National Aeronautics and Space Administration

# Ares I Overview

**Phil Sumrall**
Advanced Planning Manager
Ares Projects
*NASA MSFC*

**Masters Forum**
*May 14, 2009*

# Building on a Foundation of Proven Technologies

## - Launch Vehicle Comparisons -

mT - metric tons
TLI - Trans-Lunar Injection
LEO - Low Earth Orbit

Overall Vehicle Height, m (ft)

122 m (400 ft)
91 m (300 ft)
61 m (200 ft)
30 m (100 ft)
0

Crew
Lunar Lander
S-IVB (One J-2 engine) 108.9 mT (240.0K lbm) $LOX/LH_2$
S-II (Five J-2 engines) 453.6 mT (1,000.0K lbm) $LOX/LH_2$
S–IC (Five F-1) 1,769.0 mT (3,900.0K lbm) LOX/RP-1

### Saturn V

*1967–1972*

**Height:** 110.9 m (364.0 ft)
**Gross Liftoff Mass :**
2,948.4 mT (6,500K lbm)
**Payload Capability:**
44.9 mT (99.0K lbm) to TLI
118.8 mT (262.0K lbm) to LEO

Two 4-Segment Reusable Solid Rocket Booster (RSRB's)

### Space Shuttle

*1981–Present*

**Height:** 56.1 m (184.2 ft)
**Gross Liftoff Mass:**
2,041.1 mT (4,500.0K lbm)
**Payload Capability:**
25.0 mT (55.1K lbm)
to Low Earth Orbit (LEO)

Orion
Upper Stage (One J-2X) 137.1 mT (302.2K lbm) $LOX/LH_2$
One 5-Segment Reusable Solid Rocket Booster (RSRB)

### Ares I

*First Flight 2015*

**Height:** 99.1 m (325.0 ft)
**Gross Liftoff Mass :**
927.1 mT (2,044.0K lbm)
**Payload Capability:**
25.5 mT (56.2K lbm)
to LEO

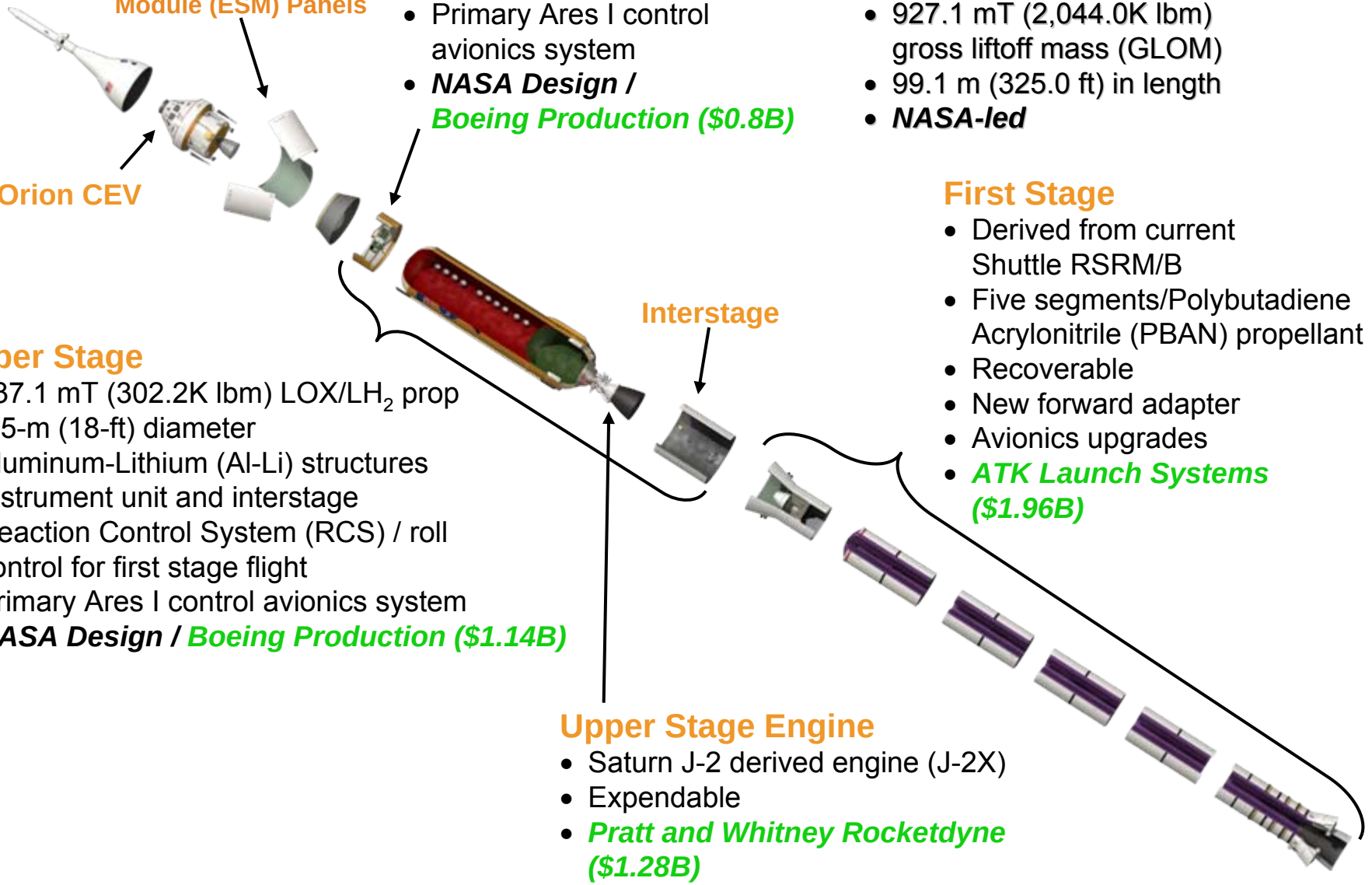
Altair
Earth Departure Stage (EDS) (1 J-2X) 253.0 mT (557.7K lbm) $LOX/LH_2$
Core Stage (Six RS-68 Engines) 1,587.3 mT (3,499.5K lbm) $LOX/LH_2$
Two 5.5-Segment Reusable Solid Rocket Booster (RSRB's)

### Ares V

*First Flight 2018*

**Height:** 116.2 m (381.1 ft)
**Gross Liftoff Mass :**
3,704.5 mT (8,167.1K lbm)
**Payload Capability:**
71.1 mT (156.7K lbm) to TLI (with Ares I)
62.8 mT (138.5K lbm) to TLI
~187.7 mT (413.8K lbm) to LEO

# Ares I Elements




## Instrument Unit

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

## Stack Integration

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

## First Stage

- Derived from current Shuttle RSRM/B
- Five segments/Polybutadiene Acrylonitrile (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- ***ATK Launch Systems ($1.96B)***

