



# **APPEL Foundations of Aerospace**

## **Implementing the U.S. Space Exploration Policy**

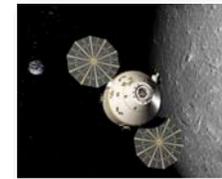
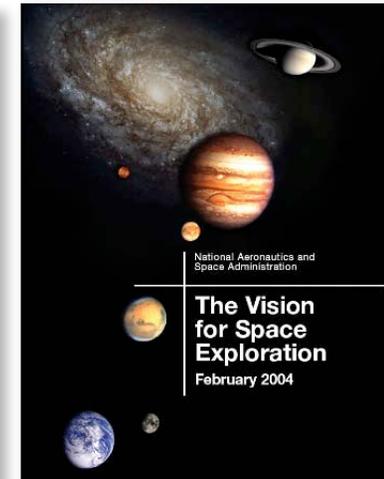
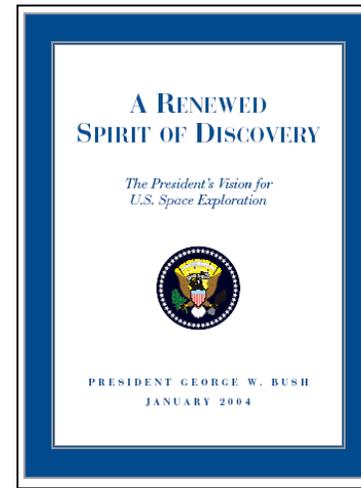
Dr. Jitendra Joshi  
NASA Exploration Systems Mission Directorate

October 28, 2008

# The Vision for Space Exploration: Foundations for Exploration



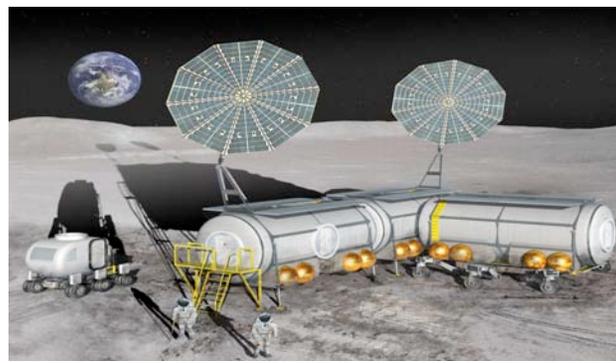
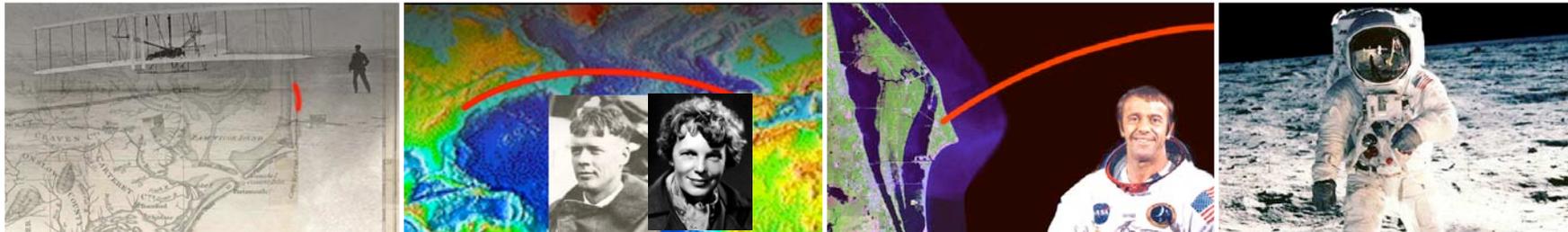
- Complete the International Space Station
- Safely fly the Space Shuttle until 2010
- Develop & fly the Crew Exploration Vehicle no later than 2014
- Return to the Moon no later than 2020
- Extend human presence across the solar system & beyond
- Implement a sustained & affordable human & robotic program
- Promote international & commercial participation in Exploration



## NASA Authorization Act of 2005

The Administrator shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program to promote exploration, science, commerce and U.S. preeminence in space, and as a stepping stone to future exploration of Mars and other destinations.

# What is the value of Exploration?



## GEOSYNCHRONOUS ORBIT

Aproximately 36,000 km/ 22,000 mi

## MID-EARTH ORBIT

Aproximately 2,000 - 36,000 km/  
1,240-22,000 mi

## LOW EARTH ORBIT

Aproximately 2,000 km/ 1,240 mi

## International Space Station

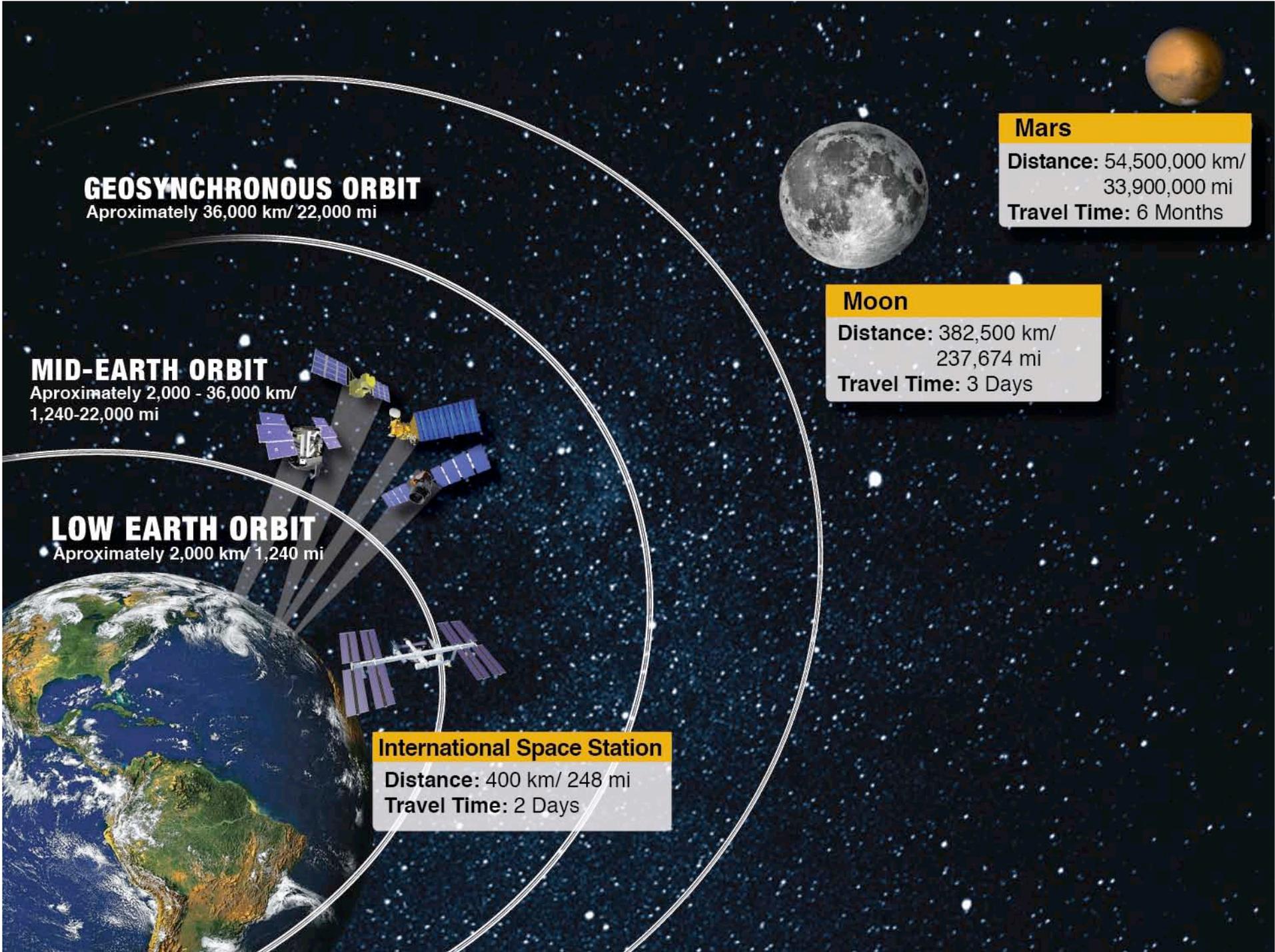
Distance: 400 km/ 248 mi  
Travel Time: 2 Days

