National Aeronautics and Space Administration

Danny Davis

Ares I Upper Stage Manager

October 15, 2008

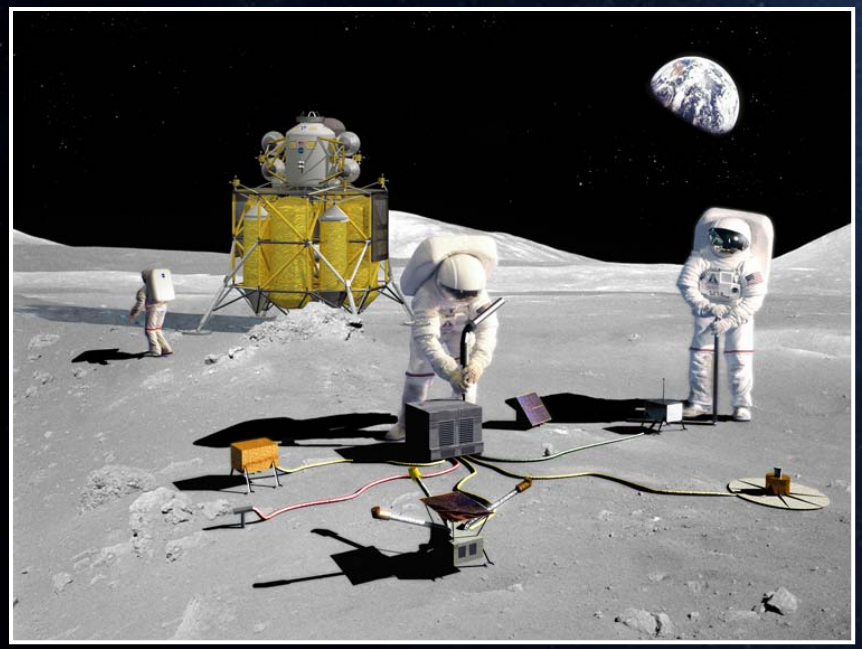
Launching to the Moon and Beyond: Ares I and V Updates

www.nasa.gov

091508

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

NASA's Exploration Roadmap

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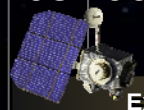
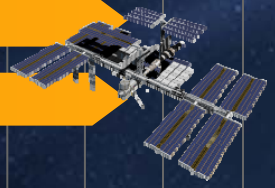


Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup

Research and Technology Development on ISS

Commercial Orbital Transportation Services for ISS



Space Shuttle Operations

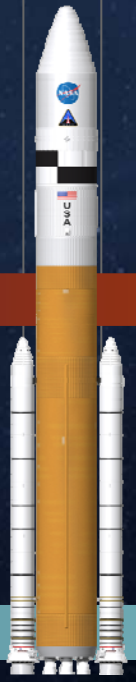
SSP Transition

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



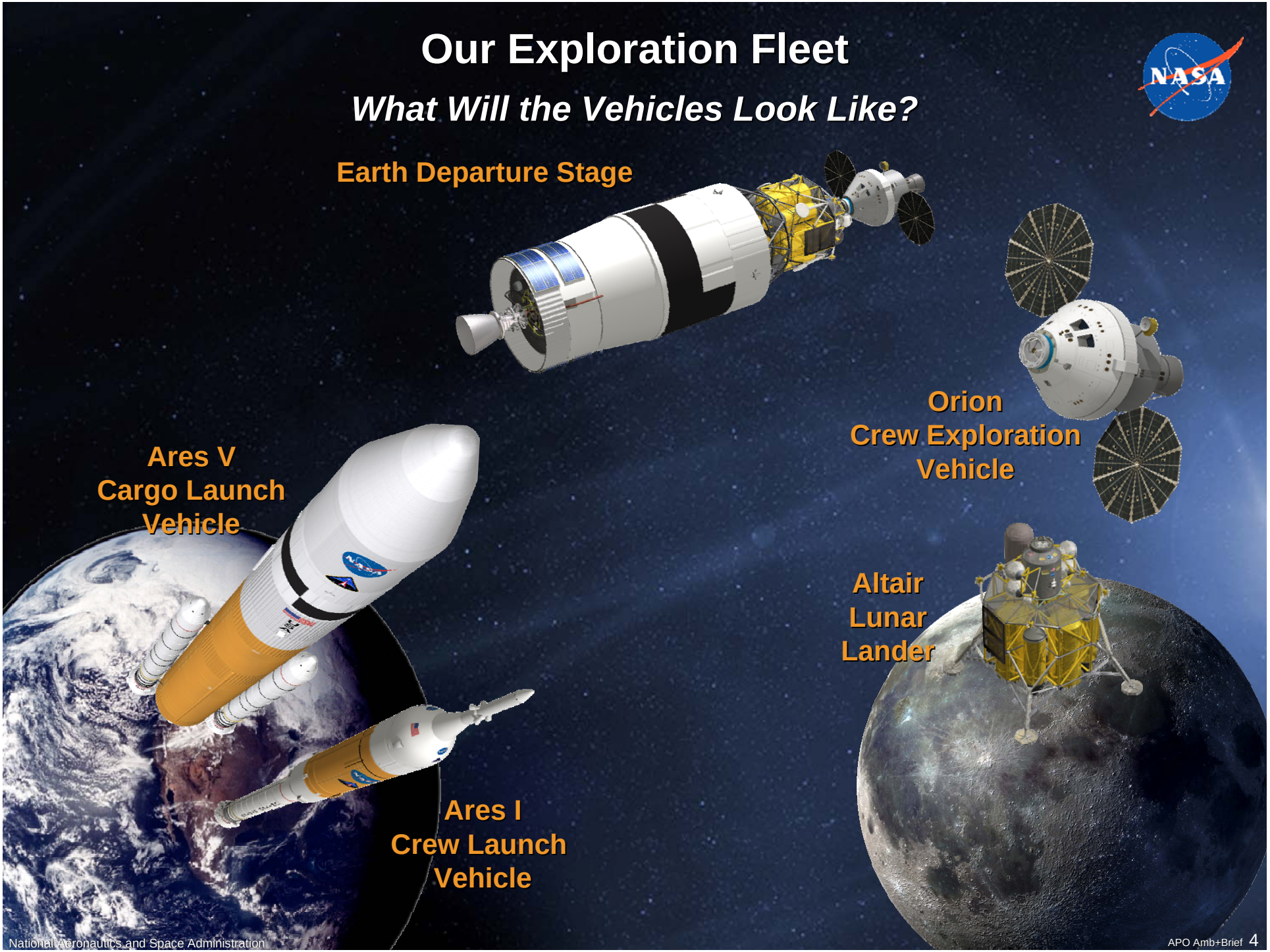
Altair Development

Ares V & Earth Departure Stage

Surface Systems Development

Our Exploration Fleet

What Will the Vehicles Look Like?



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

Space Shuttle

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)

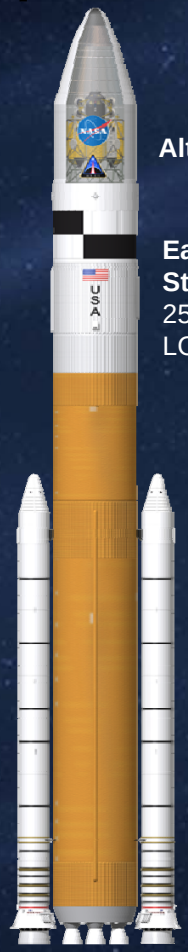
Orion

Upper Stage
(1 J-2X)
137.0 mT
(302K lbm)
LOX/LH_2

5-Segment
Reusable
Solid Rocket
Booster
(RSRB)

Ares I

Height: 99.1 m (325 ft)
Gross Liftoff Mass:
927.1 mT (2,044.0K lbm)
Payload Capability:
25.5 mT (56.2K lbm)
to LEO



Altair

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

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

2 5.5-Segment
RSRBs

Ares V

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 Direct TLI
~187.7 mT (413.8K lbm) to LEO

Crew

Lunar
Lander

S-IVB
(1 J-2 engine)
108.9 mT
(240.0K
LOX/LH_2

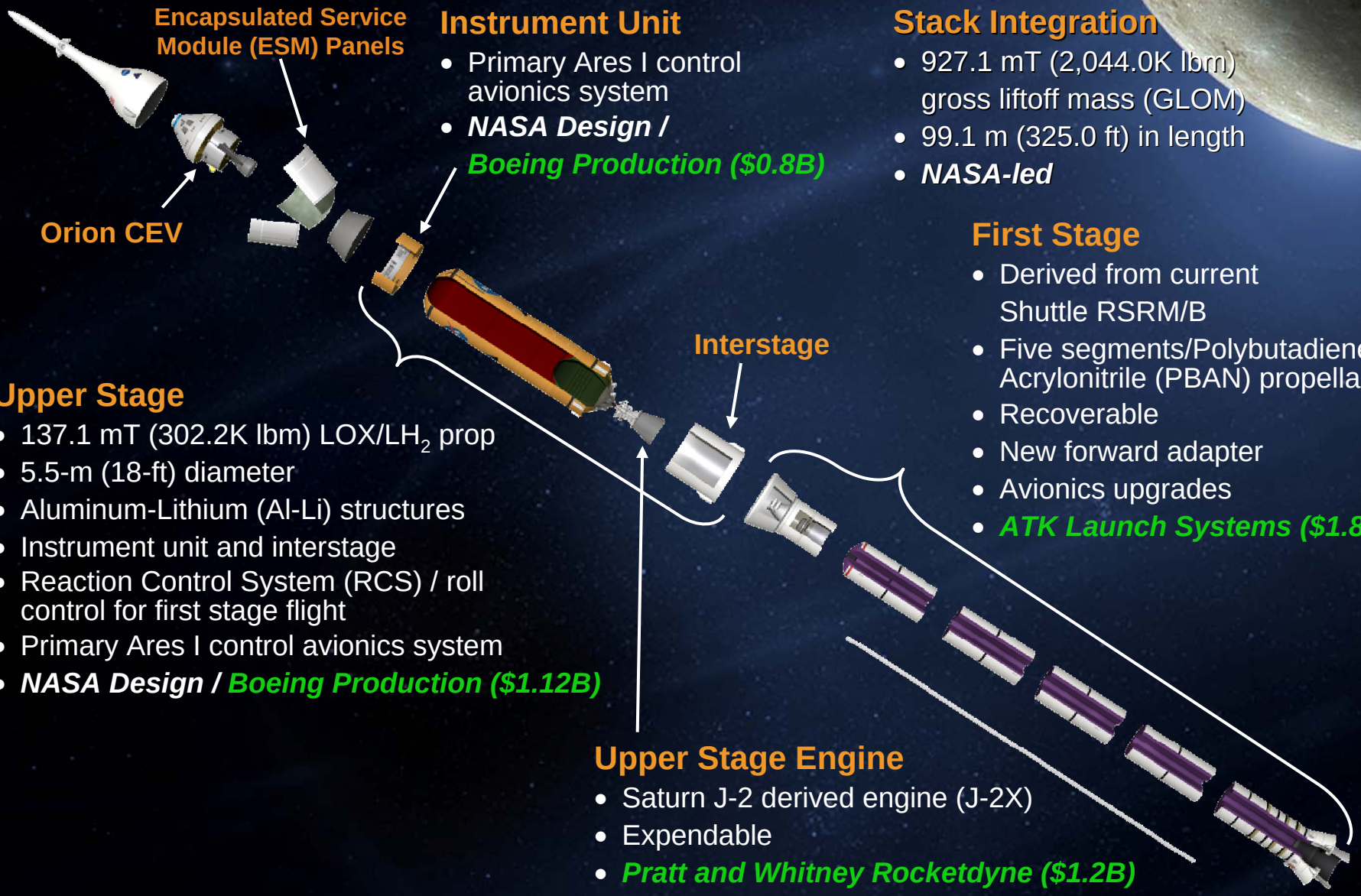
S-II
(5 J-2 engines)
453.6 mT
(1,000.0K lbm)
LOX/LH_2

