Review scheduled for 2011.

Hundreds of documents and drawings are reviewed and revised during each review. It is a time to assess and focus on issues and top risks. After each review, the vehicle integration team tracks and follows up on major actions to ensure changes have been implemented. They collect data or initiate trade studies to resolve issues identified in the review.

In 2006, the first Ares I wind tunnel tests were performed in Marshall's Aerodynamic Research Facility with a 16.5-inch scale mode. By the end of 2008, more than 7,000 hours of wind tunnel testing was completed.

The vehicle integration team determines the tests and analysis needed to solidify the best vehicle design. These tests and analysis show the launch vehicle systems elements operate together in a safe and efficient manner. Since 2006, numerous tests have been conducted to help guide designers' decisions about how to build Ares I parts, components, and subsystems. By the end of 2008, more than 7,000 hours of wind tunnel testing were completed with models of various sizes and configurations. These tests were conducted in collaboration with engineers and analysts from several NASA Centers and at numerous facilities across the country.

Flight-like conditions are simulated in wind tunnels and with analytical fluid dynamic models. They help designers determine how the vehicle will fly through the various atmospheric environments encountered on the way to orbit. Tests cover all aspects of Ares I operations from sitting on the launch pad to ascent to separation of the first and upper stage. Test results are helping the team perfect the Ares I aerodynamic design and identify potential risks.

In the fall of 2007, a loads analysis revealed thrust oscillations. These resonance vibrations in the first stage motors can be detrimental to the vehicle's structure. If levels are high enough, they can even be dangerous to the crew. A Thrust Oscillation Focus Team completed an in-depth study of the problem. In 2008, the team recommended several solutions for mitigating the oscillations. The vehicle integration group is leading efforts to further study and test the options and develop the best solution to eliminate this risk.

Ares I First Stage

The Ares I first stage benefits from more than 25 years of experience flying solid rocket boosters on the Space Shuttle. Static firings of solid rocket motors for the Space Shuttle—including one firing of a five-segment motor in 2003—have provided data to improve the Ares I first stage design. New materials for O-rings and insulation have been tested. One static firing test stand, T-97, is being refurbished for Ares I first stage testing.

In 2008, a major milestone was reached when ATK Space Systems cast the fuel for the first full-scale Ares development motor, called DM-1. It is scheduled to be test fired in 2009. ATK has also fabricated a first stage nozzle and prototypes of the control system.

Fire and smoke billow from a Space Shuttle solid rocket motor static test conducted in December 2008 at an ATK Launch Systems facility in Utah. These Shuttle tests have aided Ares I designers because the motors are outfitted with sensors to obtain valuable data. (ATK photo)

The first stage will be recovered and reused, so a new parachute recovery system is being developed. In 2008, all chutes, including the 150-foot-diameter main parachute—the largest parachute ever developed—were tested successfully. In 2009, the entire recovery system will be tested with all three-parachute systems (the pilot, drogue, and main chutes) working together. For Ares I-X test flight, an identical parachute system will be used to recover the first stage. All these tests will provide more data for refining the Ares I first stage recovery system.

All three types of parachutes needed to recover the Ares I first stage have undergone drop tests, such as main parachute test shown here. Tests are conduced at the U.S. Army Yuma Proving Ground in Arizona. Measuring 150-feet in diameter and weighing 200 pounds, the main parachute is the largest parachute of its kind.

Ares I Upper Stage

The second, or upper, stage of the Ares rocket provides propellant to send Orion to orbit. It has two tanks: one filled with liquid hydrogen and another filled with liquid oxygen. An in-house NASA Design Team leads upper stage development. In December 2007, The Boeing Company was selected as the production contractor for the upper stage and the instrument unit—the “brain” that controls Ares I. Working together, the NASA Design Team and Boeing have modified processes and refined the design. These changes significantly reduced the time it will take to manufacture and assemble an upper stage tank. This is important because the tank has some complex structures, such as a dome-shaped common bulkhead.

The team is building a test article to further refine process and fabrication methods. They will build test articles with a new friction stir welding facility.

Equipment for friction stir welding was installed at Marshall in 2007 and 2008. Trial welds were performed on several full-scale domes and barrels similar to the parts that will make up the upper stage fuel tanks. Work on the test article will continue in 2009.

