National Aeronautics and Space Administration

Ares V: Overview and Status

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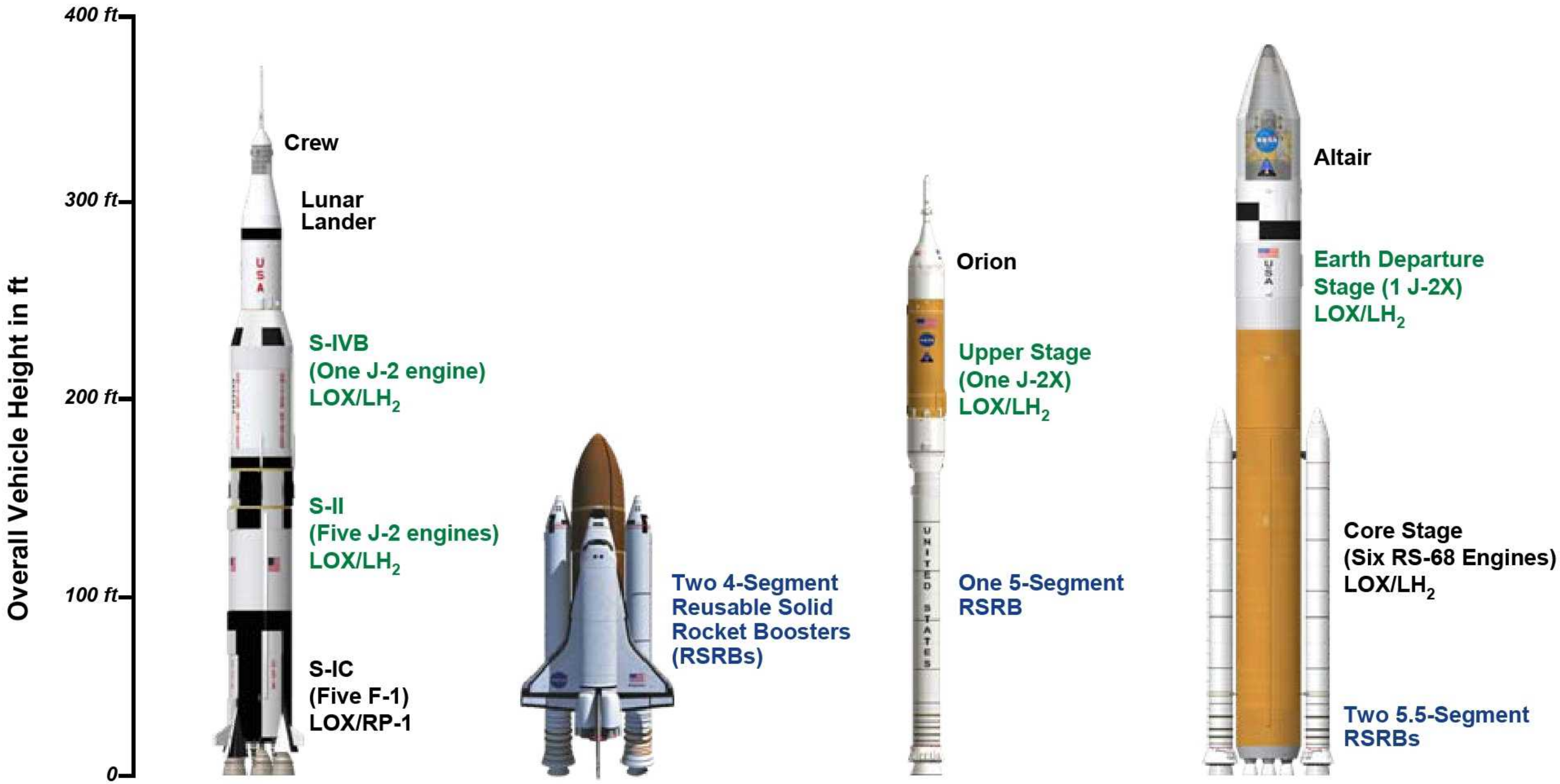
Introduction

- 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 the outcome of the Review of U.S. Human Space Flight Plans Committee and White House action
- Via commonality and proven hardware, Ares V design benefits from work well under way on the Ares V
- My goal today is to update you on the status of the Ares V vehicle

