SPACe LAUNCH SYSTEM

Bob Hawkins
Deputy Lead Engineer
SLS Integrated Avionics and Software

Exploration Class Capability for Deep Space Exploration
SLS Driving Objectives

◆ Safe
  • Human-rated to provide safe and reliable systems
  • Protecting the public, NASA workforce, high-value equipment and property, and the environment from potential harm

◆ Affordable
  • Maximum use of common elements and existing assets, infrastructure, and workforce
  • Constrained budget environment
  • Competitive opportunities for affordability on-ramps

◆ Sustainable
  • Initial capability: 70 metric tons (t), 2017–2021
    – Serves as primary transportation for Orion and human exploration missions
  • Evolved capability: 105 t and 130 t, post-2021
    – Offers large volume for science missions and payloads
    – Reduces trip times to get science results faster
    – Minimizes risk of radiation exposure and orbital debris impacts

Designed for BEO Missions of National Importance
• SLS initial configuration offers Block 1 to LEO.
• Future configurations offer Block 1B and Block 2 to LEO.
• More mass-to-orbit means larger payloads to variety of destinations.
Europa Trajectory Comparison

Atlas V 551: VEEGA

- VGA (5/14/22)
- EGA-1 (10/24/23)
- EGA-2 (10/24/25)
- Launch (11/21/21)

SLS: Direct

- JOI (5/23/24)
- DSM (7/10/22)
- Jupiter’s Orbit

Reduces Transit Time To Europa By Half
SLS Evolution Overview

- SLS Block 1: 70 t
  - Core Stage
  - Interim Cryogenic Propulsion Stage
  - Launch Vehicle Stage Adapter
  - Solid Rocket Boosters

- SLS Block 1B Crew: 105 t
  - Core Stage
  - Interstage
  - Cargo Fairing
  - Exploration Upper Stage
  - Universal Stage Adapter
  - Solid Rocket Boosters

- SLS Block 1B Cargo: 105 t
  - Core Stage
  - Interstage
  - Cargo Fairing
  - Exploration Upper Stage
  - Advanced Boosters
  - RS-25 Engines

- SLS Block 2 Cargo: 130 t
  - Core Stage
  - Interstage
  - Cargo Fairing
  - Exploration Upper Stage

Launch Abort System
Orion

SLS Block 1 Key Design Features

- Solid Rocket Boosters (2)
- RS-25 Engines (4)
- Core Stage
- Interim Cryogenic Propulsion Stage
- Orion Stage Adapter
- Spacecraft Adapter
- Encapsulated Service Module Panels
- Service Module
- Launch Vehicle Stage Adapter
- Launch Abort System Crew Module
- Orion Multi-Purpose Crew Vehicle

www.nasa.gov/sls
Five-Segment Solid Rocket Booster

Qualification Motor-1 (QM-1) March 2015, Promontory, Utah

SRB Forward Skirt Load Test May 2014, Promontory Utah

Booster Processing, Promontory, Utah

SRB Aft Skirt Avionics Testing September 2014
5-Segment Booster Test Video
RS-25 Core Stage Engine

RS-25 Adaptation Test, Stennis Space Center, January – August 2015
Core Stage Progress

LH2 Dome Assembly at Michoud, July 2015

B-2 Test Stand at Stennis Space Center

Pegasus Barge Renovation Complete

LH2 Structural Test Article (STA) Test Stand, MSFC, August 2015
Orion/MSA Mated to Delta IV for EFT-1
November 2014

DCSS for EFT-1
KSC, June 2014
Systems Engineering & Integration

- SMAT Testing, MSFC August 2014
- Booster Separation Tests, LaRC October 2014
- Base Heating Tests CUBRC, Buffalo, New York January 2015
- Core Stage Engine TVC Actuator Testing Redstone Test Center March 2015
SLS Avionics Progress
Where is SLS Avionics Located?

