Ares V: Progress Toward a Heavy Lift Capability for the Moon and Beyond

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Introduction

- The NASA Ares Projects are 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 send crews and cargo to the Moon
- The Ares V design is evolving and maturing toward an authority-to-proceed milestone in 2011
- 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

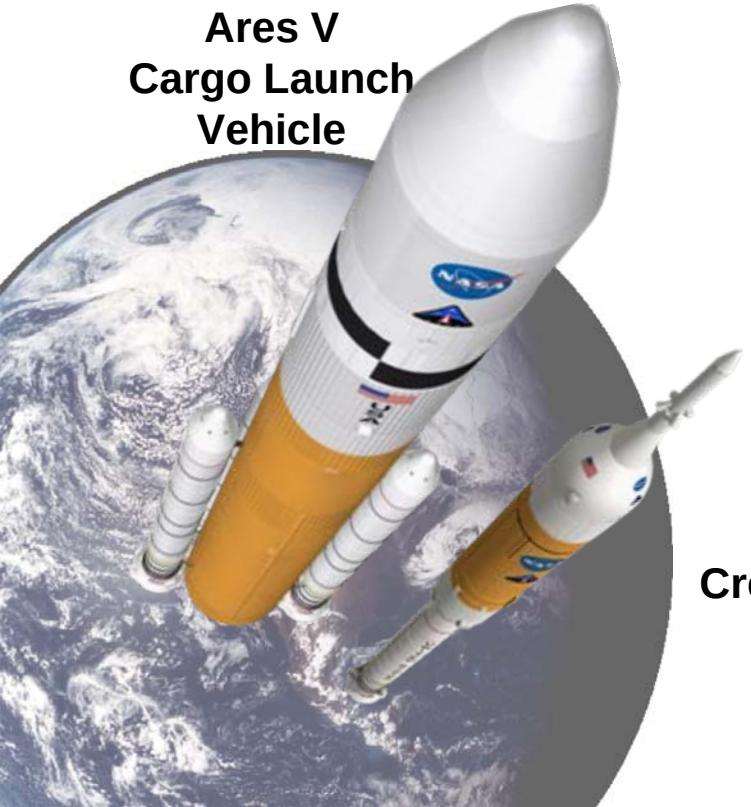
Our Exploration Fleet

What will the vehicles look like?

Earth Departure Stage

Orion
Crew Exploration
Vehicle

Ares V
Cargo Launch
Vehicle

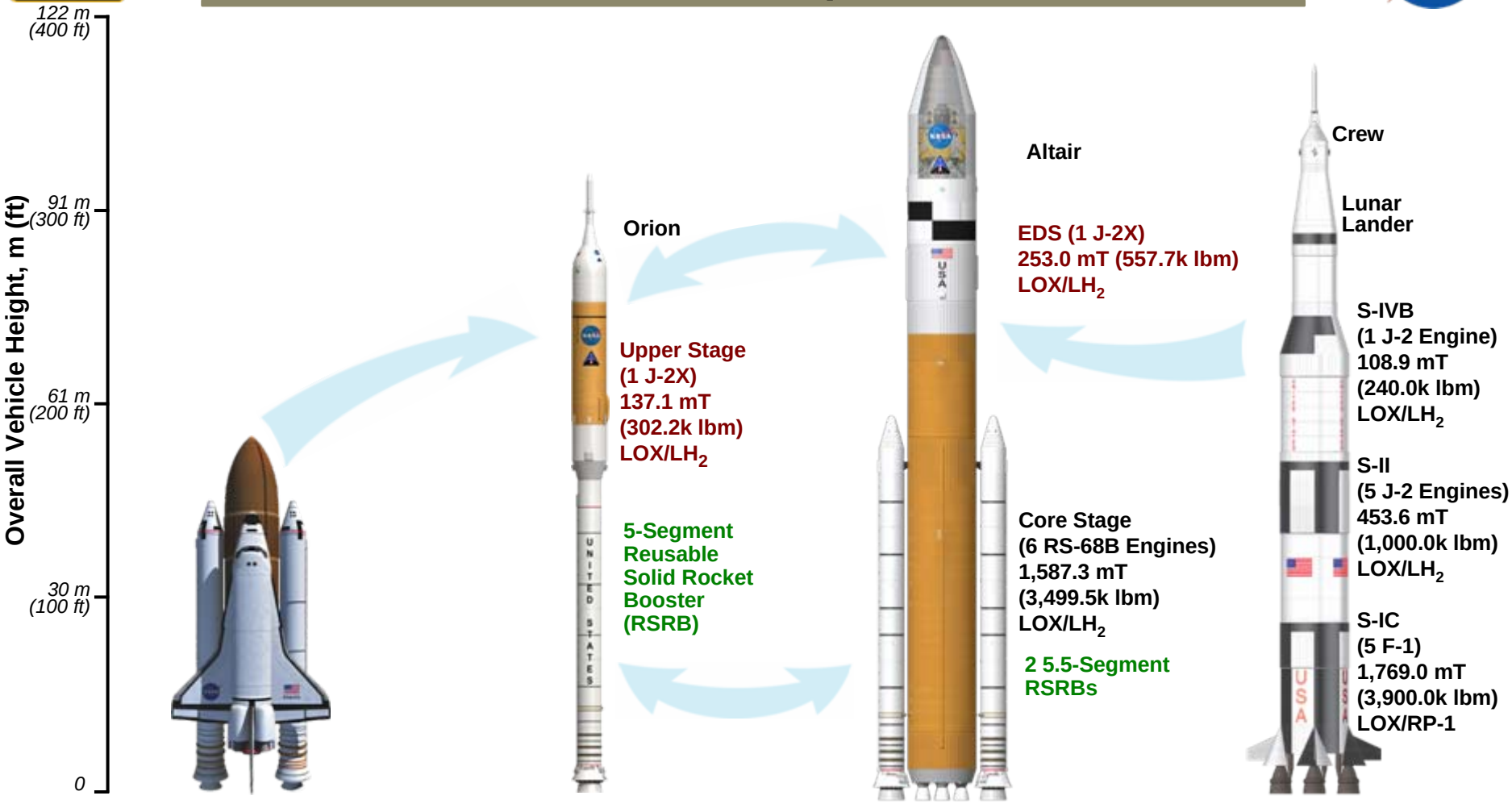


Ares I
Crew Launch
Vehicle

Altair
Lunar
Lander

Building on a Foundation of Proven Technologies

Launch Vehicle Comparisons



Space Shuttle

Height: 56 m (184 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)

Ares I

Height: 99 m (325 ft)
Gross Liftoff Mass:
927.1 mT (2,044.0k lbm)
Payload Capability:
25.5 mT (56.2k lbm)
to LEO