## Mars

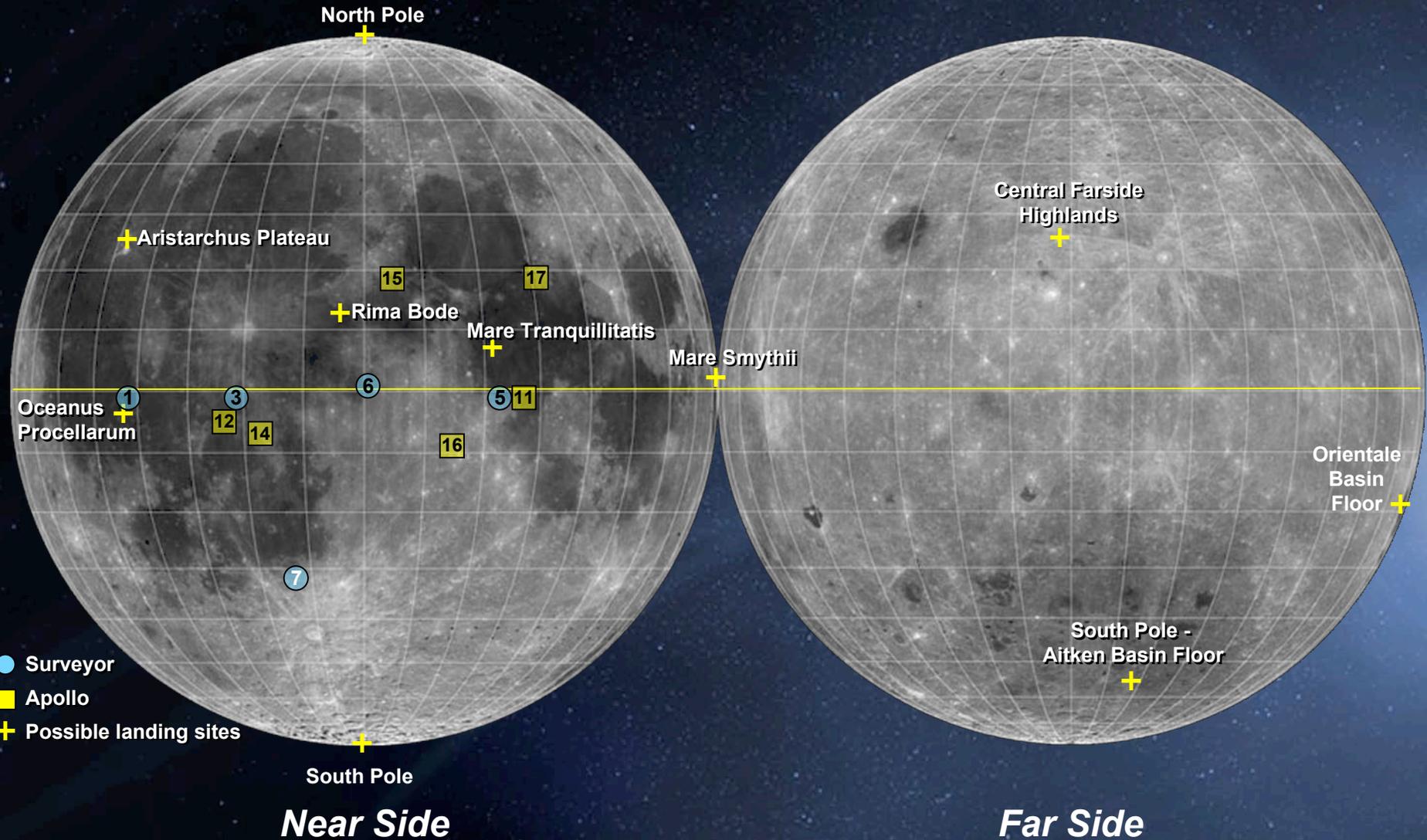
Distance: 54,500,000 km/  
33,900,000 mi  
Travel Time: 6 Months

## Moon

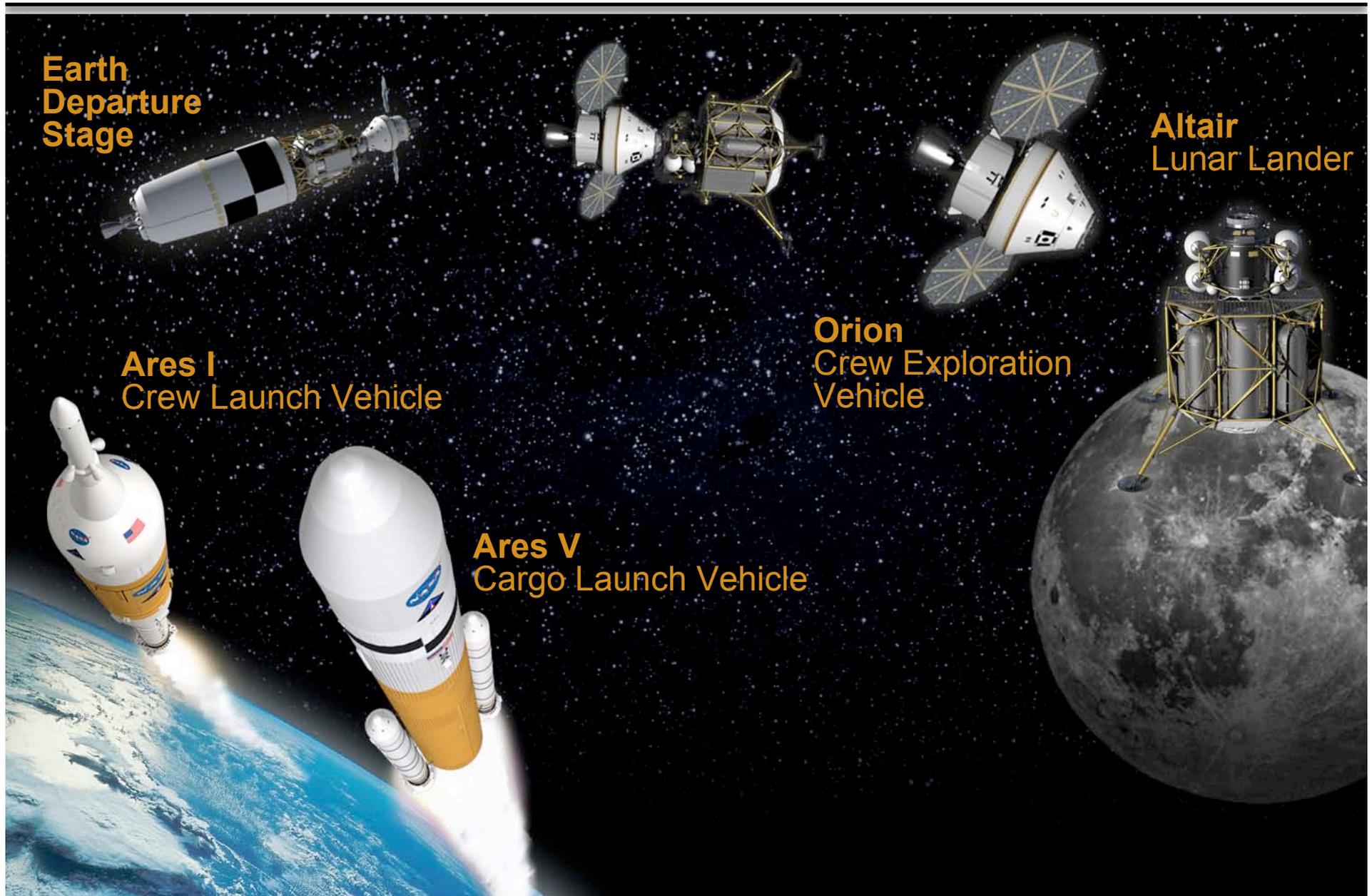
Distance: 382,500 km/  
237,674 mi  
Travel Time: 3 Days



