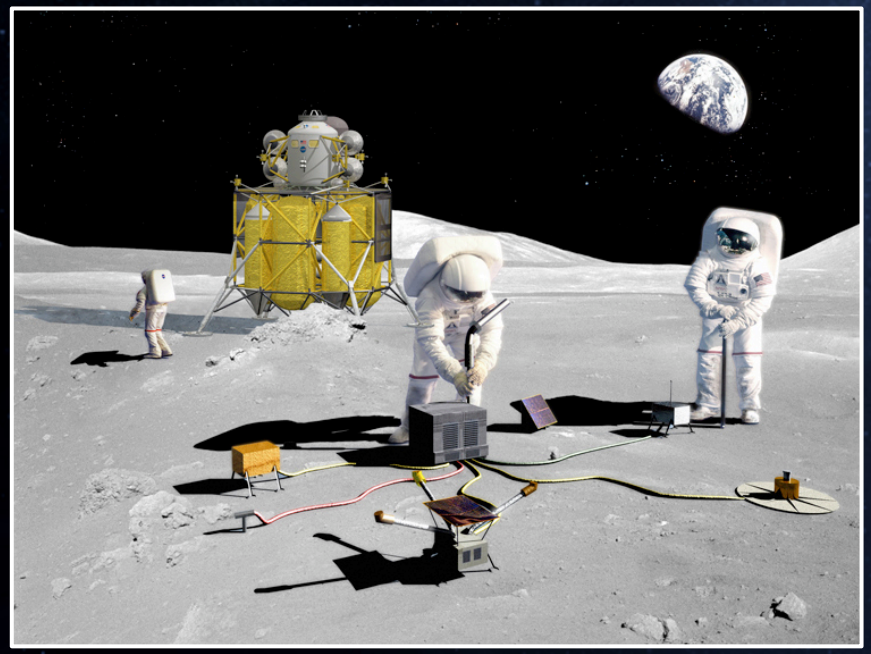
Constellation Program

The Return to Human Exploration Beyond LEO

Steve Cook,
Ares Projects Manager
April 2008

What is NASA's Mission?

- **Safely fly the Space Shuttle until 2010**
- **Complete the International Space Station (ISS)**
- **Develop a balanced program of science, exploration, and aeronautics**
- **Develop and fly the Orion Crew Exploration Vehicle (CEV)**
  - Designed for exploration but will initially service ISS
- **Land on the Moon no later than 2020**
- **Promote international and commercial participation in exploration**

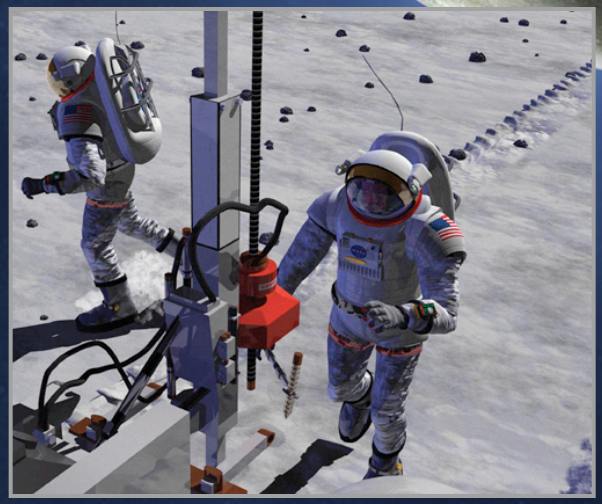


"The next steps in returning to the Moon and moving onward to Mars, the near-Earth asteroids, and beyond, are crucial in deciding the course of future space exploration. We must understand that these steps are incremental, cumulative, and incredibly powerful in their ultimate effect."

