Ares V: A National Launch Asset for the 21st Century

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The NASA Ares Projects Office is developing the launch vehicles to move the United States and humanity beyond low earth orbit.

Ares I is a crewed vehicle, and Ares V is a heavy lift vehicle being designed to launch cargo into LEO and transfer cargo and crews to the Moon.

This is a snapshot of development. Ares V is early in the requirements formulation stage of development pending a planned authority to proceed (ATP) from NASA in late 2010.

The Ares V vehicle will be considered a national asset, opening new worlds and creating unmatched opportunities for human exploration, science, national security, and space business.

My goal today is to update you on the status of the Ares V vehicle.
NASA’s Exploration Fleet

Our Exploration Fleet
What Will the Vehicles Look Like?

Earth Departure Stage

Ares V
Cargo Launch Vehicle

Orion
Crew Exploration Vehicle

Altair
Lunar Lander

Ares I
Crew Launch Vehicle
Ares Vehicles: Commonality and Heritage Hardware

Note: Vehicles Not To Scale

Upper Stage Derived Vehicle Systems

J-2X Upper Stage Engine

First Stage (5-Segment SRB)

Ares I
25.5 mT (56.2k lbm) to LEO

Elements from SRB

Ares V
71.1 mT (156.7k lbm) to TLI (with Ares I)
63.0 mT (138.5k lbm) to Direct TLI
187.7 mT (413.8k lbm) to LEO

U.S. Air Force (USAF) RS-68B Engine from Delta IV RS-68

Boeing Delta IV

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LCCR/MCR-Approved Point-of-Departure

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

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

Avionics and Software
- Primary Ares V avionics system

Solid Rocket Boosters (2)
- Two recoverable 5.5-segment PBAN-fueled, steel-casing boosters (derived from current Ares I first stage)

Gross Lift Off Mass: 3,704.5 mT (8,167.1k lbm)
Integrated Stack Length: 116 m (381 ft)
Ares V Launch Profile For Lunar Mission

CEV – Crew Exploration Vehicle
EDS – Earth Departure Stage
GLOM – Gross Liftoff Mass
MECO – Main Engine Cutoff
SRB – Solid Rocket Booster
TLI – Trans-Lunar Injection

**Shroud Separation**
Time = 295.0 sec
Altitude = 126,875 m (416.3K ft)

**EDS Engine Cutoff**
Time = 806.0 sec
Sub-Orbital Burn Duration = 502.9 sec
Injected Mass = 187.7 mT (413.8K lbm)
Orbital Altitude = 240.8 km (130.0 nmi) circ @ 29.0°

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

**EDS TLI Burn**
Orbital Altitude = 185.2 km (100.0 nmi)
circ @ 29.0°
Burn Duration = 429.5 sec

**Maximum Dynamic Pressure**
Time = 78.8 sec
Altitude = 14,383 m (47.2K ft)
Mach = 1.81

**Lunar Lander/CEV Separation**

**SRB Separation**
Time = 121.6 sec
Altitude = 36,387 m (119.4K ft)
Mach = 4.16

**SRB Splashdown**

**Core Impact in Atlantic Ocean**

**CEV Rendez. & Dock w/EDS**
Time – Assumed Up to 4 Days
Orbital Altitude Assumed To Degrade to 185.2 km (100.0 nmi)

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Original ESAS Capability
- 45.0 mT Lander
- 20.0 mT CEV
- No Loiter in LEO
- 8.4m OML
- 5 SSMEs / 2J2S

CY-06 Budget Trade to Increase
- Ares I / Ares V Commonality
- Ares I : 5 Seg RSRB / J2-X instead of Air-Start SSME
- Ares V: 1 J2-X

Detailed Cost Trade of SSME vs RS-68
- $4.25B Life Cycle Cost Savings for 5 Engine Core
- Increased Commonality with Ares I Booster
- 30-95 Day LEO Loiter Assessed

IDAC 3 Trade Space
- Lunar Architecture Team 1/2 (LAT) Studies
- Mission Delta V's increased
- Increase Margins From TLI Only to Earth through TLI
- Loiter Penalties for 30 Day Orbit Quantified

EDS Diameter Change from 8.4m to 10m
- Lunar Architecture Team 1/2 (LAT) Studies
- Lunar /Mars Systems Benefits
- Tank Assembly Tooling Commonality

Incorporate Ares I Design Lessons Learned / Parameters
- Core Engine / SRB Trades to Increase Design Margins
- Increase Subsystem Mass Growth Allowance (MGA)

