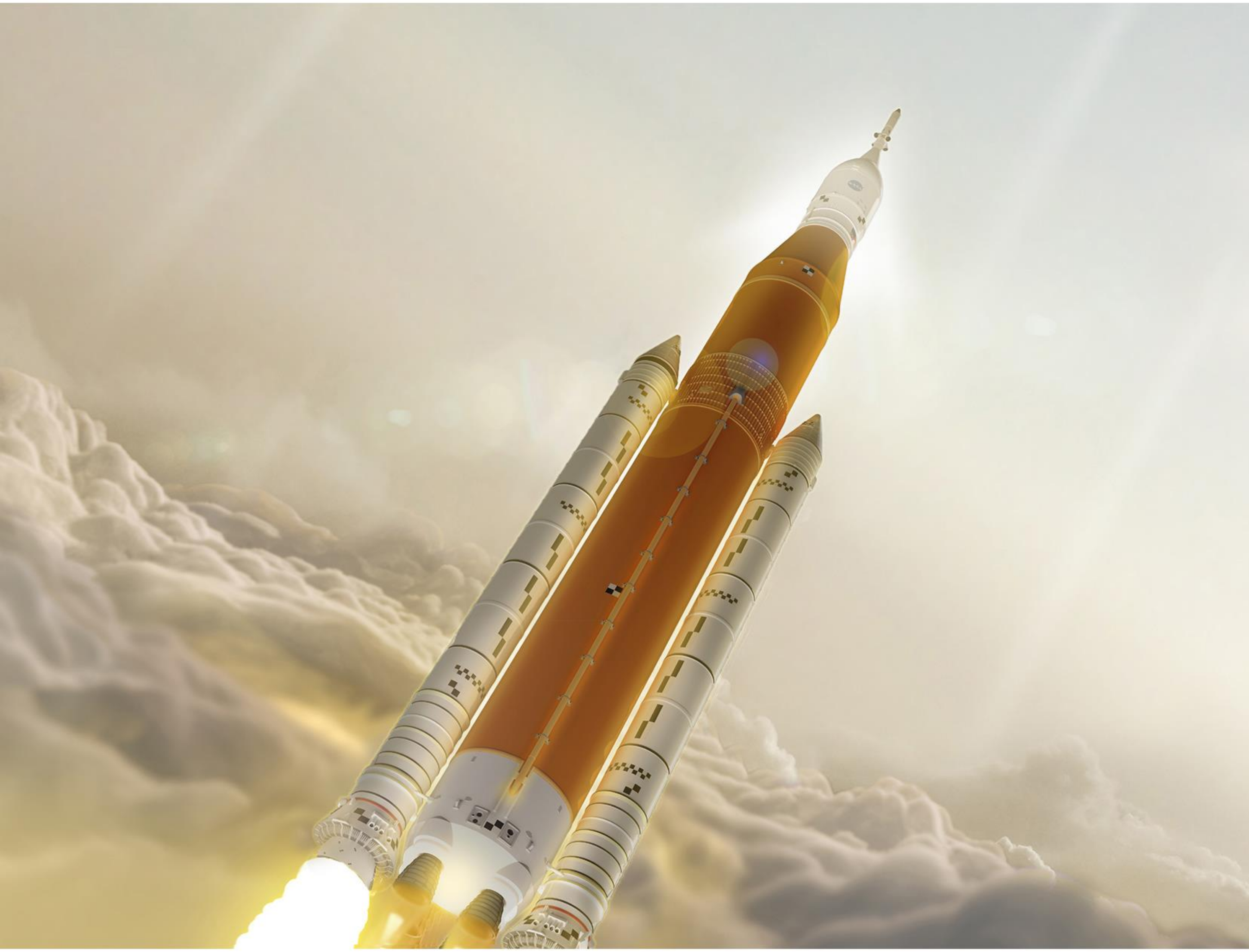
National Aeronautics and Space Administration



SPACE LAUNCH SYSTEM (SLS)
MISSION PLANNER'S GUIDE

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REVISION A
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NOTE: Updates to this document, as released by numbered changes (Change XXX), are identified by a black bar on the right margin.

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this Space Launch System (SLS) Mission Planner's Guide (MPG) is to provide future payload developers/users with sufficient insight to support preliminary SLS mission planning. Consequently, this SLS MPG is not intended to be a payload requirements document; rather, it organizes and details SLS interfaces/accommodations in a manner similar to that of current Expendable Launch Vehicle (ELV) user guides to support early feasibility assessments. Like ELV programs, specific payload requirements will be defined in unique documentation once manifested to fly on SLS. SLS users requiring additional mission planning information or more detailed technical interchange concerning specific SLS accommodations should contact the SLS Spacecraft/Payload Integration and Evolution (SPIE) office. SPIE serves as the payload point of contact to SLS and can be reached by email at NASA-slspayloads@mail.nasa.gov.

1.2 Scope

This document has been developed to respond to queries by the SLS user community concerning SLS accommodations and their general availability. This SLS MPG will be updated as needed to reflect newly baselined capabilities as the SLS payload-specific performance to destination, interfaces, and operational constraints mature.

Capabilities described within the SLS MPG are representative and not necessarily indicative of NASA space exploration intent, planning, funding or requirements. SLS provides the United States with a unique launch capability for which alternative systems do not exist. Therefore, SLS payloads will be compliant with 51 U.S.C. 50131, Requirement to Procure Commercial Space Transportation Services, and the National Space Policy directive to "refrain from conducting United States Government space activities that preclude, discourage, or compete with U.S. commercial space activities, unless required by national security or public safety."

1.3 Change Authority/Responsibility

The NASA Office of Primary Responsibility (OPR) for this document is Exploration Systems Development (ESD) Division. The OPR Designee (OPRD) is the SLS Program, Spacecraft/Payload Integration and Evolution (SPIE) Office. The OPRD is charged with development and management of updates to the document prior to submitting a formal Change Request (CR). Proposed changes to this document will be submitted via a CR to the ESD Control Board (ECB) for disposition.

2.0 DOCUMENT

Reserved.

3.0 SLS OVERVIEW

SLS is an evolvable system that offers unique capabilities in terms of payload mass, volume and departure energy. Three major SLS upgrades – Blocks 1, 1B, and 2 - are planned, each available in a crew and a cargo configuration. The initial Block 1 vehicle will send payload to the Moon via Trans-Lunar Injection (TLI) starting in early 2020s. The Block 1 crew configuration is currently planned to be used for an initial uncrewed test flight, Exploration Mission-1 (EM-1), and for the first crewed lunar flight since 1972, Exploration Mission-2 (EM-2). The Block 1 cargo configuration is under consideration for Science Mission-1 (SM-1), which will see the vehicle launch a robotic probe to Jupiter's moon Europa using a direct trajectory.

The second variant, Block 1B, will evolve over time to be capable of delivering significantly more payload beyond low-Earth orbit (LEO) by the mid 2020s followed by the Block 2 in the late 2020's. While specifically created to enable human space exploration, SLS will provide unique payload lift, volume and operational flexibility for a range of other missions of national importance. The benefits of these unique performance capabilities are shown in Figure 3-1.

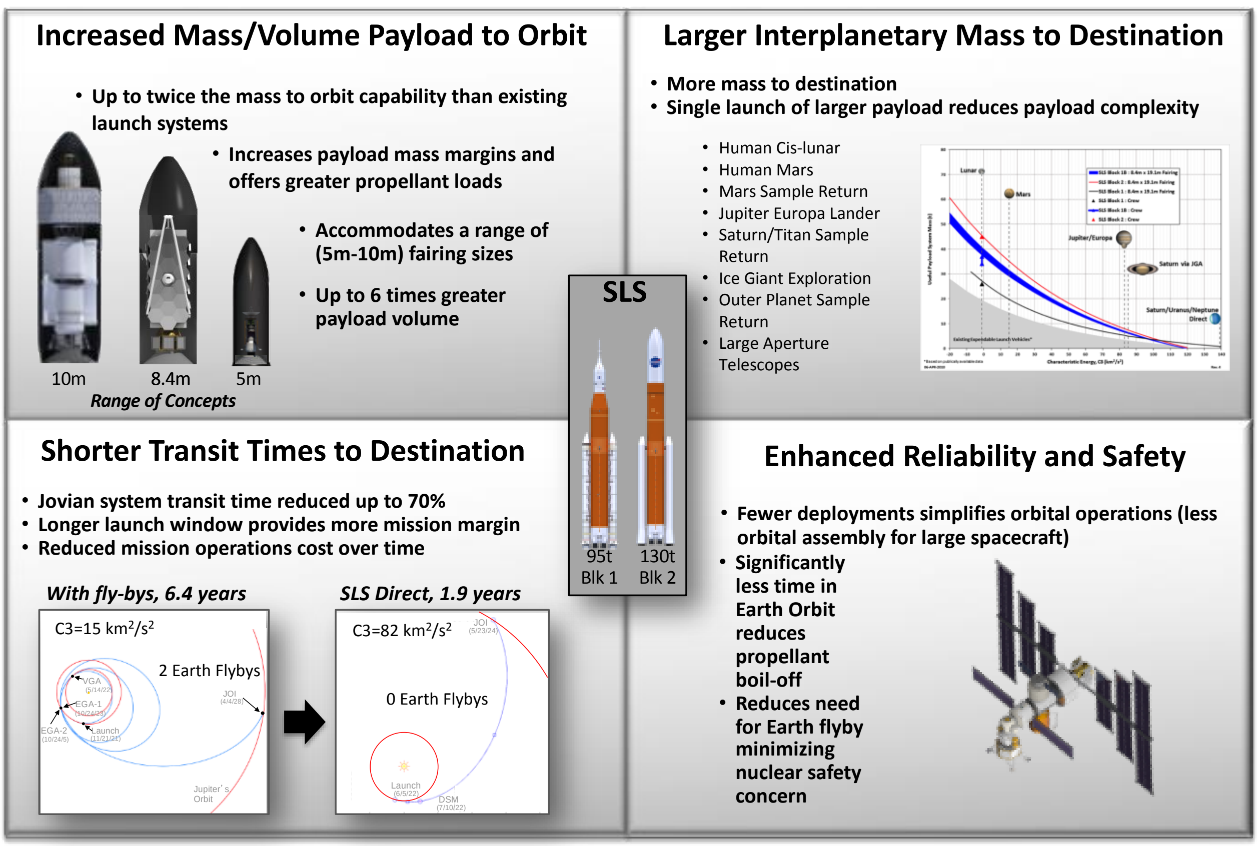
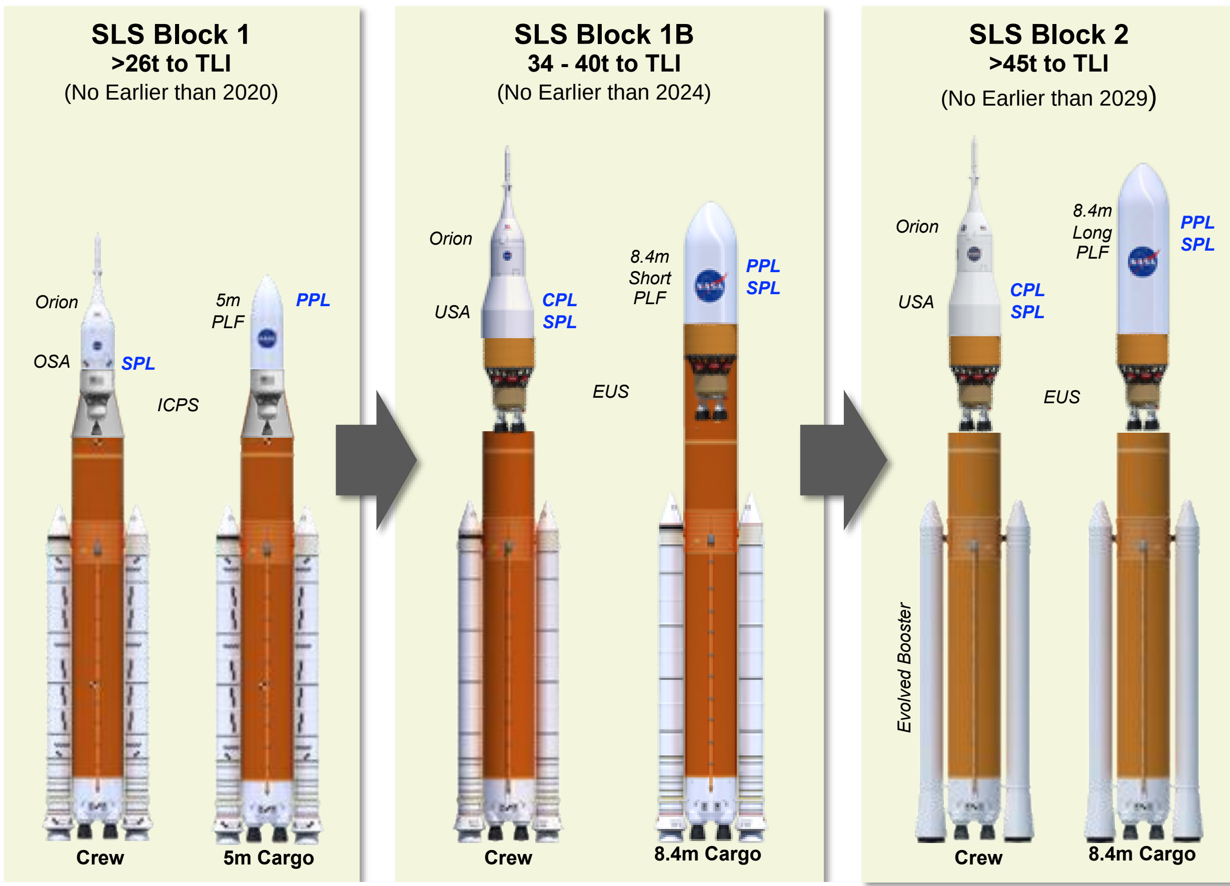


Figure 3-1. SLS Performance and Mission Capture Benefits

3.1 SLS Block Configuration Descriptions

To achieve the performance necessary to ultimately deliver 99,208 lbm (45 metric tons [t]) of payloads to TLI in support of future human lunar missions, three configurations, or "Blocks," of phased vehicle development are envisioned for SLS. These are shown in Figure 3-2.



OSA - Orion Stage Adapter ICPS - Interim Cryogenic Propulsion Stage PLF - Payload Fairing EUS – Exploration Upper Stage USA – Universal Stage Adapter
PPL – Primary Payload CPL – Co-manifested Payload SPL – Secondary Payload

Figure 3-2. SLS Block Configurations

SLS Block 1 will provide a 57,320 lbm (26 t), or greater payload delivery capability to lunar vicinity. Although SLS is not typically intended for missions to LEO, and no such missions are planned, the Block 1 capability to LEO is more than 209,439 lbm (95 t).

SLS Block 1B will utilize a new Exploration Upper Stage (EUS) to provide up to 88,185 lbm (40 t) of payload delivery to lunar vicinity. The crew version can accommodate Orion and a combination of Co-manifested Payload (CPL) and Secondary Payload (SPL), using the Universal Stage Adapter (USA). The cargo version can accommodate Primary Payload (PPL) and SPL using a range of 8.4 m diameter Payload Fairings (PLFs).

SLS Block 2 increases booster performance and uses EUS to provide a 99,208 lbm (45 t) or greater payload delivery to lunar vicinity. The crew version can accommodate Orion and a combination of

CPL and SPL using the USA. The cargo version can accommodate PPL and SPL using a range of 8.4 m and potentially larger diameter PLFs.

These SLS block configurations support an architecture development approach that minimizes life cycle program costs, enables deep space missions, maintains critical skills and effectively transitions existing infrastructure. The space shuttle-derived design takes advantage of resources established for the shuttle, including the workforce, tooling, manufacturing processes, supply chain, transportation logistics, launch infrastructure, large solid rocket motor production capability and liquid oxygen/liquid hydrogen (LOX/LH_2) propellant infrastructure.

Notes: (1) For the purposes of this SLS MPG, "crew" refers to Orion flights on SLS, and "cargo" refers to SLS delivery missions that do not fly the Orion spacecraft; (2) Common names of stages, adapters and fairings will include the diameter in meters (e.g., 8.4m PLF) compliant with international usage; (3) Where a payload accommodation is applicable to more than one SLS Block at a time, it may be referenced as "Block 1/1B/2" or "Block 1B/2".

3.2 SLS Vehicle Coordinate System

The SLS employs a Right-Handed Cartesian Body-Fixed coordinate system, with a heritage orientation derived from the Space Shuttle Program, as shown in Figure 3-3.

- +$\mathbf{X}_{SLS}$ points aft down the vehicle axis.
- +$\mathbf{Y}_{SLS}$ points to the centerline of the right-hand (RH) booster.
- +$\mathbf{Z}_{SLS}$ completes the right-hand rule.

Figure 3-3. SLS Vehicle Coordinate System

Note: RH booster is on the right side of the stack (the +$\mathbf{Y}_{SLS}$ side of the launch vehicle) when looking at SLS with the Mobile Launcher Tower beyond. In rendered views of the vehicle, the – $\mathbf{Y}_{SLS}$ (Left) booster features a black band below the nose cone.

3.3 SLS Block 1 Vehicle Configuration

SLS Block 1 utilizes an Interim Cryogenic Propulsion Stage (ICPS) to accommodate either an Orion or existing 5-m class diameter Payload Fairing (PLF) for early cislunar and deep space applications. The initial SLS Block 1 test flight, EM-1, is currently planned to accommodate an uncrewed Orion and a number of SPL. Its purpose is to test SLS launch capabilities and Orion's ability for safe translunar crew return; this is planned to be available for launch no earlier than 2020. An overview of the SLS Block 1 crew configuration is shown in Figure 3-4. The cargo version of the Block 1 vehicle uses a 16.7 ft (5.1 m) diameter PLF planned for Science Mission-1 (SM-1) which will accommodate an interplanetary Europa Clipper launch no earlier than 2022. The cargo configuration shown in Figure 3-5 does not provide SPL accommodations and will not be available after the introduction of SLS Block 1B vehicle; it is provided here for reference only.

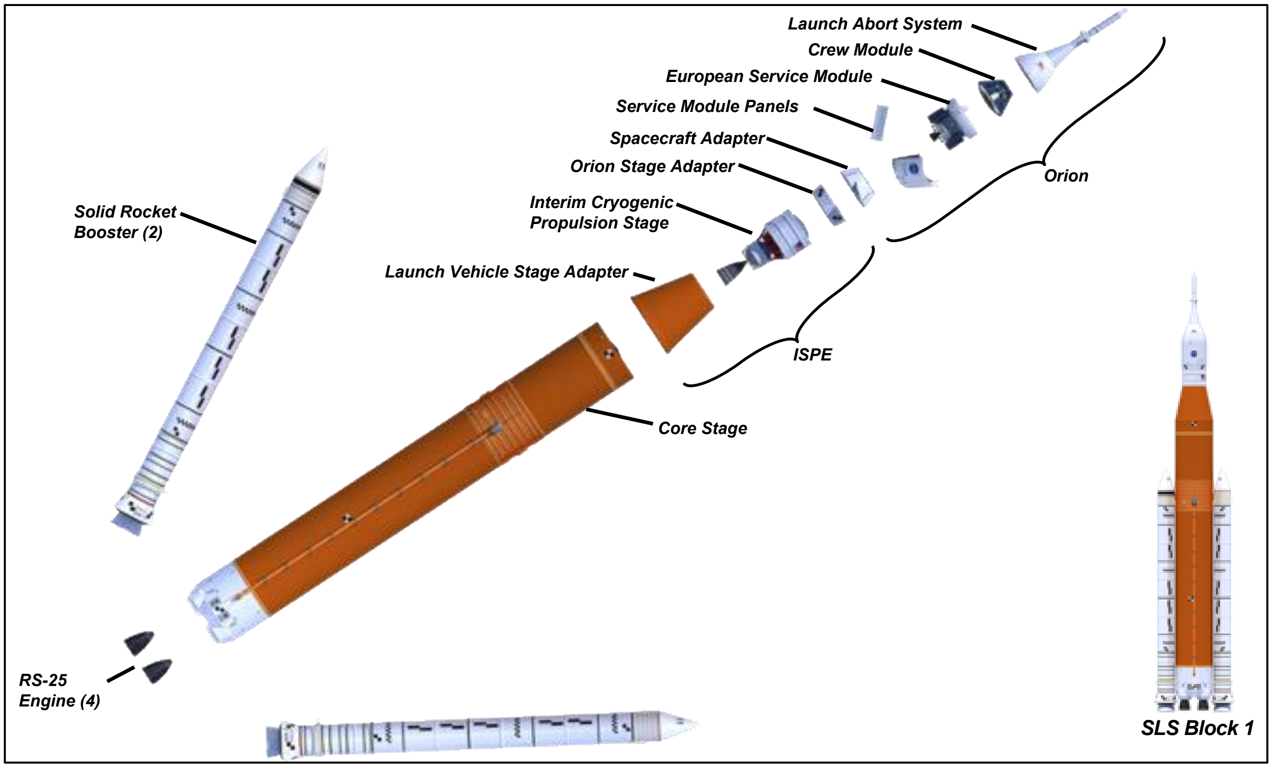


Figure 3-4. SLS Block 1 Crew Configuration

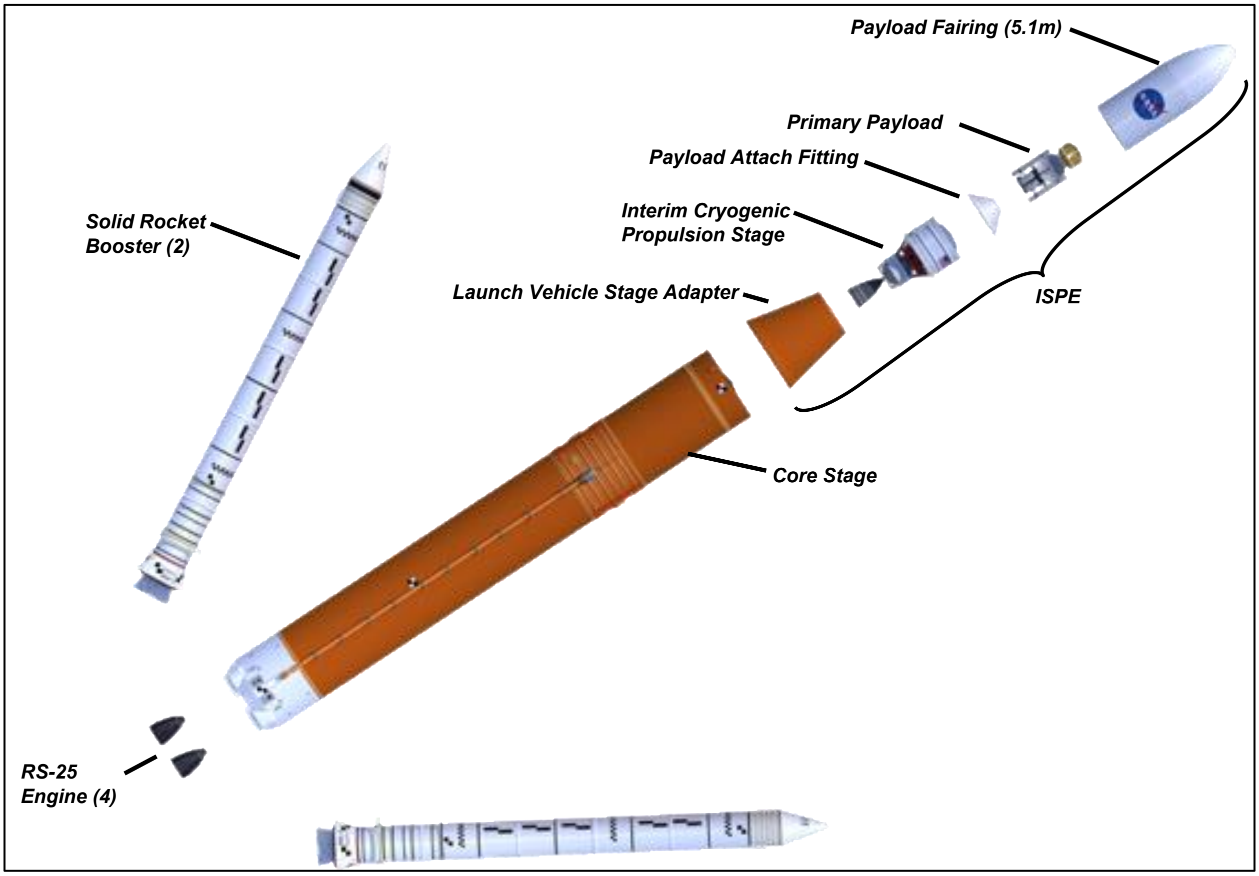


Figure 3-5. SLS Block 1 Cargo Configuration (Reference Only)

SLS Block 1 Core Stage. The SLS Core Stage is built at Marshall Space Flight Center's (MSFC's) Michoud Assembly Facility, where the Saturn stages and shuttle external tanks were manufactured. This 27.6 ft (8.4 m) diameter, 200 ft (61 m) long tank forms the rocket's structural backbone. The stage will hold the LOX/LH_2 propellants for the vehicle's main engines and also houses much of the vehicle-level avionics. Four RS-25 engines will power the SLS Core Stage. These human-rated engines support the SLS goal of safety, with a record of 100 percent mission success for the engines over 135 flights and has accumulated over 1 million seconds of ground hot-fire experience.

