National Aeronautics and Space Administration

Ares I Overview

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Masters Forum
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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

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

Orion

Upper Stage
(One J-2X)
137.1 mT
(302.2K lbm)
LOX/LH_2

One 5-Segment Reusable Solid Rocket Booster (RSRB)

Altair

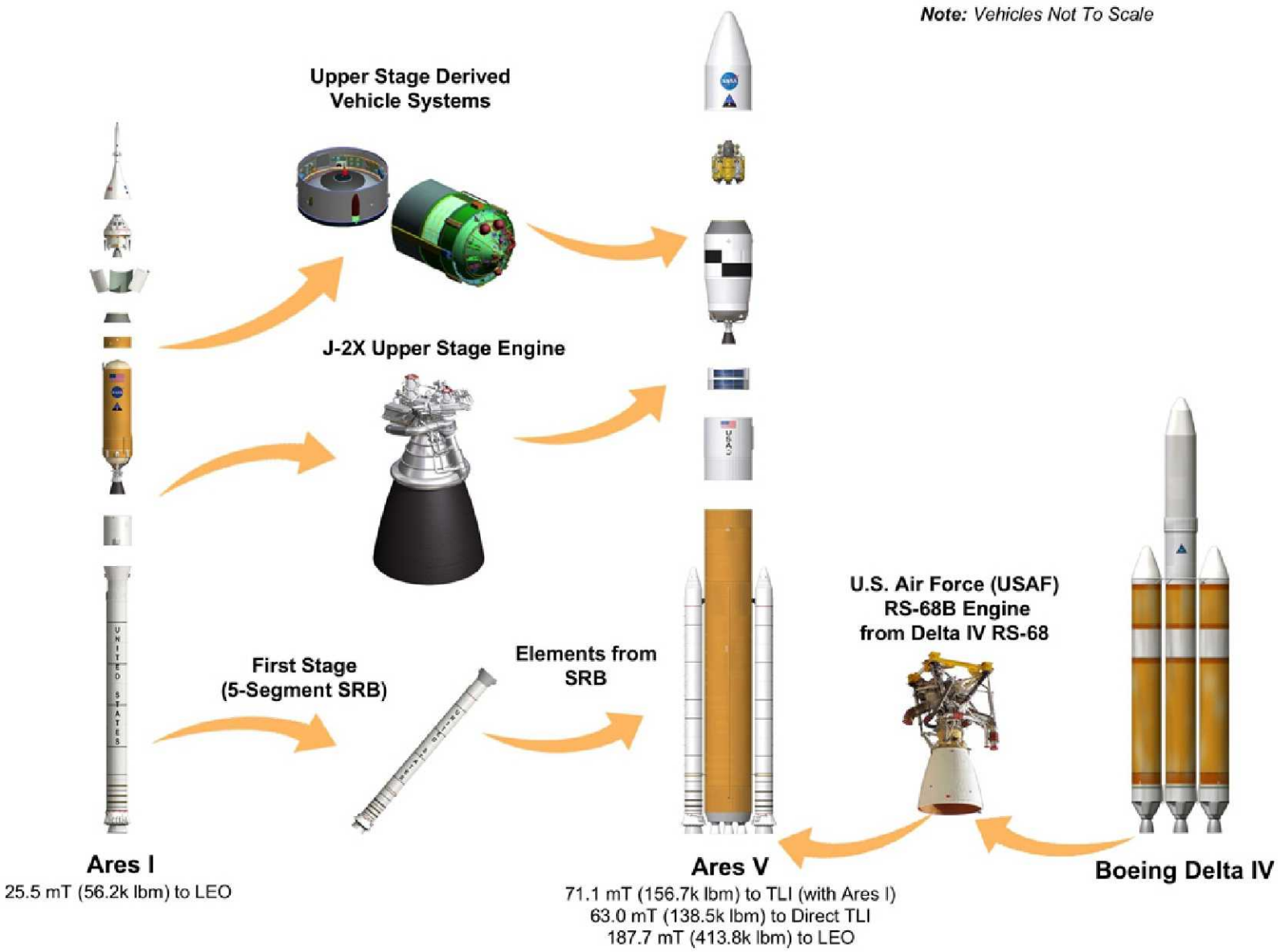
Earth Departure Stage (EDS) (1 J-2X)
253.0 mT (557.7K lbm)
LOX/LH_2

