National Aeronautics and Space Administration

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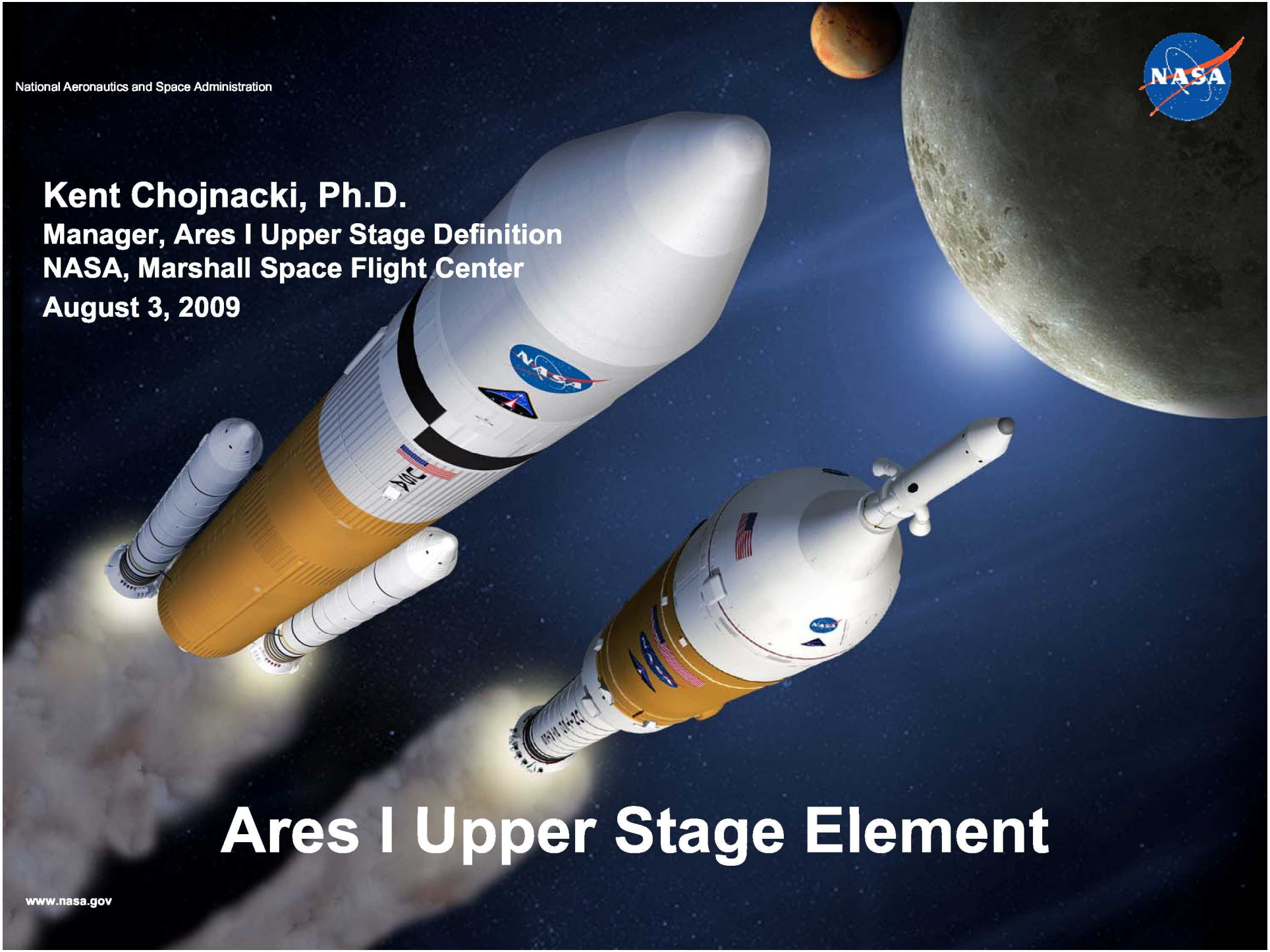

