National Aeronautics and Space Administration

Main Propulsion for the Ares Projects

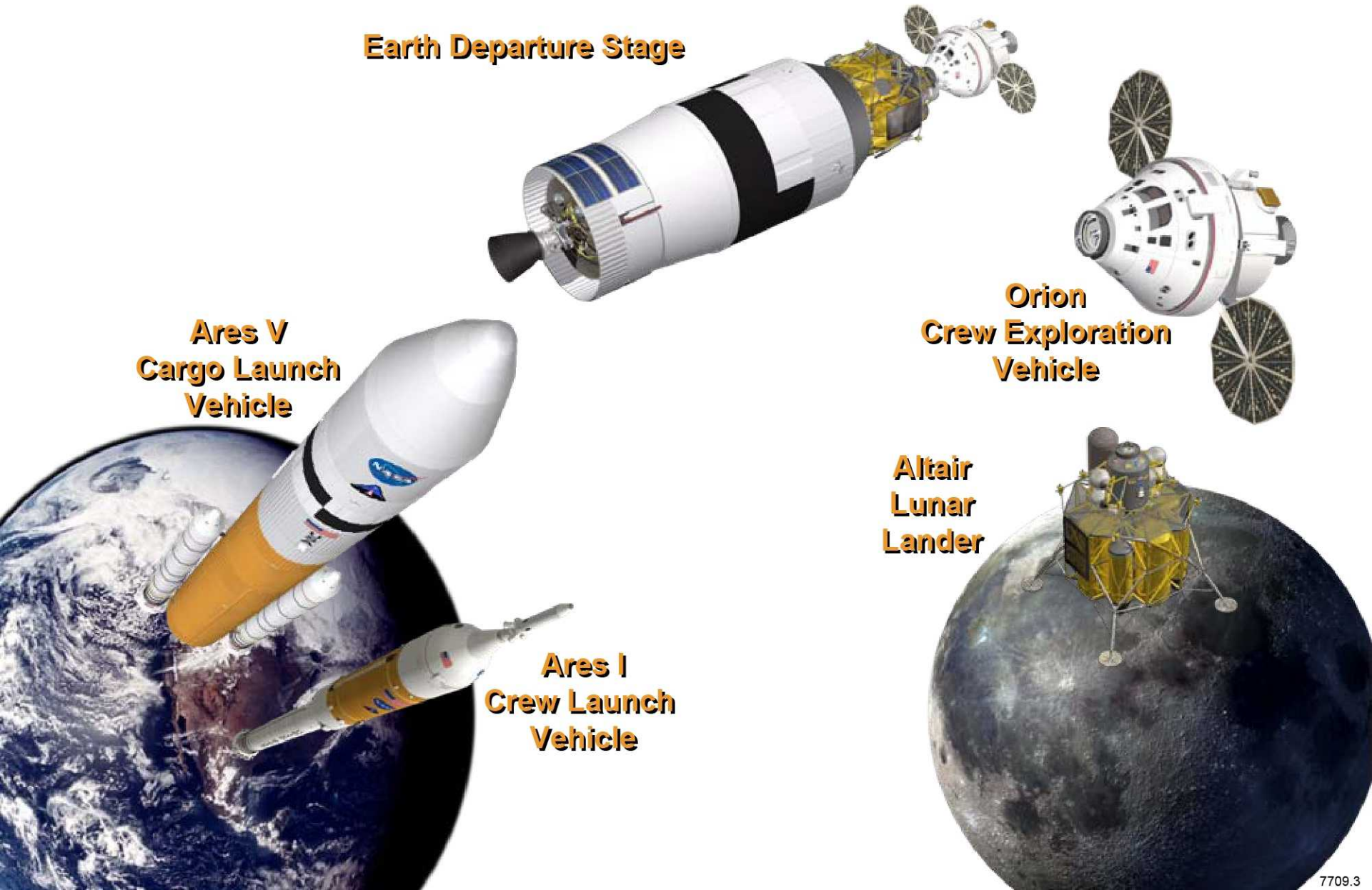
Phil Sumrall
Advanced Planning Manager
Ares Projects
NASA MSFC

