Space Launch System (SLS) Program Progress Report

Name
NASA Marshall Space Flight Center

Date
Advancing the U.S. Legacy of Human Exploration
**NASA Vision**

_To reach for new heights and reveal the unknown, so that what we do and learn will benefit all humankind._

**NASA Strategic Goals**

✔ _Extend and sustain human activities across the solar system._

✔ Expand scientific understanding of the Earth and the universe in which we live.

✔ Create the innovative new space technologies for our exploration, science, and economic future.

  Advance aeronautics research for societal benefit.

✔ Enable program and institutional capabilities to conduct NASA’s aeronautics and space activities.

✔ Share NASA with the public, educators, and students to provide opportunities to participate in our mission, foster innovation, and contribute to a strong national economy.

_SLS — Safe, Affordable, and Sustainable_
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 the Orion Multi-Purpose Crew Vehicle (MPCV) 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 the capabilities beyond Earth orbit (BEO)

Delivering on the Laws of the Land ... and Obeying the Laws of Physics
SLS Is a National Asset for Multiple Stakeholders and Partners

- Planetary Exploration
  - Mars
  - Solar System

- Exploring Other Worlds
  - Low-Gravity Bodies
  - Full-Capability Near-Earth Asteroid Missions
  - Phobos/Deimos

- Into the Solar System
  - Interplanetary Space
  - Initial Near-Earth Asteroid Missions

- Gaining the High Ground
  - Cislunar Space
  - Geostationary Orbit
  - High-Earth Orbit
  - Lunar Flyby & Orbit
  - Lunar Surface

- Initial Exploration Missions
  - Space Launch System
  - Multi-Purpose Crew Vehicle
  - 21st Century Ground Operations

SLS — Going Beyond Earth’s Orbit

Legend:
- Objective
  - Missions
**SLS Offers Flexible Capability for Exploration Missions**

**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

**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

**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

**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

**Increasing Our Reach and Expanding Our Boundaries**

National Aeronautics and Space Administration

8047_SLS Overview.6
# SLS Roadmap: Extensive Engineering and Business Analyses and Planning

## ACTIVITY

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"Take your time and get it right."
—Tom Gavin, Jet Propulsion Laboratory

SLS Mission Concept Review, March 2011
SLS Driving Objectives

♦ **Safe**
  • Loss of Crew: 1/700
  • Loss of Mission: 1/100

♦ **Affordable**
  • Constrained budget environment, with no planned escalation
  • Maximum use of common elements and existing assets, infrastructure, and workforce

♦ **Initial Capability: 70 tonnes (t), 2017–2021**
  • Primary transportation for Orion MPCV and exploration missions
  • Back-up capability for crew/cargo to ISS

♦ **Evolved Capability: 130 t, post–2022**
  • Large volume for science missions and payloads
  • Modular and flexible, sized for mission requirements

*SLS First Flight in 2017*
Many Solutions Considered: One Affordable Answer

“This enterprise is not for the faint of heart.”
—Wayne Hale
SLS Maximizes U.S. Aerospace Workforce and Capabilities

Leverages Existing Contracts, While Competing the Future

National Aeronautics and Space Administration
SLS Vehicle Configuration Decision

♦ Maintains U.S. leadership in liquid oxygen/liquid hydrogen (LOX/LH₂) technology
  • LOX/LH₂ Core Stage uses RS-25 engines
  • LOX/LH₂ Upper Stage uses J-2X engines
  • Establishes fixed central design path, with logical use of existing strength in design and modern manufacturing approaches
  • Harnesses existing knowledge base, skills, infrastructure, workforce, and industrial base for existing state-of-the-art systems

♦ Minimizes unique configurations during vehicle development
  • Evolutionary path to 130 t allows incremental development; thus, progress will be made, even within constrained budgets
  • Allows early flight certification for Orion
  • May be configured for Orion or science payloads, providing flexible/modular design and system for varying launch needs
  • Gains synergy, thus reducing design, development, test, and evaluation (DDT&E) costs and schedule by building the Core Stage and Upper Stage in parallel, thereby leveraging common tooling and engine-feed components

Technical Trade Studies and Business Planning Validated Independently
SLS Will Be the Most Capable U.S. Launch Vehicle

Sample of Proposed and Fielded U.S. Systems

National Aeronautics and Space Administration
Notional Mission Design for First Flight in 2017
Orion Certification (Lunar Flyby, No Crew)

♦ Objectives
  • Demonstrate spacecraft systems performance prior to crewed flight
    - High-speed entry (~11 km/s)
    - Thermal Protection System performance

♦ Orion BEO Configuration
  • Lunar capable heat shield
  • Two tank service module and propulsion offload for lower mass

♦ Interim Cryogenic Propulsion Stage (iCPS) provides trans-lunar injection (TLI)

♦ Orion Mission duration: 7–10 days

Mission Event Sequence
1. SLS lofts Orion and DCSS to high-apogee orbit while meeting core disposal constraints
2. iCPS performs burn to raise perigee to safe height
3. iCPS performs TLI burn
4. 3–5 day transit time
5. Lunar flyby
6. 3–5 day transit time
7. Orion reenters and lands in Pacific ocean
SLS Is a National Capability for International Cooperation

♦ Very Large Payload Diameters: 8.5–12 m
  • BEO missions require 8-m to 10-m diameter
  • Mars missions drive to diameters 10-m and larger, and increased heights above 22 m

♦ Large Mass Requirements
  • Maintains reasonable number of launches per mission
  • Simplifies on-orbit operations
  • Maximizes mission reliability

♦ National capability for other endeavors

♦ Heavy Lift Unique Payload Capacity
  • Mars Transfer Vehicle
  • Deep Space Exploration Systems
  • Planetary Landers
  • Human Habitats
  • Great Observatories
  • Space Solar Power
  • Outer Planet Missions
  • National Security

"Agencies agree that human space exploration will be most successful as an international endeavor because there are many challenges to preparing for these missions and because of the significant social, intellectual, and economic benefits to people on Earth."