Ares I Upper Stage Element

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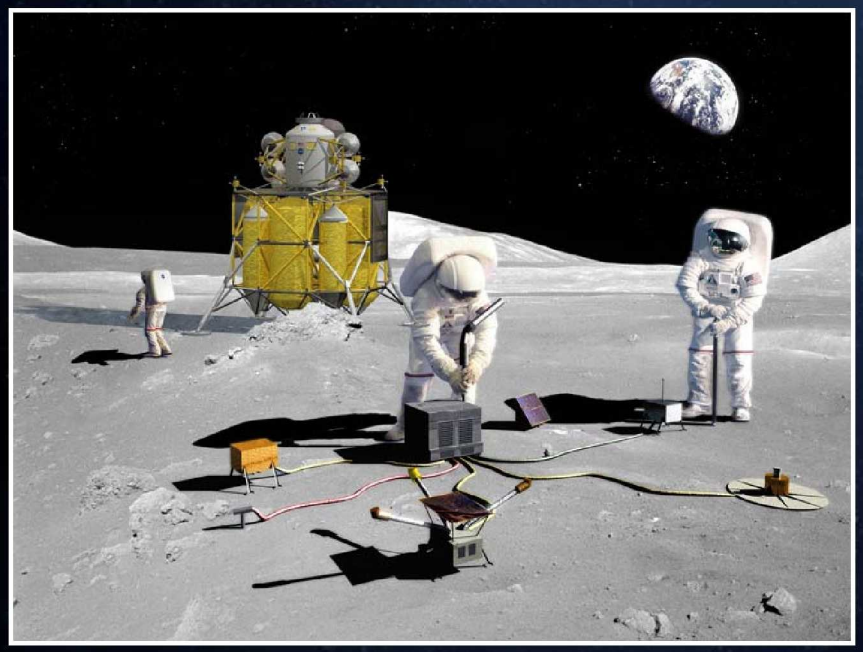
What is NASA's Mission?

- **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**



NASA's Exploration Roadmap

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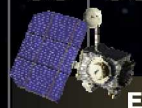
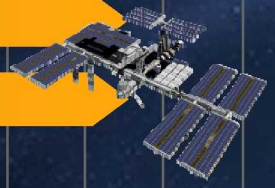


