Danny Davis
Ares I Upper Stage Manager
October 15, 2008

Launching to the Moon and Beyond:
Ares I and V Updates
What is NASA’s Mission?

- Safely fly the Space Shuttle until 2010
- Complete the International Space Station (ISS)
- Develop a balanced program of science, exploration, and aeronautics
- Develop and fly the Orion Crew Exploration Vehicle (CEV)
  - Designed for exploration but will initially service ISS
- Land on the Moon no later than 2020
- Promote international and commercial participation in exploration

“The next steps in returning to the Moon and moving onward to Mars, the near-Earth asteroids, and beyond, are crucial in deciding the course of future space exploration. We must understand that these steps are incremental, cumulative, and incredibly powerful in their ultimate effect.”

– NASA Administrator Michael Griffin
October 24, 2006
Our Exploration Fleet

What Will the Vehicles Look Like?

Earth Departure Stage

Orion
Crew Exploration
Vehicle

Altair
Lunar
Lander

Ares V
Cargo Launch
Vehicle

Ares I
Crew Launch
Vehicle
**Ares I Elements**

**Upper Stage**
- 137.1 mT (302.2K lbm) LOX/LH₂ prop
- 5.5-m (18-ft) diameter
- Aluminum-Lithium (Al-Li) structures
- Instrument unit and interstage
- Reaction Control System (RCS) / roll control for first stage flight
- Primary Ares I control avionics system
- *NASA Design / Boeing Production* ($1.12B)

**Instrument Unit**
- Primary Ares I control avionics system
- *NASA Design / Boeing Production* ($0.8B)

**Upper Stage Engine**
- Saturn J-2 derived engine (J-2X)
- Expendable
- *Pratt and Whitney Rocketdyne* ($1.2B)

**First Stage**
- Derived from current Shuttle RSRM/B
- Five segments/Polybutadiene Acrylonitrile (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- *ATK Launch Systems* ($1.8B)

**Stack Integration**
- 927.1 mT (2,044.0K lbm) gross liftoff mass (GLOM)
- 99.1 m (325.0 ft) in length
- *NASA-led*

**Encapsulated Service Module (ESM) Panels**

**Orion CEV**

**Interstage**
- Reaction Control System (RCS) / roll control for first stage flight
- Primary Ares I control avionics system
- *NASA Design / Boeing Production* ($1.12B)
**First Stage**

- **Mass:** 733 mT (1,616 lbm)
- **Thrust:** 15.8 MN
- **Burn Duration:** 126 sec
- **Height:** 53 m (174 ft)
- **Diameter:** 3.7 m (12 ft)

**Key Features:**
- **Modern Electronics**
- **Composite Frustum**
- **12-Fin Forward Segment**
- **Same propellant as Shuttle (PBAN)—Optimized for Ares Application**
- **Same cases and joints as Shuttle**
- **Booster Deceleration Motors (from Shuttle)**
- **Wide Throat Nozzle**
- **Same Aft Skirt and Thrust Vector Control as Shuttle**
- **New 45.7 m (150 ft) diameter parachutes**

**Image Description:**
- Tumble Motors (from Shuttle)
- Wide Throat Nozzle
- DAC 2 TR 6

**Source:**
- National Aeronautics and Space Administration
Propellant Load: 138 mT (304K lbm)
Total Mass: 156 mT (344K lbm)
Dry Mass: 16.3 mT (36K lbm)
Dry Mass (Interstage): 4.1 mT (9K lbm)
Length: 25.6 m (84 ft)
Diameter: 5.5 m (18 ft)
LOX Tank Pressure: 50 psig
LH₂ Tank Pressure: 42 psig
The Upper Stage Avionics will provide:
- Guidance, Navigation, and Control (GN&C)
- Command and data handling
- Pre-flight checkout

Avionics Mass: 1.1 mT (2,425 lbm)
Electrical Power: 5,145 Watts
Mass: 2.5 mT (5,511 lbm)
Thrust: 131 mT (289K lbm) (vac)
Isp: 448 sec (vac)
Height: 4.7 m (15.4 ft)
Diameter: 3.05 m (10 ft)
**Ares I Lunar Mission Profile**

