National Aeronautics and Space Administration

SPACE LAUNCH SYSTEM

SLS CubeSats, Now and the Future

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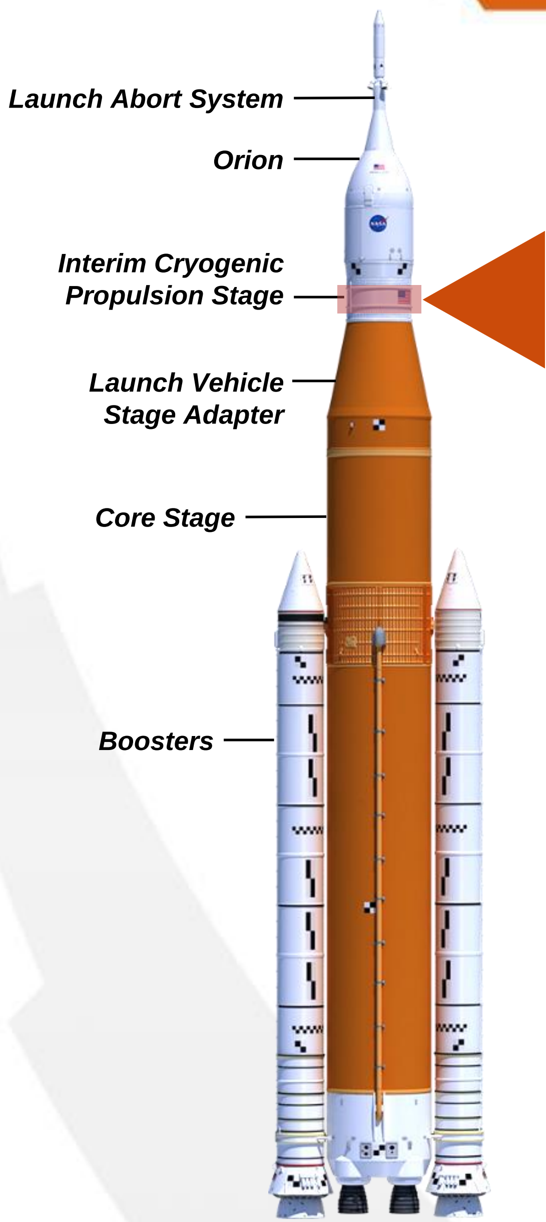
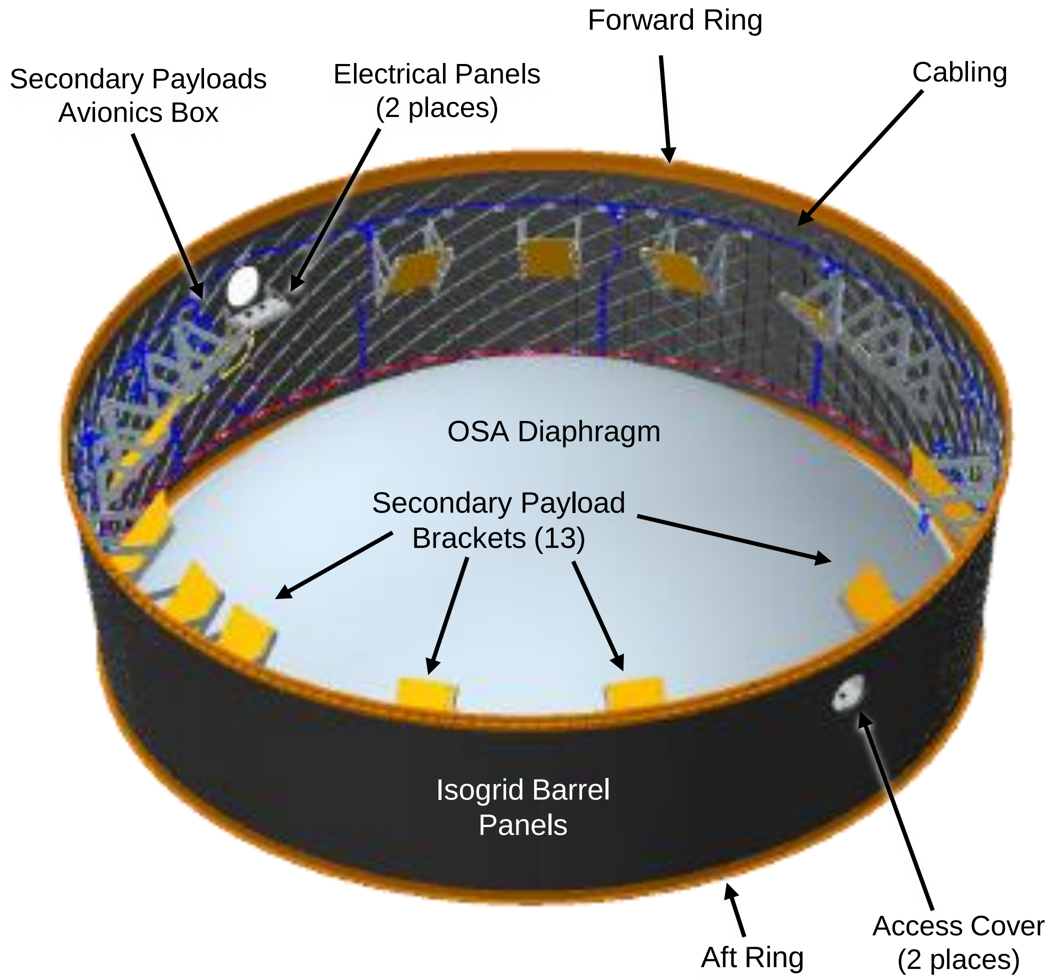
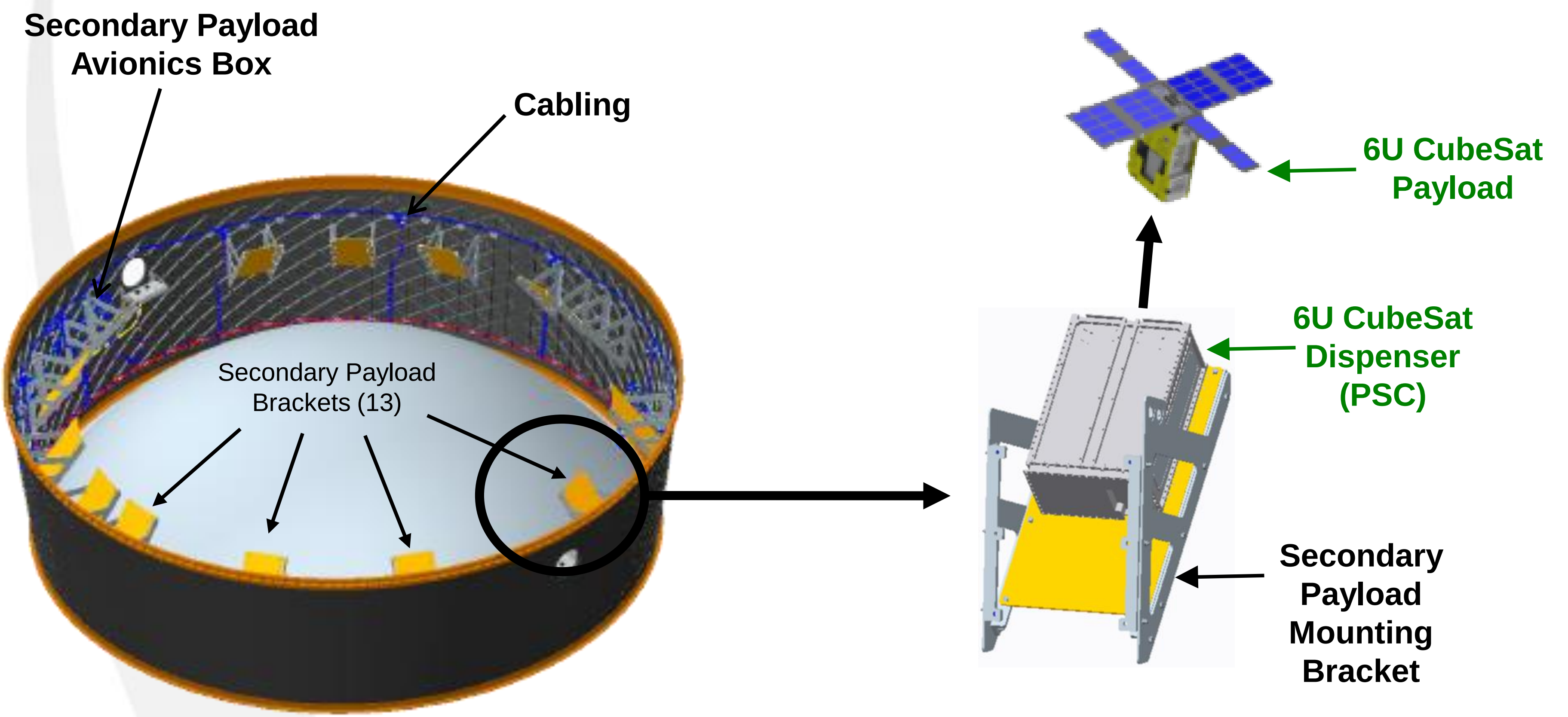
SLS BLOCK 1 EXPLORATION MISSION-1 (EM-1)