Exploration and Science Lunar Robotics Missions

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
October 2009

Orion and Ares I Production and Operation

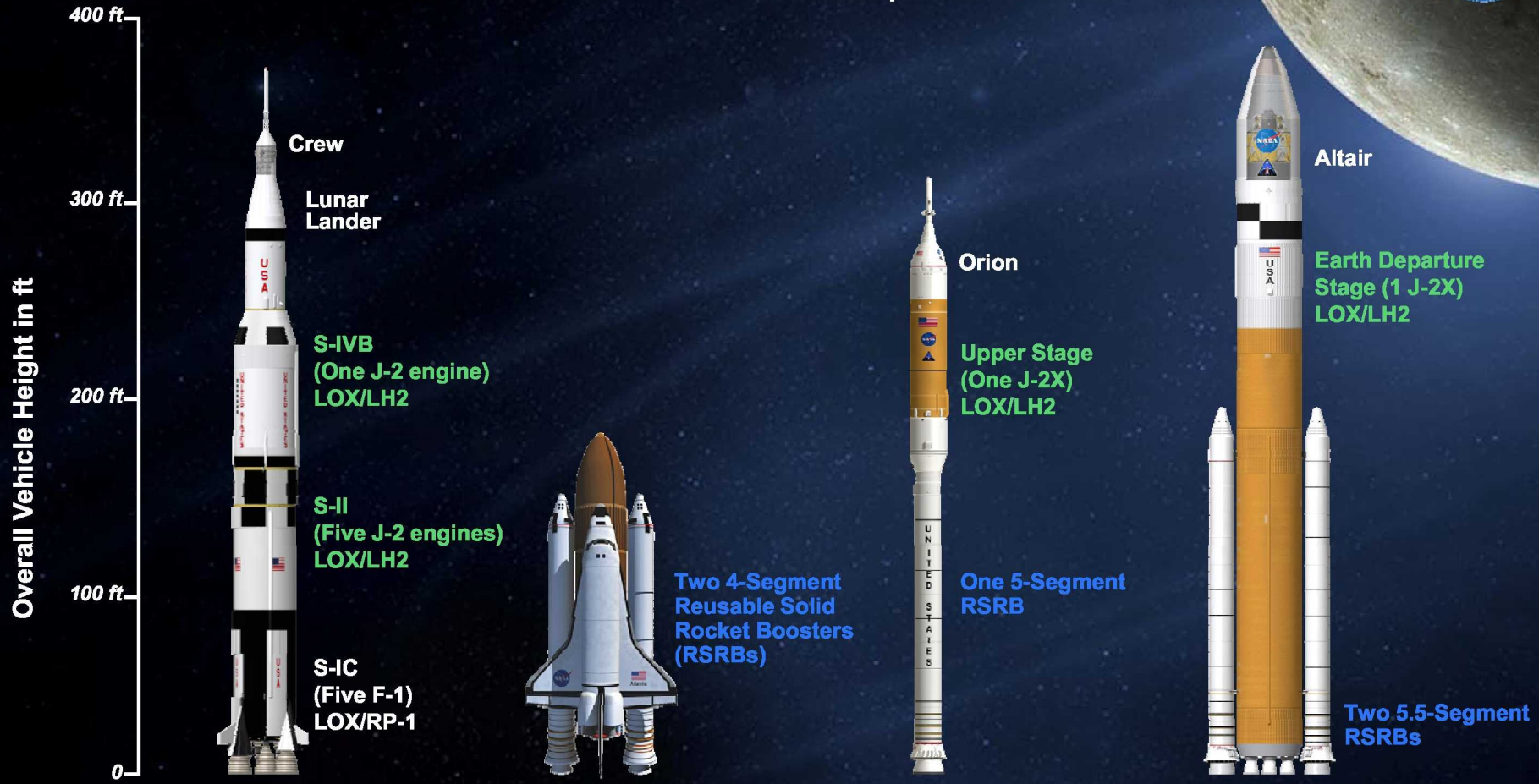
Altair Development

Ares V & Earth Departure Stage

Surface Systems Development

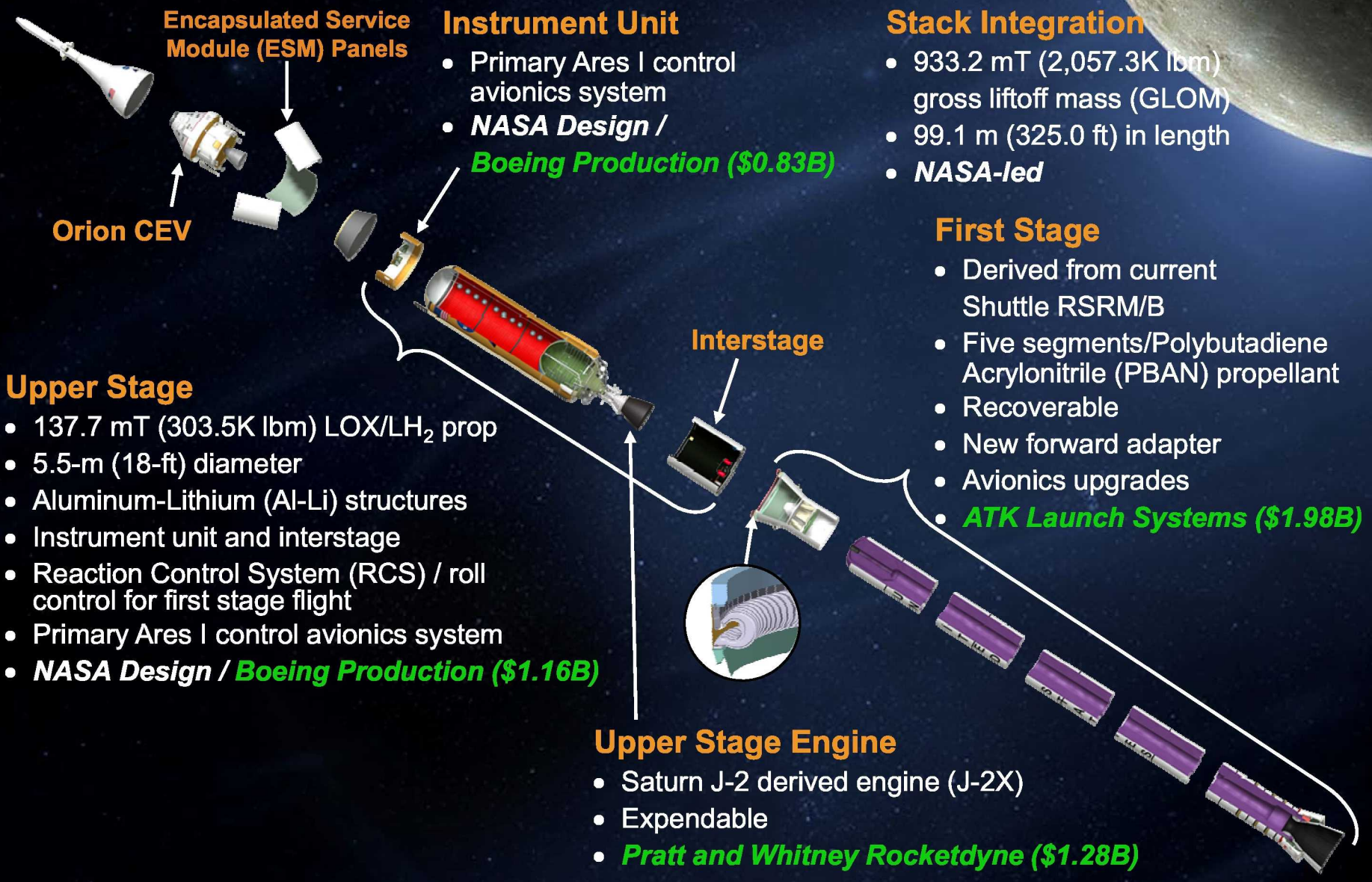
Building on a Foundation of Proven Technologies