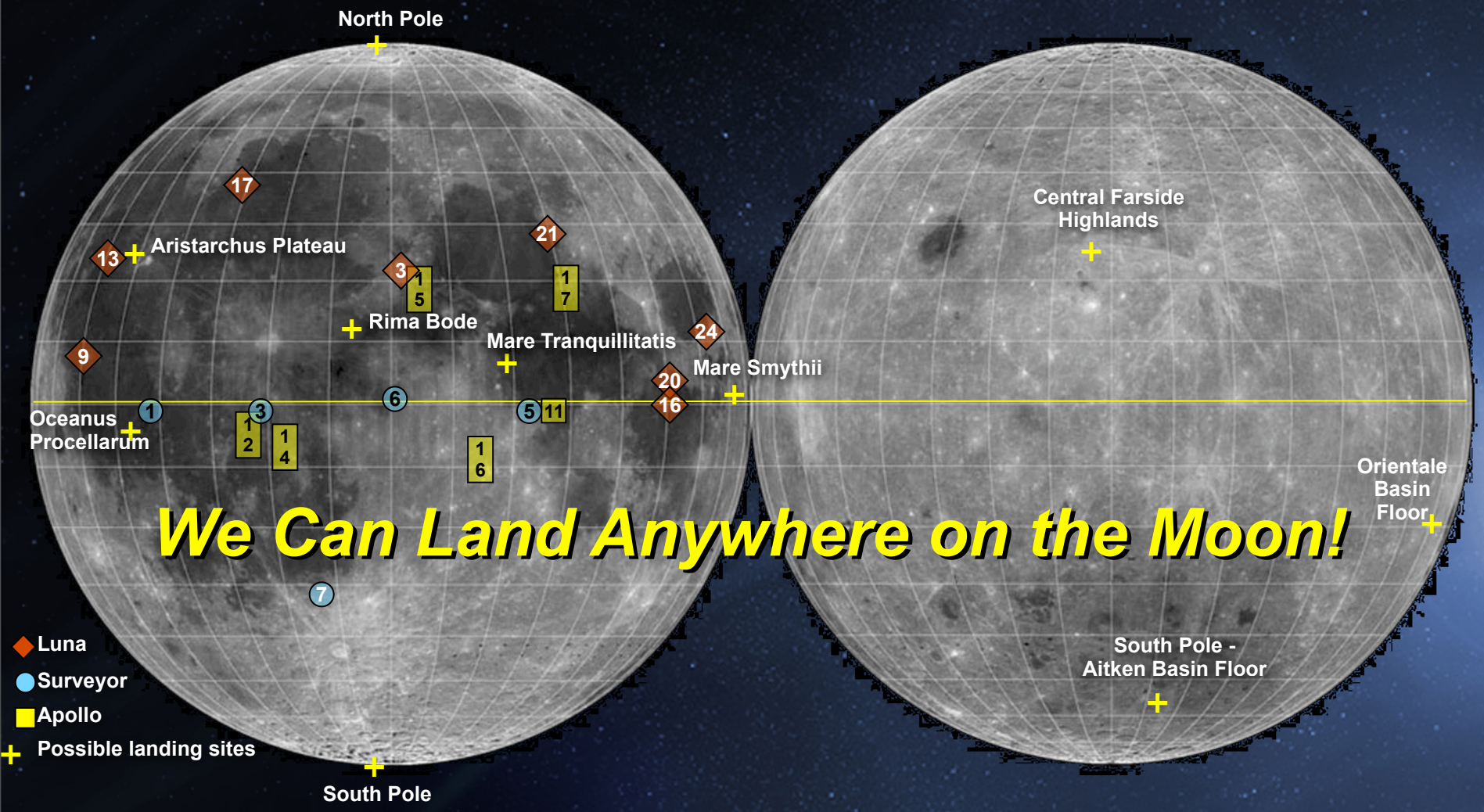
– NASA Administrator Michael Griffin
October 24, 2006

Why the Moon Next?

- It's close (3 days) and accessible – as near as Geosynchronous Earth Orbit (GEO)
- Alien yet familiar; Earth is visible to crew and TV audiences
- Moon can be reached with existing or derived launch systems
- Transport system to Moon can also access GEO, cis-Lunar, Earth-Sun Lagrangians, and some asteroids
- Retire risk to future planetary missions by re-acquiring experience and testing with lunar missions
- Development of lunar resources has potential to be a major advancement in space logistics capability
- Advance science, improve engineering state-of-the-art, inspire country



There Are Many Places To Explore



We Can Land Anywhere on the Moon!

NASA's Exploration Roadmap

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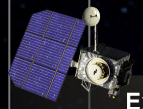
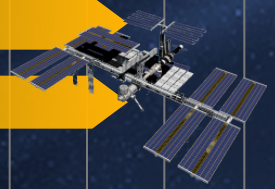


Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup

Research and Technology Development on ISS

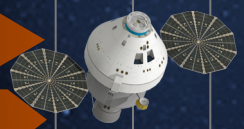
Commercial Orbital Transportation Services for ISS



Space Shuttle Operations

SSP Transition

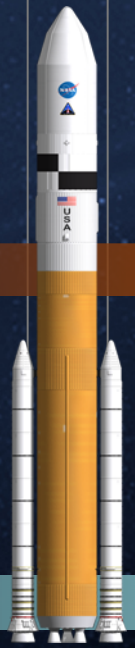
Ares I and Orion Development



Operations Capability Development
(EVA Systems, Ground Operations, Mission Operations)