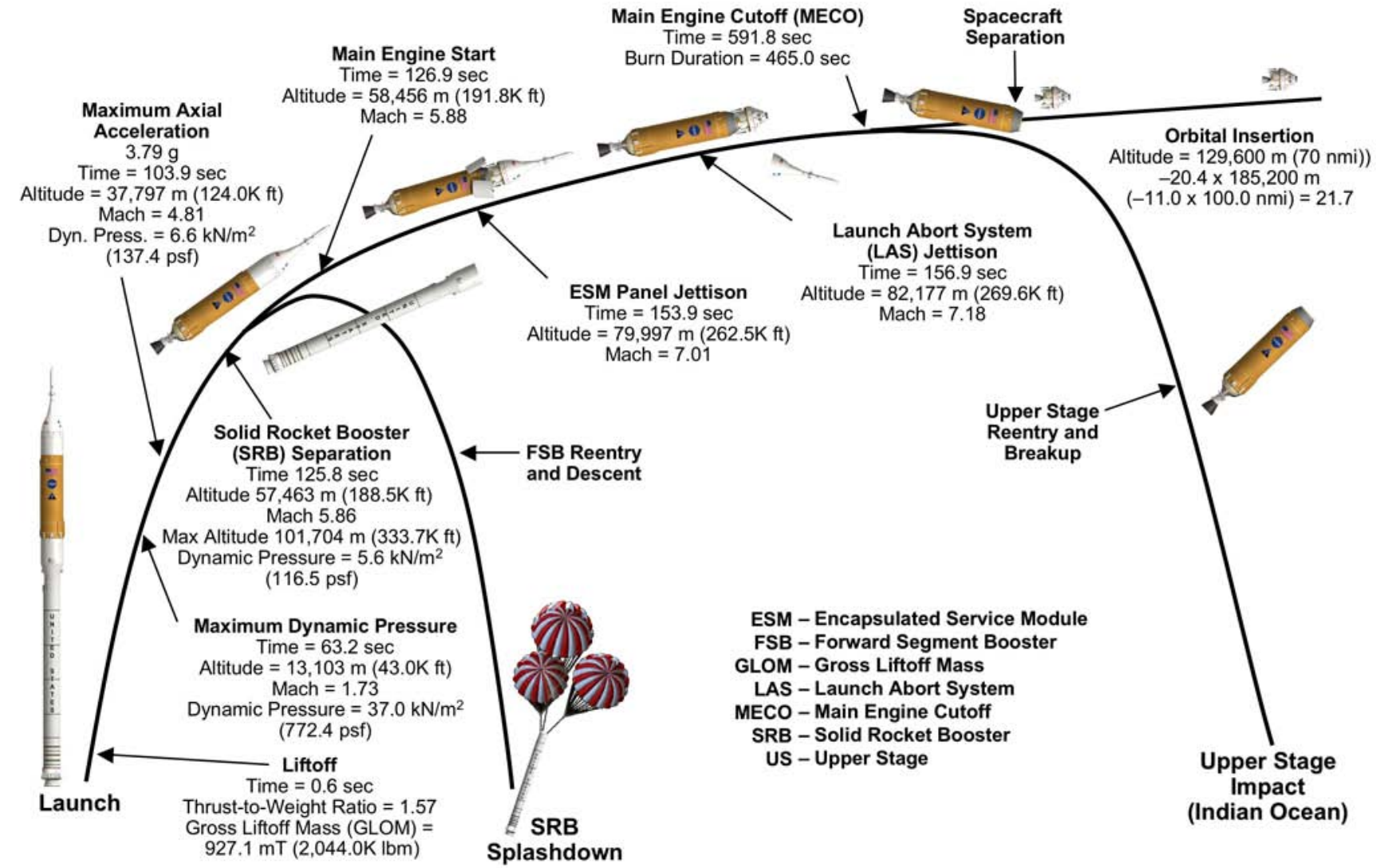
## Upper Stage

- 137.1 mT (302.2K lbm) LOX/$LH_2$ 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 ($1.14B)***

## Upper Stage Engine

- Saturn J-2 derived engine (J-2X)
- Expendable
- ***Pratt and Whitney Rocketdyne ($1.28B)***

# Ares I Ascent Profile




DAC 2 TR 6

# First Stage


Composite Frustum

Tumble Motors (from Shuttle)

Modern Electronics

New 12-Fin Forward Segment to support Ares requirement

Same propellant as Shuttle (PBAN)-Reformulated for longer burn time

Same cases and joints as Shuttle, inhibitor geometry change for better burn control

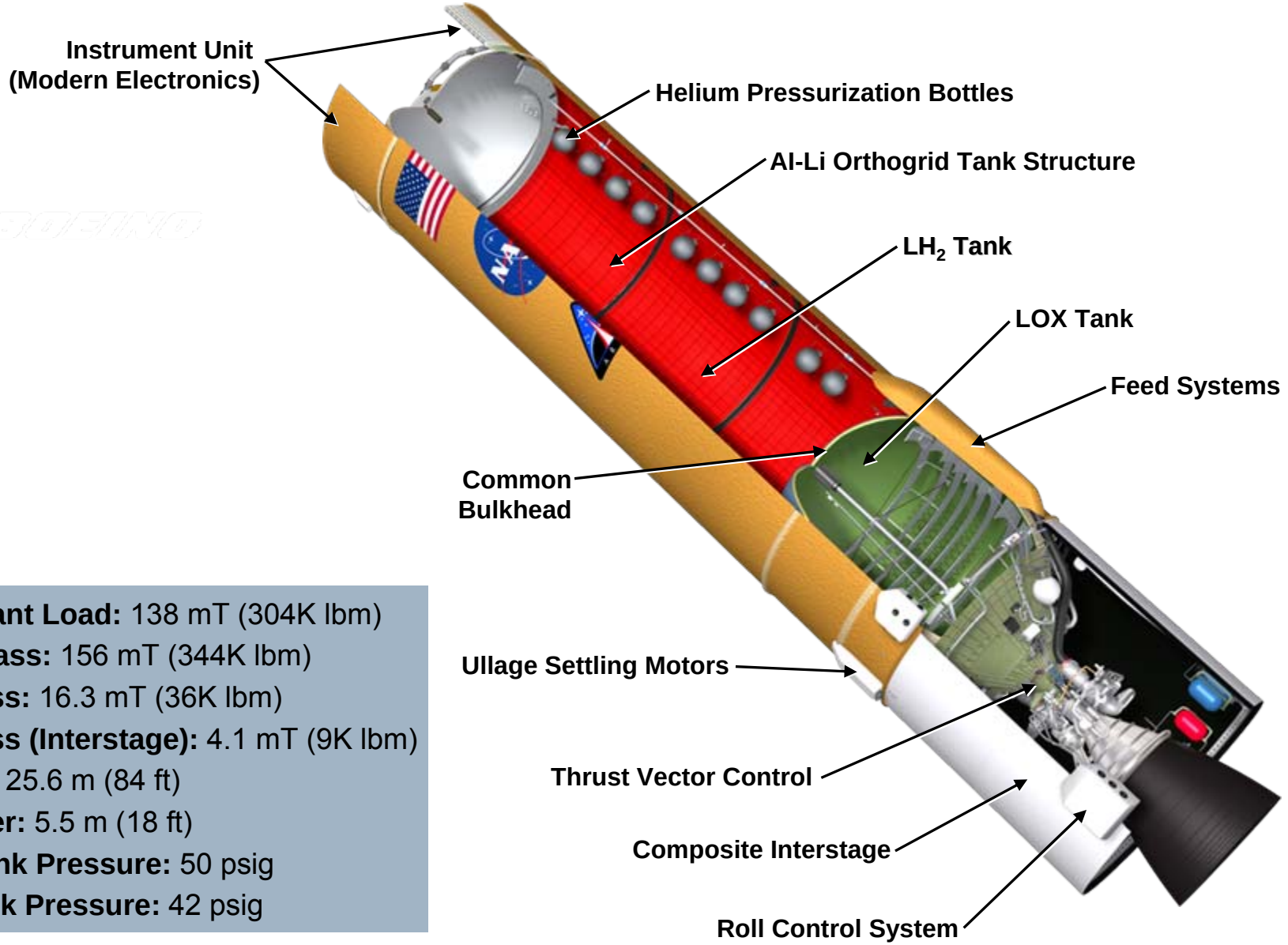
Same Aft Skirt and Thrust Vector Control as Shuttle

Booster Deceleration Motors (from Shuttle)

Nozzle upgraded to support higher motor performance

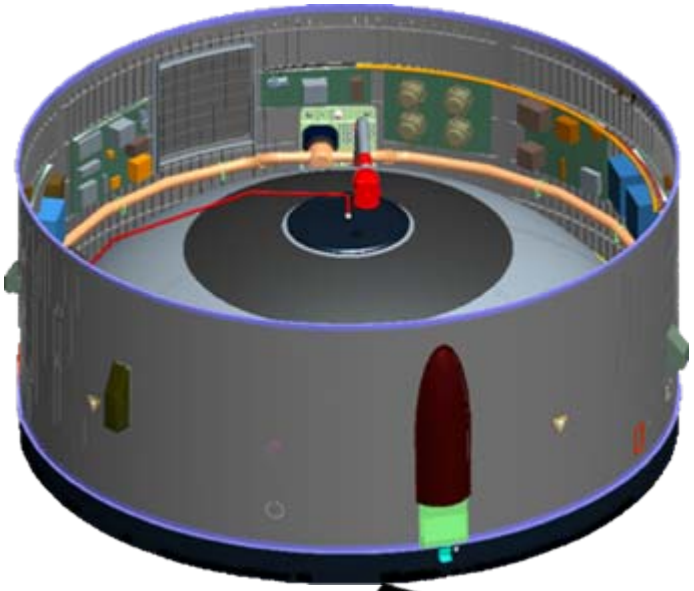
**Mass:** 733 mT (1,616 lbm)
**Thrust:** 15.8 MN
**Burn Duration:** 126 sec
**Height:** 53 m (174 ft)
**Diameter:** 3.7 m (12 ft)