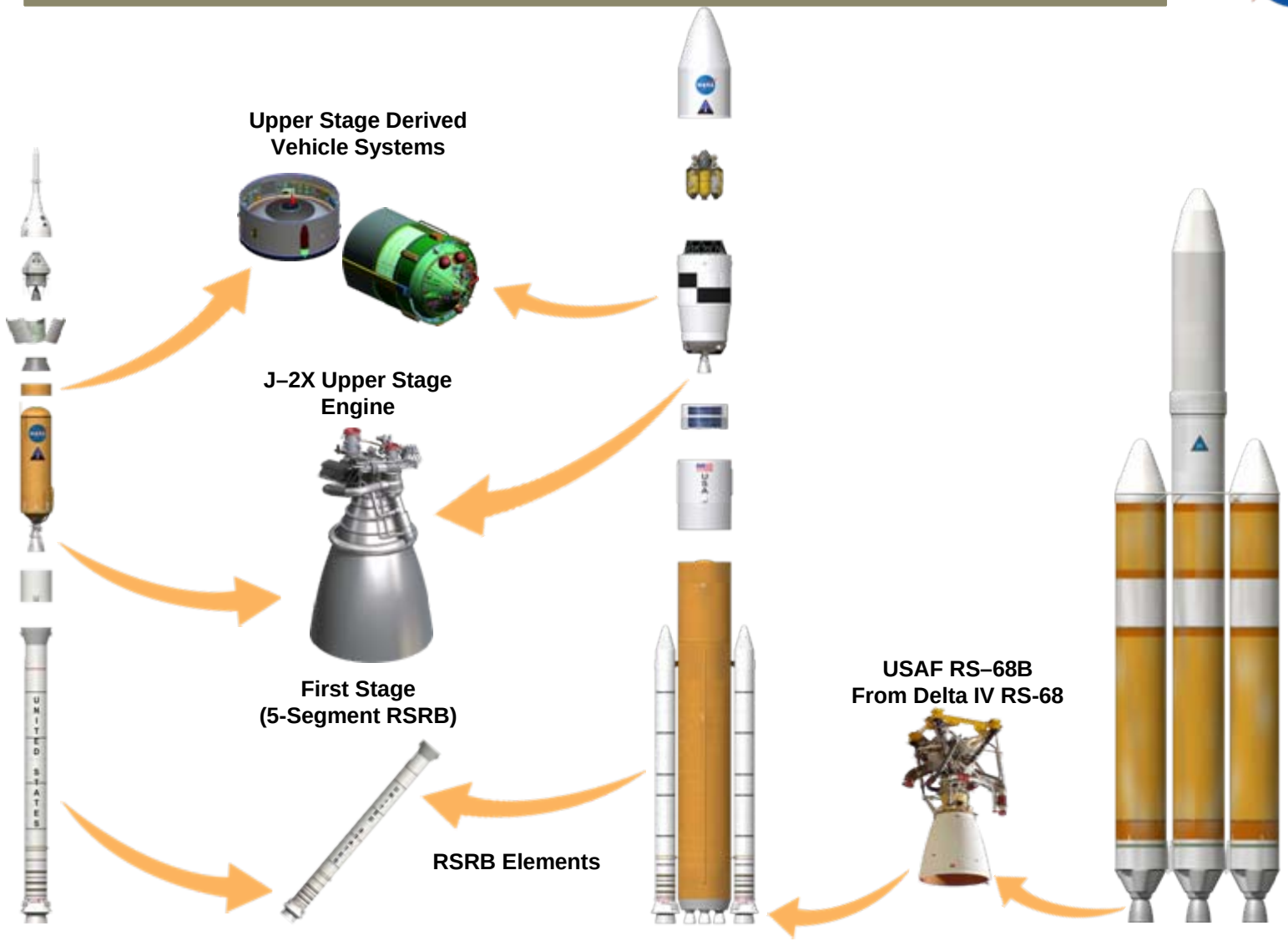
Ares V

Height: 116 m (381 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

Saturn V

Height: 111 m (364 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

Ares V Element Heritage



Ares I

25.5 mT (56.2 klbm) to
Low Earth Orbit (LEO)

Ares V (51.00.48)

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

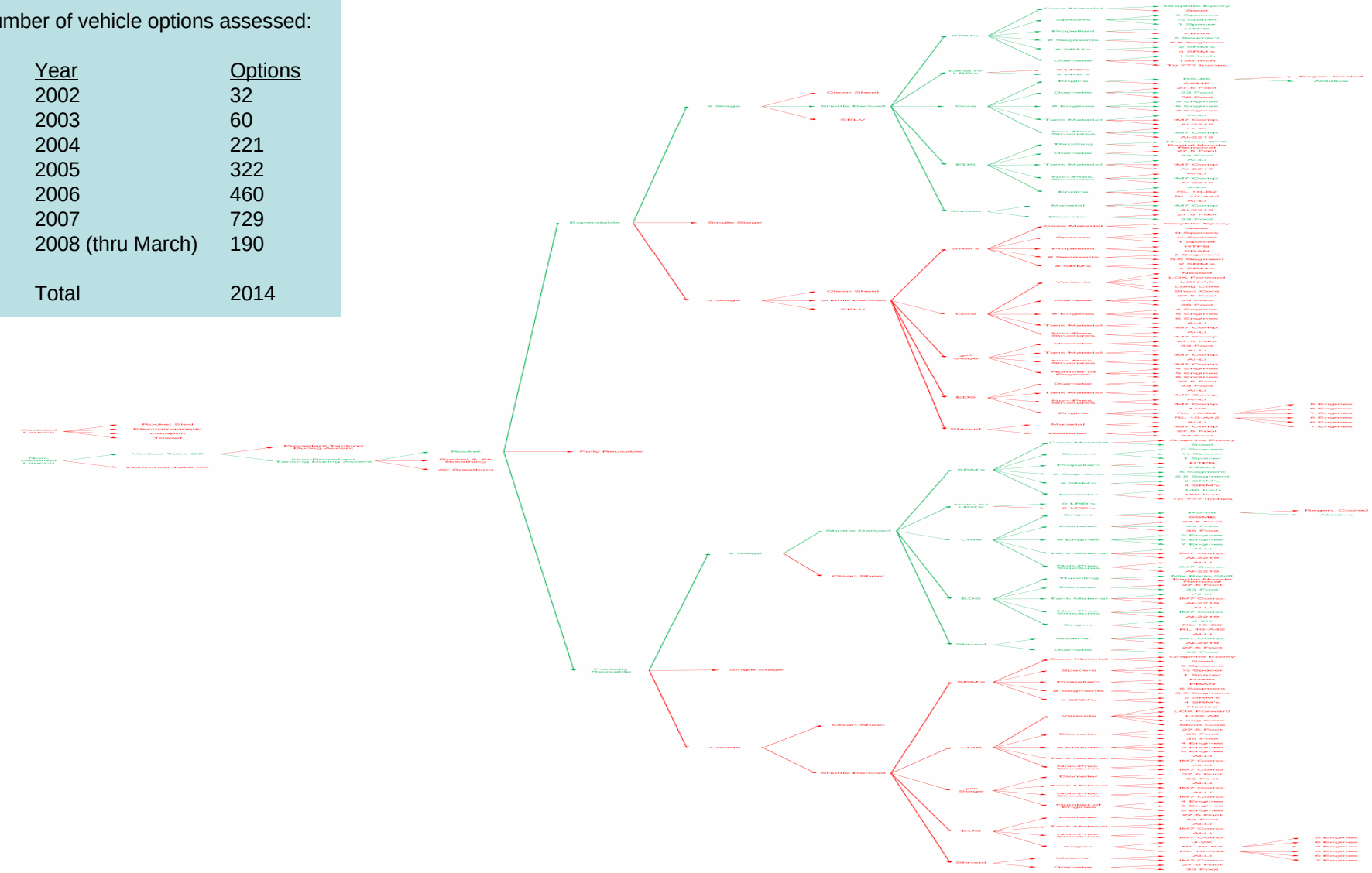
Delta IV

Integrated Trade Tree

- ESAS to LCCR -

Number of vehicle options assessed:

