SPACE LAUNCH SYSTEM

DEEP-SPACE DEPLOYMENT FOR SMALLSATS

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Manager, Spacecraft/Payload Integration & Evolution
NASA Space Launch System
FISO Tellecnon 07-12-17
SLS CAPABILITY AVAILABILITY

SLS Block 1
As Early As 2019

Provides
Initial Heavy-Lift Capability

Enables
Orion Test
SmallSats to Deep Space

SLS Block 1B Crew
As Early As 2022

Provides
105 t lift capability via Exploration Upper Stage
Co-manifested payload capability in Universal Stage Adapter

Enables
Deep Space Gateway
Larger CubeSat- and ESPA-Class Payloads

SLS Block 1B Cargo
As Early As 2023

Provides
8.4-meter fairings for primary payloads
Regular flight cadence for additional launches

Enables
Europa Clipper/Lander
Deep Space Transport
Large-Aperture Space Telescopes
Ice or Ocean Worlds Missions
Interstellar Medium

SLS Block 2
As Early As 2028

Provides
130 t lift capability via advanced boosters
10-meter fairings for primary payloads

Enables
Crewed Mars Orbit Missions
Crewed Mars Surface Missions

www.nasa.gov/sls
SLS BLOCK 1 CONFIGURATION

OVERVIEW

• Initial configuration of vehicle optimized for near-term heavy-lift capability
• Completed Critical Design Review in July 2015

UTILIZATION

• Initial demonstration of Space Launch System and Orion capabilities
• Supports launch of Orion into distant retrograde orbit around the moon

SLS Block 1

<table>
<thead>
<tr>
<th>Capability</th>
<th>&gt;70 metric tons</th>
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</thead>
<tbody>
<tr>
<td>Height</td>
<td>322 feet</td>
</tr>
<tr>
<td>Weight</td>
<td>5.75 million pounds</td>
</tr>
<tr>
<td>Thrust</td>
<td>8.8 million pounds</td>
</tr>
<tr>
<td>Available</td>
<td>2019</td>
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</table>

www.nasa.gov/sls
EM-1 SECONDARY PAYLOAD CAPABILITY

Accommodations

- SLS for Exploration Mission-1 will include thirteen 6U payload locations of up to 14kg per CubeSat

EM-1 Trajectory

- Orion will enter Distant Retrograde Orbit around the moon
- Additional cislunar trajectories being studied for future missions
# EM-1 CUBESAT BUS STOPS

<table>
<thead>
<tr>
<th>Bus Stops</th>
<th>Distance (approx.)</th>
<th>Flight Time (approx.)</th>
<th>Approx. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26,700 km</td>
<td>3 Hrs. &amp; 34 Min.</td>
<td>13°C (55°F)</td>
</tr>
<tr>
<td>2</td>
<td>64,500 km</td>
<td>7 Hrs. &amp; 51 Min.</td>
<td>-7°C (20°F)</td>
</tr>
<tr>
<td>3</td>
<td>192,300 km</td>
<td>3 Days, 6 Hrs. &amp; 12 Min.</td>
<td>-29°C (-20°F)</td>
</tr>
<tr>
<td>4</td>
<td>384,500 km</td>
<td>6 Days, 11 Hrs. &amp; 57 Min.</td>
<td>-26°C (-15°F)</td>
</tr>
<tr>
<td>5</td>
<td>411,900 km</td>
<td>7 Days, 0 Hrs. &amp; 16 Min.</td>
<td>-29°C (-20°F)</td>
</tr>
</tbody>
</table>

**Bus Stops Description**

1. First opportunity for deployment, cleared 1\textsuperscript{st} radiation belt
2. Clear both radiation belts plus ∼ 1 hour
3. Half way to the moon
4. At the moon, closest proximity (∼250 km from surface)
5. Past the moon plus ∼12 hours (lunar gravitational assist)

Note: All info based on a 6.5 day trip to the moon.
ONE LAUNCH, MULTIPLE DISCIPLINES

