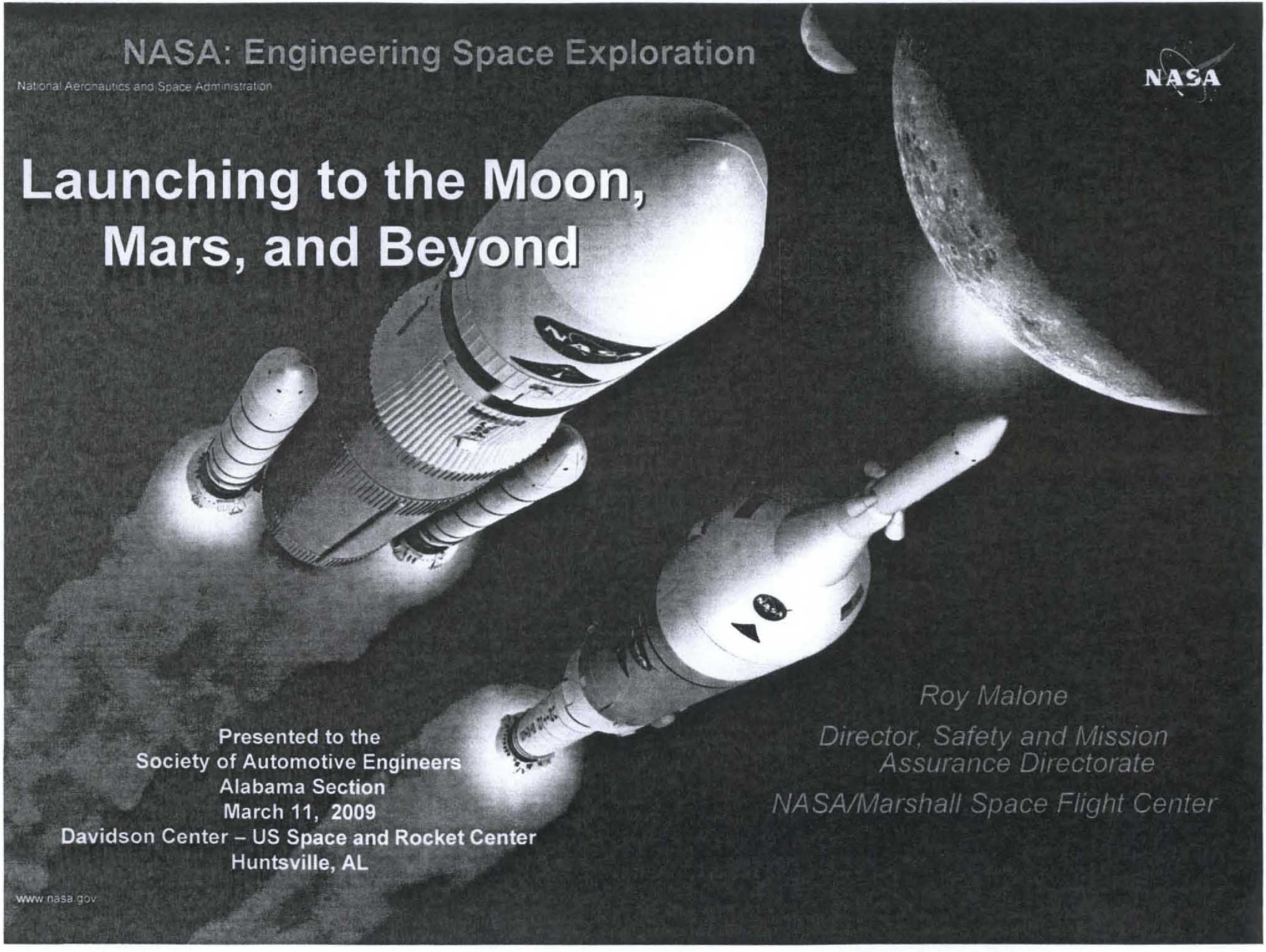
NASA: Engineering Space Exploration

National Aeronautics and Space Administration

NASA

# Launching to the Moon, Mars, and Beyond



*Roy Malone*

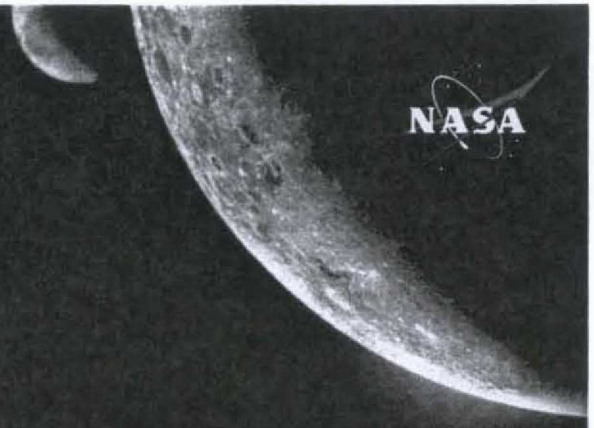
*Director, Safety and Mission Assurance Directorate*

*NASA/Marshall Space Flight Center*

**Presented to the**
**Society of Automotive Engineers**
**Alabama Section**
**March 11, 2009**
**Davidson Center – US Space and Rocket Center**
**Huntsville, AL**

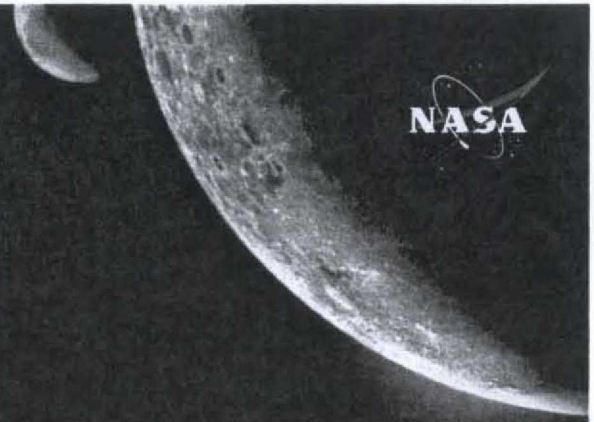
www.nasa.gov

# Today's Journey



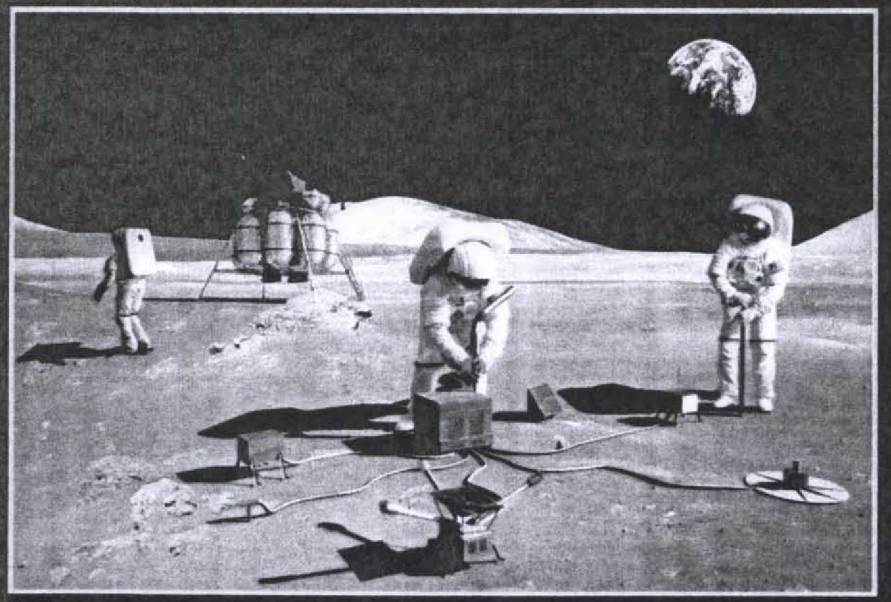
- What is NASA's mission?
- Why do we explore?
- What is our timeline?
- Why the Moon first?
- What will the vehicles look like?
- What progress have we made?
- Who will be doing the work?
- What are the benefits of space exploration?

# MSFC LEGACY



# What is NASA's Mission?

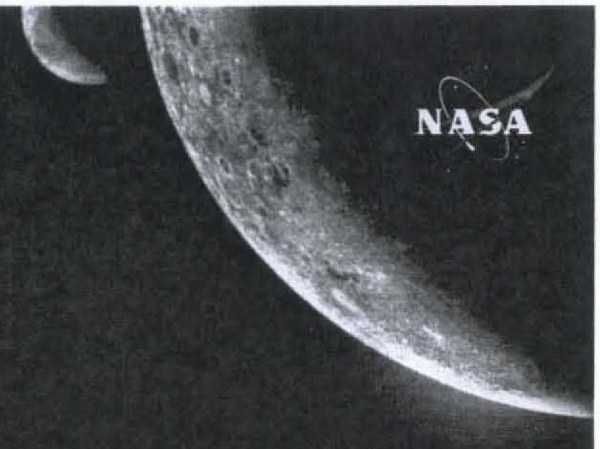
- Safely fly the Space Shuttle until 2010
- Complete the International Space Station
- Develop a balanced program of science, exploration, and aeronautics
- Develop and fly the Orion Crew Exploration Vehicle (CEV)
- Return to the Moon no later than 2020
- Promote international and commercial participation 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*

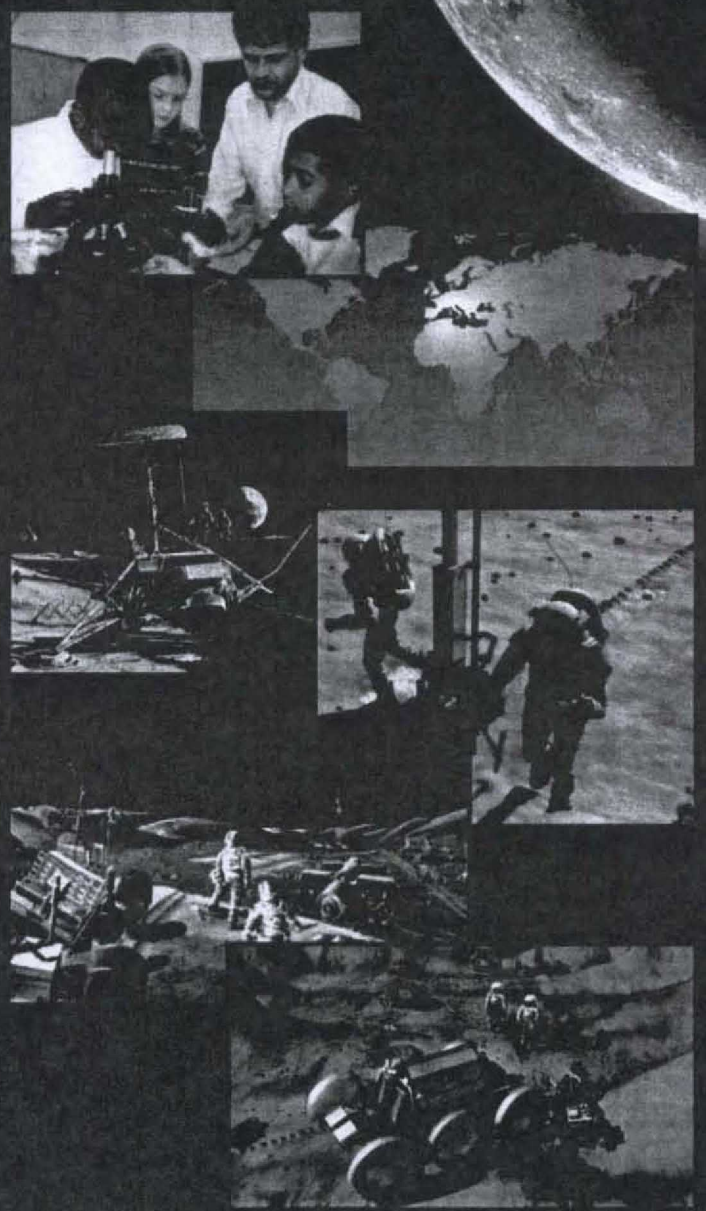
# The Next Steps



# Why Do We Explore?

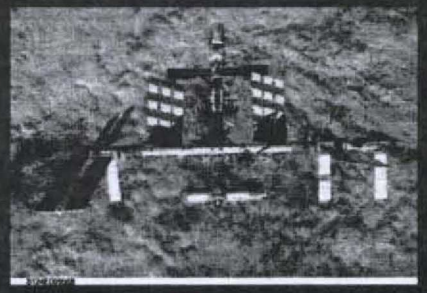
NASA

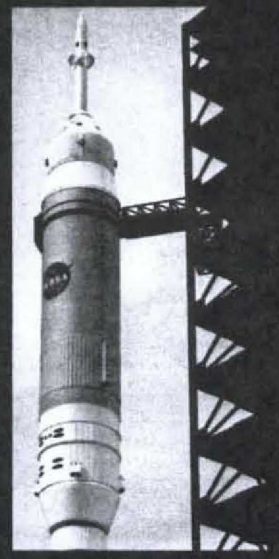
- **Inspiration**
  - Inspire students to explore, learn, contribute to our nation's economic competitiveness, and build a better future
- **Innovation**
  - Provide opportunities to develop new technologies, new jobs, and new markets
- **Discovery**
  - Discover new information about ourselves, our world, and how to manage and protect it