S-IC
(5 F-1)
1,769.0 mT
(3,900.0K lbm)
LOX/RP-1

Saturn V

Height: 110.9 m (364 ft)
Gross Liftoff Mass:
2,948.4 mT (6,500K lbm)
Payload Capability:
44.9 mT (99K kbm) to TLI
118.8 mT (262K lbm) to LEO

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 ($1.8B)***

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 ($1.12B)***

Upper Stage Engine

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

First Stage

Tumble Motors (from Shuttle)

Composite Frustum

Modern Electronics

12-Fin Forward Segment

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

Same cases and joints as Shuttle

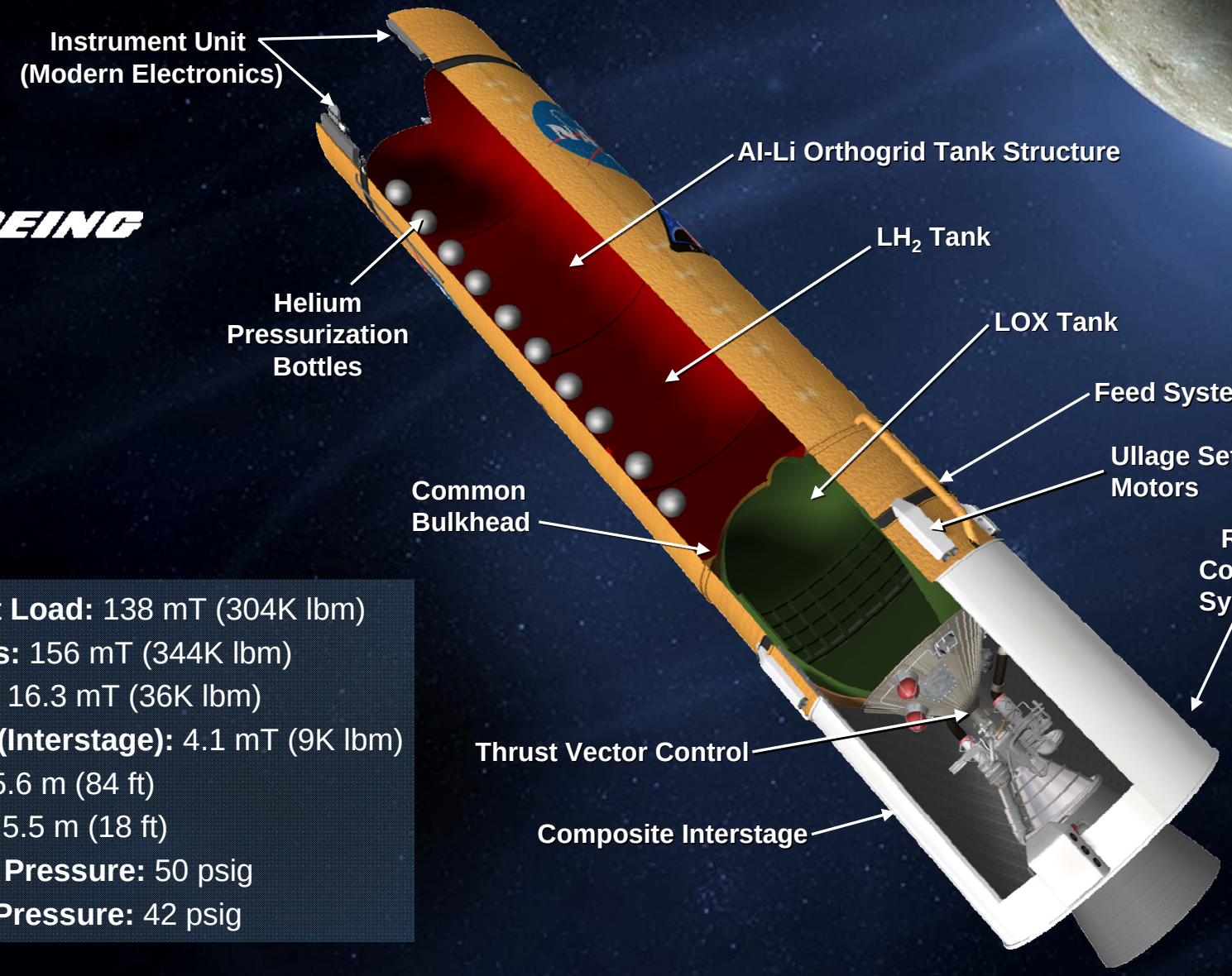
Booster Deceleration Motors (from Shuttle)

