National Aeronautics and Space Administration

Going Beyond Earth Orbit: What It Takes

AIAA Aerospace Sciences Meeting

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marshall

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NASA Authorization Act of 2010

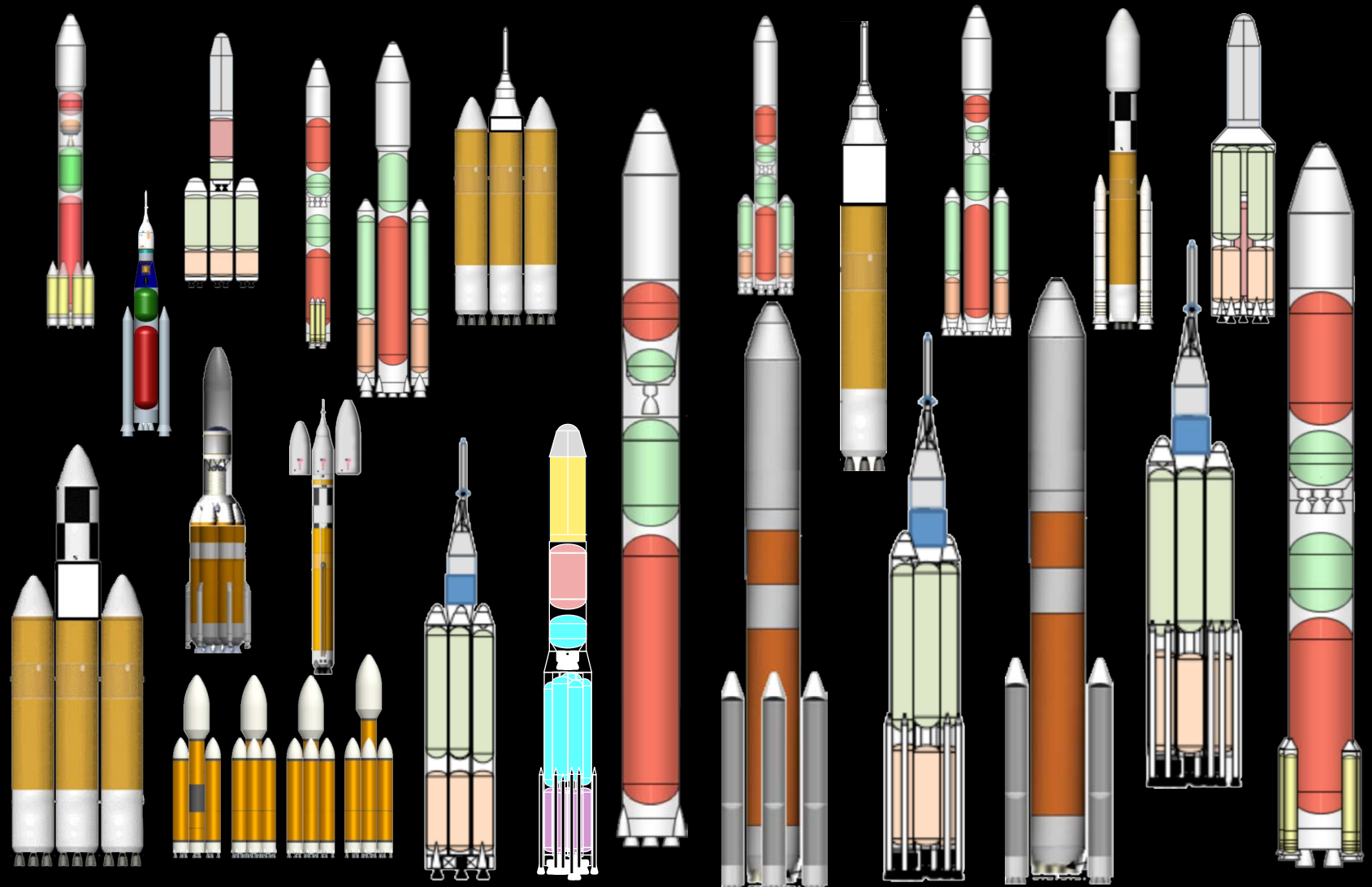
- The Congress approved and the President signed the National Aeronautics and Space Administration Authorization Act of 2010.
  - Bipartisan support for human exploration beyond low-Earth orbit (LEO).

- The Law authorizes:
  - Extension of the International Space Station (ISS) until at least 2020.
  - Strong support for a commercial space transportation industry.
  - Development of Orion and heavy lift launch capabilities.
  - A “flexible path” approach to space exploration, opening up vast opportunities including near-Earth asteroids and Mars.
  - New space technology investments to increase capabilities beyond Earth orbit (BEO).