SLS Block 1 Solid Rocket Boosters. The majority of the thrust at launch for SLS will come from a pair of SRBs, also of Space Shuttle Program heritage. The SLS Program is leveraging research, development and testing conducted under the Ares Program to upgrade the SRBs from the four-segment version flown on the shuttle to more powerful five-segment boosters. Shuttle-heritage hardware and design includes forward structures, metal cases, aft skirts and thrust vector control elements. The upgraded hardware and expendable design include solid rocket motors, avionics and asbestos-free insulation.

SLS Block 1 Integrated Spacecraft/Payload Element (ISPE). The Block 1 crew configuration ISPE is composed of the Launch Vehicle Stage Adapter (LVSA), ICPS, and SLS Orion Stage Adapter (OSA) as shown in Figure 3-4 and 3-6. The OSA provides SPL accommodations as needed during Orion missions. For the Block 1 cargo configuration ISPE, the OSA is replaced with a Commercial Off the Shelf (COTS) 5 m-class diameter payload adapter and PLF as shown in Figure 3-5. The payload adapter accommodates PPL as needed. In-space propulsion for SLS Block 1 payloads is provided by the ICPS, derived from an existing United Launch Alliance (ULA) Delta Cryogenic Second Stage (DCSS). This 16.7 ft (5.1 m) diameter stage has flown on more than 20 launches of the Delta IV Evolved Expendable Launch Vehicle (EELV). A single RL10 LOX/LH2 engine powers the stage which has a mission life of approximately 8 hours. It interfaces to the SLS Core Stage via the LVSA. The ICPS 16.7 ft (5.1 m) diameter forward skirt provides a standard interface to the Orion via the SLS OSA for crewed missions and interfaces to available 5 m-class diameter payload adapters/PLFs for a cargo mission.

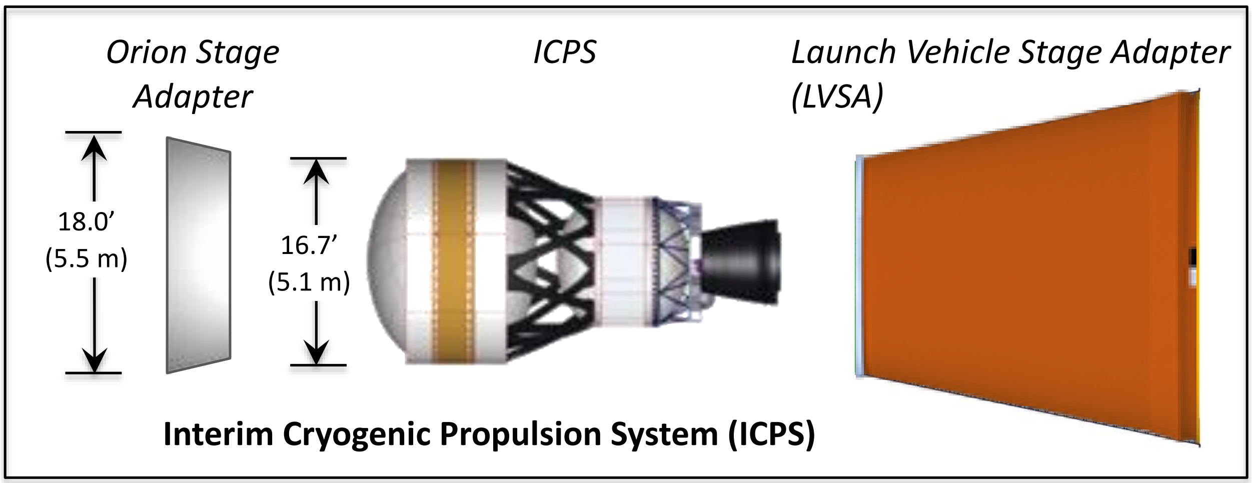


Figure 3-6. SLS Block 1 ISPE Crew Configuration

3.4 SLS Block 1B Vehicle Configuration

While the SLS Program prepares for the first SLS Block 1 flight (EM-1), development work has already begun for evolution to the higher-performance SLS Block 1B configuration. The development of the new EUS will be required in order to ultimately provide planned TLI capabilities. For Block 1B, the configuration of the Core Stage will be used with only minor subsystem changes from Block 1. This commonality-based strategy will reduce the cost and risk of Block 1B development by maintaining similar interfaces to flight hardware and ground systems as those used for Block 1. Figure 3-7 details the Block 1B crew configuration; it is planned to be first available to support EM-3, a crewed Orion flight in support of lunar Gateway assembly no earlier than 2024. Figure 3-8 details the Block 1B cargo configuration using a 27.6 ft (8.4 m) diameter PLF.

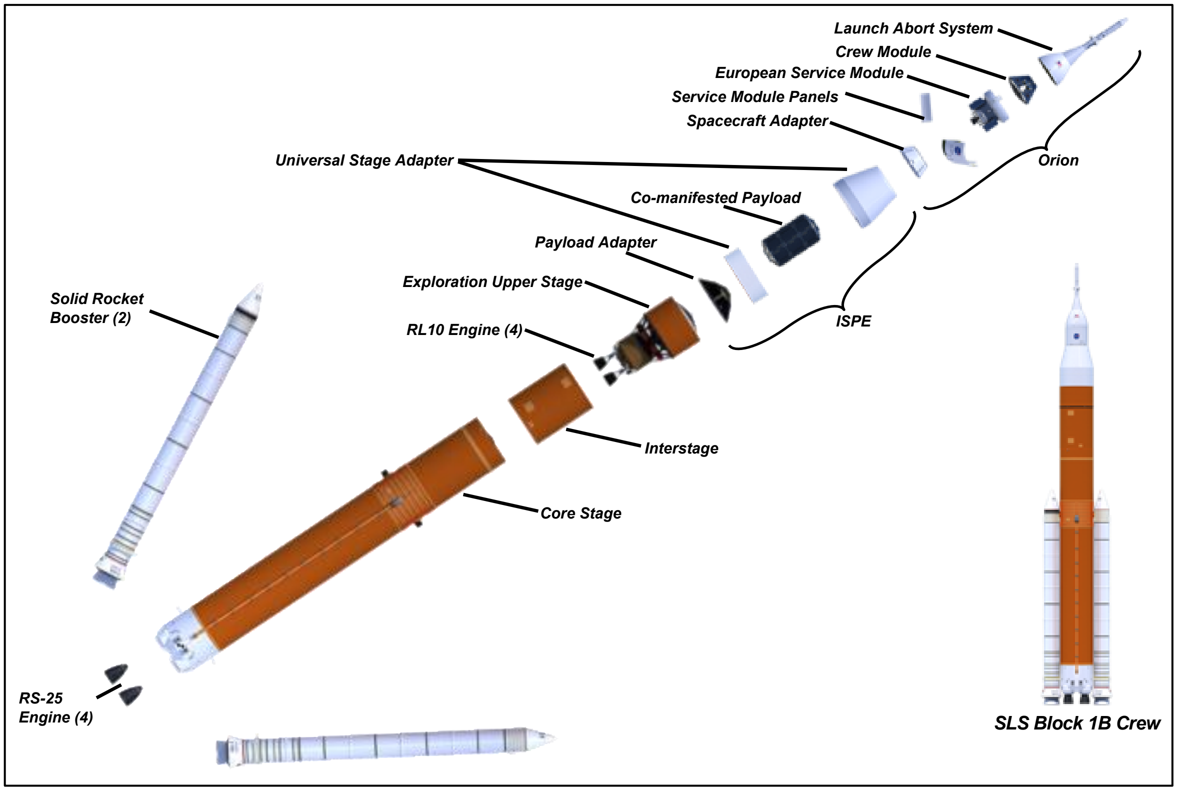


Figure 3-7. SLS Block 1B Crew Configuration

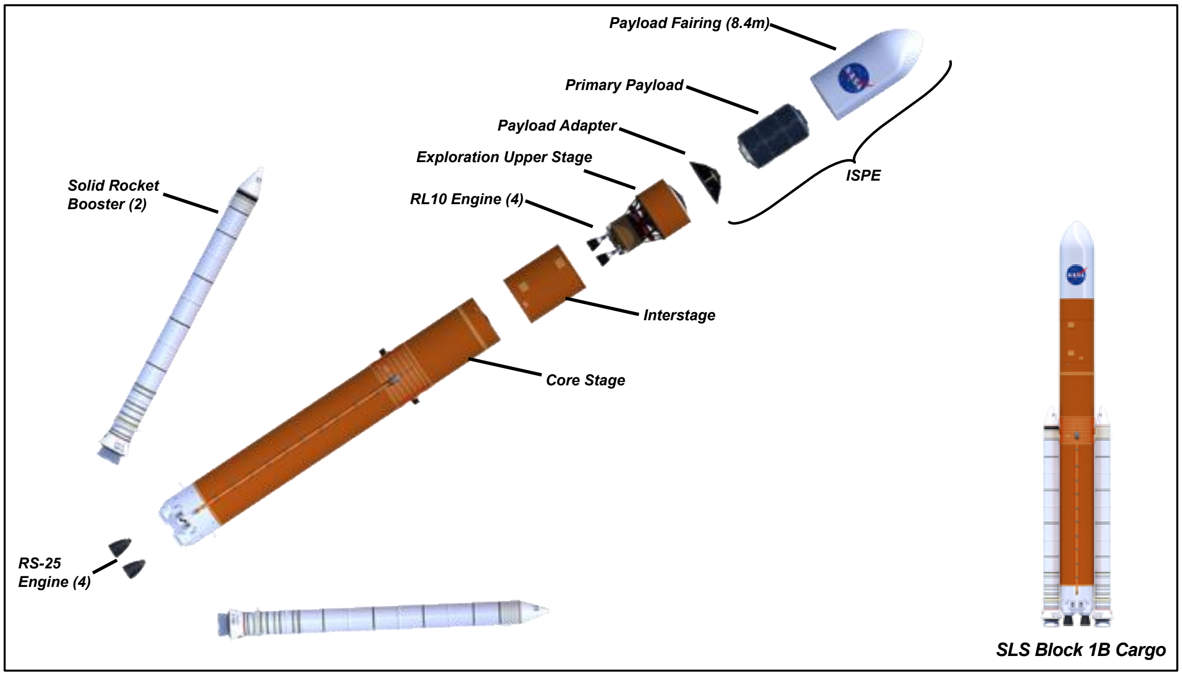


Figure 3-8. SLS Block 1B Cargo Configuration

SLS Block 1B Core Stage. Core Stage will remain essentially unchanged from the Block 1 configuration.

SLS Block 1B Solid Rocket Boosters. The Boosters will remain essentially unchanged from the Block 1 configuration.

SLS Block 1B Exploration Upper Stage (EUS). The Block 1B EUS shown in Figure 3-9 is being developed to provide both ascent/circularization and in-space transportation for payloads. Four RL10 LOX/LH_2 engines power the stage. Onboard batteries provide electrical power, while a passive thermal control system minimizes cryogenic propellant boil-off during the EUS lifetime. Mechanical interface to the SLS Core Stage is through a 27.6 ft (8.4 m) diameter Interstage. The 27.6 ft (8.4 m) diameter EUS Forward Adapter interfaces to the 8.4m-class diameter Payload Adapter (PLA).

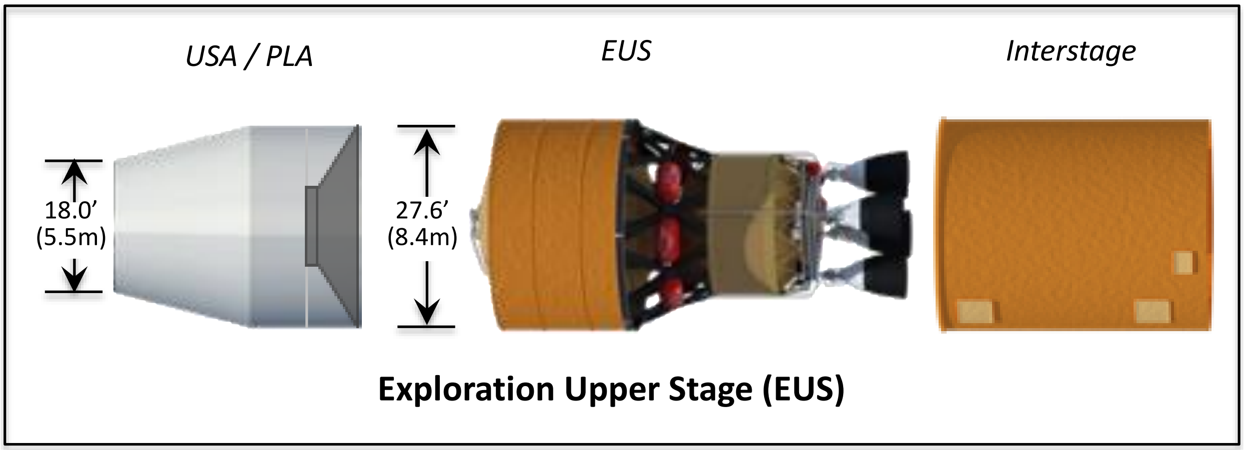


Figure 3-9. SLS Exploration Upper Stage

SLS Block 1B ISPE. The Block 1B crew configuration ISPE is composed of a SLS PLA and USA (Figure 3-7) with CPL and SPL being accommodated on the PLA as needed. The USA then provides a standard interface to the Orion Spacecraft Adapter (SA). The Block 1B cargo configuration ISPE accommodates a PPL (and SPL as needed) using a SLS PLA and PLF (Figure 3-8).

3.5 SLS Block 2 Vehicle Configuration

Differences between SLS Block 1B and Block 2 configurations are primarily due to addressing Shuttle-era hardware obsolescence and potential strengthening of vehicle structure to accommodate larger payloads. This configuration can provide unique enabling capabilities to transport human habitats and landers to the Moon and Mars. The SLS Block 2 crew configuration is similar to the Block 1B crew configuration in appearance. Figure 3-10 details the SLS Block 2 cargo vehicle configuration depicting a new 8.4 m-class diameter PLF that is longer (90 ft vs. 62.7 ft) than that used by the SLS Block 1B. SLS Block 2 is planned to be available no earlier 2029.

SLS Block 2 Core Stage. Core Stage would remain essentially unchanged from the Block 1B configuration with the exception of possible strengthening of structure to support Block 2 boosters and larger payloads.

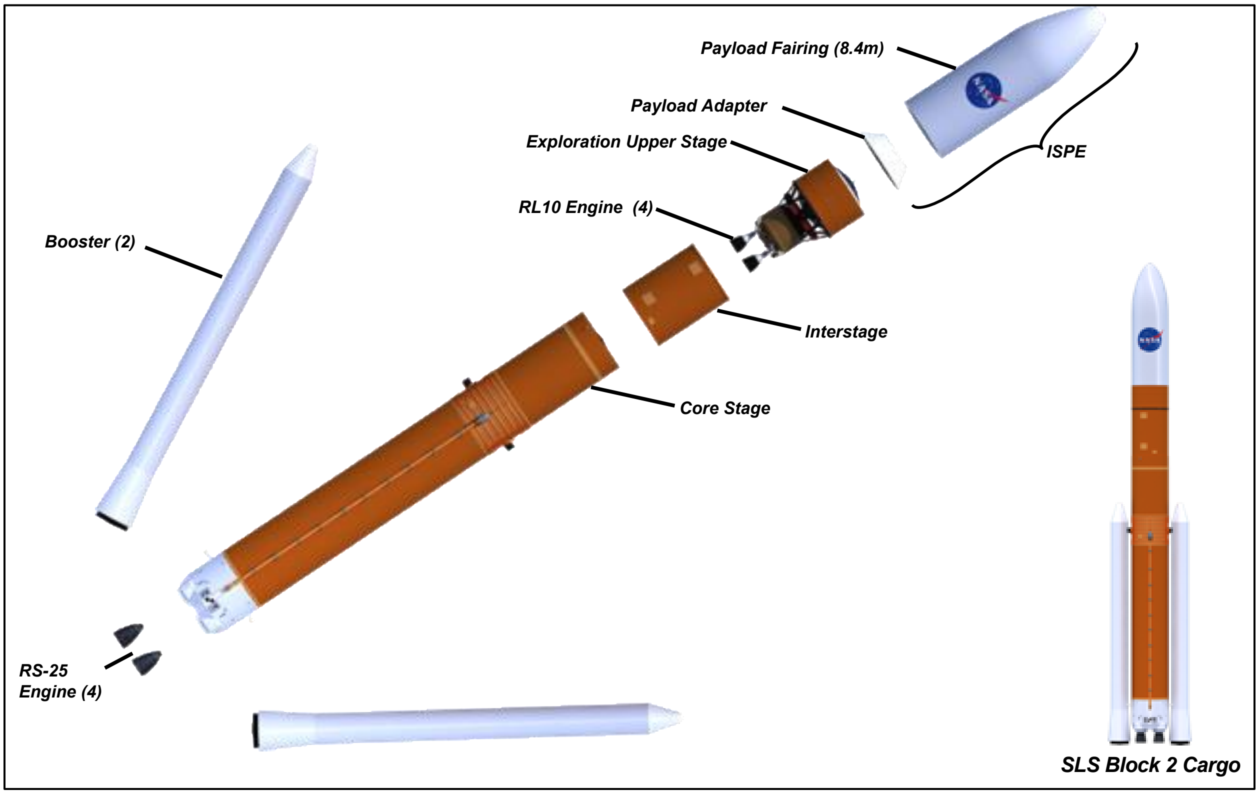


Figure 3-10. Representative SLS Block 2 Cargo Configuration

SLS Block 2 Boosters. Boosters for Block 2 will address potential obsolescence issues in flying out existing Shuttle-era surplus hardware. Bringing Shuttle-era booster design and manufacturing processes to industry state of practice will also result in a performance increase for SLS payloads.

SLS Block 2 EUS. EUS would remain essentially unchanged from the Block 1B configuration with the exception of possible strengthening of the Forward Adapter to accommodate heavier payload as well as larger PLFs.

SLS Block 2 ISPE. The Block 2 crew configuration ISPE is composed of an 8 m-class diameter SLS Payload Adapter (PLA) and USA (similar to Figure 3-7) with CPL (and SPL as needed) being accommodated on the PLA. The Block 2 cargo configuration ISPE is composed of the PLA, which accommodates PPL and SPL as needed, and an 8 m-class diameter or greater PLF (Figure 3-10).

3.6 Initial SLS Development Timing and Mission Applications

Figure 3-11 illustrates the progress to date made to support the initial launch (EM-1) and test of Block 1 SLS and its associated ground infrastructure. The SLS OSA shown in the upper right depicts the installation of SPL dispensers to support delivery to a cislunar destination and beyond. Three Block 1 flights in the early 2020's are currently planned to demonstrate critical capabilities to be leveraged for future SLS Block 1B flights beginning in the mid-2020s.

Figure 3-11. SLS Block 1 Progress in Support of First Flight (EM-1)

4.0 SLS MISSION DESIGN AND PERFORMANCE

4.1 Mission Trajectories and Performance Options

The United States Space Policy Directive-1 outlines an exploration campaign that advances human presence from Earth to the lunar vicinity to Mars, as shown in Figure 4-1.

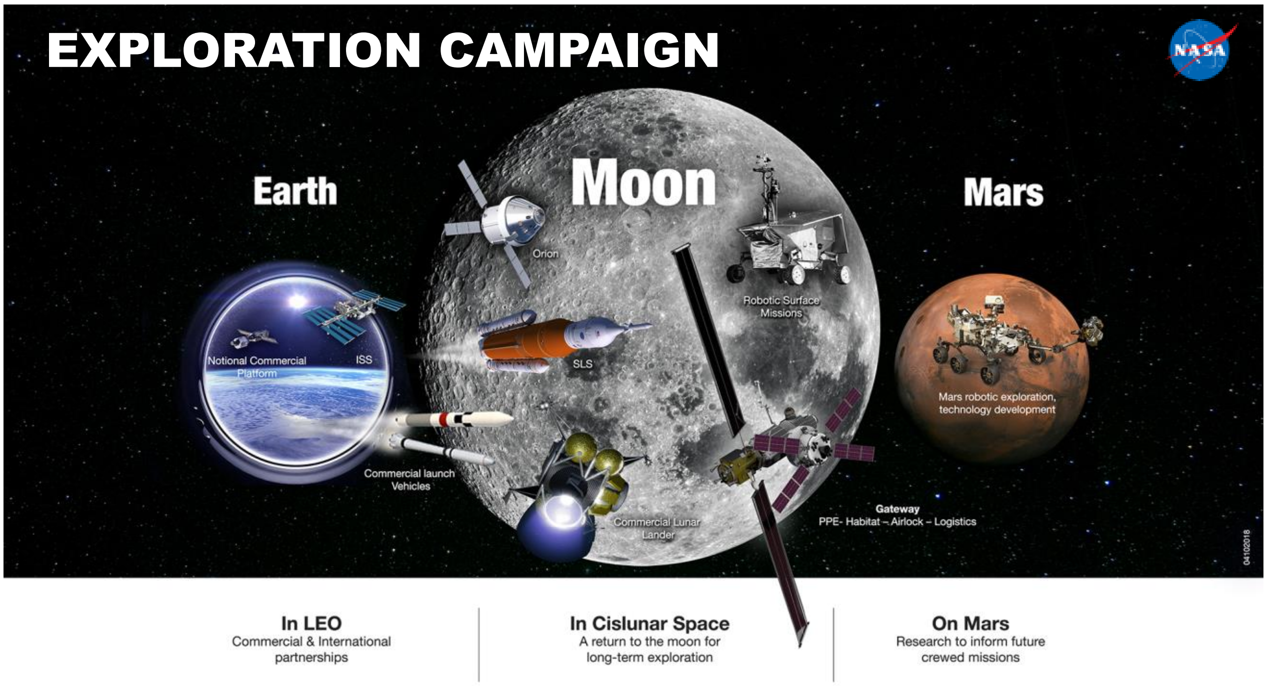


Figure 4-1. NASA's Exploration Campaign Overview

The goal of NASA's Exploration Campaign is to lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond LEO, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations. This campaign has the following steps:

- Transitioning LEO into commercial activities
  - International Space Station operations, crew and cargo delivery
- Developing a cislunar Gateway and planning for lunar surface landings
  - Focus on the lunar surface for science and exploration
  - Advancing planetary lander capabilities
  - Honing sample return operations – lunar and Mars samples
  - Deploying CubeSats, small sats and other science platforms
  - Provides opportunities for commercial ventures and international partnerships
  - Informing Mars transportation, life support systems, human health and research
- Leveraging industry spaceflight capabilities and international partnerships for long-term solar system exploration

Figure 4-2 describes the enabling SLS flight destinations that support the three phases of NASA's Exploration Campaign: Earth Orbit, Lunar Vicinity and Earth Escape.