Year	Options
2002	32
2003	60
2004	221
2005	322
2006	460
2007	729
2008 (thru March)	190
Total	2014

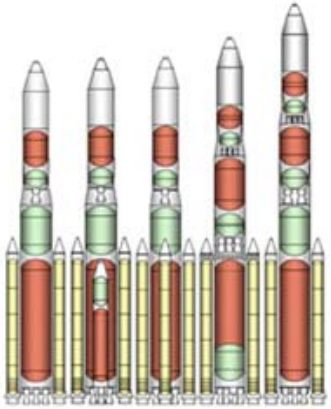


Significant Design Milestones

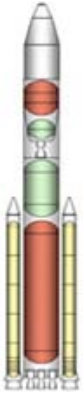
Original ESAS Capability
- *8.4 m OML*
- *SSME Core*
- *2 J2S+ EDS*
- *45.0 mT Lander*
- *20.0 mT CEV*
- *No Loiter in LEO*

EDS Engine Change
- *1 J2S+ EDS*

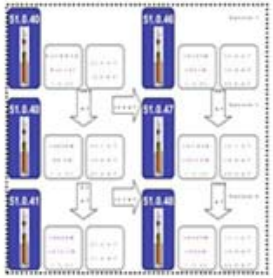
Change to RS-68B Core Engines
- *Core dia: 8.4m to 10m*
- *Fvac: 490k to 750k*
- *Isp: 452.1 to 414.7 sec*
- *Booster: HTPB to PBAN propellant (Ares I 53-06 thrust trace)*



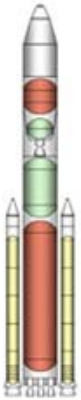
IDAC 3 Trade Space
- *SRM Propellant*
- *Stage Materials*
- *Extra Strapons*
- *Engine Type*
- *10+ m dia. Core*
- *Number of Stages*
- *Shroud Material*
- *Shroud Size*



Diameter Change
- *10m diameter EDS and Shroud*



LCCR Options
- *5.5 Segment*
- *Inert Spacers*
- *HTPB SRB Prop*
- *Composite Case SRB*
- *6 Engine Core*



Current POD
- *6 Core Engines*
- *5.5 Segment PBAN*

2005 | **2006** | **2007** | **2008**

Ares V LCCR Trade Space
March-June 2008

Core Booster	Standard Core + 5 RS-68B Engines	Opt. Core Length + 6 RS-68B Engines
5 Segment PBAN Steel Case Reusable	51.00.39 — 63.6 mT	+5.0 mT → 51.00.46 — Spacers: 1 — 68.6 mT / 60.2 mT
5 Segment HTPB Composite Case Expendable	51.00.40 — +6.1 mT → 69.7 mT / 61.5 mT	+5.0 mT → 51.00.47 — Spacers: 1 — +6.1 mT → 74.7 mT / 66.3 mT
5.5 Segment PBAN Steel Case Reusable	51.00.41 — -2.3 mT → 67.4 mT	+3.7 mT → 51.00.48 — Spacers: 0 — -3.6 mT → 71.1 mT / 63.0 mT

Initial LCCR Study Reference

Alternative New POD

Recommend for New POD

Common Design Features
Composite Dry Structures for Core Stage, EDS & Shroud
Metallic Cryo Tanks for Core Stage & EDS
RS-68B Performance: I_{sp} = 414.2 sec; Thrust = 797k lb_f @ vac
J-2X Performance: I_{sp} = 448.0 sec; Thrust = 294k lb_f @ vac
Shroud Dimensions: Barrel Dia. = 10 m; Usable Dia. = 8.8 m; Barrel Length = 9.7 m

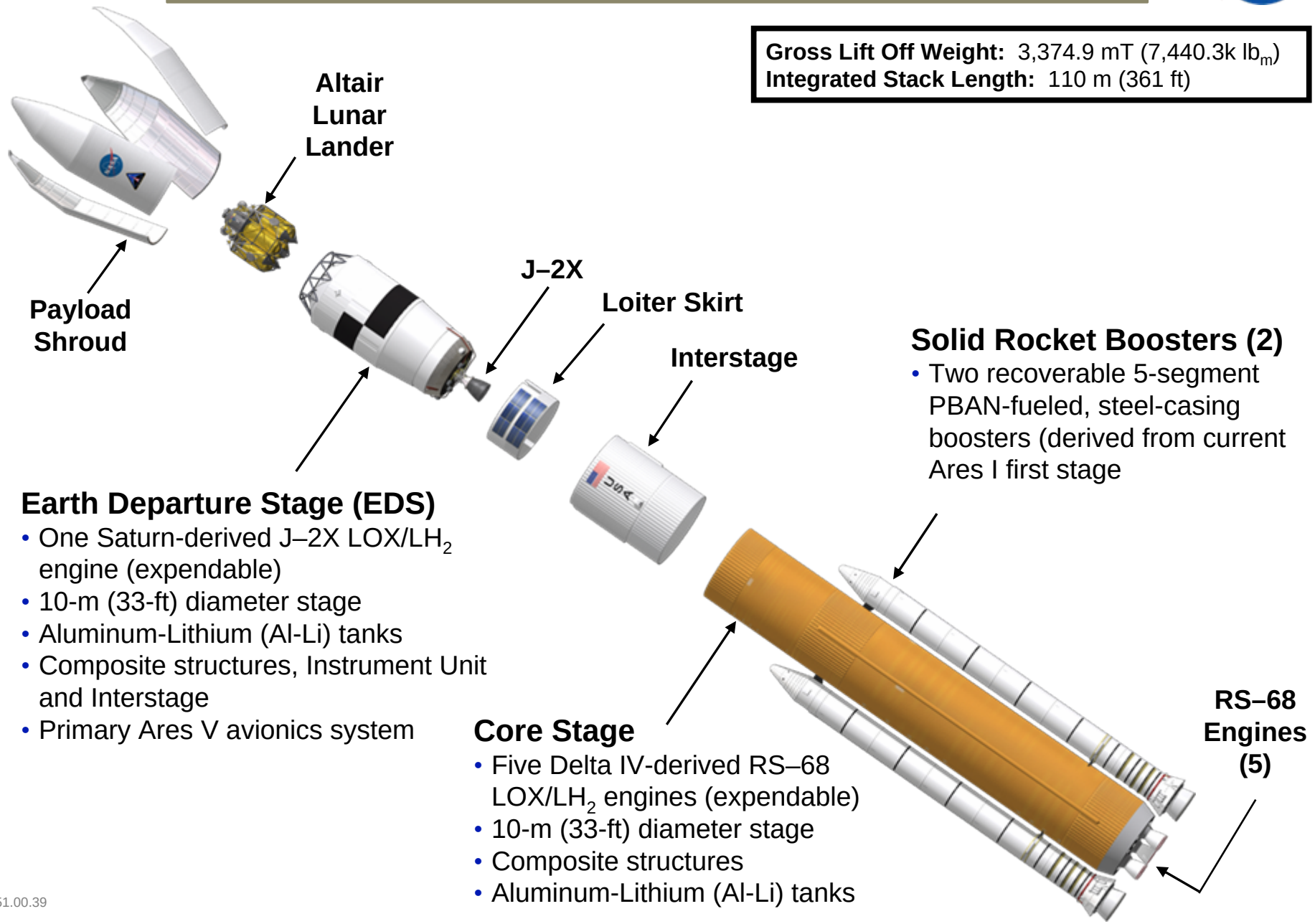
1.5 Launch TLI Capability
Cargo TLI Capability