Orion Stage Adapter (OSA)

EM-1 OSA SECONDARY PAYLOAD ACCOMMODATIONS



LEGEND:

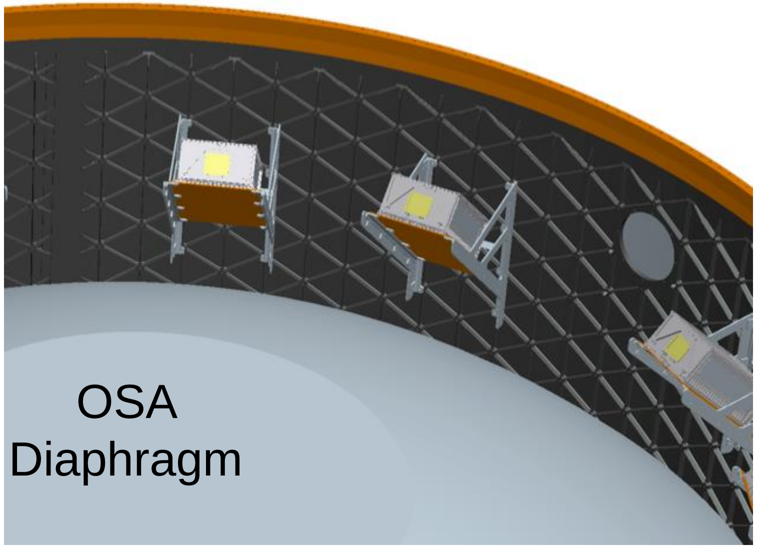
SLS Provided

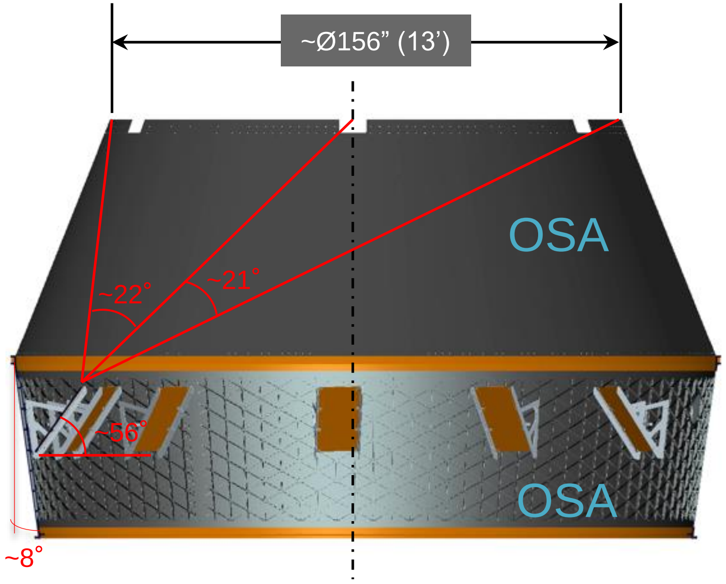
PD Provided

SYSTEM DESCRIPTION AND PURPOSE

Expand and fully utilize the SLS capabilities for exploration purposes without causing harm or inconvenience to SLS or its primary payload.