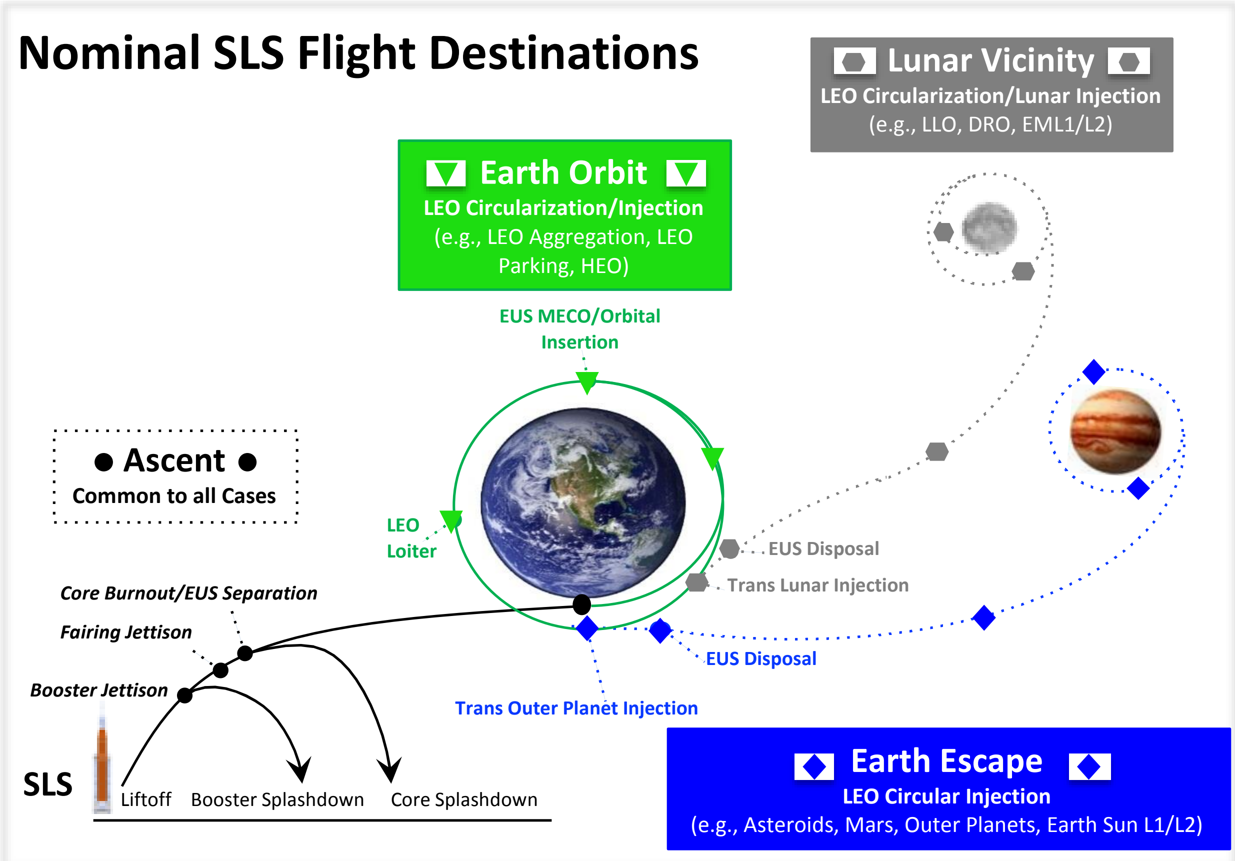


Figure 4-2. Nominal SLS Flight Destinations

4.1.1 Nominal Ascent Profile

The nominal ascent profile for SLS Block 1B cargo configuration is shown in Figure 4-3 (also similar for crew configuration). The SLS EUS is used during ascent through Earth's atmosphere, as well as to provide necessary in-space injection burns. The SLS ICPS and EUS can perform a number of engine starts based on flight requirements.

Ascent profile geometries will vary based on several factors, which will be determined during more detailed design phases for specific missions. One of these factors is that the Core Stage must burn out with a ballistic trajectory that avoids landmasses on impact. Another factor is that the mass of the payload and upper stage drive the altitude and velocity vector at Core Stage burnout.

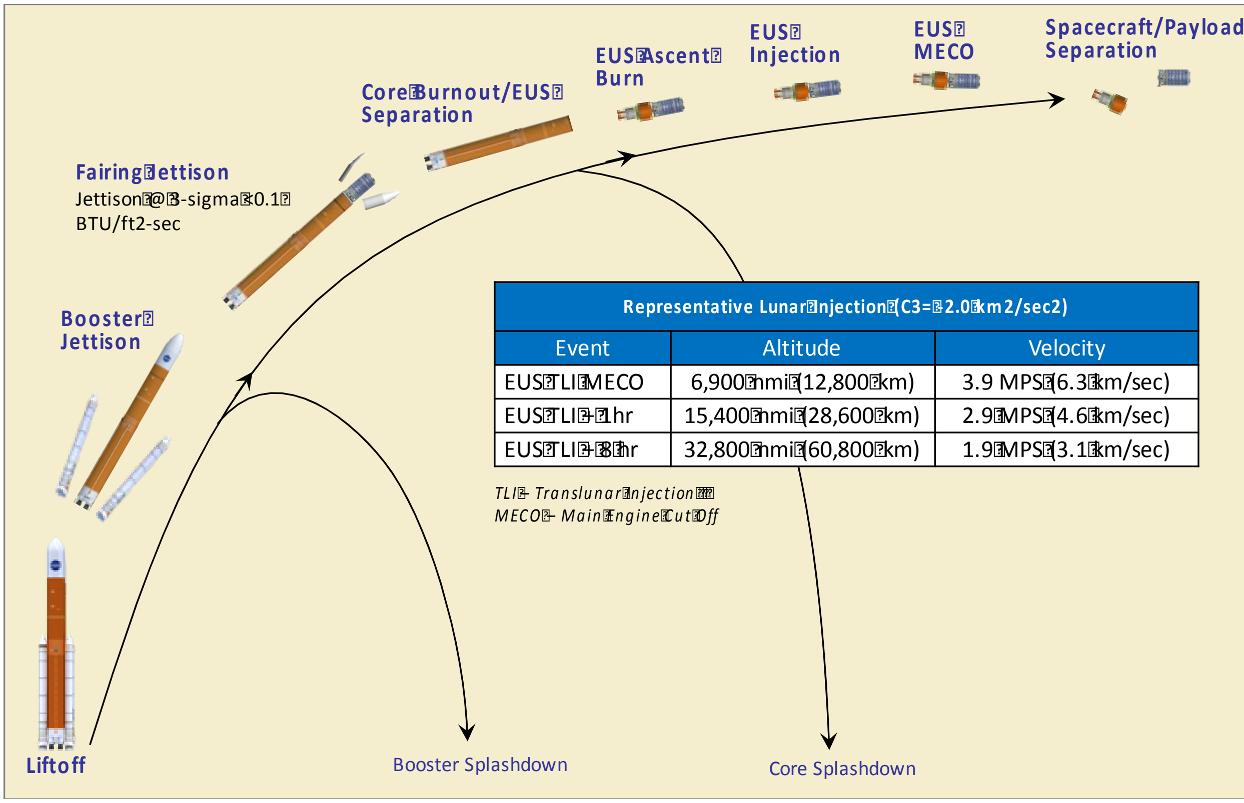


Figure 4-3. Nominal SLS Block 1B Ascent Profile (cargo shown - similar for crew)

Note that unique ascent maneuvers, whether to avoid ground over-flights or initiate orbital plane adjustments for targeting, may affect performance and ground impact zones. While fairing separation varies depending on payload requirements, vehicle performance and atmospheric heating during ascent, the fairing is typically jettisoned during the Core Stage burn when the free molecular heating rate drops below 0.1 BTU/ft^2-sec (1,136 W/m^2). If the mission requires a depressed trajectory, the fairing may be carried beyond the staging event and jettisoned during the upper stage burn. The separation of the SRBs, and then later Core Stage separation, will occur at different trajectory locations during ascent due to the rate of fuel consumption and differences in payload mass and target orbits.

4.1.2 Earth Orbit

Earth Orbital trajectories, shown in Figure 4-2, encompass activities ranging from a low orbit of 100 nm (185 km) to high orbit of 59,300 nm (110,000 km).

For SLS Block 1, the ICPS and the payload coast to apogee following Core Stage separation. ICPS performs a circularization/perigee raise burn to keep the payload from returning to Earth with the Core Stage. The final ICPS burn could be a trans-lunar or Earth-escape injection. When the ICPS completes this injection, it separates from the spacecraft and uses its attitude control system to perform a disposal burn no later than 8 hours from launch.

For SLS Block 1B/2, the EUS performs the final portion of the ascent burn and injects itself and the associated payload into some type of Earth orbit. The EUS can loiter here for a determined amount of time before performing its final burns; loiter time is dependent upon the mission's propulsive needs balanced against the degree of propellant boil-off incurred in LEO. The final EUS burn could be to raise the payload to a higher Earth orbit. For SLS crew mission CPL and SPL operations begin after Orion has separated from the EUS/USA. Depending on mission requirements, this can occur approximately five to eight hours from launch.

SLS cargo mission PPL can separate from the upper stage post-PLF separation. Depending on mission requirements, this can occur approximately one to eight hours from launch.

For LEO staging scenarios, the EUS could fly to an elliptical orbit and then if needed perform a circularization/perigee burn to establish the payload in LEO. The EUS would then re-enter Earth's atmosphere post-payload separation for disposal. Another alternative is that the EUS could insert the payload directly into a circular orbit followed by EUS disposal.

4.1.3 Lunar Vicinity

For typical lunar trajectories shown in Figure 4.2, the SLS upper stages loiter in LEO for a predetermined amount of time before performing its TLI burn. The amount of time in orbit depends on the mission's propulsive needs balanced against the degree of propellant boil-off incurred in the orbit. The upper stage then performs an injection burn to initiate a lunar transfer orbit. For SLS crew mission CPL and SPL operations begin after Orion has separated from the EUS/USA. Depending on mission requirements, this can occur approximately five to eight hours from launch.

SLS cargo mission PPL can separate from the upper stage post-PLF separation. Depending on mission requirements, this can occur approximately one to eight hours from launch.

For the uncrewed SLS test flight (planned for EM-1), the SLS Block 1 ICPS will perform a TLI maneuver to enable Orion to insert into a Distant Retrograde Orbit (DRO) around the Moon, as shown in Figure 4-4. After Orion separation, the ICPS continues on a heliocentric disposal trajectory. During this period, the SPLs can be deployed at various locations along the trajectory, as shown in Figure 4-5. The "bus stops" in Figure 4-5 are representative release points only; deployment at other locations along the disposal path is possible.

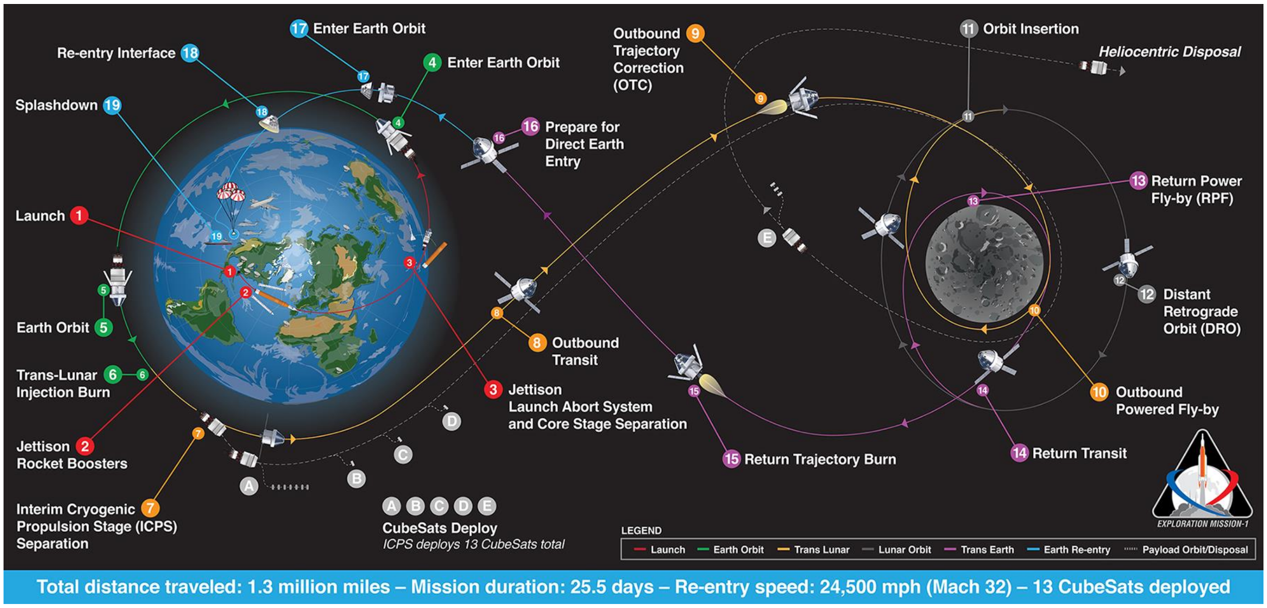


Figure 4-4. SLS Block 1 Distant Retrograde Orbit (DRO) Trajectory (EM-1)

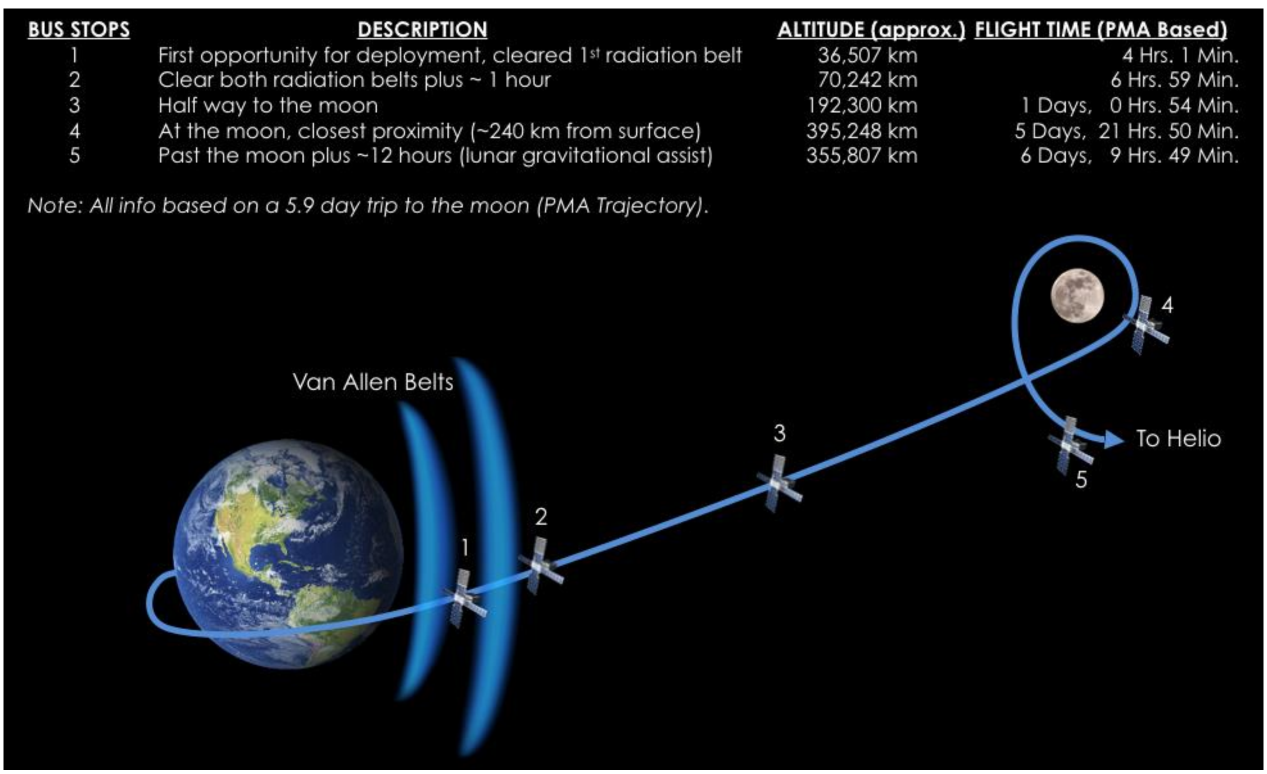


Figure 4-5. Representative Secondary Payload Jettison "Bus Stops"

For the first SLS crewed mission (planned for EM-2), the SLS Block 1 ICPS will insert Orion into an elliptical orbit to support final checkout of the spacecraft, After this, Orion flies a Hybrid Free

Return trajectory around the Moon, as shown in Figure 4-6. Following separation from Orion, ICPS will put itself on a heliocentric disposal trajectory. Deployment of any SPLs at different ICPS locations may occur during this period, as shown in Figure 4-5.

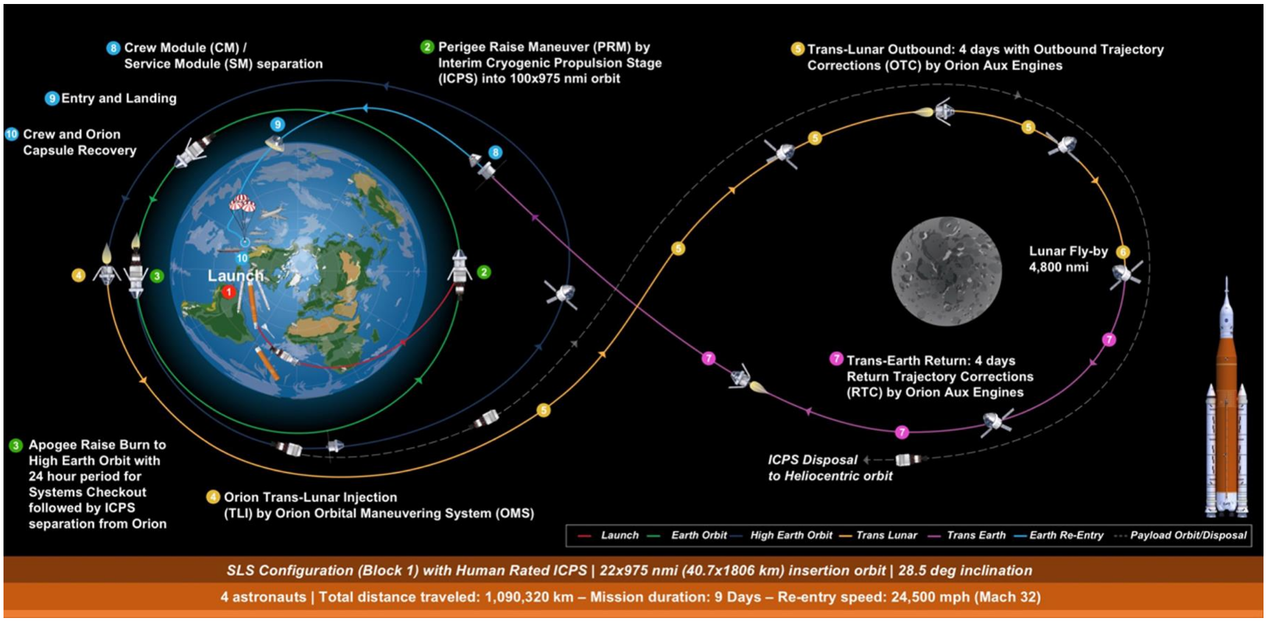


Figure 4-6. SLS Block 1 Hybrid Free Return Trajectory (EM-2)

For typical SLS Block 1B crew missions to cislunar destinations (e.g., Lunar Gateway), the SLS EUS will perform a TLI burn to enable Orion to insert into a Near Rectilinear Halo Orbit (NRHO), shown in Figure 4-7. Following separation from Orion, EUS will continue onto a heliocentric disposal trajectory. Deployment of any SPLs may occur during this period as shown in Figure 4-5.

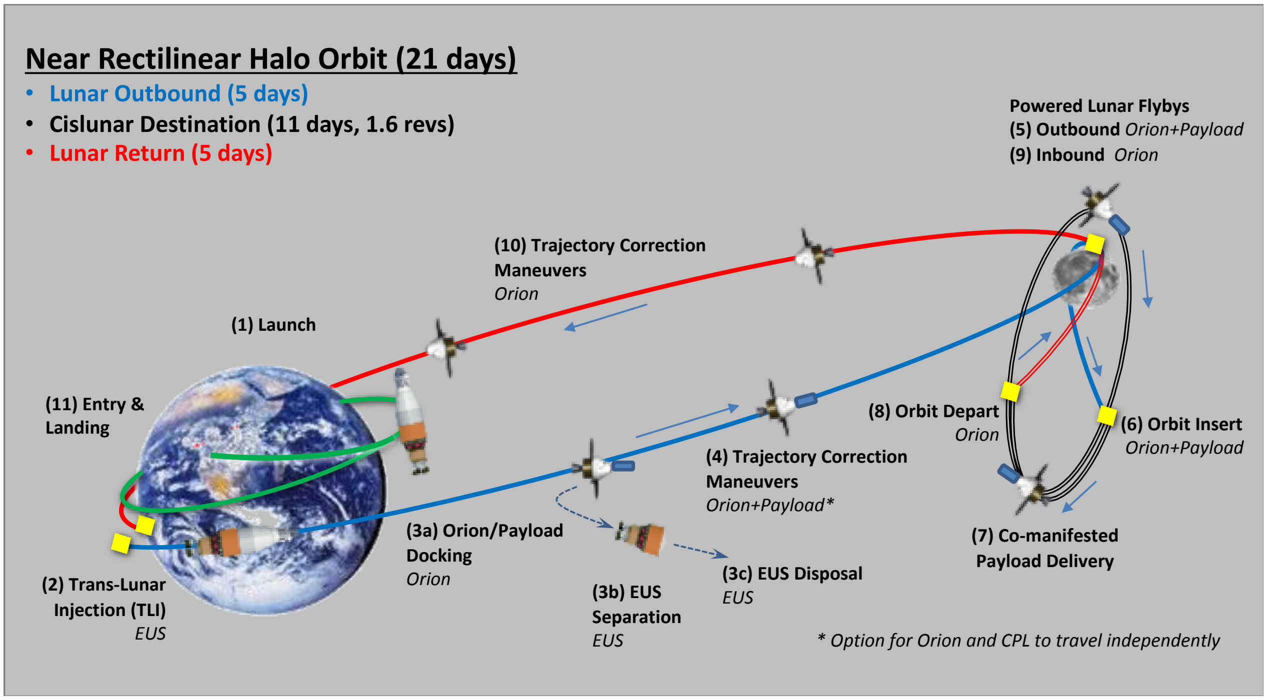


Figure 4-7. SLS Block 1B Near Rectilinear Halo Orbit (NRHO) Trajectory (EM-3)

4.1.4 Earth Escape

For typical Earth escape trajectories shown in Figure 4.2, the PLF separates and the SLS upper stage injects itself and the associated payload into a circular or elliptical orbit. The upper stage can loiter in this orbit for a predetermined amount of time before performing its final injection burn. Time in orbit is dependent upon propellant load, balanced against the degree of propellant boil-off incurred in the orbit. The SLS upper stage then performs an injection burn to initiate escape from Earth's gravitational influence. Depending on mission requirements, this can occur any time between one and eight hours after launch.