Wide Throat Nozzle

Same Aft Skirt and Thrust Vector Control as Shuttle

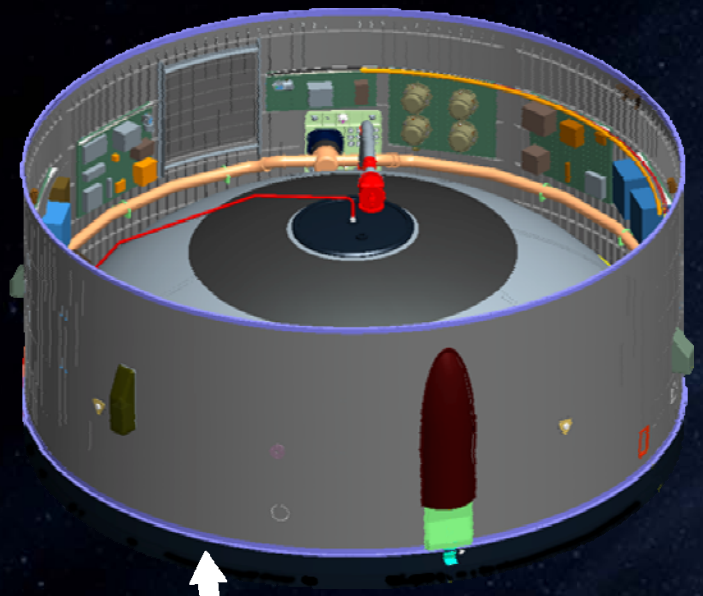
Mass: 733 mT (1,616 lbm)
Thrust: 15.8 MN
Burn Duration: 126 sec
Height: 53 m (174 ft)
Diameter: 3.7 m (12 ft)

Upper Stage



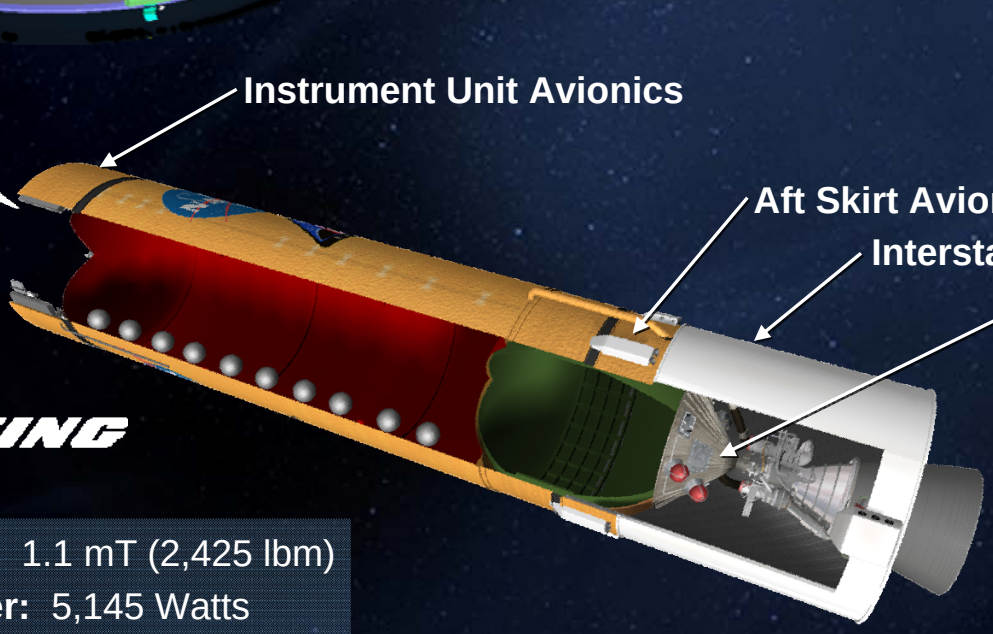
Propellant Load: 138 mT (304K lbm)
Total Mass: 156 mT (344K lbm)
Dry Mass: 16.3 mT (36K lbm)
Dry Mass (Interstage): 4.1 mT (9K lbm)
Length: 25.6 m (84 ft)
Diameter: 5.5 m (18 ft)
LOX Tank Pressure: 50 psig
LH_2 Tank Pressure: 42 psig

Upper Stage Avionics



The Upper Stage Avionics will provide:

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

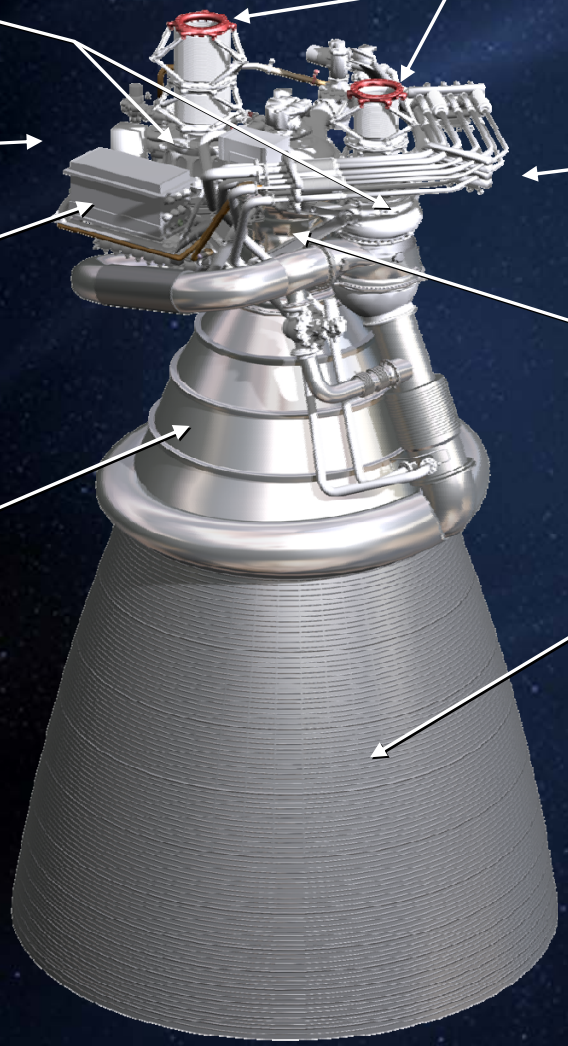


BOEING

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

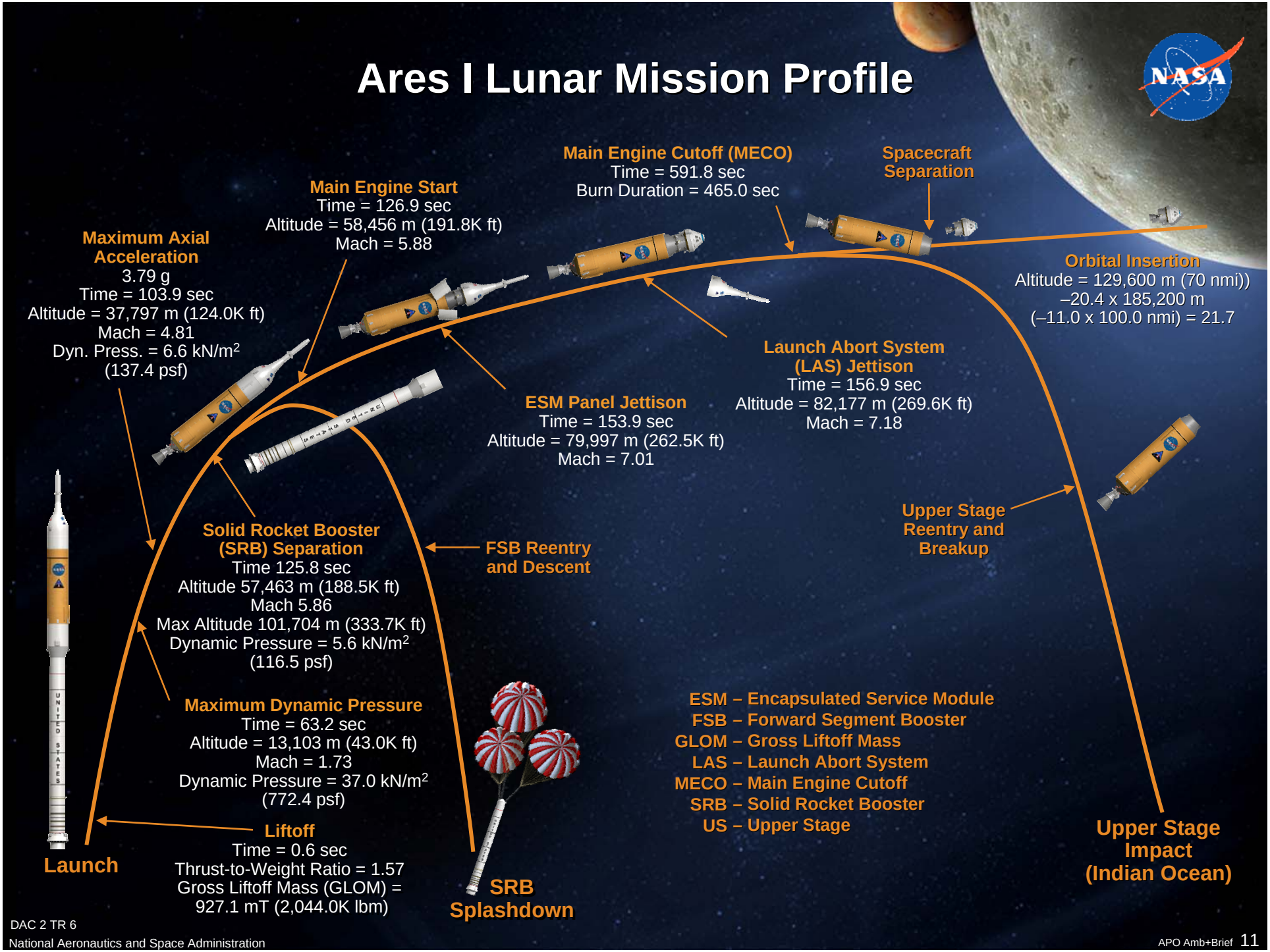
HIP-bonded MCC
- Based on RS-68 demonstrated technology

Metallic Nozzle Extension
- New design

Mass: 2.5 mT (5,511 lbm)
Thrust: 131 mT (289K lbm) (vac)
Isp: 448 sec (vac)
Height: 4.7 m (15.4 ft)
Diameter: 3.05 m (10 ft)

Pratt & Whitney
A United Technologies Company
Pratt & Whitney Rocketdyne, Inc.