Building on 50 Years of Proven Experience

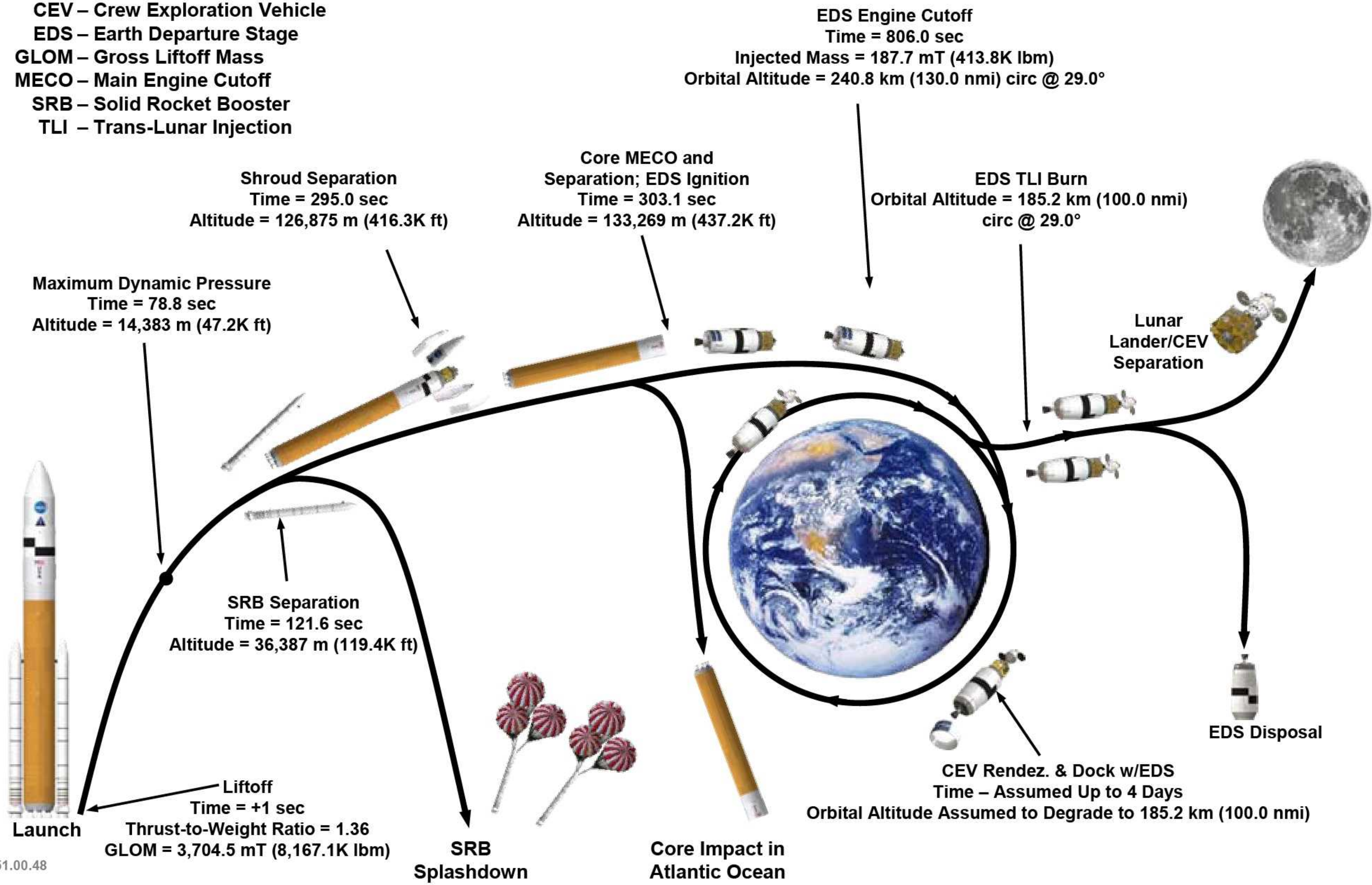
– Launch Vehicle Comparisons –



	Saturn V: 1967–1972	**Space Shuttle:** 1981–Present	**Ares I:** First Flight 2015	**Ares V:** First Flight 2018
Height	360 ft	184.2 ft	325.0 ft	381.1 ft
Gross Liftoff Mass (GLOM)	2,948.4 mT (6,500K lbm)	2,041.1 mT (4,500.0K lbm)	933.2 mT (2,057.3K lbm)	3,704.5 mT (8,167.1K lbm)
Payload Capability	99.0K lbm to TLI 262.0K lbm to LEO	55.1K lbm to LEO	54.9K lbm to LEO	156.7K lbm to TLI with Ares I 413.8K lbm to LEO