# Upper Stage



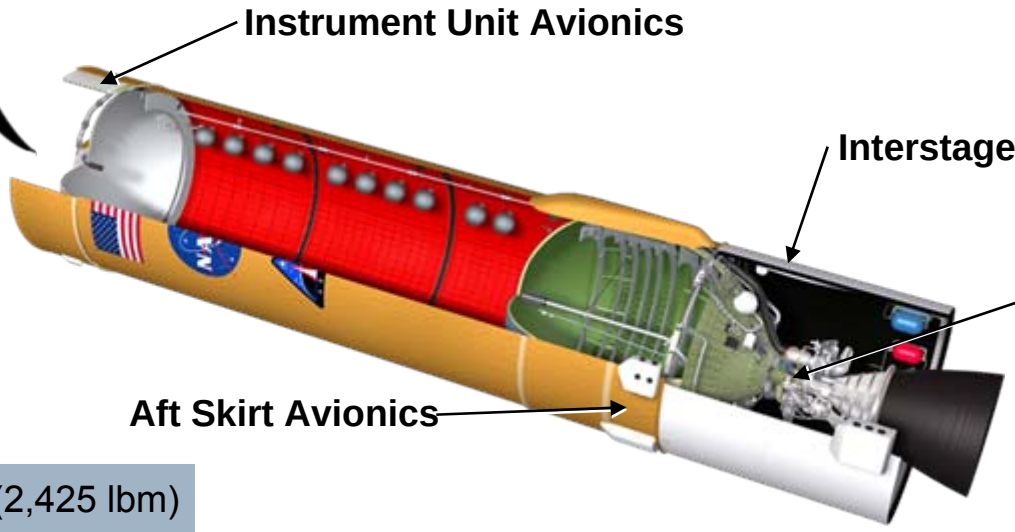

**Propellant Load:** 138 mT (304K lbm)
**Total Mass:** 156 mT (344K lbm)
**Dry Mass:** 16.3 mT (36K lbm)
**Dry Mass (Interstage):** 4.1 mT (9K lbm)
**Length:** 25.6 m (84 ft)
**Diameter:** 5.5 m (18 ft)
**LOX Tank Pressure:** 50 psig
**$LH_2$ Tank Pressure:** 42 psig

# Upper Stage Avionics



## The Upper Stage Avionics will provide:

- Guidance, Navigation, and Control (GN&C)
- Command and data handling
- Pre-flight checkout




BOEING

**Avionics Mass:** 1.1 mT (2,425 lbm)
**Electrical Power:** 5,145 Watts

# J-2X Engine

*Used on Ares I and Ares V*

**Turbomachinery**
- Based on J-2S MK-29 design

**Gas Generator**
- Based on RS-68 design

**Engine Controller**
- Based directly on RS-68 design and software architecture

**Regeneratively Cooled Nozzle Section**
- Based on long history of RS-27 success

**Flexible Inlet Ducts**
- Based on J-2 & J-2S ducts

**Open-Loop Pneumatic Control**
- Similar to J-2

**HIP-bonded MCC**
- Based on RS-68 demonstrated technology

**Metallic Nozzle Extension**
- New design

**Mass:** 2.5 mT (5,511 lbm)
**Height:** 4.7 m (15.4 ft)
**Diameter:** 3.05 m (10 ft)
**Thrust:** 1,308K N (294K lbm) (vac)
**Isp:** 448 sec (vac)
**Height:** 4.7 m (15.4 ft)
**Diameter:** 3.05 m (10 ft)
**Operation Time:** 500 sec.
**Altitude Start / On-orbit Restart**
**Operational Life:** 8 starts/ 2,600 sec

Pratt & Whitney
A United Technologies Company

Pratt & Whitney Rocketdyne, Inc.

# 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:**

| | Ares I-X | Ares I |
|---|---|---|
| **First Stage Max. Thrust (vacuum):** | 14.1 MN | 15.8 MN |
| **Max. Speed:** | Mach 4.7 | Mach 5.84 |
| **Staging Altitude:** | 39,600 m (130K ft) | 57,700 m (188K ft) |
| **Liftoff Weight:** | 816 mT (1,799K lbm) | 927 mT (2,044K lbm) |
| **Length:** | 99.7 m (327 ft) | 99.1 m (325 ft) |
| **Max. Acceleration:** | 2.46 g | 3.79 g |