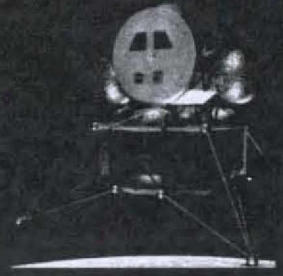


# MAJOR NASA PROGRAMS

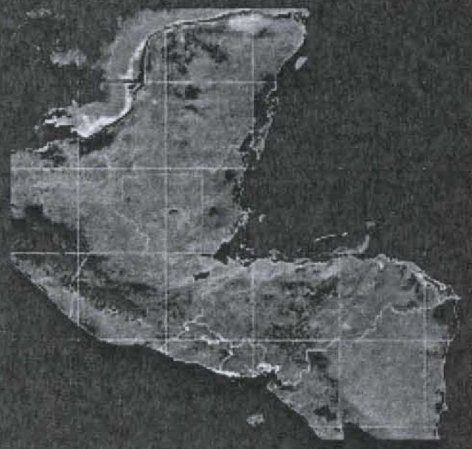
- **Space Shuttle**
- **International Space Station**
- **Earth and Space Sciences**
- **Constellation Program**
  - Crew Launch Vehicle
  - Cargo Launch Vehicle
  - Crew Exploration Vehicle
  - Crew Service Module
  - Earth Departure Stage
  - Altair Lunar Lander
  - Mars Transfer Vehicle
  - Mars Descent/Ascent Vehicle
- **Lunar Precursor Robotic Program**
  - Lunar Reconnaissance Orbiter (LRO)
  - Lunar Crater Observation and Sensing Satellite (LCROSS)



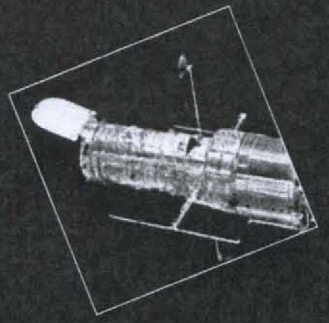


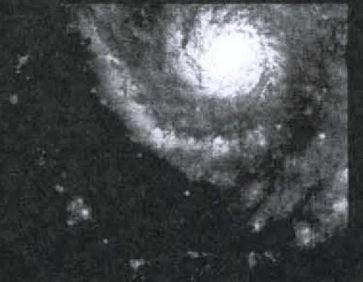


# Earth and Space Sciences

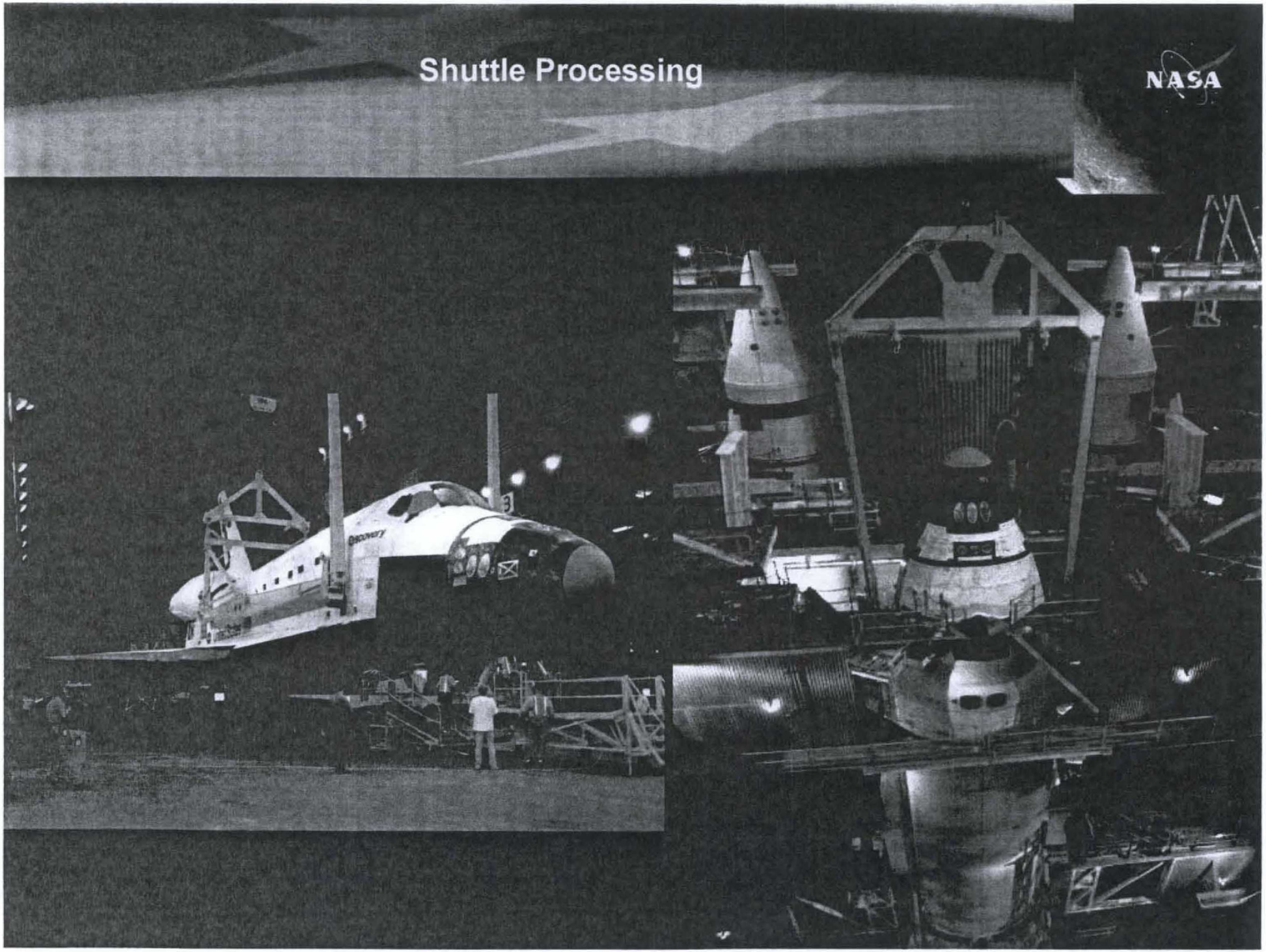


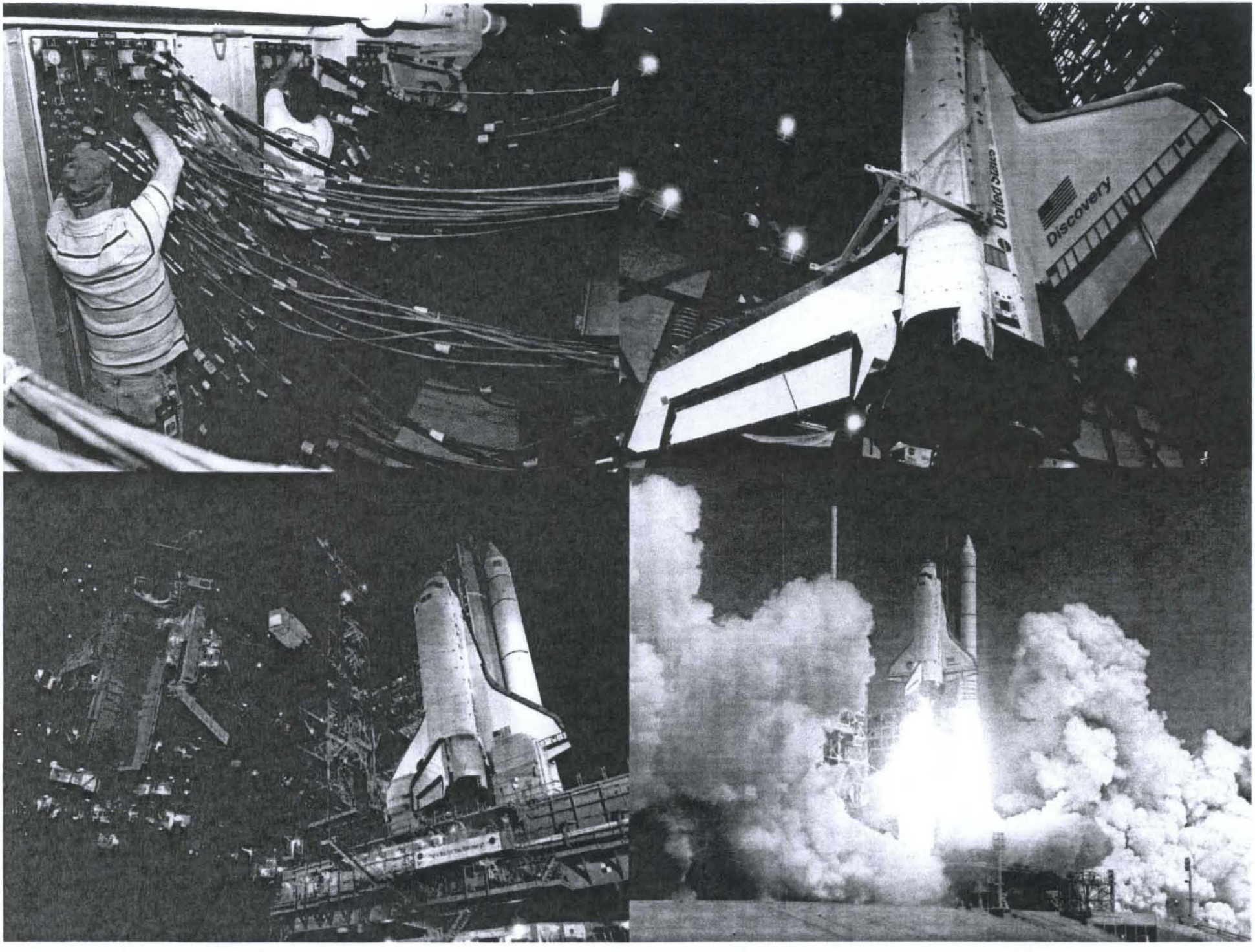
- SERVIR
  - A system providing southern Mexico and Central America data about sudden changes in environmental conditions affecting their lives
  - Beginning applications in Africa
- Hubble Space Telescope
  - STS 125 is the final servicing mission to HST
  - Extend its life and increase capabilities
- Other Space Telescopes
  - **Spitzer, Chandra, James Webb (2013)**