4.2 SLS Mission Performance to Destination

4.2.1 SLS Mass Delivery Performance Definitions

Due to the range of potential SLS payload accommodations, it is important for the user to understand SLS accounting of performance to destination when determining "useful" performance available to spacecraft/payload. For the purposes of this document, the following SLS mass delivery definitions should be used for cargo missions, as shown in Figure 4-8.

- Injected Mass at LEO (IMLEO)
  - Includes upper stage dry mass, unused upper stage fuel on-orbit and Payload System Mass (PSM)
- Payload System Mass
  - Cargo configuration payload capability
  - PSM = IMLEO - Upper Stage Burnout Mass
  - Includes mass of spacecraft/payload and associated PLAs required to interface to upper stage
- Useful PSM*
  - Useful PSM = PSM – Program Manager's Reserve (PMR)
  - (See Section 4.2.2 for SLS PMR approach)
- Spacecraft/payload – user-provided item delivered by SLS to in-space destination

**Referred to as Useful Load Mass (Delta IV) & Payload System Weight (Atlas V)*

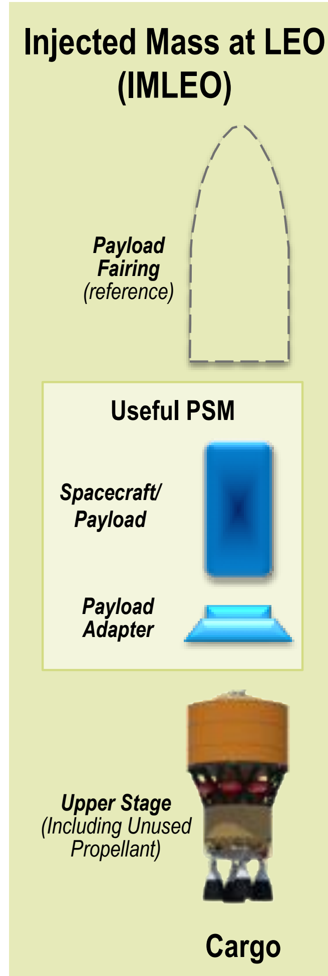


Figure 4-8. Mass Delivery Definition for Cargo Configurations

Performance relative to spacecraft/payload delivery in conjunction with crew missions (e.g., CPL) is handled differently than ELV flights due to the addition of the USA. See Section 4.2.5 for CPL performance definitions.

4.2.2 SLS Performance Margin and Reserve Approach

Since SLS Block 1B and Block 2 configurations are still in development, all performance estimates include appropriate SLS vehicle performance reserves. Payload performance identified in this document already takes these margins into account; users should not subtract these margins from published performance metrics.

Mass Growth Allowance (MGA) accounts for the inability to accurately predict hardware mass before it is fully designed and constructed. This margin is added to hardware mass estimates. The amount of MGA carried varies from system to system, according to the level of fidelity of each area of the design.

Program Manager's Reserve (PMR) is a performance allocation that is held in reserve to address unexpected events during development, such as a change to the vehicle requirements. The MGA and PMR will be maintained throughout the development of SLS to ensure performance will meet program goals despite potential increases in SLS inert mass or if the performance of its propulsion systems is lower than expected.

Flight Performance Reserve (FPR), in addition to these development phase margins, is carried as an operational margin. This performance allocation is held in reserve by vehicle management to account for day-to-day variation in launch environments and the allowable variation in hardware performance.

4.2.3 SLS Earth Orbit Performance

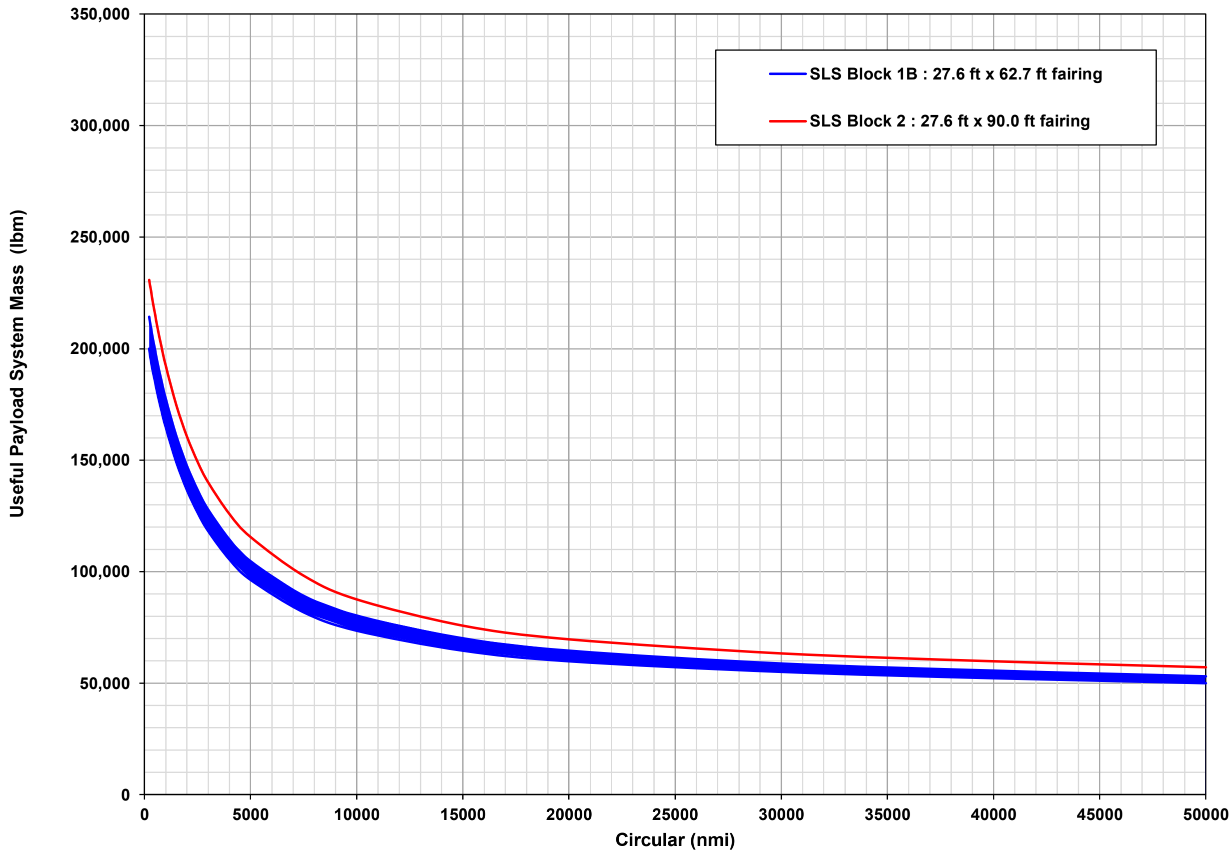
SLS capabilities are optimized for missions to deep space rather than LEO. While there are currently no plans to use SLS missions to LEO, Figures 4-9 through 4-12 provide LEO capabilities as a reference. SLS Useful Payload System Mass to various Earth orbits is given in Figures 4-9 and 4-10 for circular orbits and Figures 4-11 and 4-12 for elliptical orbits. Unless otherwise noted, all orbits are to a 28.5 degree inclination.

Performance for the SLS Block 1 to elliptical orbits is based on using a 16.4 ft (5.1 m) diameter PLF that is 62.7 ft long (19.1 m) as a maximum volume case. Use of fairings shorter than this, for example a 47 ft (14.3 m) long PLF, would increase performance available to payloads.

Performance for the SLS Block 1B is based on using a 27.6 ft (8.4 m) diameter PLF that is 62.7 ft long (19.1 m); such a configuration is also known as the SLS "8.4m PLF, Short". Both minimum and maximum performance cases are shown for Block 1B, representing a projected performance range based on current configuration development studies.

Performance for the SLS Block 2 is based on using a 27.6 ft (8.4 m) diameter PLF that is 90 ft long (27.4 m); such a configuration is also known as the SLS "8.4m PLF, Long". It represents a reasonable minimum performance available to payload at this time. Use of fairings shorter than the 8.4m PLF, Long on SLS Block 2 would increase performance available to payloads.

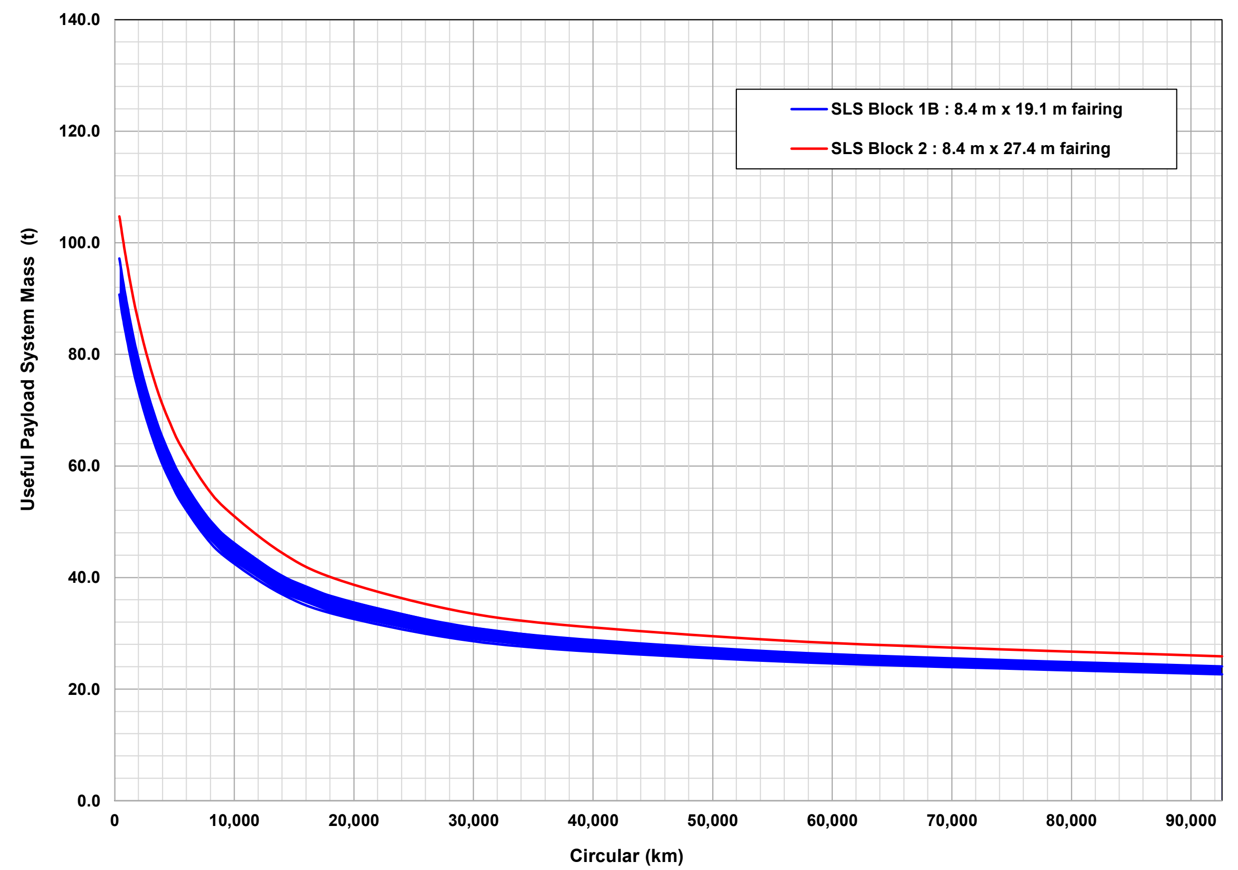
Since Core Stage disposal locations are still being assessed, final optimization will include Core Stage disposal targeting, which may affect performance predictions. More specific performance capability can be evaluated on a case by case basis; contact the SLS SPIE office at nasa-slspayloads@mail.nasa.gov for more details.



Useful Payload System Mass (lbm) with 27.6 ft Diameter Fairing

Apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft Fairing (lbm)	Apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft Fairing (lbm)	Apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft Fairing (lbm)
220	199985	214222	230799	1500	148898	160641	174455	10000	73516	80233	87559
300	194461	209417	225991	2000	136393	147285	160406	15000	64538	70043	75799
400	189424	204025	220308	2500	126319	136545	149132	20000	59832	64532	69667
500	184732	198947	214956	3000	118074	127757	139916	30000	55028	58805	63361
600	180202	194156	209905	4000	105442	114303	125801	40000	52217	55567	59809
800	171960	185336	200599	5000	96284	104558	115457	50000	49980	53038	57060
1000	164545	177402	192213	7500	81796	89155	98172				

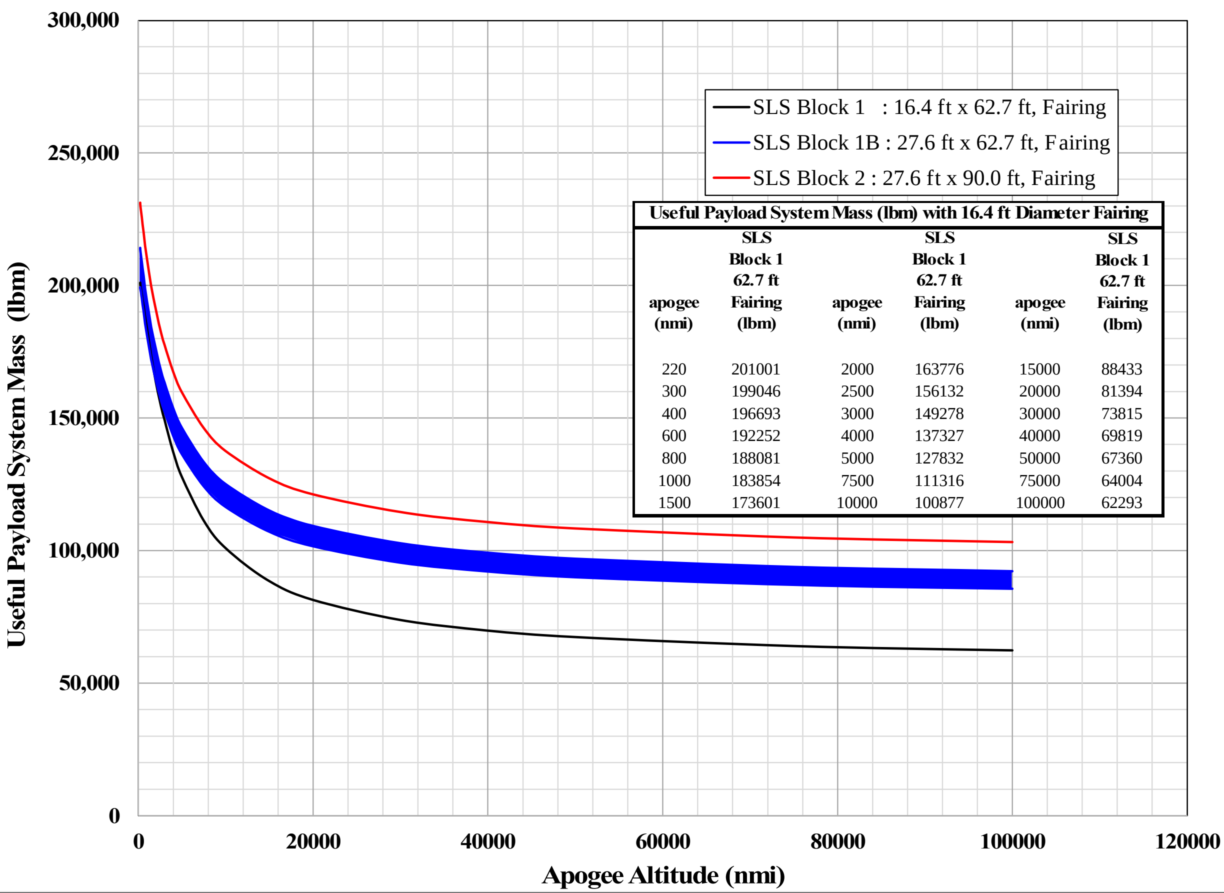
Figure 4-9. SLS Block 1B/2 Useful PSM to Circular Earth Orbits (English)



Useful Payload System Mass (t) with 8.4m Diamter Fairing

Apogee (km)	SLS Block 1B 19.1 m Fairing (t) Min.	SLS Block 1B 19.1 m Fairing (t) Max.	SLS Block 2 27.4 m Fairing (t)	Apogee (km)	SLS Block 1B 19.1 m Fairing (t) Min.	SLS Block 1B 19.1 m Fairing (t) Max.	SLS Block 2 27.4 m Fairing (t)	Apogee (km)	SLS Block 1B 19.1 m Fairing (t) Min.	SLS Block 1B 19.1 m Fairing (t) Max.	SLS Block 2 27.4 m Fairing (t)
407	90.7	97.2	104.7	2778	67.5	72.9	79.1	18520	33.3	36.4	39.7
556	88.2	95.0	102.5	3704	61.9	66.8	72.8	27780	29.3	31.8	34.4
741	85.9	92.5	99.9	4630	57.3	61.9	67.6	37040	27.1	29.3	31.6
926	83.8	90.2	97.5	5556	53.6	57.9	63.5	55560	25.0	26.7	28.7
1111	81.7	88.1	95.2	7408	47.8	51.8	57.1	74080	23.7	25.2	27.1
1482	78.0	84.1	91.0	9260	43.7	47.4	52.4	92600	22.7	24.1	25.9
1852	74.6	80.5	87.2	13890	37.1	40.4	44.5				

Figure 4-10. SLS Block 1B/2 Useful PSM to Circular Earth Orbits (SI)



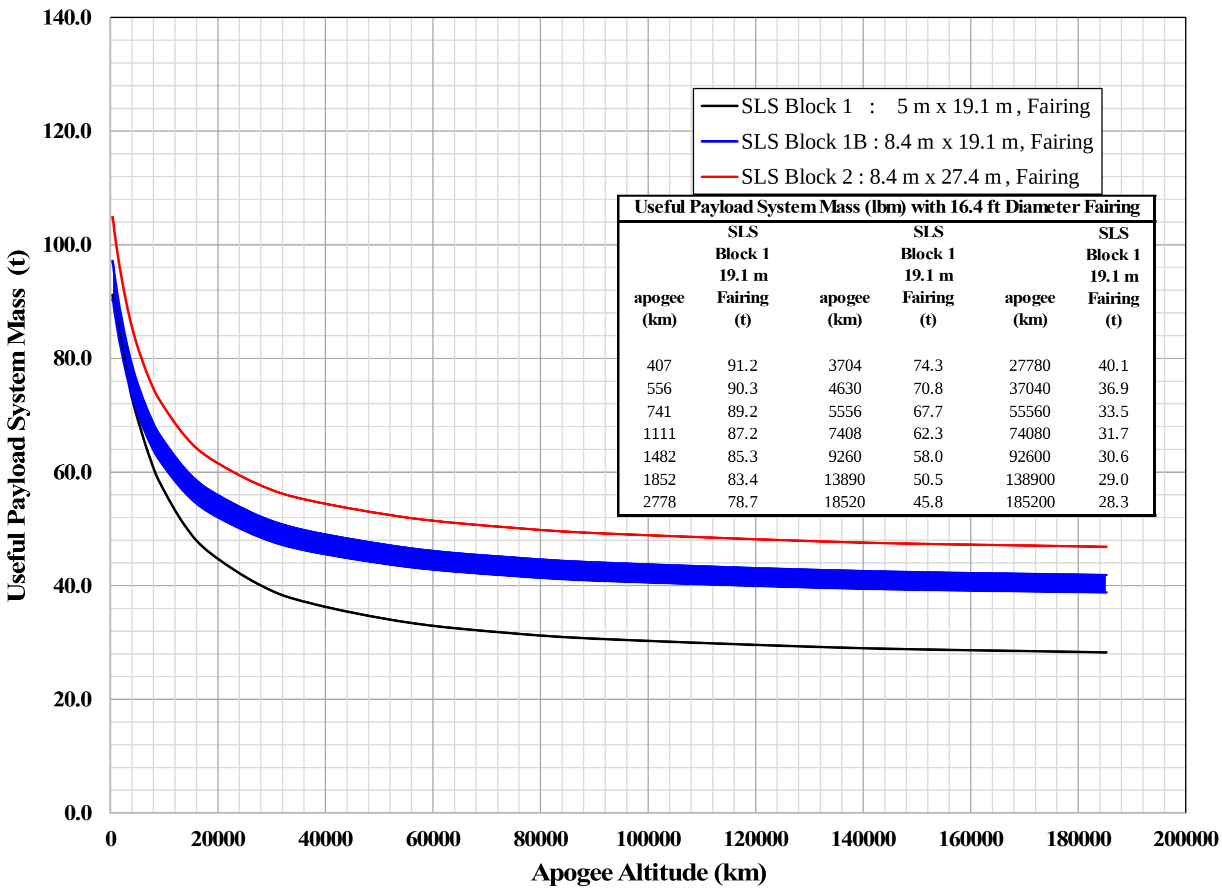
Useful Payload System Mass (lbm) with 16.4 ft Diameter Fairing

apogee (nmi)	SLS Block 1 62.7 ft Fairing (lbm)	apogee (nmi)	SLS Block 1 62.7 ft Fairing (lbm)	apogee (nmi)	SLS Block 1 62.7 ft Fairing (lbm)
220	201001	2000	163776	15000	88433
300	199046	2500	156132	20000	81394
400	196693	3000	149278	30000	73815
600	192252	4000	137327	40000	69819
800	188081	5000	127832	50000	67360
1000	183854	7500	111316	75000	64004
1500	173601	10000	100877	100000	62293

Useful Payload System Mass (lbm) with 27.6 ft Diameter Fairing

apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft Fairing (lbm)	apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft Fairing (lbm)	apogee (nmi)	SLS Block 1B 62.7 ft Fairing (lbm) Min.	SLS Block 1B 62.7 ft Fairing (lbm) Max.	SLS Block 2 90.0 ft. Fairing (lbm)
220	199284	214188	231262	2000	164463	176204	191107	15000	107046	115081	127210
300	197828	211843	228785	2500	157980	169290	183822	20000	101557	109244	121189
400	195157	208987	225768	3000	152429	163373	177596	30000	95425	102728	114476
600	190156	203641	220085	4000	143420	153774	167516	40000	92084	99177	110745
800	185568	198737	214906	5000	136422	146323	159709	50000	89979	96943	108352
1000	181345	194225	210140	7500	124273	133395	146201	75000	87049	93835	104965
1500	172133	184389	199746	10000	116473	125102	137567	100000	85528	92222	103183

Figure 4-11. SLS Block 1/1B/2 Useful PSM to Elliptical Earth Orbits (English)



Useful Payload System Mass (lbm) with 16.4 ft Diameter Fairing					
apogee (km)	SLS Block 1 19.1 m Fairing (t)	apogee (km)	SLS Block 1 19.1 m Fairing (t)	apogee (km)	SLS Block 1 19.1 m Fairing (t)
407	91.2	3704	74.3	27780	40.1
556	90.3	4630	70.8	37040	36.9
741	89.2	5556	67.7	55560	33.5
1111	87.2	7408	62.3	74080	31.7
1482	85.3	9260	58.0	92600	30.6
1852	83.4	13890	50.5	138900	29.0
2778	78.7	18520	45.8	185200	28.3

Useful Payload System Mass (t) with 8.4 m Diameter Fairing											
Apogee (km)	SLS Block 1B 19.1 m Fairing (t)		SLS Block 2 27.4 m Fairing (t)	Apogee (km)	SLS Block 1B 19.1 m Fairing (t)		SLS Block 2 27.4 m Fairing (t)	Apogee (km)	SLS Block 1B 19.1 m Fairing (t)		SLS Block 2 27.4 m Fairing (t)
	Min.	Max.			Min.	Max.			Min.	Max.	
407	90.4	97.2	104.9	3704	74.6	79.9	86.7	27780	48.6	52.2	57.7
556	89.7	96.1	103.8	4630	71.7	76.8	83.4	37040	46.1	49.6	55.0
741	88.5	94.8	102.4	5556	69.1	74.1	80.6	55560	43.3	46.6	51.9
1111	86.3	92.4	99.8	7408	65.1	69.8	76.0	74080	41.8	45.0	50.2
1482	84.2	90.1	97.5	9260	61.9	66.4	72.4	92600	40.8	44.0	49.1
1852	82.3	88.1	95.3	13890	56.4	60.5	66.3	138900	39.5	42.6	47.6
2778	78.1	83.6	90.6	18520	52.8	56.7	62.4	185200	38.8	41.8	46.8

Figure 4-12. SLS Block 1/1B/2 Useful PSM to Elliptical Earth Orbits (SI)

4.2.4 SLS Lunar Vicinity Performance

Crew and Cargo Missions. SLS Block 1, 1B and 2 configurations can deliver a range of Useful PSM through TLI ($C3 = -0.99\ km^2/s^2$) shown here in the form of a C3 curve (Figure 4-13) and corresponding C3 data (Table 4-1). SLS Block 1B performance is shown as a range between curves, based on different performance development paths still under evaluation. SLS Block 2 performance is based on the current estimate of the minimum capability expected from a booster life extension concept; more capability may be available as this design matures.