Ares I-X
Test Flight
April 2009

Orion and Ares I Production and Operation



Altair Development

Ares V & Earth Departure Stage

Surface Systems Development

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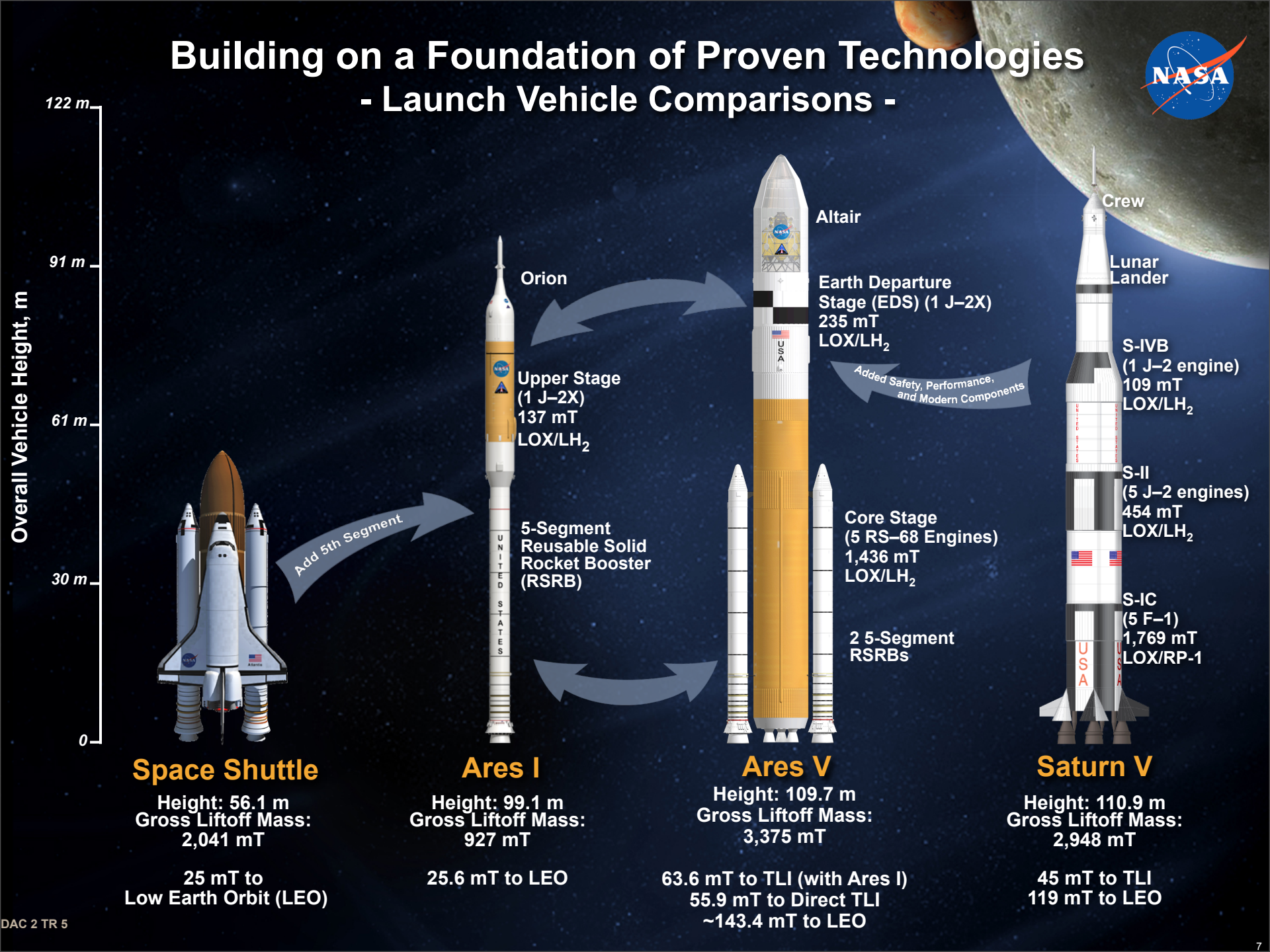
Building on a Foundation of Proven Technologies
- Launch Vehicle Comparisons -



Space Shuttle
Height: 56.1 m
Gross Liftoff Mass:
2,041 mT

25 mT to
Low Earth Orbit (LEO)

Ares I
Height: 99.1 m
Gross Liftoff Mass:
927 mT

25.6 mT to LEO

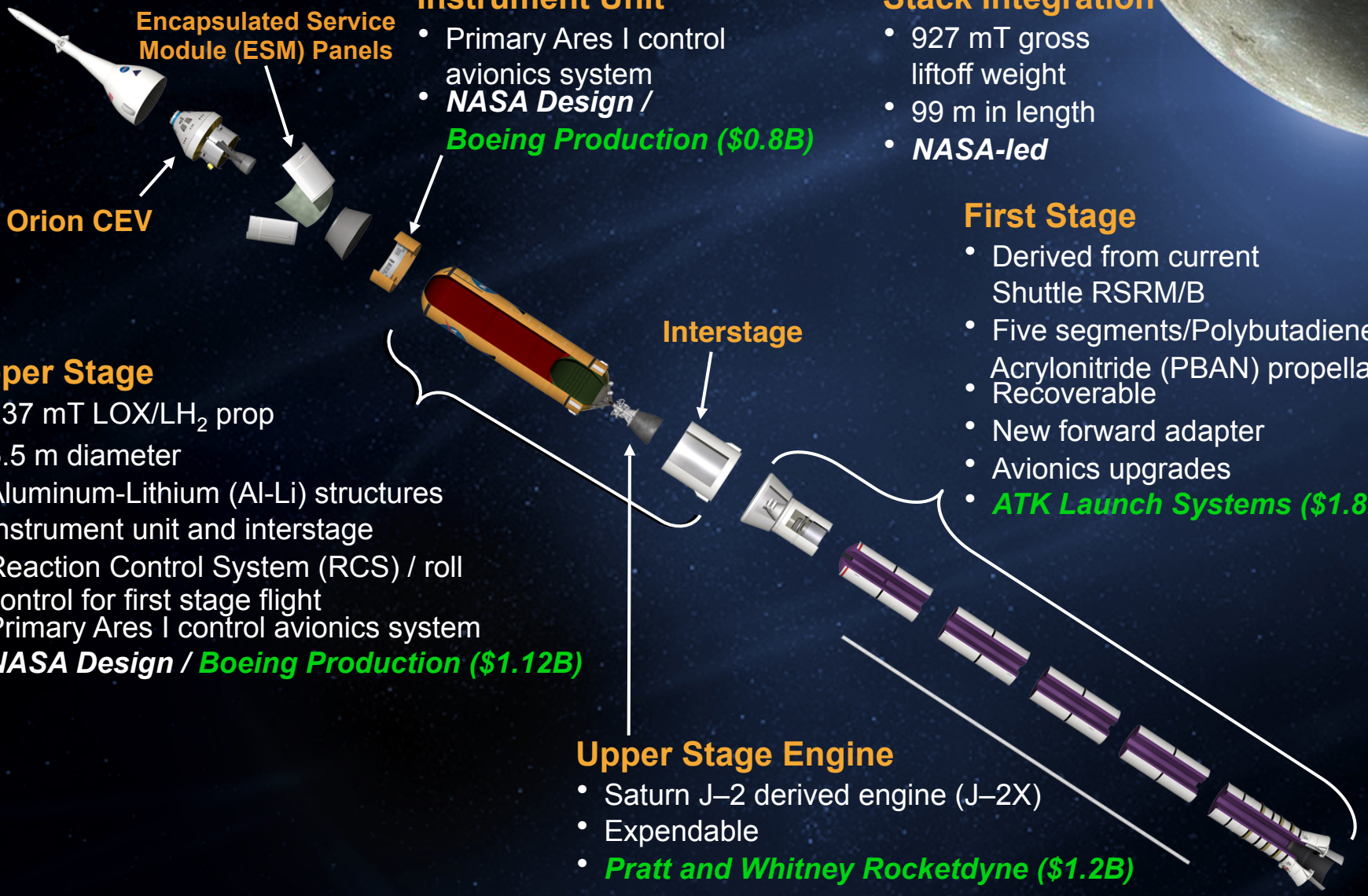
Ares V
Height: 109.7 m
Gross Liftoff Mass:
3,375 mT

