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
JOURNEY TO MARS

- HUBBLE
- INTERNATIONAL SPACE STATION
- SPACE LAUNCH SYSTEM (SLS)
- ORBITERS
- LANDERS
- PHOBOS DEIMOS
- ORION
- SOLAR ELECTRIC PROPULSION
- ASTEROID REDIRECT MISSION
- MARS TRANSFER SPACECRAFT
- IN-SPACE HABITAT

TECHNOLOGY
EXPLORATION
SCIENCE

COMMERCIAL CARGO AND CREW

MISSIONS: 6-12 MONTHS RETURN: HOURS
EARTH RELIANT
MISSIONS: 1 TO 12 MONTHS RETURN: DAYS
PROVING GROUND
MISSIONS: 2 TO 3 YEARS RETURN: MONTHS
EARTH INDEPENDENT
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.
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)

**Jupiter’s Orbit**

**SLS: Direct**

- JOI (5/23/24)
- DSM (7/10/22)
- Launch (6/5/22)
- JOI (4/4/28)

Reduces Transit Time To Europa By Half
SLS Evolution Overview

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

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

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

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

- **SLS**
  - Block 1
  - Block 1B Crew
  - Block 1B Cargo
  - Block 2 Cargo

Weights:
- **70 t**: SLS Block 1
- **105 t**: SLS Block 1B Crew, SLS Block 1B Cargo
- **130 t**: SLS Block 2 Cargo
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
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
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
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
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
SLS Block I Avionics and SW Test Labs

SITF-Q (Stages)

SITF-D (Stages)/SIL (Level 2)

Control Room

SITF-Q

HIL

SITF-D/SIL

Booster

SDF-1&2 (FC FSW)

SDF-3 (FC FSW)
Path to EM-1 (First Launch)

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 offer 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