Recommended Option
- 6 Core Engines
- 5.5 Segment PBAN

Updated Capability
- 45.0t Lander
- 20.2t CEV
- ~6t Perf. Margin
- 4 Day LEO Loiter
- Ares I Common MGAs
- Booster Decision Summer 2010

National Aeronautics and Space Administration
# LCCCR Trade Space

<table>
<thead>
<tr>
<th>Booster</th>
<th>Core</th>
<th>Standard Core + 5 RS-68B Engines</th>
<th>Opt. Core Length + 6 RS-68B Engines</th>
<th>Common Design Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>Composite Dry Structures for Core Stage, EDS &amp; Shroud</td>
</tr>
<tr>
<td></td>
<td>5 Segment PBAN Steel Case Reusable</td>
<td>51.0.39 63.6 t 61.5 t</td>
<td>51.0.46 68.6 t 60.2 t 4.5 t 1 spacer</td>
<td>Metallic Cryo Tanks for Core Stage &amp; EDS</td>
</tr>
<tr>
<td></td>
<td>5 Segment HTPB Composite Case Expendable</td>
<td>51.0.40 69.7 t 61.5 t +4.1 t 1 spacer</td>
<td>51.0.47 74.2 t 66.3 t +5.6 t 1 spacer</td>
<td>RS-68B Performance: Isp = 414.2 s Thrust = 797K lbf @ vac</td>
</tr>
<tr>
<td></td>
<td>5.5 Segment PBAN Steel Case Reusable</td>
<td>51.0.41 67.4 t 61.5 t 2.3 t 3.7 t 0 spacers</td>
<td>51.0.48 71.1 t 63.0 t 3.1 t</td>
<td>J-2X Performance: Isp = 448.0 s Thrust = 294K lbf @ vac</td>
</tr>
</tbody>
</table>

- Initial LCCR Study Reference
- Alternative New POD
- Recommend for New POD
- 1.5 Launch TLI Capability
- Cargo TLI Capability

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National Aeronautics and Space Administration
Approved New Point of Departure  
- Vehicle 51.00.48 -

◊ **Vehicle 51.00.48 approved**
  - 6 Engine Core, 5.5 Segment PBAN Steel Case Booster
  - Provides Architecture Closure with Margin
  - High Commonality with Ares I

◊ **Vehicle 51.00.47 with Composite HTPB Booster Retained as Ares V Option**
  - Final Decision on Ares V Booster at Constellation Lunar SRR (June 2010)
  - Additional Performance Capability if needed for Margin or requirements
  - Allows for competitive acquisition environment for booster
  - Fund key technology areas: composite cases, HTPB propellant characterization

**NOTE:** These are MEAN numbers

Section 06: Ares V System
National Aeronautics and Space Administration

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# Ares V Utilization: A National Asset