- **Current Ground Rules and Assumptions**
  - 4-day loiter/29 degree,130nmi insertion/100nmi TLI departure
  - TLI Payload Goal: 75.1 mT
    - Lander (45.0 mT) + Orion (20.2 mT) + Margin

- **Note: Performance (light blue) is TLI payload in conjunction with Ares I**

The 51.00.39 Point-of-Departure Concept

Gross Lift Off Weight: 3,374.9 mT (7,440.3k lb_m)
Integrated Stack Length: 110 m (361 ft)



Solid Rocket Boosters (2)

- Two recoverable 5-segment PBAN-fueled, steel-casing 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

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

Lunar Capability Concept Review (LCCR) Outcome

New Lunar Transportation POD Architecture

LCCR scope

- ***Constellation Program (CxP) review hosted at Johnson Space Center on 18–20 June 2008***
- ***Defined a POD transportation architecture for the CxP Lunar Capability which includes capability to:***
  - *Perform short duration, lunar surface crewed missions*
  - *Enable establishment of a lunar outpost*
- ***Focused on the conceptual designs and key driving requirements for Ares V and Altair (crewed and cargo)***

Ares V (Cargo Launch Vehicle (CLV))

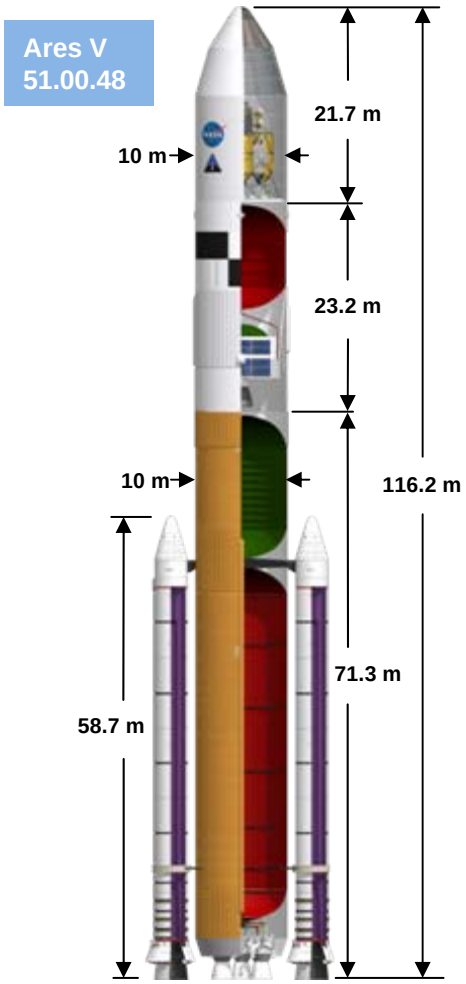
- ***Retire previous POD vehicle:*** *Ares V 51.00.39*
- ***Maximize commonality between Lunar and Initial Capabilities:*** *Ares V 51.00.48*
  - *6 RS-68B engine core, 5.5-segment PBAN steel case booster*
  - *10-m diameter integrated stack*
  - *Architecture closure with additional margin*
- ***Continue to study the benefits/risk of improved performance:*** *Ares V 51.00.47*
  - *Final decision on Ares V booster at Program System Requirements Review (SRR) in June 2010*
  - *Additional performance capability for additional mission needs*
  - *Requires further study and technology investment funding*

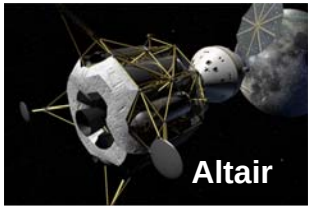
Altair (Lunar Lander)

- ***Provide a robust capability to support both crew sortie and cargo Lunar Outpost Missions ensuring global lunar access***

Orion (Crew Exploration Vehicle (CEV))

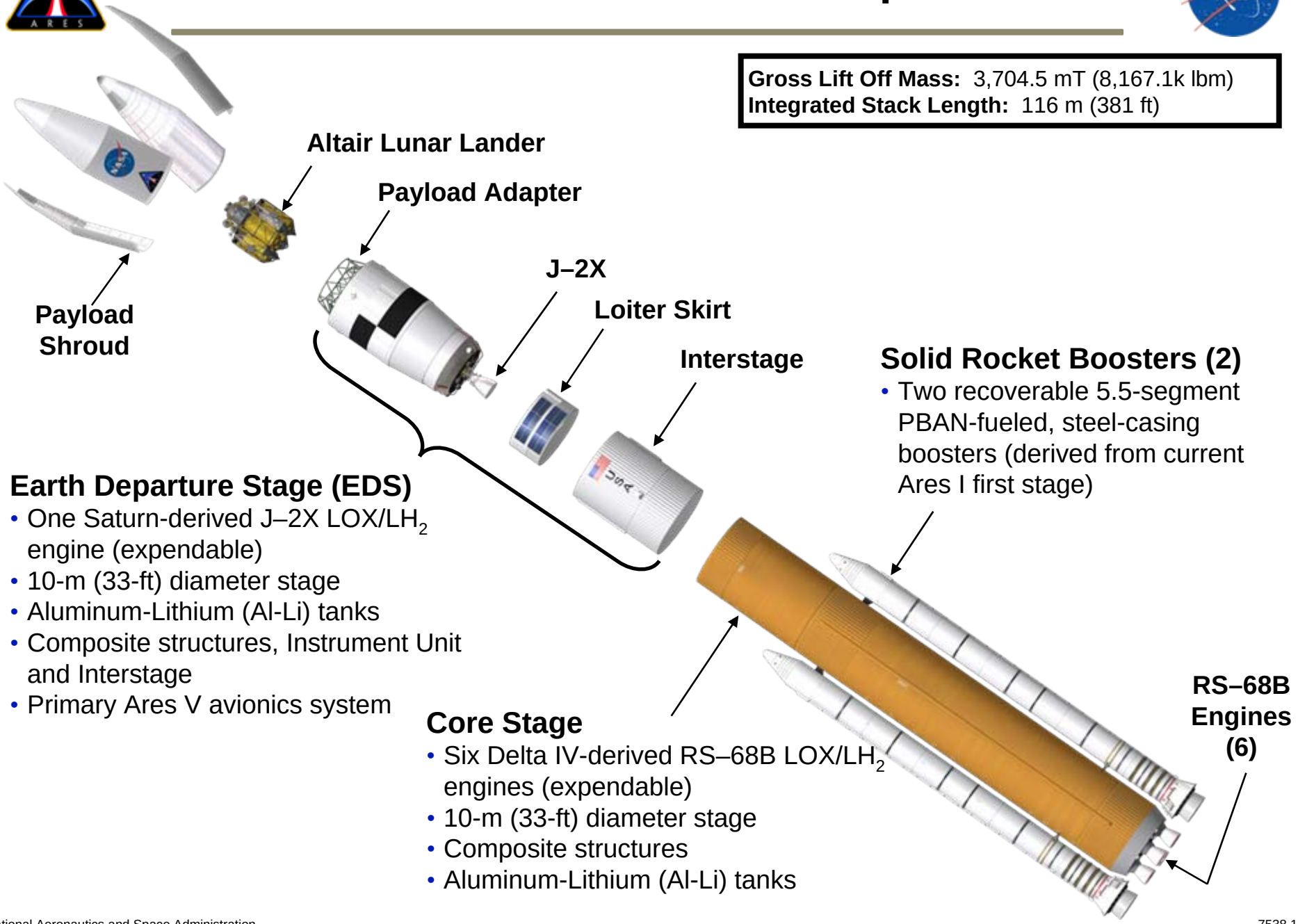
- ***Maintain control mass to 20,185 kg at TLI***