Cargo Missions. PPL performance for a Block 1 configuration is represented by a 16.7 ft (5.1 m) diameter PLF that is 62.7 ft (19.1 m) long. PPL performance for Block 1B and Block 2 configurations is represented by 27.6 ft (8.4 m) diameter PLFs that range from 62.7 ft to 90 ft (19.1 m to 27.4 m) long to illustrate a range of capability.

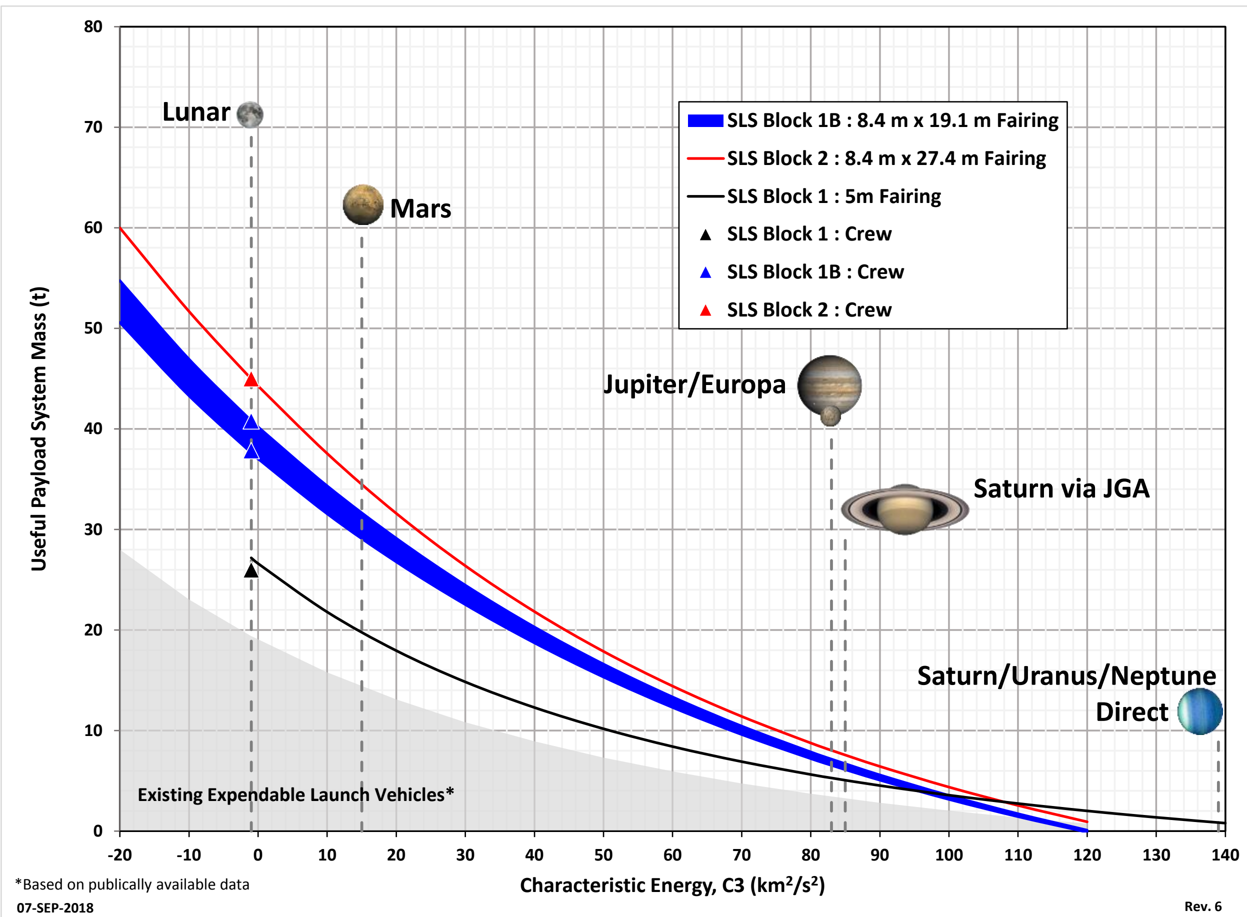


Figure 4-13. Useful SLS PSM to Earth Escape

Table 4-1. Useful PSM to Earth Escape

C3 Actual (km^2/s^2)	Block 1 5 m x 19.1 m Fairing (lbm)	Block 1 (t)	Block 1B 8.4 m x 19.1 m Fairing Min. Payload (lbm)	Min. Payload (t)	Max. Payload (lbm)	Max. Payload (t)	Block 2 8.4 m x 27.4 m Fairing (lbm)	Block 2 (t)
-20			111503	50.6	120671	54.7	132241	60.0
-10			95463	43.3	103470	46.9	113949	51.7
-0.99	59911	27.2	82848	37.6	89988	40.8	99151	45.0
0	58663	26.6	81614	37.0	88609	40.2	97589	44.3
10	48045	21.8	69570	31.6	75681	34.3	82787	37.6
20	39571	17.9	59036	26.8	64204	29.1	69663	31.6
30	32708	14.8	49666	22.5	53908	24.5	58163	26.4
40	27100	12.3	41270	18.7	44742	20.3	48133	21.8
50	22440	10.2	33782	15.3	36612	16.6	39401	17.9
60	18537	8.4	27117	12.3	29408	13.3	31793	14.4
70	15234	6.9	21183	9.6	23024	10.4	25147	11.4
80	12415	5.6	15896	7.2	17358	7.9	19319	8.8
83	11650	5.3	14424	6.5	15784	7.2	17708	8.0
90	9989	4.5	11177	5.1	12319	5.6	14188	6.4
100	7885	3.6	6958	3.2	7826	3.5	9653	4.4
110	6051	2.7	3175	1.4	3811	1.7	5629	2.6
120	4440	2.0			213	0.1	2044	0.9
130	3017	1.4						
140	1755	0.8						

Co-manifested Payload Missions. SLS Block 1B/2 can simultaneously transport Orion and CPLs using a PLA/USA to lunar destinations as needed. While SLS Block 1B performance capability for CPL is still under development, the current CPL TLI delivery mass goal for the first Block 1B flight (planned for EM-3) is 17,637 lb (8.0 t) based on an overall delivery of 80,028 lb (36.3 t) to a cis-lunar destination. The current CPL TLI delivery mass goal for the second and all subsequent Block 1B flights is 19,842 lb (9.0 t) based on an overall delivery of 82,232 lb (37.3 t) to a cis-lunar destination. SLS Block 2 CPL delivery mass to cis-lunar destinations should be in excess of 33,069 lb (15 t).

Note: All CPL delivery mass goals exclude associated PLA mass; therefore, this capability represents the mass of the actual payload delivered post separation from the EUS.

4.2.5 SLS Earth Escape Performance

The payload delivery to Earth escape for a range of characteristic energy, or C3, for SLS crew configurations and SLS 8.4m PLF, Short cargo flights is given in Figure 4-13. An interim circular orbit of 100 nm (185 km) altitude is assumed prior to C3 injection. Specific data points are provided in Table 4-1.

5.0 ENVIRONMENTS

This section describes the SLS environments to which a spacecraft or payload will be exposed, both during ground processing and in flight.

Payload providers must perform an extensive, generalized series of system-level qualification and protoflight tests in order to achieve payload acceptance for spacecraft launched on the SLS. Such tests should be structured to encompass SLS block and payload configurations. Coordination with SPIE during test criteria development is encouraged to ensure process compatibility with SLS-specified operating regimes. To comply with NASA payload integration processes, payloads must demonstrate both design qualification and flight unit acceptance. Such criteria are assessed relative to payload structural integrity, along with operation failure modes with risk of impairing launch success when subjected to predicted SLS vibration, shock and acoustic loading environments. Qualification process reasoning and test data must be provided to NASA for secondary review to prevent mission goal incompatibilities and discrepancies between requirement definition and spacecraft verification. Furthermore, the intent is to ensure minimum standards regarding spacecraft build quality are satisfied. Protoflight procedures include testing of provided payloads at maximum tolerable SLS operating conditions to verify standards are met.

5.1 Structural Loads

Spacecraft/payload accelerations are estimates from ongoing SLS analysis. Dynamic excitations, occurring predominantly during liftoff and transonic periods of SLS flights, are superimposed on steady-state accelerations from specific mission trajectory analyses to produce combined accelerations that should be used in payload structural design. The combined payload accelerations are a function of launch vehicle characteristics as well as payload dynamic characteristics and mass properties.

In general, payload maximum lateral load factors tend to be lower for high max. axial load factors and vice versa. Representative design load factors for SLS Block 1 payloads are shown in Table 5-1. Representative design load factors that envelope the rollout, prelaunch, liftoff, and boost and core stage ascent loads for Block 1B payloads are shown in Table 5-2; values in this table are sensed load factors, not kinematic accelerations. Table 5-3 provides the low frequency load factors which need to be combined with the random vibration load factors. Payload cantilevered fundamental mode frequencies are recommended to be a minimum of 8 Hz lateral and 15 Hz axial to ensure applicability of the design load factors.

Payloads wanting to utilize their own heritage separation systems will be evaluated on a case by case basis. For initial sizing, if the payload and its provided separation system meet the frequency recommendations, the provided load factors may be used. Otherwise mission-unique vehicle dynamic coupled load analyses would be performed to determine the applicable design load factors for payloads that bring their own separation systems.

Table 5-1. Block 1 SPL Component Load Factors Due to Low Frequency Loads

Flight Phases	Vehicle Axial	Vehicle Lateral and Radial
Liftoff through Ascent/Boost	+0.6, -3.5g	±3.0g
Ascent/Core through In-Space	-4.1g	±0.5g

Table 5-2. Block 1B PPL/CPL Combined Load Factors

Case	Vehicle Axial (G)	Vehicle Lateral(G)
Liftoff	+1.0	±1.5
Liftoff/Transonic	-2.0	±2.0
Max Q	-2.3	±2.0
Core Stage Flight	-3.5	±0.5
MECO	-4.1	±0.5

Table 5-3. Block 1B PPL/CPL Accelerations Due to Low Frequency Loads

Flight Phases	Vehicle Axial	Vehicle Lateral and Radial
Liftoff through Ascent/Boost	+0.6, -3.5g	±3.0g
Ascent/Core through In-Space	-4.1g	±0.5g

5.2 Thermal Environments

The spacecraft/payload thermal environment is controlled during pre-launch activity, maintained during ground transport, and controlled after mate to the launch vehicle.

Drag-on clean air from within the payload encapsulation facility will be circulated throughout the Integrated Spacecraft/Payload Element (ISPE) following payload encapsulation, until preparation for transport to the Vehicle Assembly Building (VAB). The ISPE will have a dry air blanket purge provided by Mini Portable Purge Units (MPPUs) during transportation to the VAB transfer aisle. Transit from the processing facility to VAB is identical for the PLF aft purge. A dry air purge will be provided to the ISPE while in the VAB prior to stacking on the SLS vehicle. During this VAB blanket purge prior to lifting, the USA purge, PLF aft and forward purge, and Block 1 cargo PLF have identical gas properties as their respective environments for transportation from the processing facility to the VAB. No active purge will be provided during the maximum eight-hour lifting and stacking operations. This encompasses the time between disconnecting the MPPU blanket purge and reconnecting the Mobile Launcher (ML) purge system. Once mating operations are complete, a continuous purge is established through T-0 quick disconnect fitting. A dry air and gaseous nitrogen (GN2) purge (during tanking) will be provided to the USA or PLF through the purge interface while on the ML, prior to pad rollout and through launch countdown. No active purge is provided during the transition from the ML system to the MPPUs prior to rollout, nor from the MPPUs to the pad system after rollout. The maximum outage duration during these two events is 2 to 4 hours each.

The purpose of this thermal design environments section is to present the physical interface environments and the shared compartment environments for PPL, CPL, and SPL. These environments are used to develop design criteria for payloads, systems, and major assemblies, and shall be used as boundary temperatures and analytical constraints. The environments will consist of descriptions of thermal environment characteristics throughout the mission phases of the vehicle including rollout, prelaunch (unfueled and fueled), launch, ascent and in-orbit.

Aerodynamic heating on the outside of SLS payload enclosures (OSA, USA or PLF) result in an internal time-dependent radiant heating environment around the spacecraft/payload before Orion separation, USA jettison or PLF jettison. Fairings use different coatings on external surfaces to minimize fairing skin temperatures. Spacecraft/payload thermal environments are further attenuated by acoustic suppression systems within the payload volume.

5.2.1 SLS Block 1 Crew Configuration Thermal Environments

The SLS Block 1 environmental temperature for SPL installed in a dispenser located within the OSA is shown in Table 5-4 for pre-launch, Table 5-5 for ascent, and Table 5-6 for on-orbit.

Table 5-4. Block 1 SPL Pre-Launch Environment Temperatures

Mission Phase	Integrated Payload (°F)
Rollout, NO purge, MAX	130
Rollout, NO purge, MIN	26
On-Pad, Purge ON, MAX	101
On-Pad, Purge ON, MIN	29
On-Pad, Tanked, Purge ON, MAX	95
On-Pad, Tanked, Purge ON, MIN	17
On-Pad, Tanked, Purge ON, MAX Time = 0.0 seconds	88
On-Pad, Tanked, Purge, ON, MIN Time = 0.0 seconds	24

Table 5-5. Block 1 SPL Ascent Environment Temperatures

Mission Phase	Dispenser Temperature Ascent (°F)	Dispenser Temperature On-Orbit (°F) to TLI	Dispenser Temperature Shutdown (°F)
Ascent, MAX	88	90	87
Ascent, MIN	24	18	4

Table 5-6. Block 1 SPL On-Orbit Environment Temperatures

Mission Phase	Dispenser Temperature TLI to TLI + 24 hours (°F)	Dispenser Temperature TLI + 24 hours thru Lunar Flyby (°F)
On-orbit, MAX	116	130
On-orbit, MIN	6	53

5.2.2 SLS Block 1B Crew Configuration Thermal Environments

The environments in this section are to be used for the CPL. The conduction interface temperatures, compartment bulk gas temperatures, and radiation sink temperatures documented in this section are derived from an analysis assuming a Payload Design Purge case. This purge case assumes that a cold purge is used when the external terrestrial environments are hot, and a hot purge is used when the external terrestrial environments are cold.

5.2.2.1 Conduction Interface Temperatures

Interface conditions to be used for the CPL are documented in Table 5-7. These temperatures are based on Payload Design Purge conditions, where a hot purge is used when the external terrestrial environments are cold, and a cold purge is used when the external terrestrial environments are hot. Data is only available through USA separation, as the CPL is assumed to jettison at approximately the same time.

Table 5-7. Block 1B CPL-to-PLA Interface Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	106
On-Pad Unfueled	53	103
On-Pad Fueled	34	101
Launch to Core Stage Separation	28	89
Core Stage Separation to SECO1	19	90
SECO1 to ORION Separation	-92	92
ORION Separation to USA Jettison	-106	86

5.2.2.2 Compartment Bulk Gas Temperatures

Compartment bulk gas temperatures for both the Orion-to-PLA Shared Compartment and the PLA-to-EUS compartment are documented in this section. Table 5-8 documents the compartment bulk gas temperatures for the Orion-to-PLA Shared Compartment. Table 5-9 documents the compartment bulk gas temperatures for the PLA-to-EUS Shared Compartment. This compartment gas temperature and the CPL exchange heat through convection between the gas and the areas of the CPL that have a view through the top of the PLA to the EUS below.

Table 5-8. Block 1B Orion-to-PLA Shared Compartment Gas Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	99
On-Pad Unfueled	53	98
On-Pad Fueled	48	97

Table 5-9. Block 1B PLA-to-EUS Compartment Gas Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	104
On-Pad Unfueled	52	101
On-Pad Fueled	34	94

5.2.2.3 Radiative Radiation Sink Temperatures

Radiation sink temperatures for the USA with a surface emissivity of 0.77 are documented in Table 5-10 for the USA conical section and Table 5-11 for the USA barrel section.

Table 5-10. Block 1B USA Cone Radiation Sink Temperature

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	105
On-Pad Unfueled	50	104
On-Pad Fueled	44	103
Launch to Core Stage Separation	42	131
Core Stage Separation to SECO1	52	131
SECO1 to ORION Separation	-64	127
ORION Separation to USA Jettison	-110	79

Table 5-11. Block 1B USA Barrel Radiation Sink Temperature

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	104
On-Pad Unfueled	50	103
On-Pad Fueled	44	102
Launch to Core Stage Separation	43	111
Core Stage Separation to SECO1	47	111
SECO1 to ORION Separation	-72	105
ORION Separation to USA Jettison	-112	71

5.2.3 SLS Block 1B Cargo Configuration Thermal Environments

The environments in this section are to be used for the PPL. The conduction interface temperatures, compartment bulk gas temperatures, and radiation sink temperatures documented in this section are derived from an analysis assuming a Payload Design Purge case. This purge case assumes that a cold purge is used when the external terrestrial environments are hot, and a hot purge is used when the external terrestrial environments are cold.

5.2.3.1 PLF Conduction Interface Temperatures

Interface conditions to be used for the PPL are documented in Table 5-12. Data is available from rollout through the beginning of the TLI burn, as the PPL is assumed to jettison at that time. No aero-heating or free-molecular heating is applied to the PPL after the Payload Fairing (PLF) separation.

Table 5-12. PPL-to-PLA Interface Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	100
On-Pad Unfueled	54	98
On-Pad Fueled	45	97
Launch to PLF Separation	40	91
PLF Separation to Beginning of TLI Burn	-121	150

5.2.3.2 PLF Compartment Bulk Gas Temperatures

Table 5-13 documents the compartment bulk gas temperatures for the PLF Compartment. Table 5-14 documents the compartment bulk gas temperatures for the PLF Compartment. This compartment gas temperature and the PPL exchange heat through convection between the gas and the areas of the PPL that have a view through the top of the PLA to the EUS below.

Table 5-13. PLF Compartment Gas Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	100
On-Pad Unfueled	54	99
On-Pad Fueled	49	98

Table 5-14. PLA-to-EUS Compartment Gas Temperatures

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	102
On-Pad Unfueled	56	97
On-Pad Fueled	36	93

5.2.3.3 PLF Radiation Sink Temperatures

The radiation sink temperature with an emissivity of the surface of 0.77 are documented in Table 5-15.

Table 5-15. PLF Radiation Sink Temperature

Mission Phase	Min (Deg. F)	Max (Deg. F)
Rollout	30	101
On-Pad Unfueled	53	100
On-Pad Fueled	50	98
Launch to PLF Separation	50	120

5.3 Liftoff/Ascent Venting

At approximately T-0, the ground purge is disconnected and venting becomes a function of the changing vehicle altitude and speed. During ascent, SLS Block 1B crew configuration payloads will be exposed to a compartment pressure within the envelope shown in Figure 5-1, and a peak depressurization rate of -0.30 psi/sec near 60 seconds. During ascent, SLS Block 1B cargo configuration payloads will be exposed to a compartment pressure within the PLF envelope shown in Figure 5-2, and a peak depressurization rate of -0.42 psi/sec near 60 seconds.