Baylor University
April 21, 2009

Introduction

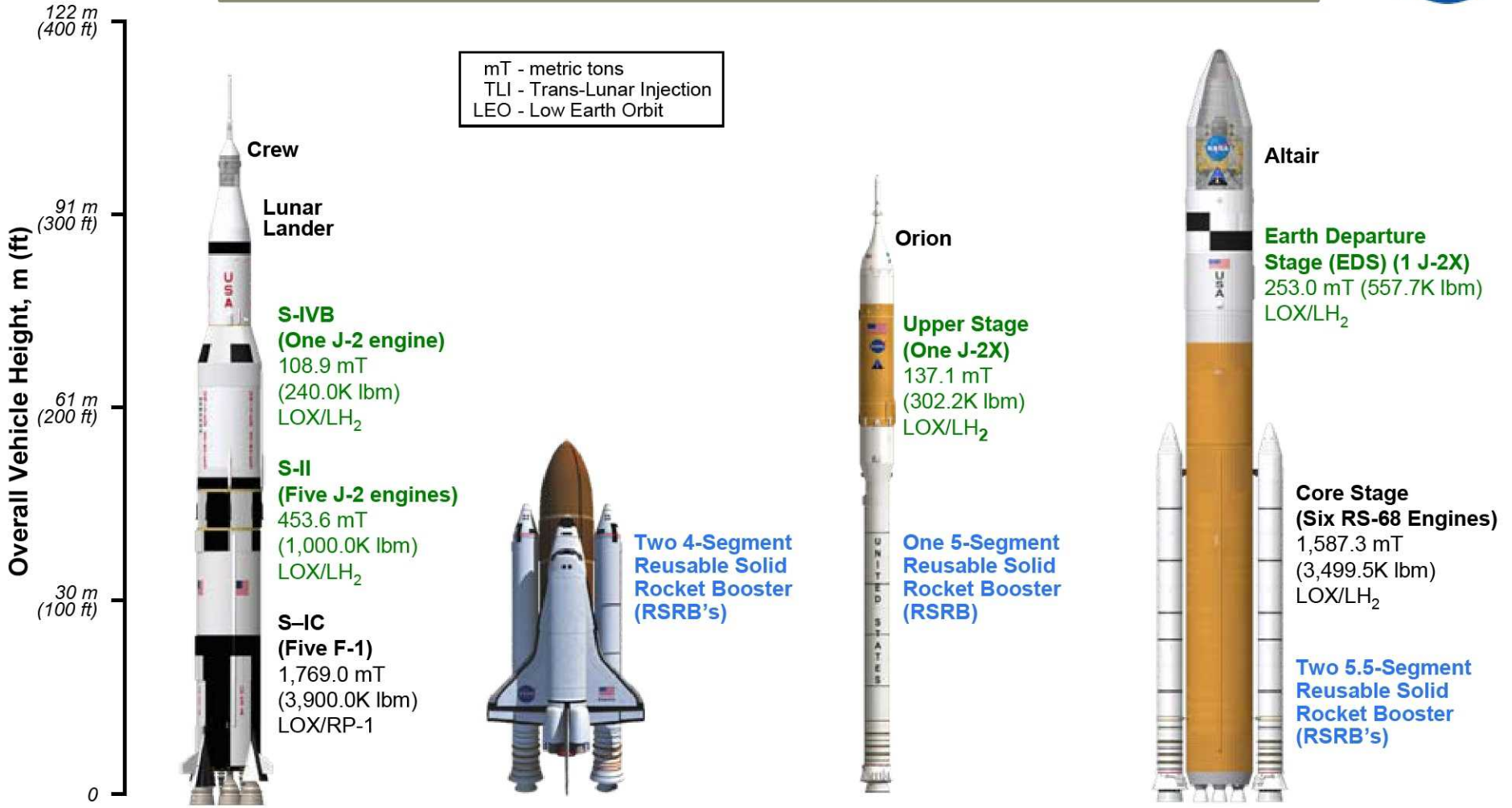
- The NASA Ares Projects Office is developing the launch vehicles to support exploration beyond low earth orbit for decades to come
- Ares I is a crewed vehicle, and Ares V is a heavy lift vehicle being designed to launch cargo into LEO and transfer cargo and crews to the Moon
- The performance, reliability, operability, and cost of the Ares propulsion systems are critical to everything we aspire to do.
- Ares propulsion systems are based on heritage hardware and experience from Apollo to the Space Shuttle to current ELVs
- My goal today is to update you on the status of Ares propulsion systems

Our Exploration Fleet
What Will the Vehicles Look Like?



