NASA’S SPACE LAUNCH SYSTEM: DEEP-SPACE OPPORTUNITIES FOR SMALLSATS

4S Symposium

Kimberly Robinson, Ph.D.
Payloads Manager

Carole McLemore, Ph.D.
Secondary Payloads Integration Manager

Space Launch System Program
May 29, 2018
NASA’S EXPLORATION PLANS

Earth
- Notional Commercial Platform
- ISS
- Commercial launch Vehicles

Moon
- Orion
- SLS
- Robotic Surface Missions
- Commercial Lunar Lander

Mars
- Lunar Orbital Platform - Gateway
- PPE - Habitat - Airlock - Logistics

In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions
SLS – ENABLING HUMAN EXPLORATION
EXPLORATION CLASS: DEEP SPACE CAPABILITIES

**VOLUME**
- **Five times more volume** than any contemporary heavy lift vehicle
- **Only vehicle** that can carry the Orion and a co-manifested payload to the Moon

**MASS**
- **Block 1**: Can launch *60% more mass* than any contemporary launch vehicle
- **Block 2**: Mars-enabling capability of **greater than 45 metric tons** to Trans Lunar Injection

**DEPARTURE ENERGY**
- **Reduce transit times by half or greater** to the outer solar system
SLS BLOCK 1 CONFIGURATION FOR EM-1

- **Launch Abort System (LAS)**
- **RS-25 Engines (4)** by Aerojet Rocketdyne
- **Service Module (SM)**
- **5 Segment Solid Rocket Boosters (2)** by Orbital ATK
- **Encapsulated Service Module (ESM) Panels**
- **Spacecraft Adapter**
- **Orion Stage Adapter** by Teledyne Brown Engineering
- **Crew Module (CM)** by Lockheed Martin
- **Orion Spacecraft** by Lockheed Martin
- **Interim Cryogenic Propulsion Stage (ICPS)** by Boeing/United Launch Alliance
- **Launch Vehicle Stage Adapter**
- **Core Stage & Avionics** by Boeing
- **Crew Module (CM)**
- **Encapsulated Service Module (ESM) Panels**
- **Spacecraft Adapter**
- **Orion Stage Adapter** by Teledyne Brown Engineering
- **Interim Cryogenic Propulsion Stage (ICPS)** by Boeing/United Launch Alliance
- **Launch Vehicle Stage Adapter**
- **Core Stage & Avionics** by Boeing
- **Launch Abort System (LAS)**
- **Crew Module (CM)**
- **Service Module (SM)**
SOLID ROCKET BOOSTERS
ENGINES
CORE STAGE
IN-SPACE STAGE AND ADAPTERS
EXPLORATION MISSION-1
FULL SYSTEMS CHECKOUT PRIOR TO CREWED MISSIONS
## Sample Deployment Locations

<table>
<thead>
<tr>
<th>Bus Stops</th>
<th>Description</th>
<th>Altitude (approx.)</th>
<th>Flight Time (PMA Based)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First opportunity for deployment, cleared 1st radiation belt</td>
<td>34,507 km</td>
<td>4 Hrs. 1 Min.</td>
</tr>
<tr>
<td>2</td>
<td>Clear both radiation belts plus ~1 hour</td>
<td>70,242 km</td>
<td>6 Hrs. 59 Min.</td>
</tr>
<tr>
<td>3</td>
<td>Half way to the moon</td>
<td>192,300 km</td>
<td>1 Days, 0 Hrs. 54 Min.</td>
</tr>
<tr>
<td>4</td>
<td>At the moon, closest proximity (~240 km from surface)</td>
<td>395,248 km</td>
<td>5 Days, 21 Hrs. 50 Min.</td>
</tr>
<tr>
<td>5</td>
<td>Past the moon plus ~12 hours (lunar gravitational assist)</td>
<td>355,807 km</td>
<td>6 Days, 9 Hrs. 49 Min.</td>
</tr>
</tbody>
</table>

Note: All info based on a 5.9 day trip to the moon (PMA Trajectory)
ONE LAUNCH, MULTIPLE DISCIPLINES
SMALLSATS TO BE DEPLOYED FROM THE ORION STAGE ADAPTER

MOON
- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- OMOTENASHI (JAXA)
- LunIR (Lockheed Martin)

ASTEROID
- NEA Scout (NASA)

EARTH
- EQUULEUS (JAXA)

AND BEYOND
- Biosentinel (NASA)
- ArgoMoon (ESA/ASI)
- Cislunar Explorers (Cornell University)
- CU-E3 (University of Colorado Boulder)
- Team Miles (Miles Space)
ONE LAUNCH, MULTIPLE DISCIPLINES
13 SMALLSATS TO BE DEPLOYED FROM THE ORION STAGE ADAPTER
EM-1 SECONDARY PAYLOAD CAPABILITY

- Orion Stage Adapter (OSA)
- Secondary Payloads
- Avionics Box
- Electrical Panels (2 places)
- Forward Ring
- Cabling
- OSA Diaphragm
- Secondary Payload Brackets (13)
- Isogrid Barrel Panels
- Aft Ring
- Access Cover (2 places)
Foundation for a generation of deep space exploration

SLS EVOLVABILITY

<table>
<thead>
<tr>
<th>Height</th>
<th>322 ft</th>
<th>364 ft</th>
<th>327 ft</th>
<th>364 ft</th>
<th>365 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Stage</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Cargo Fairing</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Exploration Upper Stage</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Interstage</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Evolved Boosters</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Solid Rocket Boosters</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Universal Stage Adapter</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Orion</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>RS-25 Engines</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Launch Vehicle Stage Adapter</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Launch Abort System</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SLS Block 1</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SLS Block 1B Crew</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SLS Block 1B Cargo</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SLS Block 2 Crew</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>SLS Block 2 Cargo</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
FUTURE SLS EXPLORATION MISSION OPTIONS FOR SMALL PAYLOADS

- **1U Football**
  - 10 cm, 14 kg
- **6U**
  - 14 kg
- **12U**
  - 25 kg
- **27U**
  - 54 kg

Ring Payload Interface (Notional)
- ~180 kg
- ~61 cm
More Information

• SLS Mission Planner’s Guide (ESD 30000)
  - Provides future payload developers/users with information to support preliminary SLS mission planning
  - Copies can be requested via email: NASA-slspayloads@mail.nasa.gov
  - www.nasa.gov/opportunities for CubeSat payload opportunities and announcements
IT'S HAPPENING NOW!

www.nasa.gov
@NASA_SLS
NASASLS
google.com/+nasa
youtube.com/nasa
@explorenasa
DEEP-SPACE OPPORTUNITIES FOR SMALLSATS