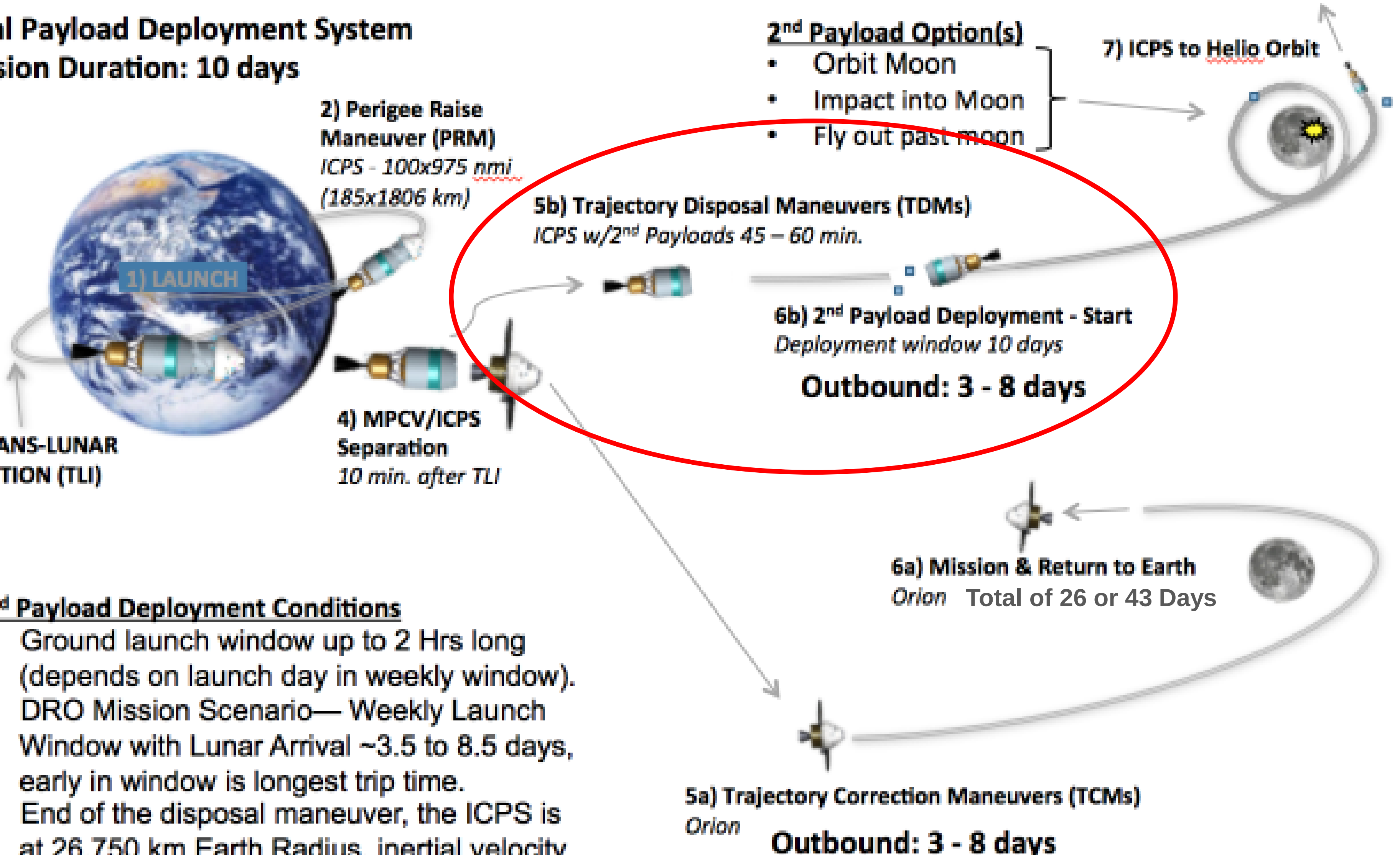
- **Thirteen (max capability 17)** 6U payload locations
- 6U volume/mass is the current standard (14 kg payload mass)
- Payloads will be **"powered off"** from turnover through Orion separation and payload deployment
- Payload Deployment System Sequencer; payload deployment will begin with pre-loaded sequence following Orion separation and **ICPS disposal** burn
- Payload requirements captured in Interface Definition and Requirements Document **(IDRD)** & **SLS-RQMT-216 Safety Requirements**