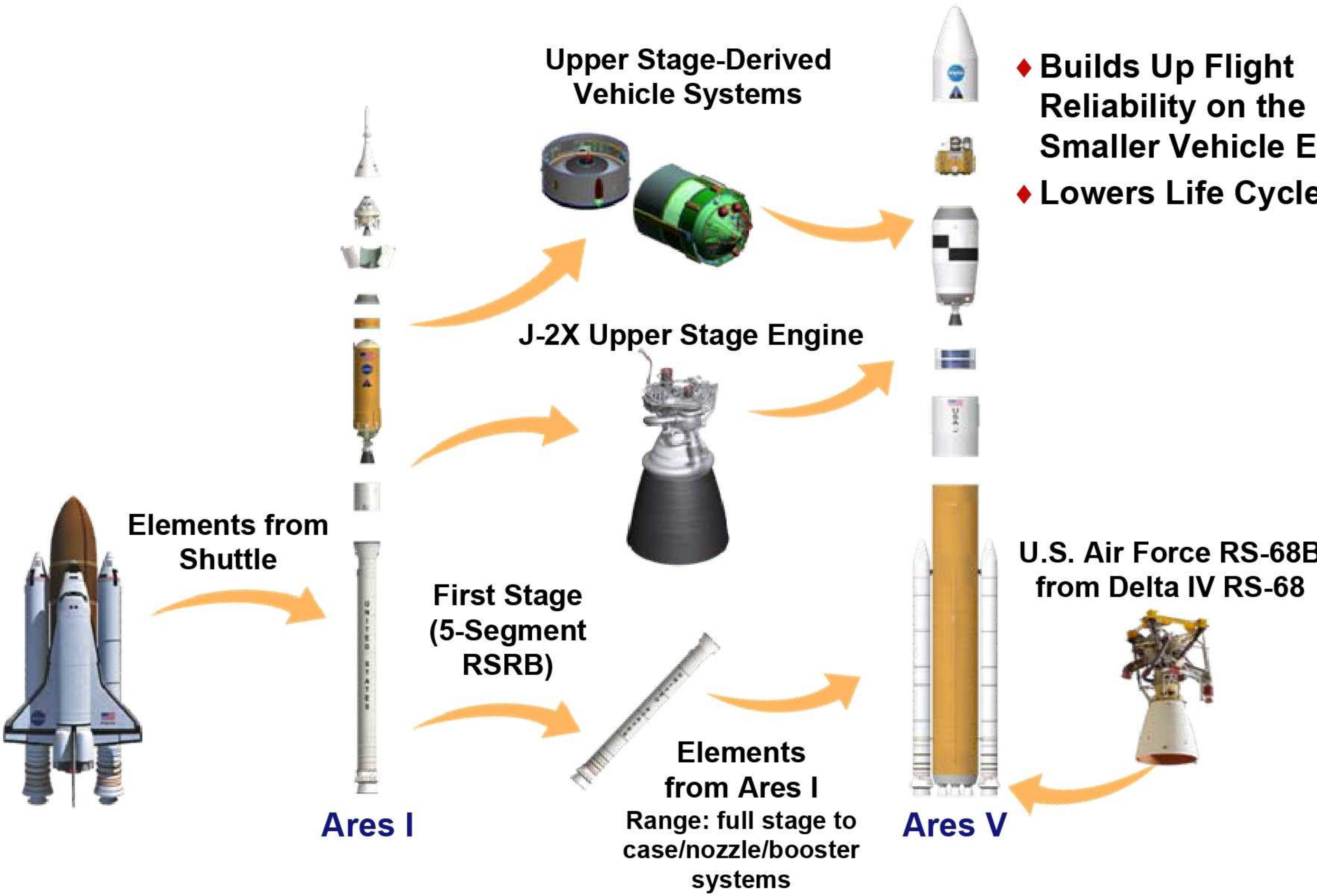
Ares V Lunar Sortie Mission Profile

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



Ares I and Ares V Commonality

- Builds Up Flight Reliability on the Smaller Vehicle Earlier
- Lowers Life Cycle Cost



Ares V Key Requirements

LUNAR SORTIE MISSION			
CARD Requirement	**Mass (t)**	**Mass (lb_m)**	**Derived Performance Rqt.**
Orion [CA4139]	20.2	44,500	
Crewed Lander [CA0836]	45.0	99,208	
Total TLI [CA0848]	66.9	147,575	Derived TLI > 66.9 t
	45.0	99,208	Derived ETO > 45.0 t

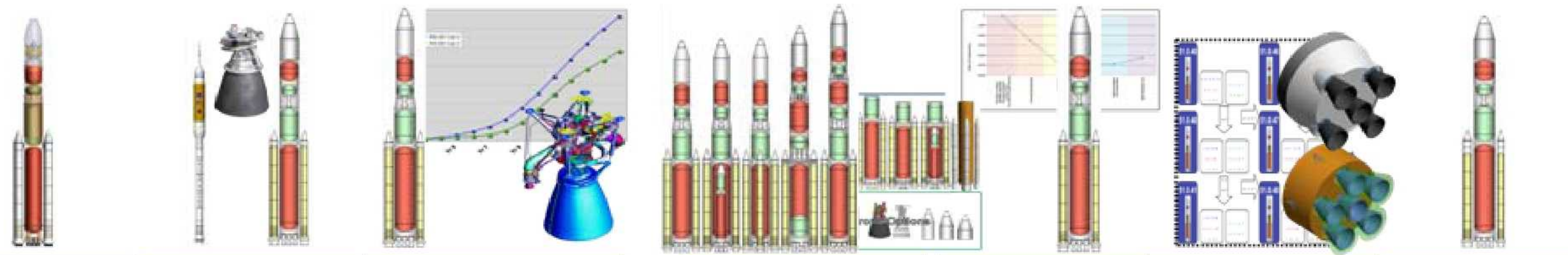
- ETO Mission Destination: 130 nmi, 29°
- Loiter Duration: 4 days (CARD TBD)
- TLI Maneuver Starting Conditions: 100 nmi, 29°
- TLI ΔV = 3175 m/s + Gravity Loss

LUNAR CARGO MISSION			
CARD Requirement	**Mass (t)**	**Mass (lb_m)**	**Derived Performance Rqt.**
Cargo Lander [CA5231]	53.6	118,168	
Total TLI [CA0847]	54.6	120,372	Derived TLI > 54.6 t
Total ETO Goal [CA0847]	54.6	120,372	Derived ETO > 54.6 t

- ETO Mission Destination: Phasing Orbit
- Loiter Duration: None (no loiter capability on EDS)
- Note that Saturn V TLI payload capability was 48.6 t (Apollo 17 - CM/SM/ LM/SLA) and
- Ares V Earth-to-TLI requirement exceeds Saturn V Capability by 31%

LCCR focus is to determine driving requirements and establish appropriate performance margin

Exploration Systems Architecture Study (ESAS) (2005) to Lunar Capability Concept Review (LCCR) (2008) Design Milestones



Original ESAS Capability

- *45.0 mT Lander*
- *20.0 mT CEV*
- *No Loiter in LEO*
- *8.4 m OML*
- *5 SSMEs / 2 J2s*