Building on a Foundation of Proven Technologies

- Launch Vehicle Comparisons -



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

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)

Ares I

First Flight 2015

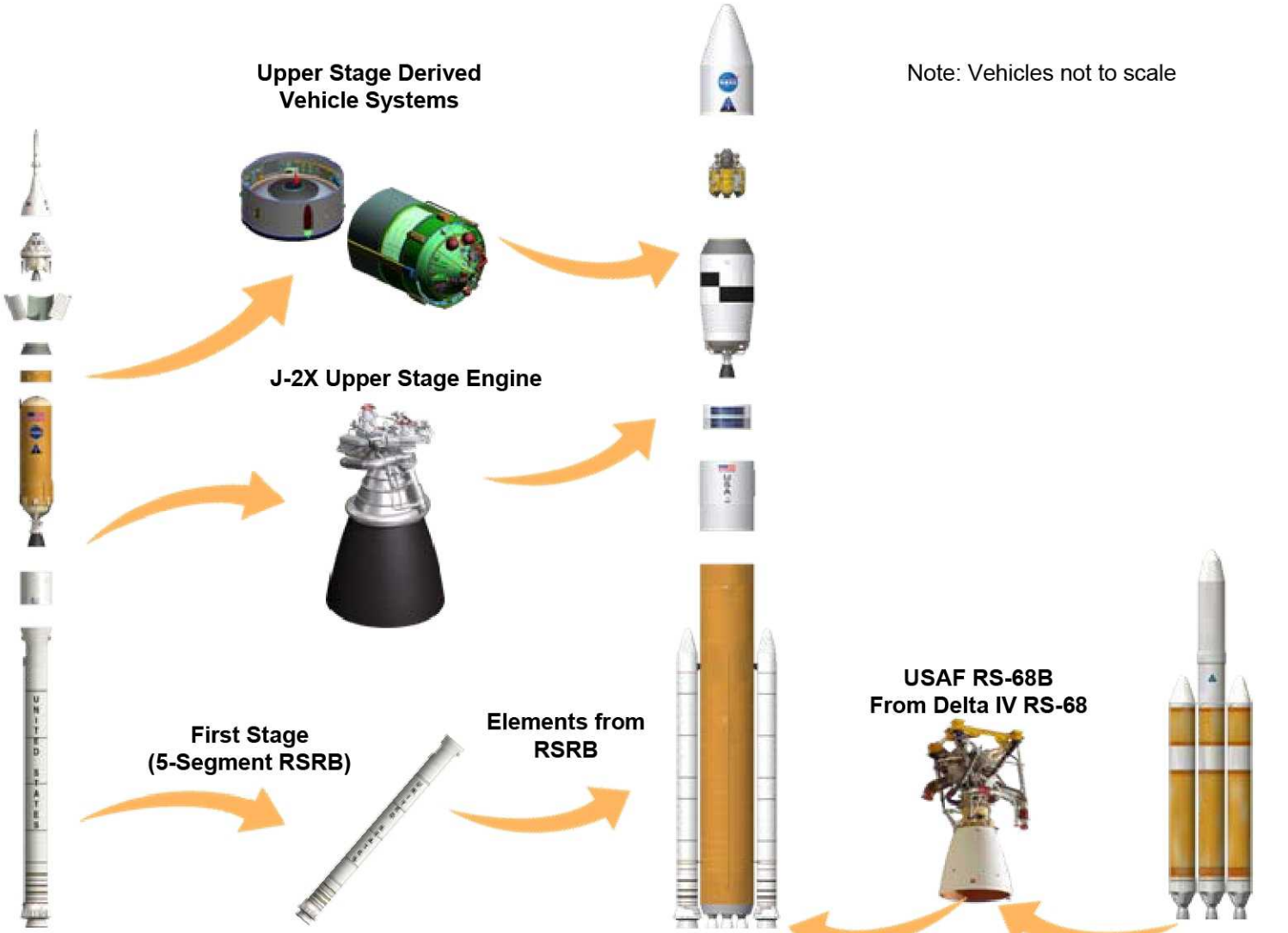
Height: 99.1 m (325.0 ft)
Gross Liftoff Mass :
927.1 mT (2,044.0K lbm)
Payload Capability:
25.5 mT (56.2K lbm)
to LEO