- 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 I Elements



Instrument Unit

- Primary Ares I control avionics system
- ***NASA Design / Boeing Production ($0.83B)***

Stack Integration

- 933.2 mT (2,057.3K 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 ($1.98B)***

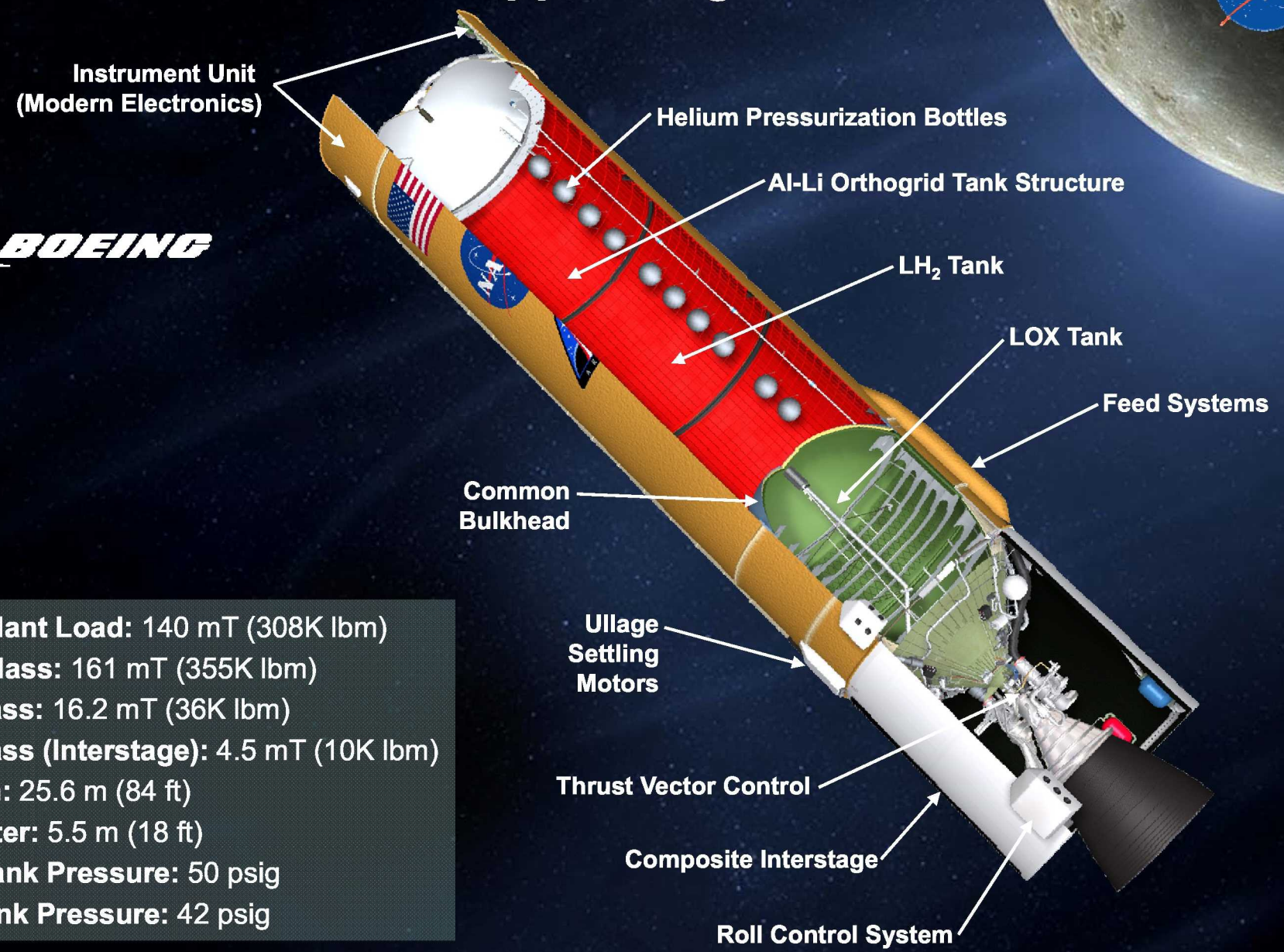
Upper Stage

- 137.7 mT (303.5K 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 ($1.16B)***

Upper Stage Engine

