Ares I-X: First Flight of a New Era

Stephan R. Davis, Deputy Mission Manager
Bruce R. Askins, Project Integration Manager
Ares I-X Mission Management Office
Marshall Space Flight Center
Huntsville, AL 35812

Abstract

Since 2005, NASA's Constellation Program has been designing, building, and testing the next generation of launch and space vehicles to carry humans beyond low-Earth orbit (LEO). The Ares Projects at Marshall Space Flight Center (MSFC) are developing the Ares I crew launch vehicle and Ares V cargo launch vehicle. On October 28, 2009, the first development flight test of the Ares I crew launch vehicle, Ares I-X, lifted off from a launch pad at Kennedy Space Center (KSC) on successful suborbital flight.

Basing exploration launch vehicle designs on Ares I-X information puts NASA one step closer to full-up "test as you fly," a best practice in vehicle design. Although the final Constellation Program architecture is under review, the Ares I-X data and experience in vehicle design and operations can be applied to any launch vehicle.

This paper presents the mission background as well as results and lessons learned from the flight.

The Ares I is designed to carry up to four astronauts to the International Space Station (ISS) no later than 2015. It also can be used with the Ares V cargo launch vehicle for a variety of missions beyond LEO. The Ares I-X development flight test was conceived in 2006 to acquire early engineering and environment data during liftoff, ascent, and first stage recovery. Engineers are using the test flight data to improve the Ares I design before the critical design review—the final review before manufacturing of the flight vehicle begins. The test achieved the following primary objectives:

- Demonstrated control of a dynamically similar, integrated Ares I/Orion, using Ares I relevant ascent control algorithms
- Performed an in-flight separation/staging event between a Ares I-similar First Stage and a representative Upper Stage
- Demonstrated assembly and recovery of a new Ares I-like First Stage element at KSC
- Demonstrated First Stage separation sequencing, and quantify First Stage atmospheric entry dynamics, and parachute performance
- Characterized the magnitude of integrated vehicle roll torque throughout First Stage flight.

Figure 1. The Ares I-X Flight Test Vehicle incorporates both flight-like and mass simulator hardware.

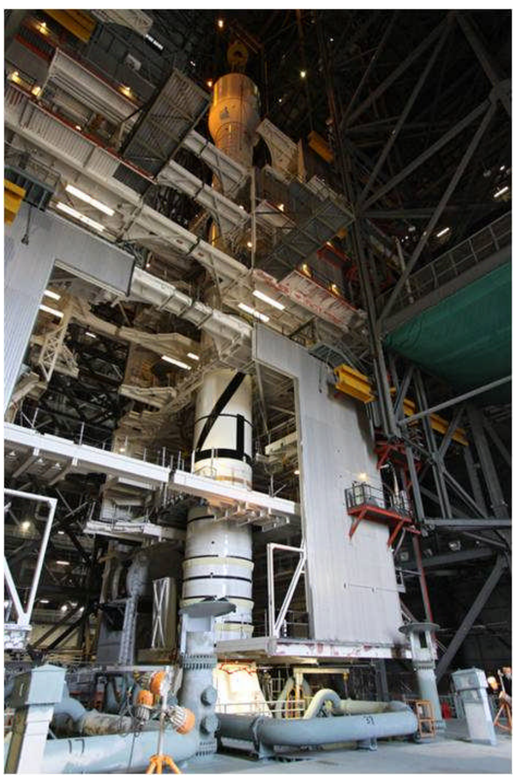

Figure 3. The Ares I-X first stage and new forward structures stacked in the Vehicle Assembly Building

Vehicle Configuration

The Ares I-X Flight Test Vehicle (FTV) incorporated a mix of flight and mockup hardware, reflecting a similar length and mass to the operational vehicle. It was powered by a four-segment SRB from the Space Shuttle inventory, and was modified to include a fifth, spacer segment that made the booster approximately the same size as the five-segment SRB.