The New 51.00.48 Point-of-Departure

Gross Lift Off Mass: 3,704.5 mT (8,167.1k lbm)
Integrated Stack Length: 116 m (381 ft)



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Earth Departure Stage (EDS)

- One Saturn-derived J–2X LOX/LH_2 engine (expendable)
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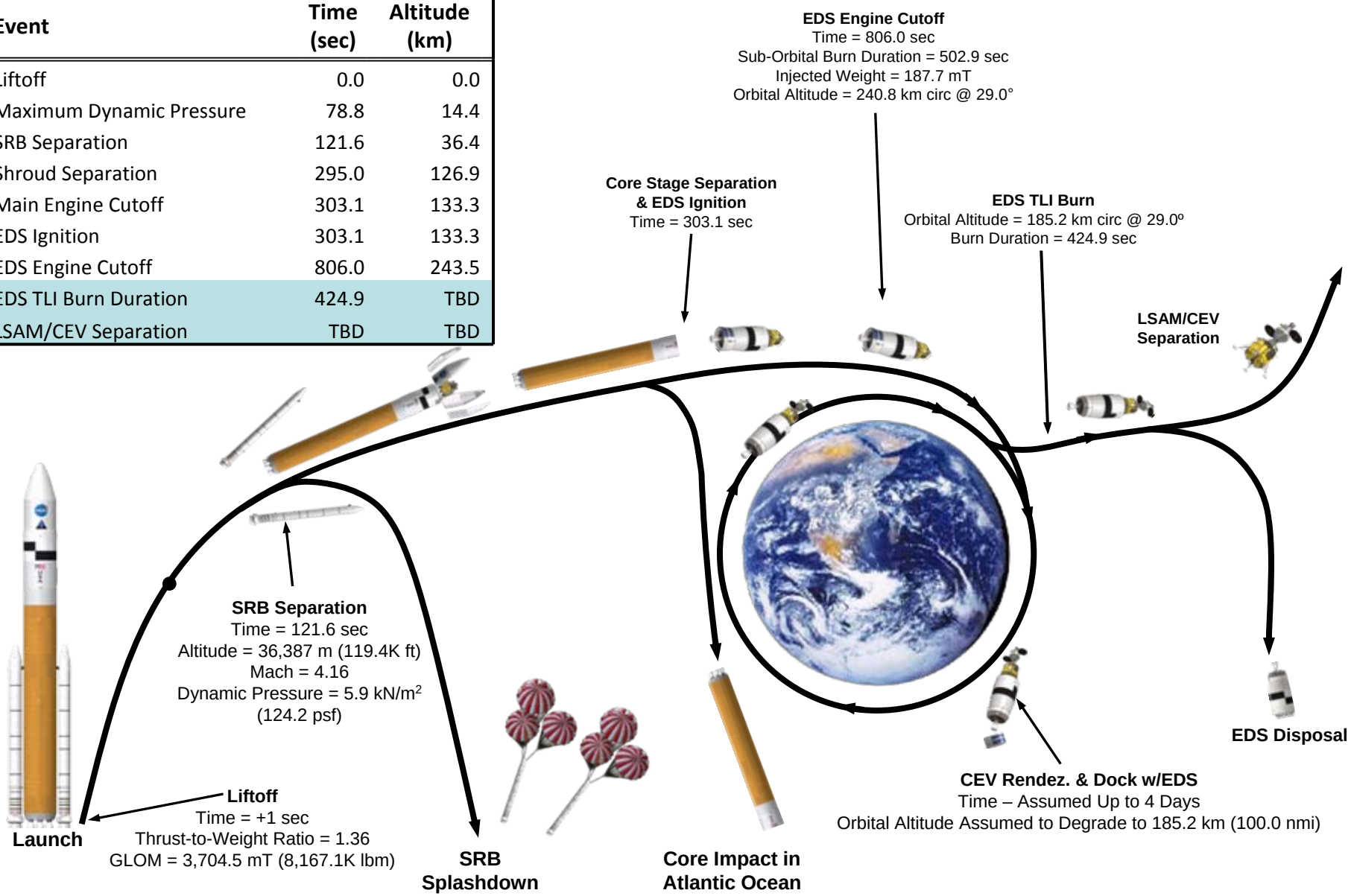
Core Stage