Core Stage
(Six RS-68 Engines)
1,587.3 mT
(3,499.5K lbm)
LOX/LH_2

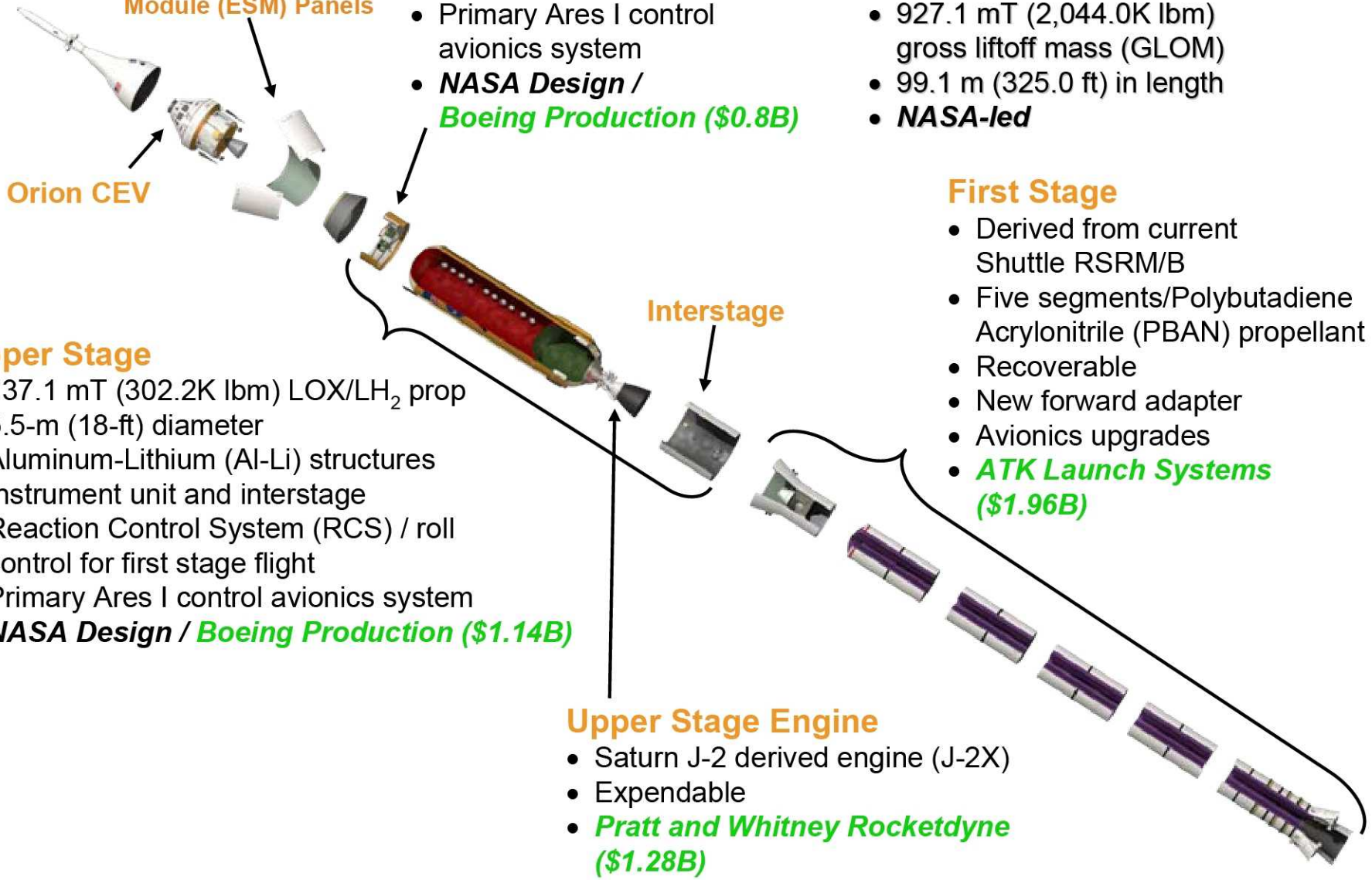
Two 5.5-Segment Reusable Solid Rocket Booster (RSRB's)

Saturn V	Space Shuttle	Ares I	Ares V
1967–1972	*1981–Present*	*First Flight 2015*	*First Flight 2018*
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	**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)	**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	**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