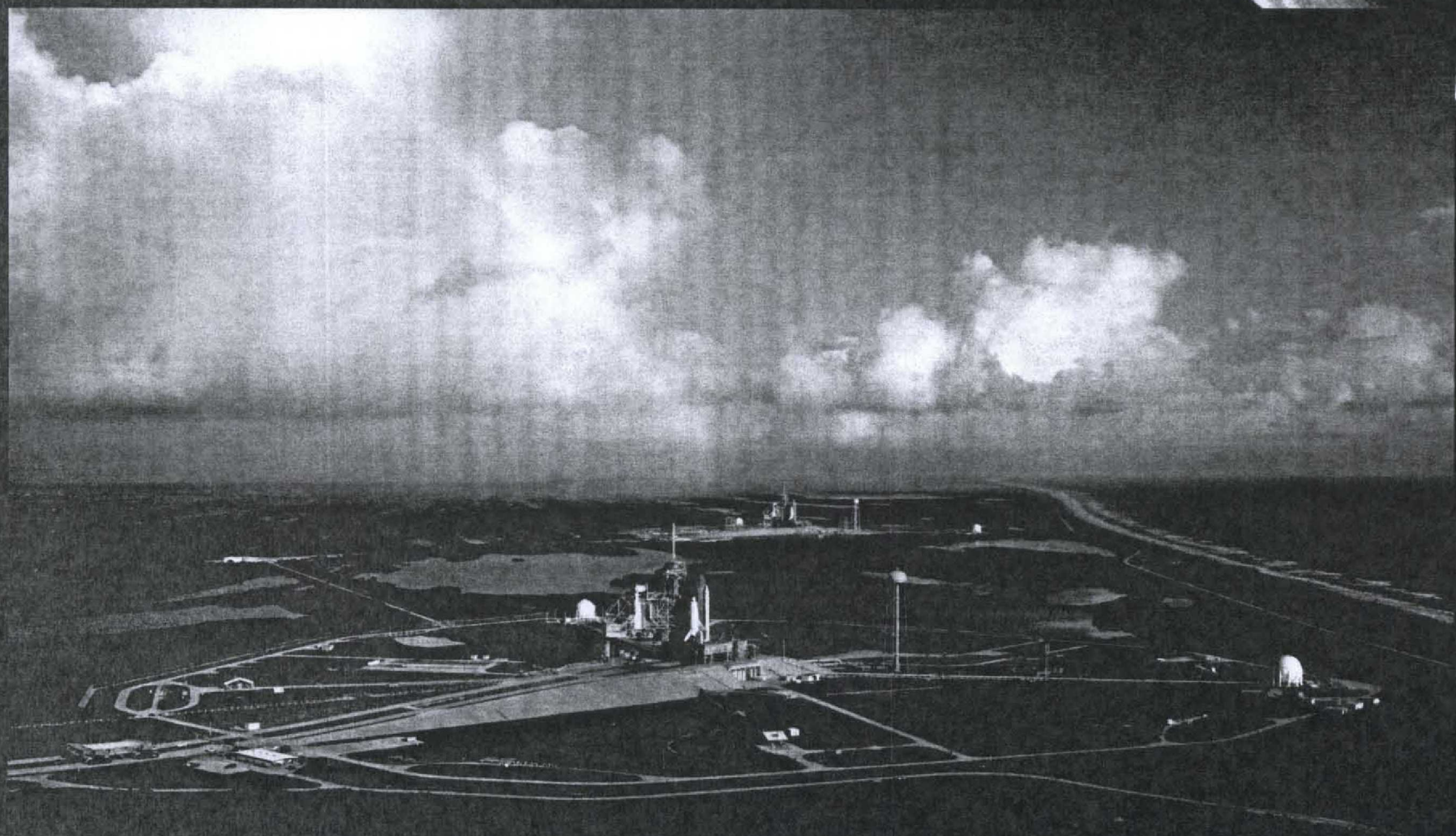
# Shuttle Processing



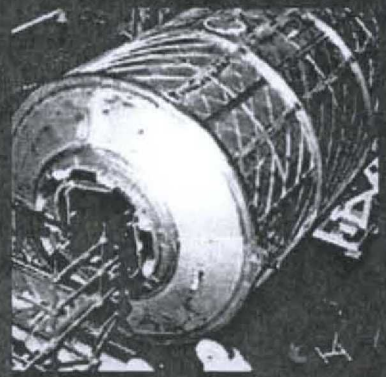

Discovery
United States

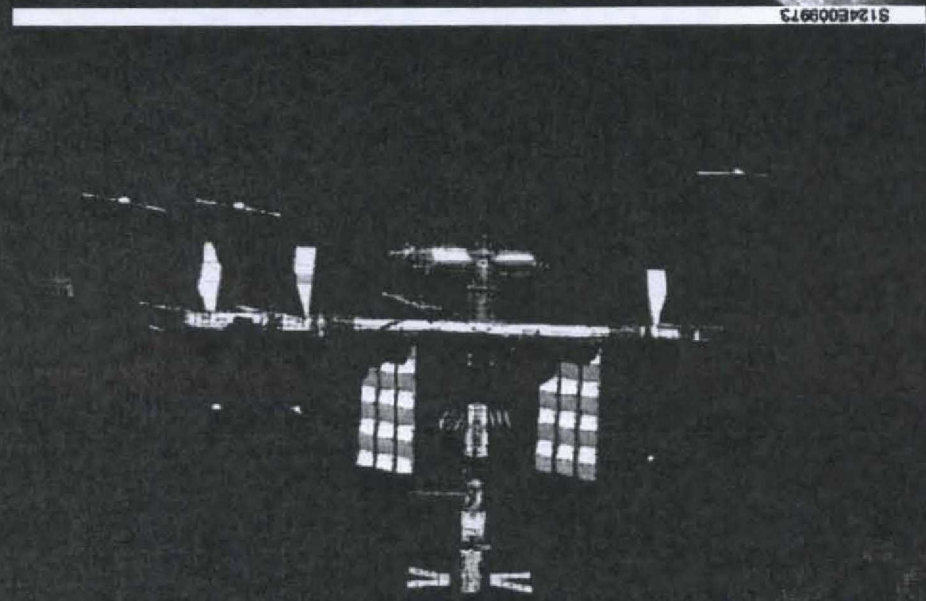
# Rare Site – Two Shuttle on Pads
# October 20, 2008

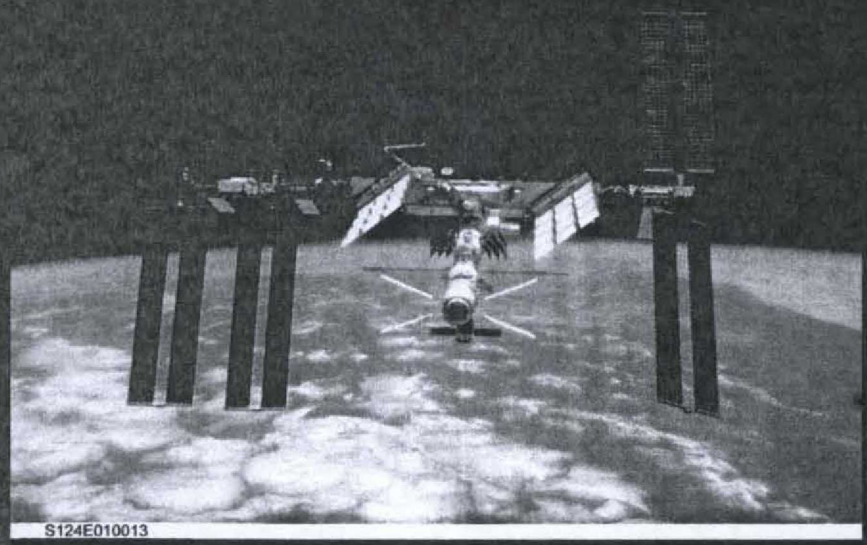
NASA

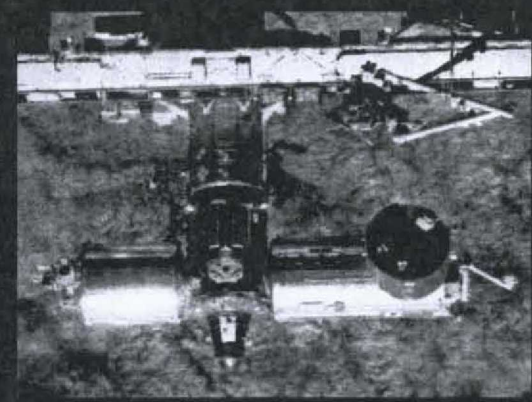


# International Space Station

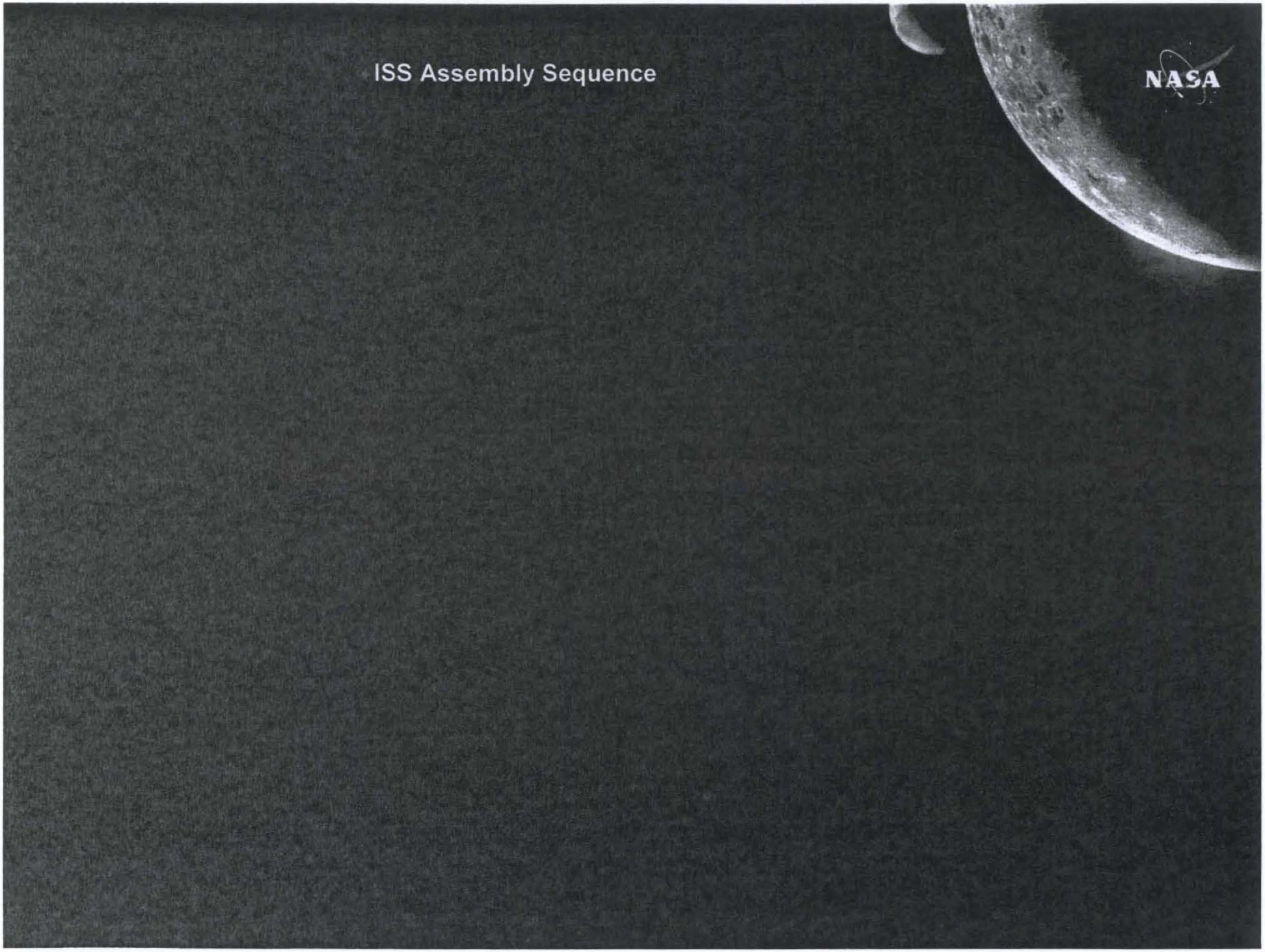






ISS Assembly Sequence



# NASA's Exploration Roadmap

NASA

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25...