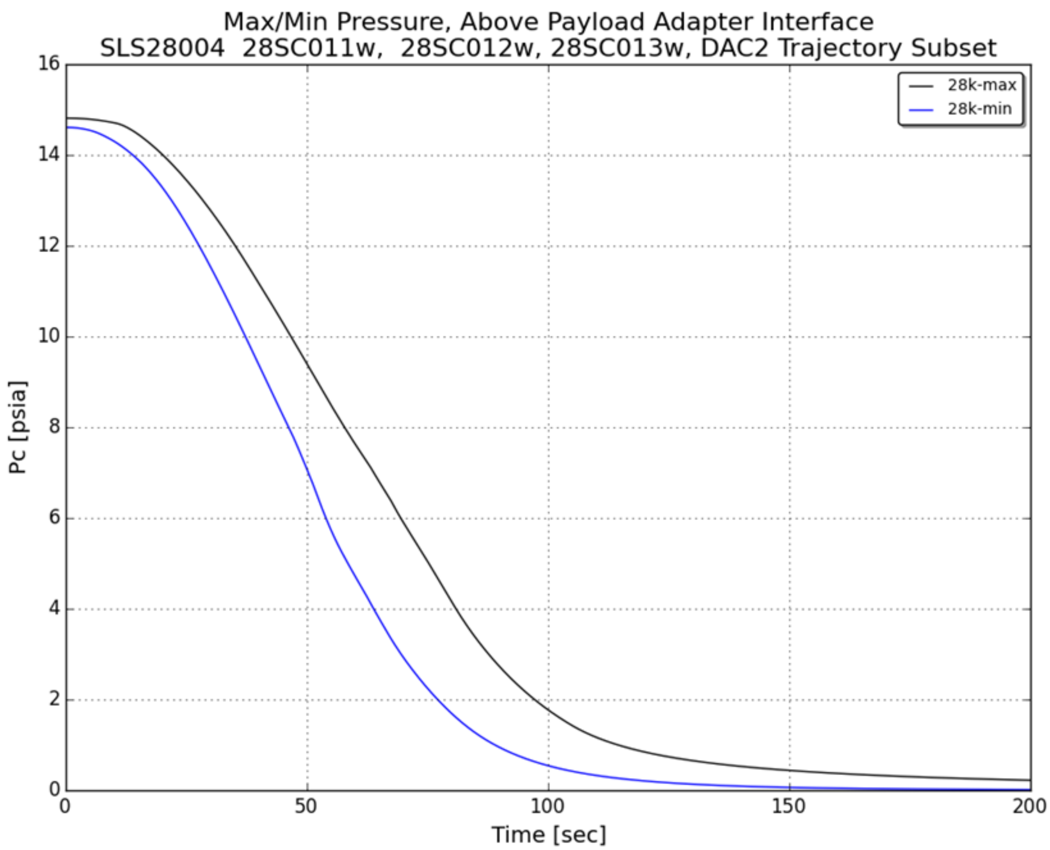


Figure 5-1. Pressure Envelope Block 1B Crew Configuration Payloads

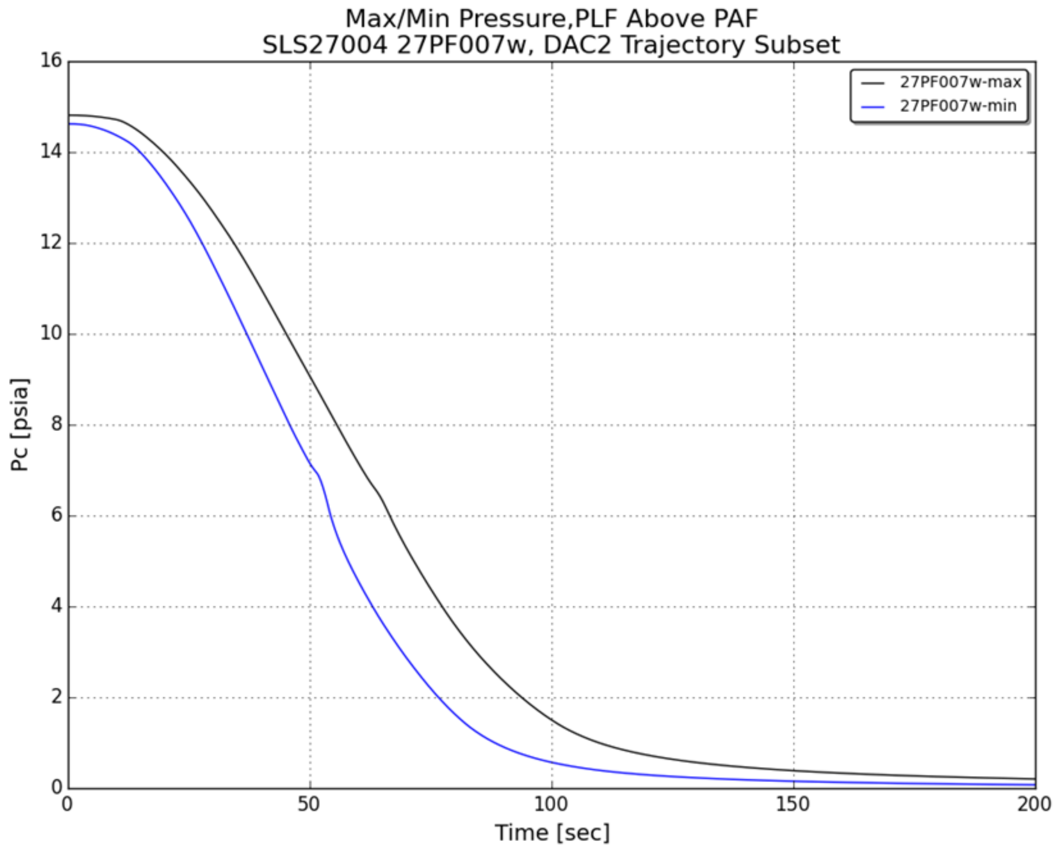


Figure 5-2. Pressure Envelope Block 1B Cargo Configuration Payloads

5.4 Acoustics

The spacecraft/payload is exposed to an internal acoustic environment that occurs during the liftoff and transonic portion of flight. The acoustic level inside the OSA, USA or PLF will vary slightly with different spacecraft/payload, depending on its acoustic absorption properties and the payload fill factor. A range of acoustic mitigation systems are available depending on payload needs. For example, acoustic levels can be mitigated to a certain extent by adding more acoustic foam.

5.4.1 SLS Block 1 Crewed Configuration Internal Acoustics

The SLS Block 1 OSA-Mounted SPL maximum expected internal acoustic environment is shown in Table 5-16. The internal acoustic environment represents a 95 percent probability, with a 50 percent confidence level and no blanketed section.

Table 5-16. Block 1 SPL Internal Acoustic Environments, No Blanket Included

1/3-Octave Band Center Frequency (Hz)	Sound Pressure Level (dB re: 20 μPa)
20	115.4
25	120.7
31.5	125.5
40	130.1
50	131.5
63	132.8
80	133.5
100	133.8
125	134.2
160	134.0
200	134.0
250	132.2
315	130.1
400	127.4
500	124.8
630	122.4
800	119.1
1000	116.3
1250	112.9
1600	109.1
2000	106.4
2500	103.6
3150	101.0
4000	98.0
5000	95.1
6300	92.2
8000	89.4
10000	86.9
Overall Sound Pressure Level	**143.2**

5.4.2 SLS Block 1B Internal Acoustics

The payload internal acoustic environment is considered equivalent for both the SLS Block 1B crew (USA) and cargo (PLF) configurations. Therefore, acoustic environments for PPL, CPL and SPL are defined in Figure 5-3 and Table 5-17. Potential for additional

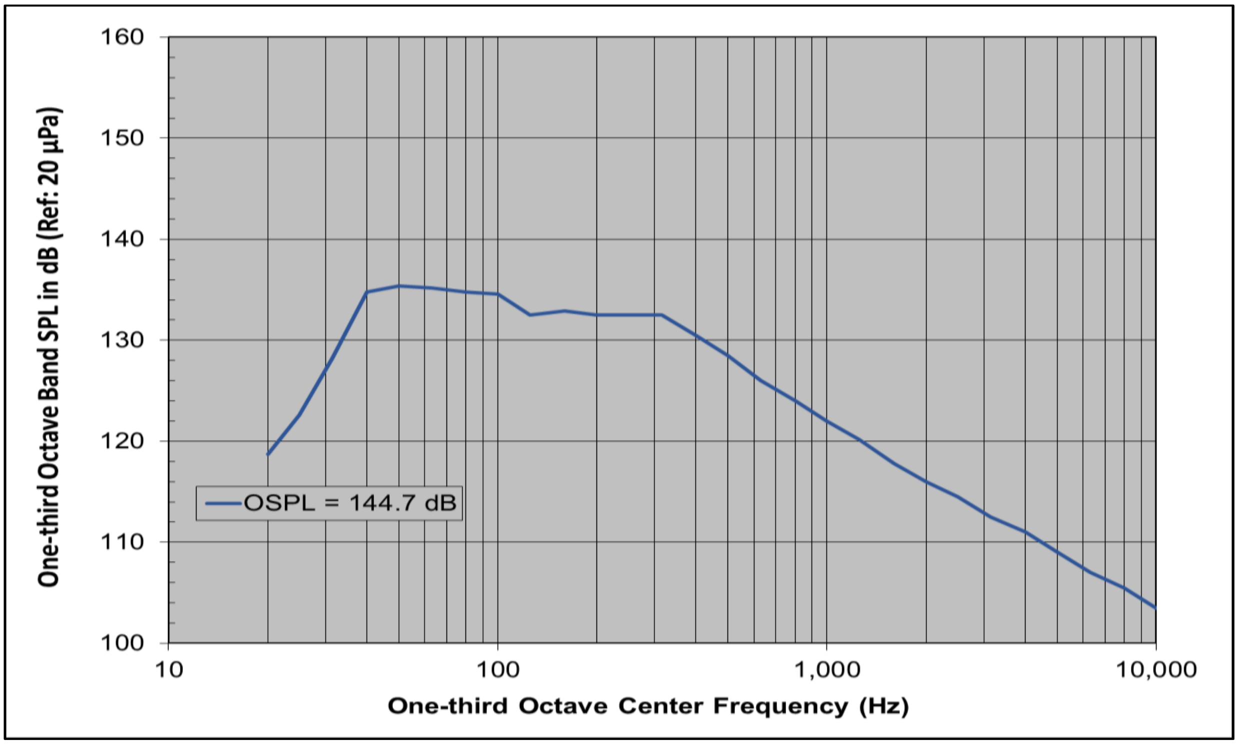


Figure 5-3. Block 1B USA/PLF Internal Acoustic Environment, 95/50, 60% Fill Effect

Table 5-17. Block 1B USA/PLF Internal Acoustics Environment, 95/50, 60% Fill Effect

1/3-Octave Band Center Frequency (Hz)	Sound Pressure Level (dB re: 20 µPa)
20	118.7
25	122.6
31.5	128.2
40	134.8
50	135.4
63	135.2
80	134.8
100	134.6
125	132.5
160	132.9
200	132.5
250	132.5
315	132.5
400	130.5
500	128.5
630	126.0
800	124.0
1000	122.0
1250	120.2
1600	117.8
2000	116.0
2500	114.5
3150	112.5
4000	111.0
5000	109.0
6300	107.0
8000	105.5
10000	103.5
Overall Sound Pressure Level	144.7

5.5 Vibration

5.5.1 SLS Block 1B Crew Configuration Random Vibration

No random vibration environment is defined for the CPL interface. At the CPL interface, for frequency less than 100 Hz, the random vibration environment is covered by the sine environment defined in Section 5.5.2. The USA internal acoustic environment, in Section 5.4.2, covers excitation produced by random vibration at the CPL interface, for frequency greater than 100 Hz. No random vibration load factor is defined for the CPL. The USA internal acoustic levels, in Section 5.4.2 are a more appropriate source environment for CPL secondary structures and components.

5.5.2 SLS Block 1B Crew Configuration Sinusoidal Vibration

The sinusoidal vibration levels should be used in conjunction with the low frequency loads to aid in the design of CPL secondary structure. The CPL sinusoidal vibration MPE level at the PLA interface is shown in Table 5-18.

Table 5-18. CPL Vehicle Dynamics Criteria

Frequency (Hz)	Normal		Frequency (Hz)	In Plane	
	Input (g)	Slope (dB/Octave)		Input (g)	Slope (dB/Octave)
5	0.22		5	0.22	
20	0.22		22	0.22	
27	0.26	2.15	31	0.31	
35	0.26		60	0.31	4.23
60	0.16	-4.92			

5.5.3 SLS Block 1B Cargo Configuration Random Vibration

No random vibration environment is defined for the PPL. At the PPL interface, for frequency less than 100 Hz, the random vibration environment is covered by the sine environment defined in Section 5.5.4. The PLF internal acoustic environment, in Section 5.4.3, covers excitation produced by random vibration at the CPL interface, for frequency greater than 100 Hz. No random vibration load factor is defined for the PPL. The PLF internal acoustic levels, in Section 5.4.3 are a more appropriate source environment for PPL secondary structures and components.

5.5.4 SLS Block 1B Cargo Configuration Sinusoidal Vibration

The sinusoidal vibration levels should be used in conjunction with the low frequency loads to aid in the design of PPL secondary structure. The PPL sinusoidal vibration MPE level at the PLA interface is shown in Table 5-19.

Table 5-19. PPL Vehicle Dynamics Criteria

Frequency (Hz)	Normal		Frequency (Hz)	In Plane	
	Input (g)	Slope (dB/Octave)		Input (g)	Slope (dB/Octave)
5	0.22		5	0.22	
20	0.22		22	0.22	
27	0.26	2.15	31	0.31	
35	0.26		60	0.31	4.23
60	0.16	-4.92			

5.6 Shock

Separation events during an SLS flight that could affect payloads are: the PLF jettison, USA jettison, and the spacecraft/payload separation from the PLA. The spacecraft/payload separation device located at the top of the PLA is typically closest to the spacecraft/payload and generally produces the highest shock levels. The SLS Program's goal is to utilize current ELV fairings and spacecraft/payload separation systems, where applicable for SLS Block 1; those shock environments (generally 2,000-4,500 g) for existing launch systems are readily available in ELV payload user's guides for initial payload definition. Representative payload separation system-induced shock environment for Block 1B payloads are shown in Table 5-20. There can be a unique condition where a heritage separation system is supplied by the payload developer. For the heritage separation system supplied by the payload developer, a maximum allowable shock level at the PLA/SLS interface will be provided to the payload developer.

Table 5-20. Block 1B PPL/CPL Shock Environment at the PLA Interface (Q=10)

Frequency (Hz)	Shock Response Spectrum (SRS)
100	100 g
100 - 800	+9.8 dB/Oct
800 – 8,000	3,000 g
8,000 – 10,000	+7.8 dB/Oct
10,000	4,000 g

5.7 Radio Frequency (RF) Electromagnetic Environment (EME)

RF Environment. The Launch RF environment is provided in Table 5-20 and Figure 5-4, and the on-orbit external RF environment is provided in Table 5-21 and Figure 5-5. The environment should be assumed to be the level as indicated on the graph even if tabular data is not available for a specific frequency of interest. The on-orbit environment is given at an inclination angle of 57° and an altitude of 100 nmi. If this environment does not envelope mission parameters, please contact the payload office for further data. The environment can be controlled at the request of the payload.

Table 5-20. Launch RF EME

Frequency (MHz)	Peak (V/m)	Average (V/m)
49	6	5
437–447	7	5
2040	8	8
2106	7	7
2865	17	5
3100–3500	9	5
4440	9	9
4560	9	9
4640	9	9
4740	9	9
5400–5650	113	5
5650.01-5850	189	11
5850.01–5900	113	21
5900.01–5925	21	21
9370–9500	17	5
9500.01–9800	40	7
9800.01–9990	17	5
13750–14000	32	32

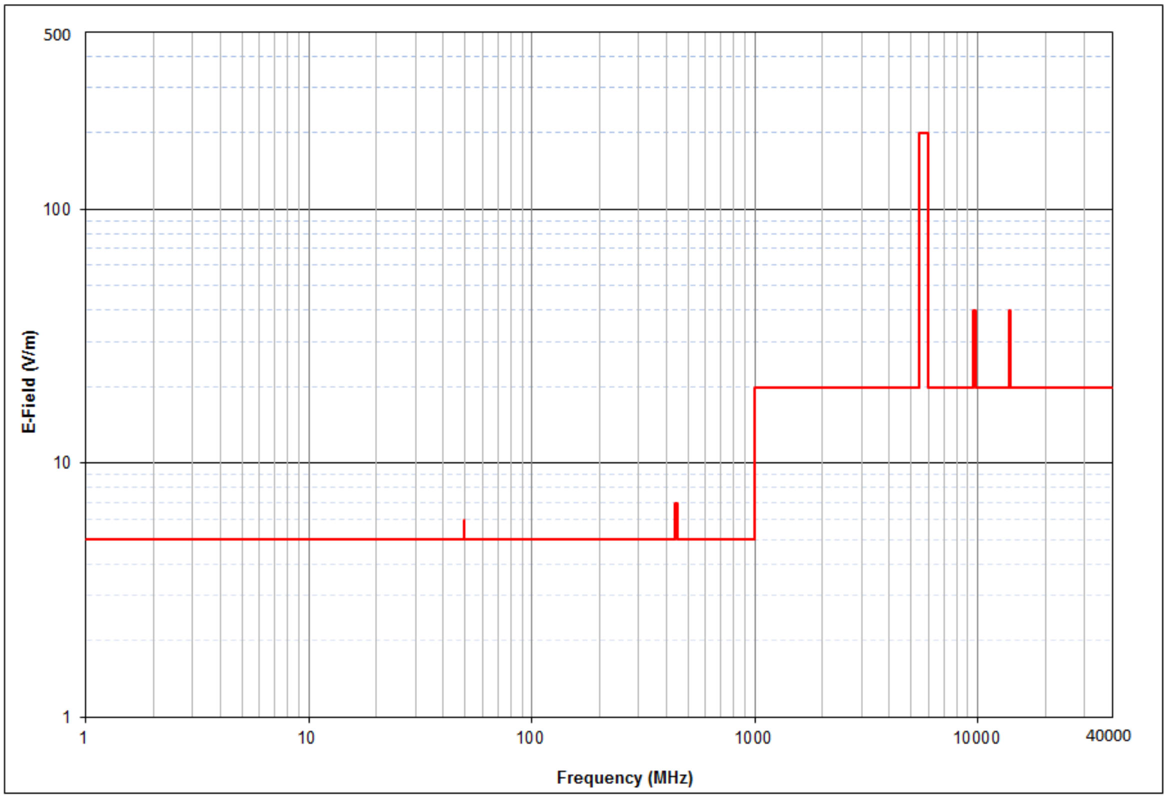


Figure 5-4. Launch RF EME (Peak Environment)

Table 5-21. On Orbit RF EME

Frequency (MHz)	Peak (V/m)	Average (V/m)
11–12	27	27
108.00	17	17
404–420.00	11	5
420.01–437.00	14	14
437.01–447.00	23	14
447.01–450.00	14	14
1175–1375	30	8
1550–1786.99	14	5
1787.00	43	43
1787.1–2090.99	14	5
2091.00	30	30

Frequency (MHz)	Peak (V/m)	Average (V/m)
2091.1–2110.00	14	5
2110.01–2120.00	30	30
2120.01–2144.99	14	5
2145.00	93	5
2145.10–2379.99	14	5
2380.00	189	189
2380.1–2839.99	14	7
2840.00	24	6
2840.1–2869.99	14	6
2870.00	24	6
2870.1–2950.99	14	6
2951.00	22	5
2951.1–3999.99	14	6
4000.00	85	85
4000.1–5399.99	15	5
5400.00–5659.99	27	5
5660.00	27	11
5660.1–5850.00	27	5
5850.01–5925.00	27	25
5925.01–6425	9	9
7155–7189	24	24
7209	6	6
8500–8559.99	7	5
8560.00	117	117
8560.10–9354.99	7	5
9355.00	142	5
9355.1–9999.99	7	5
10000.00	48	5
10593.00	10	10
14000–14500	10	10
16700	17	10
23530–23575	24	24
34316	7	7
34500–35200	11	11

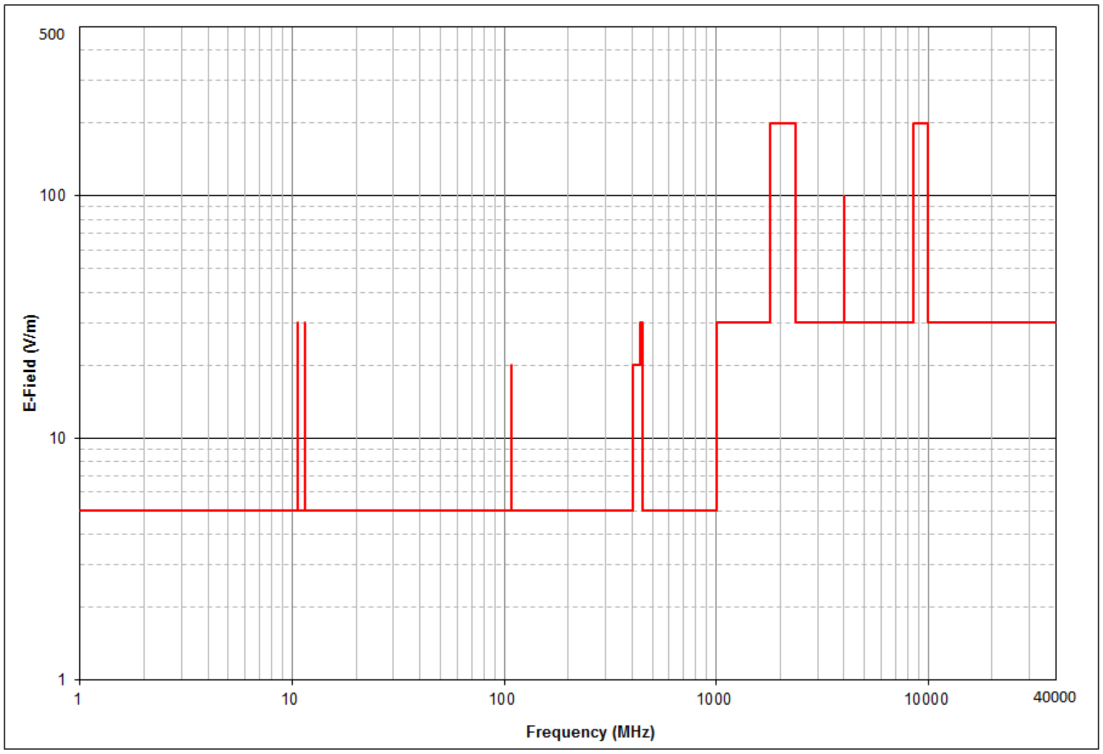


Figure 5-5. On-Orbit RF EME (Peak Environment – 57° Inclination)

Lightning Mitigation. Lightning direct effects are mitigated by a lightning protection catenary wire system at launch pad 39B. However, energy from a nearby lightning strike can couple into launch vehicle and spacecraft/payload cables. Operational controls and shielded umbilical cables will be in place to provide a limited level of protection. Magnetic field levels generated at the vehicle are a function of distance from the lightning event and strength of the lightning event. Given the protections in place, magnetic fields at the vehicle due to a lightning event will likely not exceed 200 A/m and levels this high should be considered rare. Magnetic fields on the order of 20A/m-40A/m will be more common. Weather-related events at the launch complex (LC)-39B pad, such as lightning, are recorded and measured continuously. Sensor data will be available for comparison against payload susceptibility levels. An illustration of the LC 39B pad is given in Figure 5-6. The ML portion of the weather subsystem measures electromagnetic transients associated with lightning events to or near the ML as well as performing a similar function for voltage and current transients measured at the Ground Support Equipment (GSE) power supply feeds to the launch vehicle. The Orion lightning monitoring system provides monitoring during rollout and at the pad. Additional measures beyond these capabilities will be the responsibility of the payload.