EM-1 OVERVIEW

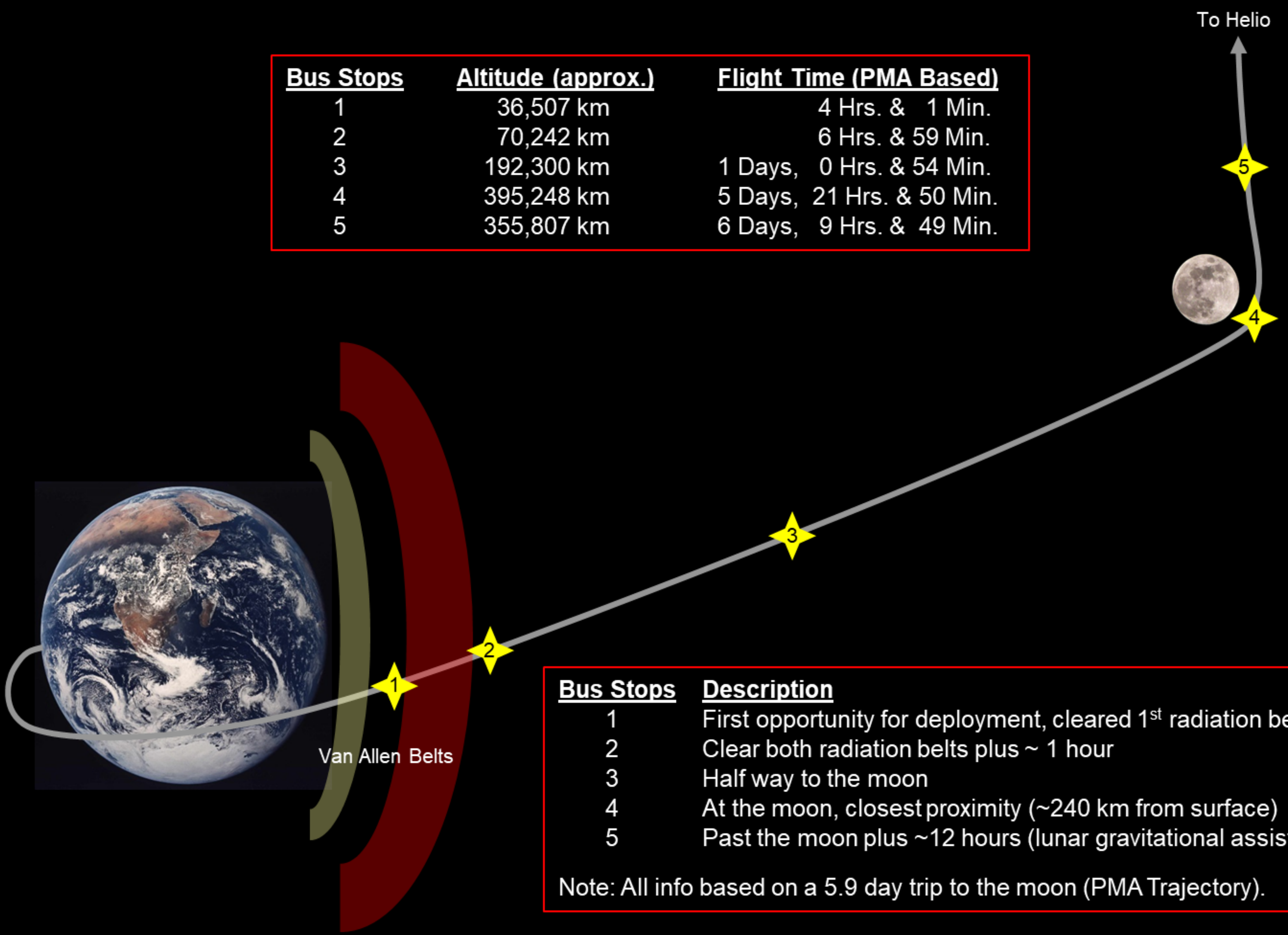
Total Payload Deployment System
Mission Duration: 10 days