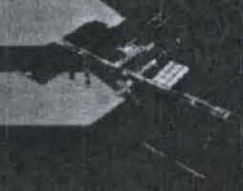
Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup

Mars Expedition ~2030

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 2009

Orion and Ares I Production and Operation

Altair Development

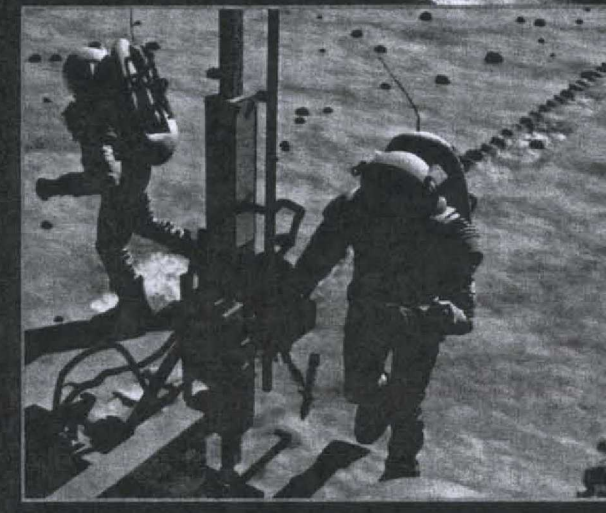
Ares V & Earth Departure Stage

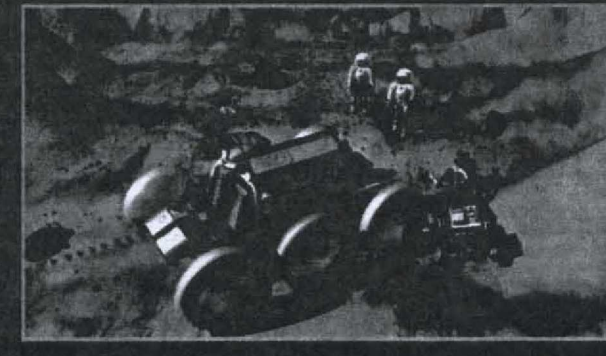
Surface Systems Development

# The Moon

NASA

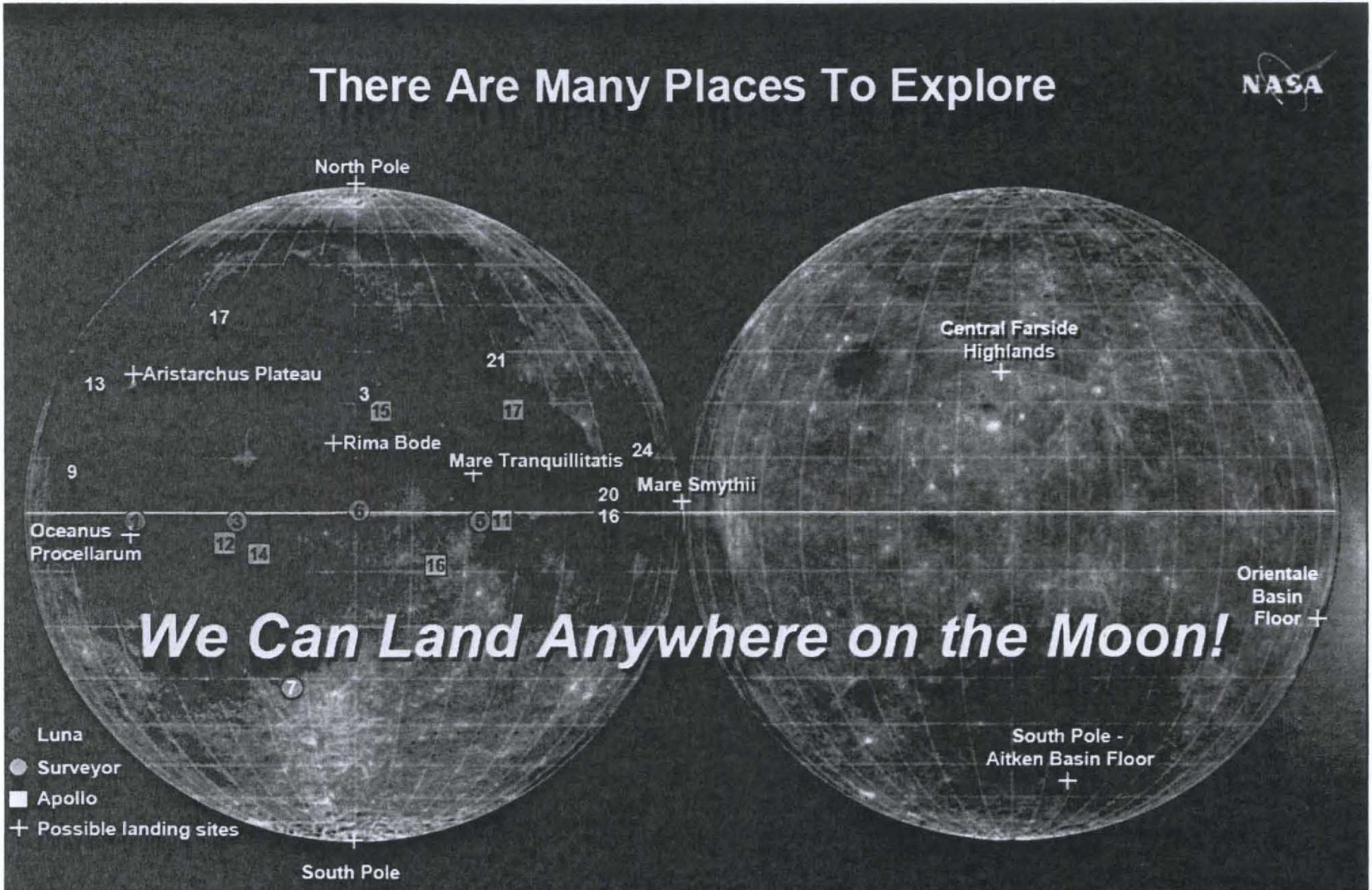
- **Lunar missions allow us to:**
  - Gain exploration experience
    - Space no longer a short-term destination
    - Will test human support systems
    - Use Moon to prove ability to build and repair long-duration space assets
  - Develop exploration technologies
    - Launch and exploration vehicles
    - *In-situ* resource utilization
    - Power and robotic systems
  - Conduct fundamental science
    - Astronomy, physics, astrobiology, geology, exobiology