New state-of-the-art friction stir welding machines have been installed at Marshall. Engineers are using the machines to perfect welding techniques and make a manufacturing demonstration article of the Ares I upper stage.

In preparation for fabricating larger tank panels, engineers built confidence panels. These smaller panels were used to verify the structural characteristics of the aluminum-lithium materials and to determine the proper thickness for the tanks. The goal is to make tanks strong but light. If the spacecraft weighs less, heavier payloads can be carried to orbit. Companies began delivering and installing welding equipment and tooling at the Marshall-managed Michoud Assembly Facility in New Orleans, where the upper stages and Orion will be manufactured.

Tests on other upper stage components have been conducted. In 2008, Marshall engineers designed, built, and tested a small solid rocket called an ullage settling motor. The motor settles propellant in the upper stage tanks, which

is especially important in allowing fuel to flow to the engine correctly. These tests will continue in 2009.

Marshall Center engineers designed and built ullage settling motors for the Ares I upper stage. These small solids, which settle propellant so that it flows smoothly to the engine, were tested in 2008.

Ares I J-2X Upper Stage Engine

The J-2X will power the upper stages of both Ares I and Ares V. In 2007, 14 hot-fire tests at Marshall examined how different injector systems channeled propellants into the engine's combustion chamber. Two other test series examined various configurations for the gas generator that powers the engine turbines. Both test series helped engineers improve injector and gas generator designs.

In 2008, a series of six hot-fire tests of heritage J-2 hardware from the Saturn and X-33 programs provided more than 1,300 seconds of operating time at power levels equivalent to 274,000 pounds of thrust. The results helped engineers refine the design of the J-2X, which must perform to higher thrust, safety, and reliability standards than its predecessor. More powerpack tests with development J-2X hardware are scheduled for 2010.

The J-2X engine is based on the J-2 engine used by the Saturn V upper stages. The powerpack from a modified J-2 engine was used for engine performance tests. Powerpack 1A, Test 8 (shown here) ran for 324.4 seconds on April 24, 2008.

In 2008, NASA awarded Pratt & Whitney Rocketdyne with a contract to design, development, test, and evaluate the J-2X engine. They have ordered basic materials and started casting and machining parts. In November 2008, the engine became the first element of the Ares Projects to complete a critical design review. Successfully achieving this milestone indicates NASA is ready to begin producing development engines. These engines will undergo a rigorous series of test firings at Stennis Space Center.

In 2007 and 2008, workers made substantial progress on clearing the site, pouring the foundation, and erecting the first structural steel for a new engine test stand at NASA's Stennis Space Center in Mississippi. The A-3 Test Stand will allow NASA—for the first time—to simulate starting and operating the J-2X at the high altitudes required for the Ares I and Ares V missions.

For the first time in 30 years, NASA is building a new rocket engine test stand. In 2008, construction was started on the steel tower that makes up the A-3 test stand tower. The A-3 will be the first NASA stand capable of simulating atmospheric conditions similar to those the J-2X engine will experience when it is required to ignite and send the Ares I and Ares V into orbit.