# Ares V Overview

**Phil Sumrall**
*Advanced Planning Manager*
*Ares Projects*
*NASA MSFC*

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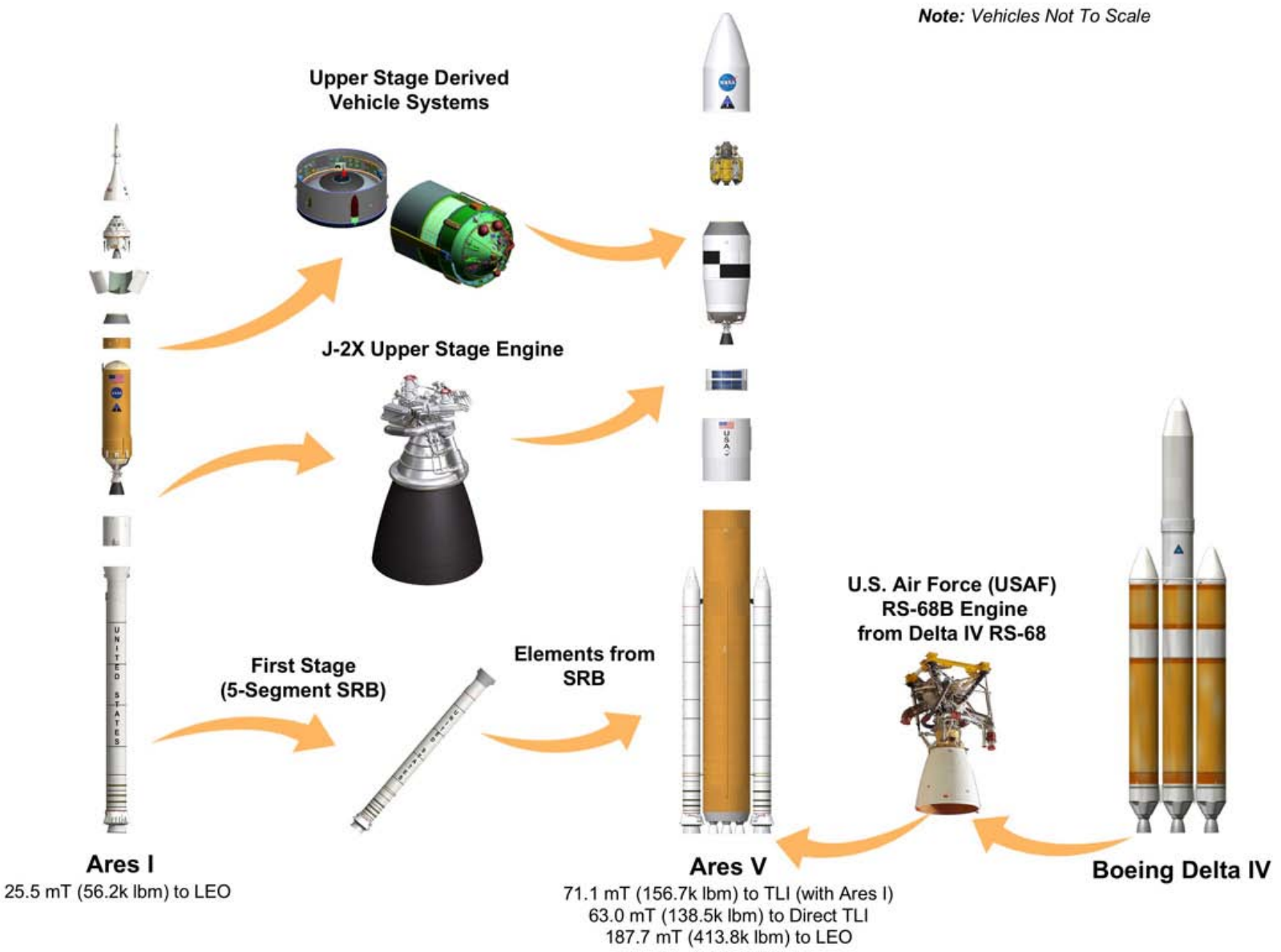
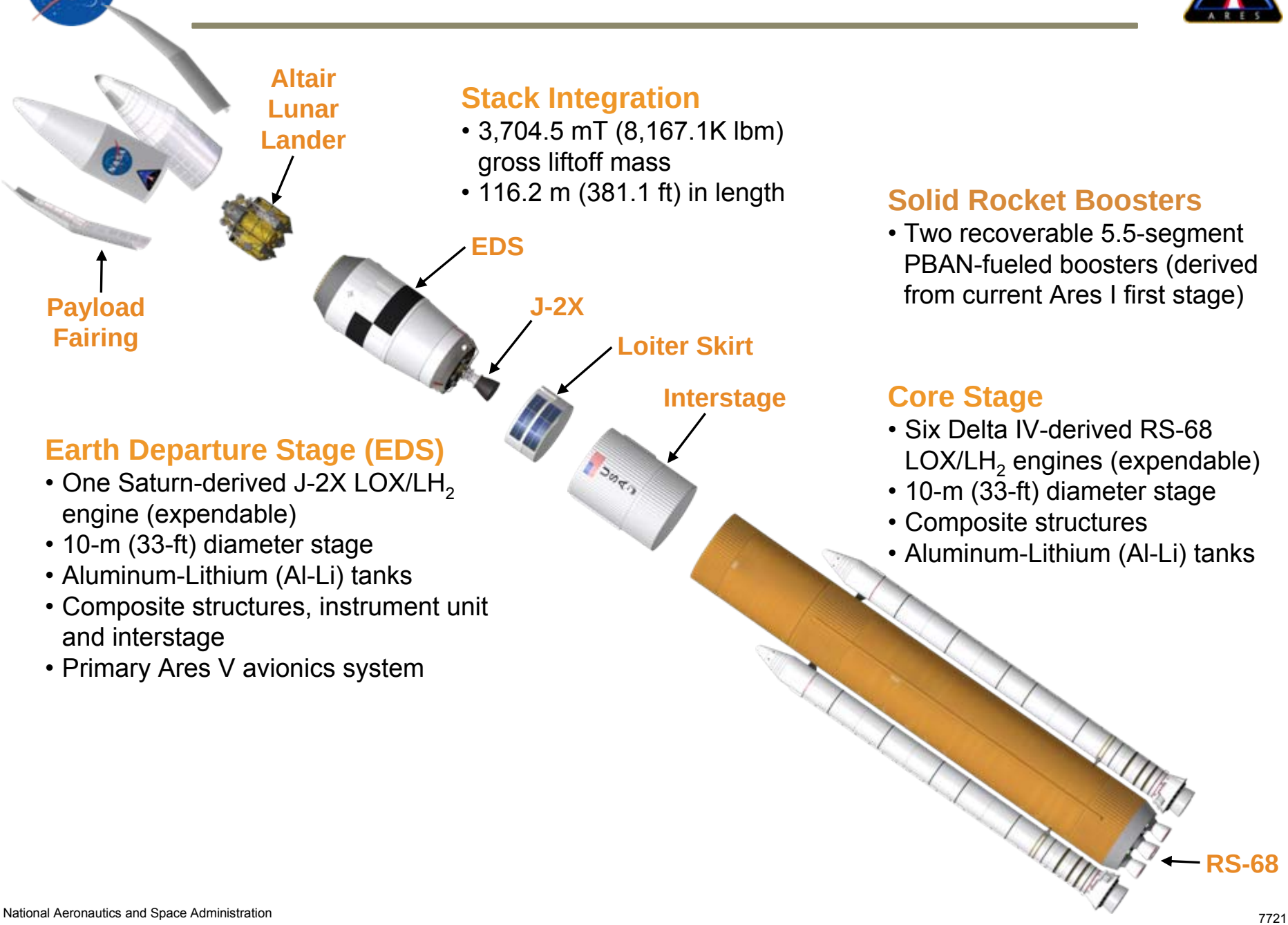
# Employing Common Hardware to Reduce Operations Costs



# Ares V Elements




## 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)

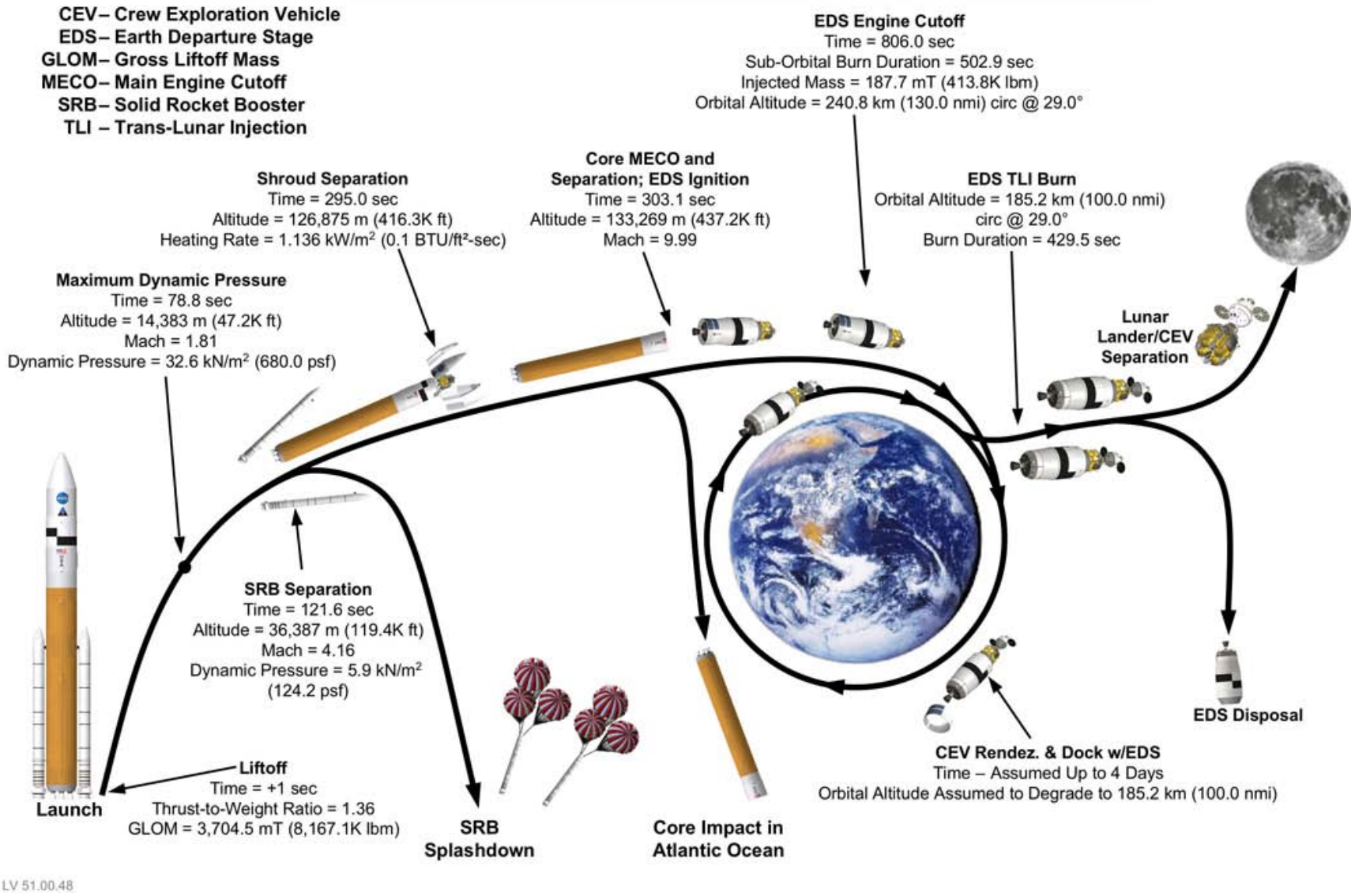
## Earth Departure Stage (EDS)