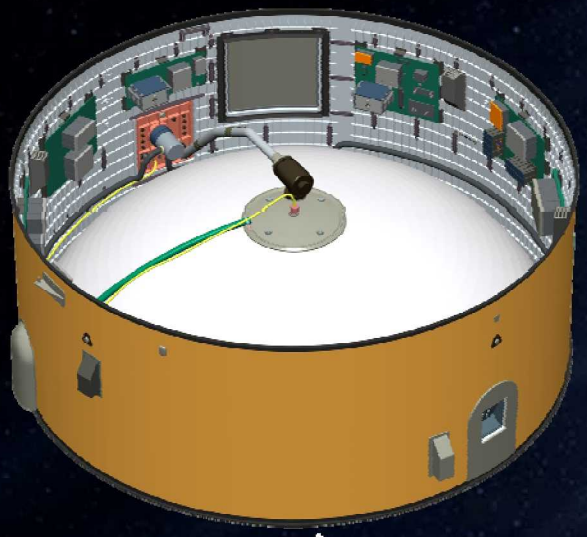
- Saturn J-2 derived engine (J-2X)
- Expendable
- ***Pratt and Whitney Rocketdyne ($1.28B)***

Upper Stage



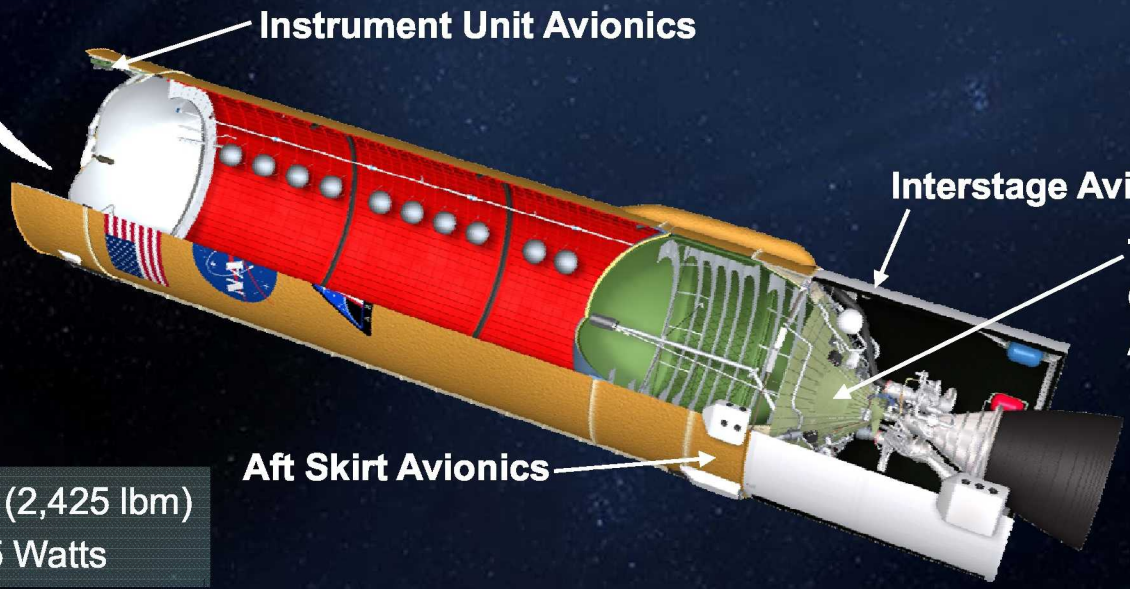
Propellant Load: 140 mT (308K lbm)
Total Mass: 161 mT (355K lbm)
Dry Mass: 16.2 mT (36K lbm)
Dry Mass (Interstage): 4.5 mT (10K lbm)
Length: 25.6 m (84 ft)
Diameter: 5.5 m (18 ft)
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