Employing Common Hardware to Reduce Operations Costs



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)***

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

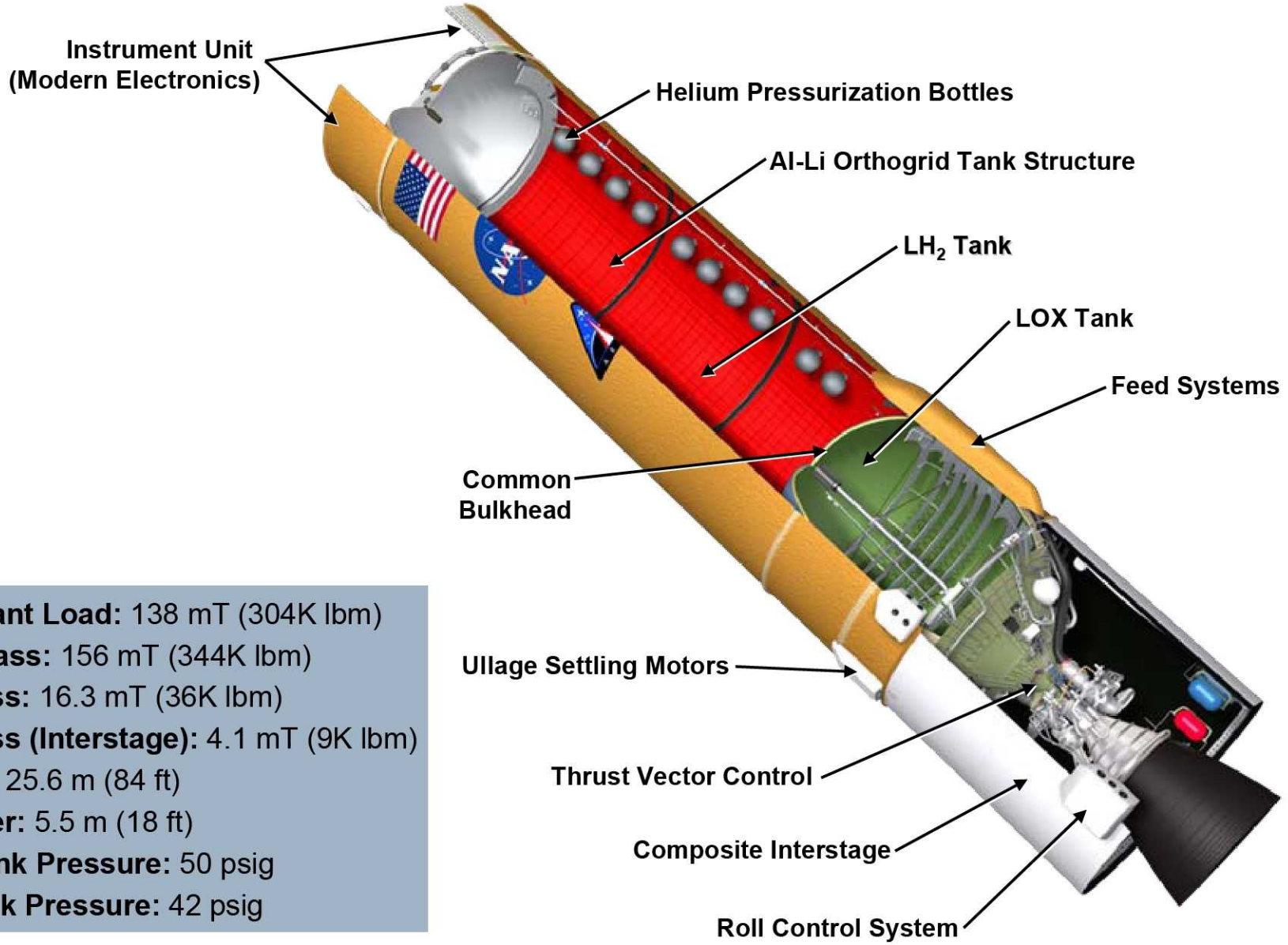
Same Aft Skirt and Thrust Vector Control as Shuttle

Booster Deceleration Motors (from Shuttle)

Nozzle upgraded to support higher motor performance

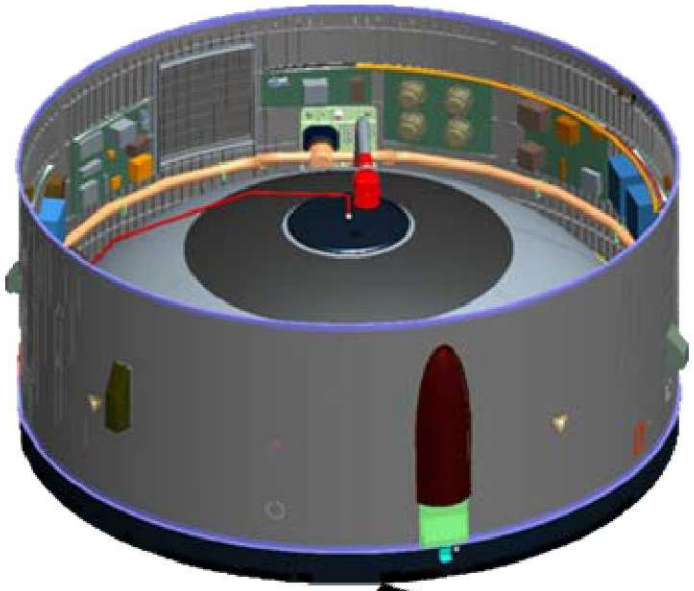
Mass: 733 mT (1,616 lbm)
Thrust: 15.8 MN
Burn Duration: 126 sec
Height: 53 m (174 ft)
Diameter: 3.7 m (12 ft)

Upper Stage



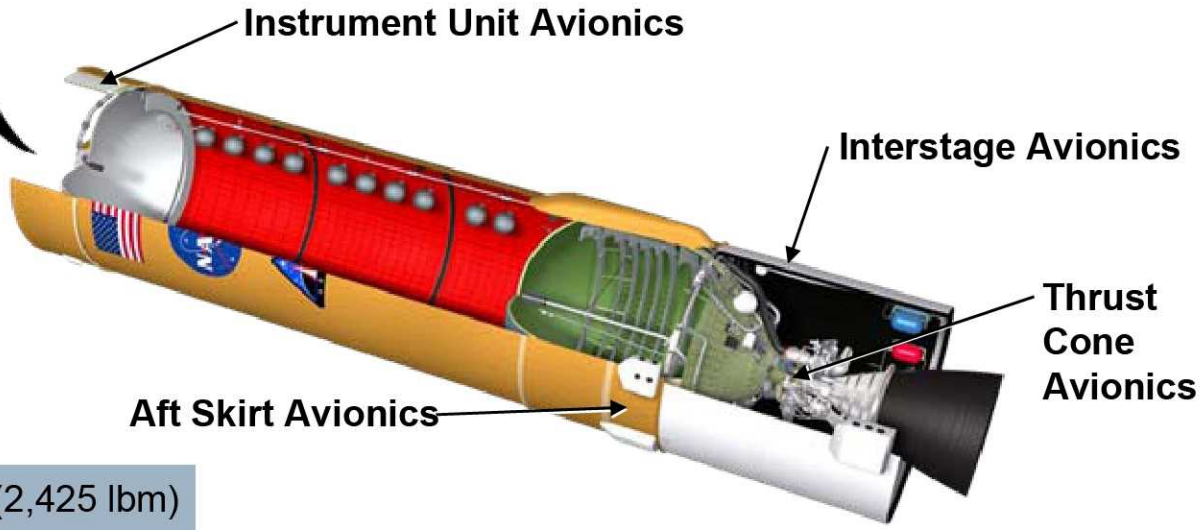
Propellant Load: 138 mT (304K lbm)
Total Mass: 156 mT (344K lbm)
Dry Mass: 16.3 mT (36K lbm)
Dry Mass (Interstage): 4.1 mT (9K lbm)
Length: 25.6 m (84 ft)
Diameter: 5.5 m (18 ft)
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