- One Saturn-derived J-2X LOX/$LH_2$ engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

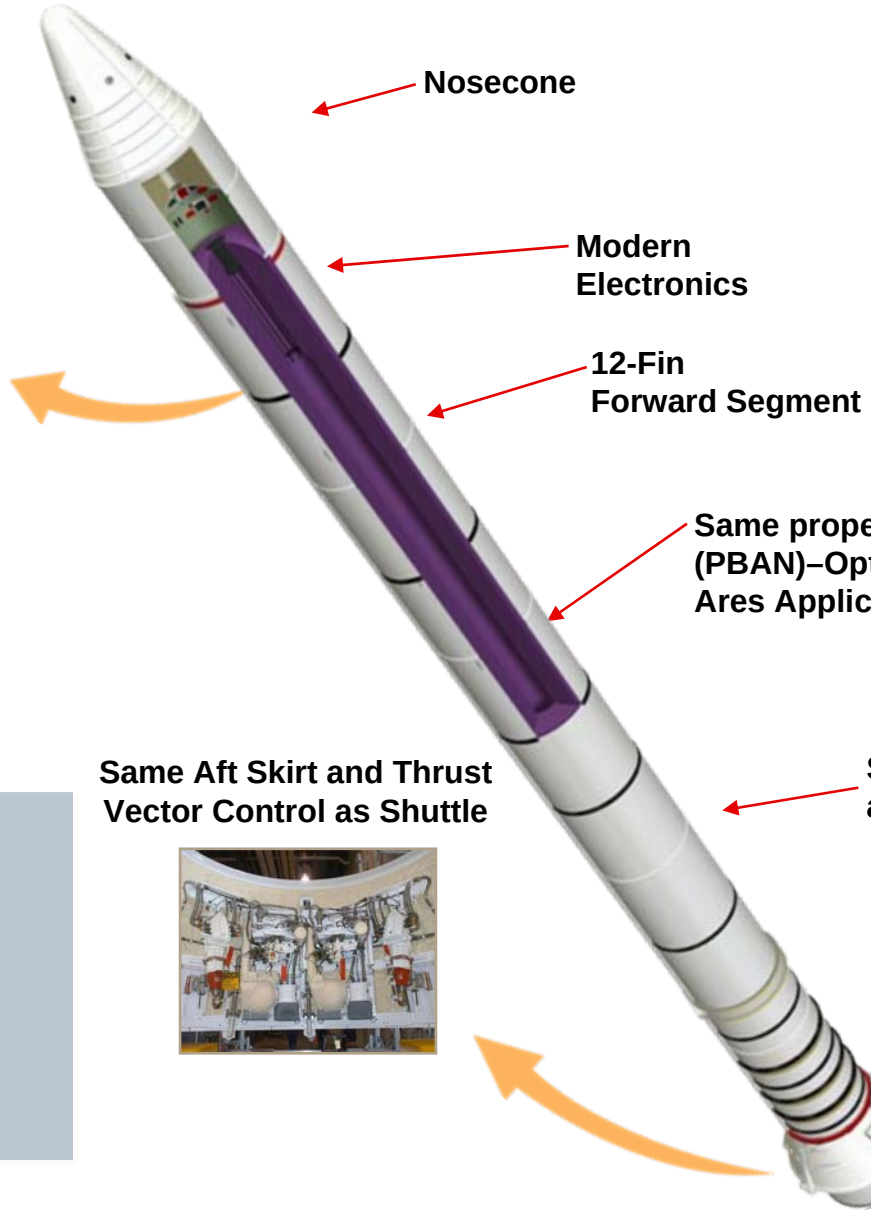
## Core Stage

- Six Delta IV-derived RS-68 LOX/$LH_2$ engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

# Ares V Ascent Profile



# Ares V Solid Rocket Booster (SRB)


*Ares V SRB is similar to Space Shuttle and Ares I but optimized for lunar missions*

**Same Aft Skirt and Thrust Vector Control as Shuttle**



**Each Booster:**

**Mass:** 791.5 t (1,744.9 $klb_m$)

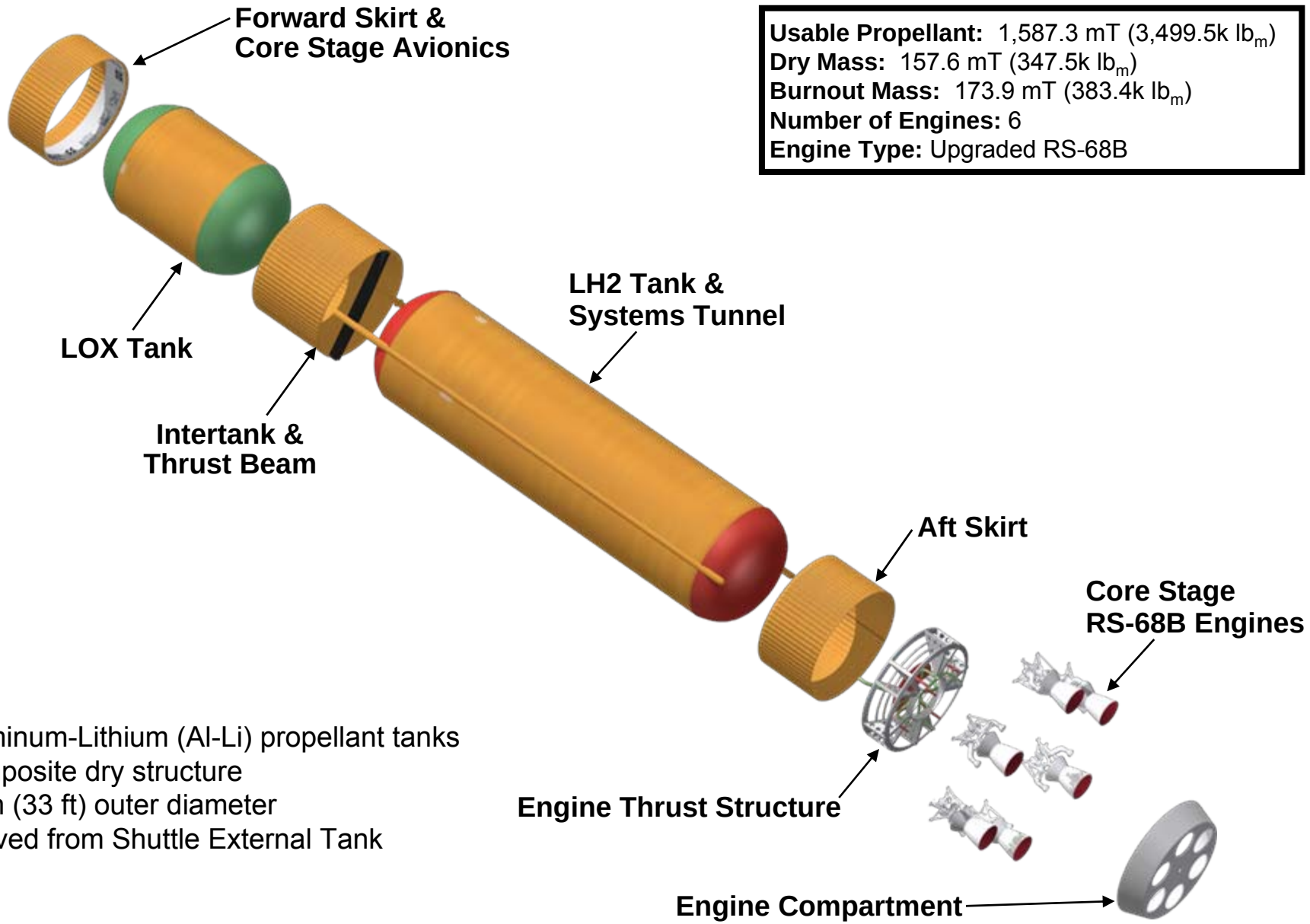
**Thrust:** 16.86 MN (3.79 $Mlb_f$)