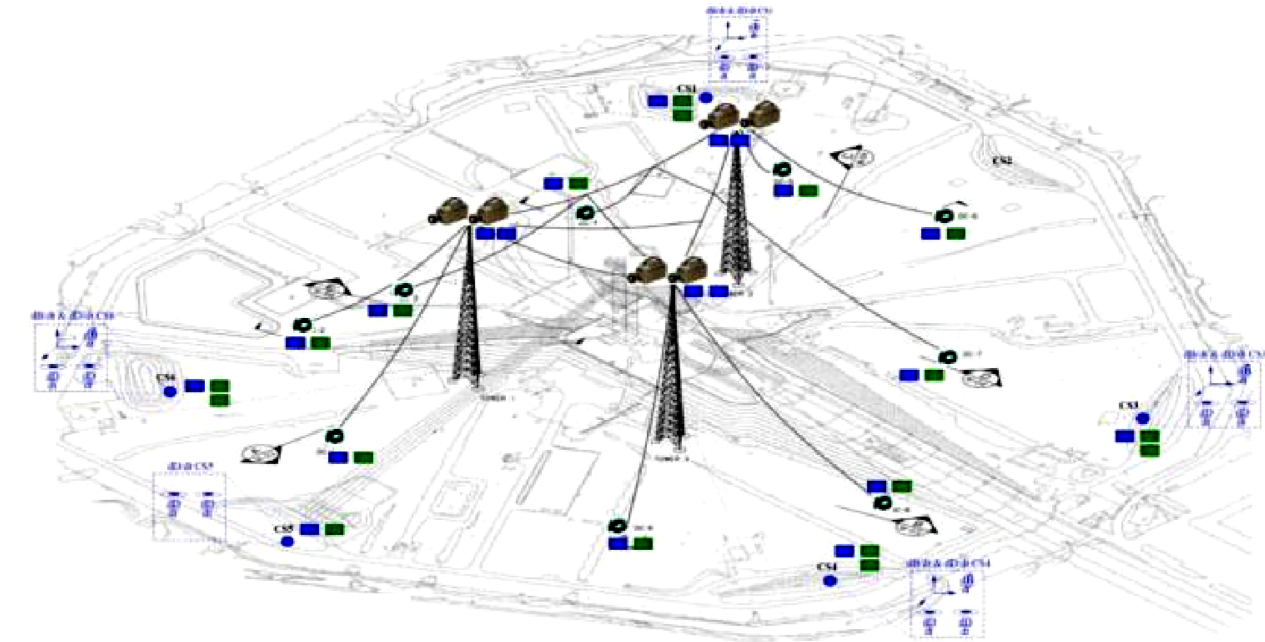


Figure 5-6. LC 39B Lightning Protection System Representation

5.8 SLS Contamination and Cleanliness

Launch vehicle hardware that comes into contact with the spacecraft/payload's environment is designed and manufactured according to strict contamination control requirements and guidelines. Ground operations at the launch site have been designed to ensure a clean environment for the spacecraft/payload. Details regarding Clean Work Area (CWA) classifications for launch site facilities are outlined in Section 7.0. However, cleanliness requirements for each spacecraft/payload will be evaluated on a case-by-case basis. All SLS payloads will follow specified contamination control procedures to prevent particle release and minimize Foreign Object Debris to ensure mission safety and success. Contamination-critical hardware surfaces will be visually inspected to verify established contamination and nonvolatile residue (NVR) criteria are met. In addition, the surface can also be cleaned using a solvent flush. The solvent is filtered and the particles on the filter are measured and counted. This provides a particle count (within a specific size range) per square foot. Particle fallout filters or wafers may also be placed in an area for a period of time. Afterwards, filters are microscopically examined or scanned electronically to provide a particle count. Additional verification techniques shown below can be provided on a mission-unique basis:

1. Particulate Obscuration — Tape lift sampling
2. NVR — Solvent wipe sampling
3. Particulate Obscuration — Ultraviolet light inspection
4. Particulate and Molecular Fallout — Witness plates

After encapsulation, the USA or PLF environment can be continuously purged with air filtered with High-Efficiency Particulate Air (HEPA) filters to ensure the cleanliness of the environment and preclude ingestion of windborne contamination during transport to the launch vehicle, mate and post-mate operations. Potential for user access to the spacecraft/payload inside the encapsulated USA/PLF will be evaluated on a case-by-case basis. If available, this access can be used for subsequent incursions inside the USA/PLF through the access doors while the vehicle is within the VAB. Personnel garmenting, activities and work procedures are controlled to maintain the environment surrounding the encapsulated fairing to acceptable standards. Spacecraft/payload outgassing will be controlled within the SLS USA (which is a shared compartment with Orion and EUS) and PLF.

Cleanliness levels will be categorized as “generally” or “visibly” clean, to meet a wide range of cleanliness needs. A “generally” clean level ensures that parts are free of manufacturing residue, dirt, oil, grease, processing debris and any other extraneous contamination. This generally clean level should be assigned to hardware that is not sensitive to contamination and can be easily and quickly cleaned.

“Visibly” clean hardware will meet the requirements of the generally clean level and will be cleaned and qualitatively verified to be free of all particulate and non-particulate material visible to the normal eye. Hardware cleaned to this level will be continuously protected using heat-sealed double bagging until the hardware is integrated or assembled into the next level of assembly in a clean-room environment. If the item is too large in size or weight, the visibly clean surfaces shall be prepackaged to cover all exposed critical surfaces.

There are four levels of visibly clean requirements. The first level is Standard, which will have an incident light level greater or equal to 500 lm/m2 with an inspection distance of 5 to 10 feet (1.5 to 3 m). The next level, Sensitive, will have the same incident light level as Standard, but with a closer inspection distance of 2 to 4 feet (0.6 to 1.2 m). A Highly Sensitive level will have an incident light level greater than or equal to 1000 lm/m2 with an inspection distance of 6 to 18 inches (0.15 to 0.45 m). Lastly a Custom requirement level may be set and is specified on a project-to-project basis. In addition, the visibly clean requirements may be subject to ultraviolet inspection. This inspection will utilize a wavelength of 3,200 to 3,800 angstroms.

6.0 SPACECRAFT/PAYLOAD INTERFACES

The SLS vehicle has been sized to enable crewed Orion exploration missions beyond LEO. In addition to the Orion spacecraft, this SLS capability can also accommodate three types of payload each using unique interfaces to the launch vehicle as shown in Figure 6-1.

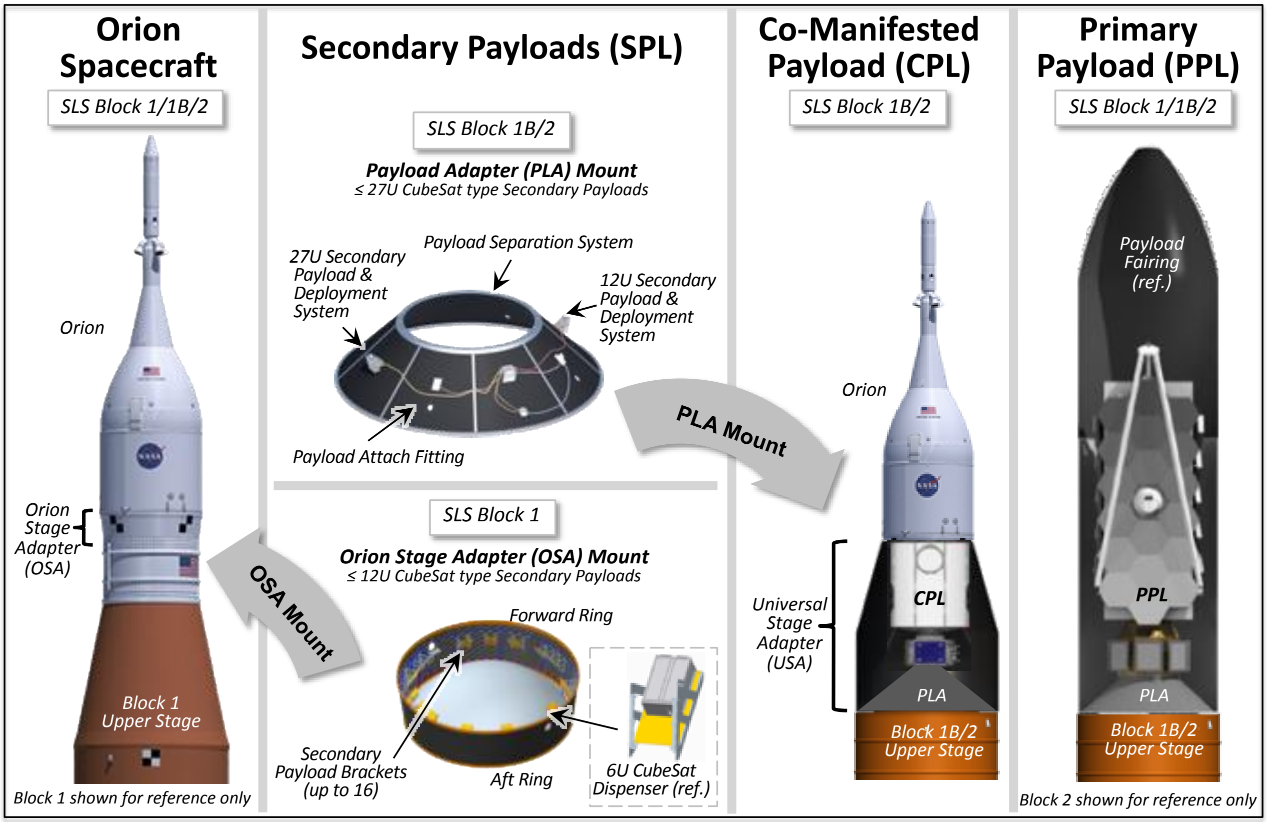


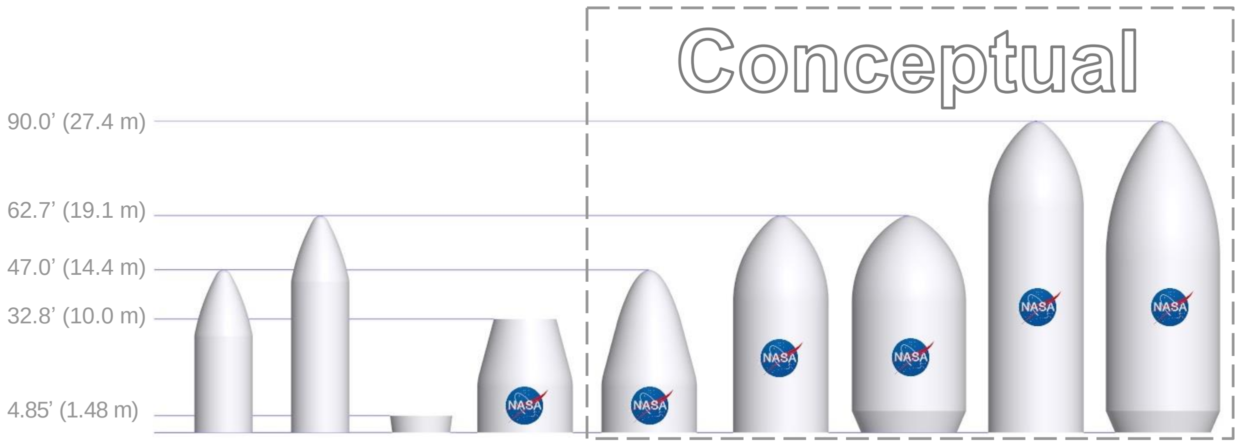
Figure 6-1. Range of SLS Spacecraft/Payload Accommodations

The SLS ISPE will accommodate a range of payload and Mission Dependent Equipment (MDE) consisting of fairings and adapters:

- Orion spacecraft – crew capsule accommodated on an SLS Block 1 OSA or Block 1B/2 USA that determines initial mission trajectory via an upper stage injection burn
- PPL – uncrewed spacecraft/payload accommodated in an SLS Block 1/1B/2 PLA/PLF that determines initial mission trajectory via an upper stage injection burn
    - 5 m-class diameter payloads can be accommodated on Block 1 (reference only)
    - 8.4 m-class diameter payloads can be accommodated on Block 1B
    - 8.4 m-class and larger diameter payloads can be accommodated on Block 2
- CPL – uncrewed spacecraft/payload accommodated within an SLS Block 1B/2 PLA/USA; compatible with an initial Orion-determined trajectory via an EUS injection burn
    - Orion docks to CPL and delivers CPL to its final destination (Orion CPL)
    - Or, post-Orion separation, CPL delivers itself to final destination (independent CPL)
- SPL – accommodated within an SLS Block 1 OSA, Block 1B/2 PLA/USA, or Block 1B/2 PLA/PLF; compatible with an Orion or PPL initial trajectory via an EUS injection burn

- SPL opportunity for flight based on available performance and minimizing impacts to overall flight and ground systems architecture while not jeopardizing crew safety or primary mission objectives
- Multiple locations available on the OSA for ≤12U-sized CubeSats
- Multiple locations available on the PLA for ≤27U-sized CubeSats
- Potential accommodation of larger than 27U SPL on or above the PLA

Figure 6-2 provides detail on a range of payload enclosure approaches potentially available to spacecraft/payload depending on mission definition and timing.



Enclosure	5.1m PLF	5.1m PLF	OSA	8.4m USA	8.4m USA PLF	8.4m PLF, Short	10m PLF Short	8.4m PLF, Long	10m PLF Long
Payload Type	5m PPL	5m PPL	5m SPL	8.4m CPL	8.4m PPL	8.4m PPL	10m PPL	8.4m PPL	10m PPL
Length	47.0 ft	62.7 ft	4.85 ft	32.8 ft	47.2 ft	62.7 ft	62.7 ft	90 ft	90 ft
	14.3 m	19.1 m	1.48 m	10.0 m	14.4 m	19.1 m	19.1 m	27.4 m	27.4 m
Diameter	16.7 ft	16.7 ft	17.7 ft	27.6 ft	27.6 ft	27.6 ft	33.0 ft	27.6 ft	33.0 ft
	5.1 m	5.1 m	5.4 m	8.4 m	8.4 m	8.4 m	10.0 m	8.4 m	10.0 m
Internal Diameter	15.1 ft	15.1 ft	16.7 ft	24.6 ft	24.6 ft	24.6 ft	29.9 ft	24.6 ft	29.9 ft
	4.6 m	4.6 m	5.1 m	7.5 m	7.5 m	7.5 m	9.1 m	7.5 m	9.1 m
Available Volume	5,358 ft^3	8,118 ft^3	516 ft^3	10,100 ft^3	11,260 ft^3	21,930 ft^3	32,470 ft^3	34,910 ft^3	46,610 ft^3
	151.7 m^3	229.9 m^3	14.6 m^3	286.0 m^3	319 m^3	621 m^3	919 m^3	988 m^3	1,320 m^3
Potential Availability *(No Earlier Than)*	COTS	COTS	2020	2024	2025	2025	2029	2029	2029

COTS: Commercial Off-the-Shelf CPL: Co-manifested Payload OSA: Orion Stage Adapter PPL: Primary Payload SPL: Secondary Payload PLF: Payload Fairing

Figure 6-2. Range of Potential SLS Payload Fairings and Stage Adapter Approaches

A commercial off-the-shelf (COTS) 5 m-class diameter PLF is planned for SLS Block 1 cargo flights (shown for reference only). For Block 1B/2 crewed flights, the SLS USA will accommodate Orion. The USA volume, which is larger than that provided by the largest available 5 m-class diameter PLF, or the Shuttle Payload Bay, allows payload to be co-manifested with Orion on every crew flight as needed. An option exists to add a nose cone to convert the USA into the 8.4 m USA PLF concept, if needed prior to the availability of a purpose-built 8.4 m PLF. The SLS 8.4m PLF, Short concept is equivalent in height to today's tallest ELV fairings and the 8.4m PLF, Long concept is the tallest fairing length that can be accommodated within existing launch site encapsulation facilities. These lengths are representative of the total range of 8.4m PLFs under consideration, and not meant to imply a particular design implementation at this time. The SLS 10m PLF concept is currently envisioned to support human lander missions, Mars exploration flights, as well as large-volume payloads (e.g., nuclear thermal propulsion, large-aperture telescopes).

These fairings and adapters are used to encapsulate payload for SLS missions. Because this "encapsulation" is both SLS Block-dependent (1, 1B or 2) and configuration-dependent (crew or cargo), the combination of fairing, adapters and payloads are referred to as the SLS ISPE. Figure 6-3 provides nominal ISPE details for SLS Block 1; the ISPE includes all equipment between the SLS Core Stage and Orion for the crew configuration and all equipment above the SLS Core Stage for the cargo configuration (shown for reference only). Figure 6-4 provides nominal ISPE details for SLS Block 1B/2; the ISPE includes all equipment between the SLS EUS and Orion for the crew configuration and all equipment above the SLS EUS for the cargo configuration.

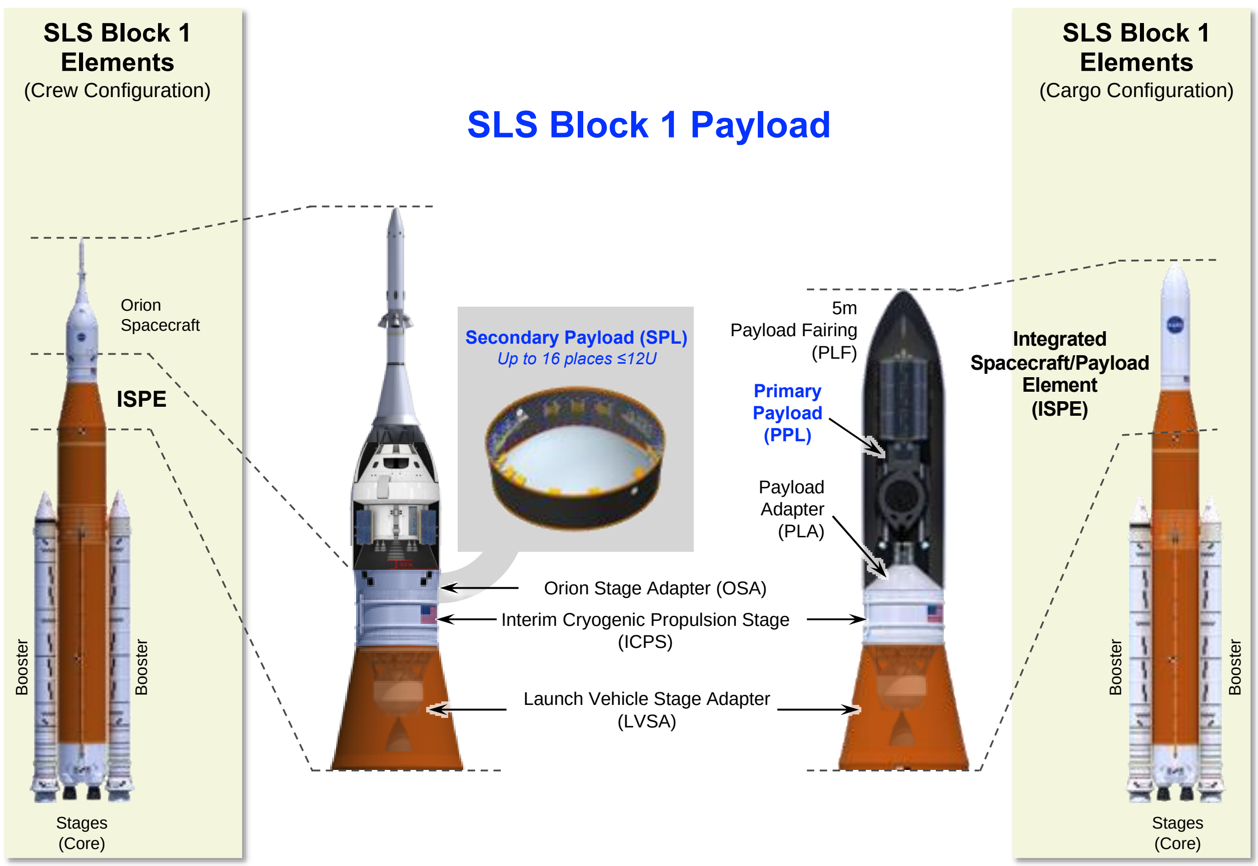


Figure 6-3. SLS Block 1 Integrated Spacecraft/Payload Element (ISPE)

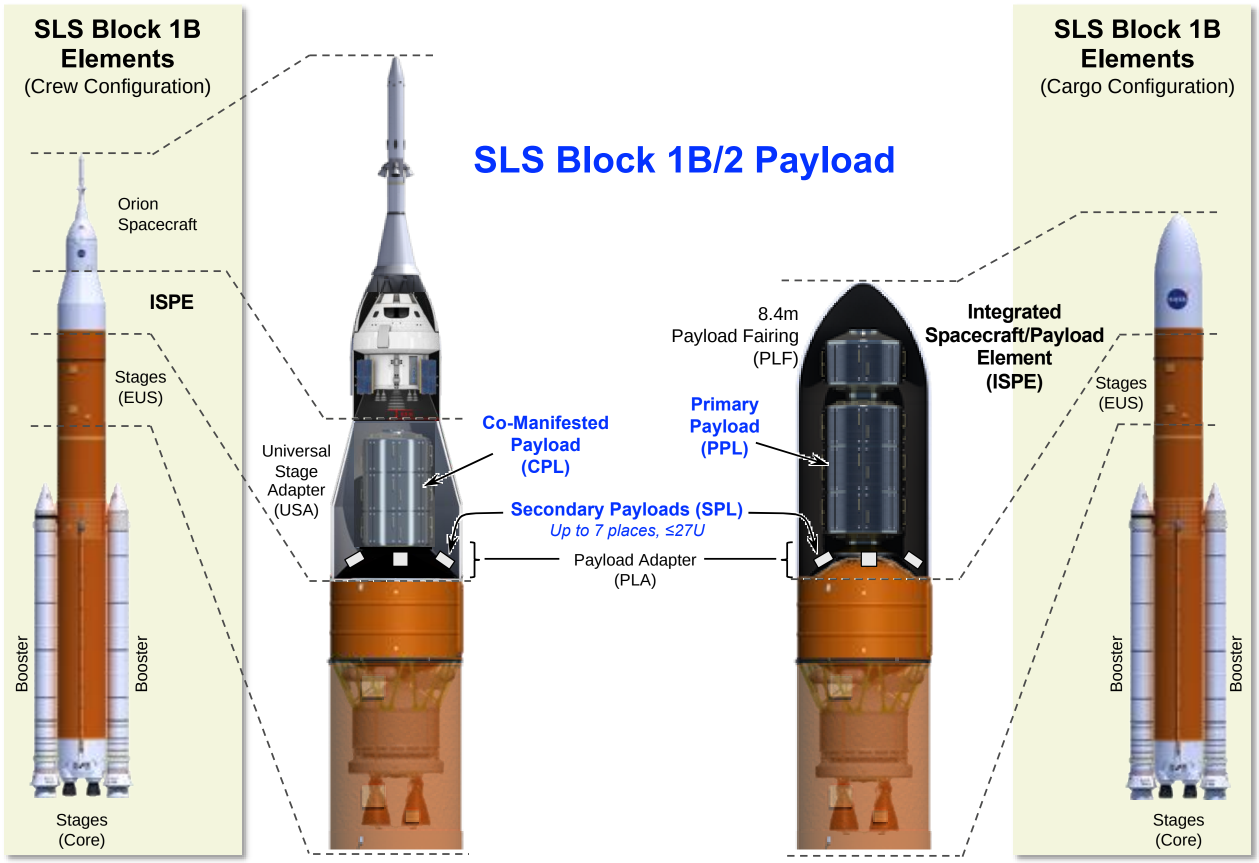


Figure 6-4. SLS Block 1B/2 Integrated Spacecraft/Payload Element (ISPE)

6.1 SLS to Orion Spacecraft Interfaces

NASA's early exploration missions are focused on crew transport to the lunar vicinity. Therefore, initial crewed flights will deliver Orion on a trajectory around the Moon to test critical launch vehicle and spacecraft systems. SLS will interface with Orion at its 18 ft (5.5 m) diameter Spacecraft Adapter (SA) aft interface as shown in Figure 6-5. SLS Block 1 accommodates the SA with a SLS provided OSA which provides a 16.7 ft (5.1 m) diameter interface to the ICPS. SLS Block 1B/2 accommodates the SA with a SLS provided USA that provides a 27.6 ft (8.4 m) diameter interface to the EUS. Upon Orion separation from SLS, the Orion SA remains attached to the SLS OSA (Block 1) or USA (Block 1B/2) during payload operations.