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

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Ares V Overview

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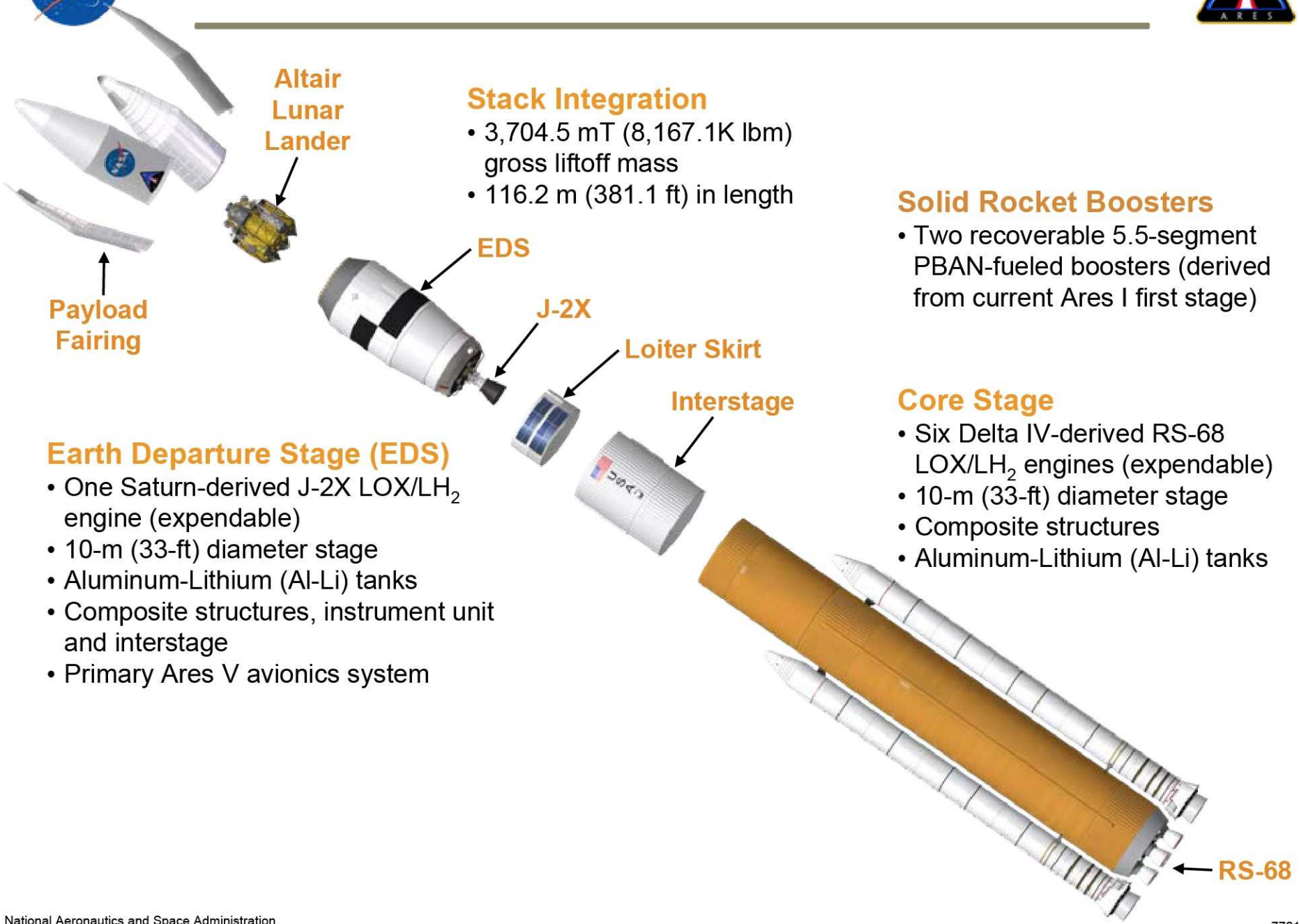
Ares V Elements



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)