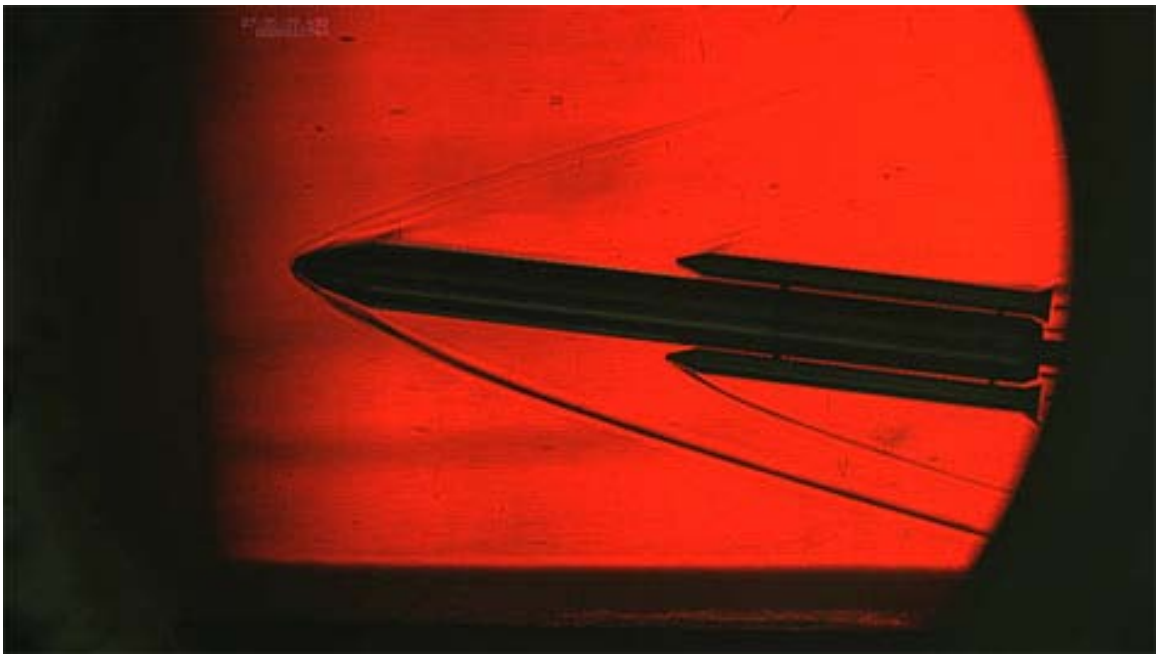
Ares V Conceptual Design

Ares V is still in an early, conceptual design phase. In 2008, the initial, or point-of-departure, configuration started wind tunnel testing. Engineers and managers evaluated the Ares V design during the 2008 Lunar Capabilities Concept Review. This historic review examined all requirements for the lunar mission, from launch vehicles to surface systems.

To increase performance, the Ares V core stage engine cluster was increased from five RS-68B engines to six. The booster length was increased from five segments to five-and-a-half segments. In 2007 and 2008, tests and upgrades to the RS-68B engine were completed in collaboration with the U.S. Air Force, which uses the engine on the Boeing Delta IV rockets.

Because the Ares I and Ares V both use the J-2X, the Ares V is benefiting from J-2X development work for Ares I. Work on the Ares I upper stage fuel tanks will be useful when NASA designs the Ares V core stage. The core stage will be larger than the Saturn V first and second stages combined.

During 2008, several study groups and workshops explored how Ares V's enormous cargo capacity of more than 400,000 pounds to low-Earth orbit could be used for telescopes, satellites, and other scientific payloads. In December 2008, NASA issued a draft solicitation for industry proposals to refine the Ares V concept and develop requirements. The Ares V team also briefed industry representatives on its procurement plans. Concept definition contracts should be awarded in 2009.



The schlieren photo depicts one of the first Ares V wind tunnel tests at Marshall in October 2008. The photo shows airflow over a 0.35 percent model of the Ares V launch vehicle. Marshall engineers are collecting aerodynamic data to help the Ares V team determine basic requirements for guidance, navigation, and control of the huge Ares V cargo launch vehicle.

Flight and Integrated Testing

The Ares flight and integrated testing group is planning integrated tests for the Ares rockets. This involves determining which facilities are needed and available to verify spacecraft are qualified and ready for flight.

Construction workers and engineers are refurbishing the Dynamic Test Stand, originally built at the Marshall Center to test the Saturn V and later used

for the Shuttle. This facility will be used for ground vibration testing of the full-scale integrated Ares stack including Orion and the Launch Abort System.