CY-06 Budget Trade to Increase

•Ares I / Ares V Commonality

•Ares I: 5-Seg RSRB / J-2X instead of Air-Start SSME

•Ares V: 1 J-2X

Detailed Cost Trade of SSME vs. RS-68

•~$4.25B Life Cycle Cost Savings

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

220 Concepts Evaluated

320 Concepts Evaluated

730 Concepts Evaluated

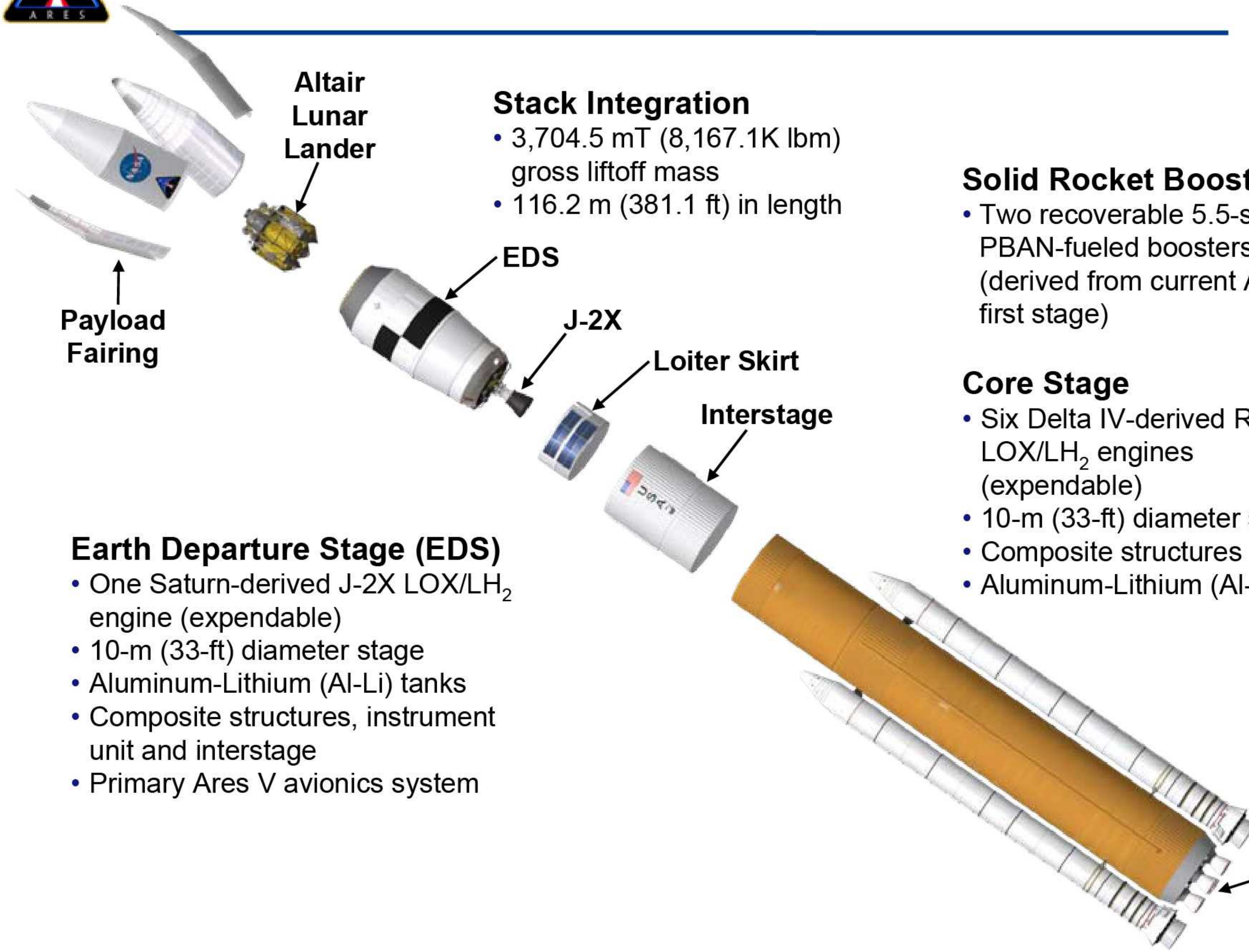
460 Concepts Evaluated

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

Ares I ATP — Orion ATP — Ares I SRR — Orion SRR — Ares I SDR — Ares V MCR

Ares V Elements

Stack Integration
- 3,704.5 mT (8,167.1K lbm) gross liftoff mass
- 116.2 m (381.1 ft) in length