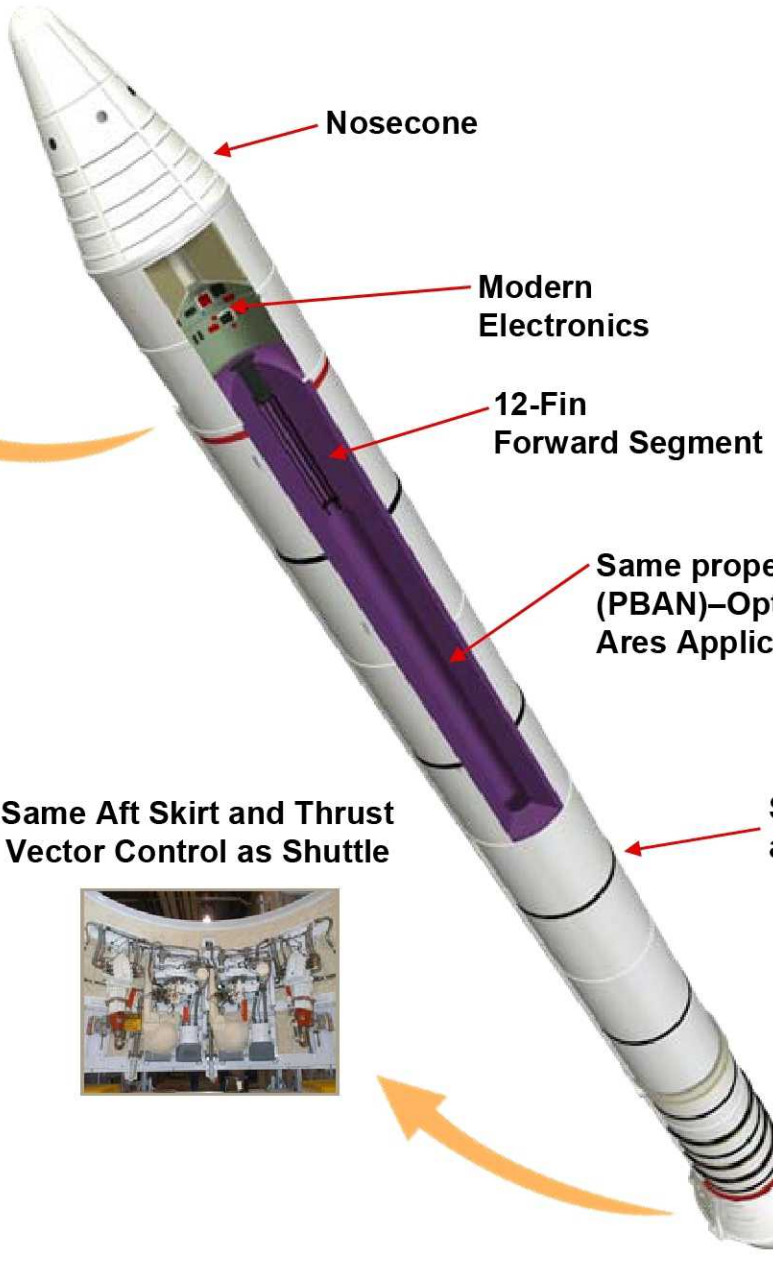
Earth Departure Stage (EDS)

- 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 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)

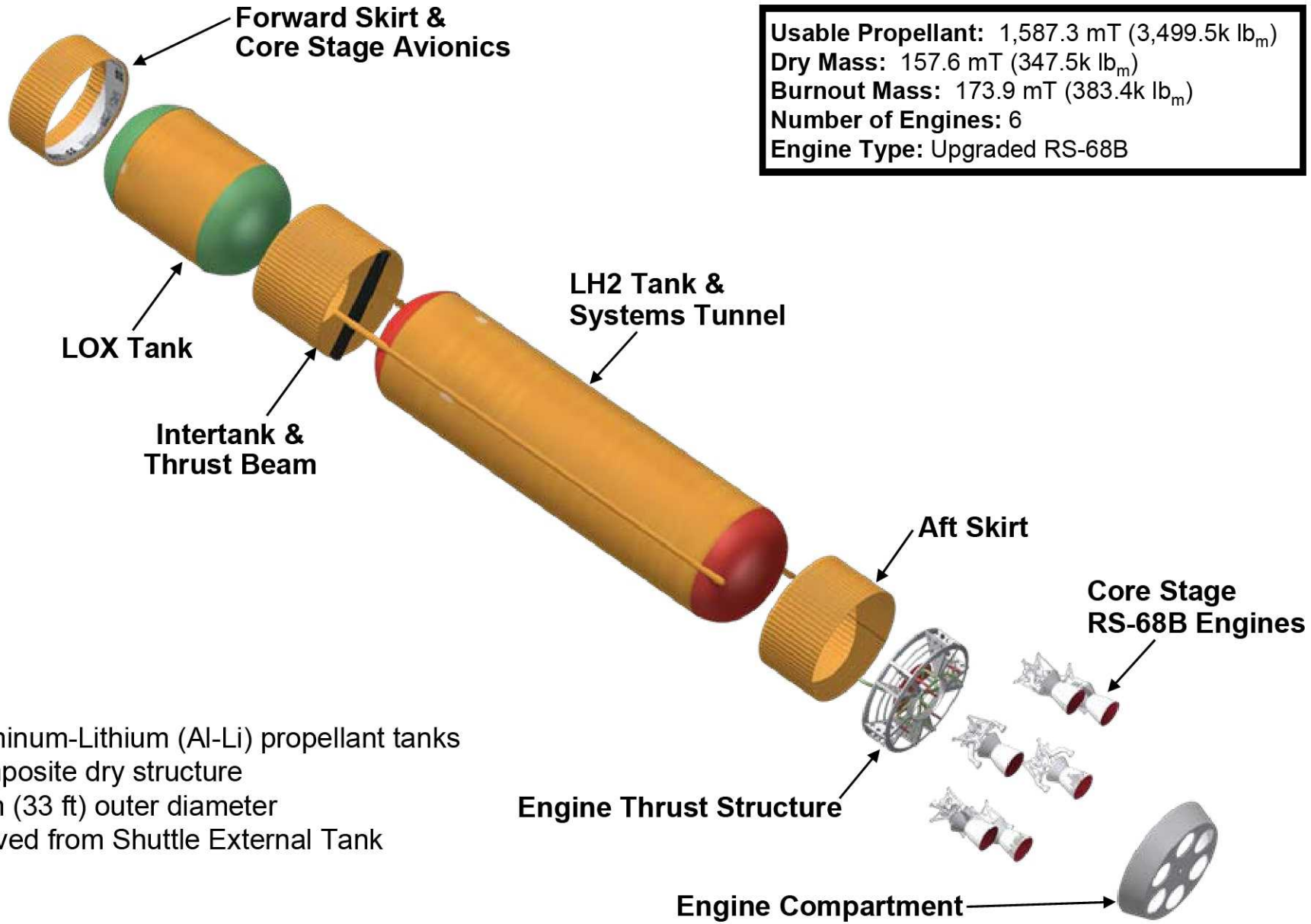
Thrust: 16.86 MN (3.79 Mlb_f)