<table>
<thead>
<tr>
<th>Saturn V Saturn V Apollo 15</th>
<th>Ares V Reference 51.00.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>363.0 STACK HEIGHT (ft)</td>
<td>360.5</td>
</tr>
<tr>
<td>6,495,000 GROSS (lb)</td>
<td>7,440,326</td>
</tr>
<tr>
<td>309,787 LEO INSERTION MASS (lbm)</td>
<td>372,616</td>
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<tr>
<td>143,981 TLI INSERTION MASS (lbm)</td>
<td>195,464</td>
</tr>
<tr>
<td>686 MAX Q (psf)</td>
<td>623</td>
</tr>
<tr>
<td>4.00 MAX GRAVITATIONAL LOAD (g)</td>
<td>3.90</td>
</tr>
<tr>
<td>24,914 DRY MASS (lbm), EDS STAGE</td>
<td>50,144</td>
</tr>
<tr>
<td>230,000 TOTAL THRUST (lbf, vac), EDS STAGE</td>
<td>294,000</td>
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<tr>
<td>0.87 THRUST / WEIGHT, EDS STAGE</td>
<td>0.43</td>
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<tr>
<td>30 AL 2014 TANK MATERIAL, EDS STAGE</td>
<td>AL-LI 2195</td>
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<tr>
<td>424.0 LOX/LH2 PROPELLANT TYPE, EDS STAGE</td>
<td>LOX/LH2</td>
</tr>
<tr>
<td>23.0 ENGINE Isp (sec, vac), EDS STAGE</td>
<td>448.0</td>
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<tr>
<td>23.0 STAGING MACH #, EDS STAGE</td>
<td>9.1</td>
</tr>
<tr>
<td>88,000 DRY MASS (lbm), 2nd STAGE</td>
<td>131.6</td>
</tr>
<tr>
<td>1,150,000 TOTAL THRUST (lbf, vac), 2nd STAGE</td>
<td>131.6</td>
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<tr>
<td>1.05 THRUST / WEIGHT, 2nd STAGE</td>
<td>1.05</td>
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<tr>
<td>30 AL 2219 TANK MATERIAL, 2nd STAGE</td>
<td>AL-LI 2195</td>
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<tr>
<td>424.0 LOX/LH2 PROPELLANT TYPE, 2nd STAGE</td>
<td>LOX/LH2</td>
</tr>
<tr>
<td>19.4 ENGINE Isp (sec, vac), 2nd STAGE</td>
<td>8.8</td>
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<tr>
<td>96.1 STAGING ALTITUDE (nmi), 2nd STAGE</td>
<td>76.0</td>
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<tr>
<td>305,232 DRY MASS (lbm), 1st STAGE</td>
<td>398.500</td>
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<tr>
<td>7,765,000 TOTAL THRUST (lbf, vac), 1st STAGE</td>
<td>3985.000</td>
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<td>1.20 THRUST / WEIGHT, 1st STAGE</td>
<td>1.32</td>
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<tr>
<td>304.0 LOX/RP-1 PROPELLANT TYPE, 1st STAGE</td>
<td>LOX/LH2</td>
</tr>
<tr>
<td>7.0 ENGINE Isp (sec, vac), 1st STAGE</td>
<td>414.2</td>
</tr>
<tr>
<td>40.5 STAGING ALTITUDE (nmi), 1st STAGE</td>
<td>76.0</td>
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<tr>
<td><strong>Burnout Mass (lbm), RSRB</strong></td>
<td><strong>Burnout Mass (lbm), RSRB</strong></td>
</tr>
<tr>
<td><strong>Total Thrust (lbf, vac), RSRB</strong></td>
<td><strong>Total Thrust (lbf, vac), RSRB</strong></td>
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<tr>
<td><strong>Thrust / Weight, Ignition + 1.0 SEC</strong></td>
<td><strong>Thrust / Weight, Ignition + 1.0 SEC</strong></td>
</tr>
<tr>
<td><strong>Tank Material, RSRB</strong></td>
<td><strong>Tank Material, RSRB</strong></td>
</tr>
<tr>
<td><strong>Propellant Type, RSRB</strong></td>
<td><strong>Propellant Type, RSRB</strong></td>
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<td><strong>Engine Isp (sec, vac), RSRB</strong></td>
<td><strong>Engine Isp (sec, vac), RSRB</strong></td>
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<td><strong>Staging Mach #, RSRB</strong></td>
<td><strong>Staging Mach #, RSRB</strong></td>
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<tr>
<td><strong>Staging Altitude (nmi), RSRB</strong></td>
<td><strong>Staging Altitude (nmi), RSRB</strong></td>
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</table>

**Most numbers for Saturn V reference the Apollo 15 Mission; ACO 09-FEB-2007**

**Numbers for Ares V reference the 51.00.39 mission; ACO 10-JAN-2008**

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Payload Shroud Point Of Departure

- Composite sandwich construction (Carbon-Epoxy face sheets, Al honeycomb core)
- Painted cork TPS bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)

Quad Sector Design
Frangible Joint Horizontal Separation
Thrust Rail Vertical Separation System
Payload umbilical separation

Mass: 9.1 mT (20.0k lbm)
POD Geometry: Biconic
Design: Quad sector
Barrel Diameter: 10 m (33 ft)
Barrel Length: 9.7 m (32 ft)
Total Length: 22 m (72 ft)
The Ares V Shroud Compared