63.6 mT to TLI (with Ares I)
55.9 mT to Direct TLI
~143.4 mT to LEO

Saturn V
Height: 110.9 m
Gross Liftoff Mass:
2,948 mT

45 mT to TLI
119 mT to LEO

Ares I Elements



Instrument Unit

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

Stack Integration

- 927 mT gross liftoff weight
- 99 m in length
- ***NASA-led***

First Stage

- Derived from current Shuttle RSRM/B
- Five segments/Polybutadiene Acrylonitride (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- ***ATK Launch Systems ($1.8B)***

Upper Stage

- 137 mT LOX/LH_2 prop
- 5.5 m 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 ($1.12B)***

Upper Stage Engine

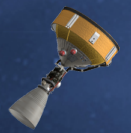
- Saturn J–2 derived engine (J–2X)
- Expendable
- ***Pratt and Whitney Rocketdyne ($1.2B)***

Ares Nationwide Team

ATK Launch Systems

Ames

Marshall



Glenn

Langley

Pratt & Whitney Rocketdyne

Johnson

Michoud Assembly Facility

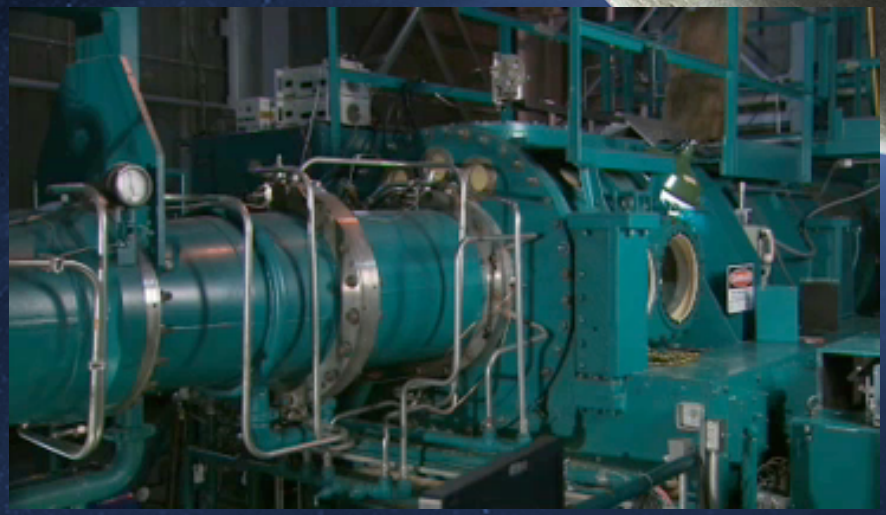
Stennis

Boeing

Kennedy

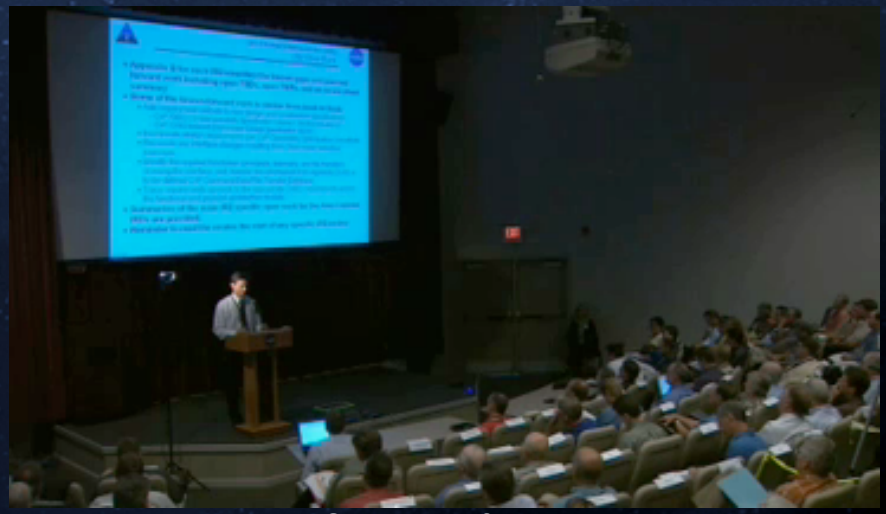
Vehicle Integration Accomplishments

Wind Tunnel Testing—Boeing, Langley Research Center (LaRC), Ames Research Center (ARC), CA



3% First Stage Reentry Testing
Arnold Air Force Base, TN

Ares I-X Rigid Buffet Model
LaRC, VA



Ares I System Definition Review
Huntsville, AL

First Stage

Used on Ares I and Ares V

ATK

NASA

Composite Frustum

Tumble Motors (from Shuttle)

Modern Electronics

12-Fin Forward Segment

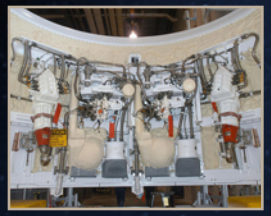
Same propellant as Shuttle (PBAN)–Optimized for Ares Application