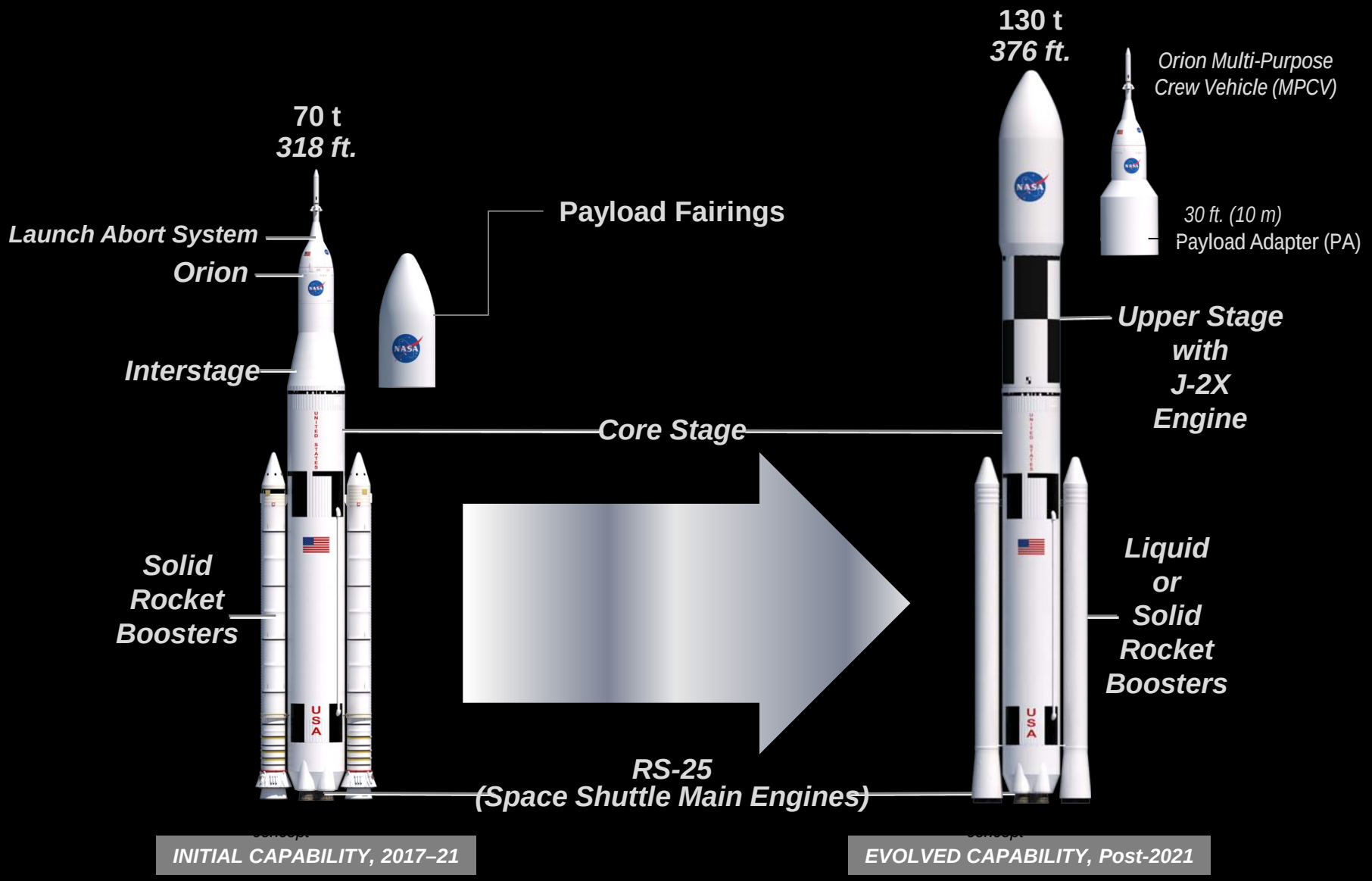
This rockett easie is key to implementing the plan laid out by President Obama and Congress in the bipartisan 2010 NASA Authorization Act.
— NASA Administrator Charles Bolden
September 14, 2011

Delivering on the Laws of the Land … and Obeying the Laws of Physics

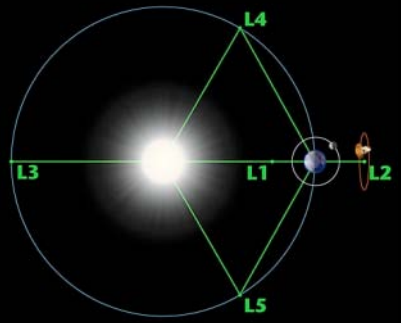
Many Possible Solutions, One Affordable Answer



SLS Architecture Uses Existing and Evolved Technologies to Fly in 2017



SLS Offers Flexible Capability for Exploration Missions



High-Earth Orbit (HEO)/Geosynchronous-Earth Orbit (GEO)/Lagrange Points

– Microgravity destinations beyond LEO.
– Opportunities for construction, fueling, and repair of complex in-space systems .
– Excellent locations for advanced space telescopes and Earth observatories.

