The Space Launch System: NASA’s Exploration Rocket

Christopher Blackerby
June 3, 2013
“To reach for new heights...

and reveal the unknown so that what we do and learn will benefit all humankind.”

SLS Launches in 2017

- Extend & sustain human activities across the solar system.
- Expand scientific understanding of the Earth & the universe in which we live.

NASA 2011 Strategic Plan
The Next Great Ship
The Space Launch System [will] be the backbone of its manned spaceflight program for decades. It [will] be the most powerful rocket in NASA’s history…and puts NASA on a more sustainable path to continue our tradition of innovative space exploration.

President Obama’s Accomplishments for NASA
May 22, 2012
Exploration Systems Development

- Space Launch System
- Orion Multi-Purpose Crew Vehicle
- Ground Systems Development and Operations
SLS Launch Schedule

Asteroid
Detection,
Characterization,
& Selection
Segment

2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

SST
PS-2
Geosynchronous Earth Orbit-hosted payload detection
Final target selection

Enhanced Ground Assets & Initial candidates

Asteroid
Redirection
Segment

Exploration Flight Test: Un-crewed Orion Flight in Earth Orbit
Exploration Mission-1 (EM-1): Un-crewed Orion Test Flight Beyond the Moon
Mission Launch & Solar Electric Propulsion Demo
Asteroid Rendezvous & Capture

Orion & SLS
Crewed
Asteroid
Exploration
Segment

EM-2: Crewed Orion Flight Beyond the Moon
Enhanced Ground Assets & Initial candidates

NOTIONAL – SUBJECT TO CHANGE AS MISSION CONCEPT EVOLVES
Unsurpassed Mission-Enabling Capability

**Earth-Sun Libration Points**
Serviceable Large Diameter Telescopes

**Asteroids**
Human missions
Robotic missions with sample return

**Mars, Phobos, Deimos**
Human missions
Single-launch robotic sample return

**Deep Space/Planetary**
Robotic sample return missions
Reduced flight time (years)

**Earth-Moon Libration Points**
Waystations

**Commercial Space Stations**
Large diameter
Single launch

**Moon**
Large-scale robotic precursor missions
Human settlement with resource utilization

*Entirely New Missions Never Before Possible*
Mars: Making the Ultimate Goal a Reality

Mars Landing: Heading for the High Ground

Courtesy of Dan Durda
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.

Platform for Missions Beyond Earth’s Orbit
Building on the U.S. Infrastructure

INITIAL CAPABILITY, 2017–21

- Orion Multi-Purpose Crew Vehicle (MPCV)
  - Lockheed Martin

- 5-Segment Solid Rocket Boosters
  - ATK

- Interim Cryogenic Propulsion Stage
  - Early flight certification for Orion
  - Flexible for a range of payloads
  - Boeing

- Launch Abort System

- Core/Upper Stage
  - Boeing
  - Boeing

- Evolutionary Path to Future Capabilities
  - Minimizes unique configurations
  - Allows incremental development
  - Advanced Development contracts awarded in Fiscal Year 2013 (FY13)

- RS-25 Core Stage Engines
  - Using Space Shuttle Main Engine inventory assets
  - Building on the U.S. state of the art in liquid oxygen/hydrogen
  - Initial missions: Pratt & Whitney Rocketdyne
  - Future missions: Agency is determining acquisition strategy

EVOLVED CAPABILITY, Post-2021

- 130 t
  - 384 ft

- Fairings (27.5' or 33')
  - Right-sized for the payload
  - Received industry input in FY13

- Upper Stage
  - Boeing
  - Boeing

- Advanced Boosters
  - Competitive opportunities for affordable upgrades
  - Risk-reduction contracts awarded in FY13

Working with Industry Partners to Develop America’s Heavy-Lift Rocket
SLS 70 metric ton Expanded View

Initial Capability Stands on the Shoulders of Legacy Systems
Core Stage Progress

Next Big Steps

<table>
<thead>
<tr>
<th>Tooling Availability</th>
<th>May 2013 - Enhanced Robotic Weld Tool (ERWT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June 2013 - Vertical Weld Center (VWC)</td>
</tr>
</tbody>
</table>

Circumferential Dome Weld Tool (CDWT)
Vertical Weld Center (VWC)
Segmented Ring Tool (SRT)
Enhanced Robotic Weld Tool (ERWT)
Vertical Assembly Center (VAC)
Manufacturing Layout
Michoud Assembly Facility
(New Orleans, LA)
RS-25 Core Stage Engines In Stock

- Inventory at Stennis Space Center for first 4 SLS flights
- Utilizing proven, existing hardware supports SLS safety and affordability goals
- Preparations under way for RS-25 engine testing
5-Segment Solid Rocket Booster Progress

Development Motor Testing Completed
DM Test 3
September 8, 2011
ATK Promontory, Utah

Qualification Motor Testing Begins in 2013
QM Casting, July 2012

Developing the World's Largest Solid Rocket Booster
Multi-Purpose Crew Vehicle Stage Adapter (MSA) Progress

Production of MSA at Marshall Space Flight Center in early 2013, for Orion’s Exploration Flight Test to Earth Orbit in 2014

Assembling the MSA pathfinder hardware in 2012

Delivering MSA rings to Marshall in Dec 2012
Interim Cryogenic Propulsion Stage

- ICPS provides in-space power to send Orion to destinations beyond Earth’s orbit
- Modified version of commercially available Delta Cryogenic Second Stage

Partnering with Industry for Cost-Effective Solutions
SLS 130 metric ton Expanded View

Evolving to Mars-Class Capabilities
J-2X Engine: In Testing

Technology Research & Development:

- Yielded Common Engine Controller for RS-25 Core Stage Engine
- Testing includes Selective Laser Melted engine part manufactured in days rather than weeks

Shortest Time to Full Power Level Ever Recorded
Advanced Research and Development

Enabling Affordable Performance Upgrades
Pursuing Affordability Solutions

- Lean, Integrated Teams with Accelerated Decision Making
- Robust Designs and Margins
- Risk-Informed Government Insight/Oversight Model
- Right-Sized Documentation and Standards
- Evolvable Development Approach
- Hardware Commonality

Sustainability through Life-Cycle Affordability
The Road to First Flight in 2017

<table>
<thead>
<tr>
<th>NASA Life Cycle Phases</th>
<th>Approval for Formulation</th>
<th>FORMULATION</th>
<th>Approval for Implementation</th>
<th>IMPLEMENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Phase A: Concept Studies</td>
<td>Key Decision Point A</td>
<td>KDP B</td>
<td>KDP C</td>
<td>KDP D</td>
</tr>
<tr>
<td>Phase A: Concept &amp; Technology Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase B: Preliminary Design &amp; Technology Completion</td>
<td></td>
<td></td>
<td></td>
<td>EFT-1 Launch</td>
</tr>
<tr>
<td>Phase C: Final Design &amp; Fabrication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase D: System Assembly, Int. &amp; Test, Launch &amp; Checkout</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase E: Operations &amp; Sustainment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase F: Closeout</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Program Life Cycle Gates and Major Events

Human Space Flight Project Reviews

- MCR: Mission Concept Review
- SRR/SDR: System Requirement/Definition Review
- PDR: Preliminary Design Review
- CDR: Critical Design Review
- SR: System Requirements Review
- FRR: Flight Readiness Review
- EFT: Exploration Flight Test
- EM: Exploration Mission
- SIR: System Integration Review
- KDP: Key Decision Point
- SRR: System Requirements Review

[A] monumental effort … has gone into this Program…. I don’t think anyone would have thought in September [2011] that this Program might be this far so fast.

Leroy Cain, Chair
Standing Review Board
NASA Directorate Program Management Council
June 29, 2012
NASA’s Space Launch System

On Course for First Flight in 2017

**Engines**
Tested selective laser melted part on J-2X at Stennis Space Center (March 2013)

**Boosters**
Conducted Thrust Vector Flight Control Test at ATK in Promontory, UT (Jan 2013)

**Core Stage**
Produced Core Stage test panel at AMRO Fabricating Corp. in South El Monte, CA (Dec 2012)

**Preparing segmented ring tool for Core Stage construction at the Michoud Assembly Facility in New Orleans**

**Spacecraft & Payload Integration**
Produced Multi-Purpose Crew Vehicle Stage Adapter for 2014 Exploration Flight Test at the Marshall Space Flight Center (Feb 2013)

**Advanced Development**
Conducted F-1 engine hot-fire testing at Marshall (Jan 2013)

**Tested buffet model in Langley Research Center’s Transonic Dynamics Wind Tunnel (Nov 2012)**

**Systems Engineering & Integration**

SAFE, AFFORDABLE, SUSTAINABLE
SLS Program Organization at MSFC

Chief Engineer (CE) Garry Lyles
Deputy CE John Honeycutt
Procurement Manager Earl Pendley

Chief Safety Officer (CSO) Rick Burt
Deputy CSO Dan Mullane

Boosters Manager Alex Priskos (XP10)
Deputy Manager Bruce Tiller

Engines Manager Mike Kynard (XP20)

Assistant Manager Andrew Schorr
Ground Operations Liaison Manager Brian Matisak (XP60)

Assistant Manager Andy Warren

Spacecraft & Payload Integration Manager David Beaman (XP50)

Stages Manager Tony Lavoie (XP30)

Advanced Development Office Manager Chris Crumbly (XP70)

Deputy Manager Julie Bassler

Deputy Manager Andy Warren

Strategic Development Manager Steve Creech (XP01)

Program Integration Manager Mark Richards (XP02)

Program Planning & Control Manager Keith Hefner (XP03)

Deputy Manager Daryl Woods

Deputy Manager Sheryl Kittredge

Vacant

Chief Safety Officer (CSO)
Deputy CSO
Procurement Manager

Deputy Program Manager
Assistant Program Manager

Program Manager
Deputy Manager
Assistant Manager

Deputy CE
Program Manager
Stages Manager
Boosters Manager
Engines Manager

Deputy Engineer Manager

Deputy Deputy Manager

Deputy Manager

Deputy Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager

Deputy Manager
SLS Partnerships Nationwide

208 Subcontracts in 28 States

- Engaging the U.S. Aerospace Industry
- Strengthening Sectors such as Manufacturing
- Advancing Technology and Innovation

2012 Data
Exploring Space for America’s Future

New National Capability

- National Security
- Scientific Knowledge
- Economic Prosperity
- Global Partnerships
- Technology Development

Inspiration
Summary

- Powerful, versatile, and capable vehicle for entirely new missions to deep space
- Vital to NASA’s exploration strategy and the Nation’s space agenda
- Safe, affordable, and sustainable
- Engaging the U.S. aerospace workforce and infrastructure
- Competitive opportunities for innovations that affordably upgrade performance
- Successfully meeting milestones in preparation for Preliminary Design Review in 2013
- On course for first flight in 2017
A National Infrastructure Asset

For Beyond-Earth Orbit Exploration

2017
Somewhere, something incredible is waiting to be known.

— Carl Sagan

For More Information

www.nasa.gov/sls

www.twitter.com/nasa_sls

www.facebook.com/nasasls