**Burn Duration:** 126 sec

**Height:** 59 m (193 ft)

**Diameter:** 3.7 m (12 ft)

# Ares V Core Stage



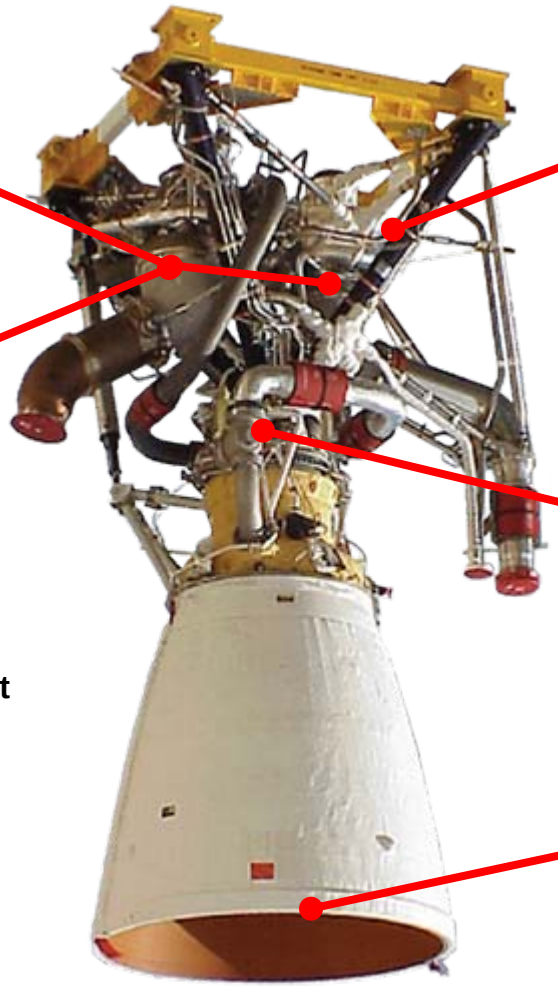

**Usable Propellant:** 1,587.3 mT (3,499.5k $lb_m$)
**Dry Mass:** 157.6 mT (347.5k $lb_m$)
**Burnout Mass:** 173.9 mT (383.4k $lb_m$)
**Number of Engines:** 6
**Engine Type:** Upgraded RS-68B

- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10 m (33 ft) outer diameter
- Derived from Shuttle External Tank

# RS-68 to RS-68B

* Redesigned turbine nozzles to increase maximum power level by ≈ 2%

Redesigned turbine seals to significantly reduce helium usage for pre-launch



Helium spin-start duct redesign, along with start sequence modifications, to help minimize pre-ignition free hydrogen

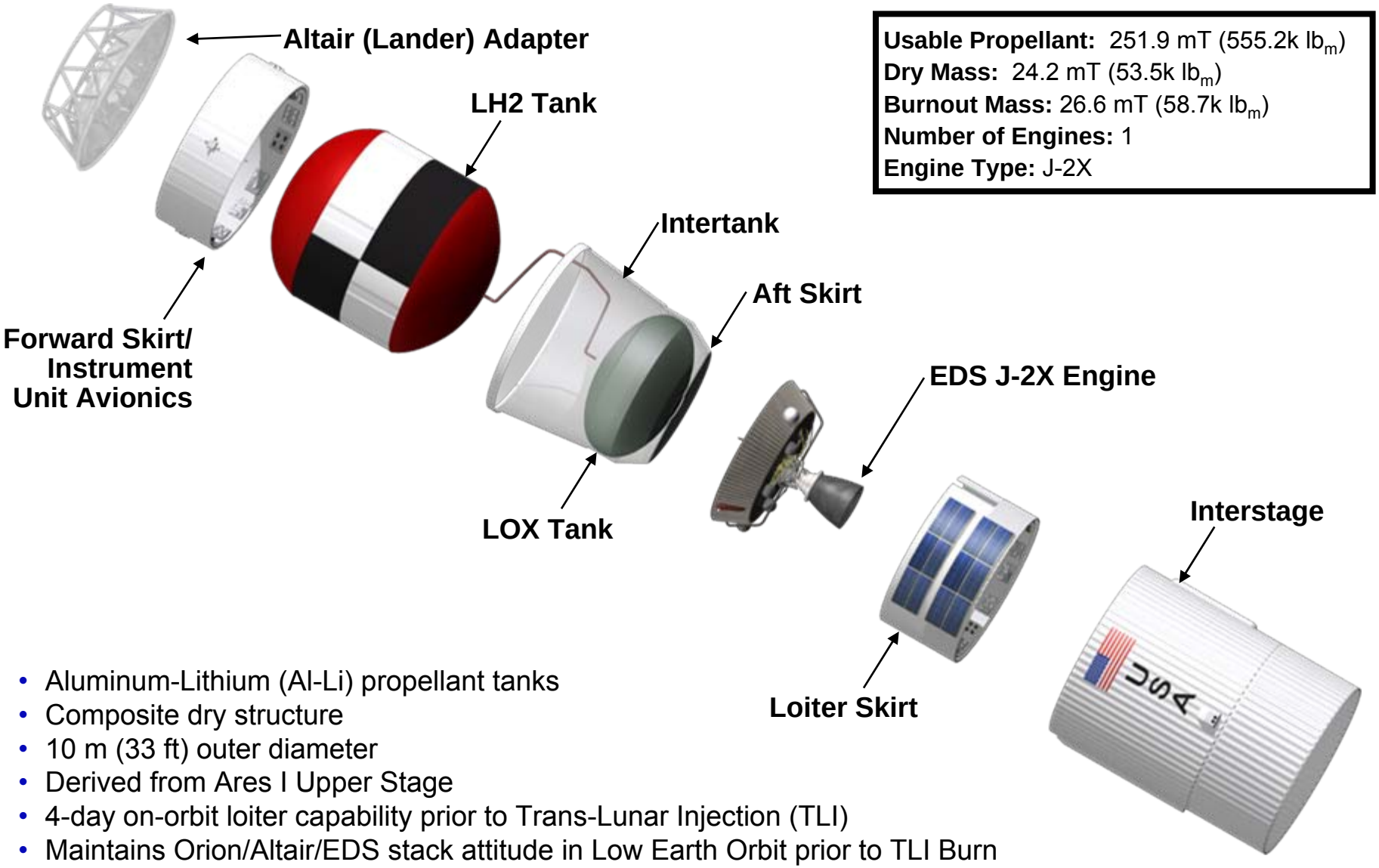
* Higher element density main injector improving specific impulse by ≈ 2% and thrust by ≈ 4%

Increased duration capability ablative nozzle

♦ **Other RS-68A upgrades or changes that may be included:**
- Bearing material change
- New Gas Generator igniter design
- Improved Oxidizer Turbo Pump temp sensor
- Improved hot gas sensor
- 2nd stage Fuel Turbo Pump blisk crack mitigation
- Cavitation suppression
- ECU parts upgrade

* **RS-68A Upgrades**

# Ares V Earth Departure Stage




**Usable Propellant:** 251.9 mT (555.2k $lb_m$)
**Dry Mass:** 24.2 mT (53.5k $lb_m$)
**Burnout Mass:** 26.6 mT (58.7k $lb_m$)
**Number of Engines:** 1
**Engine Type:** J-2X

- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10 m (33 ft) outer diameter
- Derived from Ares I Upper Stage
- 4-day on-orbit loiter capability prior to Trans-Lunar Injection (TLI)
- Maintains Orion/Altair/EDS stack attitude in Low Earth Orbit prior to TLI Burn
- EDS provide 1.5 kW of power to Altair from launch to TLI