# Why The Moon?



# Constellation Program Fleet of Vehicles



**Earth  
Departure  
Stage**

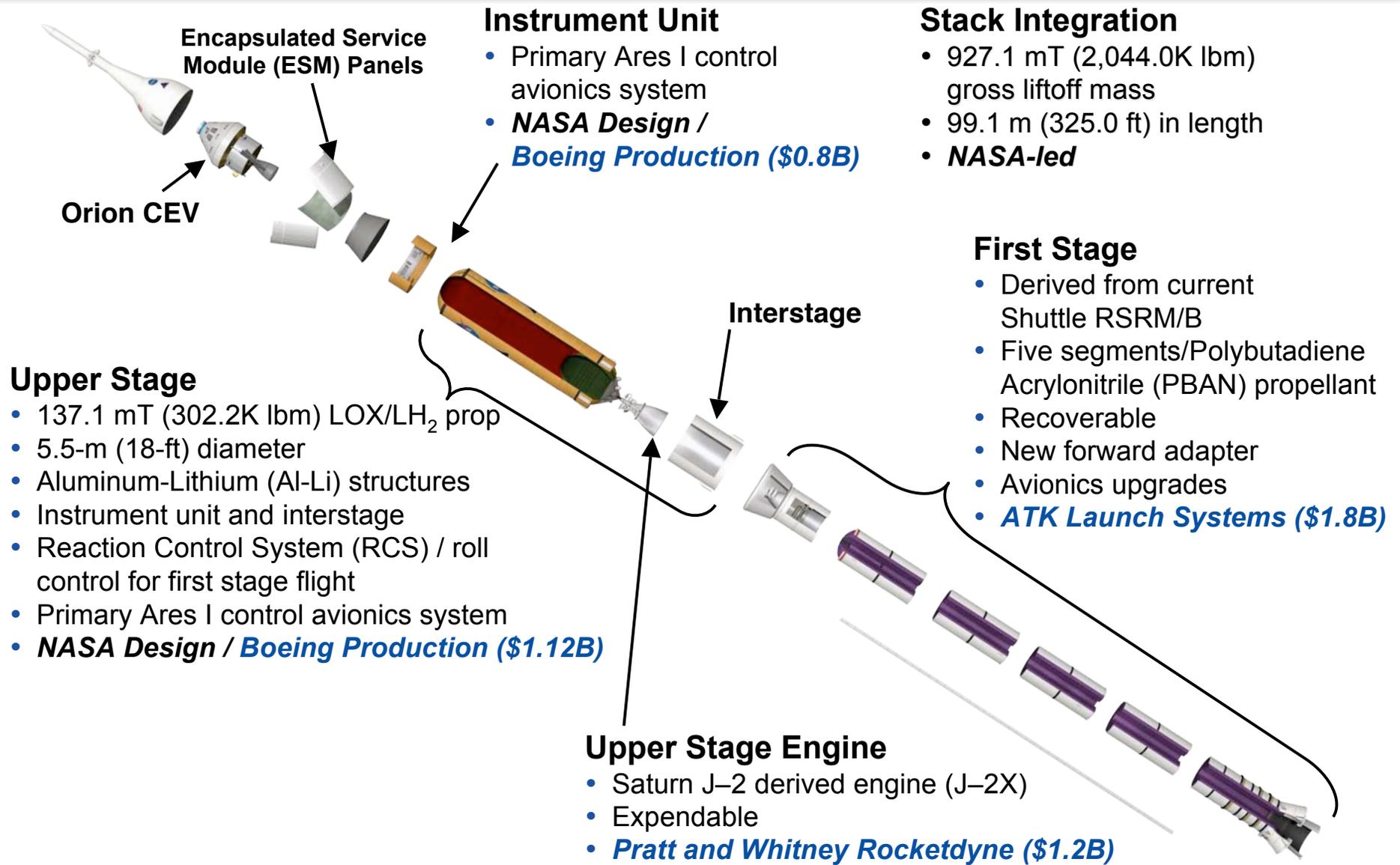
**Ares I  
Crew Launch Vehicle**

**Ares V  
Cargo Launch Vehicle**

**Orion  
Crew Exploration  
Vehicle**

**Altair  
Lunar Lander**

# Ares I Elements



# Orion Elements



## Orion Crew Exploration vehicle (JSC)

*NASA Management and Integration*

Prime contract Lockheed Martin: design, development, and production

### Crew Module (JSC)

- Crew and cargo transport
- Under Prime contract

### Launch Abort System (LaRC)

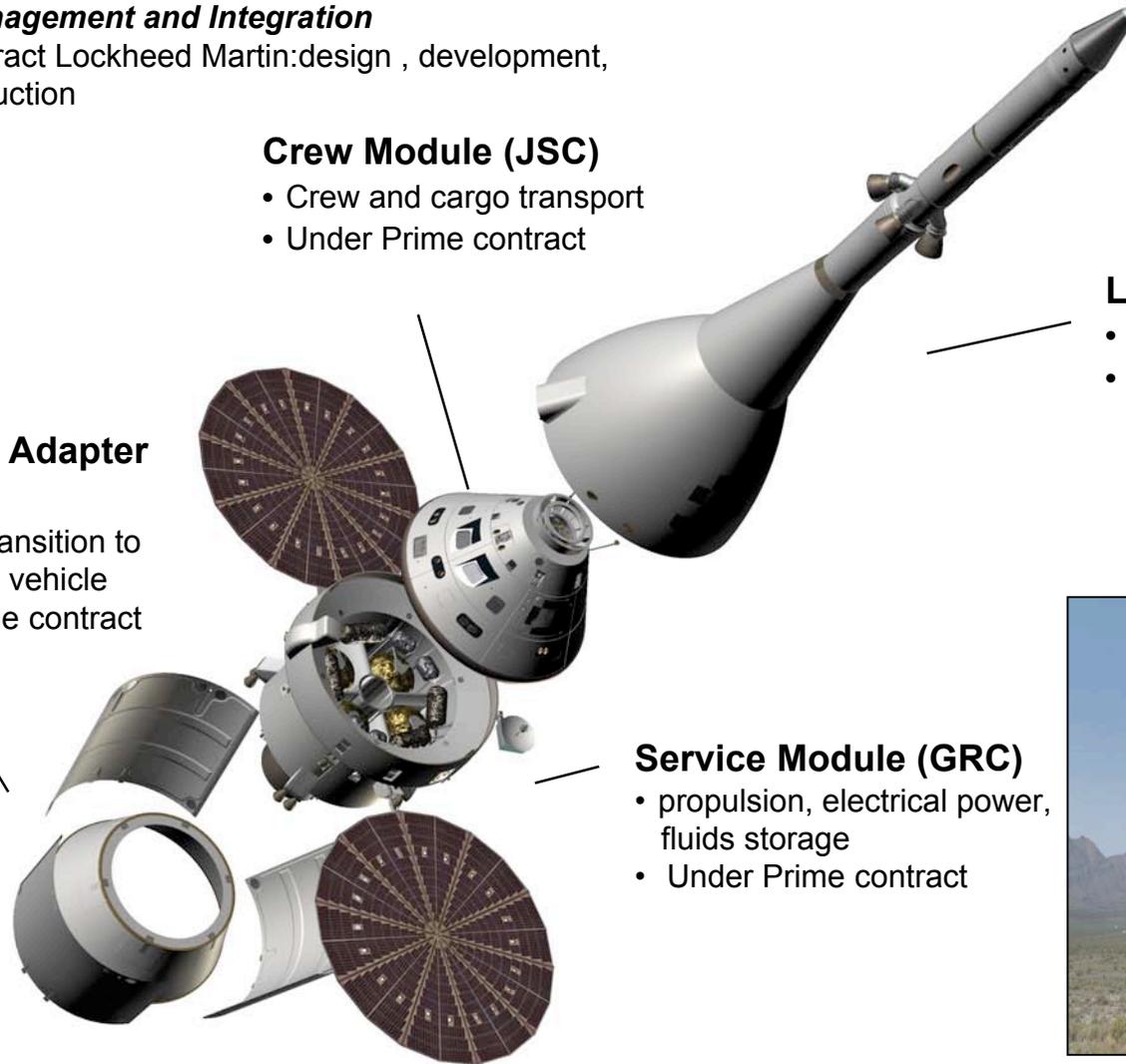
- Emergency escape during launch
- Under Prime contract

### Spacecraft Adapter (GRC)

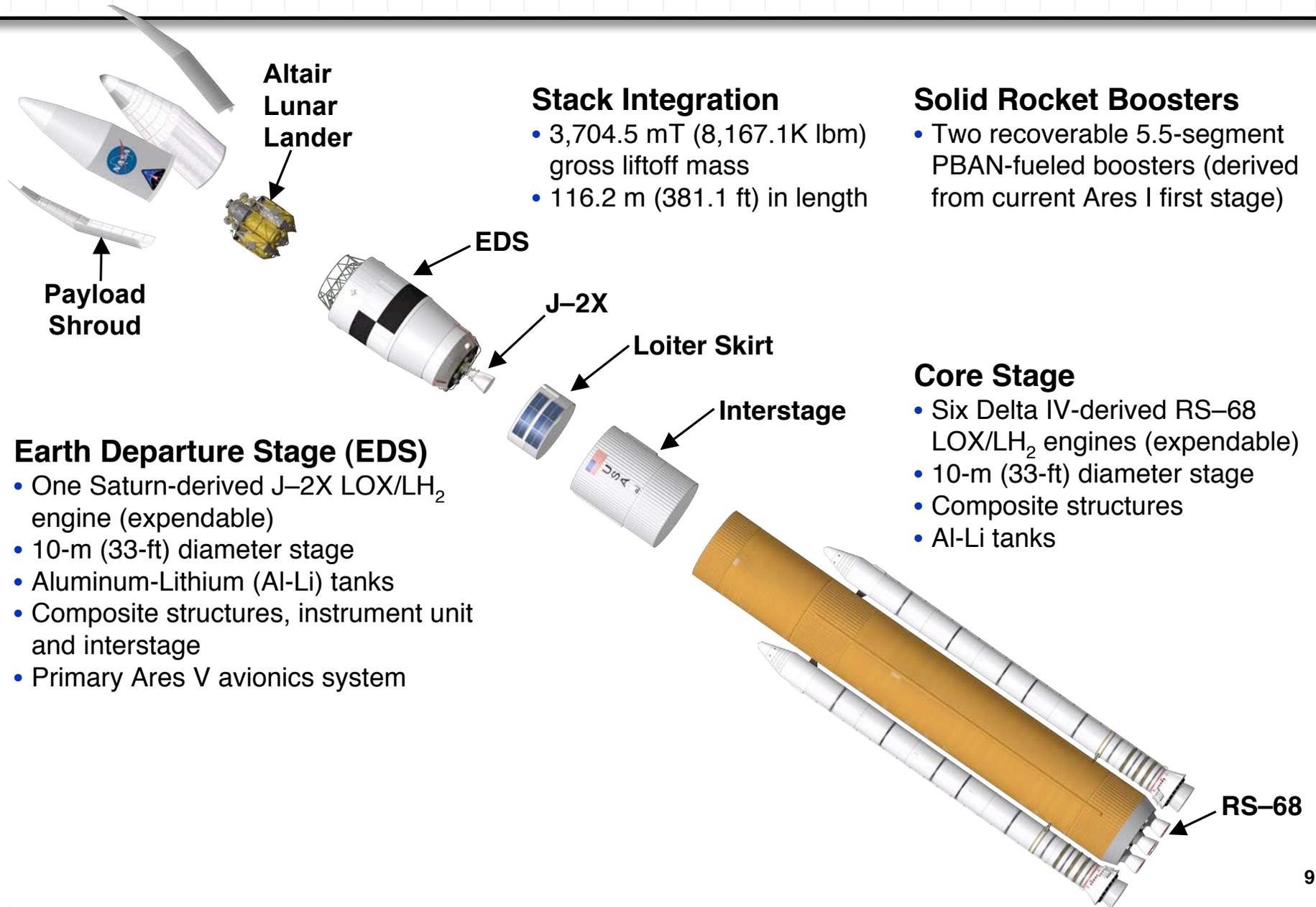
- Structural transition to Ares launch vehicle
- Under Prime contract

### Service Module (GRC)

- propulsion, electrical power, fluids storage
- Under Prime contract



# Ares V Elements



# Leveraging Our Infrastructure



- **KSC / Operations & Checkout Building**
  - Highbay for Orion final assembly



- **SSC / A-1 & A-2 Test Stands**
  - J2-X Power Pack Assembly Installed



- **KSC / Pad 39B**
  - Launch Pad and Support Facilities
  - Lightning Protection System

