National Aeronautics and Space Administration

Jim Taylor
Manager, Ares Projects Flight
& Integrated Test Office

Wernher von Braun
Memorial Symposium
October 21, 2008

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
  - LH_2/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

Critical Design Review

Additional ground testing, analysis, requirements verification, and vehicle qualification testing

Design Certification

♦ 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

♦ 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

♦ 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

Jumbo Drop Test Vehicle (JDTV)

First Stage DDT-1

Solid Rocket Motor Test Firing

- **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

J-2X PPA-1A

Workhorse GG Test

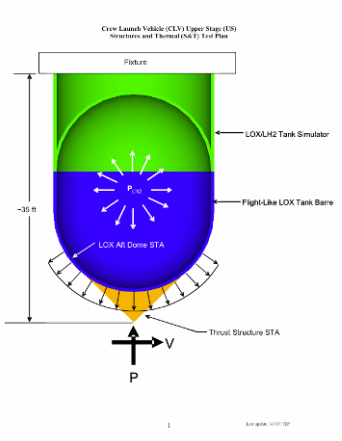
PPA-2 Concept

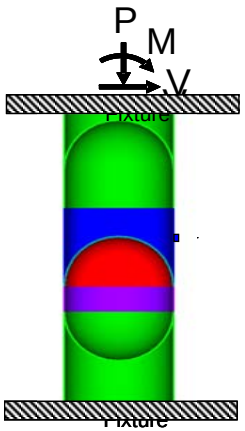
- **Early risk reduction testing**
  - Power Pack Assembly 1A (PPA-1A) testing with heritage J-2 turbomachinery and gas generator completed in May 2008
  - Subscale injector testing complete
  - Workhorse gas generator testing is underway
- **J-2X Power Pack Assembly #2 (PPA-2)**
  - Planned for early 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

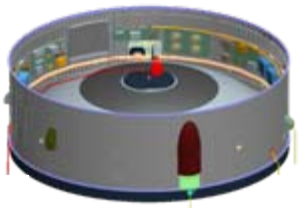
J-2X Engine Facility Readiness

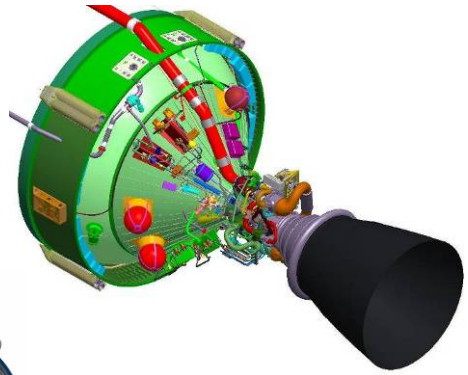
- **SSC A-1 Test Stand**
  - Provides sea-level test capability (no diffuser)
  - Power-pack and engine testing (no nozzle extension)
- **SSC A-2 Test Stand**
  - Capable of sea-level testing or steady-state altitude simulation (no altitude start)
  - Facility modifications to support J-2X
- **SSC A-3 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

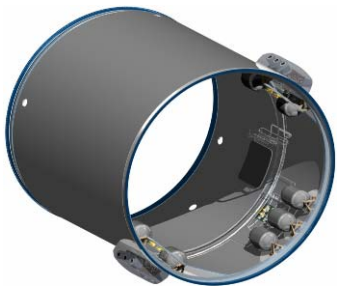
Upper Stage
Structural and Thermal Test and Evaluation





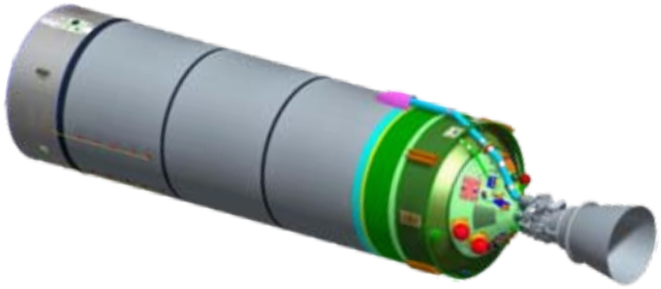






- **Development test articles**
  - Common bulkhead
  - LOX tank/aft dome/thrust structure
  - Damage tolerance testing
- **Qualification Test Articles**
  - Instrument Unit
    - Structural qualification units for IU and avionics panels
    - Thermal qualification for IU avionics
  - Interstage
    - 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)

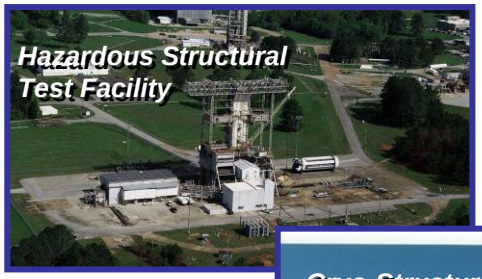


- **Test purpose**
  - Test-bed for propellant management and stage operations of an Integrated Upper Stage (US and J-2X Engine)
- **Specific test objectives**
  - Propellant management
  - Thermal model validation
  - Pressurization system performance
  - Transient and main stage performance
  - Terminal 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

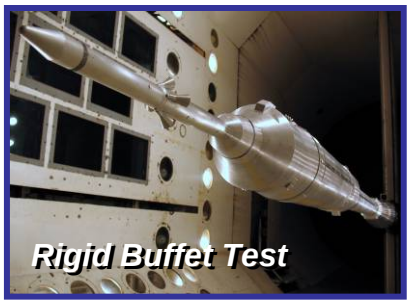
Dynamic Test Stand

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

Aerodynamic Testing

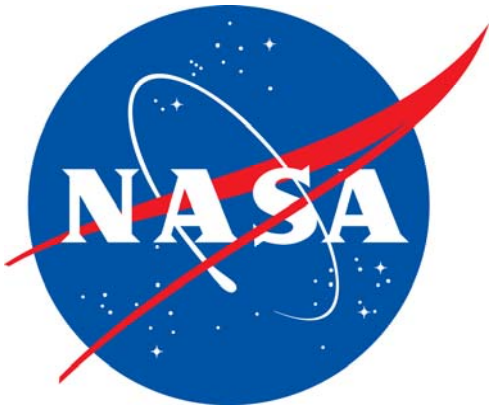


- **Testing at the Preliminary Design Review (PDR) stage**
  - Multiple facilities and speed regimes (subsonic, transonic, and supersonic) to support aerodynamic characterization for ascent, stage separation, and booster re-entry
  - 0.5-percent and 1.0-percent scale models
  - Completed approximately 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**



www.nasa.gov