Ares I Lunar Mission Profile



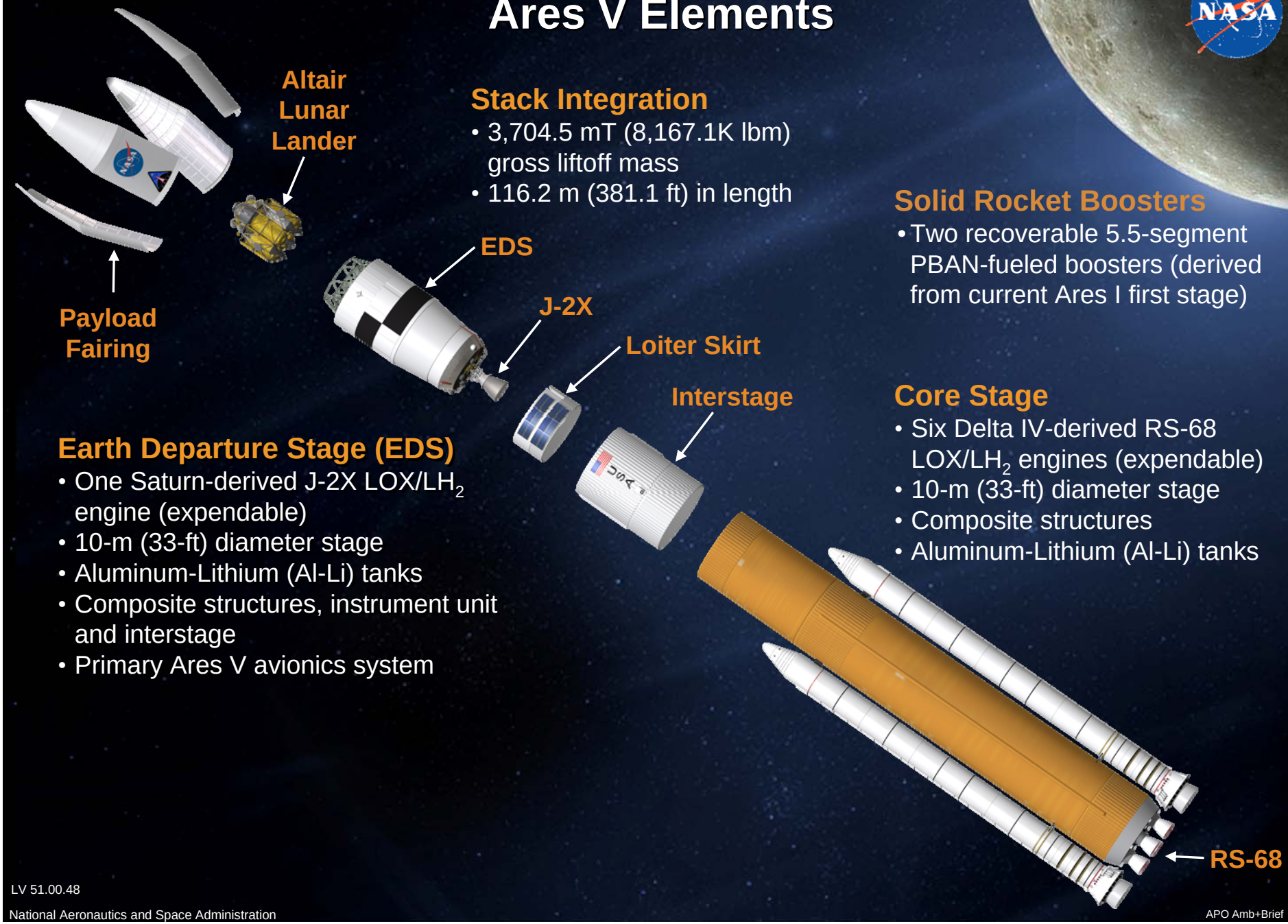
Ares I–X Test Flight

- **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

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)

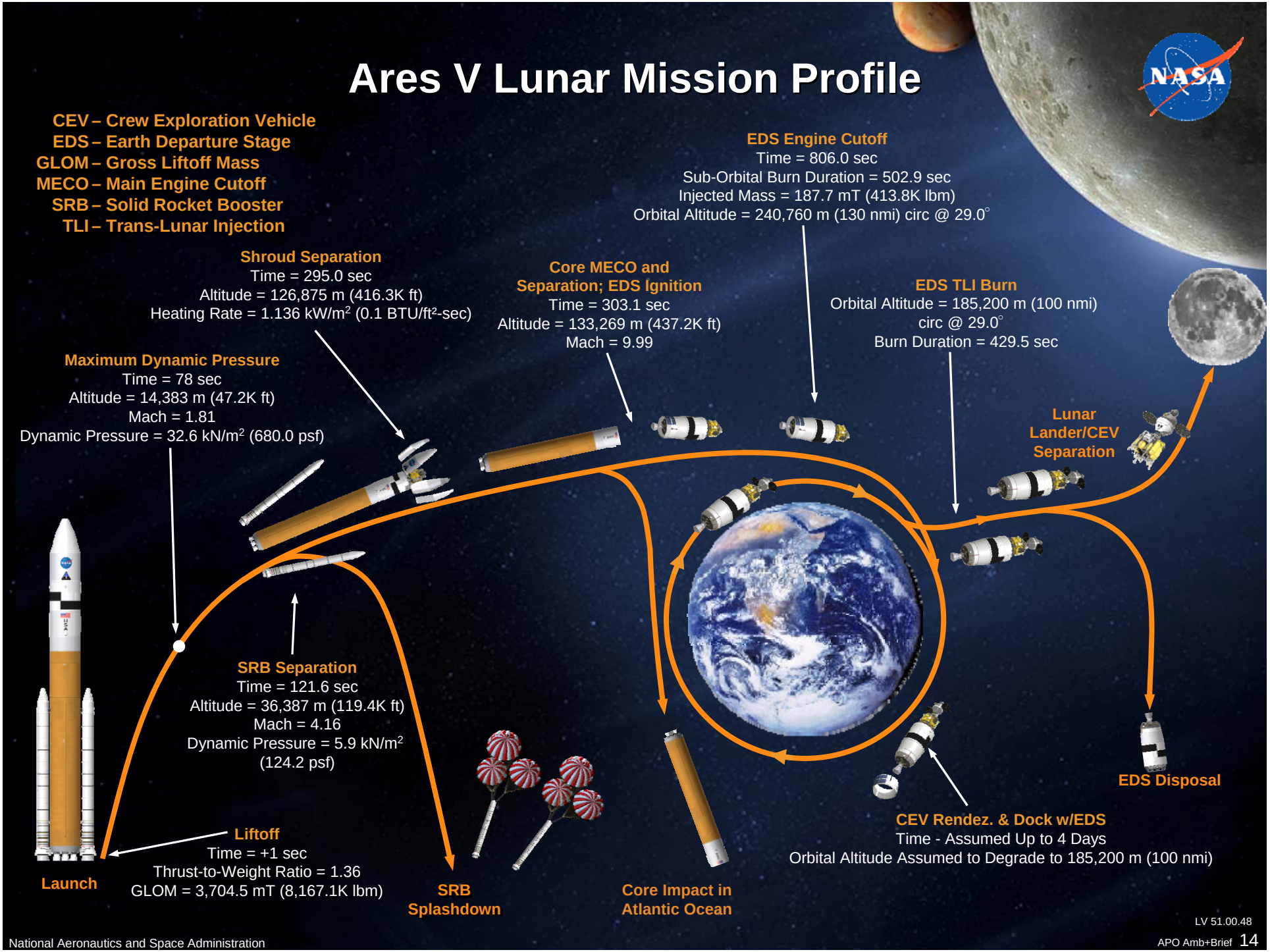
Earth Departure Stage (EDS)