New 45.7 m diameter parachutes

Same cases and joints as Shuttle

Booster Deceleration Motors (from Shuttle)

Wide Throat Nozzle



Same Aft Skirt and Thrust Vector Control as Shuttle

Mass: 726 mT
Thrust: 15.6 MN
Burn Duration: 126 sec
Height: 4.4 m
Diameter: 3.7 m

First Stage Accomplishments

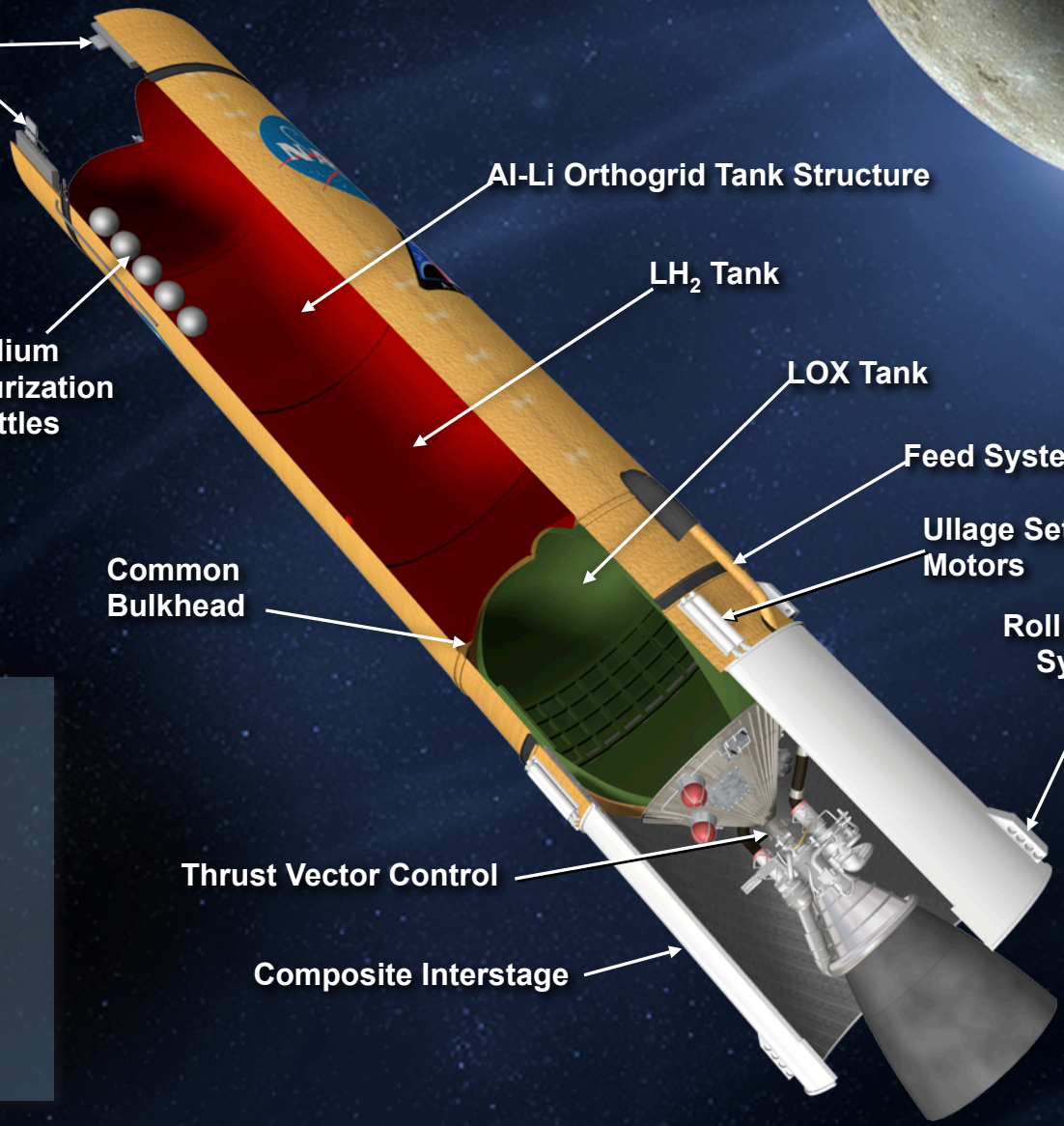
Nozzle Process Simulation Article
Promontory, UT

Installation of New SRM Insulation
Promontory, UT

Main Parachute Fabrication/Columbia, MS
Main Parachute Test/Yuma, AZ

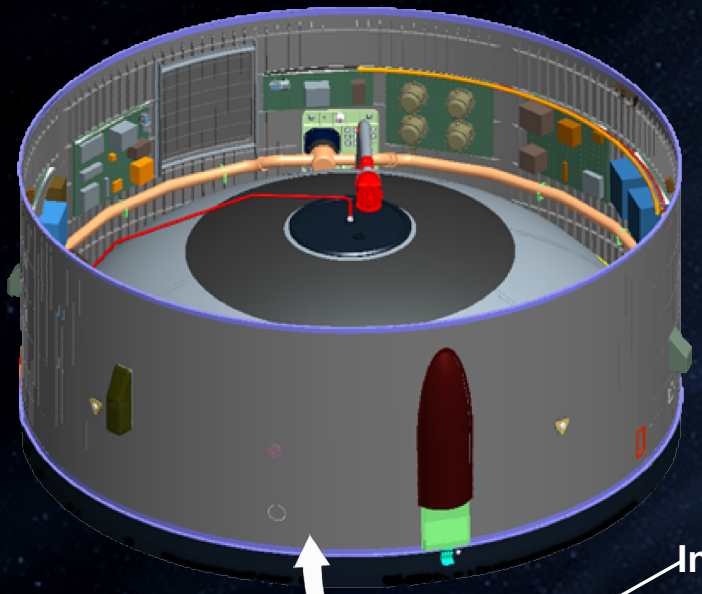
Solid Rocket Motor Testing
Promontory, UT