- **Launch**
  - Time: 0.6 sec
  - Thrust-to-Weight Ratio: 1.57
  - Gross Liftoff Mass (GLOM): 927.1 mT (2,044.0K lbm)

- **SRB Splashdown**
  - Time: 126.9 sec
  - Altitude: 58,456 m (191.8K ft)
  - Mach: 5.88

- **Maximum Dynamic Pressure**
  - Time: 63.2 sec
  - Altitude: 13,103 m (43.0K ft)
  - Mach: 1.73
  - Dynamic Pressure: 37.0 kN/m² (772.4 psf)

- **Main Engine Start**
  - Time: 125.8 sec
  - Altitude: 57,463 m (188.5K ft)
  - Mach: 5.86
  - Max Altitude: 101,704 m (333.7K ft)
  - Dynamic Pressure: 5.6 kN/m² (116.5 psf)

- **Main Engine Cutoff (MECO)**
  - Time: 591.8 sec
  - Burn Duration: 465.0 sec

- **Spacecraft Separation**

- **SRB Reentry and Descent**

- **ESM Panel Jettison**
  - Time: 153.9 sec
  - Altitude: 79,997 m (262.5K ft)
  - Mach: 7.01

- **Launch Abort System (LAS) Jettison**
  - Time: 156.9 sec
  - Altitude: 82,177 m (269.6K ft)
  - Mach: 7.18

- **Upper Stage Reentry and Breakup**

- **Orbital Insertion**
  - Altitude: 129,600 m (70 nmi)
  - Altitude: 20.4 x 185,200 m
  - Altitude: 11.0 x 100.0 nmi
  - = 21.7

- **Upper Stage Impact (Indian Ocean)**

- **FSE Reentry and Descent**

- **Encapsulated Service Module (ESM)**

- **Forward Segment Booster (FSB)**

- **Gross Liftoff Mass (GLOM)**

- **Launch Abort System (LAS)**

- **Main Engine Cutoff (MECO)**

- **Solid Rocket Booster (SRB) Separation**
  - Time: 125.8 sec
  - Altitude: 57,463 m (188.5K ft)
  - Mach: 5.86
  - Max Altitude: 101,704 m (333.7K ft)
  - Dynamic Pressure: 5.6 kN/m² (116.5 psf)

- **Maximum Axial Acceleration**
  - 3.79 g
  - Time: 103.9 sec
  - Altitude: 37,797 m (124.0K ft)
  - Mach: 4.81
  - Dyn. Press. = 6.6 kN/m² (137.4 psf)

- **Liftoff**
  - Time: 0.6 sec
  - Thrust-to-Weight Ratio: 1.57
  - Gross Liftoff Mass (GLOM): 927.1 mT (2,044.0K lbm)
Ares I–X Test Flight

♦ Demonstrate and collect key data to inform the Ares I design:
  • Vehicle integration, assembly, and KSC launch operations
  • Staging/separation
  • Roll and overall vehicle control
  • Aerodynamics and vehicle loads
  • First stage entry dynamics for recovery

♦ Performance Data:

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<tr>
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<th>Ares I-X</th>
<th>Ares I</th>
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<tr>
<td>First Stage Max. Thrust (vacuum):</td>
<td>14.1 MN</td>
<td>15.8 MN</td>
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<td>Max. Speed:</td>
<td>Mach 4.7</td>
<td>Mach 5.84</td>
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<td>Staging Altitude:</td>
<td>39,600 m (130K ft)</td>
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<td>Liftoff Weight:</td>
<td>816 mT (1,799K lbm)</td>
<td>927 mT (2,044K lbm)</td>
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<td>Length:</td>
<td>99.7 m (327 ft)</td>
<td>99.1 m (325 ft)</td>
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<td>Max. Acceleration:</td>
<td>2.46 g</td>
<td>3.79 g</td>
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Ares V Elements

Earth Departure Stage (EDS)
- One Saturn-derived J-2X LOX/LH₂ engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

Stack Integration
- 3,704.5 mT (8,167.1K lbm) gross liftoff mass
- 116.2 m (381.1 ft) in length

Solid Rocket Boosters
- Two recoverable 5.5-segment PBAN-fueled boosters (derived from current Ares I first stage)

Core Stage
- Six Delta IV-derived RS-68 LOX/LH₂ engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