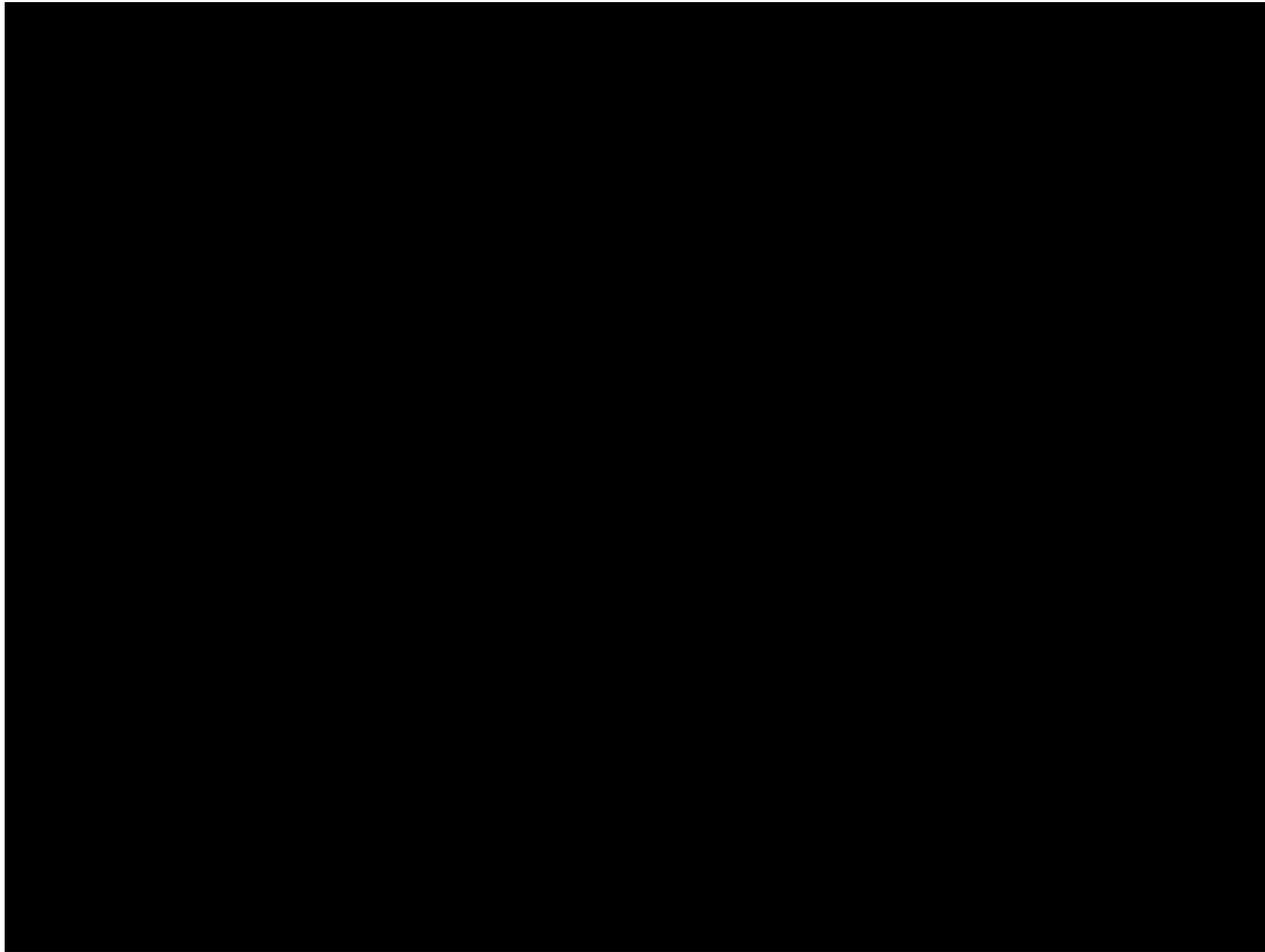


## **Michoud Assembly Facility (MAF)**

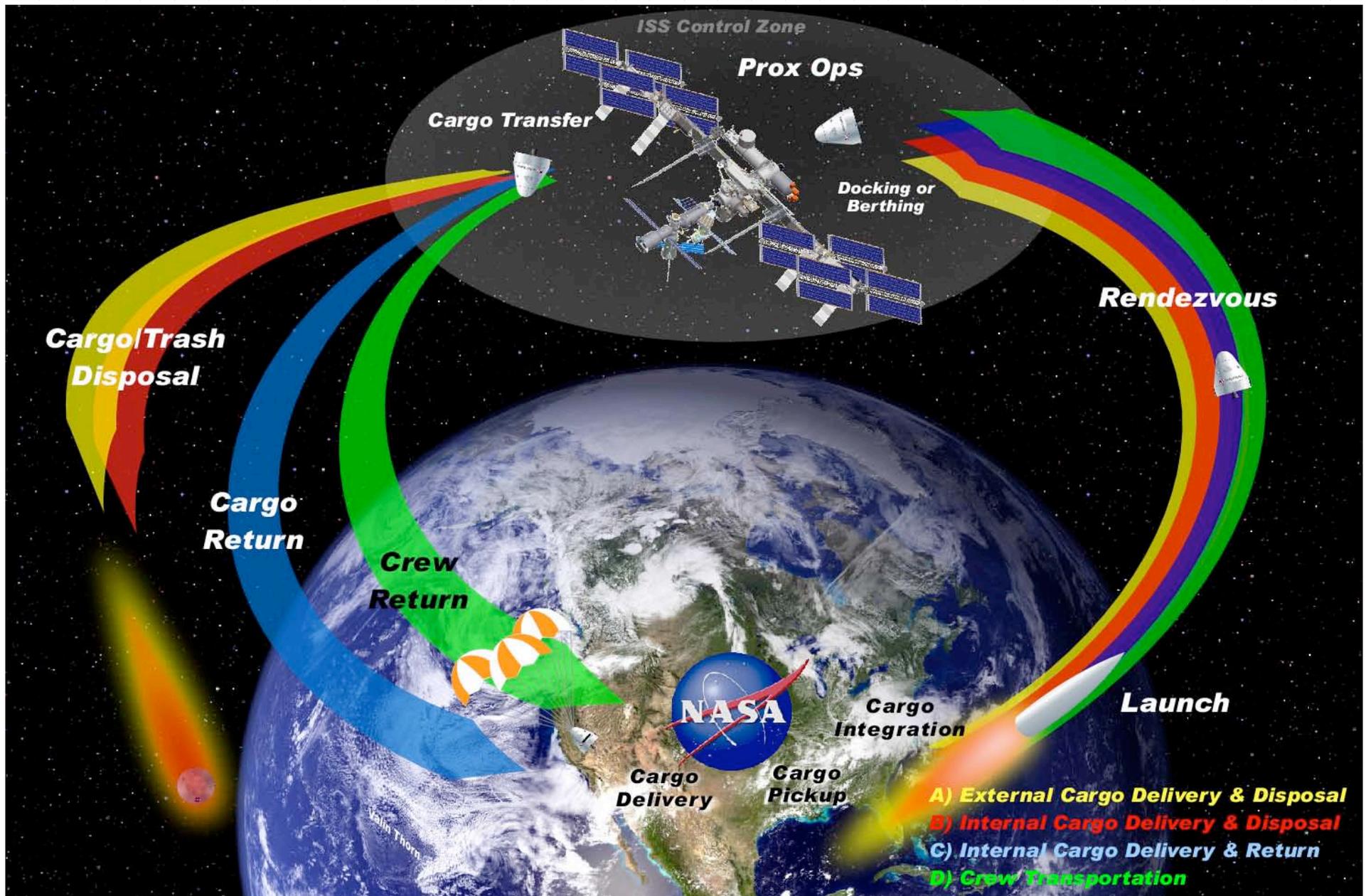
- Primary structure manufacturing
- Composite and metal fabrication
- Planned Users: Orion, Ares I Upper Stage, Ares V Earth Departure Stage, Ares V Core Stage, COTS

# The Power to Explore

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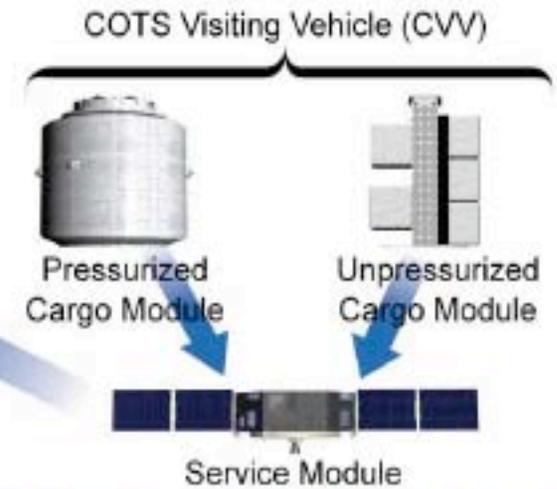
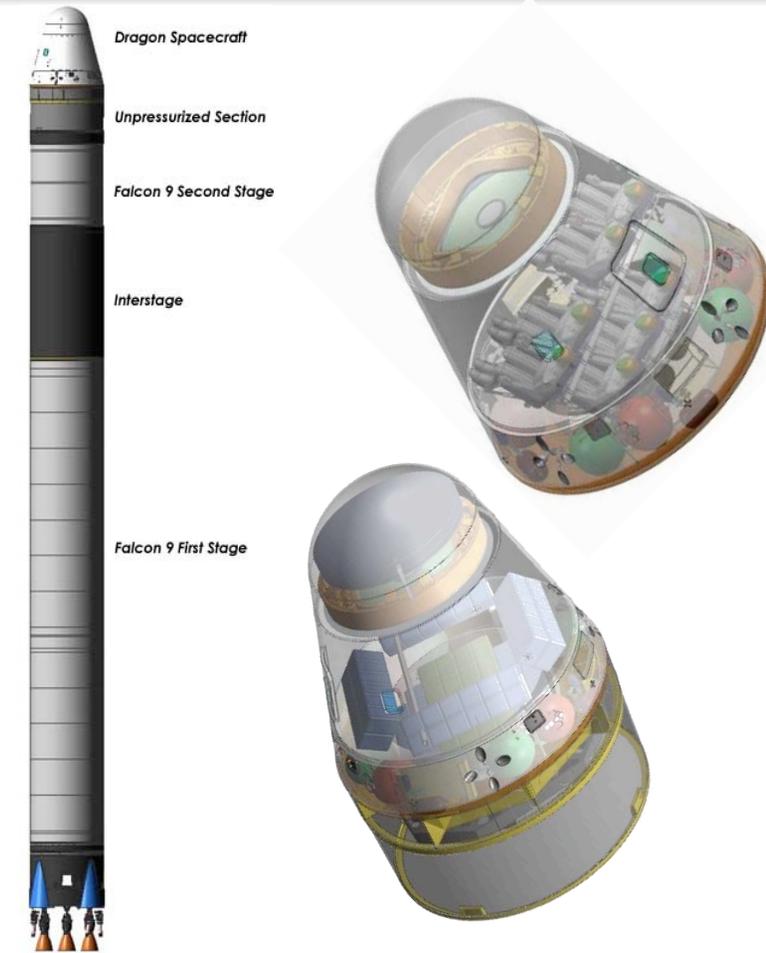
# NASA Commercial Crew/Cargo Project Commercial Orbital Transportation Services