—Global Exploration Roadmap, September 2011
SLS Affordability Tenets

♦ Evolvable Development Approach
  • Manage within constrained, flat budgets
  • Leverage existing National capabilities
  • Infuse new design solutions for affordability

♦ Robust Designs and Margins
  • Performance traded for cost and schedule

♦ Risk-Informed Government Insight/Oversight Model
  • Insight based on:
    - Historic failures
    - Industry partner past performance and gaps
    - Complexity and design challenges
  • Judicious oversight:
    - Discrete oversight vs. near-continuous oversight
    - Timely and effective decisions

♦ Right Sized Documentation and Standards
  • Reduction in the number of Program documents
  • Industry practices and tailored NASA standards

♦ Lean, Integrated Teams with Accelerated Decision Making
  • Simple, clear technical interfaces with contractor
  • Integrated Systems Engineering & Integration organization
  • Empowered decision makers at all levels

Improved Human Space Flight Affordability Required for Sustainability
Potential to Build on Heritage Hardware and Facilities

**J-2X Test Firing/Space Shuttle Main Engine Testing**
Stennis Space Center

**Payloads**
Goddard Space Flight Center

**Orion Integration**
Johnson Space Center

**Composite Structures**
Glenn Research Center

**Ground and Launch Operations**
Kennedy Space Center

**Manufacturing and Transportation**
Michoud Assembly Facility

**Wind Tunnel Testing**
Langley Research Center

**Standing Review Team**
Jet Propulsion Laboratory

**Physics-Based Analysis**
Ames Research Center

**J-2X Upper Stage Engine Injector Firing**
Marshall Space Flight Center

*Smartly Selecting the Most Efficient Infrastructure*
SLS Recent Activities and Accomplishments

♦ NASA Pre-Formulation Phase Completed
  • Program chartered
  • Control Board chartered
  • Team formed

♦ Hardware Accomplishments
  • J-2X testing
  • Development Motor 3 firing

♦ Formulation Activities
  • Formulation Authorization Document
  • Key Decision Point A memo
  • FY13 budget submitted
  • Initial General Accountability Office engagement
  • System Requirements Review checkpoint in Oct.

♦ SLS Program Roll-Out
  • Marshall team all-hands meeting
  • Industry Day with 600 potential business partners
  • Website launched
SLS is a national capability that empowers entirely new exploration missions.

Program key tenets are safety, affordability, and sustainability.

SLS builds on a solid foundation of experience and current capabilities to enable a fast start and a flexible heavy-lift capacity for missions of national importance.

The SLS acquisition will help U.S. aerospace industry stay strong as it develops initial capabilities, as well as provide competitive opportunities for advanced technologies for evolved capabilities.

The SLS Team has made significant progress and looks forward to working with you to continue America’s leadership in space.
Exploring Space for America’s Future

New National Capability

National Security

Public Engagement

Scientific Knowledge

Economic Prosperity

Global Partnerships

Technology Development
SLS Maximizes U.S. Aerospace Workforce and Capabilities

♦ Boosters
  - 5-segment Solid Rocket Booster in-scope modification to existing Ares contract with ATK for initial flights through 2021
  - Advanced Boosters
    - Engineering demonstration and risk reduction via NASA Research Announcement (NRA): Full and Open Competition later this year
    - Design, Develop, Test, & Evaluation (DDT&E): Full and Open Competition

♦ Stages
  - Core/Upper Stage: Justification for Other Than Full and Open Competition (JOFOC) to Boeing, modifying current Ares Upper Stage contract
  - Avionics
    - Instrument Unit Avionics: In-scope modification to existing Ares contract with Boeing; to be consolidated with Stages contract to Boeing

♦ Engines
  - Core Stage Engine: RS-25 JOFOC to existing Space Shuttle contract with Pratt & Whitney Rocketdyne (PWR)
  - Upper Stage Engine: J-2X in-scope modification to existing Ares contract with PWR

♦ Spacecraft and Payload adapter and Fairing
  - Full and Open Competition to begin in FY13

♦ Advanced Development
  - Broad Agency Announcement (BAA)/NRA: Full and Open Competition
  - Future Core Stage Engine: Separate contract activity to be held in the future

Delivers Near-Term Initial Capabilities and Spurs Competition for Evolved Capabilities
Key Milestones

National Aeronautics and Space Administration

Human Exploration And Operations/Exploration Systems Development (HEO/ESD) Milestones

- CP-SRR KDP
- CP-SDR KDP
- C-SRR
- C-SDR

SLS Major Milestones

- MCR
- KDP-A TBD
- KDP-B
- KDP-C
- ASM
- SRR Ckpt
- PDR
- CDR
- DCR
- PSM
- SRR/SDR

Flight Manifest

- EM-1 70 t (Uncrewed)
- EM-2 70 t (Crewed)