The Ares I-X flight closely approximated flight conditions the Ares I will experience through Mach 4.5, at an altitude of about 130,000 feet and through a maximum dynamic pressure (“Max Q”) of approximately 850 pounds per square foot.

First Stage (FS)

Since the FS team used a four-segment SRB from the Space Shuttle inventory, most new work focused on building the new forward structures that connect the booster to the Upper Stage Simulator (USS).

The five-segment SRB was heavier than the four-segment booster used for the Space Shuttle, so Ares I-X tested new parachutes to accommodate the additional loads. Although ground drop tests were completed before the test flight, Ares I-X served as the first operational test of the new parachutes.

Upper Stage Simulator (USS)

Glenn Research Center in Ohio built the USS in a series of 11 smaller "tuna can" segments. In October 2008, the segments were delivered by truck and barge to KSC where they were stacked and integrated. To allow for worker access on the launch pad, each tuna can had a set of platforms and ladders built inside.

Roll Control System (RoCS)

NASA engineers were concerned that the rocket would tend to roll around its direction of forward motion due to aerodynamic forces and torque from the first stage. A primary objective of Ares I-X was to measure and counteract this roll using an active roll control system (RoCS). Axial engines harvested from Peacekeeper missiles that were due to be decommissioned were modified and repackaged for the FTV by Teledyne Brown Engineering in Alabama, under management by MSFC. The RoCS was delivered to KSC in January 2009.

Avionics

The Ares I-X avionics hardware used a combination of avionics components from the Atlas V Evolved Expendable Launch Vehicle (EELV), heritage Space Shuttle systems, off-the-shelf development flight instrumentation (DFI) from several sources, and new hardware designed to translate signals between the Atlas hardware and Shuttle-heritage thrust vector control (TVC) system. The avionics hardware for this flight was not required to be extensible to Ares I; however, the guidance and control algorithm was based on the one planned for Ares I. Testing of the Guidance, Navigation, and Control (GN&C) algorithms was a primary objective of the Ares I-X flight test.

Integration of the avionics was the primary responsibility of Jacobs Technology in Alabama, with Lockheed Martin in Colorado as a major subcontractor.

Final delivery, installation, and integrated testing of the avionics occurred at KSC from April to October 2009.

Command Module/Launch Abort System (CM/LAS) Simulator

Because Ares I-X was a test of the Ares launch vehicle only, there was no Orion payload on board. Instead, the CM and LAS were mass simulator hardware built at NASA's Langley Research Center in Virginia. Sensors on the forward structures will enable NASA engineers to obtain accurate information about aerodynamic and acoustic loads in a flight environment.

Summary

Ares I-X is the first step in the long journey to destinations farther than a few hundred miles above Earth. This suborbital test was NASA's first flight of a new human-rated launch vehicle in over a generation. The Ares I-X MMO team, having executed a successful launch, will now focus on analyzing the flight data and extracting lessons learned that can be used to support the development of any future vehicle the agency chooses to build.

Nomenclature

BDM	Booster Deceleration Motor
CM	Crew Module
DFI	Developmental Flight Instrumentation
EELV	Evolved Expendable Launch Vehicle
FS	First Stage
FTV	Flight Test Vehicle
GC3	Ground Command, Control, and Communication
GN&C	Guidance, Navigation, and Control
GRC	Glenn Research Center
ISS	International Space Station
JSC	Johnson Space Center

KSC	Kennedy Space Center
LaRC	Langley Research Center
LAS	Launch Abort System
LEO	Low-Earth Orbit
LH_2	Liquid Hydrogen
LOX	Liquid Oxygen
MLP	Mobile Launcher Platform
MMO	Mission Management Office
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
RoCS	Roll Control System
SE&I	Systems Engineering and Integration
SIL	Systems Integration Laboratory
SRB	Solid Rocket Booster
TVC	Thrust Vector Control
USS	Upper Stage Simulator