# COTS Funded Space Act Agreements



## Orbital Sciences



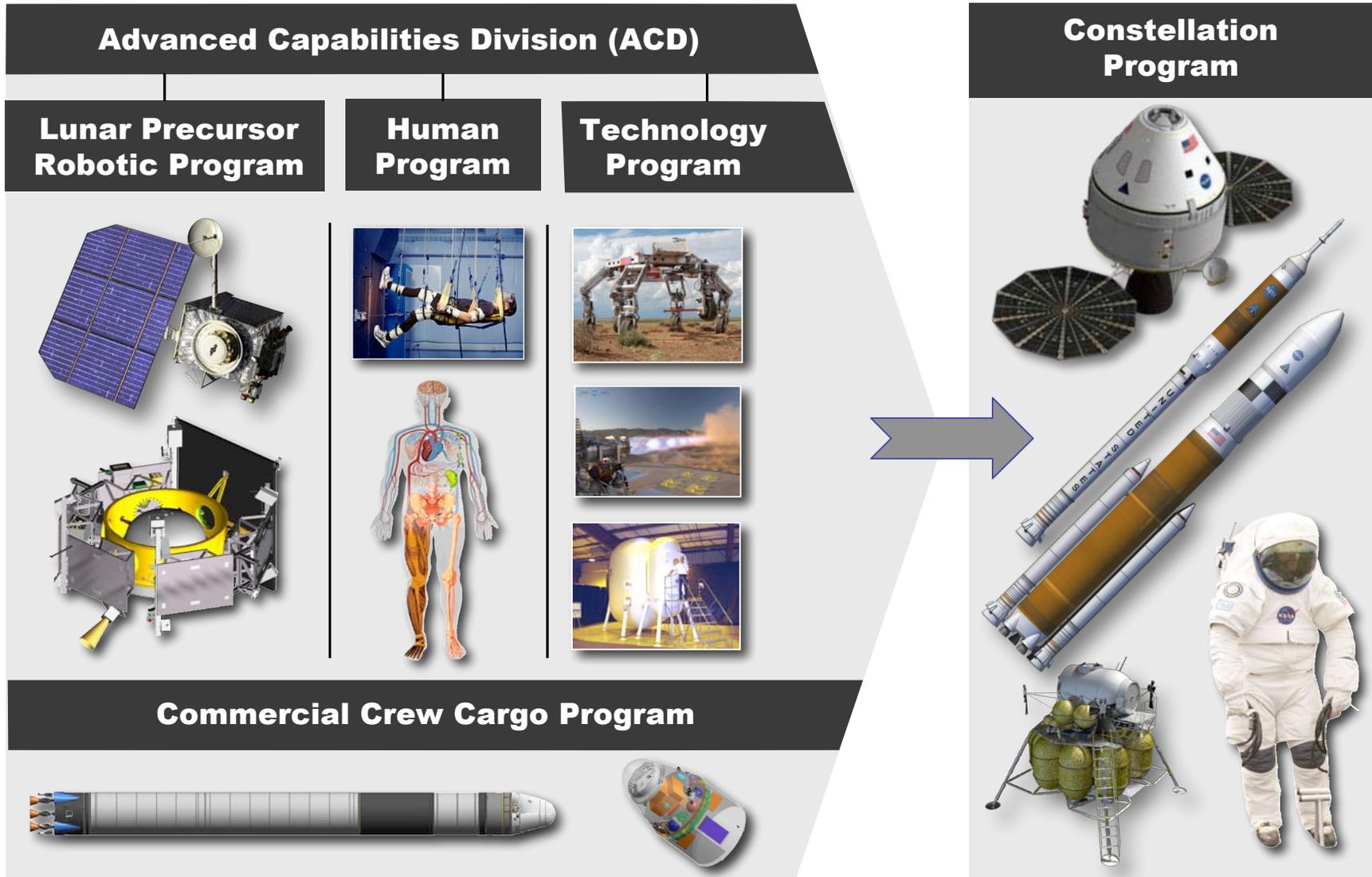
Orbital Satellite Manufacturing Facility    Astrotech Payload Processing Facility    Orbital Mission Control Center

Ground & Mission Operations Infrastructure

COTS Ph1 068k



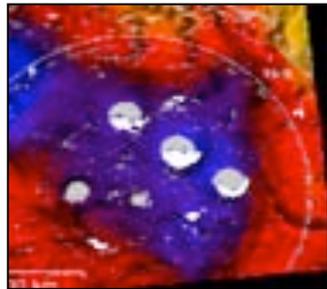
# Enabling Exploration



# Lunar Reconnaissance Orbiter (LRO)



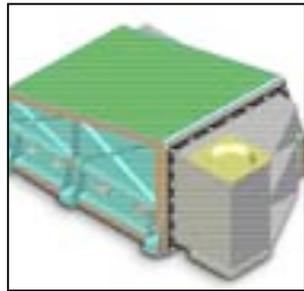
**LROC** - Lunar Reconnaissance Orbiter Camera



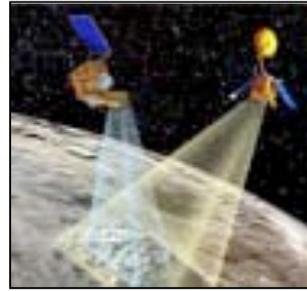
**LEND** - Lunar Exploration Neutron Detector



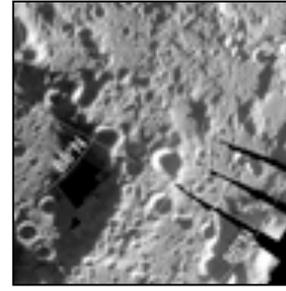
**DLRE** - Diviner Lunar Radiometer Experiment



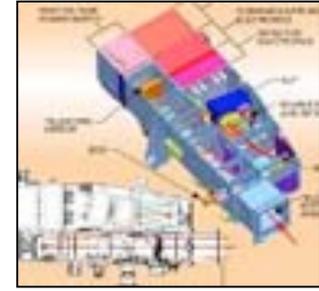
**CRaTER** - Cosmic Ray Telescope for the Effects of Radiation



**MINI-RF** Synthetic Aperture Radar

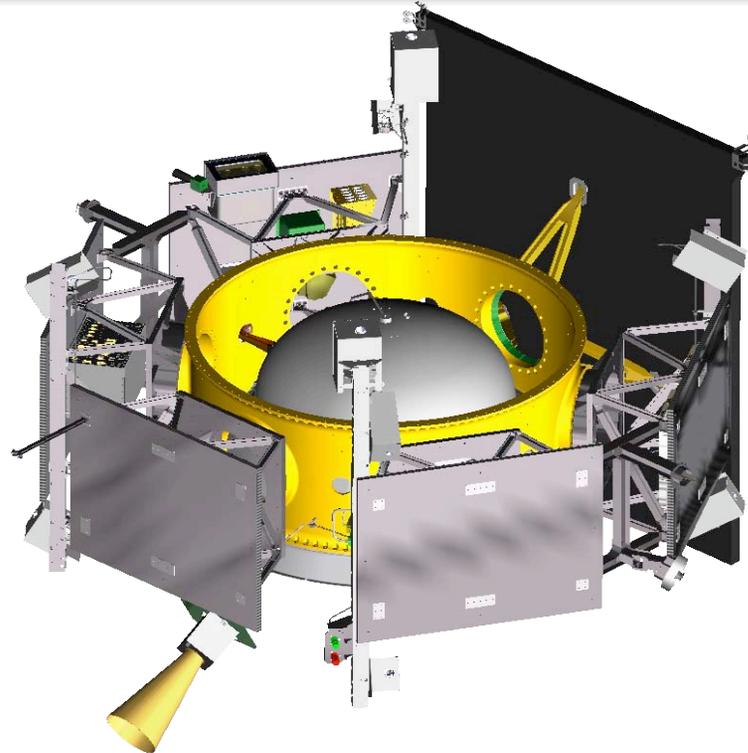


**LOLA** - Lunar Orbiter Laser Altimeter



**LAMP** - Lyman Alpha Mapping Project

# Lunar CRater Observation & Sensing Satellite



## Mid-Infrared Camera

- Curtain, Crater Temperature
- Curtain Morphology
- Water Ice



## Visible Camera

- Impact Context
- Curtain Morphology



## Near Infrared Camera

- Water Ice / Curtain Morphology
- NIR Context



## Visible Spectrometer

- Flash Spectroscopy
- Water Vapor
- Organics



## Near Infrared Spectrometers

- Curtain Water Ice & Vapor
- Hydrated minerals

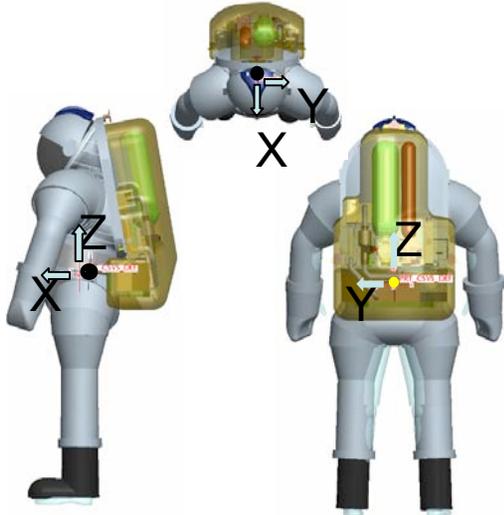
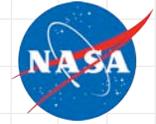
# LRO/LCROSS





# LRO/LCROSS Mission Profile

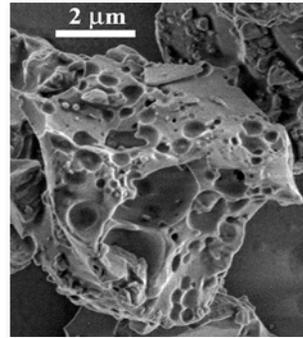
# Human Research Program Activities



EVA physiology testing has improved the design of the new planetary suit with a lower center of gravity.



Completed investigation of countermeasure for risk of renal stone formation during long duration missions



NASA scientists have produced activated simulants of lunar dust for toxicity testing.