LV 51.00.48
Ares V Lunar Mission Profile

**Launch**
- Time: +1 sec
- Thrust-to-Weight Ratio: 1.36
- GLOM: 3,704.5 mT (8,167.1K lbm)

**Liftoff**
- Time: +1 sec
- Thrust-to-Weight Ratio: 1.36
- GLOM: 3,704.5 mT (8,167.1K lbm)

**SRB Separation**
- Time: 121.6 sec
- Altitude: 36,387 m (119.4K ft)
- Mach: 4.16
- Dynamic Pressure: 5.9 kN/m² (124.2 psf)

**Shroud Separation**
- Time: 295.0 sec
- Altitude: 126,875 m (416.3K ft)
- Heating Rate: 1.136 kW/m² (0.1 BTU/ft²-sec)

**Maximum Dynamic Pressure**
- Time: 78 sec
- Altitude: 14,383 m (47.2K ft)
- Mach: 1.81
- Dynamic Pressure: 32.6 kN/m² (680.0 psf)

**Core MECO and Separation, EDS Ignition**
- Time: 303.1 sec
- Altitude: 133,269 m (437.2K ft)
- Mach: 9.99

**Core Impact in Atlantic Ocean**
- Time: 303.1 sec
- Altitude: 133,269 m (437.2K ft)
- Mach: 9.99

**EDS Engine Cutoff**
- Time: 806.0 sec
- Sub-Orbital Burn Duration: 502.9 sec
- Injected Mass: 187.7 mT (413.8K lbm)
- Orbital Altitude: 240,760 m (130 nmi) circ @ 29.0°

**Lunar Lander/CEV Separation**
- Time: Assumed Up to 4 Days
- Orbital Altitude Assumed to Degrade to 185,200 m (100 nmi)

**EDS TLI Burn**
- Orbital Altitude: 185,200 m (100 nmi) circ @ 29.0°
- Burn Duration: 429.5 sec

**CEV Rendez & Dock w/EDS**
- Time: Assumed Up to 4 Days
- Orbital Altitude: 185,200 m (100 nmi)

**EDS Disposal**
What Progress Have We Made?

♦ Programmatic Milestones
  • Completed Ares I and Element System Requirements Reviews, System Definition Reviews, and Preliminary Design Reviews
  • Contracts awarded for building the first stage, J-2X engine, upper stage, instrument unit, and Orion
  • RFP issued for MSFOC Contract at MAF
  • Ares I-X test flight scheduled for 2009

♦ Technical Accomplishments
  • Testing first stage parachutes and developing nozzles
  • Constructing new J-2X test stand at Stennis Space Center
  • Performing J-2X injector tests and power pack tests
  • Fabricating Ares I-X hardware
  • Robotic Weld Tool installed and operational at MSFC

For more information go to www.nasa.gov/ares
Ares I and V Production at Michoud Assembly Facility (MAF)
Merged Manufacturing Flow

- Manufacturing Value Stream Map
  - Vertical Tack and Weld
  - Horizontal TPS Application
- Producability Summit
- Manufacturing Plan
- Manufacturing Floor Plan at Michoud
- Tooling Design and Fabrication

Boeing, working with NASA, Reduced Assembly Flow Over 100 days

Metrics
- NASA Baseline 420 days
- Boeing Contract 347 days
- Merged VSM 320 days
- With learning <300 days
Ares I Upper Stage Summary
PMR 08 Rev 1 Re-Plan Preliminary

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Shift from MSFC to MAF
USP/AP provides first Flight Design at MAF

Testing at MSFC
Long Lead US-00 (Orion) M&A
TT
Long Lead US-01 (Ares 1-Y) M&A
Long Lead US-02
Long Lead (Ares 1-Y) M&A
Ares 1-Y
Summary

- The Ares family will provide the U.S. with unprecedented exploration capabilities
  - Can inject ~40% more mass to the Moon than Apollo/Saturn

- The Ares team has made significant progress since its inception in October 2005
  - Full team is onboard
  - All major milestones met to-date, with PDR completed late Summer 2008
  - Ares I-X test flight is on schedule for 2009

- We are making extensive use of lessons learned to minimize cost, technical, and schedule risks

- The NASA-led / Contractor partnership is very effective in developing the Ares I