Ares V

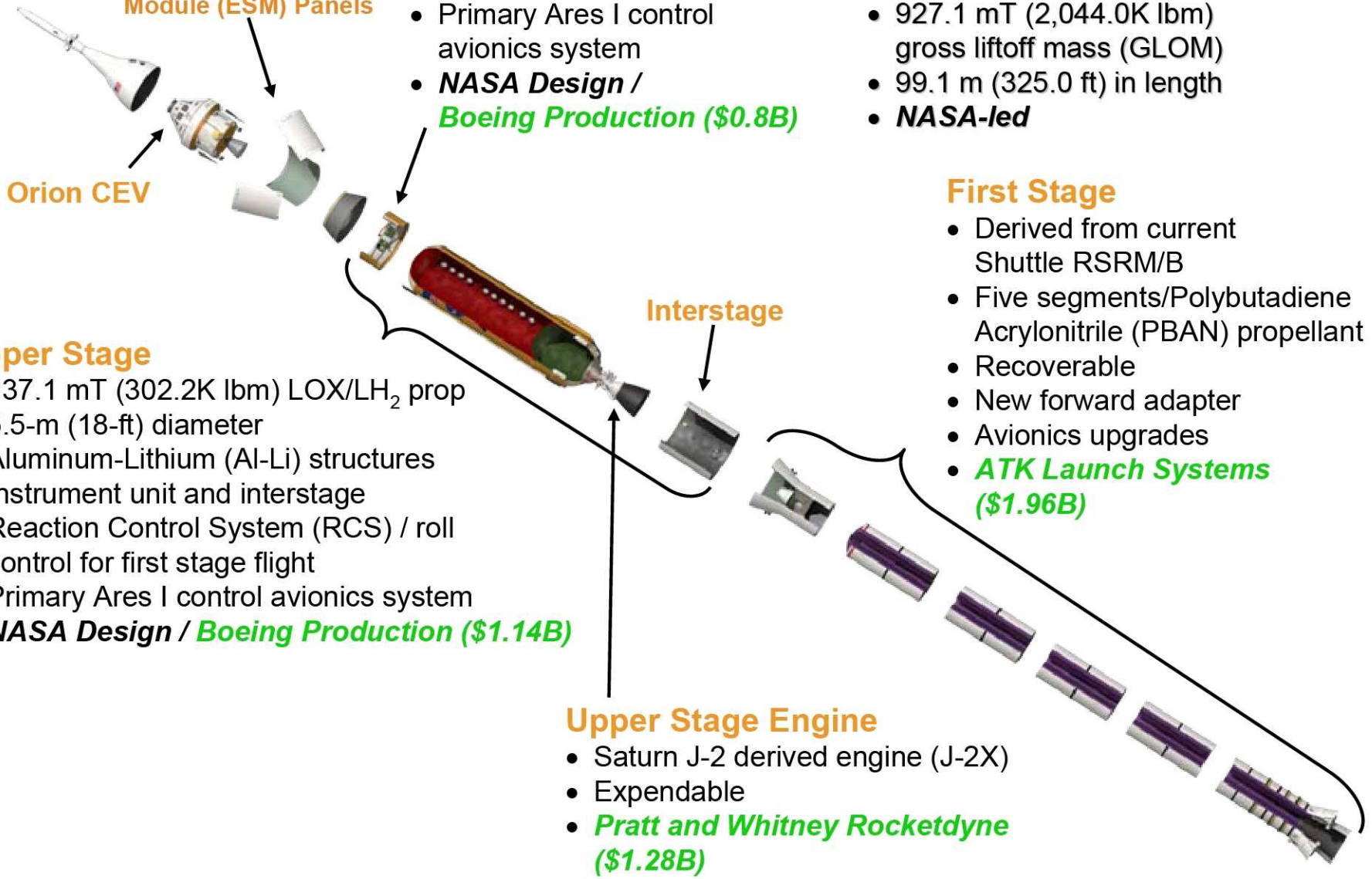
First Flight 2018

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 Vehicles: Commonality & Heritage Hardware