Burn Duration: 126 sec

Height: 59 m (193 ft)

Diameter: 3.7 m (12 ft)

Ares V Core Stage



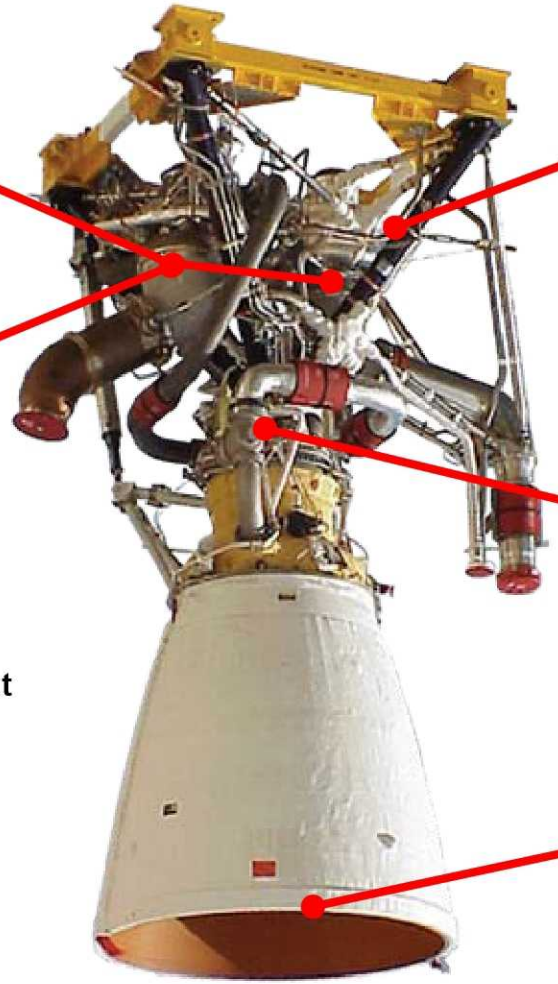
Usable Propellant: 1,587.3 mT (3,499.5k lb_m)
Dry Mass: 157.6 mT (347.5k lb_m)
Burnout Mass: 173.9 mT (383.4k lb_m)
Number of Engines: 6
Engine Type: Upgraded RS-68B