***Next Step in Fulfilling Our Destiny as Explorers***

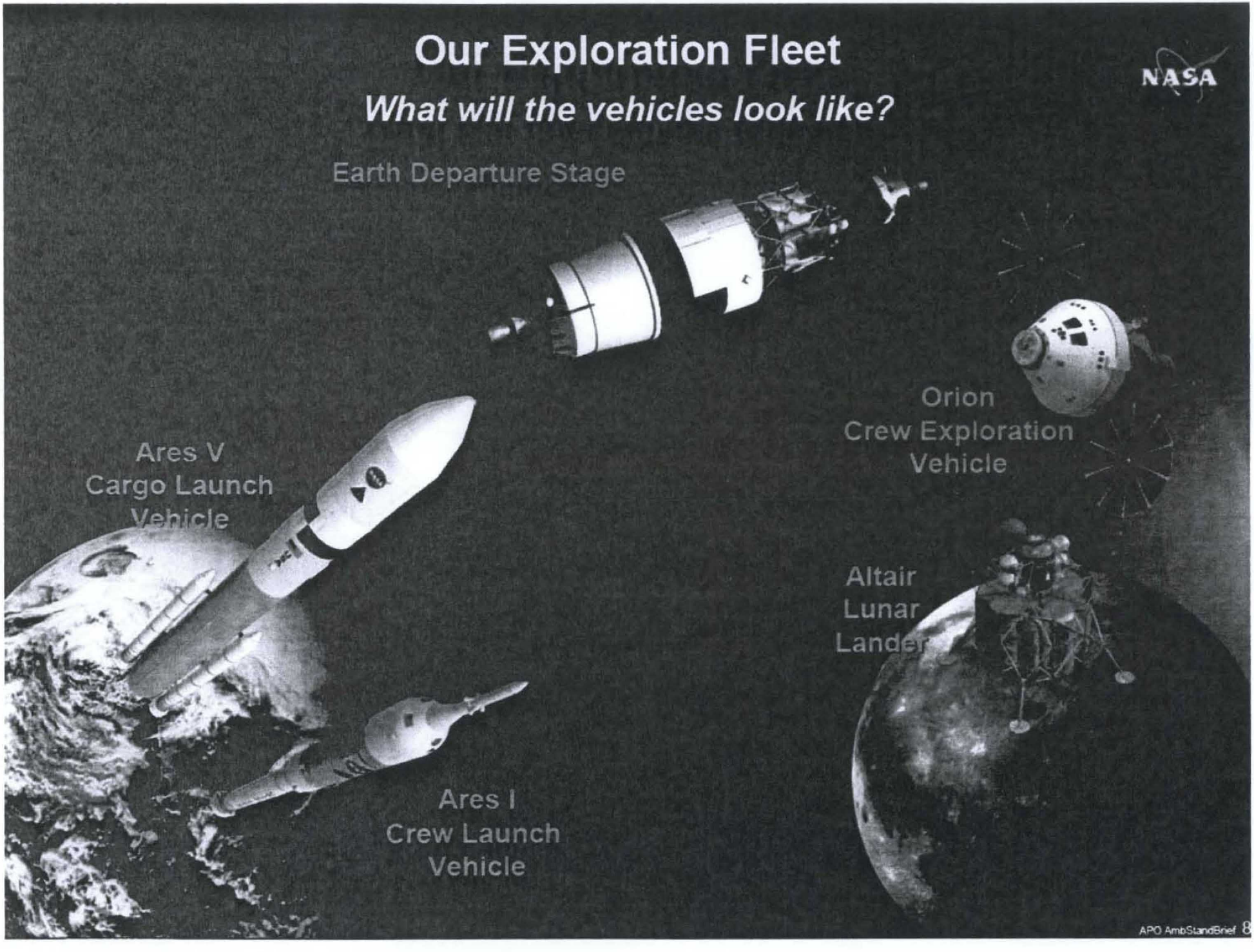
# There Are Many Places To Explore



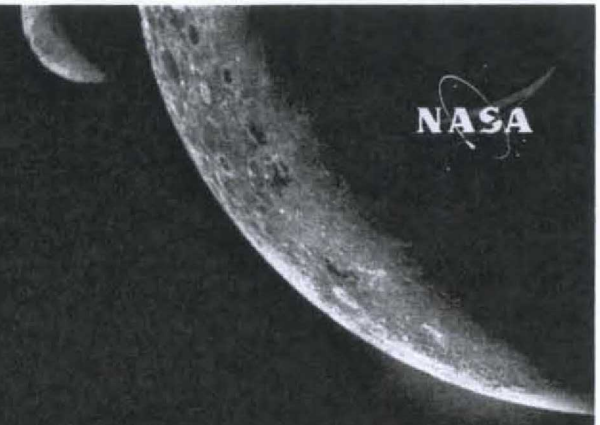

***We Can Land Anywhere on the Moon!***

# Our Exploration Fleet

***What will the vehicles look like?***



# Journey to the Moon

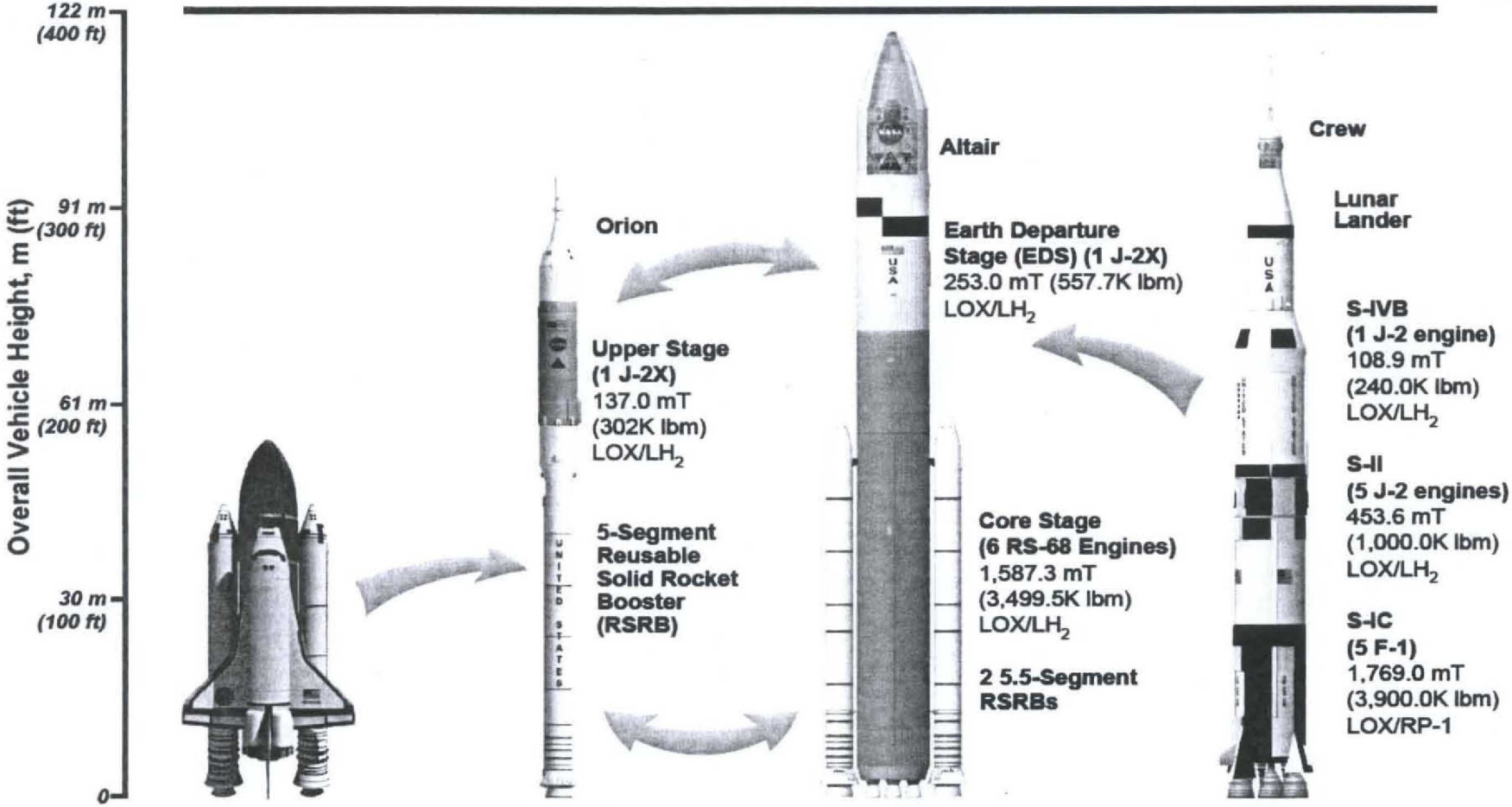


# Ares

- **Ares architecture**
  - Selected after systematically evaluating hundreds of concepts
  - Lowest cost, highest safety/reliability, lowest risk exploration solution
  - Built on foundation of proven technologies
- **Ares I**
  - Met all key milestones to date
  - Four major prime contracts awarded
- **Ares V**
  - Request for Proposal issued November 2008
  - A National asset with unprecedented performance and payload volume
    - 60% more mass delivered to Trans Lunar Insertion than Saturn V
- **Ares I and V – fastest and most prudent path to closing the Human Space Flight gap while enabling exploration of Earth's Moon and beyond**

# 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)

### 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

### 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

### Saturn V

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

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National Aeronautics and Space Administration

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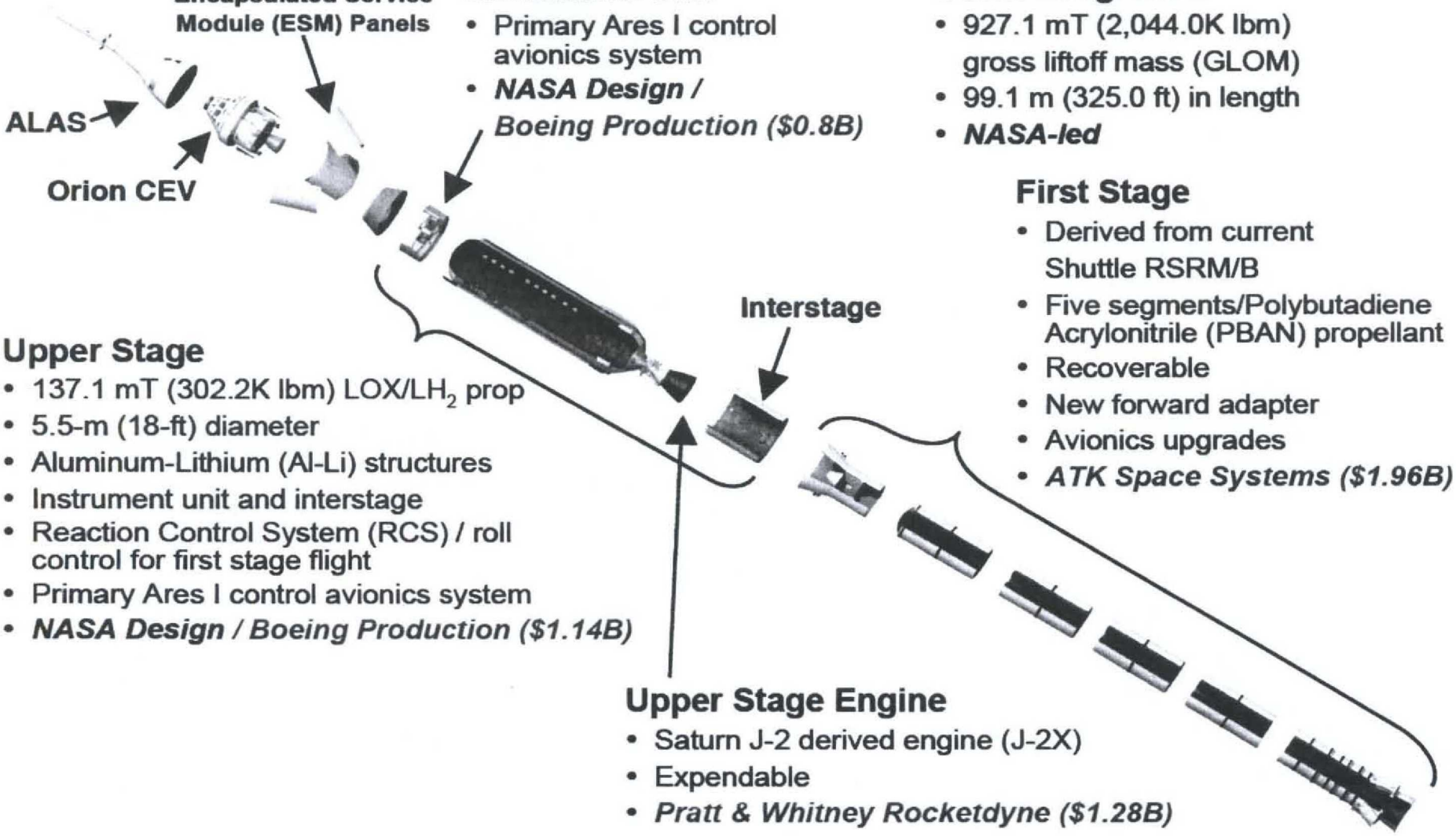
# Ares I Elements

*Over $5.18B in Prime Contract Value*




## 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 Space 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)***

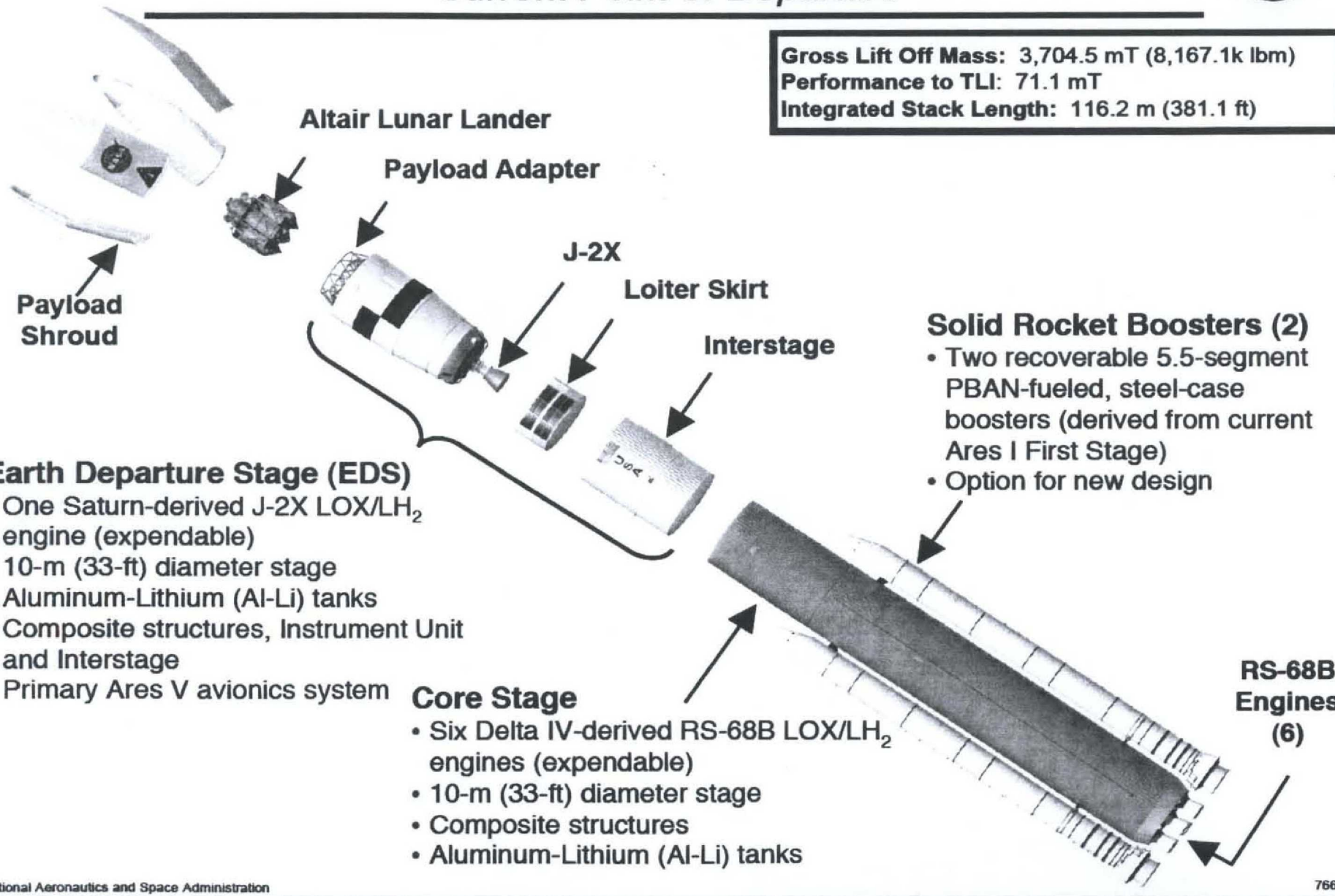
## Upper Stage Engine

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

# Ares V Elements

*Current Point-of-Departure*

**Gross Lift Off Mass:** 3,704.5 mT (8,167.1k lbm)
**Performance to TLI:** 71.1 mT
**Integrated Stack Length:** 116.2 m (381.1 ft)