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

Ares V Profile for 1.5 Launch DRM

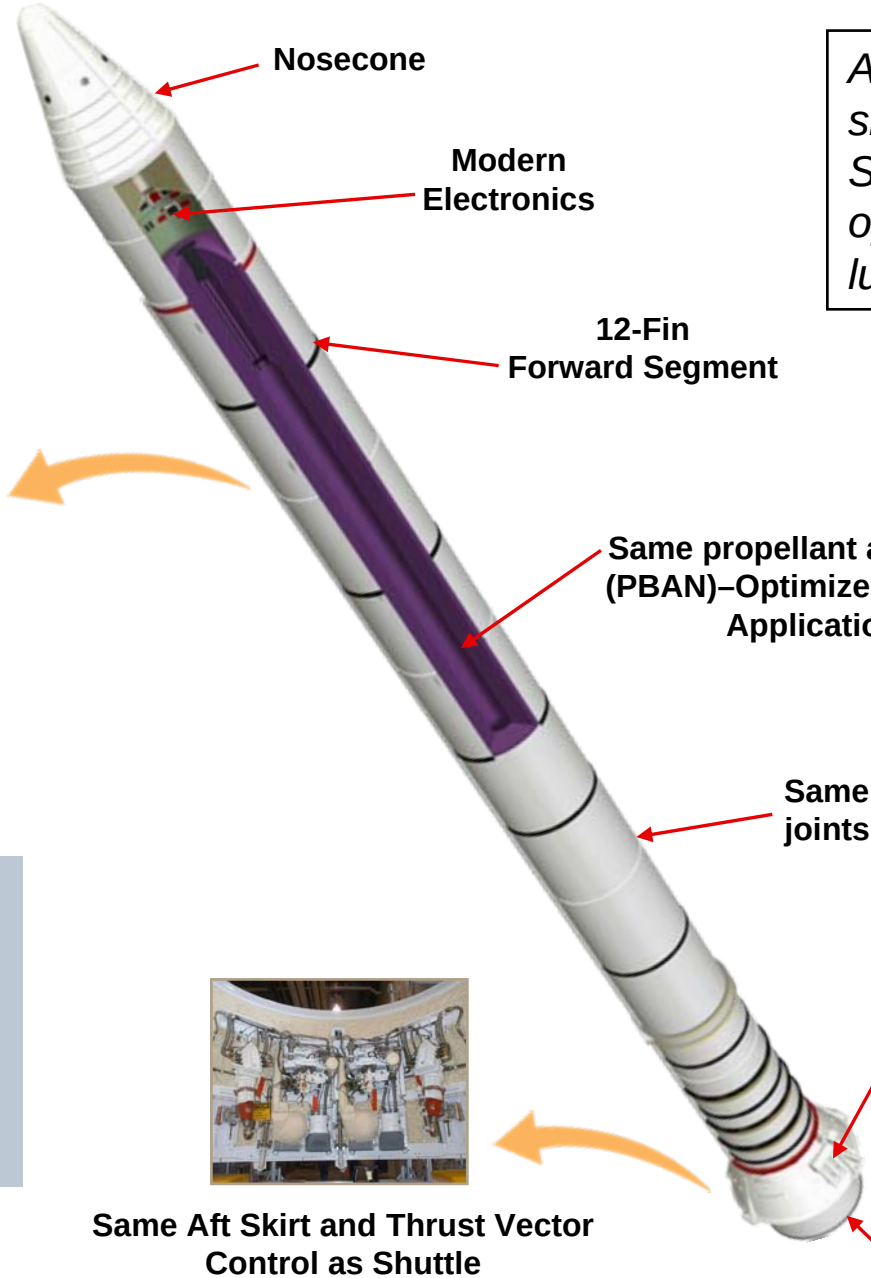
51.00.48 Point Of Departure (Lunar Sortie)

Event	Time (sec)	Altitude (km)
Liftoff	0.0	0.0
Maximum Dynamic Pressure	78.8	14.4
SRB Separation	121.6	36.4
Shroud Separation	295.0	126.9
Main Engine Cutoff	303.1	133.3
EDS Ignition	303.1	133.3
EDS Engine Cutoff	806.0	243.5
EDS TLI Burn Duration	424.9	TBD
LSAM/CEV Separation	TBD	TBD



Ares V (51.00.48) Solid Rocket Booster (SRB)

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

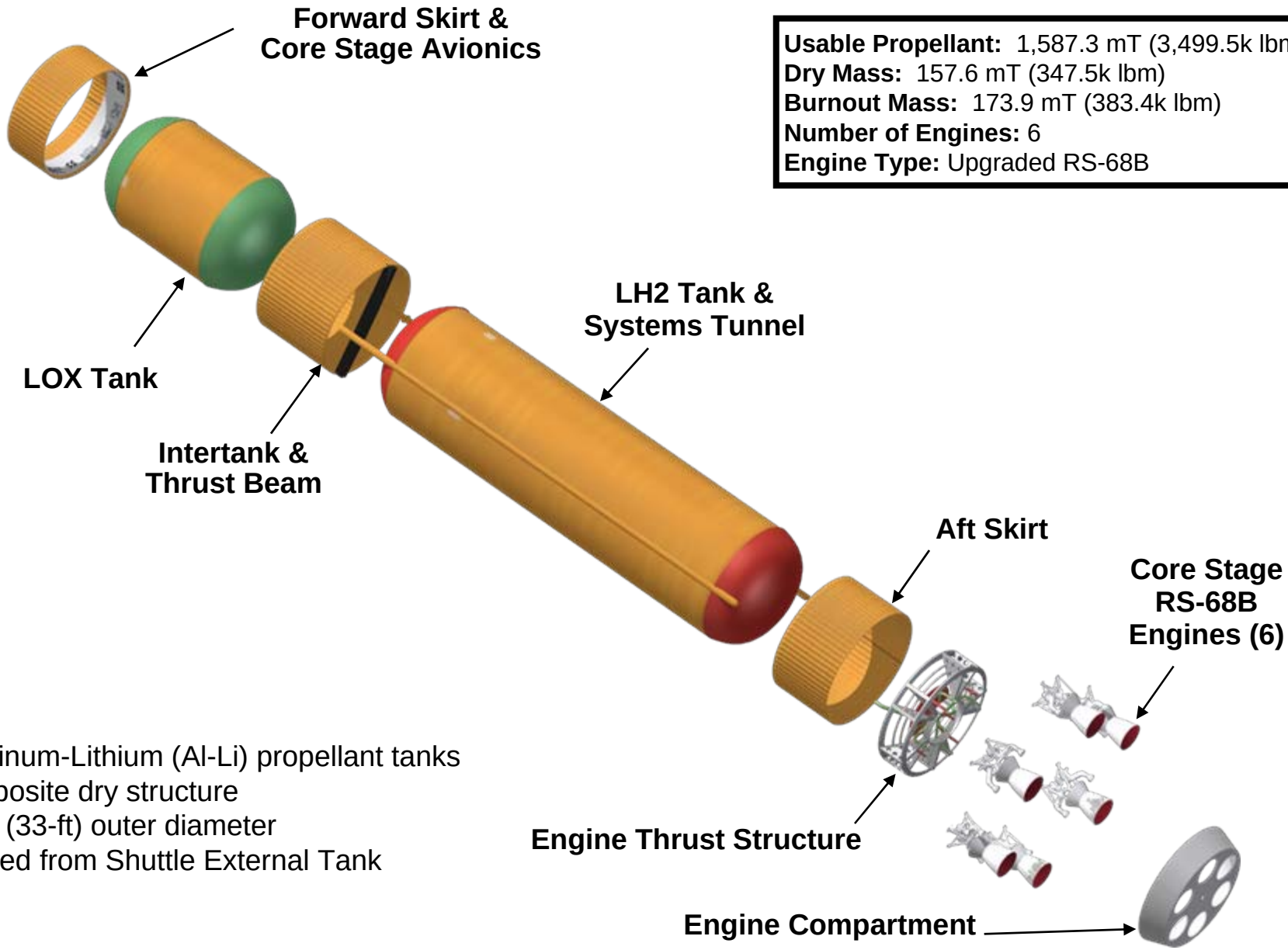


Same Aft Skirt and Thrust Vector Control as Shuttle

Mass: 794 mT (1.8M lbm)
Thrust: 15.8M N (3.5M lbf)
Burn Duration: 126 sec
Height: 55 m (180 ft)
Diameter: 3.7 m (12 ft)