- 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

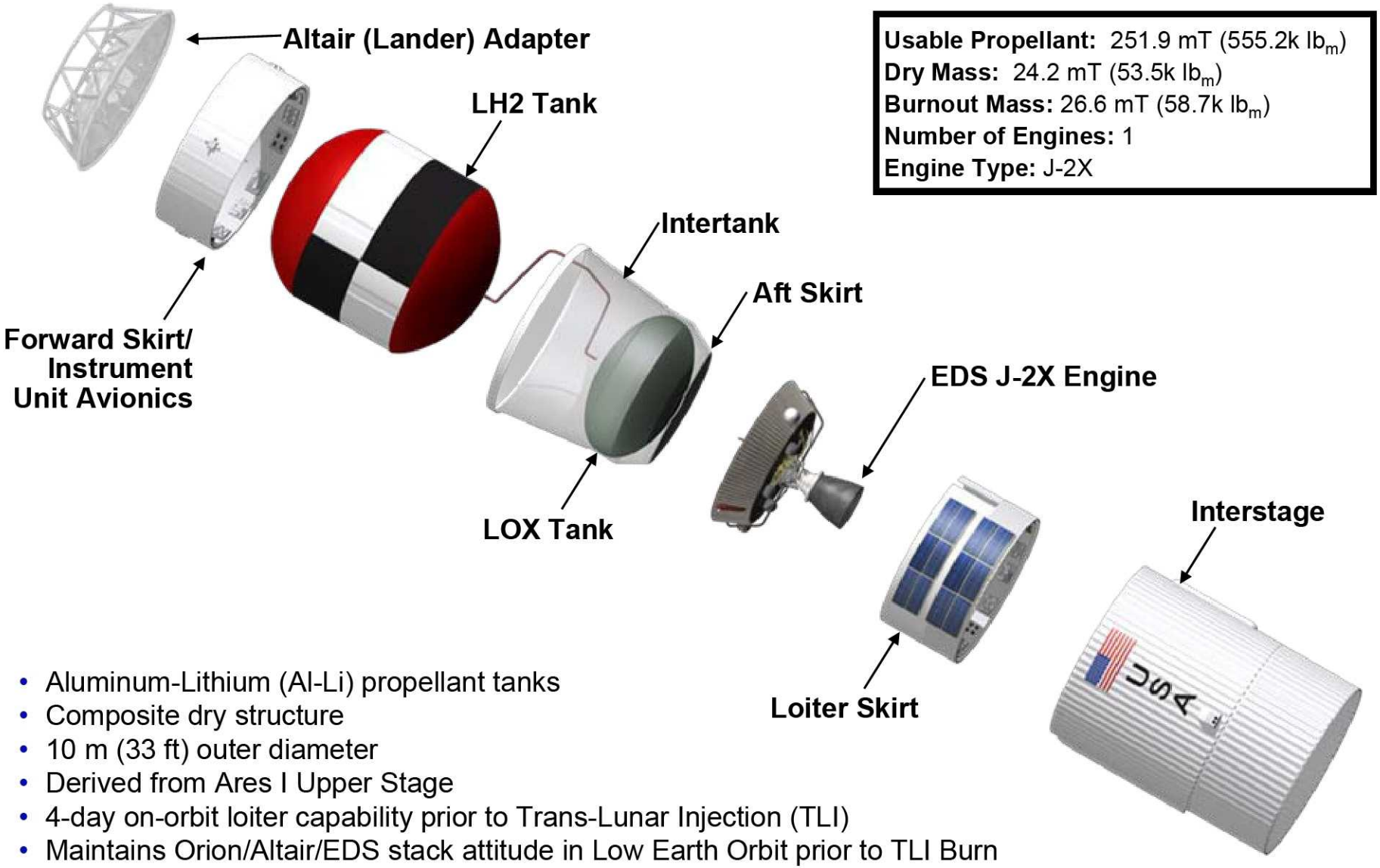
* Higher element density main injector improving specific impulse by ≈ 2% and thrust by ≈ 4%

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

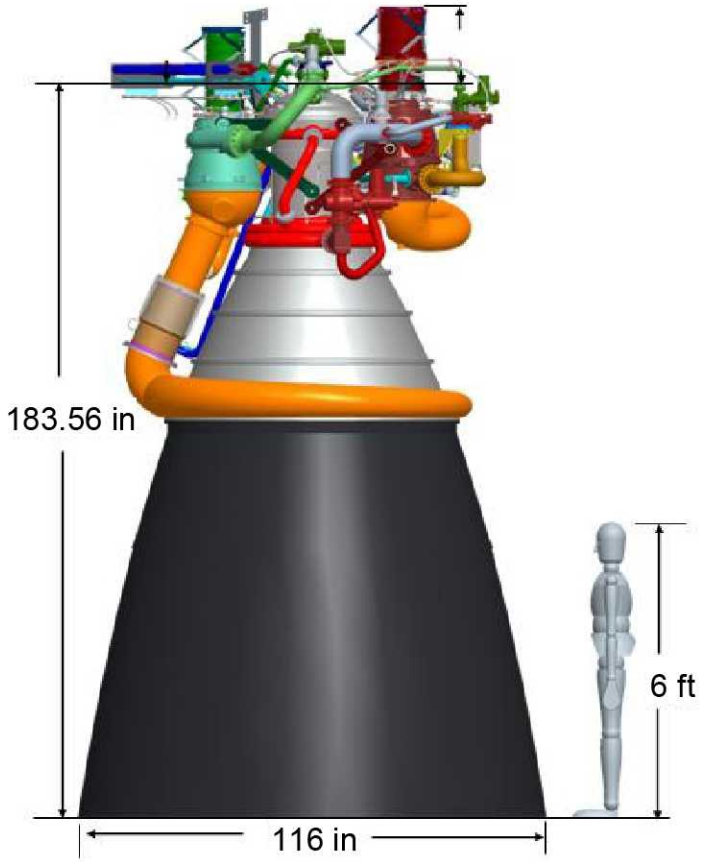
- **Upper Stage Engine Element challenge:**
  Design an engine…
  based on an evolution of the Apollo/Saturn era J-2 (GG cycle, 230,000 lbf, 424 seconds I_{sp})…