## 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

## Solid Rocket Boosters (2)

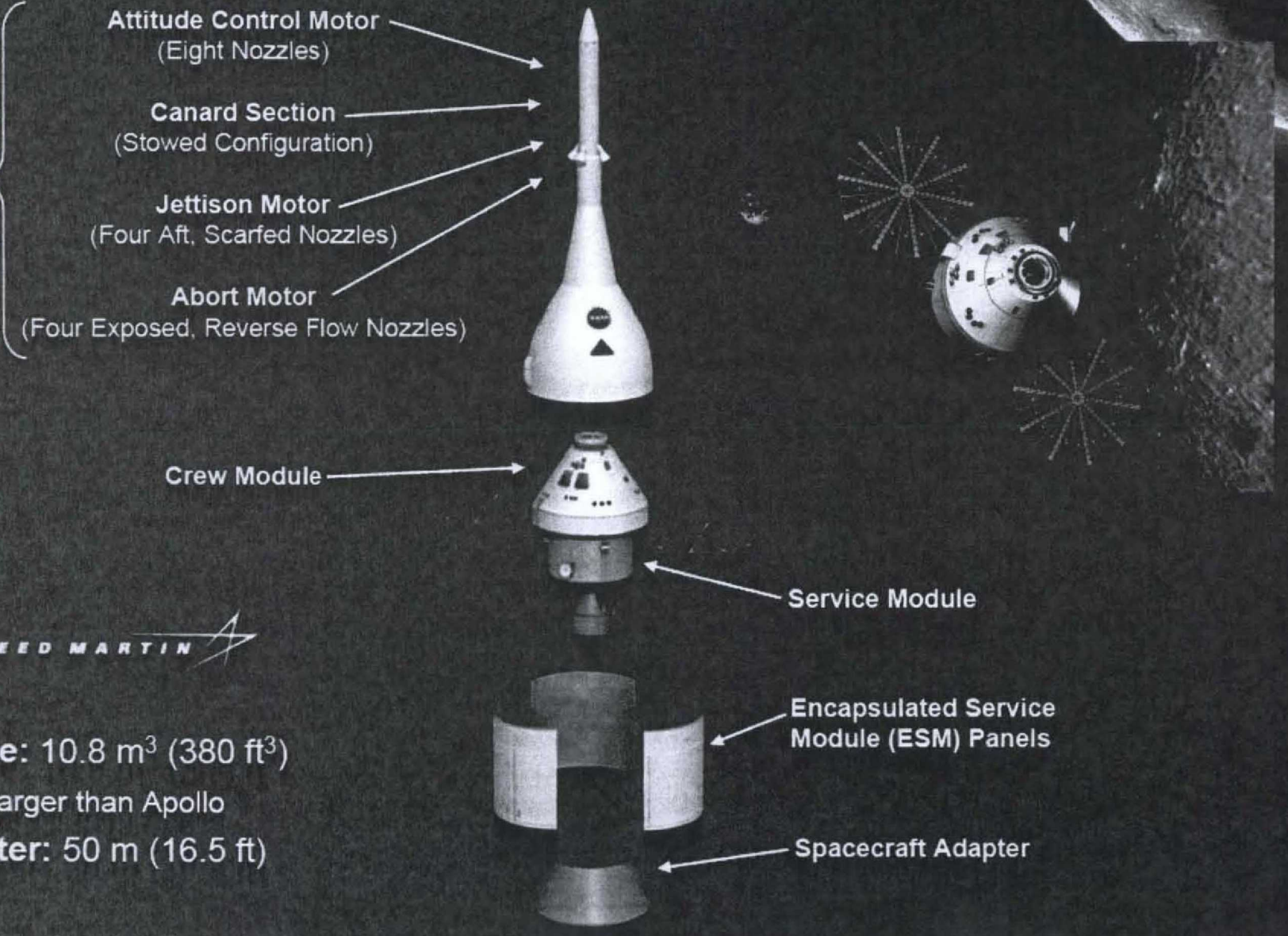
- Two recoverable 5.5-segment PBAN-fueled, steel-case boosters (derived from current Ares I First Stage)
- Option for new design

## 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

# Orion Crew Exploration Vehicle

NASA

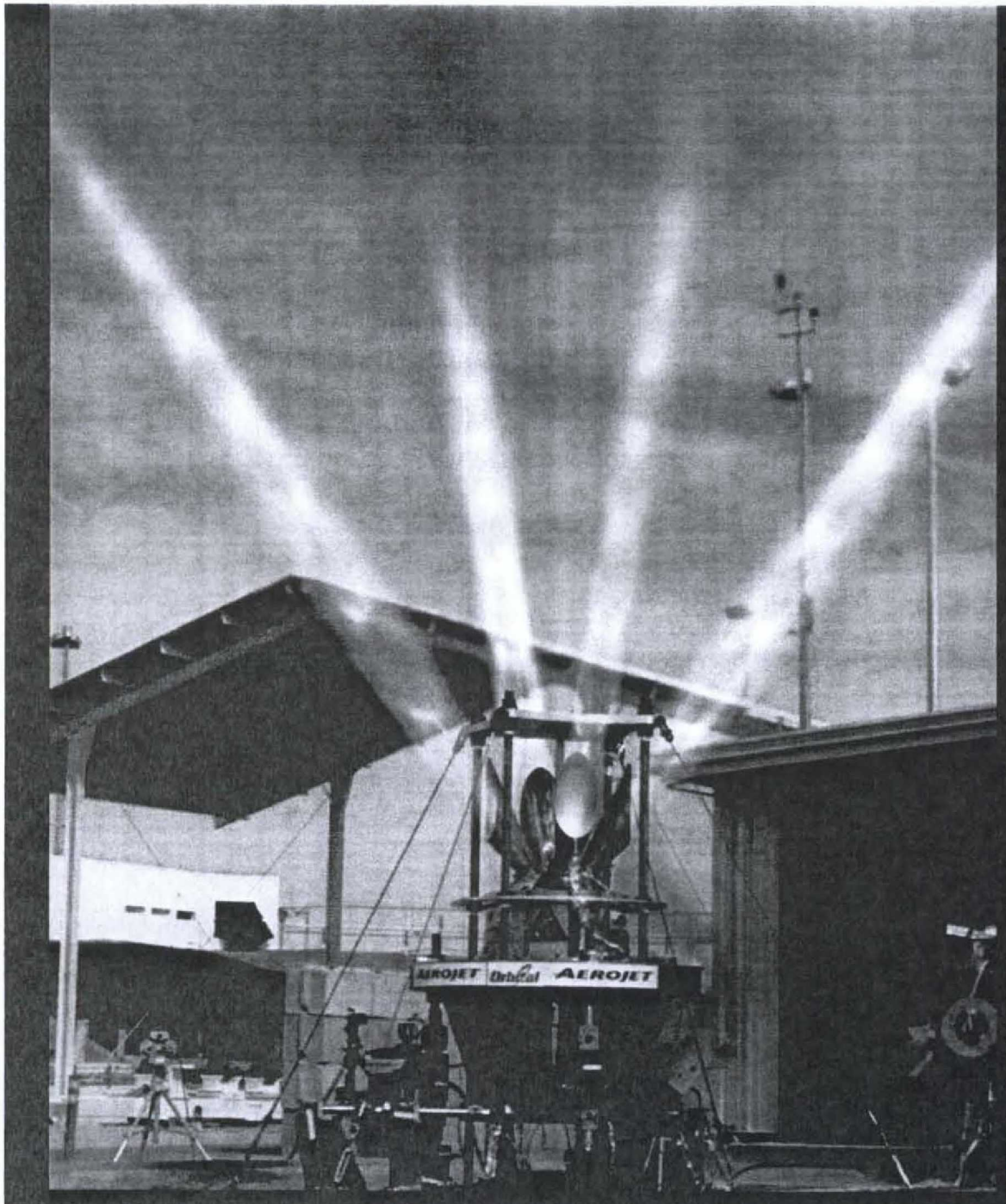



LOCKHEED MARTIN

**Volume:** 10.8 $m^3$ (380 $ft^3$)

- 80% larger than Apollo

**Diameter:** 50 m (16.5 ft)

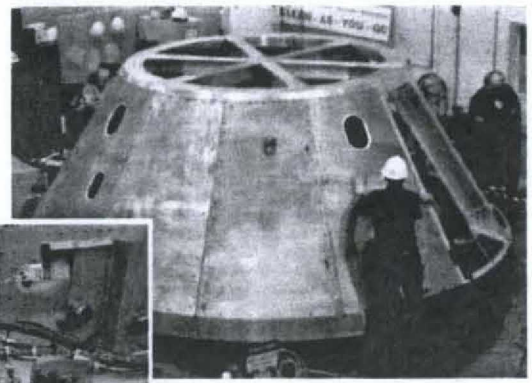


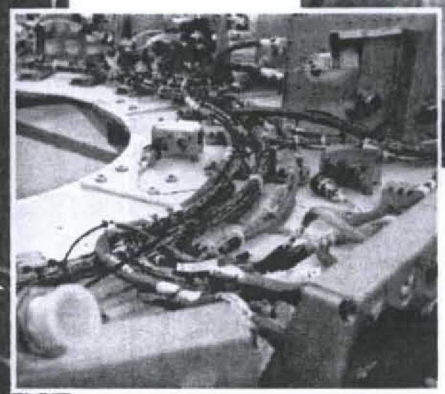

NASA

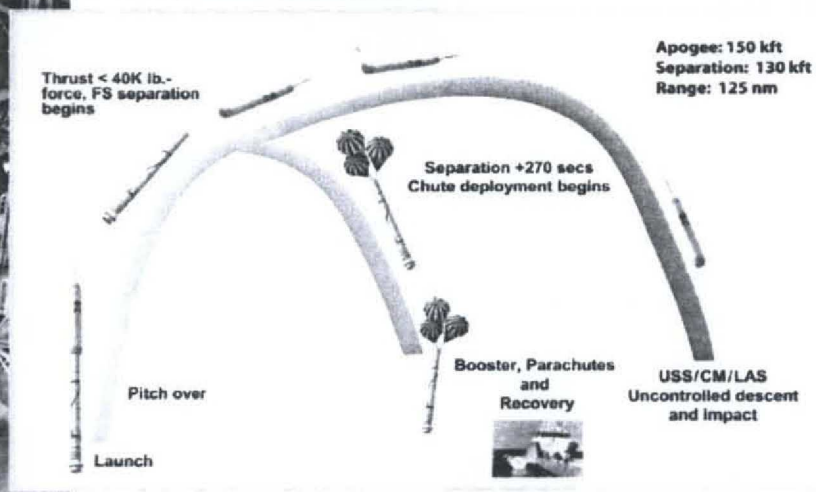
## First full-scale rocket motor test for the Orion spacecraft

- Test of a solid rocket that will be used to jettison the craft's launch abort system
- Separates the craft's launch abort system from the Orion crew module during launch
- The Orion launch abort system is a larger solid rocket motor system that will provide a safe escape for the crew in an emergency on the launch pad or during the climb to orbit
- Completed March 2008