Upper Stage



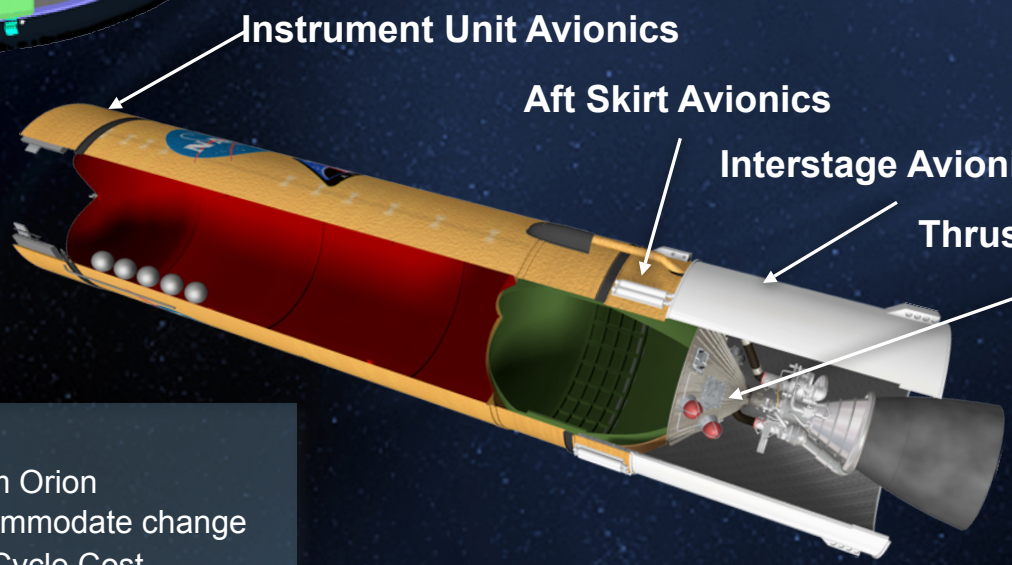
Propellant Load: 138 mT
Total Mass: 156 mT
Dry Mass: 17.5 mT
Dry Mass (Interstage): 4.1 mT
Length: 25.6 m
Diameter: 5.5 m
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

Upper Stage Avionics



The Upper Stage Avionics will provide:

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



- Fault Tolerant Modern Avionics
- Autonomous Flight Control from Orion
- Designed to economically accommodate change
- Design Influenced for Low-life Cycle Cost
- On-board Range Tracking supports ground asset reductions

BOEING

Upper Stage Accomplishments

Friction Stir Weld Process Development System
Marshall Space Flight Center (MSFC), AL

Liquid Hydrogen Tank Dome Gore
Los Angeles, CA

Large Scale, Thin Gage Welding Demonstration
MSFC, AL

New Vertical Weld Tool
MSFC, 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

Nozzle Extension
- Based on RL10–B2

Mass: 2.5 mT
Thrust: 1.3 MN (vac)
Isp: 448 sec (vac)
Height: 4.7 m
Diameter: 3.05 m

Pratt & Whitney
A United Technologies Company

Pratt & Whitney Rocketdyne, Inc.

Upper Stage Engine Accomplishments

E-3 Subscale Diffuse Testing
Stennis Space Center (SSC), MS

Test Stand A-3 Foundation
SSC, MS

J-2X Powerpack 1A Testing
SSC, MS

J-2X Materials Testing
MSFC, AL

Orion Crew Exploration Vehicle

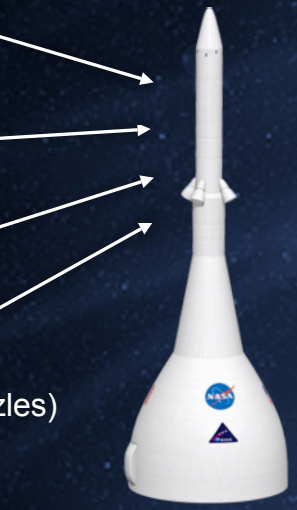
Launch Abort System

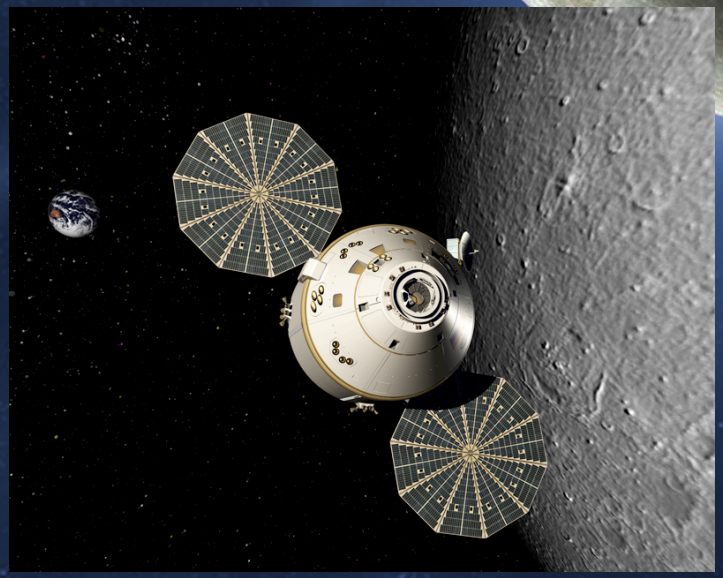
Attitude Control Motor
(Eight Nozzles)