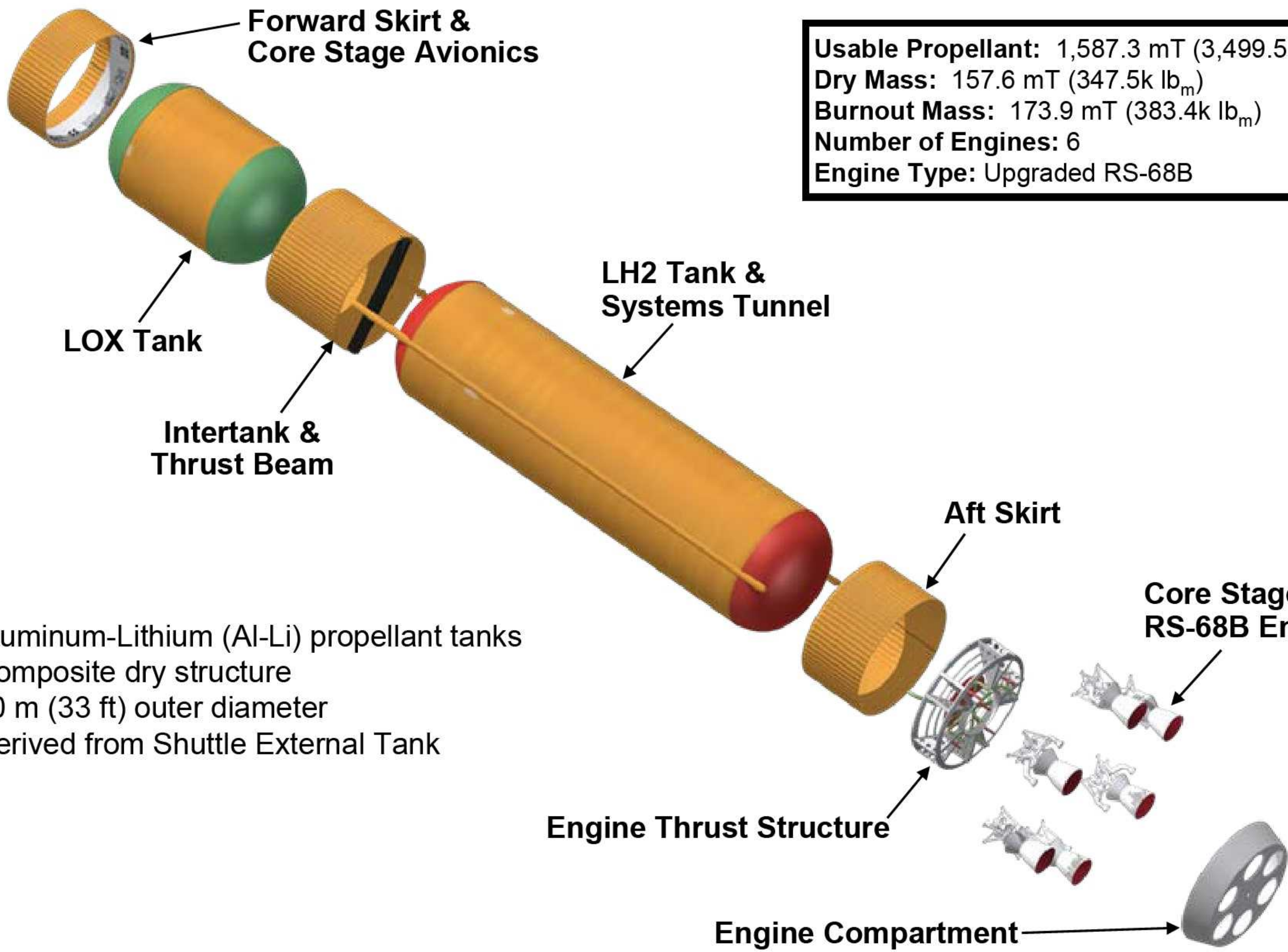


Solid Rocket Boosters
- Two recoverable 5.5-segment PBAN-fueled boosters (derived from current Ares I first stage)

Core Stage
- Six Delta IV-derived RS-68B 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

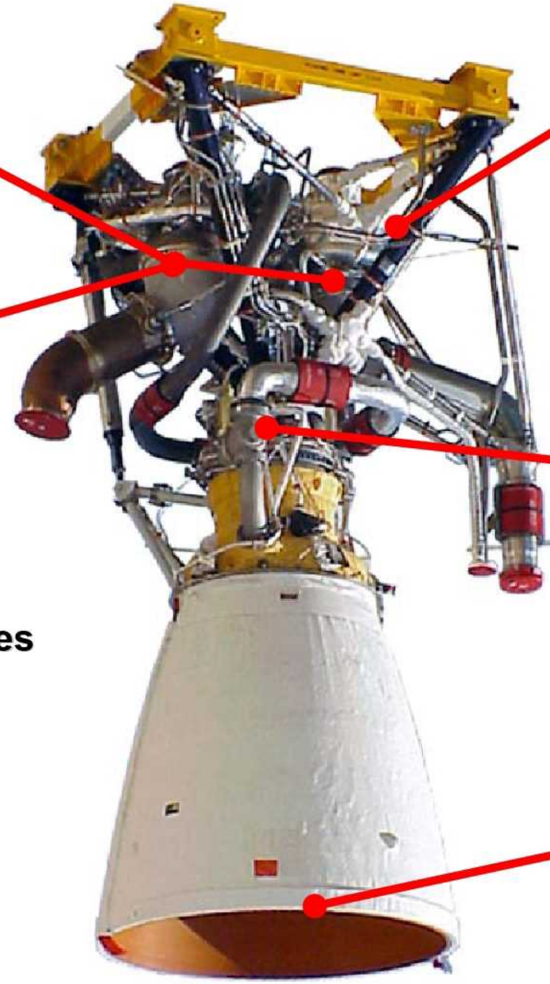
Ares V Core Stage



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%

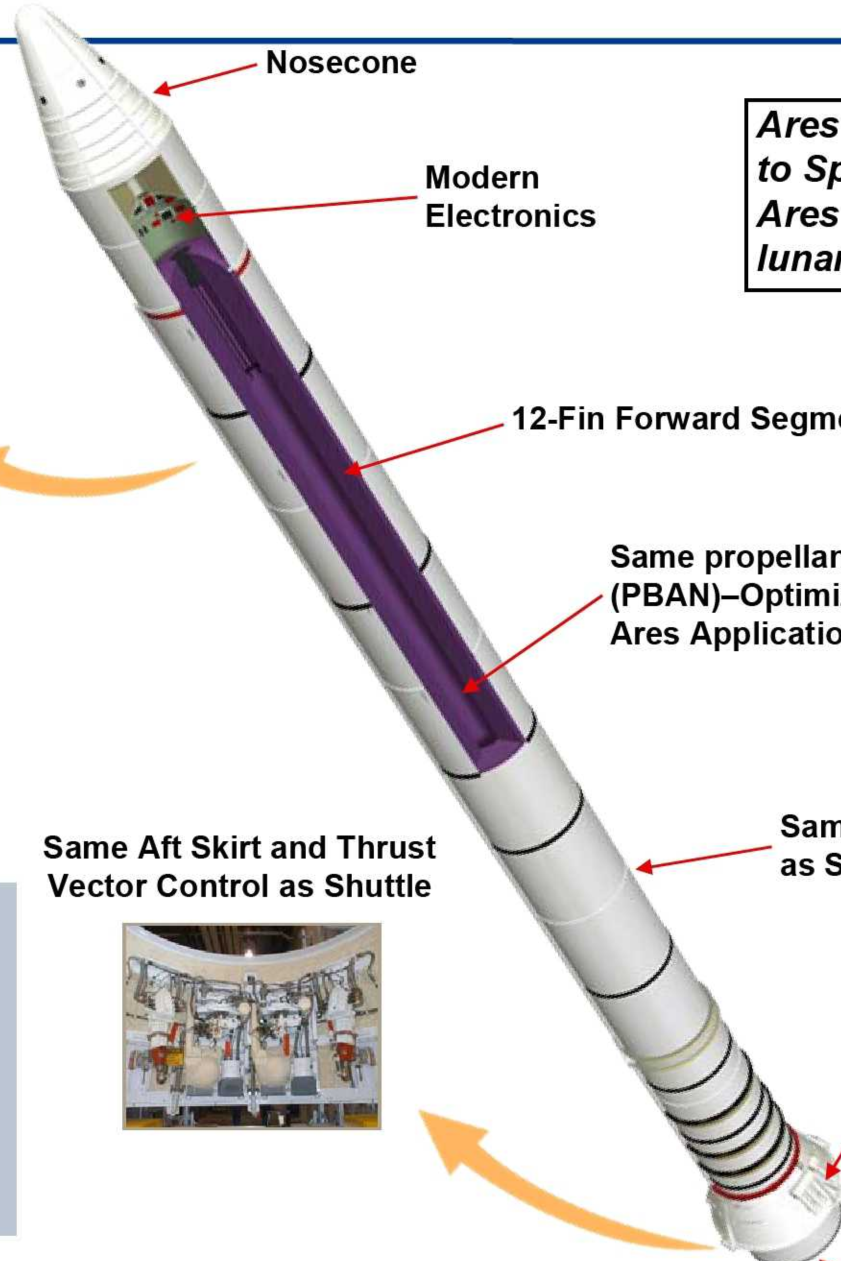
Increased duration capability ablative nozzle