Core Stage Design Concept
Expanded View

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

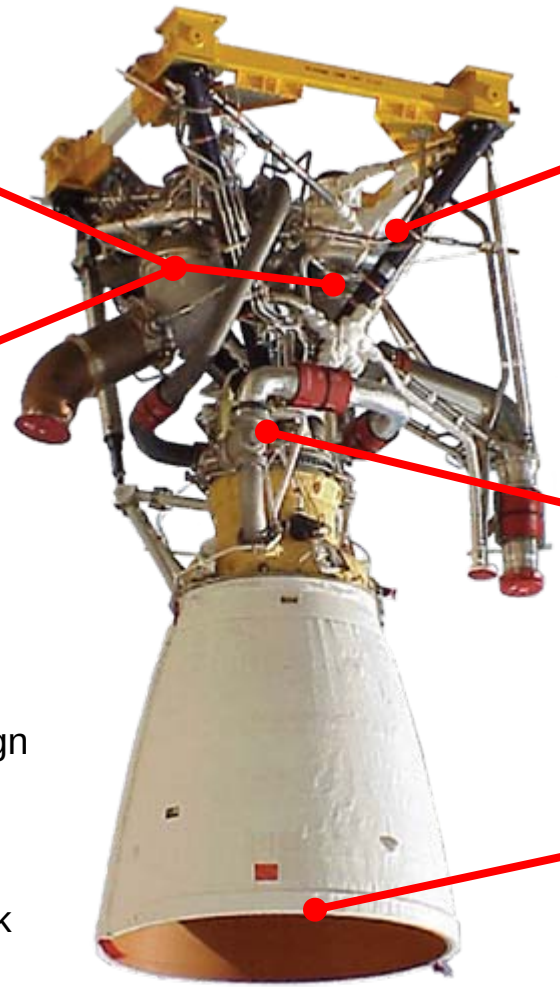


- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Shuttle External Tank

Core Stage Upgraded USAF RS-68B Engine

* 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 and thrust

Increased duration capability ablative nozzle

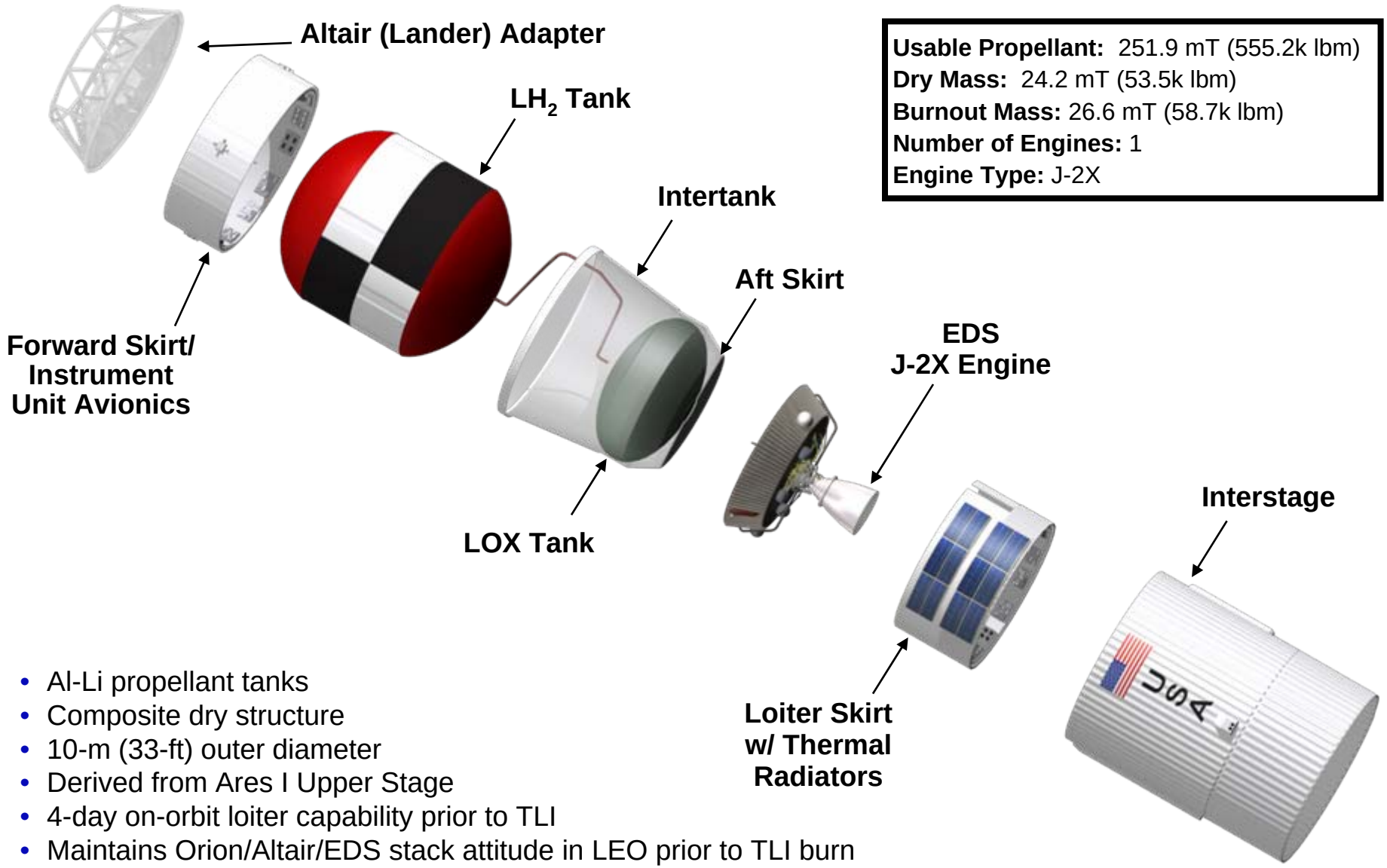
Other RS-68A upgrades or changes that may be included:

- 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**

EDS Current Design Concept

Expanded View



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

- 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 TLI
- Maintains Orion/Altair/EDS stack attitude in LEO prior to TLI burn
- EDS provides 1.5 kW of power to Altair from launch to TLI

Earth Departure Stage J-2X Engine

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 (5.5k lbm)
Thrust: 1.3M N (294.0k lbm) @ vac
Isp: 448 sec (vac)
Height: 4.7 m (185 in)
Diameter: 3.0 m (120 in)