Canard Section
(Stowed Configuration)

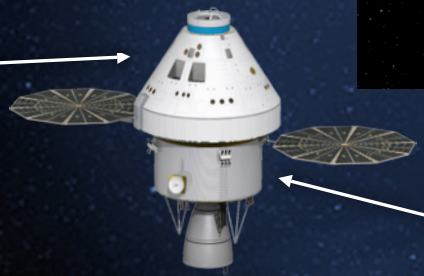
Jettison Motor
(Four Aft, Scarfed Nozzles)

Abort Motor
(Four Exposed, Reverse Flow Nozzles)





Crew Module



Service Module

LOCKHEED MARTIN

Encapsulated Service Module (ESM) Panels

Spacecraft Adapter

Volume: 115.8 m^3
- 80% larger than Apollo

Diameter: 5.5 m

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

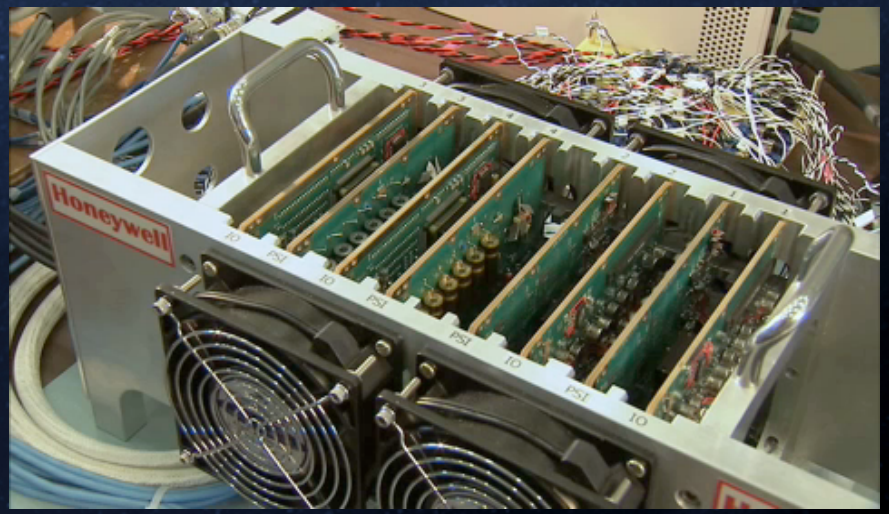
	Ares I–X	Ares I
First Stage Max. Thrust (vacuum):	14.1 MN	15.6 MN
Max. Speed:	Mach 4.7	Mach 5.84
Staging Altitude:	39,600 m	57,400 m
Liftoff Weight:	816 mT	907 mT
Length:	99.7 m	99 m
Max. Acceleration:	2.46 g	3.79 g

Ares I-X Accomplishments

Upper Stage Simulator Assembly
Glenn Research Center (GRC), OH

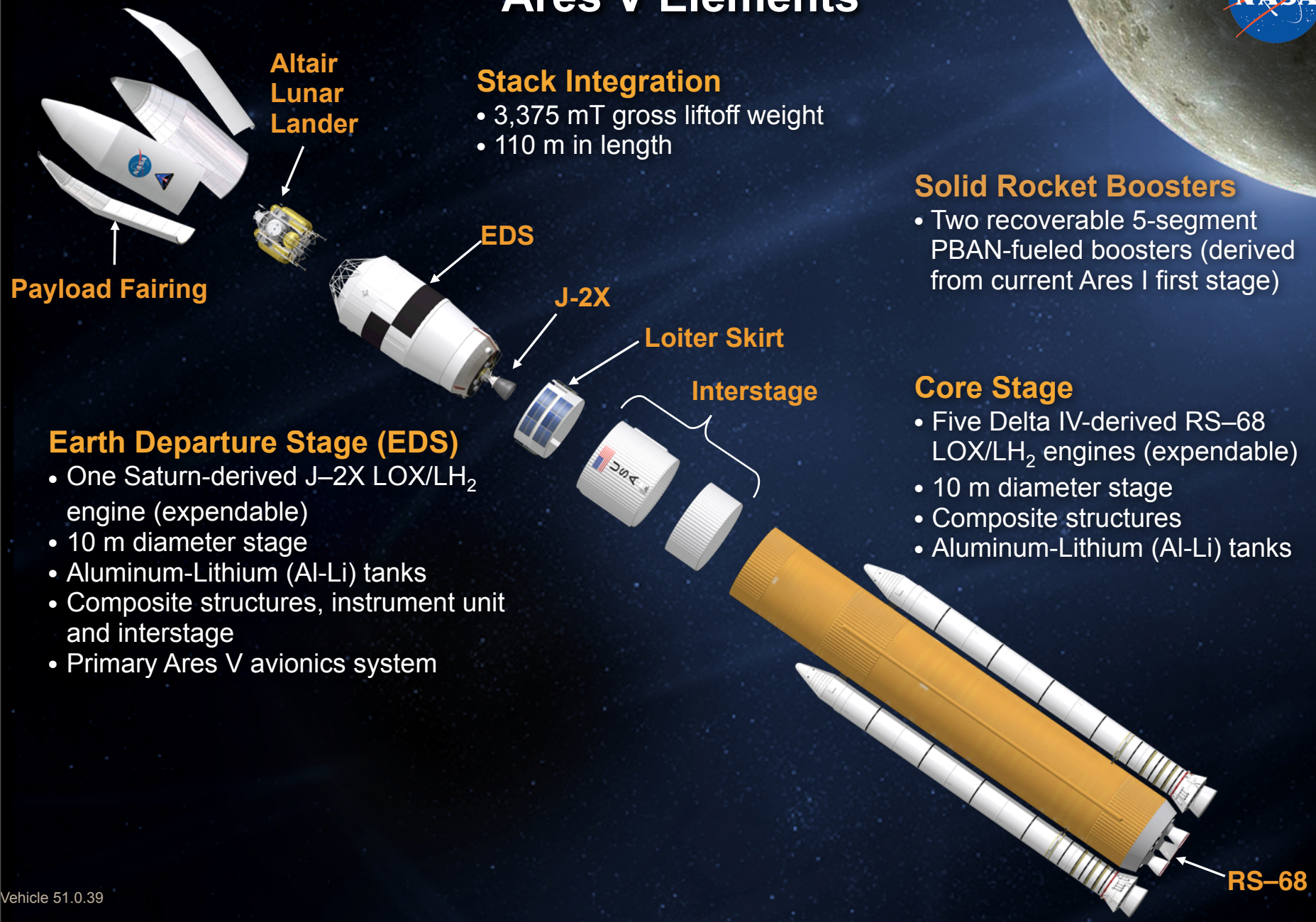
Roll Control System Test and Fabrication
Huntsville, AL and WSTF, NM