# Ares I-X Flight Test Overview

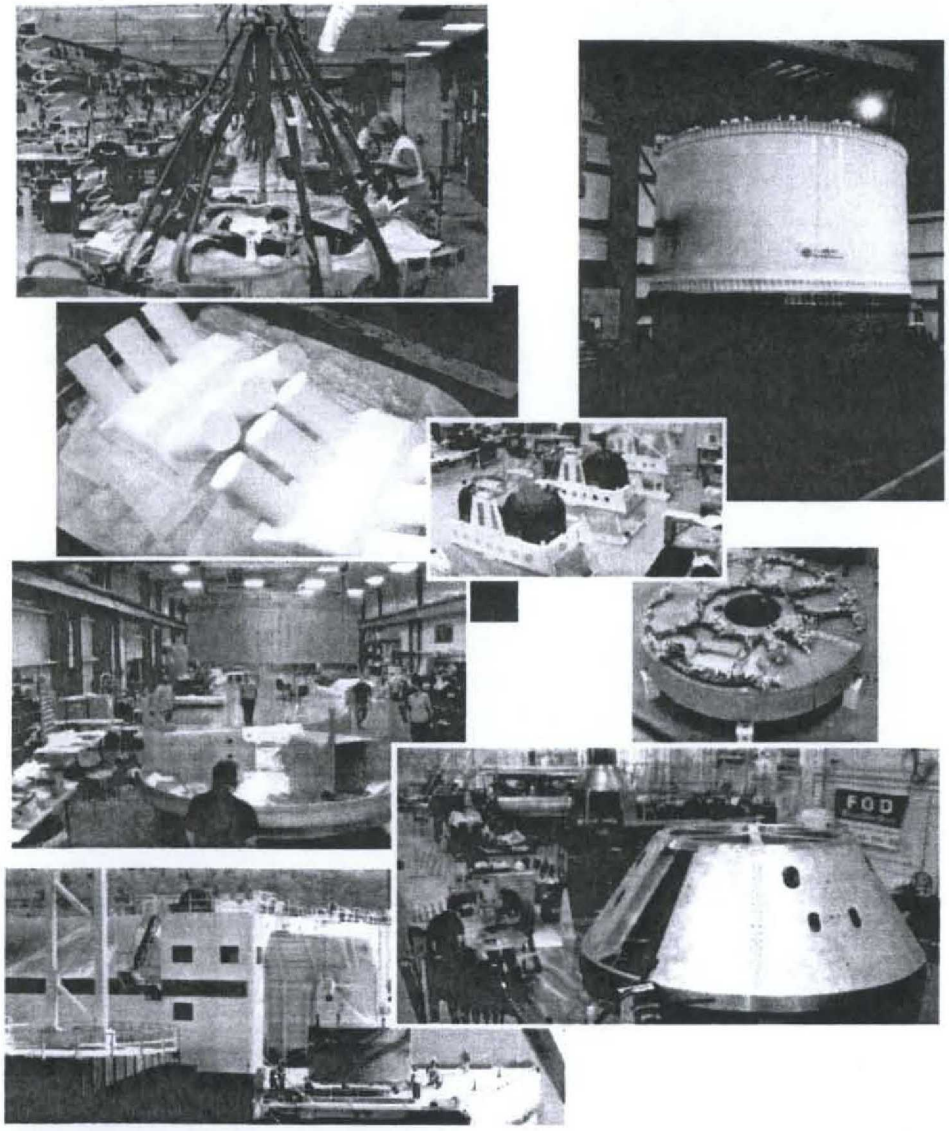







- **Ares I-X is the first suborbital, developmental flight test of Ares I, which will:**
  - Demonstrate control of a dynamically similar, integrated Ares I/Orion, using Ares I relevant ascent control algorithms
  - Perform an in-flight separation/staging event between a Ares I -similar first stage and a representative upper stage
  - Demonstrate assembly and recovery of a new Ares I-like first stage element at KSC
  - Demonstrate first stage separation sequencing, and quantify first stage atmospheric entry dynamics, and parachute performance
  - Characterize magnitude of integrated vehicle roll torque throughout first stage flight

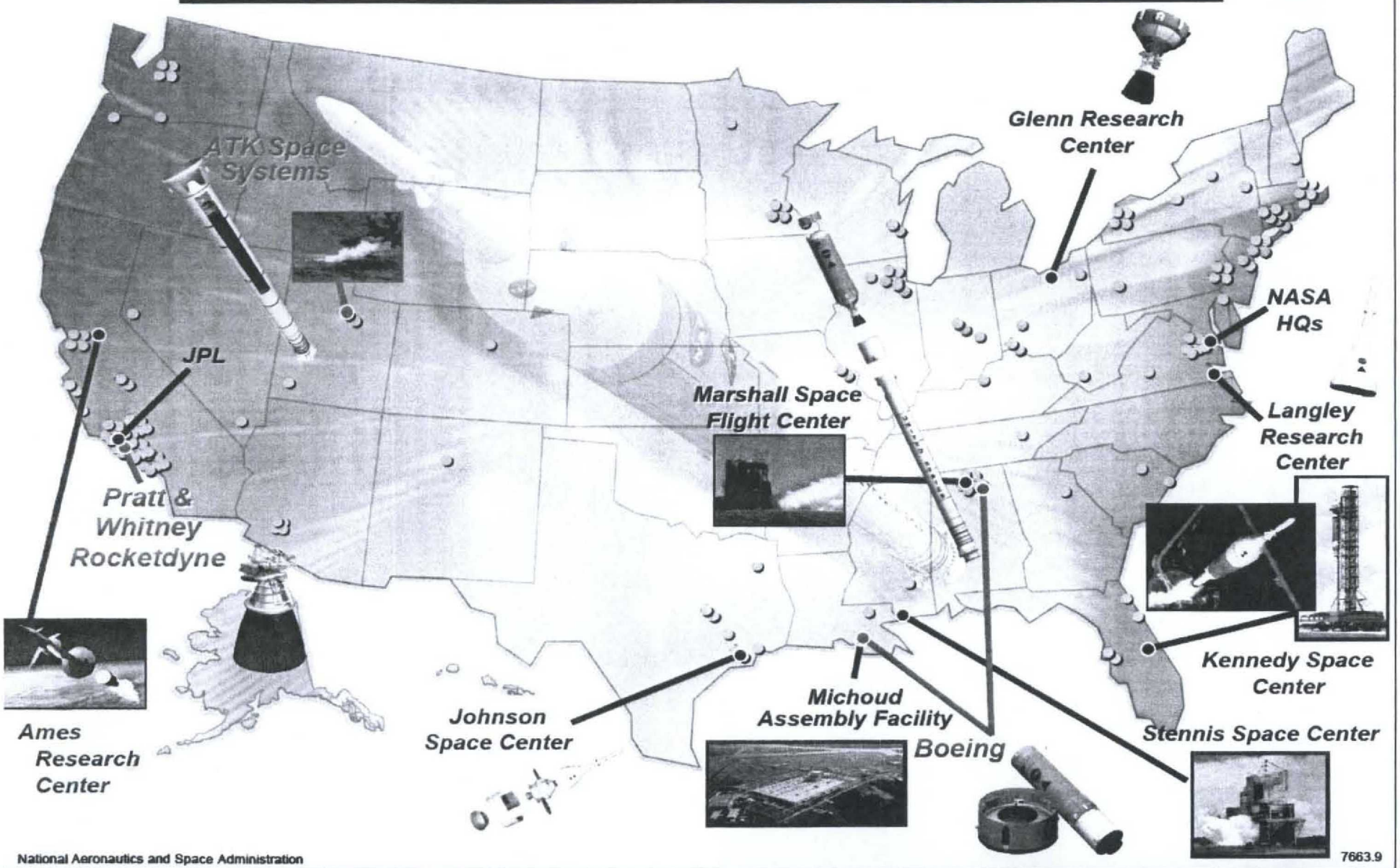
# Ares I-X Status




- **First stage:** Motor from Shuttle inventory, new forward structures being completed – delivery to KSC January – March
- **Upper Stage Simulator:** Delivered to KSC for stacking November 2008
- **Roll Control System:** Final testing in November – delivery to KSC in December
- **Avionics:** In fabrication. Hardware deliveries October – March
- **Crew Module / Launch Abort System Simulator:** In fabrication – delivery to KSC January
- **Ground Systems & Operations:** Operational readiness reviews November – June
- **Launch Scheduled for July 2009**

# 3,700 Ares Team Members Nationwide

*Over 200 Different Organizations*



# What progress have we made?

NASA

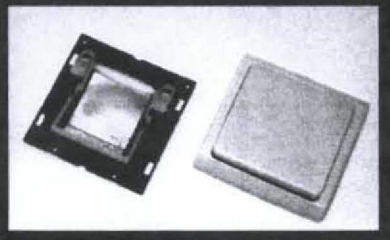
For more information go to www.nasa.gov/ares

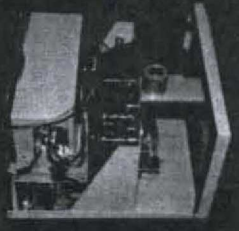
# Down-to-Earth Benefits from the Space Economy

NASA

*NASA powers innovation that creates new jobs, new markets, and new technologies*

- **Personal Health**
  - Eye tracker for LASIK surgery
  - Breast biopsy system
  - 3D Imaging for surgery
- **Consumer Products**
  - Wireless light switch
  - Remote appliance programmer
  - Global Positioning Systems (GPS)
- **Environmental**
  - Water Filtration system
  - Environmentally friendly chemical cleanup
- **Security**
  - Stair-climbing tactical robot
  - Crime scene video enhancement



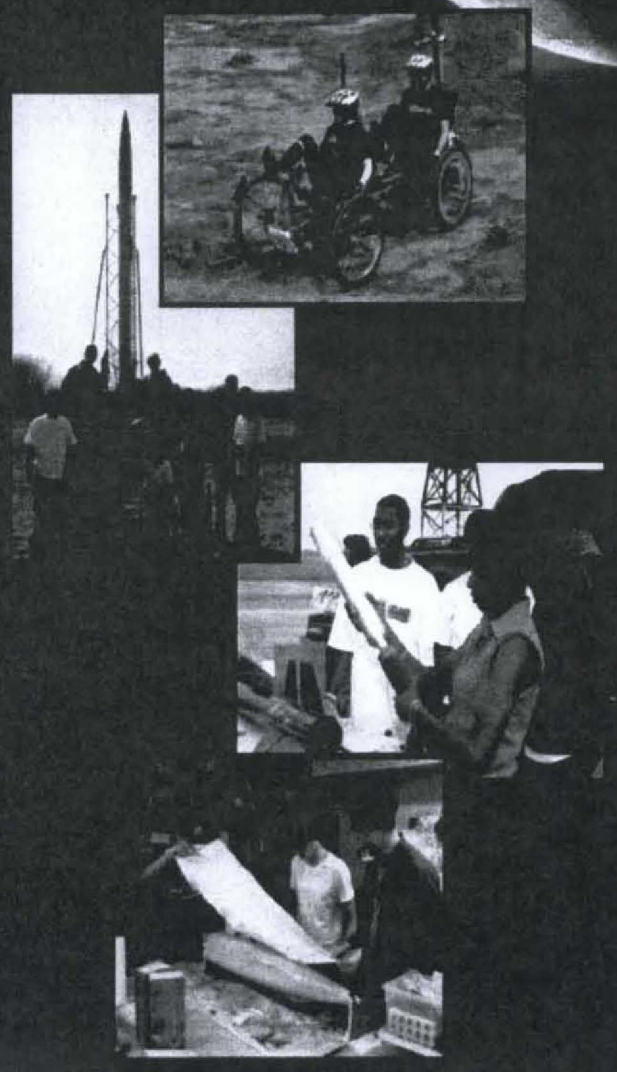
*For more information see http://technology.jsc.nasa.gov*