Completed pilot study on intermittent exposure to artificial gravity utilizing the short arm centrifuge at the University of Texas Medical Branch, Galveston, TX



Direct measurements of Oxygen Uptake Measurement using Pulmonary Function System will improve understanding of astronaut fitness level in flight



Nutritional Status Assessment investigation started. Will provide insights into time course of changes in nutritional status, bone loss

# Research and Technology Development on the ISS

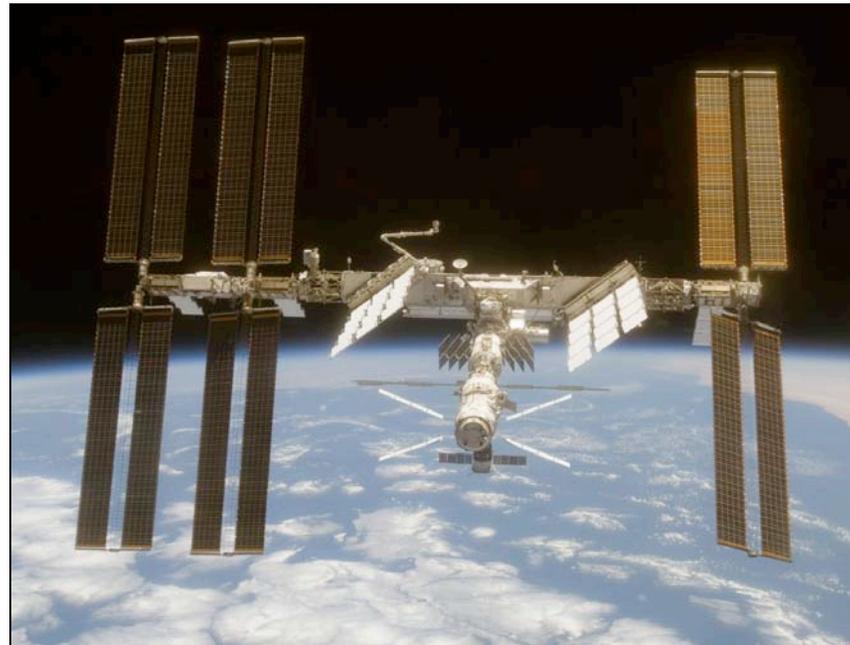


Lab-on-a-Chip Application Development - Portable Test System

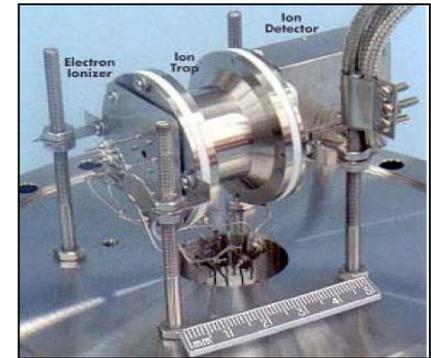


CIR

**Advanced Environmental Monitoring & Control:** Developing ENose and Vehicle Cabin Air Monitor (VCAM) instruments to detect atmospheric contaminants, and LOCAD-PTS instrument to detect harmful bacteria.



**ISS Research:** Developing Combustion Integrated Rack (CIR) and Fluids Integrated Rack (FIR) to conduct basic microgravity research on combustion and fluid physics



VCAM



FIR

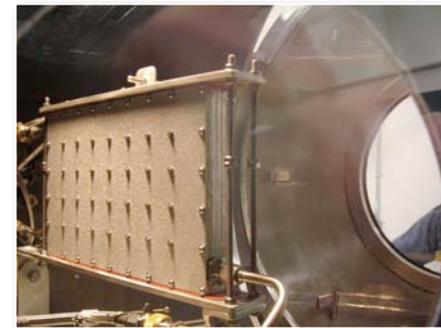
# Technology Development for Orion



**AR&D Sensors:** Characterizing optical and laser sensors that measure the range and orientation of a target vehicle during autonomous rendezvous and docking.



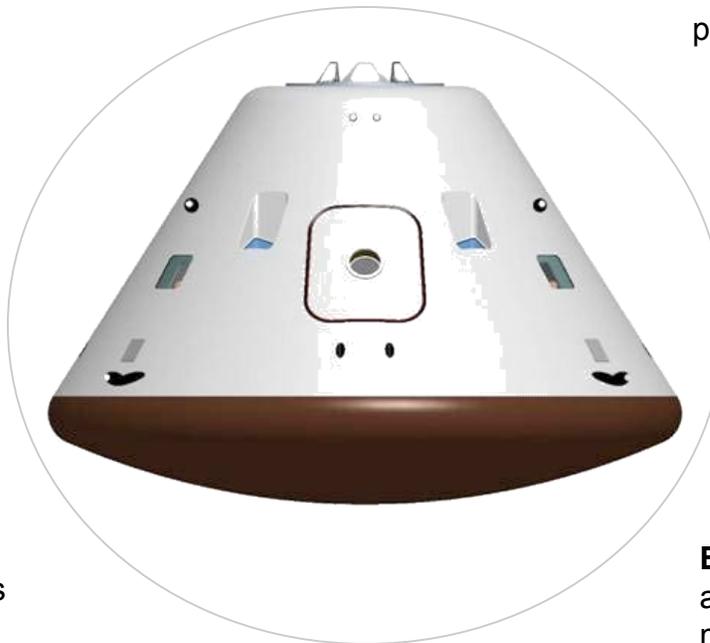
**Structures & Materials:** Developing lightweight, high-strength parachute materials.



**Thermal Control:** Developing prototype flash evaporator, sublimator, and composite radiator for thermal control during different phases of mission.



**Ablative TPS:** Qualifying thermal protection system materials in arcjet tests and developing a prototype heat shield.



**Exploration Life Support:** Developing a prototype carbon dioxide and moisture removal system.

# Technology Development for Ares



**Structures & Materials:** Developing friction stir welding and spin forming manufacturing processes for Ares I Upper Stage propellant tanks.



**Integrated Systems Health Monitoring:** Developing health monitoring system for Solid Rocket Motor.



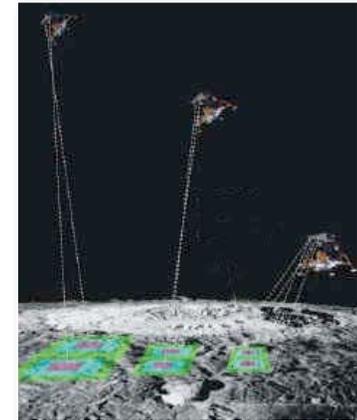
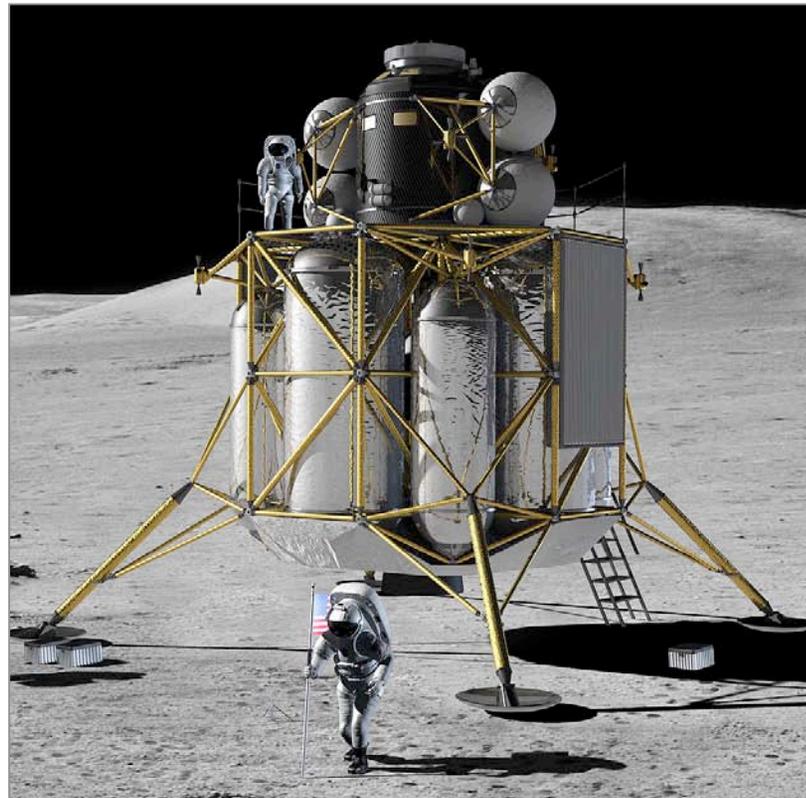
# Technology Development for the Lunar Lander



**Propulsion & Cryogenics:**  
Prototype LOX-Methane  
engine for ascent stage



**Propulsion & Cryogenics:**  
Prototype deep throttling RL-  
10 engine for descent stage



**Autonomous Precision  
Landing:** Guidance  
algorithms and lidar sensors  
to enable precision landing  
and hazard avoidance.



**Propulsion & Cryogenics:**  
Zero boil off cryogenic  
propellant storage to enable  
long duration missions

# Technology Development for EVA



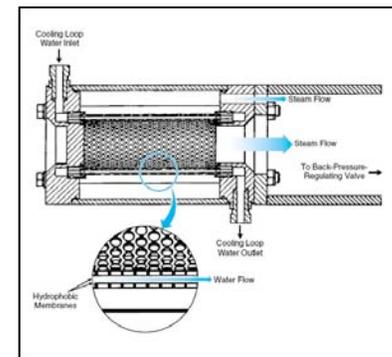
**Energy Storage:** High energy density lithium-ion batteries for Portable Life Support System



**Life Support:** High pressure oxygen supply and carbon dioxide removal systems

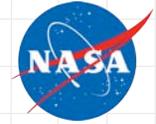


**Dust Mitigation:** Dust resistant fabrics and seals



**Thermal Control:** Suit water membrane evaporator

# Technology Development for the Lunar Outpost



**Human Robotic Systems:** Developing surface mobility systems to transport crew and large payloads across lunar surface.



**Energy Storage:** Developing lithium-ion batteries and regenerative fuel cells to power lunar surface systems.



**Fission Surface Power:** Developing concepts and technologies for affordable nuclear power systems.



**Structures & Materials:** Developing structural concepts for lunar surface habitats.



**In-Situ Resource Utilization:** Developing systems to produce oxygen from lunar regolith



**Dust Mitigation:** Characterizing effects of lunar dust on surface systems and developing technologies to prevent dust accumulation.

