NASA's Space Launch System: Powering the Journey to Mars

FISO Telecon
Aug 3, 2016
Why the Nation Needs to Go Beyond Low Earth Orbit

• To answer fundamental questions about the universe
  • Are we alone? Where did we come from? Where are we going?
  • Human-robot teams exponentially accelerate scientific discovery

• To ignite innovation and prosperity
  • Space drives breakthroughs in medicine, electronics, Earth science and robotics
  • Inspire a new generation to pursue STEM, and spark economic growth

• Because we’ve never been closer than we are today
  • Great nations set grand goals and achieve them
  • Generations from now, humanity will look to this moment as a turning point

• Importance of U.S. leadership in space
  • Leadership in Space ensures continued economic benefit to the nation
  • $330B annual global market
  • Visible demonstration of world-leading capability to operate in space
  • Over 250,000 high-tech American workers make space exploration possible
What it Takes to Go Beyond Low Earth Orbit

- 220 MILES
  45 MINUTES TO EARTH
- 240,000 MILES
  5 DAYS TO EARTH
- 34 MILLION MILES
  >180 DAYS TO EARTH
Mars is the Logical Next Step for Human Exploration

✓ Robotic exploration has paved the way for human missions

✓ Mars geology is right for the advantages of direct human interaction and sampling

• “A human could do in about 15 minutes what a rover could do in a day,” Steve Squyres, Mars Exploration Rover principal investigator

✓ Radiation exposure

• “No showstoppers” for trip to Mars

✓ Mars can teach us a lot about Earth, about what can happen in the future to Earth and the possibility of life on other worlds

Notable Mars Scientists Agree: We Need Humans on Mars to Make the Search for Life Possible
Precursor Missions Set the Stage for Humans

1970’s
Viking 1 Lander 1976
Pathfinder / Sojourner 1997
Viking 2 Lander 1976
Global Surveyor 1997

2000’s
Odyssey 2001
MRO 2006
Curiosity / MSL 2012

2020’s
Spirit / Opportunity 2004
Phoenix 2008
InSight 2018
MAVEN 2014

Humans to Mars
Cislunar 2021
Robotic Staging 2026
Mars Surface 2033

Precursor Missions Set the Stage for Humans
Why an Incremental Approach Makes Sense

**Phase 0**
Demonstrate technologies and conduct research to support exploration
- Deep Space Technologies
- Human Health

**Phase 1**
Demonstrate Critical Systems near the Moon [Early 2020’s]
- Orion
- Space Launch System
- Exploration Habitat
- Solar Electric Propulsion

**Phase 2**
Validate Mars-Class Systems and Operational Readiness [Late 2020’s]
- Lunar Science
- Lunar Landing – International
- Simulated Mars mission

**Phase 3+**
Journey to the Mars System [2030+]

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**Earth Reliant**
Missions: 6-12 months
Return: Hours
~250 miles

**Proving Ground**
Missions: 1-12 months
Return: Days
~240,000 miles

**Earth Independent**
Missions: 2-3 years
Return: Months
~140 million miles
Size Matters in Rockets

**More Mass** – Fewer launches, fully assembled payloads, less complex operations = lower risk

**More Volume** – Big mirrors, additional instruments, simple packaging = more science

**More Speed** – Get to the outer reaches of Solar System and beyond faster = less radiation exposure for crew and cargo

*Big Rockets are Enabling for Exploration and Science*
Evolvable Rocket

- **Launch Abort System**
- **Orion**
- **Interim Cryogenic Propulsion Stage**
- **Launch Vehicle Stage Adapter**
- **Universal Stage Adapter**
- **Core Stage**
- **Solid Rocket Boosters**
- **Cargo Fairing**
- **Exploration Upper Stage**
- **Interstage**
- **Advanced Boosters**
- **RS-25 Engines**

**Specifications:**
- **SLS Block 1**
  - 70t
- **SLS Block 1B Crew**
  - 105t
- **SLS Block 1B Cargo**
  - 105t
- **SLS Block 2 Cargo**
  - 130t

** Heights:**
- **322 ft.**
- **364 ft.**
- **327 ft.**
- **365 ft.**
The Anatomy of the Nation’s Next Big Rocket

- **Universal Stage Adapter**
- **Exploration Upper Stage & RL10 Engines (4)**
- **Core Stage**
- **Interstage**
- **Payload Attach Fitting**
- **Orion Multi-Purpose Crew Vehicle**
- **Solid Rocket Booster (2)**
- **RS-25 Main Engines (4)**

- Volume: Less complex and less expensive
- Mass: Bigger Payloads
- Speed: Saves time and money
How Do We Launch Humans to Mars

SLS will be the largest, most powerful rocket ever built, capable of launching crew and cargo to deep space, faster and farther.