Moon
- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- OMOTENASHI (JAXA)

Asteroid
- NEA Scout (NASA)

Sun
- CuSP (Southwest Research Institute)

Earth
- EQUULEUS (JAXA)
- Skyfire (Lockheed Martin)

And Beyond
- Biosentinel (NASA)
- ArgoMoon (ESA/ASI)
- Cislunar Explorers (Cornell University)
- CU-E3 (University of Colorado Boulder)
- Team Miles (Fluid & Reason)
**Lunar Flashlight**
- Payload Developer: Jet Propulsion Laboratory
- Objective: Search for lunar surface ice deposits using near-IR band lasers
- Mission Destination: Lunar Orbit

**Near Earth Asteroid Scout (NEA Scout)**
- Payload Developer: Marshall Space Flight Center
- Objective: Perform target detection, reconnaissance and close proximity imaging of a NEA
- Mission Destination: A Near Earth Asteroid (within ~1.0 AU distance from Earth)

**BioSentinel**
- Payload Developer: Ames Research Center
- Objective: Quantify DNA damage from space radiation environment
- Destination: Heliocentric Trajectory

**Lunar IceCube**
- Payload Developer: Moorehead State University
- Objective: Prospect for water (ice, liquid & vapor) & other lunar volatiles using IR spectrometer
- Mission Destination: Lunar Orbit

**SkyFire**
- Payload Developer: Lockheed Martin Space Systems
- Objective: Collect IR imaging of Lunar Surface
- Mission Destination: Heliocentric via Lunar Flyby
Cubesat to Study Solar Particles (CuSP)
- Payload Developer: Southwest Research Institute (SwRI)
- Objective: Observations of Interplanetary Space environment to gain insight into space weather
- Destination: Heliocentric Trajectory

LUNAr polar Hydrogen Mapper (LunaH-Map)
- Payload Developer: Arizona State University (ASU)
- Objective: Perform neutron spectroscopy of lunar surface to determine hydrogen abundance
- Mission Destination: Lunar Orbit
**INTERNATIONAL PARTNERS**

**ArgoMoon**
- Payload Developer: ASI
- Objective: Provide photography of EM-1 Mission, detailed imagery of ICPS as well as demonstrate image system operability
- Mission Destination: Elliptical Earth Orbit (ICPS proximity)

**Outstanding Moon exploration TEchnologies demonstrated by NAno Semi-Hard Impactor (OMOTENASHI)**
- Payload Developer: JAXA
- Objective: Develop worlds smallest lunar lander and observe lunar radiation environment
- Mission Destination: Lunar Surface

**EQUilibriUm Lunar-Earth point 6U Spacecraft (EQUULEUS)**
- Payload Developer: JAXA
- Objective: Characterize radiation environment in geospace by imaging the Earth’s plasmasphere
- Mission Destination: Earth-Moon L2
Goal: Foster innovation in small spacecraft navigation, operations, and communications techniques for deep space.

- CubeSat design limited to 6U and 14kg. Participants may qualify for EM-1 launch or provide their own ride. $5 million prize money available.

**Lunar Derby**
While in lunar orbit

- Achieve Lunar Orbit - $1.5M/shared, $1M max per team
- Error-free Communication
  - Burst Rate - $225k/25k
  - Total Volume - $675k/75k
- Longevity
  - $450k/50k

**Deep Space Derby**
While range ≥4M km

- Farthest Distance
  - $225k/25k
- Error-free Communication
  - Burst Rate - $225k/25k
  - Total Volume - $675k/75k
- Longevity
  - $225k/25k

**Ground Tournaments (GT)**
4 Rounds
Approx every 6 months

Top 5 teams receive incremental funding (max $100k per team)

Top 3 teams launch free on EM-1
Team Miles
- Payload Developer: Fluid & Reason, LLC
- Objective: Compete in the Deep Space Derby for Furthest Communication Distance from Earth prize
- Mission Destination: Deep Space