Pratt & Whitney
A United Technologies Company

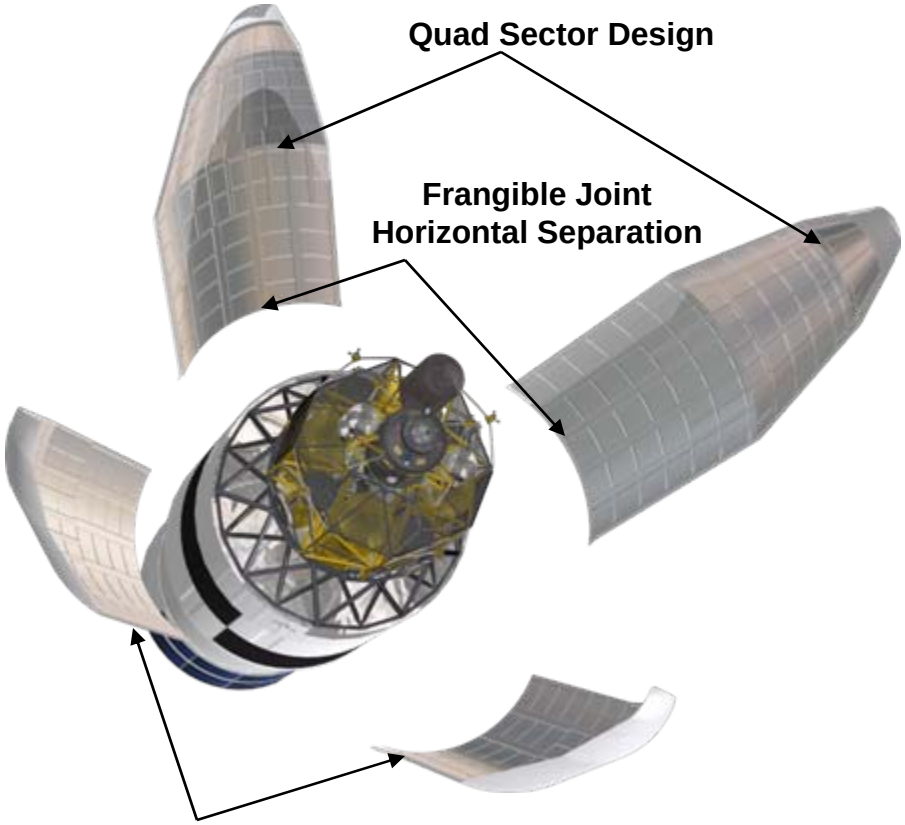
Pratt & Whitney Rocketdyne

Payload Shroud Point Of Departure

Point of Departure (Biconic)

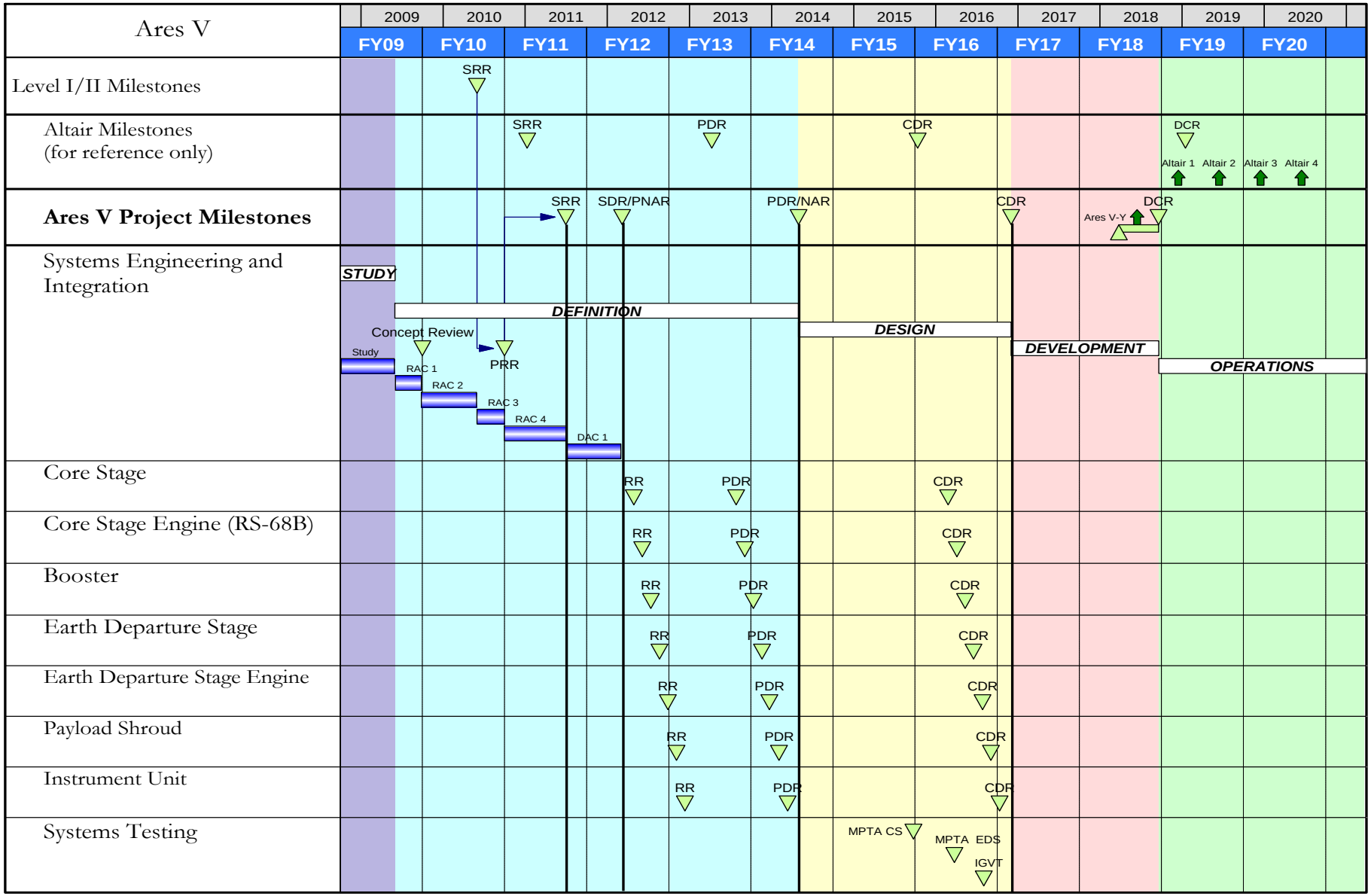
Leading Candidate (Ogive)

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)

Ares V LCCR Summary Schedule



Current Ares V Status

- Current Ares V Point-of-Departure (51.00.48) exceeds Saturn mass capability by ~40%
- Ares V is sensitive to loiter, attitude, power, and altitude requirements in addition to payload performance
- LCCR-approved 51.00.48 POD 5.5-segment steel case booster/6 engine core) Ares V can meet current Human Lunar Return requirements with ~6 mT of Margin
- LCCR-approved 51.00.47 option (5 segment HTPB composite case booster/6 engine core) can meet HLR requirement with more than 9 mT Margin
- Developed preliminary resource-loaded schedule to SRR
- Benchmarked Ares I SRR actuals (schedule and resources) and lessons learned

Forward Work

- **Developing Phase 1 acquisition strategy**
  - July 2008 RFI for industry input
  - Industry inputs received August 2008 and are being evaluated
- **Continue Concept Validation Study**
  - Incorporates results from LCCR
- **Ares V DAC-0 kickoff Spring 2009**
- **Continue outreach to external organizations**
  - Potential uses in scientific, national security, and commercial sectors

Questions?

www.nasa.gov/ares