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

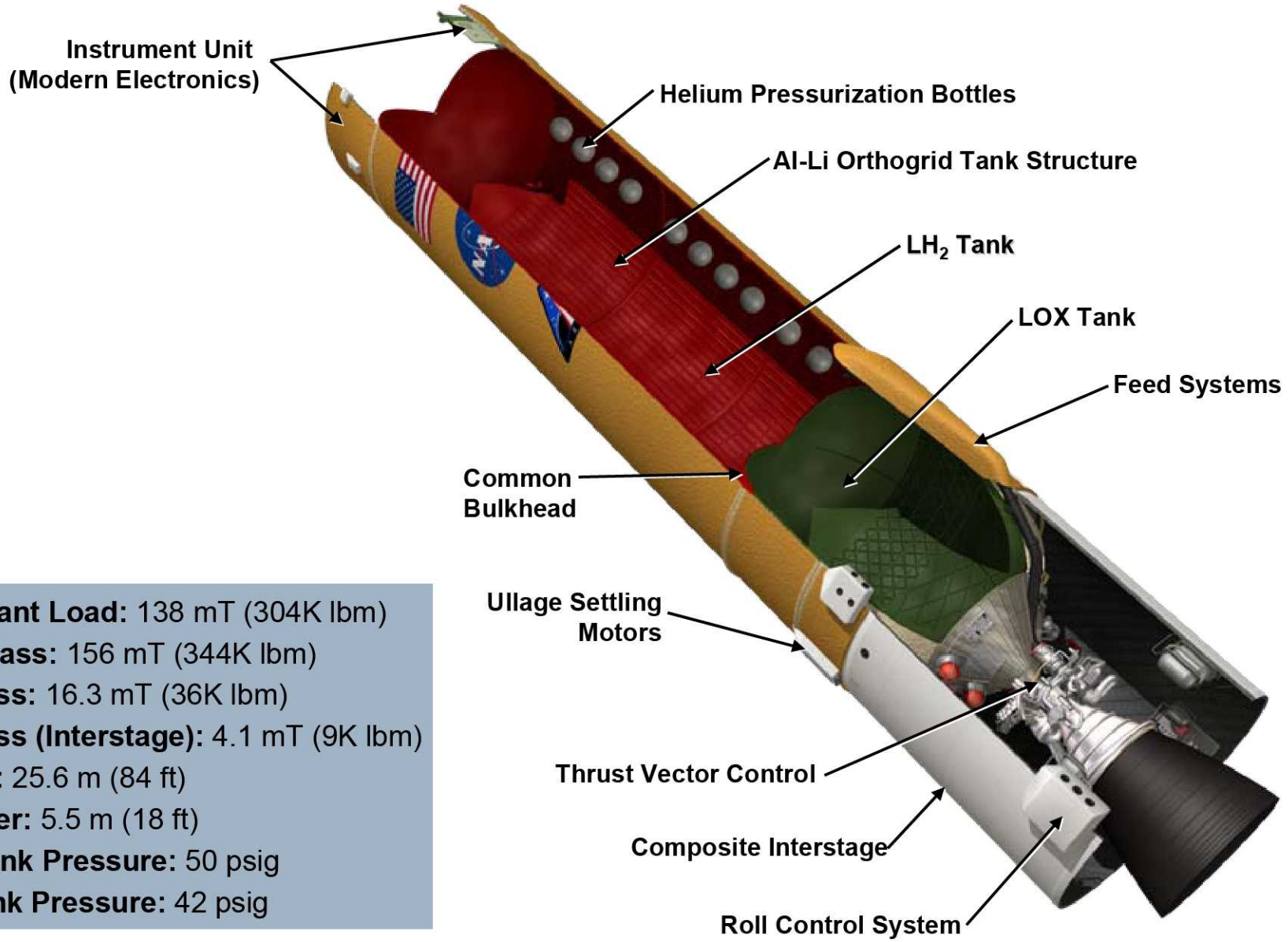
Same Aft Skirt and Thrust Vector Control as Shuttle

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

J-2X Upper Stage Engine for Ares I and Ares V

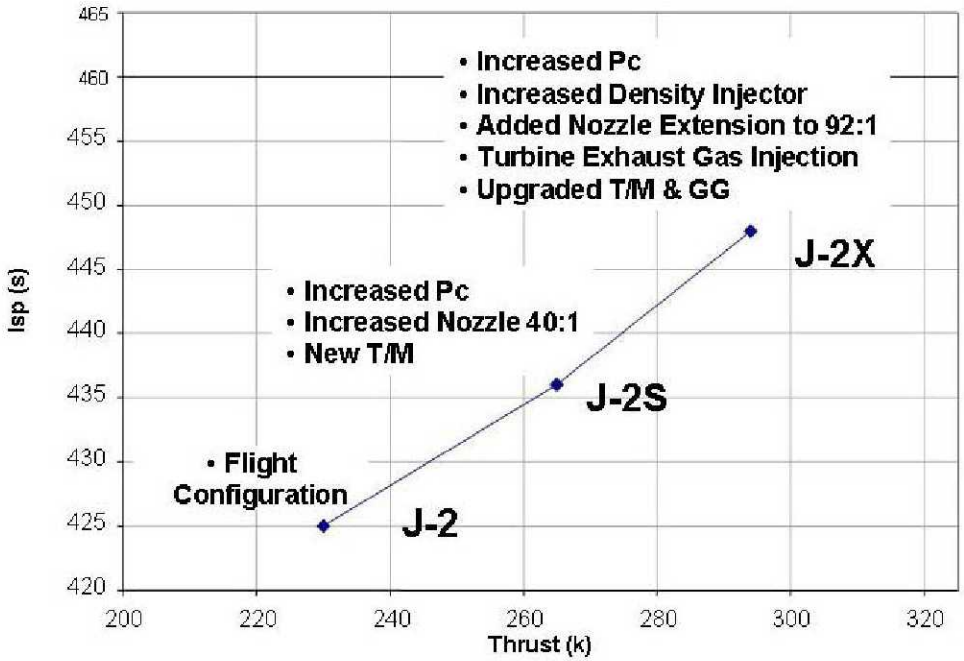
- **Upper Stage Engine Element challenge:**
  Design an engine…
  based on an evolution of the Apollo/Saturn era J-2 (GG cycle, 230,000 lbf, 424 seconds I_{sp})…