Upper Stage Avionics



The Upper Stage Avionics will provide:

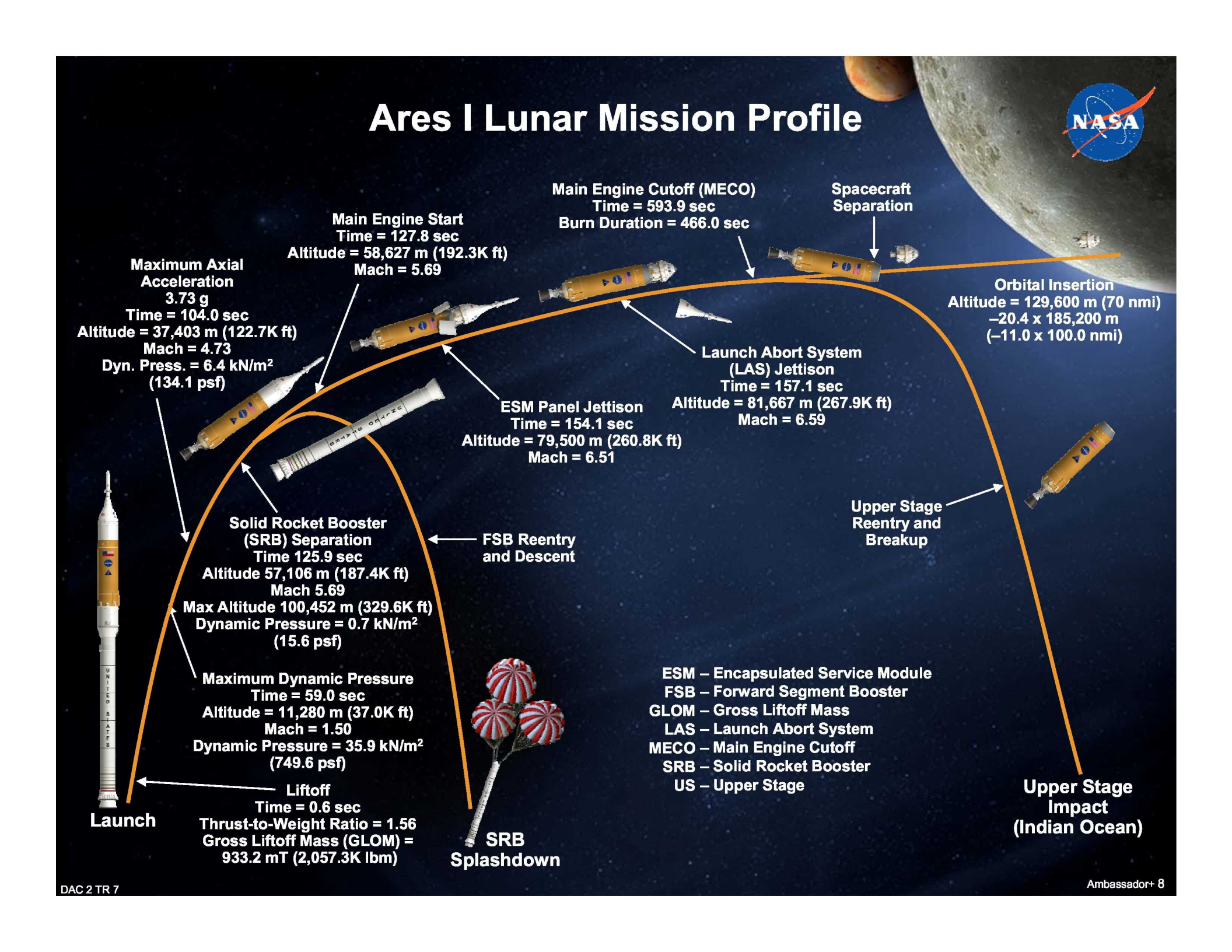
- Guidance, Navigation, and Control (GN&C)
- Command and data handling
- Pre-flight checkout



