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Ares I Integrated Test Approach
Ares Launch Vehicles

♦ Ares I Crew Launch Vehicle
  • Carries Orion crew exploration vehicle with crew of 6 to International Space Station or 4 to Moon
  • LH₂/LOX upper stage
    – Powered by a single engine derived from the Saturn J-2
  • Single 5-segment RSRM first stage

♦ Ares V Cargo Launch Vehicle
  • Carries Altair lunar lander and performs trans-lunar injection burn to send Orion and Altair to Moon
  • Twin 5.5-segment RSRM first stage
  • Core stage derived from the external tank (ET) and Saturn V, powered by six RS-68 engines
  • Ares I-derived avionics
  • Earth departure stage (EDS)a
    – Powered by a single J-2X upper stage engine – completes orbital burn and performs trans-lunar injection
    – Ares I-derived Main Propulsion System (MPS) and avionics
Flight Test Events
Leading to Design Certification

Ares I-Y Validation Flight Test
• First flight of a five-segment booster
• Demonstration of first stage-upper stage separation
• High-altitude abort demonstration following stage separation
• Vehicle assembly, test, and processing using modified launch facilities

Ares I-X Development Flight Test
• Flight data to validate key engineering models
• Shuttle 4-segment solid rocket booster with inert 5th-segment
• Mass simulator upper stage, Orion, and LAS
• First stage ascent and separation of the upper stage

Orion-1 Operational Flight Test
• First powered flight of J-2X engine through second stage of flight
• Demonstration of orbital mission capability
• Re-entry, landing, and recovery of Orion
First Stage Test and Evaluation

- **Drogue Parachute Drop Test (DDT-1) successfully completed**
  - First drop test of the new Ares I first stage booster reentry drogue parachute
  - Jumbo Drop Test Vehicle (JDTV) extraction from C-17 aircraft
  - Descended to test condition
  - Deployment and inflation of the drogue test parachute was successful

- **Ares I-X will provide flight testing for main parachutes**

- **Development test motor series**
  - Four development motor firings planned
  - DM-1 fabrication is underway

- **Qualification test motor series**
  - Three qualification motor firings planned
J-2X Engine Test and Evaluation

♦ Early risk reduction testing
  • Power Pack Assembly 1A (PPA-1A) testing with heritage J-2 turbomachinery and gas generator completed in May 2008
  • Subscale injector testing complete
  • Workhorse gas generator testing is underway

♦ J-2X Power Pack Assembly #2 (PPA-2)
  • Planned for early 2010
  • Expand on the test results from the PPA-1 series with flight-design components
  • Evaluate turbomachinery, inlet ducts, gas generator, and other components

♦ Development and certification engines
  • More than 200 engine hot-fire tests with 9 engines planned
  • Sea-level and simulated altitude conditions
J-2X Engine Facility Readiness

- **SSC A-1 Test Stand**
  - Provides sea-level test capability (no diffuser)
  - Power-pack and engine testing (no nozzle extension)

- **SSC A-2 Test Stand**
  - Capable of sea-level testing or steady-state altitude simulation (no altitude start)
  - Facility modifications to support J-2X

- **SSC A-3 Test Stand**
  - New facility to provide altitude test capability for J-2X
  - Tests the J-2X engine over the 500-sec duration burn at simulated altitudes over 100,000 feet
  - Perform system start and shutdown without sea-level transient loads
  - Development, certification, and acceptance testing
Upper Stage
Structural and Thermal Test and Evaluation

♦ Development test articles
  • Common bulkhead
  • LOX tank/aft dome/thrust structure
  • Damage tolerance testing

♦ Qualification Test Articles
  • Instrument Unit
    – Structural qualification units for IU and avionics panels
    – Thermal qualification for IU avionics
  • Interstage
    – Structural qualification
    – Life cycle testing
    – Thermal qualification
  • Structural qualification test articles
    – LOX tank/aft dome/thrust structure
    – “Core” upper stage integrated stack with LH2 / LOX tanks, aft dome, and thrust structure
Main Propulsion Test Article (MPTA)

♦ Test purpose
  • Test-bed for propellant management and stage operations of an Integrated Upper Stage (US and J-2X Engine)

♦ Specific test objectives
  • Propellant management
  • Thermal model validation
  • Pressurization system performance
  • Transient and main stage performance
  • Terminal drain demonstration
  • Cryogenic operation of MPS components
  • Avionics demo
  • TVC operations

♦ Approach
  • Integration with J-2X development test Engine after engine sea-level testing
  • Cold-flow test objectives complete prior to Ares I-Y
  • Hot fire testing complete prior to Orion 1
Upper Stage Green Run Testing

♦ Test purpose
  • Final acceptance of the integrated upper stage and upper stage engine configuration before eventual transport to launch site

♦ Objectives
  • Hot fire test of the flight upper stages with the J-2X flight engine
  • Possible verification testing for early stages leading to flight readiness

♦ Approach
  • Potential cold-flow testing with Ares I-Y stage
    – Risk reduction for Ares I-Y tanking
    – Test stand activation
  • First three stages beginning with Orion 1
    – Need for continued testing will be evaluated after Operational Capability is achieved
Upper Stage Facility Readiness

- **MSFC Hazardous Structural Strength Test Facility**
  - LOX tank/aft dome structural development and qualification testing

- **MSFC Cryo-structural Test Facility**
  - Core structural qualification test article

- **MSFC Advanced Engine Test Facility**
  - Main Propulsion Test Article

- **SSC B-2 Test Facility**
  - Stage green run testing
  - Plans for further modification to support Ares V core stage testing
Integrated Vehicle Ground Vibration Test (IVGVT)

♦ Test purpose
  • Provide test-verified models for structural dynamics and flight control system

♦ Specific test objectives
  • Obtain and verify mode shapes, frequencies, generalized mass, and damping characteristics which are used in the stability equations
  • Obtain experimental non-linear characteristics of the vehicle
  • Obtain amplitude and phase response data at flight control sensor locations

♦ Approach
  • Full-scale test articles to simulate flight-like Ares I vehicle dynamic response
  • Test at NASA-MSFC Dynamic Test Stand
IVGVT Dynamic Test Stand Readiness

Workers cutting a section of the platform prior to removal

A section of the platform being removed

Lowering of the crosswalk to facilitate platform removal

Dynamic Test Stand
Aerodynamic Testing

♦ Testing at the Preliminary Design Review (PDR) stage
  • Multiple facilities and speed regimes (subsonic, transonic, and supersonic) to support aerodynamic characterization for ascent, stage separation, and booster re-entry
  • 0.5-percent and 1.0-percent scale models
  • Completed approximately 60 percent of total wind tunnel test program (approximately 6,000 hours)

♦ Additional testing prior to CDR
  • Reynolds number scale effects
  • Aerodynamic interference effects during stage separation
  • Plume interactions from reaction control systems
  • Higher fidelity configuration assessments
Summary

♦ NASA is maturing test and evaluation plans leading to flight readiness of the Ares I crew launch vehicle

♦ Key development, qualification, and verification tests are planned
  • Upper stage engine sea-level and altitude testing
  • First stage development and qualification motors
  • Upper stage structural and thermal development and qualification test articles
  • Main Propulsion Test Article (MPTA)
  • Upper stage green run testing
  • Integrated Vehicle Ground Vibration Testing (IVGVT)
  • Aerodynamic characterization testing

♦ Test and evaluation supports initial validation flights (Ares I-Y and Orion 1) and design certification