***Every Dollar Invested in Space is Spent on Earth***

# NASA Explores for Answers that Power Our Future

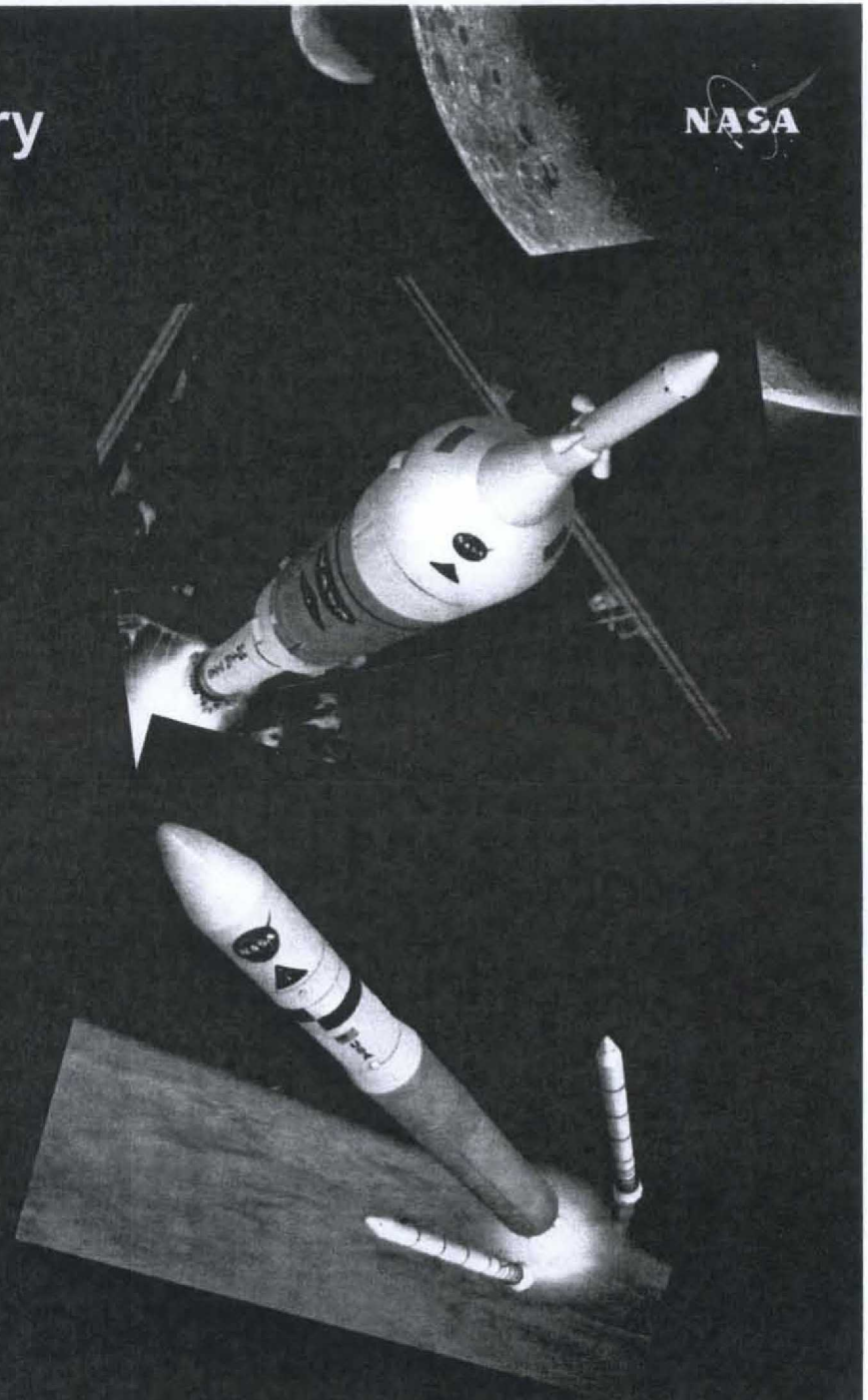
*NASA powers inspiration that encourages future generations to explore, learn, and build a better future.*

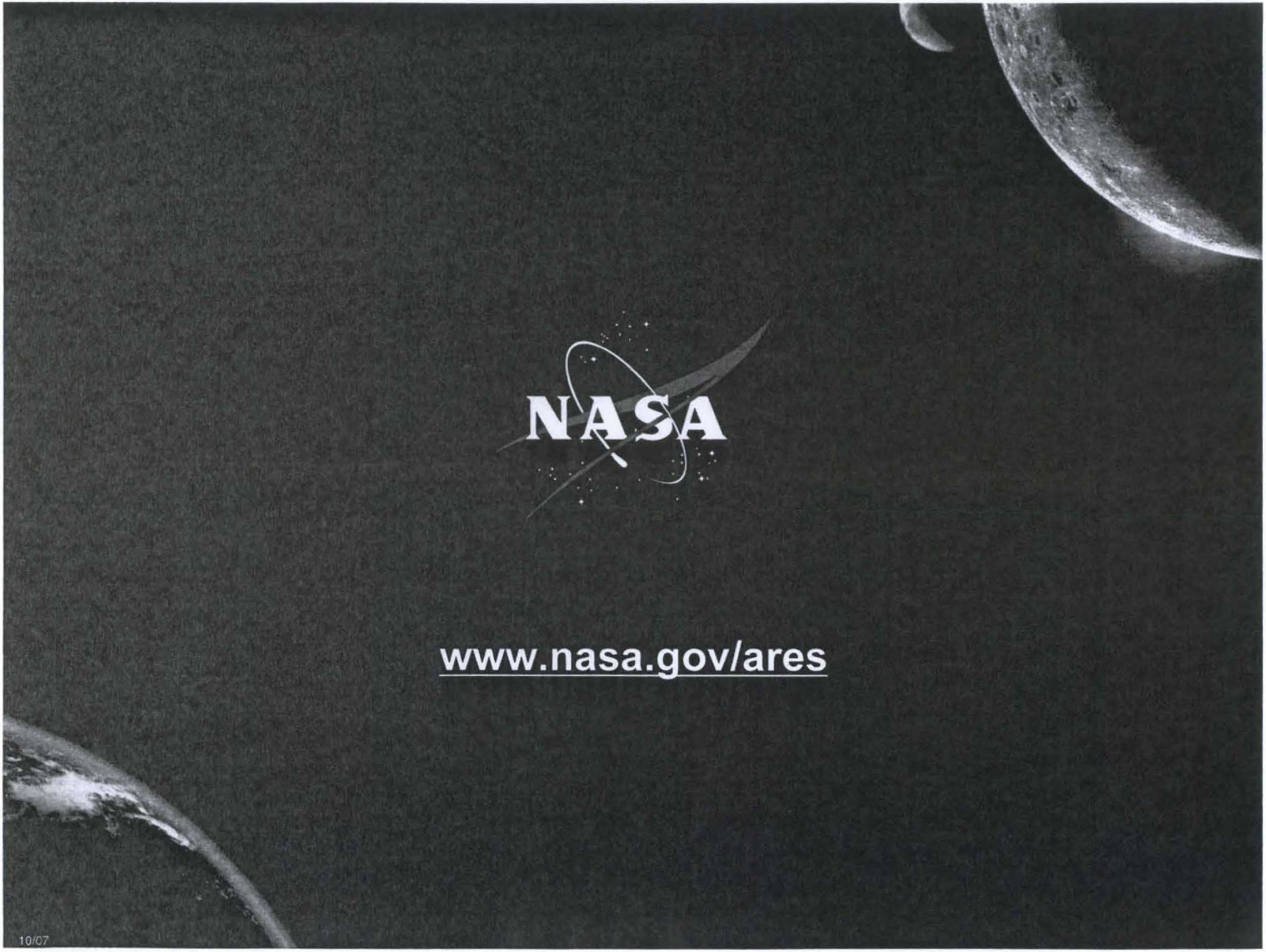
- **NASA relies on a well-educated U.S. workforce to carry out missions of scientific discovery that improve life on Earth.**
- **America's technological edge is diminishing.**
  - Fewer engineering graduates from U.S. colleges and universities
  - More engineering and science graduates in other countries
- **The global marketplace is increasingly competitive and technology-driven.**
- **Students need motivating goals and teachers with information to share.**
- **NASA continues to develop educational tools and experiences that inspire, educate, and motivate.**



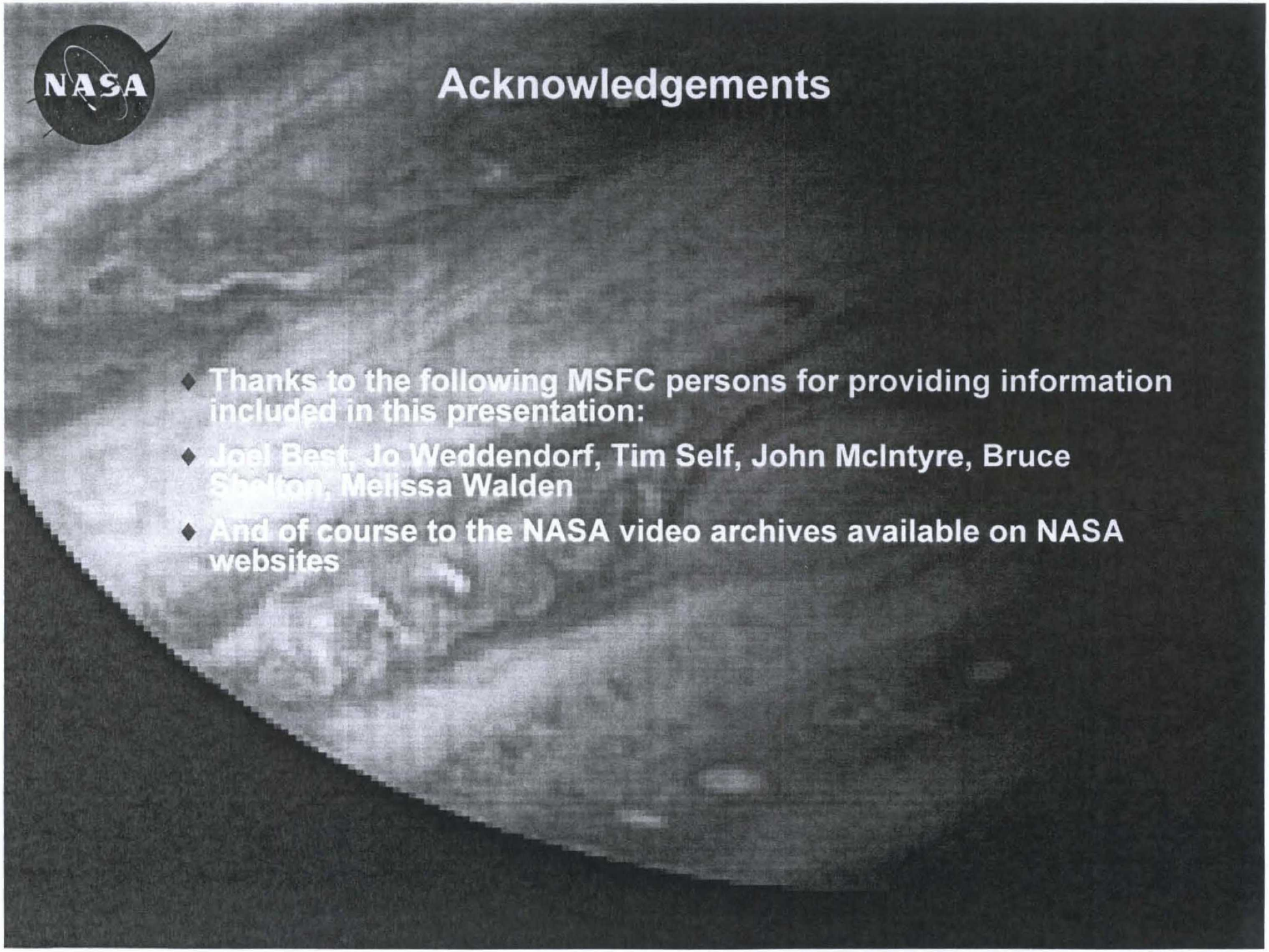
# Summary

- Human beings will explore the Moon, Mars, 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.
- Exploring the Moon will help us reach Mars and beyond.
- Team is on board and making good progress – the Ares I-X test flight is scheduled in 2009.






www.nasa.gov/ares

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