- **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 Solid Rocket Booster (SRB)

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




New 150 ft diameter parachutes

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)

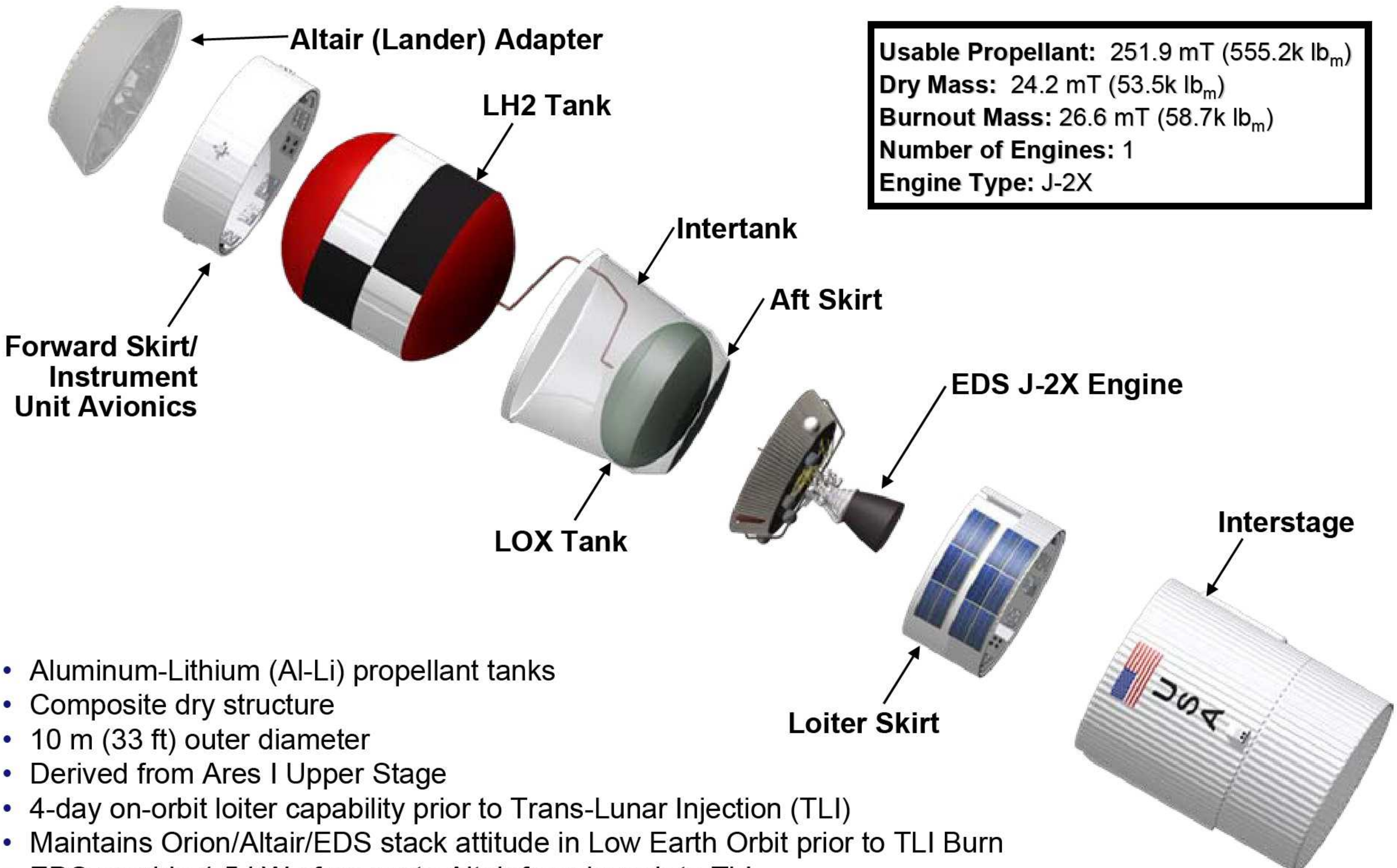
Diameter: 3.7 m (12 ft)

DM-1 in T-97 Test Stand

Promontory, UT

Ares I-X First Stage Accomplishments

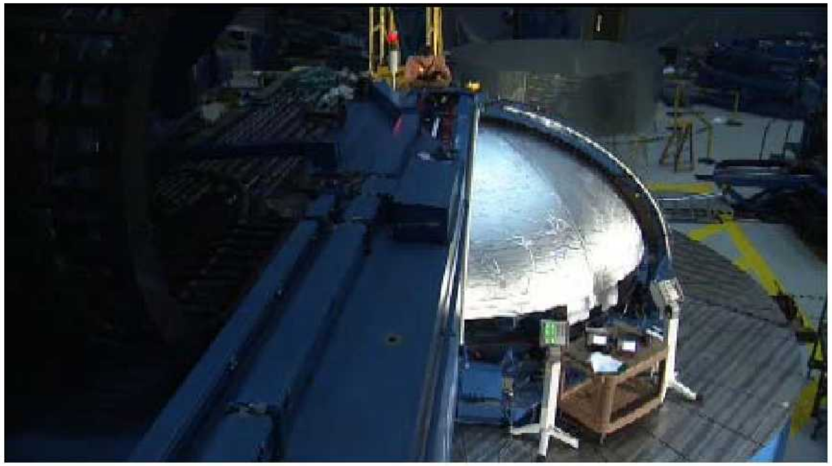
Ares V Earth Departure Stage



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

Upper Stage Accomplishments



Manufacturing Demonstration Article Full Dome Weld
Marshall Space Flight Center, AL

Ares Vertical Milling Machine Development
Chicago, IL

Roll Control Thruster Hot-Fire Testing
Sacramento, CA

Al-Li Orthogrid Panel Buckling Testing
Marshall Space Flight Center, AL

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)

Operation Time: 500 sec.