# Integrated Analog Testing

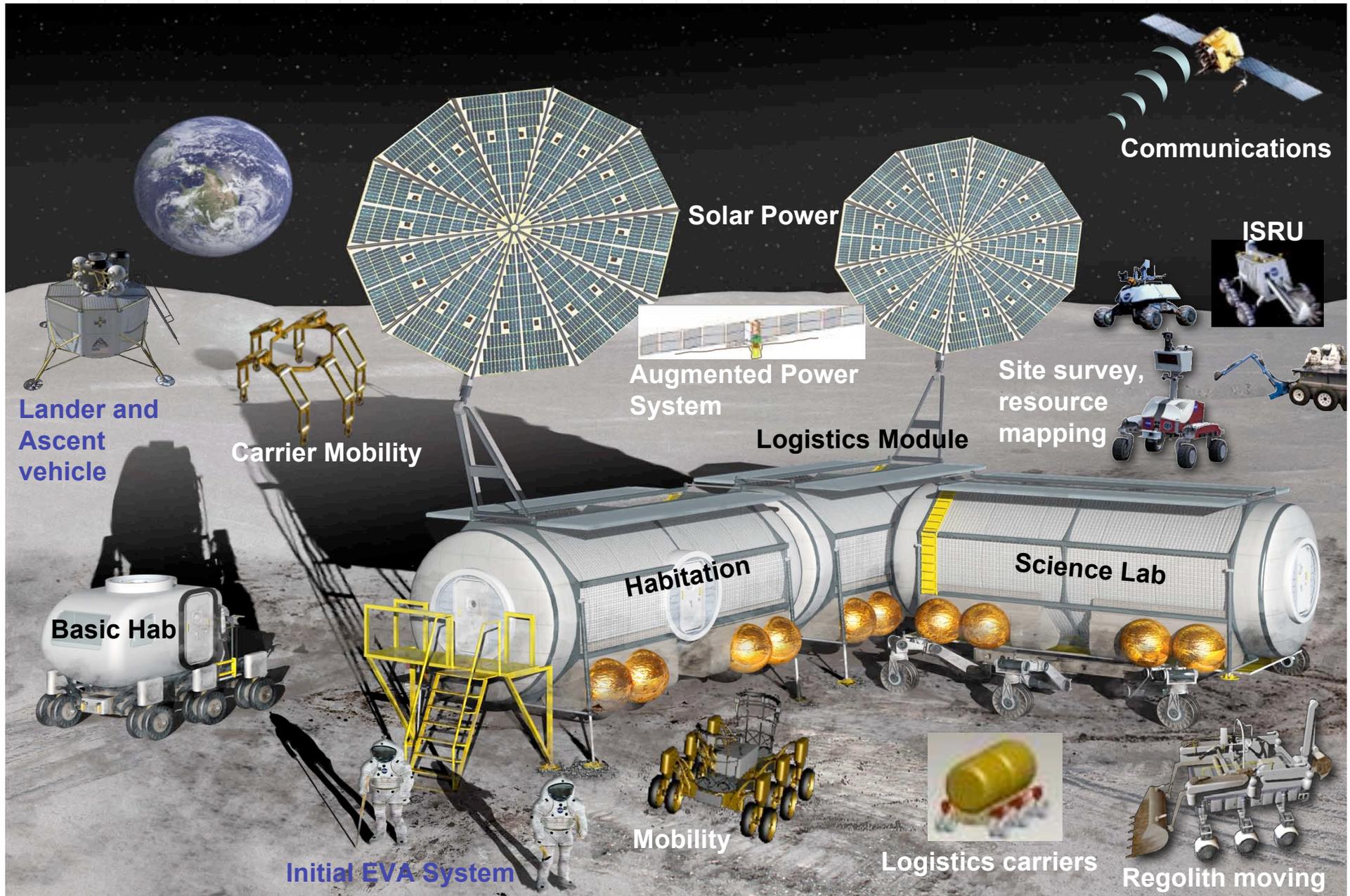


# Outposts on the Moon



Preliminary Designs

# Notional Elements of an Outpost

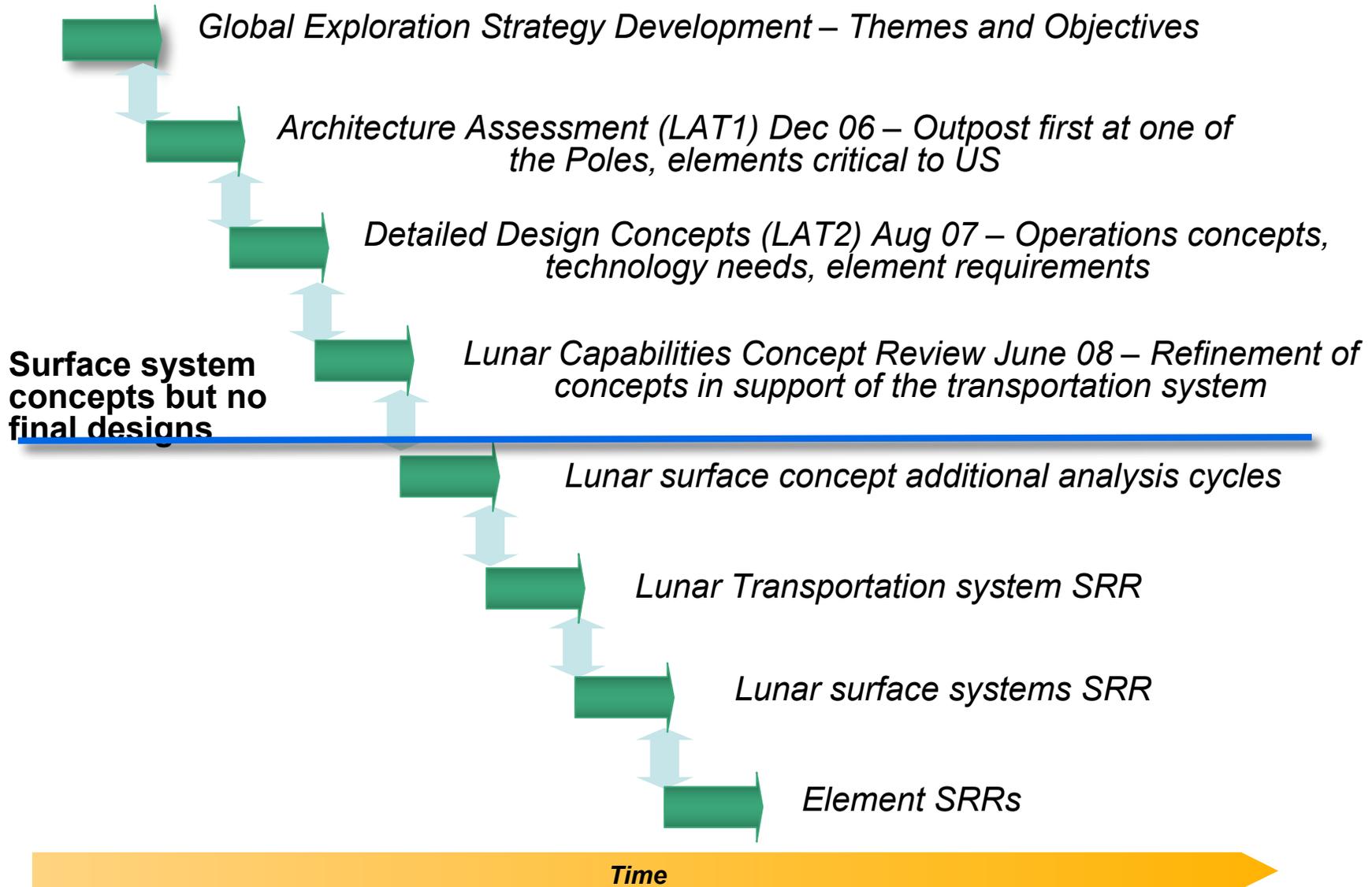


# Global Plan: Exploration Strategy



# Architecture Driven By A Strategy

## Where We Have Been and Next Steps





# Backup Slides

# Why Do We Explore?



- **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



# Learn more about Exploration

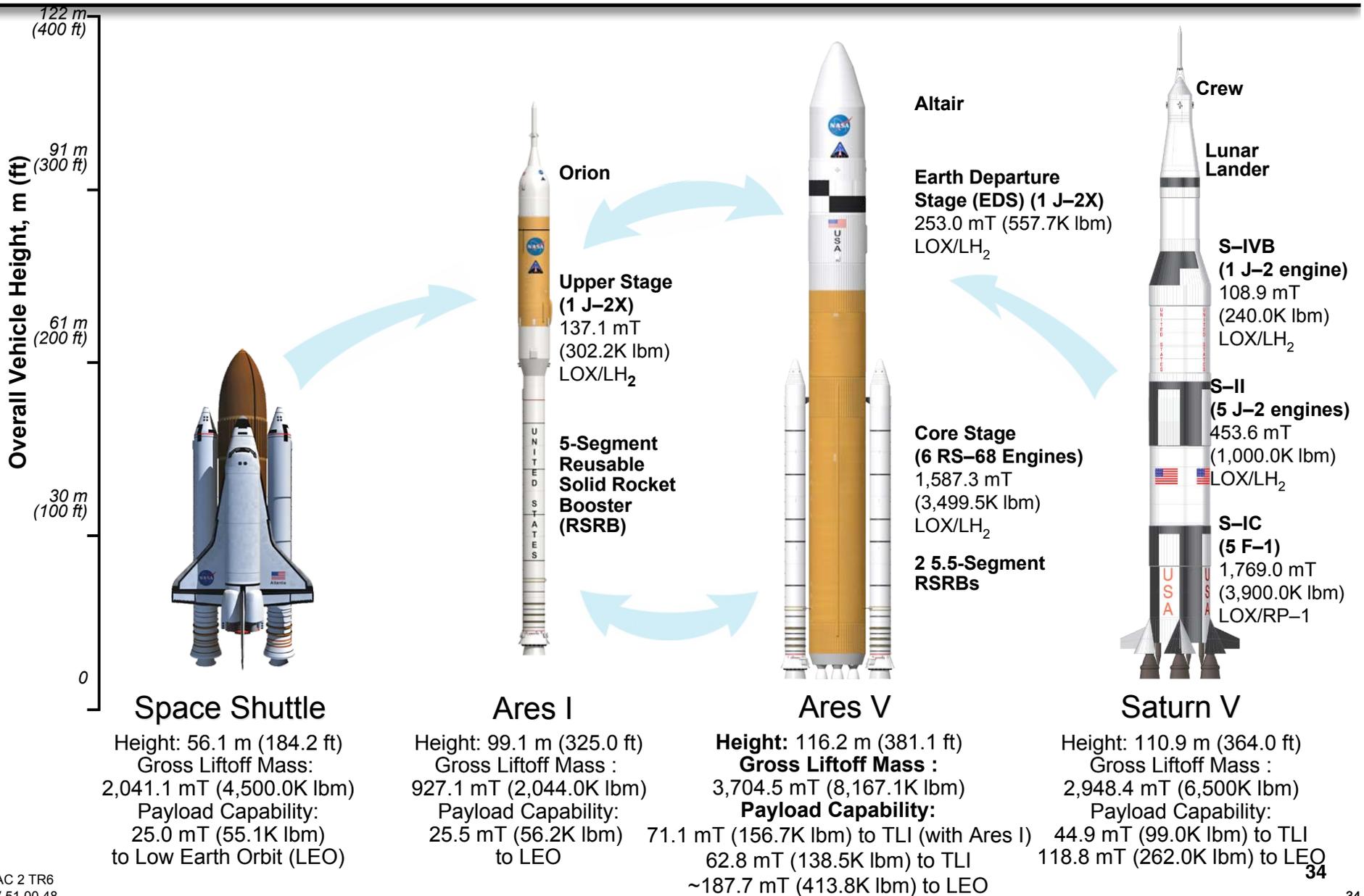


- The NASA Homepage
  - [www.nasa.gov](http://www.nasa.gov)
- The NASA Exploration Homepage
  - <http://www.nasa.gov/exploration>
- Download NASA pod casts