Launch Vehicle Lift Capabilities

Payload (metric tons) to:
- Low Earth Orbit
- Earth's Moon
- Geosynchronous Transfer
- Mars

Note: Orion Multi-Purpose Crew Vehicle = 28.0 metric tons
Science Missions Enhanced by SLS

<table>
<thead>
<tr>
<th>Mission</th>
<th>SLS Block 1B Benefit</th>
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<tbody>
<tr>
<td>Jupiter/ Europa</td>
<td>Saves 4.5 years and Delivers 2 Times the Payload</td>
</tr>
<tr>
<td>Saturn/ Titan Enceladus</td>
<td>Saves 3 Years and Provides 5 times the Payload</td>
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<tr>
<td>Jupiter Trojan Asteroids</td>
<td>Provides 6 times the Payload</td>
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<tr>
<td>Mars Sample Return</td>
<td>1 Launch instead of 3</td>
</tr>
<tr>
<td>Comet Sample Return</td>
<td>Saves 2 years and Provides 4 Times the Payload</td>
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Europa - In 4.5 Fewer Years than Atlas Launch

Atlas Launch Vehicle:
Cruise Time Earth-Jupiter: 6.5 years

SLS Launch:
Direct trajectory: Cruise time
Earth-Jupiter: 2.0 years
Bigger rockets enable bigger telescopes, and thus bigger science.

Value of human assembly and maintenance proven on Hubble Space Telescope.

Images Courtesy of the Space Telescope Science Institute
The First SLS/Orion Mission - 2018
SLS Preparing for First Launch in 2018

SLS Core Stage
Michoud, New Orleans, Louisiana

RS-25 Engine
Stennis Space Center, Mississippi

Booster
Orbital ATK, Promontory, Utah
Core Stage
Proven Liquid Main Engines
The Most Powerful Operational Booster
Ground Systems Development and Operations (GSDO)

- Successful review of plans for the facilities and ground support systems
- Completed the fifth of 10 levels of work platforms that will surround and provide access to the SLS rocket and Orion spacecraft
- Each platform half is about 62 feet wide and 38 feet long and weigh between 300,000 and 325,000 pounds
- The top platform shown is located about 200 feet above the floor
6 Essential Capabilities for the Journey to Mars

Orion
- Full scale development underway
- Successful uncrewed flight test Dec 2014
- Second flight in 2018 - 1st human-rated spacecraft flight to moon since 1972
- Human lunar flight in 2021

Habitat
- ECLSS systems testing underway on ISS
- Habitat & subsystem studies underway
  - Advanced hab testing during in late 2020s

Mars Ascent Vehicle (MAV)
- Component level testing with LOX /Methane
  - Lunar Lander in mid 2020’s
  - Mars precursor mission in late 2020’s
  - Mars MAV ready in early 2030s

Space Launch System
- Full Scale Development Underway
- Critical Design Review completed
  - 2018 first flight hardware in production
  - Exploration Upper Stage in 2021 increasing SLS capability

Power
- Next generation array testing underway at ISS
  - Initial 50 kW demonstration - Asteroid Redirect Mission
  - 150 kW - Translunar SEP tug

Mars Lander & Surface Systems
- Capability testing with lunar landers and habs
- Precursor EDL testing with robotic missions
With design and development work mostly complete, the SLS Program is now building and testing components of the world’s most powerful rocket to be ready for launch in 2018. Each of these steps advance NASA on the Journey to Mars.
Summary

- Human exploration of Mars is ACHIEVABLE by taking the long view.

- **We can pack for the long haul journey to Mars.** SLS provides unprecedented payload capability that can enable human and science deep space missions not previously achievable. We can go farther, faster, carrying more payload, than ever before possible.

- **We can safely carry crew beyond Earth** for deep space mission transfer – and back again. Orion is built for launching – and protecting – our astronauts.

- **We have the orbiting lab** to test technologies and scenarios before deep space launches. In fact, the International Space Station every day models on-orbit challenges and solutions.

- Industry partners are advancing key capabilities and technologies, like Solar Electric Propulsion.

- Cis-lunar space advancing habitation systems and capabilities.

- Long term sustainable program of human exploration.

- **We are building tomorrow’s space systems …. Today.**
Want to Learn More

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