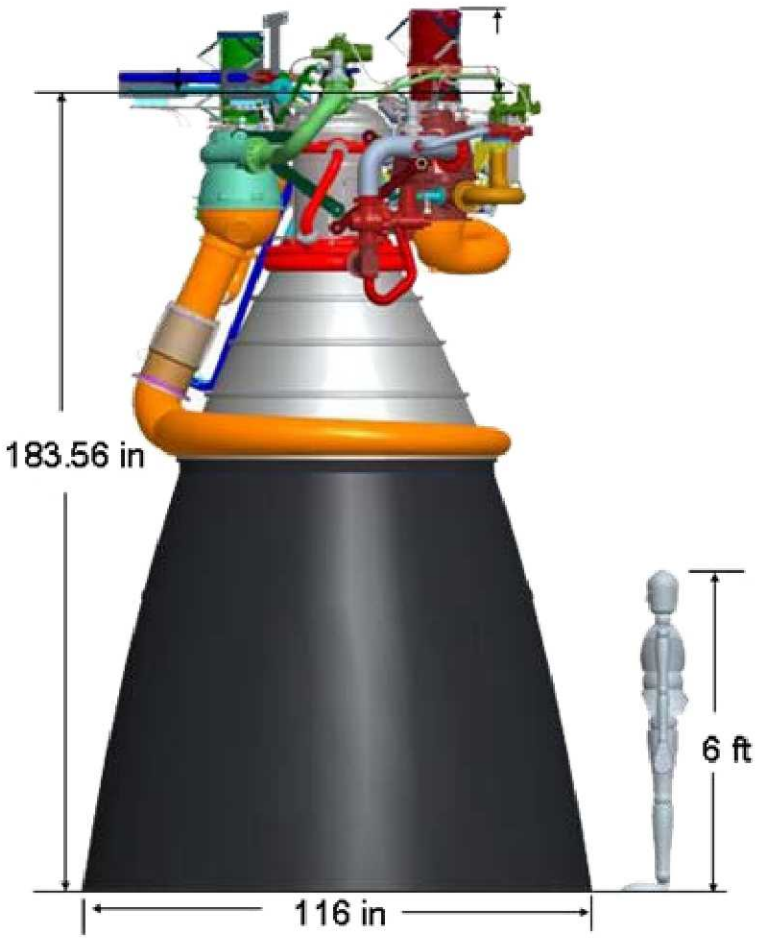
  increased to 294,000 lbf (1.3M Newtons) thrust…

  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.





