

The Orion Pad Abort 1 (PA-1) Flight Test: A Propulsion Success

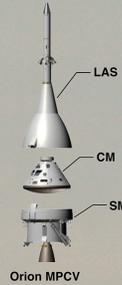


Human Spaceflight and the Orion MPCV

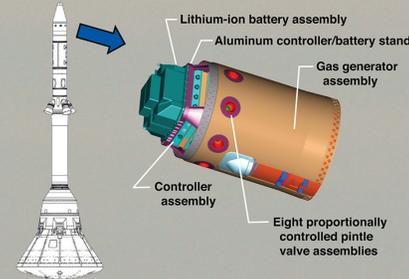
- The Constellation program Ares I architecture
 - Included the Orion Crew Exploration Vehicle (CEV)
 - Planned for utilization after the retirement of the Space Shuttle
 - Constellation program was cancelled in 2010
- The Space Launch System (SLS) architecture
 - Includes the Orion Multi-Purpose Crew Vehicle (MPCV)
 - Transport humans beyond low-Earth orbit (LEO)
 - Provide a transport capability to the International Space Station (ISS), as a backup for commercially developed vehicles



- The Orion MPCV includes:
 - Launch Abort System (LAS)
 - Crew Module (CM)
 - Service Module (SM)
- The Orion Abort Flight Test (AFT) project:
 - Purpose: To conduct a series of flight tests in several launch abort scenarios to certify Orion LAS capability
 - Responsibility: The Orion Flight Test Office, at NASA JSC
 - The Orion PA-1 flight-test vehicle integration and operations effort was led by the NASA Dryden Flight Research Center (now the NASA Armstrong Flight Research Center)

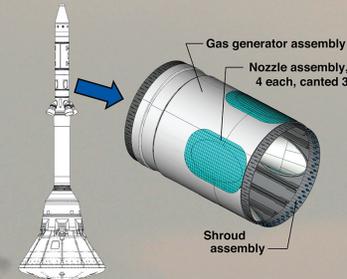


Orion PA-1 LAS ACM Overview



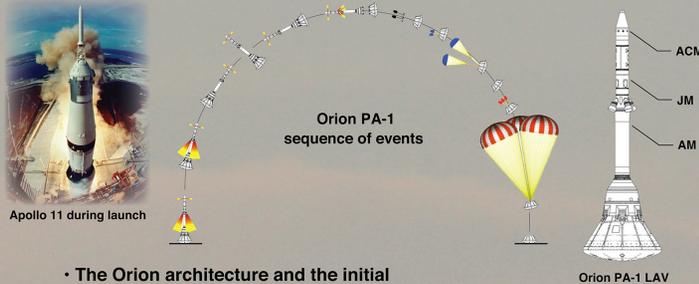
- Purpose: Provide pitch and yaw control to optimize the LAV abort trajectory
 - Boost phase: Utilized for LAV directional control and stabilization
 - Sustain phase: Utilized to pitch-over and reorient the LAV
 - PA-1 LAS ACM maximum thrust: ~7,000 lbf
 - PA-1 LAS ACM action time: ~35 seconds
- Developed by: Alliant Techsystems, Inc. (ATK) in Elkton, Maryland

Orion PA-1 LAS JM Overview



- Purpose: Provide the thrust force required to jettison the LAS from the Orion CM, in both the abort and nominal flight scenarios
 - Abort scenario: Utilized after the AM and ACM have performed their functions
 - Nominal scenario: Utilized with fully loaded AM and ACM propellant
 - PA-1 LAS JM nominal maximum thrust: ~44,000 lbf
 - PA-1 LAS JM action time: ~2 seconds
- Developed by: Aerojet in Sacramento, California (now part of Aerojet Rocketdyne)

Propulsion on the Orion PA-1 Vehicle



Ensuring Flight Safety

- The Orion LAS provides an abort capability in the unlikely event of a booster failure
 - Abort capability exists while on the launch pad or during mission vehicle ascent
- The architecture of any human-rated launch vehicle and spacecraft will always require the greatest level of safety
- The Orion PA-1 Flight Test Vehicle demonstrated an abort capability from the launch pad
 - Flight test occurred on May 6, 2010 at the White Sands Missile Range, in New Mexico
 - All three motors successfully demonstrated their required functions during the PA-1 flight



- The Orion architecture and the initial AFT project flight test manifest had similarities with those of Apollo
- The Orion PA-1 Flight Test Vehicle was the first in a series of several planned vehicles to certify LAS capability
- The Orion PA-1 Launch Abort Vehicle (LAV) consisted of the LAS and CM combined
- The Orion LAS includes several subsystems, three of which are solid rocket motors:
 - Attitude Control Motor (ACM)
 - Jettison Motor (JM)
 - Abort Motor (AM)

- Future flight-testing (beyond PA-1) will ensure LAS capability on the Orion MPCV for the SLS
- More detailed information on propulsion for the Orion AFT project has been published:
 - “Executive Summary of Propulsion on the Orion Abort Flight-Test Vehicles,” AIAA 2012-3891

Orion PA-1 LAS AM Overview

- Purpose: Provide the thrust force necessary to propel the LAV safely away from a failed booster
 - Thrust is balanced between the desire to escape quickly and the human tolerance for acceleration
 - PA-1 LAS AM nominal maximum thrust: ~500,000 lbf
 - PA-1 LAS AM action time: ~7 seconds
- Developed by: ATK in Utah