Mars and Its Moons, Phobos and Deimos

– A premier destination for discovery: Is there life beyond Earth? How did Mars evolve?
– True possibility for extended, even permanent, stays.
– Significant opportunities for international collaboration.
– Technological driver for space systems.

Earth's Moon

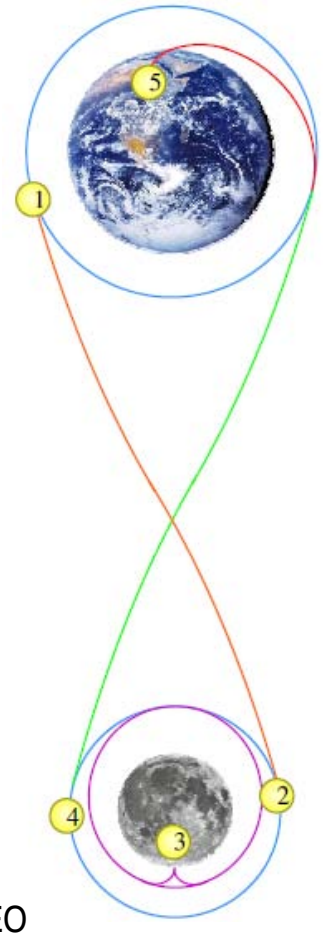
– Witness to the birth of the Earth and inner planets.
– Has critical resources to sustain humans.
– Significant opportunities for commercial and international collaboration.

Near-Earth Asteroids

– Compelling science questions: How did the Solar System form? Where did Earth's water and organics come from?
– Planetary defense: Understanding and mitigating the threat of impact.
– Potential for valuable space resources.
– Excellent stepping stone for Mars.

Increasing Our Reach and Expanding Our Boundaries

Major Architecture Considerations: Gear Ratios for Various Architecture Waypoints



1 - LEO
2 - Lunar Destination Orbit
3 - Lunar Surface
4 - Lunar Rendezvous Orbit
5 - Earth Surface

A Kilogram of Mass Delivered Here…	…Adds This Much Initial Architecture Mass in LEO
LEO to Lunar Orbit (#1→#2)	~4.3 kg
LEO to Lunar Surface (#1→#3; e.g., Descent Stage)	~7.5 kg
LEO to Lunar Orbit to Earth Surface (#1→#4→#5; e.g., Orion Crew Module)	~9.0 kg
Lunar Surface to Earth Surface (#3→#5; e.g., Lunar Sample)	~12.0 kg
LEO to Lunar Surface to Lunar Orbit (#1→#3→#4; e.g., Ascent Stage)	~14.7 kg
LEO to Lunar Surface to Earth Surface (#1→#3→#5; e.g., Crew)	~19.4 kg

Earth surface to LEO – ~20.4 kg
Earth surface to lunar surface - ~153 kg

Notional Lunar Mission Vehicle Masses

Surface Habitat Delivery

Surface Habitat
14,500 kg

Lunar Lander
24,260 kg

Lunar Transfer Stage
179,000 kg

Crew Landing Mission

Crew of 4
500 kg

Crew Vehicle
20,200 kg

Lunar Lander
29,500 kg

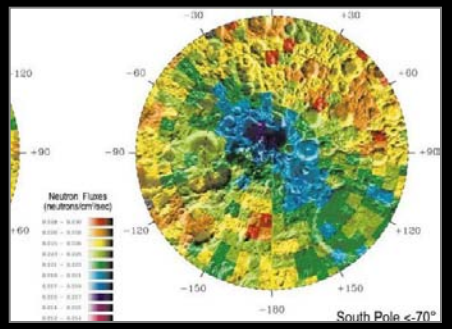
Lunar Transfer Stage
186,000 kg

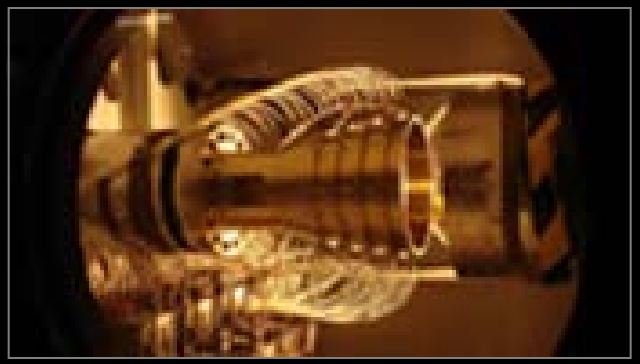
Space Launch System
3,242,000 kg

What Else is Needed?