Altitude Start / On-orbit Restart

Operational Life: 8 starts/ 2,600 sec

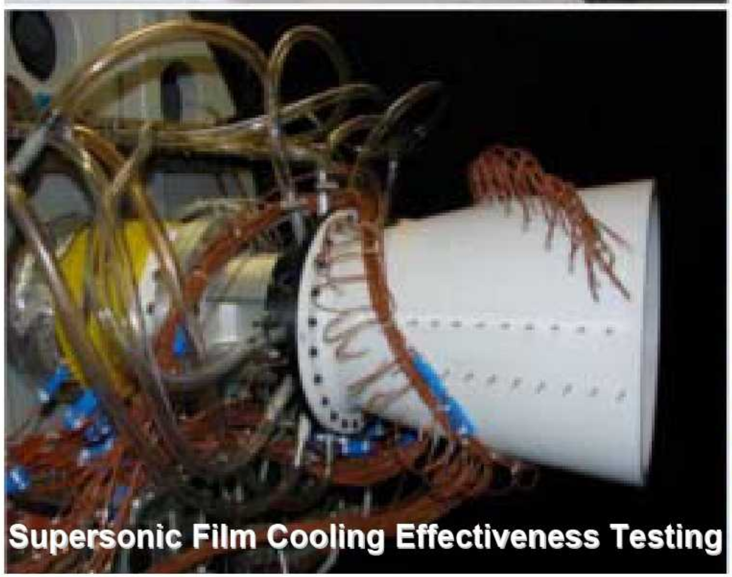
Pratt & Whitney
A United Technologies Company

Pratt & Whitney Rocketdyne, Inc.

J-2X Upper Stage Engine Progress

OTP Shaft and First Stage Blisk

Nozzle Turbine Exhaust Manifold Base Ring Forging

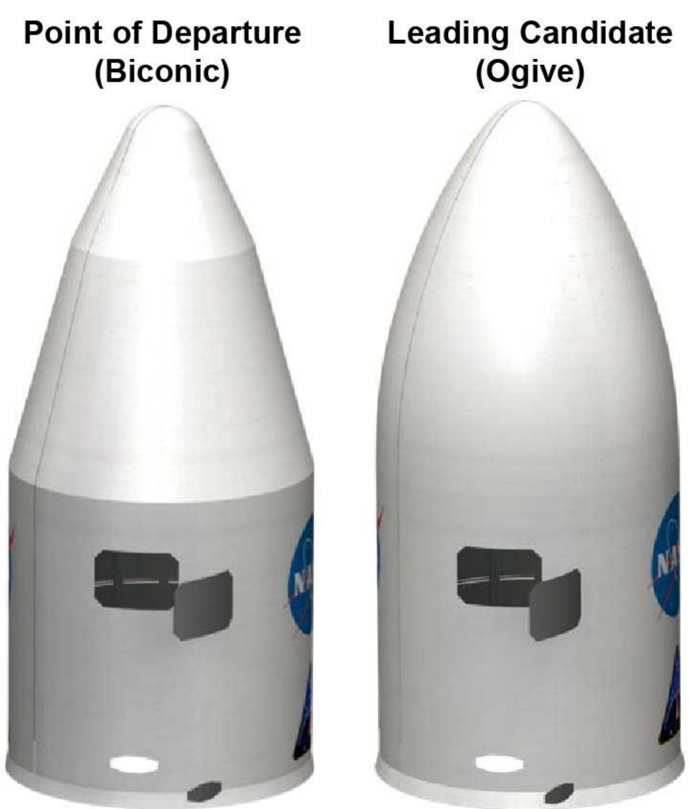


Supersonic Film Cooling Effectiveness Testing

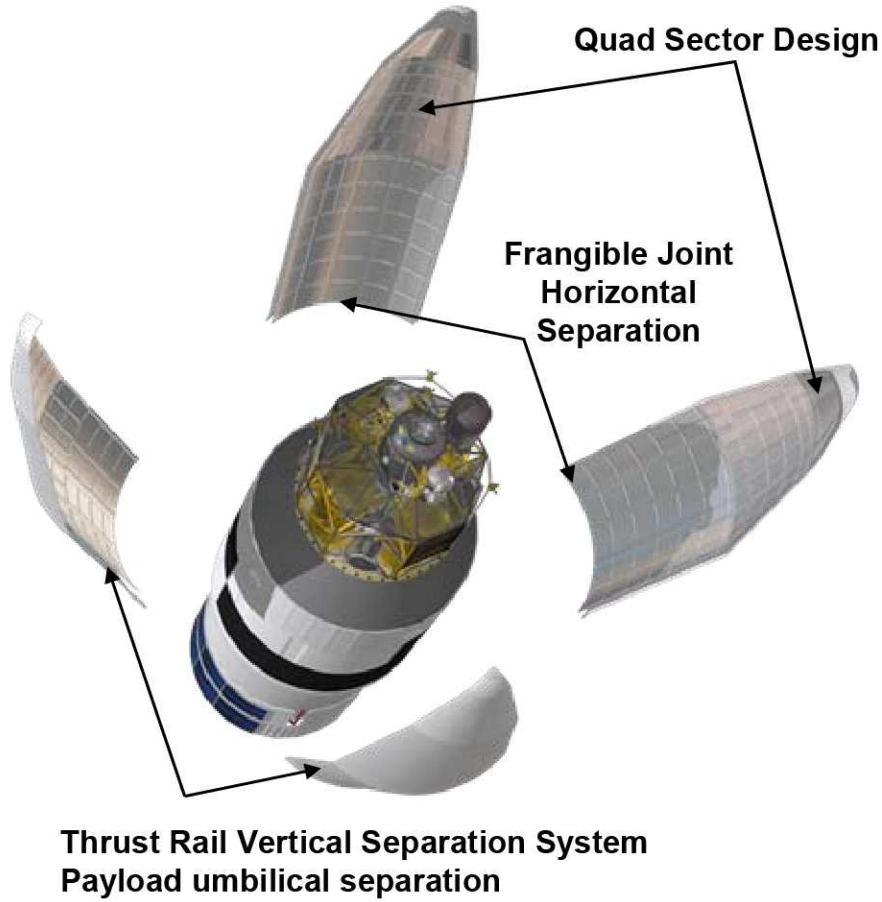
Workhorse Gas Generator/Turbine Simulator Testing

