Ares I
First Stage: Powering Exploration

Bruce K. Tiller
Ares First Stage Deputy
Agenda

- Introduction
- Schedules
- First Stage Progress to Date
Building on the legacy of the Space Shuttle and other NASA space exploration initiatives, the propulsion for the Ares I First Stage will be a Shuttle derived reusable solid rocket motor.

Significant progress has been made to date by the Ares First Stage Team.

This brief status provides an update on the design and development of the Ares First Stage propulsion system.
- Height: 360.0 ft
- Gross Liftoff Mass (GLOM): 6,500.0K lbm
- Payload Capability: 44.9 mT Trans-Lunar Injection (TLI); 118.8 mT to LEO

Space Shuttle: 1981–Present
- Height: 184.2 ft
- Gross Liftoff Mass (GLOM): 4,500.0K lbm
- Payload Capability: 25.0 mT to LEO

Ares I: First Flight 2015
- Height: 325.0 ft
- Gross Liftoff Mass (GLOM): 2,057.3K lbm
- Payload Capability: 24.9 mT to LEO

Ares V: First Flight 2018
- Height: 381.1 ft
- Gross Liftoff Mass (GLOM): 8,167.1K lbm
- Payload Capability: 71.1 mT to TLI with Ares I; 62.8 mT to TLI; ~187.7 mT to LEO

Building on 50 Years of Proven Experience
Launch Vehicle Comparisons

Saturn V:
- Crew
- Lunar Lander
  - S-IVB (One J-2 Liquid Oxygen/Liquid Hydrogen (LOX/LH₂) engine)
  - S-II (Five J-2 LOX/LH₂ engines)
  - S-IC (Five F-1 LOX/RP-1 engines)

Space Shuttle:
- Crew
- Orbiter
- Solid Rocket Boosters (SRBs)

Ares I:
- Core Stage (Six RS-68 LOX/LH₂ engines)
- Upper Stage (One J-2X LOX/LH₂ engine)
- One 5-Segment RSRB

Ares V:
- Core Stage (Six RS-68 LOX/LH₂ engines)
- Upper Stage (One J-2X LOX/LH₂ engine)
- Two 5.5-Segment RSRBs

Lunar Lander
- S-IVB (One J-2 Liquid Oxygen/Liquid Hydrogen (LOX/LH₂) engine)
- S-II (Five J-2 LOX/LH₂ engines)
- S-IC (Five F-1 LOX/RP-1 engines)
- Two 4-Segment Reusable Solid Rocket Boosters (RSRBs)

National Aeronautics and Space Administration
Ares I Acquisition Model

**Overall Integration**
- NASA-led
- Multi-generational program
- Lessons learned from DoD: robust internal systems engineering, tightly managed requirements
- NASA becomes “smart buyer” downstream
- Marries best of NASA and industry skills

**Instrument Unit**
- NASA Design/Boeing Production

**Orion Crew Exploration Vehicle**

**Upper Stage**
- NASA Design/Boeing Production

**Upper Stage Engine**
- Pratt and Whitney Rocketdyne

**First Stage**
- ATK Launch Systems
Ares I First Stage Overview

- Legacy motor casings, aft skirt
- New forward structures
  - Forward Skirt
  - Forward Skirt Extension
  - Aeroshell
  - Frustum
- Metal and composite materials
- Shuttle-derived five-segment solid rocket motor
  - Increased performance
  - Extensibility to Ares V

Thrust trace comparison: Shuttle versus Ares I

National Aeronautics and Space Administration
Ares I First Stage

C-Spring isolators

Asbestos free insulation/liner

Tumble Motors (from Shuttle)

Same propellant as Shuttle (PBAN) - optimized for Ares application

Same cases and joints as Shuttle

Booster Deceleration Motors (from Shuttle)