Forward Frustum Fabrication
Indianapolis, IN



1st Stage Actuator Systems Testing
MSFC, AL

Ares V Elements



Stack Integration
- 3,375 mT gross liftoff weight
- 110 m in length

Solid Rocket Boosters
- Two recoverable 5-segment PBAN-fueled boosters (derived from current Ares I first stage)

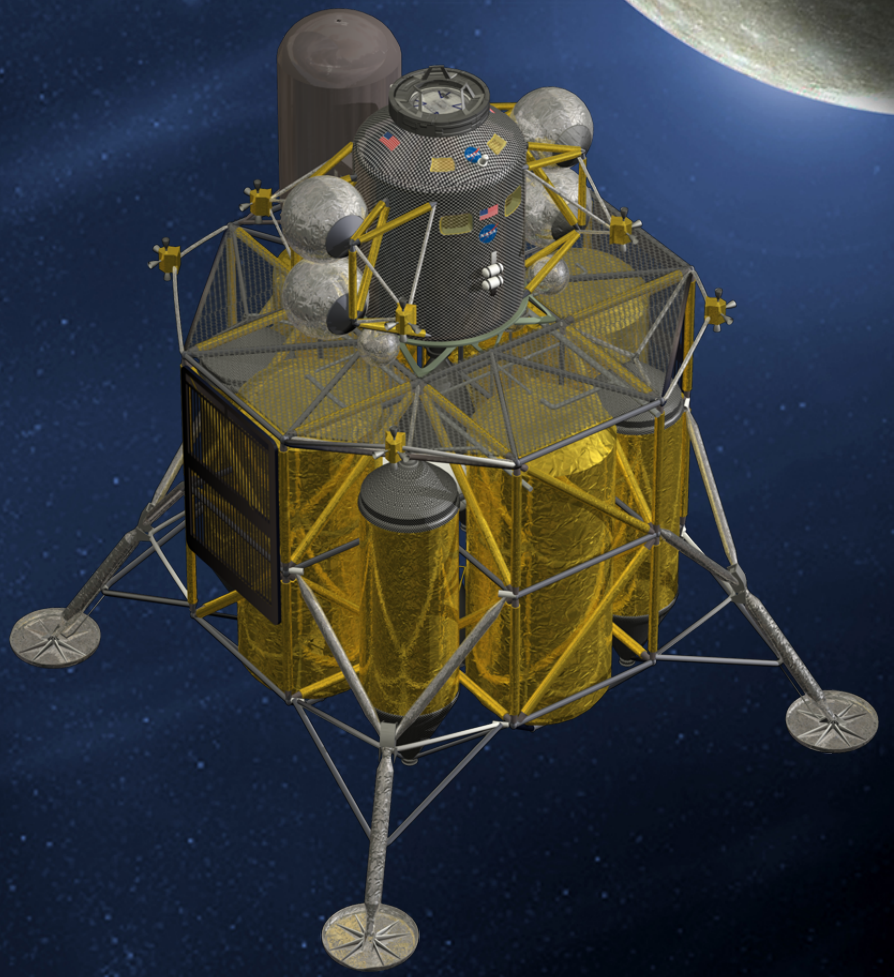
Earth Departure Stage (EDS)
- One Saturn-derived J–2X LOX/LH_2 engine (expendable)
- 10 m diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

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

Vehicle 51.0.39

Altair Lunar Lander

- **Transport 4 crewmembers to and from the surface**
  - Visits start with 7 days on surface
  - Length of stays increases step-by-step
  - Builds up to 6 month lunar outpost crew rotations
- **Global access capability**
- **Return to Earth anytime**
- **Deliver about 16 metric tons of dedicated cargo**
- **Provide airlock for surface activities**
- **Descent stage:**
  - Liquid oxygen / liquid hydrogen propulsion
- **Ascent stage:**
  - Storable propellants



Summary

- Human beings will explore the Moon and beyond to encourage inspiration, innovation, and discovery.
- We must build beyond our current capability to ferry astronauts and cargo to low Earth orbit.
- We are starting to design and build new vehicles, using extensive lessons learned to minimize cost, technical, and schedule risks.
- Team is onboard and making good progress—the Ares I–X test flight is on schedule for April 2009.

Questions?

www.nasa.gov/ares