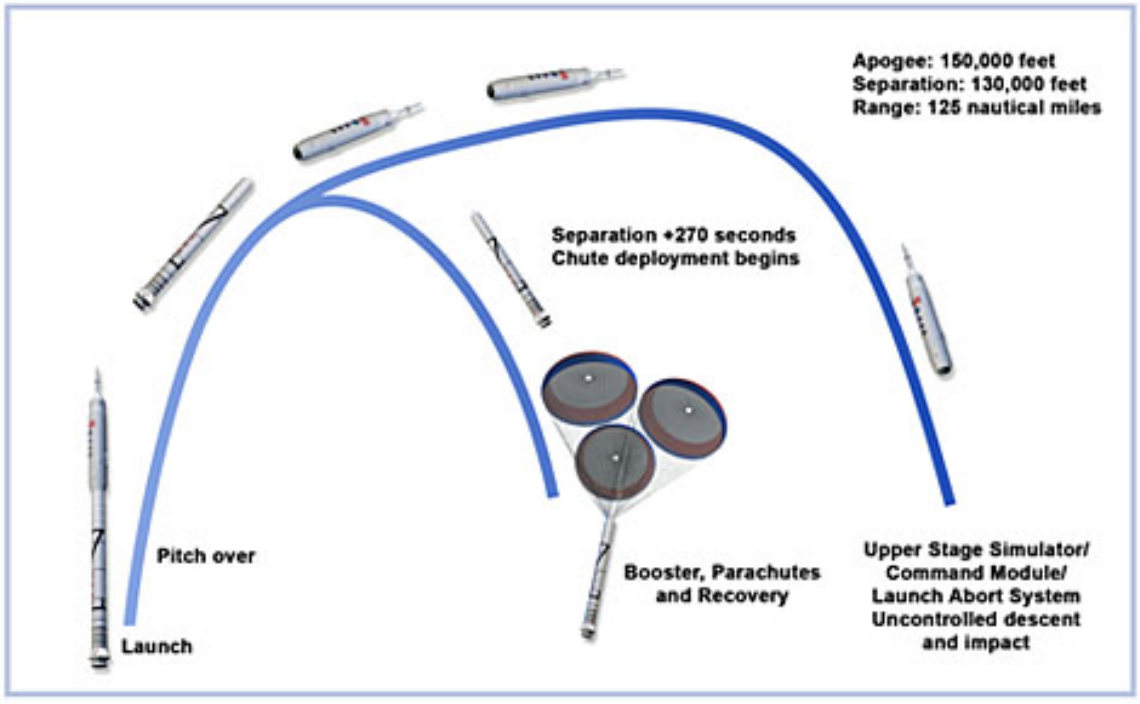
The flight and integrated testing team plans both ground and flight tests. The team helped define the first Ares I test flight—the upcoming Ares I-X mission. Currently, they are determining objectives for the Ares I-Y, the second unmanned flight test for Ares I. Ares I-Y is scheduled for 2013. One major objective of this flight is to test the Launch Abort System at high altitudes during a flight. Ares I-Y will be the first flight of a functional upper stage.

In 2008, engineers and construction workers began refurbishing the Dynamic Test Stand at the Marshall Center for ground vibration testing of the Ares I.

2009
Launching the Ares I-X Test Flight

Marshall employees are excited about the first test flight of Ares I—called Ares I-X—scheduled to launch in 2009. This vehicle's suborbital flight will test the flight characteristics of Ares I from liftoff to first stage separation and recovery. The flight will

- demonstrate computer hardware and software (avionics) needed to control the vehicle
- deploy parachutes that allow the first stage booster to land in the ocean safely
- measure and control how much the rocket rolls during flight
- test and measure the effects of first stage separation
- develop and refine new ground handling and rocket stacking procedures in the Vehicle Assembly Building at Kennedy Space Center in Florida.



The Ares I-X test flight will mirror early ballistic flight tests of the Saturn I and Saturn IB.

Developing a test flight this early in Ares I development was challenging. However, the flight will provide critical data for the Ares I design. This information will reduce the risks associated with a new launch vehicle. It will increase the efficiency of ground operations and handling and even help designers make the vehicle more operations friendly.