BOEING

Avionics Mass: 1.1 mT (2,425 lbm)
Electrical Power: 5,145 Watts

Ares I Lunar Mission Profile



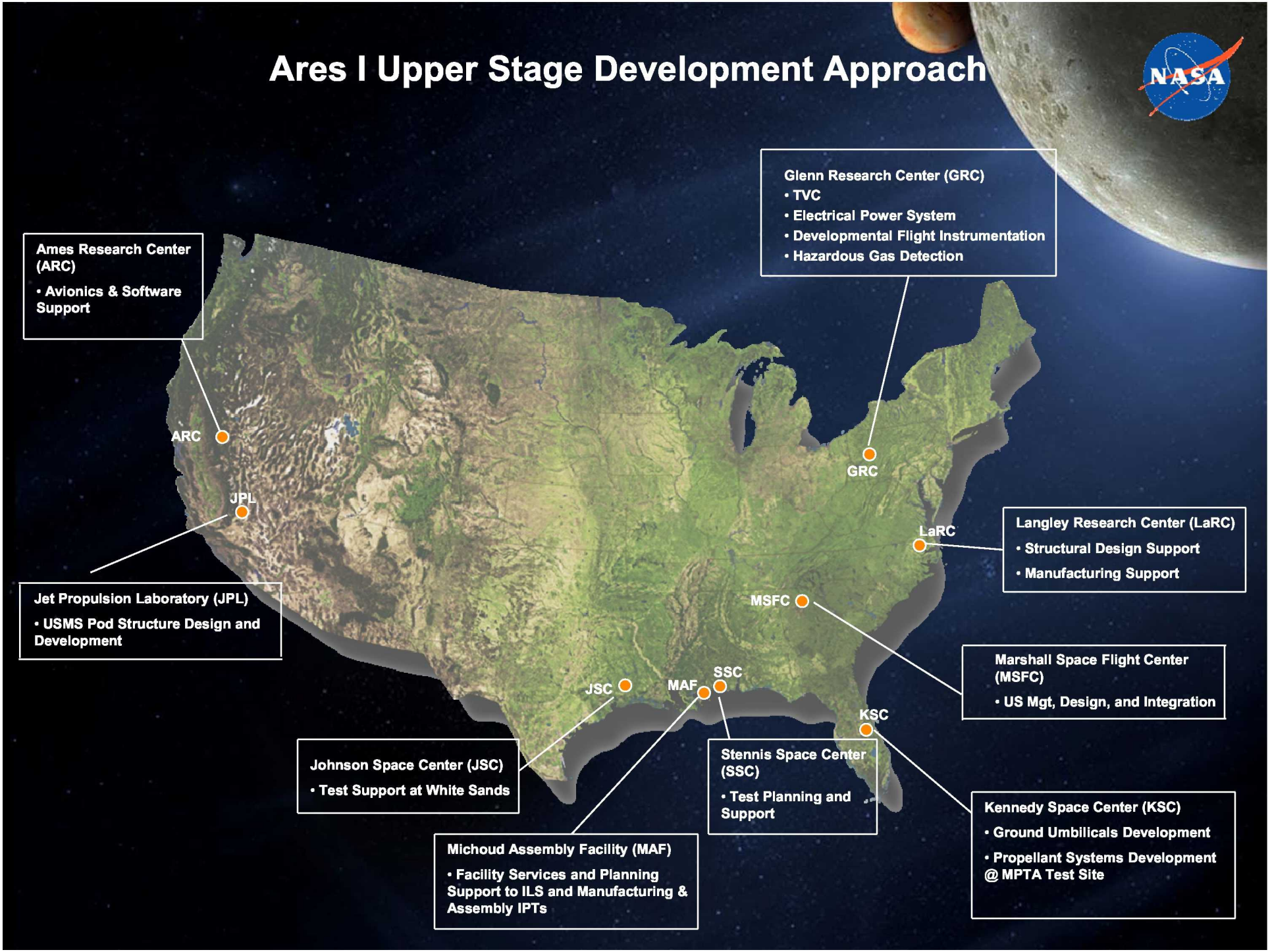
Upper Stage Objectives

- **Upper Stage Primary Objectives:**
  - Provide Safe Upper Stage Operations and Flight
  - Meet Performance Requirements
  - Make it Affordable to Produce and Operate
- **US Design and Production planning is at the appropriate maturity:**
  - Safety issues are understood and mitigated by design features and operations
  - Requirements are understood and supported by the design
  - Affordability opportunities are understood and included in the design
  - Robust risk mitigation and advanced development activities are in place
  - Management Systems and Engineering Processes are in place

Boeing Producibility Team

- **Boeing has been selected as Upper Stage Production Contractor (USPC) and Instrument Unit Avionics Contractor (IUAC)**
  - Producibility and Design Support
  - Manufacturing
  - Operations
  - Sustaining Engineering
- **Team is engaged with the NASA Design Team**
  - Manufacturing Value Stream Mapping
  - Producibility Summit
  - Tooling Design Support
  - Schedule Development
  - Component Cost Updates
  - Test Article Planning Support
  - Special Studies

Ares I Upper Stage Development Approach



Ares I Design and Development at MSFC

- The Ares I Upper Stage is currently being designed and developed at the Marshall Space Flight Center (MSFC) in Huntsville, AL.
- Production of the Upper Stage will occur at the NASA Michoud Assembly Facility (MAF) in New Orleans.
- At MSFC, Friction Stir Welding equipment capable of assembling full-scale Ares I hardware has been installed and is fully operational in the Advanced Weld Development Facility at Building 4755.

Robotic Weld Tool

Vertical Weld Tool

Full Scale Welding Process Development

- The tools and equipment being installed in the Advanced Weld Development Facility will be used to assemble full-scale manufacturing demonstration and development articles.
- Full-Scale development allows engineers to trouble-shoot issues that will inevitably arise during the development of large scale hardware.
- Only at full scale can the true challenges associated with production be identified and dealt with.

Hardware Delivery

18-Foot Diameter 1-piece Y-Ring