- 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 Lunar 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

Shroud Separation
Time = 295.0 sec
Altitude = 126,875 m (416.3K ft)
Heating Rate = 1.136 kW/m^2 (0.1 BTU/ft^2-sec)

Maximum Dynamic Pressure
Time = 78 sec
Altitude = 14,383 m (47.2K ft)
Mach = 1.81
Dynamic Pressure = 32.6 kN/m^2 (680.0 psf)

Core MECO and Separation; EDS Ignition
Time = 303.1 sec
Altitude = 133,269 m (437.2K ft)
Mach = 9.99

EDS Engine Cutoff
Time = 806.0 sec
Sub-Orbital Burn Duration = 502.9 sec
Injected Mass = 187.7 mT (413.8K lbm)
Orbital Altitude = 240,760 m (130 nmi) circ @ 29.0°

EDS TLI Burn
Orbital Altitude = 185,200 m (100 nmi) circ @ 29.0°
Burn Duration = 429.5 sec

Lunar Lander/CEV Separation

SRB Separation
Time = 121.6 sec
Altitude = 36,387 m (119.4K ft)
Mach = 4.16
Dynamic Pressure = 5.9 kN/m^2 (124.2 psf)

Liftoff
Time = +1 sec
Thrust-to-Weight Ratio = 1.36
GLOM = 3,704.5 mT (8,167.1K lbm)

Launch

SRB Splashdown

Core Impact in Atlantic Ocean

CEV Rendez. & Dock w/EDS
Time - Assumed Up to 4 Days
Orbital Altitude Assumed to Degrade to 185,200 m (100 nmi)

EDS Disposal

What Progress Have We Made?

- **Programmatic Milestones**
  - Completed Ares I and Element System Requirements Reviews, System Definition Reviews, and Preliminary Design Reviews
  - Contracts awarded for building the first stage, J-2X engine, upper stage, instrument unit, and Orion
  - RFP issued for MSFOC Contract at MAF
  - Ares I-X test flight scheduled for 2009
- **Technical Accomplishments**
  - Testing first stage parachutes and developing nozzles
  - Constructing new J-2X test stand at Stennis Space Center
  - Performing J-2X injector tests and power pack tests
  - Fabricating Ares I-X hardware
  - Robotic Weld Tool installed and operational at MSFC