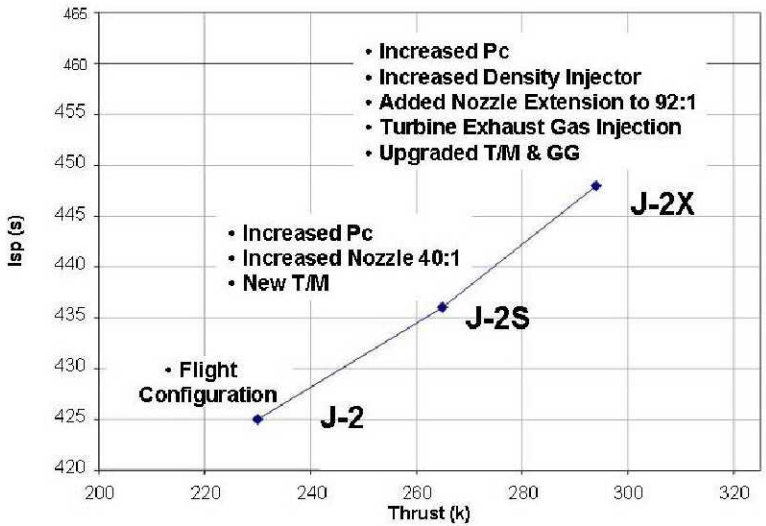
  increased to 294,000 lbf (1.3M Newtons) thrust…

  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…

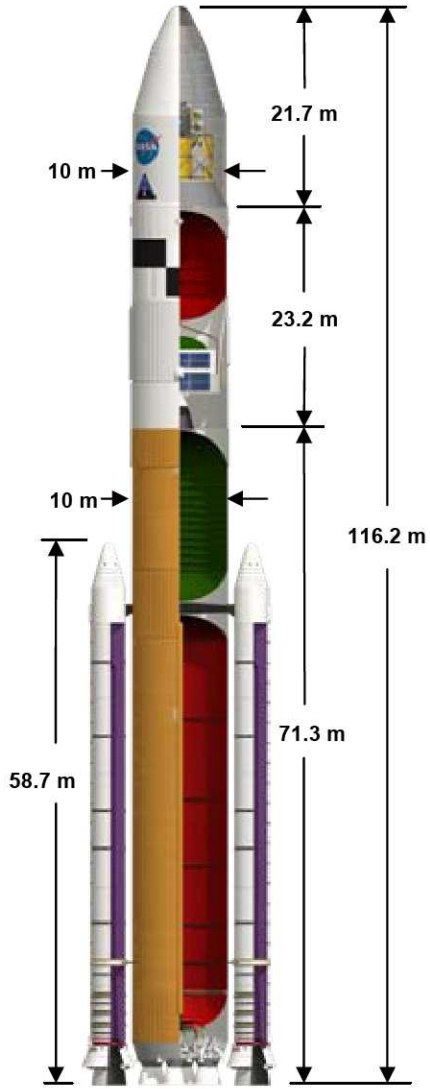
  and make it work for two different vehicles with two different missions, keeping as much commonality as possible.





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

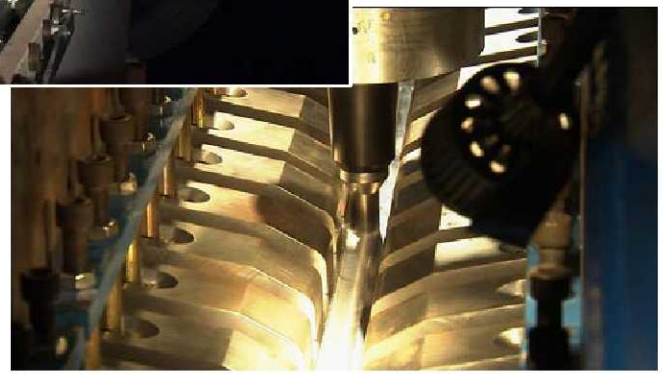
Ares I/V Progress

- **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

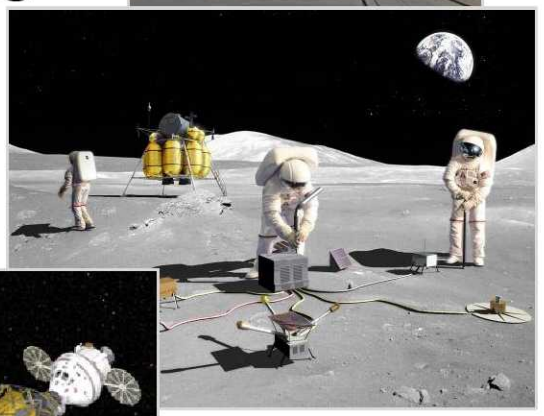
Big Picture Challenges of the Ares Projects

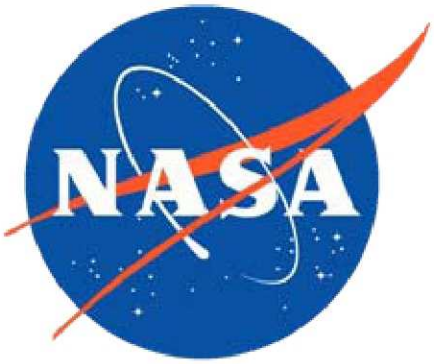
Current and Ongoing Management Challenges

- **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