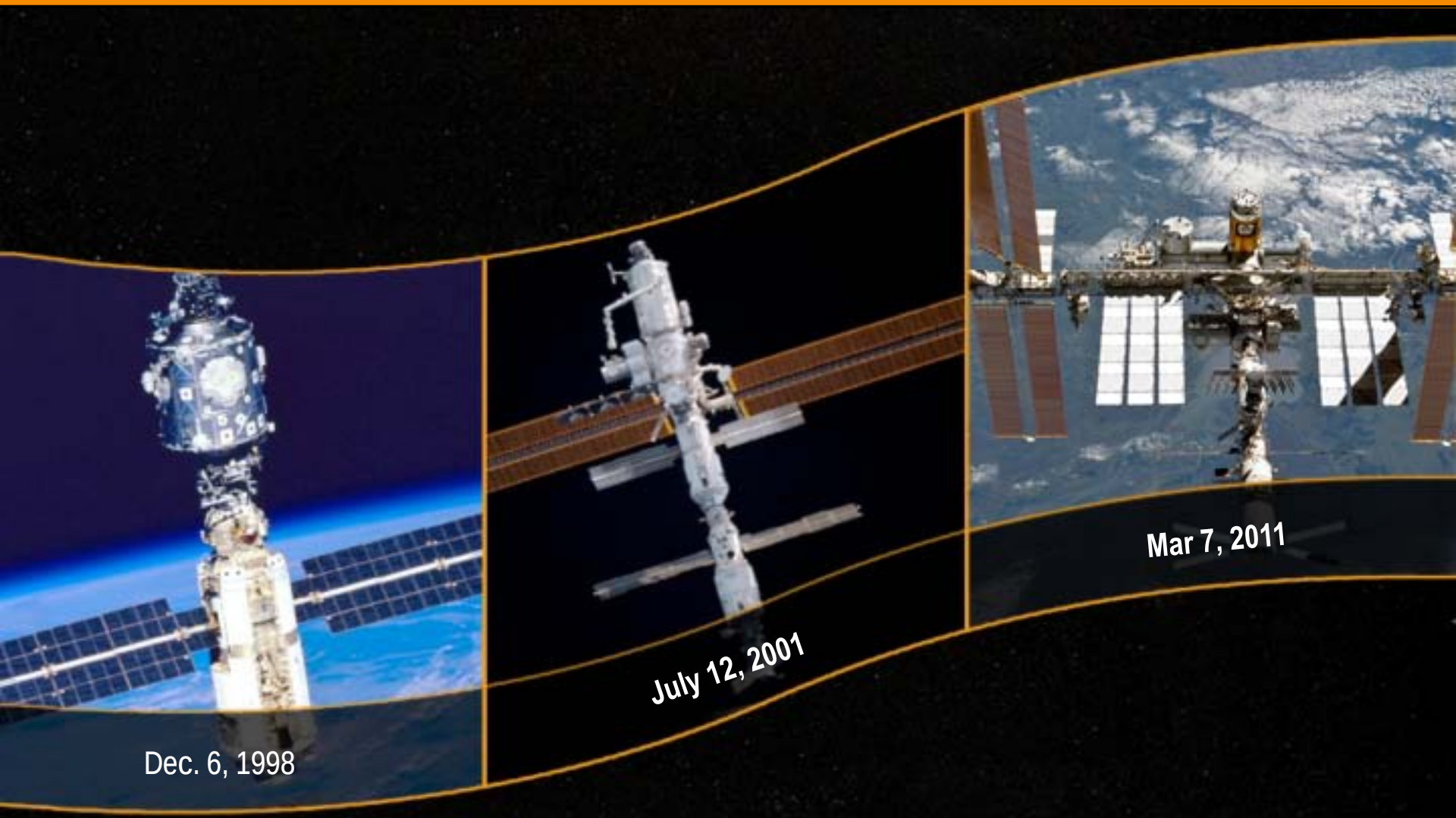
- Transportation Architecture is important,
  but it's only one of many challenges, including:
  - Human health and safety
  - Science objectives
  - Technologies for transportation and surface ops
  - Manufacturing

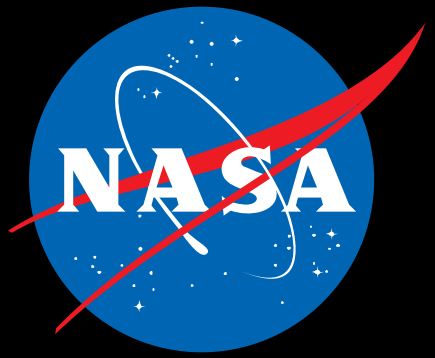
- "AND" not "OR"





Sustained Commitment is Required

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