Cutting Dome Gore Panels for LH_2 Tank

Powerpack 1A at SSC

Robotic Weld Tool for Friction Stir Welding

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

Ares Nationwide Team

ATK Launch Systems

Marshall

Glenn

Ames

Langley

Pratt & Whitney Rocketdyne

Johnson

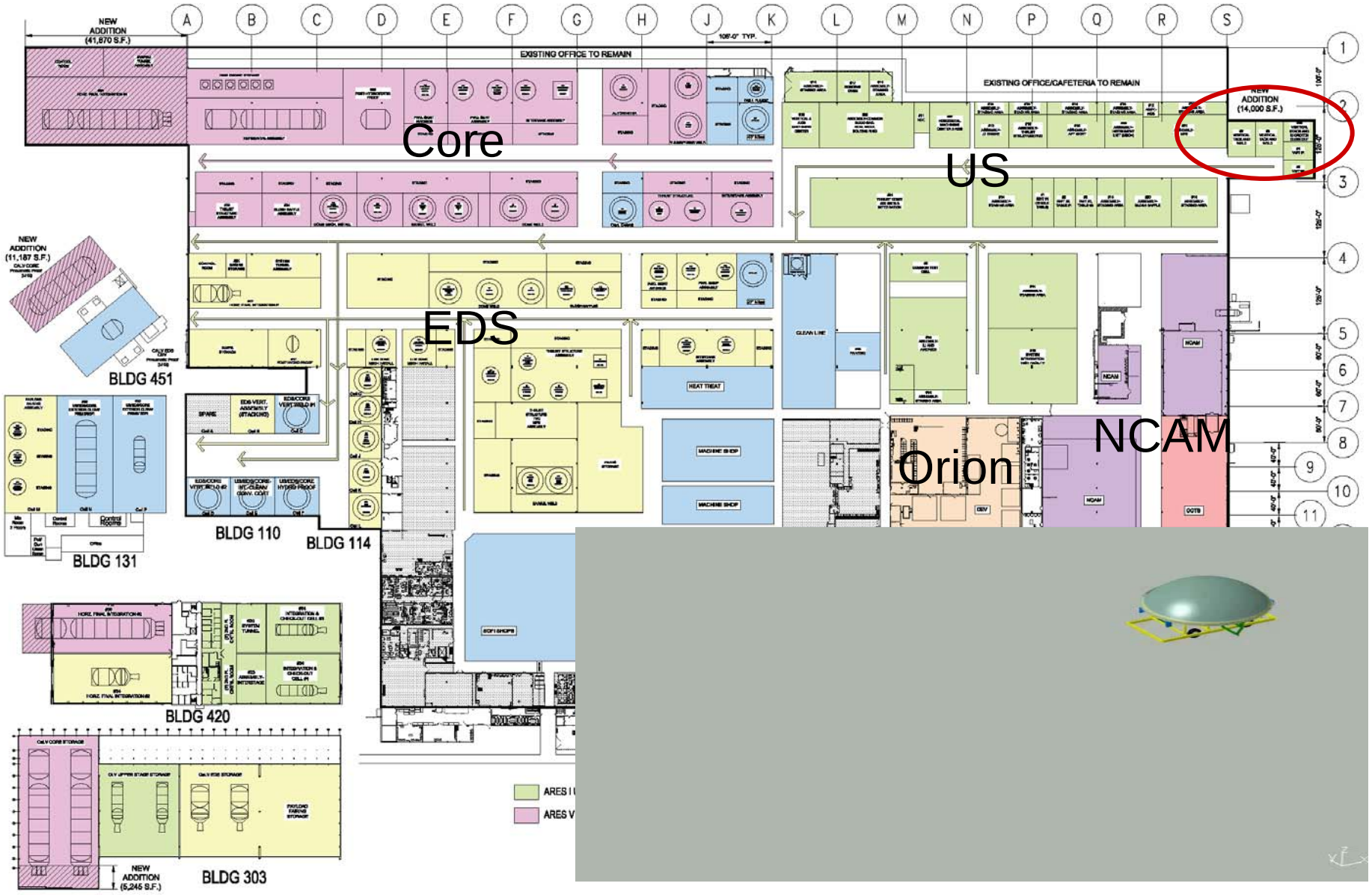
Kennedy

Michoud Assembly Facility

Stennis

Boeing

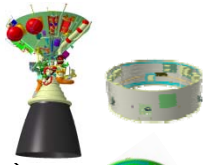
Ares I and V Production at Michoud Assembly Facility (MAF)



Merged Manufacturing Flow

- Manufacturing Value Stream Map
  - Vertical Tack and Weld
  - Horizontal TPS Application
- Producability Summit
- Manufacturing Plan
- Manufacturing Floor Plan at Michoud
- Tooling Design and Fabrication

Common Test Cell



125.00 J2X 5.50 → G1 153.5 TC 34 → G2 TC 120 9.5 → CTC

177.63 ASB 32.63 → AS 145 35 → CTC

225.75 IUB 18.75 → G1 IU 24 → IUAC 60 → G2 IU 123 13 → CTC 110 14

Metrics

NASA Baseline	420 days
Boeing Contract	347 days
Merged VSM	320 days
With learning	<300 days

LH2 Tank

217 HB1, 217 HB2, 217 HB3 → G1 VTWB 11.00 → G2 VTWB 12.00

213 FD 31 → G3 VTWA 182 6

LOX Tank

246 AD 39.5 → G1 VTWA 5

G2 232.75 LTB 19.00 → G1 LTB 7.00 → G1 VTWA 5

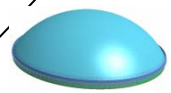
G1 VTWA 5 → G2 VTWA 201.75 7.75

Critical Path

G2 VTWB 12.00 → G3 VTWA 182 6 → G1 HT 11.5 → G2 HT 45.5 → G3 HT 23 → G1 INT 96 7 → G2 INT 11 → G3 INT 7.5 → G4 INT 33.5 → G5 INT 37

312.50 OFD 12.75 → G1 CB 32 → G3 CB 66

288.50 HAD 12.75 → G2 CB 8 → G3 CB 66



Common Bulkhead

Vertical Tank Assembly

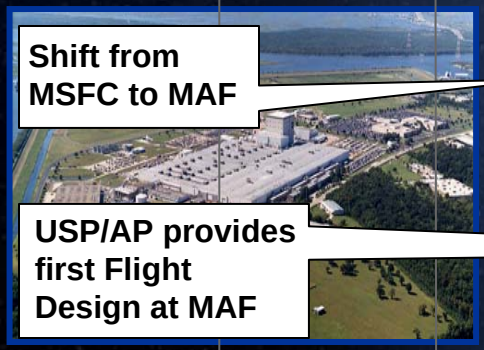
Final Assembly & Integration

84 TN 13 → 84 IS 46.5

Boeing, working with NASA, Reduced Assembly Flow Over 100 days

Ares I Upper Stage Summary
PMR 08 Rev 1 Re-Plan Preliminary

	FY07	FY08	FY09	FY10	FY11	FY12	FY13
Design							
Mfg Process Develop/Demo							
Mfg Demo			CB Complete ▼				
CB Mfg Demo				Proof Test & NDE ▼			
CB Dev Art					Test		
Engine Delivery					✓ISTA		✓Orion-1 ✓Orion-2
MAF Construction/Activation							
Shift from MSFC to MAF							
USP/AP provides first Flight Design at MAF							
Long Lead / Fab Test Stage @ MAF / Testing at MSFC							
Long Lead / US-00 (Orion) M&A / TT							Ares 1-Y US-00 on Dock @ KSC
Long Lead / US-01 (Ares 1-Y) M&A							
Long Lead / US-02							
US Milestones	US SRR ▼	USPC Award ▼ / US SDR ▼	IUAC Award ▼	US PDR ▼	US CDR ▼		(Ares 1-Y) M&A ▲ Ares 1-Y



Summary

- **The Ares family will provide the U.S. with unprecedented exploration capabilities**
  - Can inject ~40% more mass to the Moon than Apollo/Saturn
- **The Ares team has made significant progress since its inception in October 2005**
  - Full team is onboard
  - All major milestones met to-date, with PDR completed late Summer 2008
  - Ares I-X test flight is on schedule for 2009
- **We are making extensive use of lessons learned to minimize cost, technical, and schedule risks**
- **The NASA-led / Contractor partnership is very effective in developing the Ares I**


NASA
www.nasa.gov/ares