<table>
<thead>
<tr>
<th>Shroud</th>
<th>Length</th>
<th>Diameter</th>
<th>Area</th>
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<tbody>
<tr>
<td>Ares V</td>
<td>10 x 9.7</td>
<td>~561 m²</td>
<td></td>
</tr>
<tr>
<td>Ares V</td>
<td>8.4 x 12</td>
<td>~493 m²</td>
<td></td>
</tr>
<tr>
<td>Atlas V</td>
<td>5.4 x 12.4</td>
<td>~311 m²</td>
<td></td>
</tr>
<tr>
<td>Delta IV</td>
<td>5.1 x 13</td>
<td>~277 m²</td>
<td></td>
</tr>
<tr>
<td>Skylab</td>
<td>6.5 x 10</td>
<td>~305 m²</td>
<td></td>
</tr>
<tr>
<td>Ariane</td>
<td>5.4 x 10.6</td>
<td>~254 m²</td>
<td></td>
</tr>
<tr>
<td>Apollo SLA</td>
<td>6.6/5.6</td>
<td>~142 m²</td>
<td></td>
</tr>
<tr>
<td>Delta II</td>
<td>3 x 4.2</td>
<td>~63 m²</td>
<td></td>
</tr>
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</table>
Ares V Payload vs. Altitude and Inclination

Ares V Payload vs. Altitude & Inclination (LV 51.00.39)

Payload (tonnes)

Circular Orbital Altitude (km)

Inclination = 29 deg
Inclination = 35 deg
Inclination = 40 deg
Inclination = 45 deg
Inclination = 51.6 deg

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Ares V Payload Mass vs. C3 Energy

Payload vs. C3 Energy

- Ares V
- Ares V with Centaur V2

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## Ares V Performance for Selected Trajectories

<table>
<thead>
<tr>
<th>Mission Profile</th>
<th>Target</th>
<th>Constellation POD Shroud</th>
<th>Extended Shroud</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Payload (lbm)</td>
<td>Payload (mt)</td>
</tr>
<tr>
<td>1) LEO (@29° inclination)</td>
<td>241 x 241 km</td>
<td>315,000</td>
<td>143</td>
</tr>
<tr>
<td>2) GEO</td>
<td>Transfer DV 14,100 ft/s</td>
<td>77,000</td>
<td>35</td>
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<tr>
<td>3) Cargo Lunar Outpost (TLI Direct), Reference</td>
<td>C3 of -1.8 km²/s²</td>
<td>126,000</td>
<td>57</td>
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<tr>
<td>4) Sun-Earth L2 Transfer Orbit Injection</td>
<td>C3 of -0.7 km²/s²</td>
<td>124,000</td>
<td>56.5</td>
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<tr>
<td>5) Earth-Moon L2 Transfer Orbit Injection</td>
<td>C3 of -1.7 km²/s²</td>
<td>126,000</td>
<td>57.0</td>
</tr>
<tr>
<td>6) GTO Injection</td>
<td>Transfer DV 8,200 ft/s</td>
<td>153,000</td>
<td>69.5</td>
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<tr>
<td>7) Mars Cargo (TMI Direct)</td>
<td>C3 of 9 km²/s²</td>
<td>106,000</td>
<td>48</td>
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</tbody>
</table>
Current Activities

♦ Ares V concept definition/requirements development industry proposals
♦ Structural test approach
♦ Structural test articles
♦ Ares V-Y flight test objectives
♦ Ares V aerodynamic characterization
♦ Manufacturing, test, and launch facilities
♦ Core Stage and EDS propulsion test approach and facilities assessment
♦ Technology prioritization
♦ Ares V Cost threat risk assessment
♦ Ares V performance risk assessment
### Ares V Planning Calendar

#### Level I/II Milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
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<tr>
<td>SRR</td>
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#### Altair Milestones (for reference only)

- Altair 1
- Altair 2
- Altair 3
- Altair 4

#### Ares V Project Milestones

### Systems Engineering and Integration

**STUDY**

- Concept Review
- SRR

**DEFINITION**

- PDR
- RAC 1
- RAC 2
- RAC 3
- PDR/NAR

**DESIGN**

- CDR

**DEVELOPMENT**

- Engineering Assessment
- RAC 1
- RAC 2

**OPERATIONS**

- Core Stage
- Core Stage Engine (RS-68B)
- Booster
- Earth Departure Stage
- Earth Departure Stage Engine
- Payload Shroud
- Instrument Unit
- Systems Testing

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Conclusions

♦ Ares V current concept (51.00.48) exceeds Saturn V mass capability to trans lunar injection by almost 40% alone or almost 60% with Ares I

♦ This concept vehicle can meet current Human Lunar Return requirements with ~6 mT of Margin

♦ 2009 activities focused on refining vehicle and operational concept, refining requirements, working with potential non-Constellation users to understand vehicle/payload benefits and design issues

♦ Ares V is sensitive to loiter time, attitude, power, and altitude requirements, in addition to payload performance