2nd Payload Deployment Conditions
- Ground launch window up to 2 Hrs long (depends on launch day in weekly window).
- DRO Mission Scenario— Weekly Launch Window with Lunar Arrival ~3.5 to 8.5 days, early in window is longest trip time.
- End of the disposal maneuver, the ICPS is at 26,750 km Earth Radius, inertial velocity of 5.279 km/s.

EM-1 CUBESAT BUS STOPS

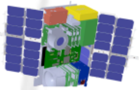
Bus Stops	Altitude (approx.)	Flight Time (PMA Based)
1	36,507 km	4 Hrs. & 1 Min.
2	70,242 km	6 Hrs. & 59 Min.
3	192,300 km	1 Days, 0 Hrs. & 54 Min.
4	395,248 km	5 Days, 21 Hrs. & 50 Min.
5	355,807 km	6 Days, 9 Hrs. & 49 Min.



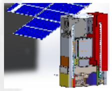
Bus Stops	Description
1	First opportunity for deployment, cleared 1st radiation belt
2	Clear both radiation belts plus ~ 1 hour
3	Half way to the moon
4	At the moon, closest proximity (~240 km from surface)
5	Past the moon plus ~12 hours (lunar gravitational assist)

Note: All info based on a 5.9 day trip to the moon (PMA Trajectory).

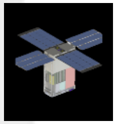
EM-1 PAYLOAD MANIFEST (HEO, SMD, STMD & IP)



- **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



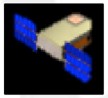
- **LUNAr polar Hydrogen Mapper (LunaH-Map)**
  - Payload Developer: Arizona State University (ASU)
  - Objective: Perform neutron spectroscopy of lunar surface to determine H abundance
  - Mission Destination: Lunar Orbit



- **Lunar Flashlight**
  - Payload Developer: Jet Propulsion Laboratory
  - Objective: Search for lunar surface ice deposits using near-IR band lasers
  - Mission Destination: Lunar Orbit

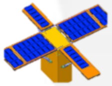
Centennial Challenge Payloads on next page (three will fly)

- **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

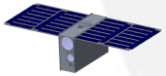
- **Lunar IceCube**
  - Payload Developer: Moorehead State University
  - Objective: Prospect for water (ice, liquid & vapor) & other lunar volatiles using IR spectrometer
  - Mission Destination: Lunar Orbit



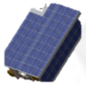
- **LunIR**
  - Payload Developer: Lockheed Martin Space Systems
  - Objective: Collect IR imaging of Lunar Surface
  - Mission Destination: Heliocentric via Lunar Flyby

↑ **Domestic**

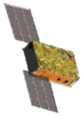
International ↓



- **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



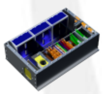
- **EQUULEUS**
  - Payload Developer: JAXA
  - Objective: Characterize radiation environment in geospace by imaging the Earth's plasmasphere
  - Mission Destination: Earth-Moon L2

STMD EM-1 CENTENNIAL CHALLENGES PAYLOADS

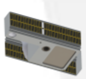
- **STMD Centennial Challenges**
  - Ground Tournaments #1-3 (of 4) complete
  - Three will be selected from the 6 payloads identified below (Mar 2017)
    - Two will be carried as back-ups

Candidate CubeSats

- **KitCube**
  - Payload Developer: Project Selene – Collaborative set of California High Schools
  - Objective: Compete in **Lunar Derby** for the Achieve Lunar Orbit, Best Burst Data Rate, Largest aggregate Data Volume Sustained over time and Spacecraft Longevity prizes
  - Mission Destination: Lunar Orbit



- **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

- **Heimdallr**
  - Payload Developer: Ragnarok Industries
  - Objective: Compete in the **Lunar Derby** for the Achieve Lunar Orbit, Best Burst Data Rate, Largest aggregate Data Volume Sustained over time and Spacecraft Longevity prizes
  - Mission Destination: Lunar Orbit