Ares Vertical Milling Machining Center

- The Ares Vertical Milling Machine, currently being installed in MSFC Building 4705, will be the world's largest horizontal multi-access milling machine for machining large, complex parts.
- The Ingersoll Company in Rockford, IL, is building this 7-axis milling machine for MSFC and a second identical machine at MAF in New Orleans.
- The machines will primarily machine domes for the Ares I Upper Stage, cylindrical support tubes for Ares I, and bulkheads for Ares I.
- 4705 facility to be fully operational in September 2009.

TPS Development Facility Capabilities

- Provides both Thermal Protection System (TPS) primer and Spray-On Foam Installation (SOFI) material processing capabilities in a single Class I Div I Rated environmentally controlled facility
- Designed for booth temperatures of 65ºF to 130ºF and temperature dependent relative humidity ranges of 5 % to 75%
- Spray booth is 30 feet wide by 30 feet high by 85 feet long
- Working area can accommodate hardware up to 20 foot diameter and 70 foot length
- Provides a full-scale processing capability at MSFC for test articles and provides a backup capability for production
- 4765 facility to be fully operational in December 2009

Recent Upper Stage Test/Hardware Highlights

Manufacturing Demonstration Article (MDA) full dome weld in Building 4755

Ullage Settling Motor System (USMS) Heavy Weight Motor Hot-Fire Test

Reaction Control System (ReCS) Development Test Article Delivery

Thrust Vector Control (TVC) 2-Axis Test Rig

Summary

- **The Ares I Upper Stage team is utilizing extensive lessons learned to place NASA and the United States into another great era of space exploration**
  - Ares I team must build beyond its current capability to ferry astronauts and cargo to Low Earth Orbit
  - To reach for Mars and beyond, the team must first reach for the moon
  - We are using the best of NASA to design the stage, and the best of industry to build the stage
- **NASA and Boeing teams are now integrated, working together, and making good progress**
  - Designing and building the Ares I Upper Stage to minimize:
    - Cost risks
    - Technical risks
    - Schedule risks

"This Nation has tossed its cap over the wall of space, and we have no choice but to follow it."

– President John F. Kennedy, 1962