Test Facilities Progress: A-3 Stand Construction

Payload Shroud Point Of Departure



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)



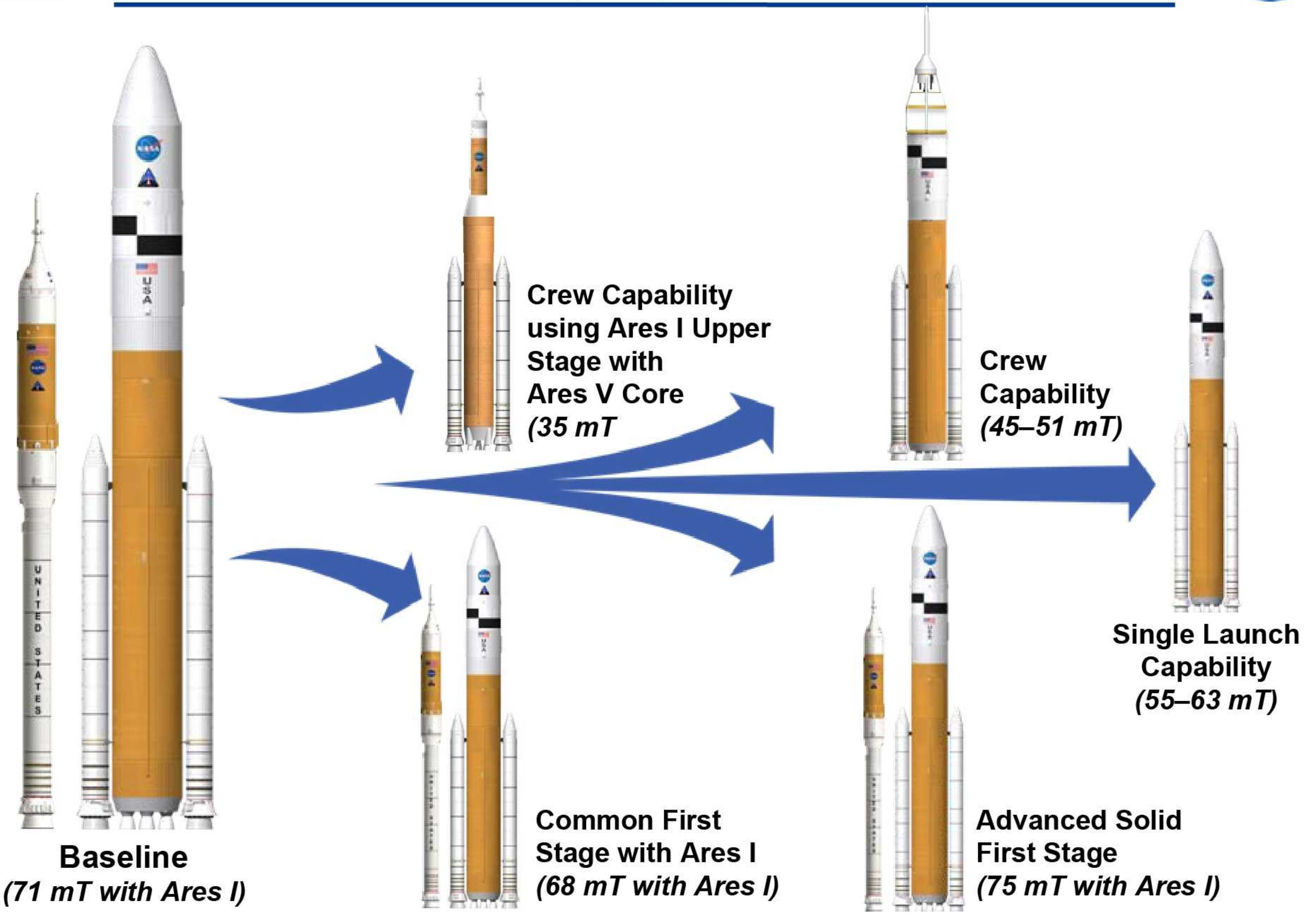
- Composite sandwich construction (Carbon-Epoxy face sheets, Al honeycomb core)
- Painted cork TPS bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)

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

Range of Architecture Options Enabled

A Few Examples (Payload to TLI)



Ares V Summary

- NASA has begun preliminary concept work on the vehicle. Over 1,700 alternatives have been investigated since ESAS
- Focused on design of EDS, payload shroud, core stage, and RS-68 core stage engines
- Recent point of departure update was made following the Lunar Capability Concept Review
  - Adds additional performance margin using an additional RS-68
  - Adds half segment on the first stage boosters
- Shroud size is dictated by eventual size of Altair lunar lander
- Also investigating alternate uses for Ares V not related to human space exploration
  - Astronomy applications (e.g., large aperture telescopes)
  - Deep space missions
  - DoD applications
  - Other applications

www.nasa.gov/ares