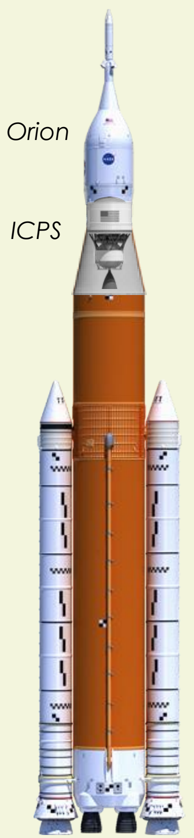
- **CU-E^3**
  - Payload Developer: University of Colorado
  - Objective: Compete in the **Deep Space Derby** for Best Burst Data Rate, Largest Aggregate Data Volume Sustained over time, Spacecraft Longevity and Furthest Communication Distance from Earth prizes
  - Mission Destination: Deep Space

- **SEDS Triteria**
  - Payload Developer: University of California San Diego
  - Objective: Compete in the **Lunar Derby** for the Achieve Lunar Orbit and Spacecraft Longevity prizes
  - Mission Destination: Lunar Orbit

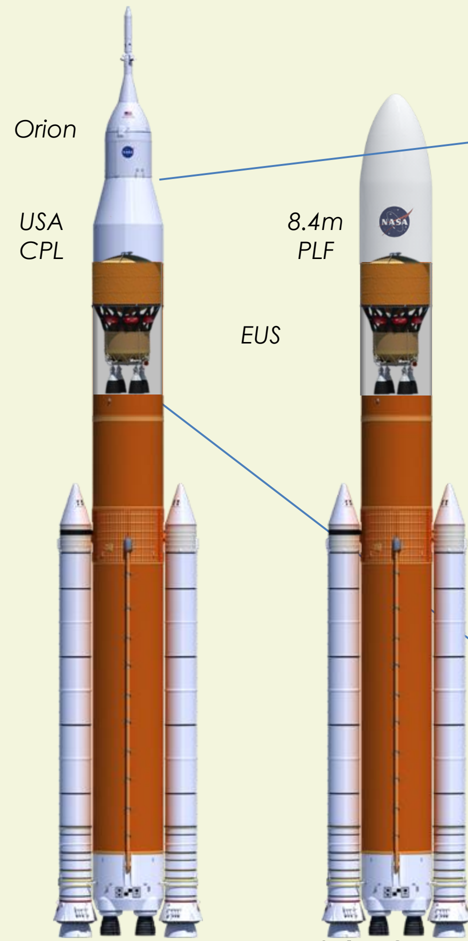
EM-1 SECONDARY PAYLOAD DEPLOYMENT

SECONDARY PAYLOADS BEYOND EM-1

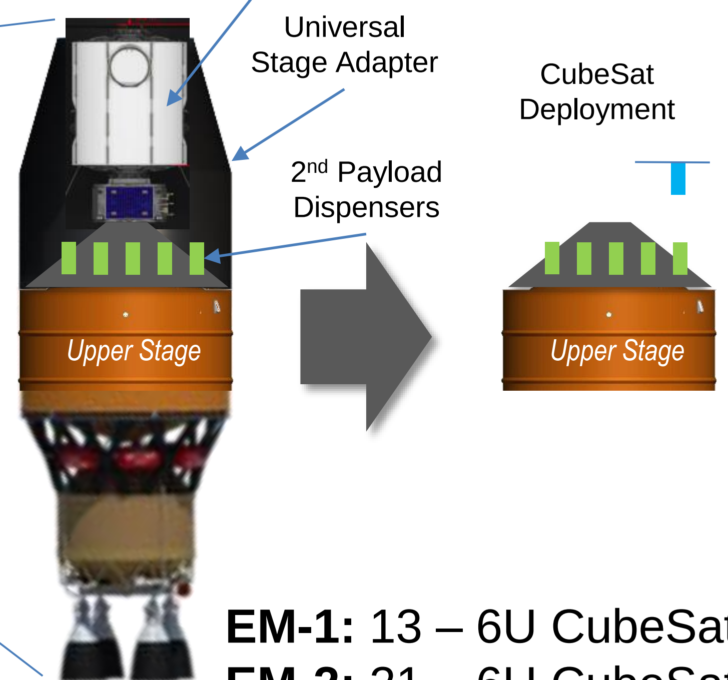
SLS Block 1
70t+ to LEO
(No Earlier than 2019)



SLS Block 1B
105t+ to LEO
(No Earlier than 2022)



CubeSat deployments start after USA & CPL departure, 10 day period



EM-1: 13 – 6U CubeSats
EM-2: 21 – 6U CubeSats
Also able for 12U & 27U CubeSats

Your imagination is the limit!