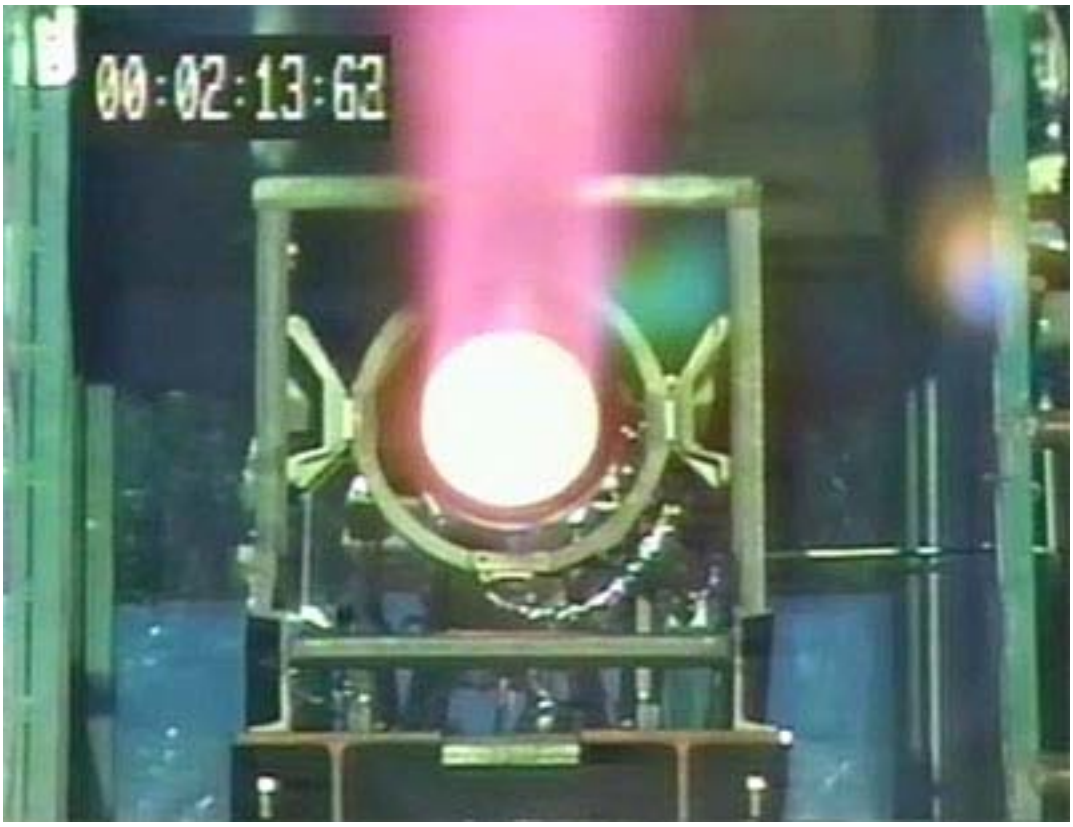
As of late 2008, all Ares I-X major elements completed their critical design reviews and were nearing final fabrication. The first stage—a four-segment solid rocket booster from the Space Shuttle inventory—incorporates new simulated forward structures to match the Ares I five-segment booster. The upper stage, Orion crew module, and Launch Abort System are simulator hardware. They are similar to the Ares I in size and configuration, but they are not real flight hardware.

The entire rocket is outfitted with developmental flight instrumentation for collecting essential data during the mission. The upper stage simulator consists of smaller cylindrical segments and ballast plates. In November 2008, they were transported from NASA's Glenn Research Center in Ohio to the Kennedy Space Center in Florida.

Simulators for Orion and the Launch Abort System were built at Langley Research Center in Virginia and will be shipped to Florida in early 2009. The Ares I-X mission management team has been located at the Langley Center. In 2009, they will move to the Kennedy Center to help prepare for the launch.

One of the Deputy Mission Managers for Ares I-X, Steve Davis is at the Marshall Center. He leads teams working on the Ares I-X first stage, avionics system, and roll control system. Davis will also move to Kennedy to assist with launch preparations.

All Ares I-X hardware is scheduled to arrive at the Kennedy Space Center in Florida by spring 2009. To follow the Ares I-X flight test, visit: http://www.nasa.gov/mission_pages/constellation/ares/flighttests/aresIx/index.html



Marshall is the lead for developing the Ares I-X roll control system shown during a test firing. The roll control system uses retired Peacekeeper Missile hardware.

This artist concept shows Ares I-X on the launch pad.

Into the Future
Upcoming Milestones

In the coming year, Ares will continue to stride toward its first operational flight planned for no later than 2015. Upcoming milestones include:

- Fabrication and test firing of the first stage development motor
- Testing of hardware to mitigate Ares I thrust oscillation
- Manufacturing of the first J-2X development engine
- A three-parachute “cluster” drop of the first stage recovery system
- Creation of the upper stage manufacturing and demonstration article
- Award of a contract to further refine the Ares V design concept
- Integrated design and performance studies of the Ares V core stage, boosters, departure stage, and shroud
- The Ares I-X launch.

People across the nation are building and testing components, constructing and refurbishing facilities, and installing tooling to build America’s new rockets. Many well-built test and launch facilities used for Shuttle and Saturn have gained a new life and are being refurbished and outfitted for Ares. By building rockets to send people to the Moon, Mars, and other destinations, the Ares Projects team is leading the way for new journeys beyond Earth orbit.

To learn more about Ares launch vehicles and view quarterly video updates highlighting progress, visit:

http://www.nasa.gov/ares

March 16, 2009