Wide throat nozzle

New 150 ft diameter parachutes

Modern electronics

Same aft skirt and thrust vector control as Shuttle

National Aeronautics and Space Administration
Ares First Stage Upgrades

- Increased number of fins from 11 to 12 in fwd segment
- Burn rate lowered to meet Ares I requirements
- Propellant chamfers on aft and center segments
- Modified height and thickness to prevent bore choking
- Added Segment
- Wider throat and nozzle extension for increased mass flow
- Insulation and liner formulations modified to eliminate Chrysotile fibers
- Lay-up optimized to provide additional thermal protection

Modifications to the motor were made to:
- Improve performance (thrust)
- Improve reliability
- Eliminate hazardous materials
- Replace obsolete materials

National Aeronautics and Space Administration
First Stage Progress to Date

- **Successful Preliminary Design Review Completed in June, 2008**
- **Major Test Programs**
  - Parachute drop tests
  - Stage separation pyrotechnics
  - Development motor (scheduled for August 25, 2009)
- **Several Major Items Manufactured**
  - Ares I-X motor segments
  - Development motor (DM-1) Nozzle
  - DM-1 segments completed and motor installed in T-97 Test Stand
  - through insulation
  - Insulation lay-up has begun on DM-2 segments
- **Ares 1-X Support**
  - Completed all Hardware Acceptance Reviews
  - Motor segments were completed and shipped to KSC in March 2009
  - All hardware has been transferred to Ground Ops
  - Hardware being mated at KSC

*National Aeronautics and Space Administration*
First Stage Thrust Oscillation

Status:
♦ June Program Review was completed with decision to baseline and implement Dual Plane (DP) Isolation
  • Baseline design established as a DP isolation system with the first plane between first stage and upper stage with a reference stiffness of 8M lb/in and an upper plane between US and Orion, on the US side of the interface with a reference stiffness of 1.2M lb/in
  • Upper Stage will begin design efforts to include the second plane isolator and coordinate interface design requirements with Orion

Four basic ways to attack problem:
♦ Reduce forcing function
♦ Detune system response away from forcing function frequency
♦ Actively create an opposing forcing function
♦ Passively absorb forcing function
Comparison of Mitigation Options

**Working Baseline**

- Dual-Plane Isolation

**Risk Mitigation Options**

- Propellant Damper Single-Plane Isolation
- Active RMAs plus Single-Plane Isolation

*National Aeronautics and Space Administration*
Full Scale Frustum Separation Test
Promontory, UT

National Aeronautics and Space Administration
Cluster Drop Test (CDT)-1
Yuma Proving Grounds, AZ

National Aeronautics and Space Administration
First Stage Accomplishments

Main Parachute Drop Test
Yuma Proving Ground, AZ

Ares I-X Motor En Route to KSC
Corinne, UT

Ares I-X Super Stack
Kennedy Space Center, FL

National Aeronautics and Space Administration
Ares I-X C/A Mated to Aft Booster on MLP
DM-1 Segment Processing
Casting/X-ray Operations

DM-1 Fwd Segment Casting
Promontory, UT

DM-1 Aft Segment Casting
Promontory, UT

DM-1 C/A Segment Casting
Promontory, UT

National Aeronautics and Space Administration
First Stage Accomplishments

Built-up Thrust Vector Control/Discrete Interface Module
Cincinnati, OH

Thrust Oscillation Flexure Design (A) and Testing (B)
San Luis Obispo, CA

DM-1 Igniter Test
Promontory, UT

DM-1 Installation into Test Stand
Promontory, UT

National Aeronautics and Space Administration
DM-1 in T-97 Test Stand
Promontory, UT
Conclusion

- **Ares First Stage design is on schedule**
  - Avionics
  - Major Structures
  - Motor
  - Deceleration System
- **Ares I-X hardware is complete and assembly at KSC is underway**
  - Launch scheduled for October 31.
- **Recovery system testing is on schedule**
  - Drogue
  - Main chute
  - Cluster
- **DM-1 static firing is scheduled for August 25, 2009**
Questions