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

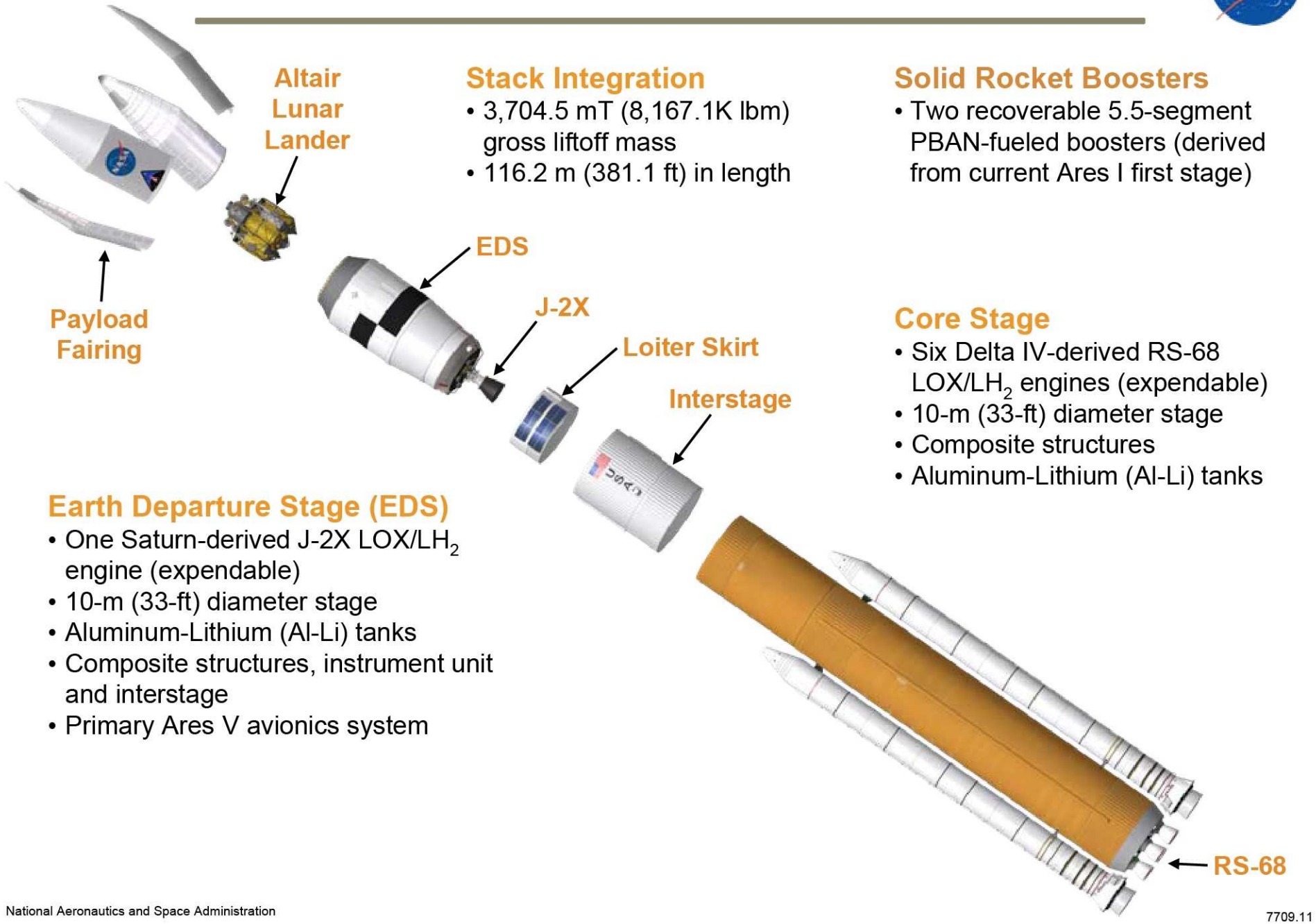
Metallic Nozzle Extension
- New design

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 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)