Back – Up Charts

BRIEF DESCRIPTION

The Secondary Payload Deployment System (SPDS) is comprised of the mounting brackets, cable harnesses, & the avionics unit. The payloads are responsible for their payload, the dispenser, & any vibration isolation system or thermal protection. The cable harnesses and the brackets are being developed, built, & installed into the MSA by NASA at MSFC. They have agreed to install the avionics unit (vendor developed) into the MSA at MSFC. We plan to do an integrated end-to-end test of the SPDS using the MSFC developed EGSE. The EGSE will simulate the ICPS & dispenser functions. The SPDS will be shipped to KSC in the MSA. An abbreviated check-out test will be performed as part of MSFC handover to KSC GSDO. Exactly where the MSA will be at KCS for payload integration is currently in flux. The payloads will be delivered to KSC via an LSP vendor (Tyvak). The payloads will already be integrated into the dispensers and cable pigtails, vib isolation, & thermal protection (if needed) will be attached to the dispenser at the time of handover to GSDO. GSDO will install the integrated payload/dispenser into the MSA, record fastener torqueing's, & measure/record grounding/bonding between the dispenser and the bracket. At some point (this part is in flux) the MSA will be attached to the ICPS and Orion will be installed on top. When Orion is installed there is no further physical access to the payloads. Approx. 2 weeks prior to the first roll out (vehicle wet rehearsal) GSDO will connect the SPDS EGSE to the SPDS via the ICPS forward skirt access to the MSA “dog house” connectors. GSDO will then provide battery charging to the SPDS avionics unit & the appropriate payloads that meet the conditions for battery charging. If needed we will also have the ability to reload the “skit” tables in the avionics unit at that time. The skits are what determine which payloads are deployed at what time based on the flight time to the moon. Just prior to the final vehicle roll-out the EGSE is removed from the vehicle. There is no further interaction w/the SPDS or payloads by GSDO, in a nominal process. The day of launch ULA will load the ICPS operational parameters for that day’s flight. One of those parameters is the number (1, 2, or 3) for which skit will be selected for that flight (based on trip time to the moon). After the launch, ICPS separation from the core, TLI burn, Orion separation/departure, & majority of ICPS disposal activities the ICPS will turn on the SPDS and send the appropriate number of discretes for skit selection. The ICPS will put itself into a 1 rpm roll and proceed w/ hydrazine depletion. Once the propellant is spent ICPS plans to take one more set of readings, downlink those readings, & shut down. At this point ICPS is a dead rock in space. Shortly there after SPDS, which has been counting since it was activated, comes to “bus stop” #1 & starts deploying the first set of payloads per the selected skit. Currently bus stop #1 has 7 payloads being deployed. Currently we are planning to deploy payloads at 1 minute intervals even though we can deploy them at 5 sec. intervals. We are currently using 1 minute to help assure no re-contact between payloads during their initial release. When the avionics unit sends the discrete to the dispenser the door will open & the spring loaded dispenser plate will shove the payload into space. At bus stop #2 5 more payloads will be released. Bus stop #2 is roughly 1 hour outside of the second belt of the Van Allen Belt. Once the ICPS flies past the moon (approximately 8 hours), at the final bus stop, the last payload will be released. Shortly after that the avionics system will shut itself down, completing the SPDS mission. Since there is no SPDS system feedback to Earth and ICPS is dead. The only way we’ll know if the SPDS was successful is if the payloads make contact w/Earth or if a payload with a camera takes a picture of the inside of the MSA to show all of the dispenser doors open & sends that back to Earth.