5...4...3...2...1...

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 Mass-to-Orbit Comparison**

- 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.

<table>
<thead>
<tr>
<th>Payload Mass (mT)</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>20</td>
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<td>120</td>
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<td>140</td>
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**Medium/Intermediate**
- ULA Atlas V 551
- SpaceX Falcon 9
- ULA Delta IV H
- NASA Space Shuttle
- NASA Saturn V
- NASA Block 1
- NASA Block 2

**Heavy**

**Super Heavy**

**Retired**
- NASA Space Shuttle
- NASA Saturn V

www.nasa.gov/sls
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)
- JOI (4/4/28)

SLS: Direct

- JOI (5/23/24)
- DSM (7/10/22)
- Launch (6/5/22)

Reduces Transit Time To Europa By Half
SLS Evolution Overview

- **SLS Block 1**
  - **Core Stage**
  - **Solid Rocket Boosters**
  - **Interim Cryogenic Propulsion Stage**
  - **Launch Vehicle Stage Adapter**
  - **Orion**

- **SLS Block 1B Crew**
  - **Core Stage**
  - **Solid Rocket Boosters**
  - **Universal Stage Adapter**

- **SLS Block 1B Cargo**
  - **Core Stage**
  - **Solid Rocket Boosters**
  - **Interstage**
  - **Cargo Fairing**

- **SLS Block 2 Cargo**
  - **Core Stage**
  - **Advanced Boosters**
  - **RS-25 Engines**
  - **Cargo Fairing**

- **SLS Block 2 Cargo**
  - **Core Stage**
  - **Exploration Upper Stage**
  - **Interstage**
  - **Cargo Fairing**

- **SLS Block 2 Cargo**
  - **Core Stage**
  - **Advanced Boosters**
  - **RS-25 Engines**
  - **Cargo Fairing**
SLS Block 1 Key Design Features

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

Pegasus Barge Renovation Complete

B-2 Test Stand at Stennis Space Center

LH2 Structural Test Article (STA) Test Stand, MSFC, August 2015
SLS MAF/Stages Progress Video
Spacecraft/Payload Integration and Evolution

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 Avionics Architecture

MPCV Orion

To Secondary Payloads
Event Notification Discretions
RF

ICPS

CTC-1

CCU

CTC-2

DFIS

DACU1

DACU2,3

CSEC

Ground Systems

RFCS Tx

DFI Tx

Left Booster (identical to right booster)

FSS

DFIS

ACU

OIB

Instr

BCPDU

ISC

HPUC

RS-422

1553

"EF"

1553

"AF"

RINU

Fwd Skirt

Intertank

PDCU

CLSS

C TAC

Engine Section

Ground Systems

100 Base TX

1553

"UF"

Engine Shutdown Discretions
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:** ULA Common Avionics Based
**Developer:** ULA
**Category:** Flight Critical
**Function:** Primary ICPS Flight Control and Health Monitoring

**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
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.

• 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