Cislunar Explorers
- Payload Developer: Cornell University
- Objective: Compete in the Lunar Derby for Achieving Lunar Orbit and Spacecraft Longevity prizes
- Mission Destination: Lunar Orbit

CU-E3
- Payload Developer: University of Colorado Boulder
- Objective: Compete in the Deep Space Derby for Best Burst Data Rate, Largest Aggregate Data Volume Sustained over time, Spacecraft Longevity and Furthest Communication Distance from Earth prizes
- Mission Destination: Deep Space
SLS BLOCK 1B CONFIGURATION

OVERVIEW

- Replaces Interim Cryogenic Propulsion Stage with human-rated Exploration Upper Stage
- EUS has completed checkpoint prior to Preliminary Design Review

UTILIZATION

- Supports launch of Orion and co-manifested exploration systems in “Proving Ground” of cis-lunar space
- With large 8.4-meter fairing, can launch game-changing science missions and other high-priority payloads

SLS Block 1B

- Capability: >105 metric tons
- Height: 364 feet
- Weight: 6 million pounds
- Thrust: 8.8 million pounds
- Available: No earlier than 2021
<table>
<thead>
<tr>
<th></th>
<th>EM-1</th>
<th>Europa Clipper</th>
<th>EM-2</th>
<th>EM-3</th>
<th>EM-4</th>
<th>EM-5</th>
<th>2026</th>
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<tr>
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**These essential Gateway elements can support multiple U.S. and International partner objectives in Phase 1 and beyond.**

**Known Parameters:**
- Gateway to architecture supports Phase 2 and beyond activities
- International and U.S. commercial development of elements and systems
- Gateway will translate uncrewed between cislunar orbits
- Ability to support science objectives in cislunar space

**Open Opportunities:**
- Order of logistics flights and logistics providers
- Use of logistics modules for available volume
- Ability to support lunar surface missions
BLOCK 1B SMALL PAYLOAD OPTIONS

VOLUME AND MASS RANGE

- 1U Soccer Ball: 10 cm, 14 kg
- 6U: 14 kg
- 12U: 25 kg
- 27U: 54 kg
- Ring Payload Interface (Notional): ~180 kg
~61 cm
PROGRESS TOWARD EM-2/BLOCK 1B

EM-2 Core Stage Welding

EM-2 Booster Insulation Installation

EM-2 Flight Engine Testing

Universal Stage Adapter Contract

EUS Development Panel Forming
Summary

• SLS provides a unique opportunity for the CubeSat/smallsat community
  – Enables access to Earth, Moon, Sun & Deep Space
  – Opportunity to manifest payloads from 6U/12U/27U to ESPA-Class

• First Flight (EM-1) hardware production in-progress
  – Block 1B initiating procurement/production activities

More Information

• SLS Mission Planner’s Guide (ESD 30000)
  – Provides future payload developers/users with information to support preliminary SLS mission planning
  – Covers Block 1B (105mT*) & Block 2 (130mT*) configurations
  – Copies can be requested by email to: NASA-slspayloads@mail.nasa.gov

* Payload Mass to Low Earth Orbit
EXPLORATION MISSION-1: LAUNCHING SCIENCE & TECHNOLOGY SECONDARY PAYLOADS

1 PRIMARY MISSION
TESTING SLS AND ORION SPACE LAUNCH SYSTEM (SLS) LIFTS MORE THAN ANY EXISTING LAUNCH VEHICLE

ORION STAGE ADAPTER
Supports both primary mission and secondary payloads

ORION SPACECRAFT
Traveling thousands of miles beyond the Moon, where no crew vehicle has gone before

SECONDARY PAYLOADS
The ring that will connect the Orion spacecraft to NASA's SLS also has room for 13 hitchhiker payloads

SHOEBOX SIZE
Payloads expand our knowledge for the journey to Mars

13 CUBESAT EXPLORERS
Going to deep space where few cubesats have ever gone before

AVIONICS
(Self-contained and independent from the primary mission) send cubesats on their way

#RideOnSLS