  - <http://www.nasa.gov/multimedia/podcasting/index.html>
- Watch NASA TV
  - At home (see local providers for listings)
  - On the web: <http://www.nasa.gov/multimedia/nasatv/index.html>

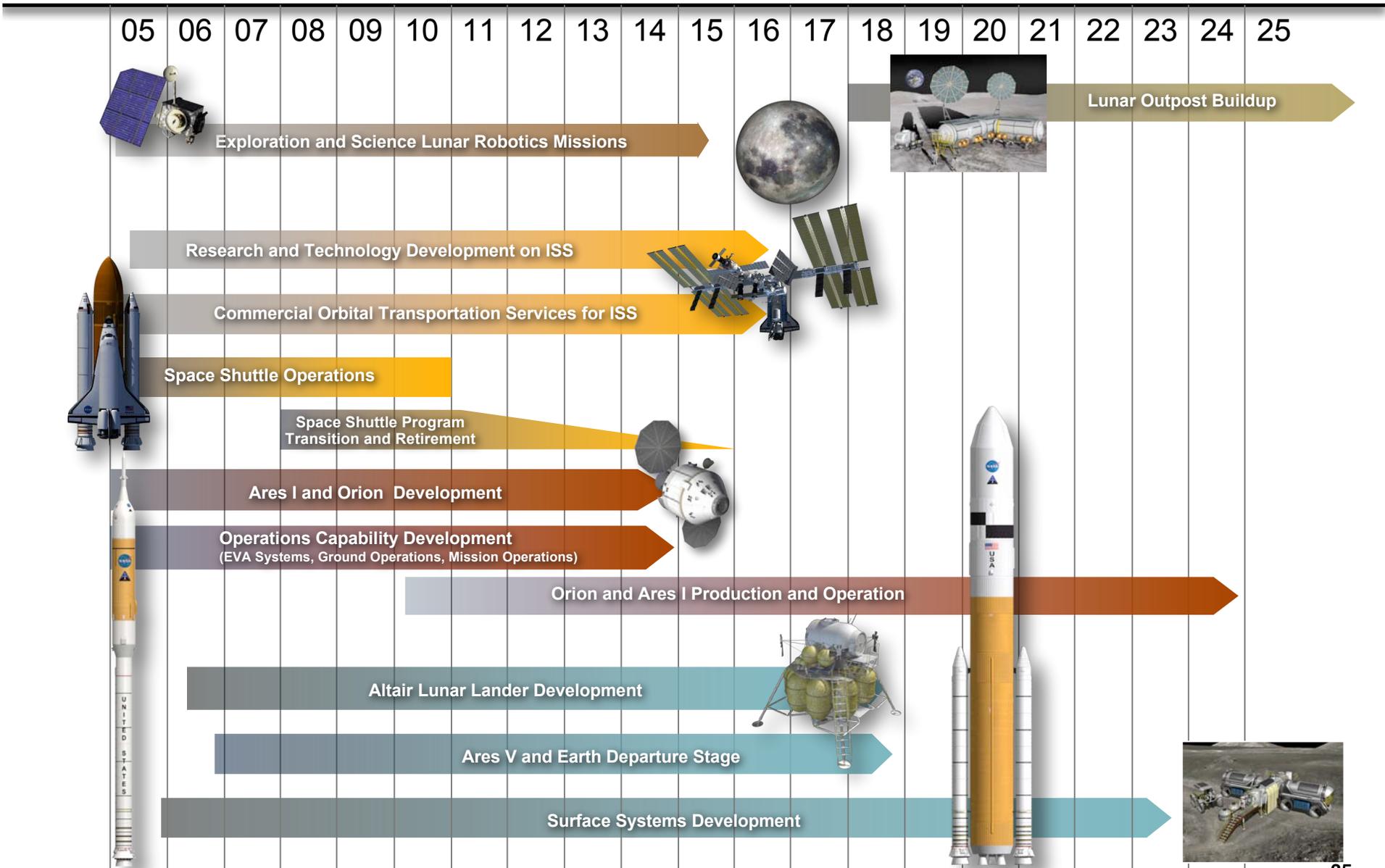


# Building on a Foundation of Proven Technologies

## – Launch Vehicle Comparisons –



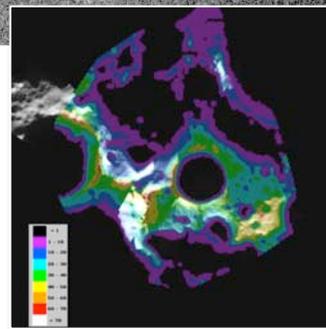
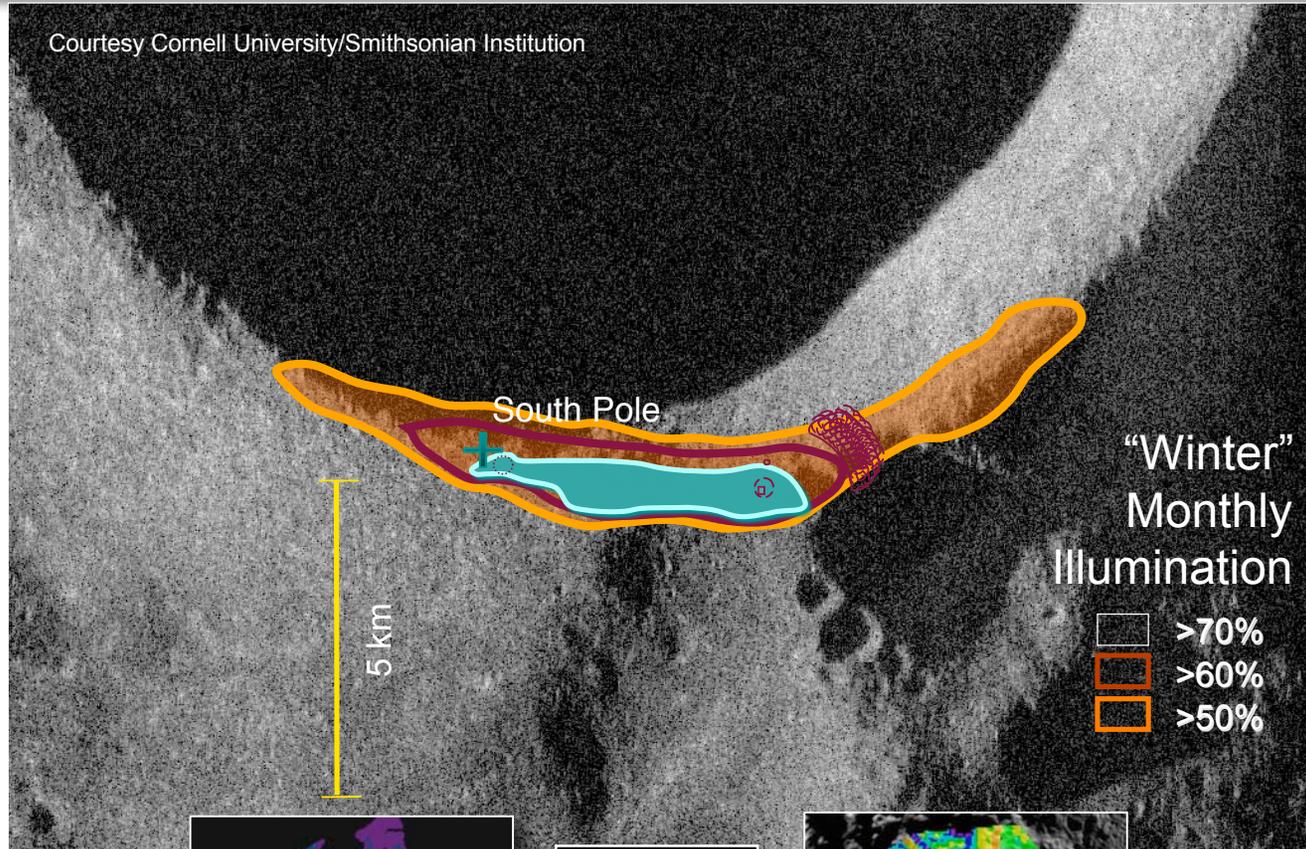
# Exploration Roadmap



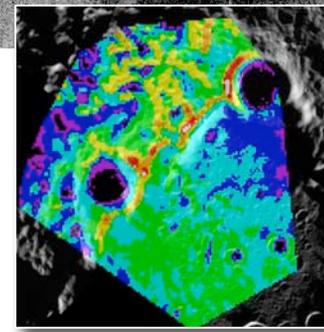
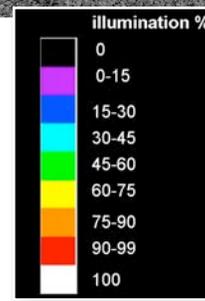
# The Rim of Shackleton Crater



Courtesy Cornell University/Smithsonian Institution



Bussey, et al, 1999



Data obtained during northern summer (maximum sunlight)