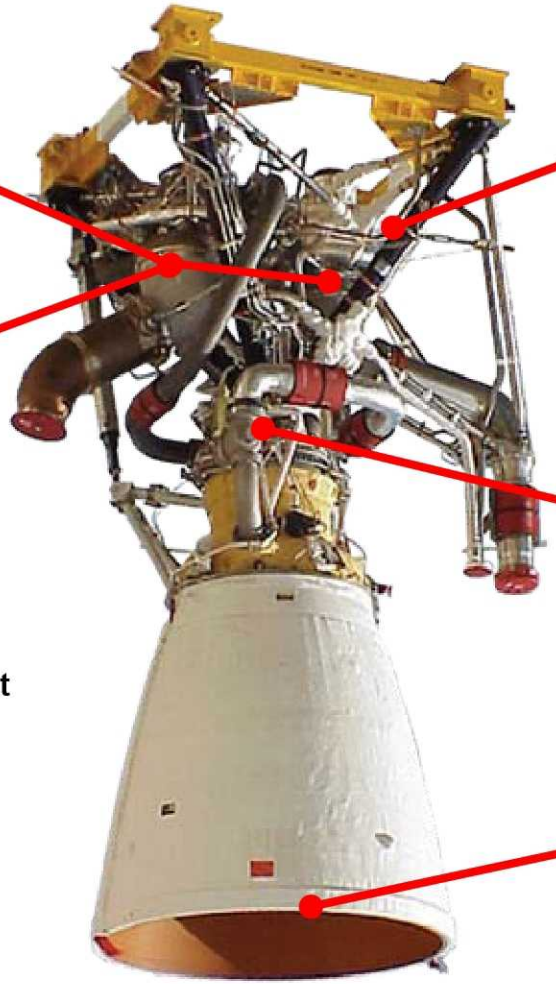
Core Stage

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

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

RS-68 to RS-68B



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

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

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

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

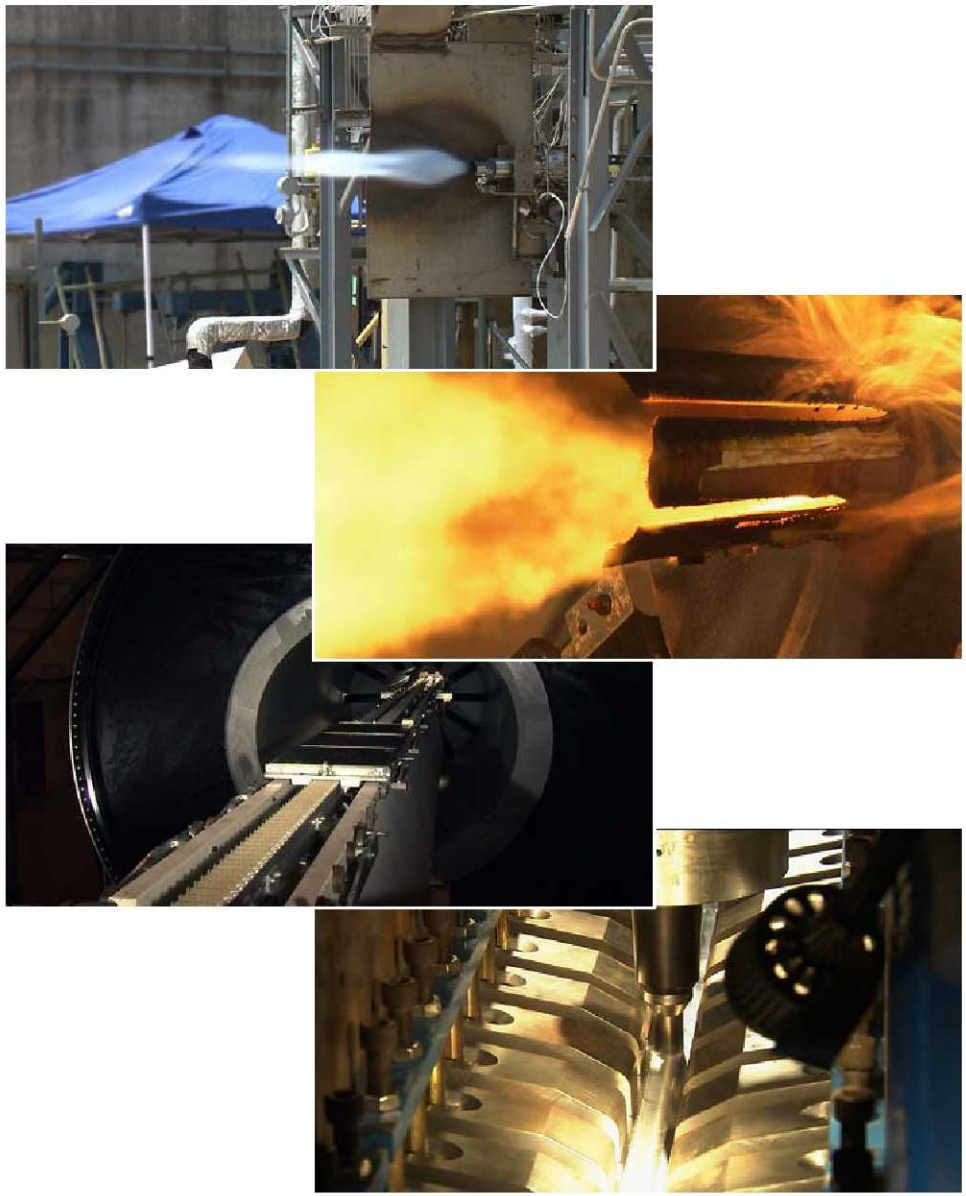
- **Other RS-68A upgrades or changes that may be included:**
  - Bearing material change
  - New Gas Generator igniter design
  - Improved Oxidizer Turbo Pump temp sensor
  - Improved hot gas sensor
  - 2nd stage Fuel Turbo Pump blisk crack mitigation
  - Cavitation suppression
  - ECU parts upgrade

Increased duration capability ablative nozzle

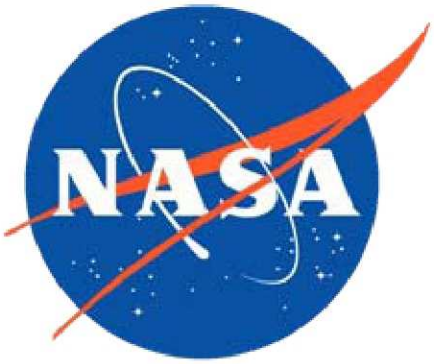
* **RS-68A Upgrades**

What Progress Have We Made?

- **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
- **J-2X**
  - Completed 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, and powerpack tests and CFD completed in support of turbomachinery, combustion devices, etc.
  - 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



For more information go to www.nasa.gov/ares



www.nasa.gov/ares