# J-2X Engine 'Kitted' for Ares V Mission

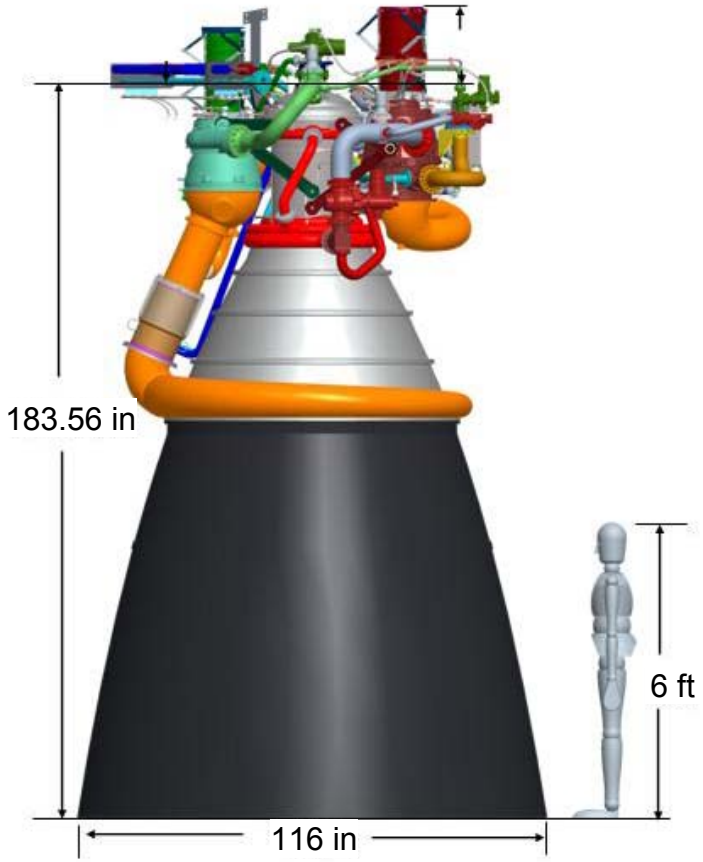
- **Upper Stage Engine Element challenge:**
  Design an engine…
  based on an evolution of the Apollo/Saturn era J-2 (GG cycle, 230,000 lbf, 424 seconds $I_{sp}$)…

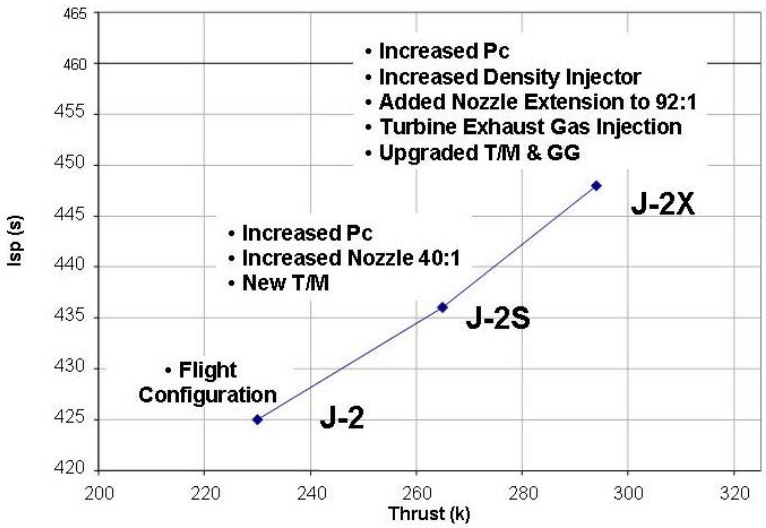
  increased to 294,000 lbf (1.3M Newtons) thrust…

  increased to 448 seconds of specific impulse (highest ever Isp for an engine of this class) …

  nearly two years faster than an engine of this class has been developed…

  *and* make it work for two different vehicles with two different missions, keeping as much commonality as possible.



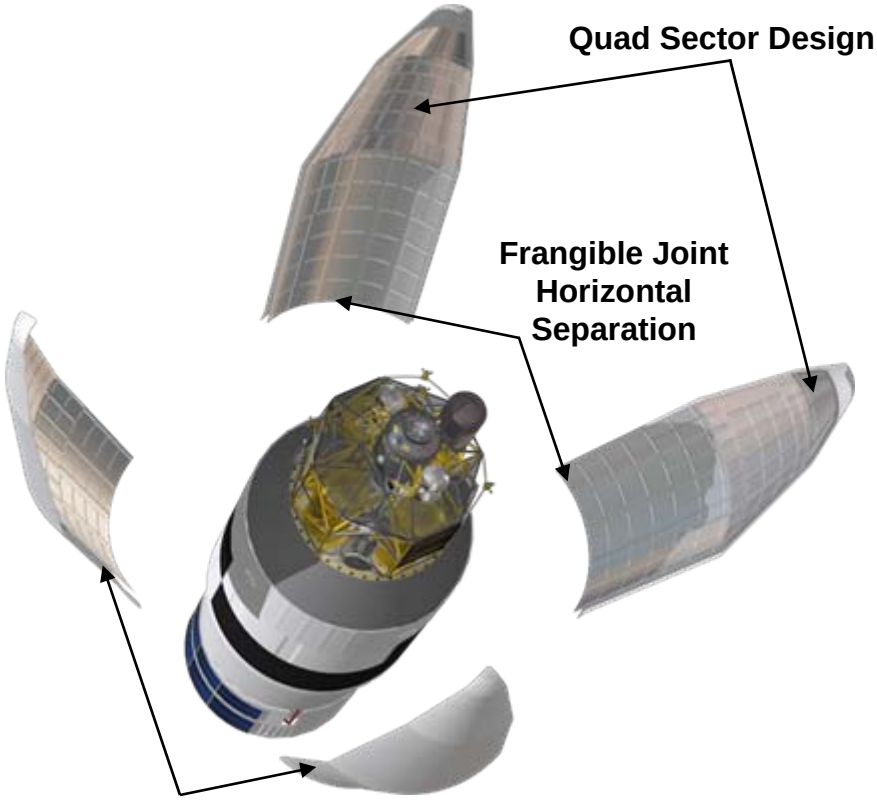



# Payload Shroud Point Of Departure

**Point of Departure (Biconic)** | **Leading Candidate (Ogive)**

**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 (72ft)

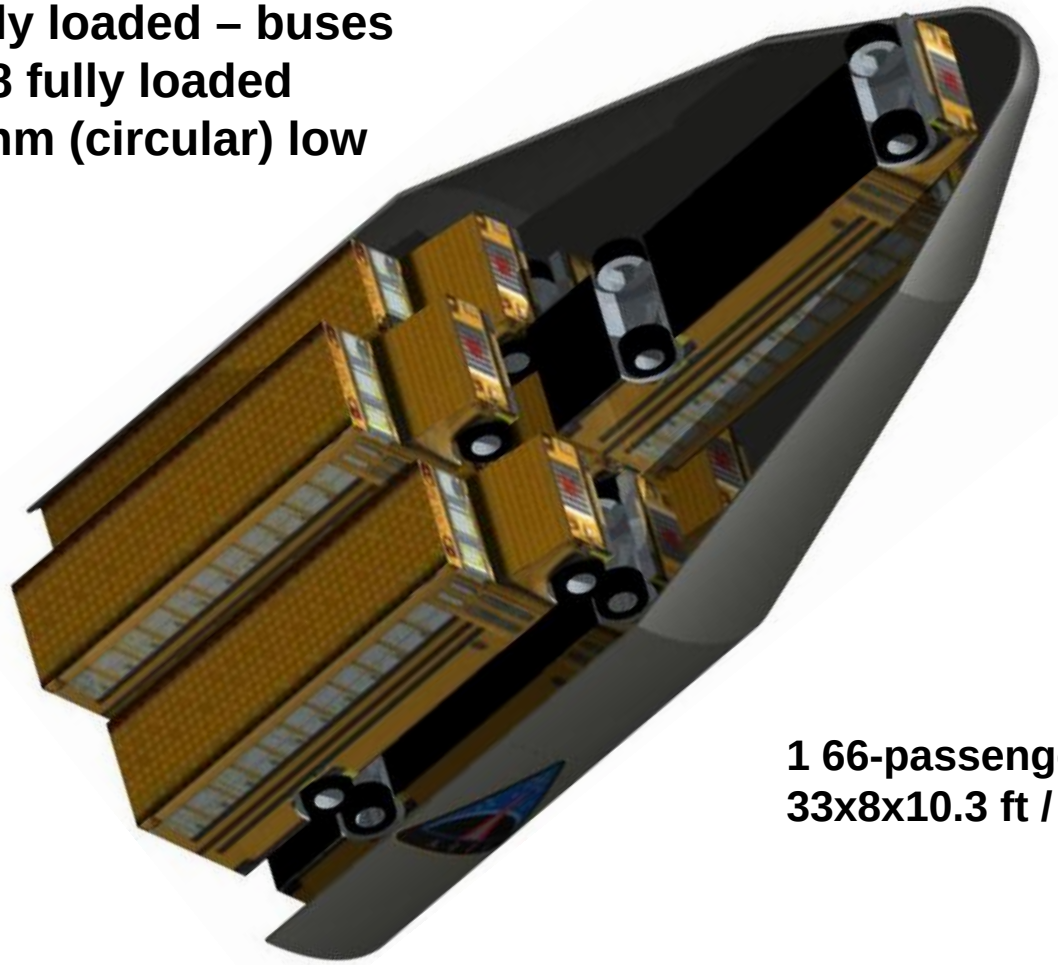
- Composite sandwich construction (Carbon-Epoxy face sheets, Al honeycomb core)
- Painted cork TPS bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)