- **Booster Avionics**
- **Interim Cryogenic Propulsion Stage Avionics**
- **Launch Vehicle Stage Adapter** (Two Cameras for ICPS Separation)
- **Core Stage Avionics** (Flight Computers, Command and Telemetry Controller, Inertial Navigation Equipment, RF Transmitter)
- **Core Stage Avionics** (Command and Telemetry Controller, Power Distribution, Data Acquisition, Camera Equipment, Liquid Level Sensors, Rate Gyro, RF Transmitter)
- **Core Stage Avionics** (Main Propulsion System Valve Control, Core Stage Thrust Vector Control, Rate Gyro)
- **Core Stage Engine Controllers**
SLS Block I Software Providers

**System:** Flight Computer (FC)
**Type:** Byzantine Fault Resilient
3 String Voting Architecture
**Developer:** MSFC In-House
**Category:** Flight Critical
**Function:** Primary SLS Vehicle Flight Control System

**System:** Redundant Inertial Navigation Unit (RINU)
**Type:** Internally Self-Checking Architecture
**Developer:** Stages Subcontractor (Honeywell)
**Category:** Flight Critical
**Function:** Provide Navigation and Flight Control inputs to FCs

**System:** Rate Gyro Assembly
**Type:** Internally Self-Checking Architecture
**Developer:** Stages Subcontractor (Honeywell)
**Category:** Flight Critical
**Function:** Provide vehicle rate inputs to FCs

**System:** Core Stage Engine Controller (CSEC)
**Type:** Self-Checking Pair of Pairs (Prime/Backup)
**Developer:** Engines Contractor - Aerojet Rocketdyne (AR)
**Category:** Flight Critical
**Function:** Control/Monitor of RS-25 Engine

**System:** ULA Common Avionics Based
**Developer:** ULA
**Function:** Primary ICPS Flight Control and Health Monitoring
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.

### Path to EM-1 (First Launch)

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Mission Concept Review</td>
</tr>
<tr>
<td>2012</td>
<td>System Requirements Review/System Definition Review</td>
</tr>
<tr>
<td>2013</td>
<td>Key Decision Point-C</td>
</tr>
<tr>
<td>2014</td>
<td>Critical Design Review</td>
</tr>
<tr>
<td>2015</td>
<td>Booster Qualification Tests</td>
</tr>
<tr>
<td>2016</td>
<td>Boosters Fabrication Complete</td>
</tr>
<tr>
<td>2017</td>
<td>Design Certification Review</td>
</tr>
<tr>
<td>2018</td>
<td>Launch Availability</td>
</tr>
</tbody>
</table>

- **2011**: SLS Design Chosen
- **2012**: Engines Delivered to Inventory
- **2013**: Manufacturing Tooling Installation
- **2014**: RS-25 Development Testing Begins
- **2015**: RS-25 Flight Testing Begins
- **2016**: Core Stage Production Begins
- **2017**: Core Stage Assembly Complete
- **2018**: Booster Assembly at KSC

**Production of Adapter for Orion Flight Test**

**Core Stage Structural Testing**

**Integrated Upper Stage Structural Testing**

**SLS Launch Readiness**

**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

- SLS provides capability for human exploration missions.
  - Block 1 configuration enables initial flight tests.
  - Evolved configurations enable missions including humans to Mars.

- SLS offers unrivaled benefits for a variety of missions.
  - Block 1 provides greater mass lift than any contemporary launch vehicle; Block 2 offers greater lift than any launch vehicle, ever.
  - With 8.4m and 10m fairings, SLS will over greater volume lift capability than any other vehicle.
  - Updated Mission Planner’s Guide provides capabilities information.

- SLS is currently on schedule for first launch.
  - Critical design review completed in July 2015; SLS is now in implementation phase.
  - Manufacture and testing are currently underway.
  - Hardware now exists representing all SLS elements.

SLS will be the Biggest and Most Capable Rocket ever Built
Questions?