**Thrust Rail Vertical Separation System**
**Payload umbilical separation**

# Re-defining “The Box”

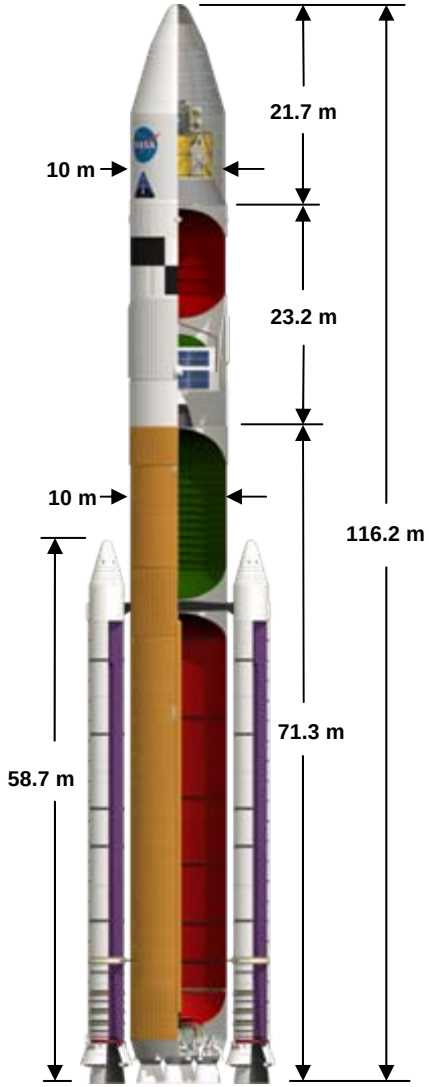
**Combining mass and volume capability, Ares V could launch 5 empty – or 3 fully loaded – buses to the Moon or 8 fully loaded buses to a 130 nm (circular) low Earth orbit**



**1 66-passenger school bus = 33x8x10.3 ft / 20,100 lb empty**

# LCCR/MCR-Approved Point of Departure

*- Vehicle 51.0.48 -*




*NOTE: These are MEAN numbers*

- **Vehicle 51.0.48 approved in 2008**
  - 6 Engine Core, 5.5 Segment PBAN steel case booster
  - Provides architecture closure with margin
- **Approved maintaining Vehicle 51.0.47 with composite HTPB booster as Ares V option**
  - Final decision on Ares V booster at Constellation Lunar SRR (2010)
  - Additional performance capability if needed for margin or requirements
  - Allows for competitive acquisition environment for booster
- **Near Term Plan to Maintain Booster Options**
  - Fund key technology areas: composite cases, HTPB propellant characterization
  - Competitive Phase 1 industry studies

# Ares I/V Progress

## ♦ Ares I

- Ares I, First Stage, & Upper Stage PDRs complete in ’08
- Numerous First Stage development and static motor casting & firing tests, wind tunnel, nozzle, materials, parachute drop tests complete
- All Ares I-X hardware at KSC for ‘09 launch
- Completed J-2X PDR in ’07, CDR in ’08
- SSC A-1 test stand converted, A-3 stand construction under way to support J-2X
- Numerous heritage/component/ subscale/powerpack tests and CFD completed in support of J-2X turbomachinery, combustion devices, etc.
- J-2X casting/machining trials under way/long-lead parts procured

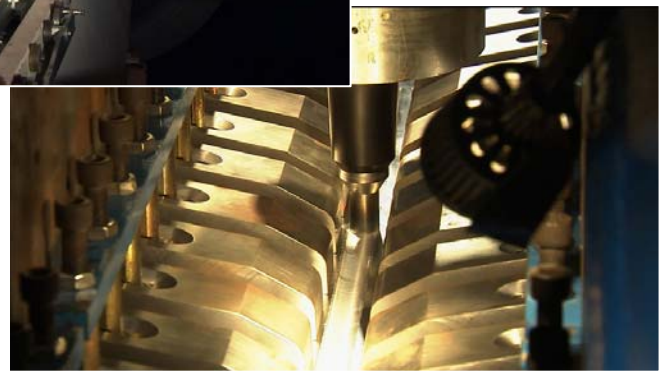
## ♦ Ares V

- Subscale main injector tests, analysis conducted on RS-68B
- LCCR establishes POD concept ’08
- RFP for concept definition issued ‘09

Workhorse Gas Generator Test

Nozzle Burnthrough Test

Inert Forward Segment X-Ray

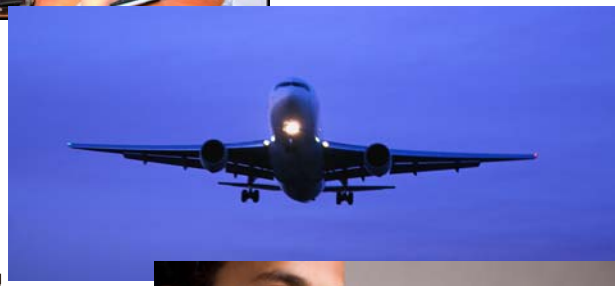


Tank Barrel Structural Test

# Big Picture Challenges of the Ares Projects

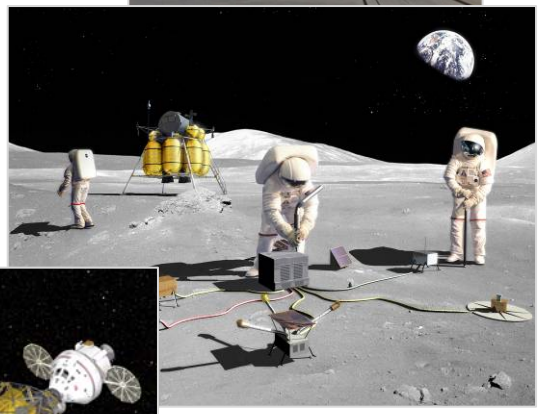
# Current and Ongoing Management Challenges

- **Integrating technical products and people**
  - Within Ares
  - With other Constellation Projects
  - With other stakeholders
- **Ensuring ownership and accountability**
- **Managing workload**
- **Managing communication**
  - Controlling distribution of sensitive information
  - Managing internal and external communications in the Internet age
- **Balancing need to reduce costs with the need to maintain a motivated, knowledgeable workforce**



# Fully Understanding Programmatic and Technical Challenges

- Usable Analogs – Apollo, Shuttle, ISS?
- Dual-Launch Architecture – ground ops, on-orbit
- A much larger rocket – Ares V
- Reduced touch labor, simplified operations
- International and commercial participation
- Sustained operations with a pay-as-you-go budget
- Ending Shuttle ops, completing ISS, and transition to lunar exploration
- Infrastructure sustainment – facilities, workforce, industrial base
- Accommodating science/exploration




**www.nasa.gov/ares**