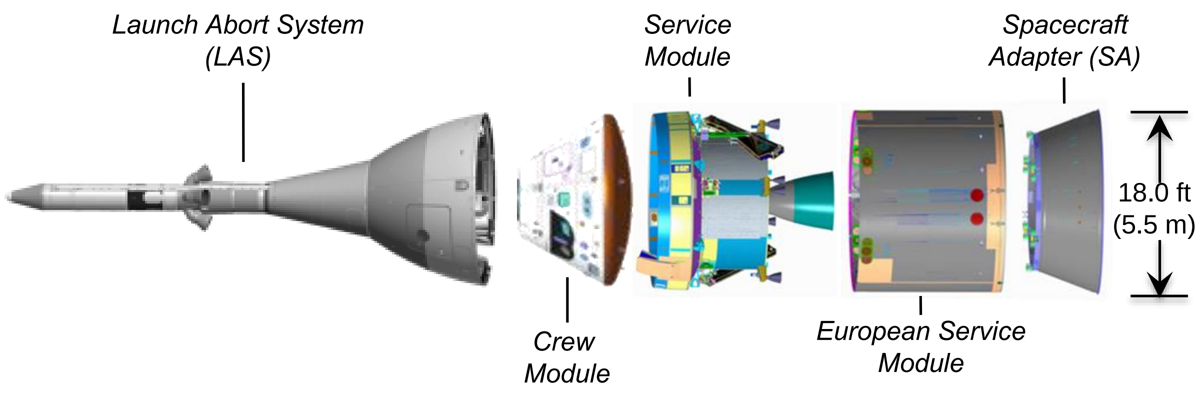


Figure 6-5. Orion Interfaces to SLS Crew Configurations (Block 1/1B/2)

6.2 SLS to Primary Payload Interfaces

PPL launched on SLS are protected by a PLF that shields them from the external environment and contamination during ground operations, launch and ascent. PLFs incorporate hardware to control thermal, acoustic, electromagnetic and contamination environments for the payload. Ground services can provide the fairing with conditioned air, fueling/draining, power and command/telemetry relay, and standard access door locations. Ground services may also provide additional payload access to the encapsulated payload while in the VAB or nitrogen purge at the pad as optional services. During vehicle ascent, fairings protect the payload from aerodynamic, acoustic and thermal loads, and are jettisoned when an acceptable free molecular heating rate is reached.

SLS can accommodate a wide variety of fairings, ranging from existing ELV 5m-class diameter PLFs to SLS 8.4m or 10m-class diameter PLF concepts. The internal fairing envelopes shown in the following sections define the available payload dynamic envelope, relative to the payload separation plane. All SLS 8.4 m and 10 m PLFs envelopes presented here are still in the conceptual design stage. With the user community's help, the SLS Program is in the process of identifying preferred fairing diameters and lengths to best accommodate potential exploration missions. Therefore, potential users should use the following information only for initial feasibility assessments. For the latest information on payload fairing accommodations, users should contact the SLS SPIE office directly at nasa-slspayloads@mail.nasa.gov.

6.2.1 5 m-class Diameter Payload Fairings (SLS Block 1 Reference Only)

For more information on using the composite 5.1 diameter PLFs (and their associated payload adapter interface to the ICPS) on SLS Block 1 shown in Figure 6.2, refer to the Delta IV User's Guide. Other ELV provided 5m-class fairings may be compatible with Block 1, but would need to be assessed on a case-by-case basis.

6.2.2 8.4 m-class Diameter Payload Fairings (SLS Block 1B/2)

As shown in Figure 6-2, a number of representative SLS Block 1B/2 8.4m PLF concepts are under evaluation.

Adding a nose cone to the USA creates a composite 47 ft (14.4 m) long USA PLF that, while heavier than a custom-built 8.4m PLF, could be available earlier to support near term, non-Orion flights. The available USA PLF static envelope is shown in Figure 6-6. It is anticipated the USA PLF will offer installation of differently sized access doors, as needed, and an interior surface compatible with acoustic treatments, to meet environmental requirements.

The USA PLF concept of operations assumes that once in orbit, the upper portion of the USA PLF “canister” is jettisoned from the EUS (note: this is in contrast to a PLF, which is jettisoned in “sectors” during ascent and prior to orbit). The non-separable portion of the USA PLF remains with EUS during the injection burn; the height of this non-separable portion is less than the PLA interface.

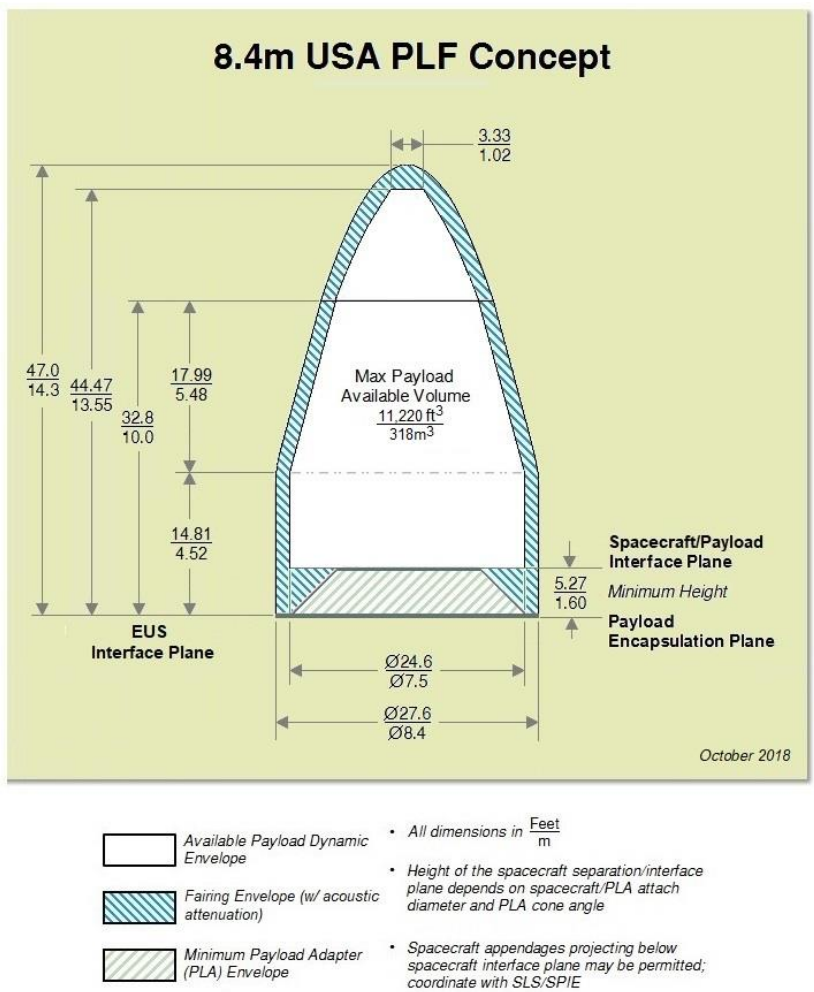


Figure 6-6. Composite 8.4 m USA PLF Concept

Figures 6-7 and 6-8 provide the available static envelope for the 8.4 m diameter short and long composite PLF concepts. These fairings jettison using traditional sectors versus the canister approach employed on USA PLF. Sectors are jettisoned during ascent (prior to LEO or direct insertion by the EUS).

The current length of 62.7 ft (19.1 m) for 8.4m PLF, Short concept represents the maximum length possible, based on ceiling hook height constraints of Kennedy Space Center’s (KSC) Payload Hazardous Servicing Facility. Potential exists for longer PLFs by lengthening the cylindrical section, as needed. The current maximum PLF length of 90 ft (27 m), as shown in the 8.4m PLF, Long, is constrained by the door and ceiling heights of Cape Canaveral Air Force Station’s (CCAFS’s) largest encapsulation facility.

As the Block 1B/2 design continues to mature, the structural limits of the SLS vehicle stack may preclude use of certain PLF diameter and length combinations. Therefore, potential users are encouraged to work with the SPIE office as soon as possible to define the feasibility of specific spacecraft/payload PLF diameter and length needs.

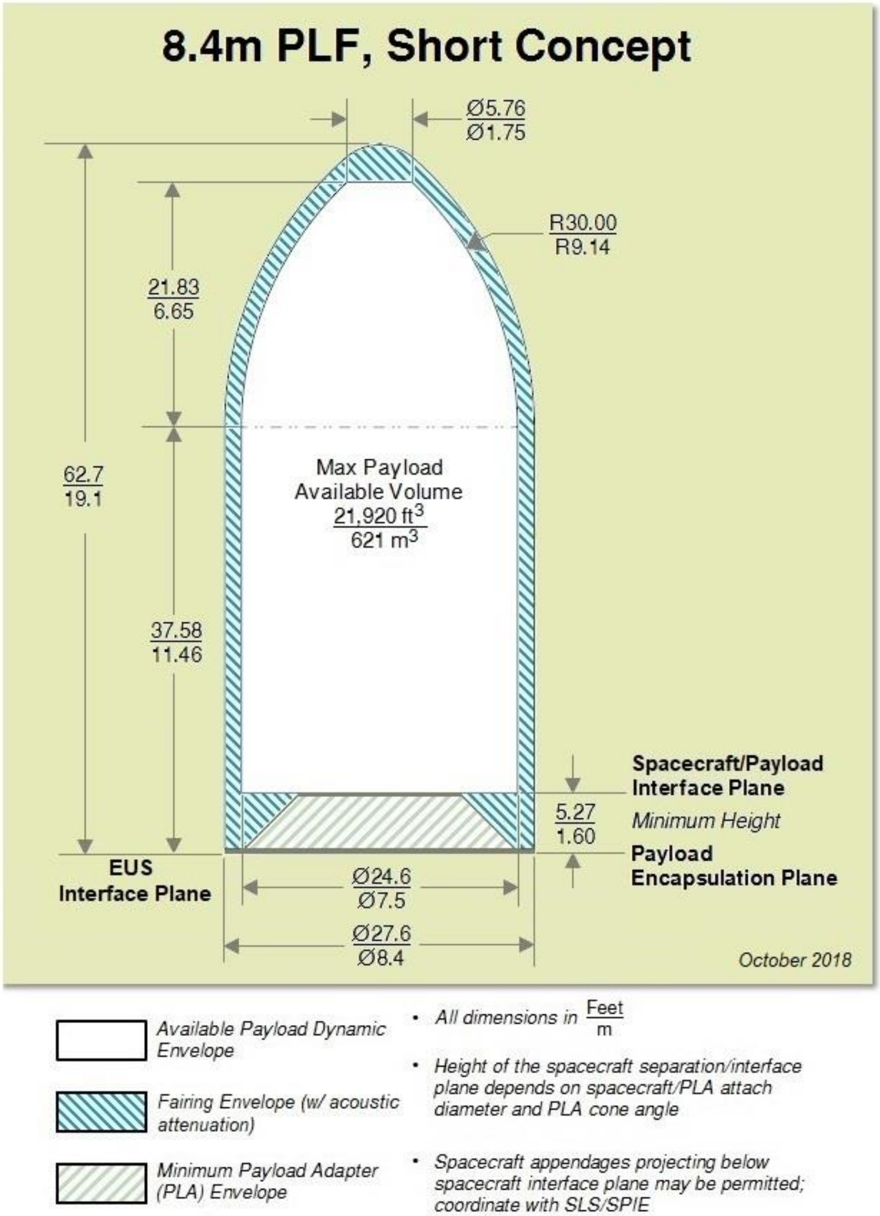


Figure 6-7. Composite 8.4m PLF, Short Concept

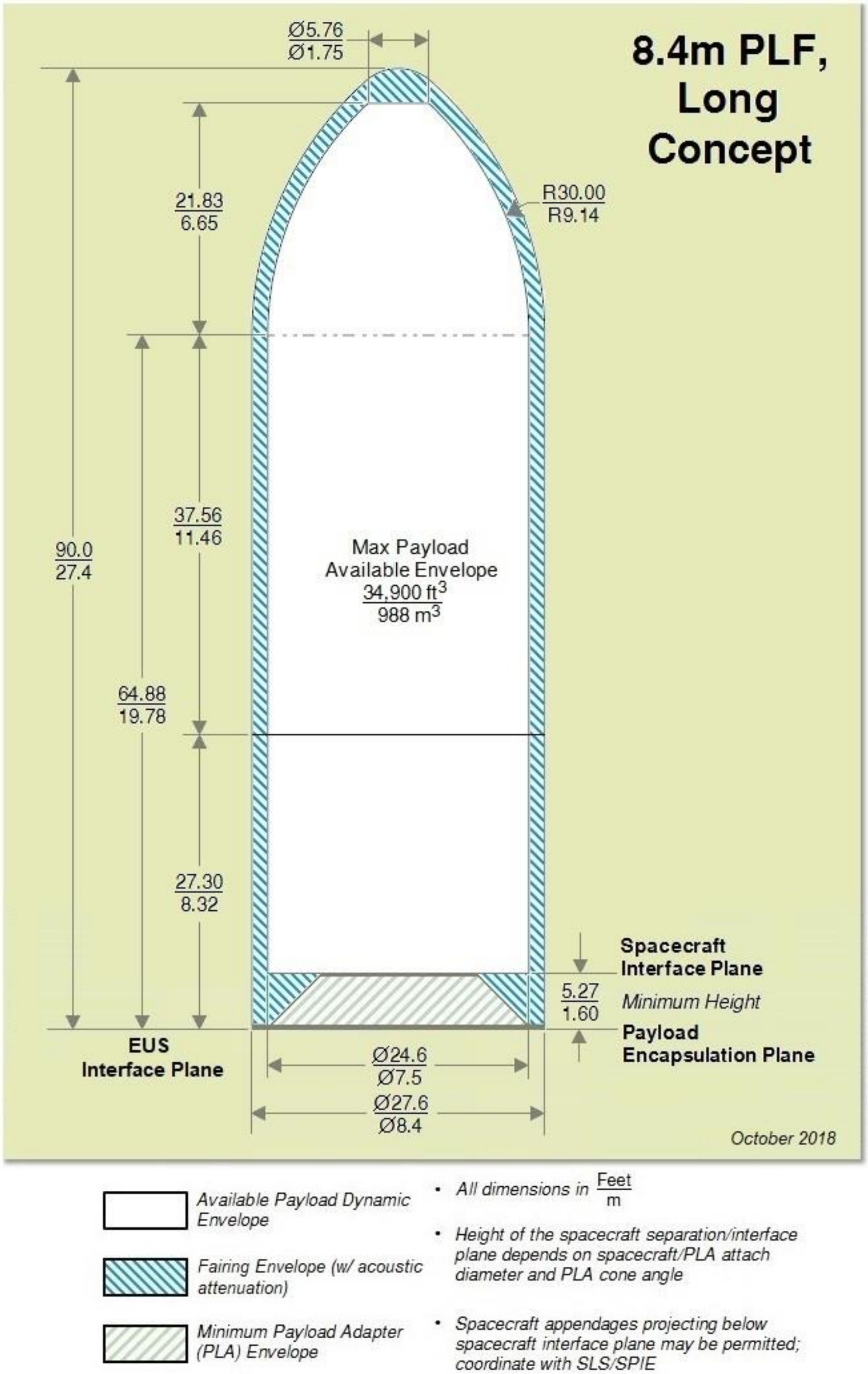


Figure 6-8. Composite 8.4m PLF, Long Concept

6.2.3 10 m-class Diameter Payload Fairings (SLS Block 2)

Once SLS transitions to the Block 2 configuration, using the enhanced performance of an 8.4 m diameter EUS and improved performance boosters, potential accommodation of larger diameter PLFs in the 10 m-class diameter is under analysis.

The current 10m PLF, Long concept represents the maximum 90 ft (27.4 m) length possible based on door width and door and ceiling hook height constraints of CCAFS's largest encapsulation facility. Figure 6-9 provides the available static envelope for this 10 m diameter PLF. Potential exists for shorter 10m PLFs by shortening the cylindrical section as shown in Figure 6-10. A 62.7 ft (19.1 m) long 10m PLF can physically fit within KSC's Payload Hazardous Servicing Facility for encapsulation, although additional study is required to determine the feasibility of simultaneous payload staging, handling and integration within the existing facility footprint.

As the Block 1B/2 design continues to mature, the structural limits of the SLS vehicle stack may preclude use of certain PLF diameter and length combinations. Therefore, potential users are encouraged to work with the SPIE office as soon as possible to define the feasibility of specific spacecraft/payload PLF diameter and length needs.

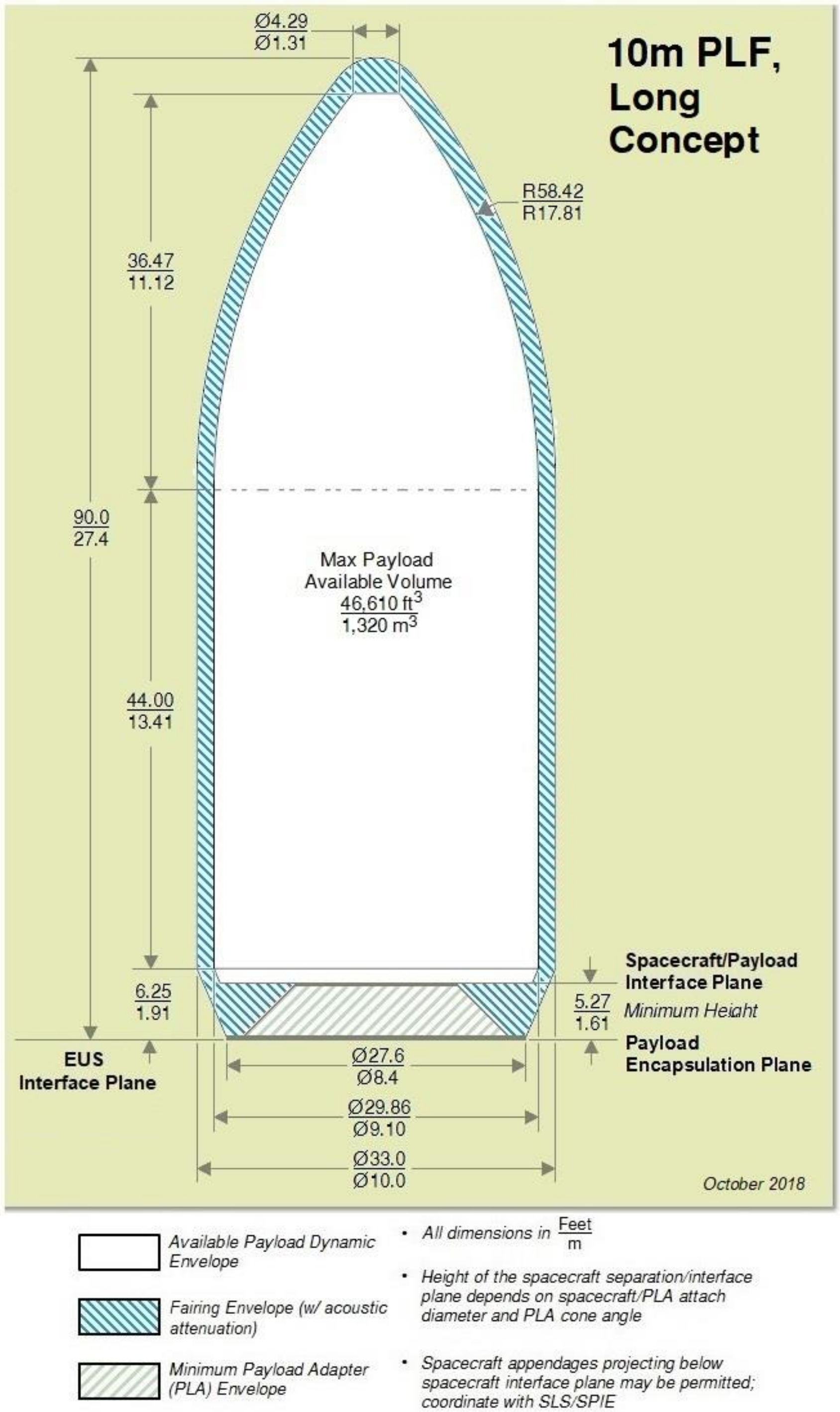


Figure 6-9. Composite 10m PLF, Long Concept

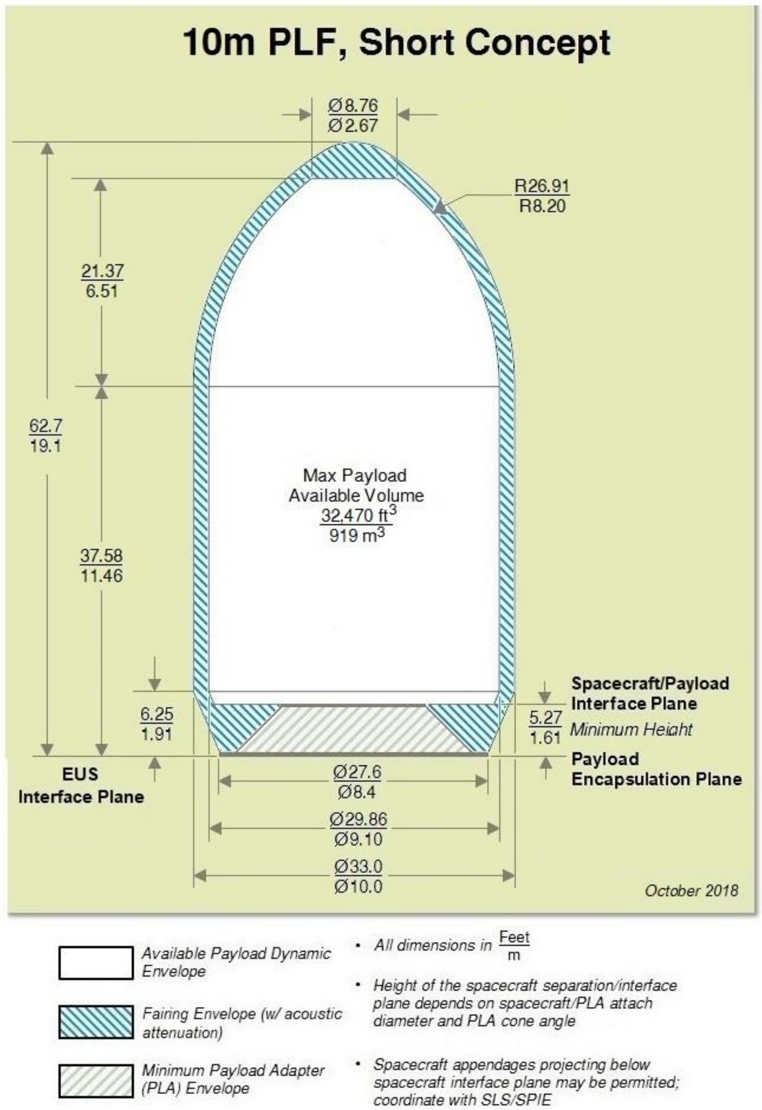


Figure 6-10. Composite 10m PLF, Short Concept

6.3 SLS to Co-manifested Payload Interfaces

The Block 1B/2 configurations will use the enhanced performance of the EUS, which provides the potential of flying large or small CPLs (and potentially SPLs) within the USA during crewed Orion missions. Figure 6-11 provides the available static envelope for the 27.6 ft (8.4 m) diameter composite USA. This stage adapter offers installation of different-sized access doors, as needed, and an interior surface compatible with acoustic treatments, to meet environmental requirements.

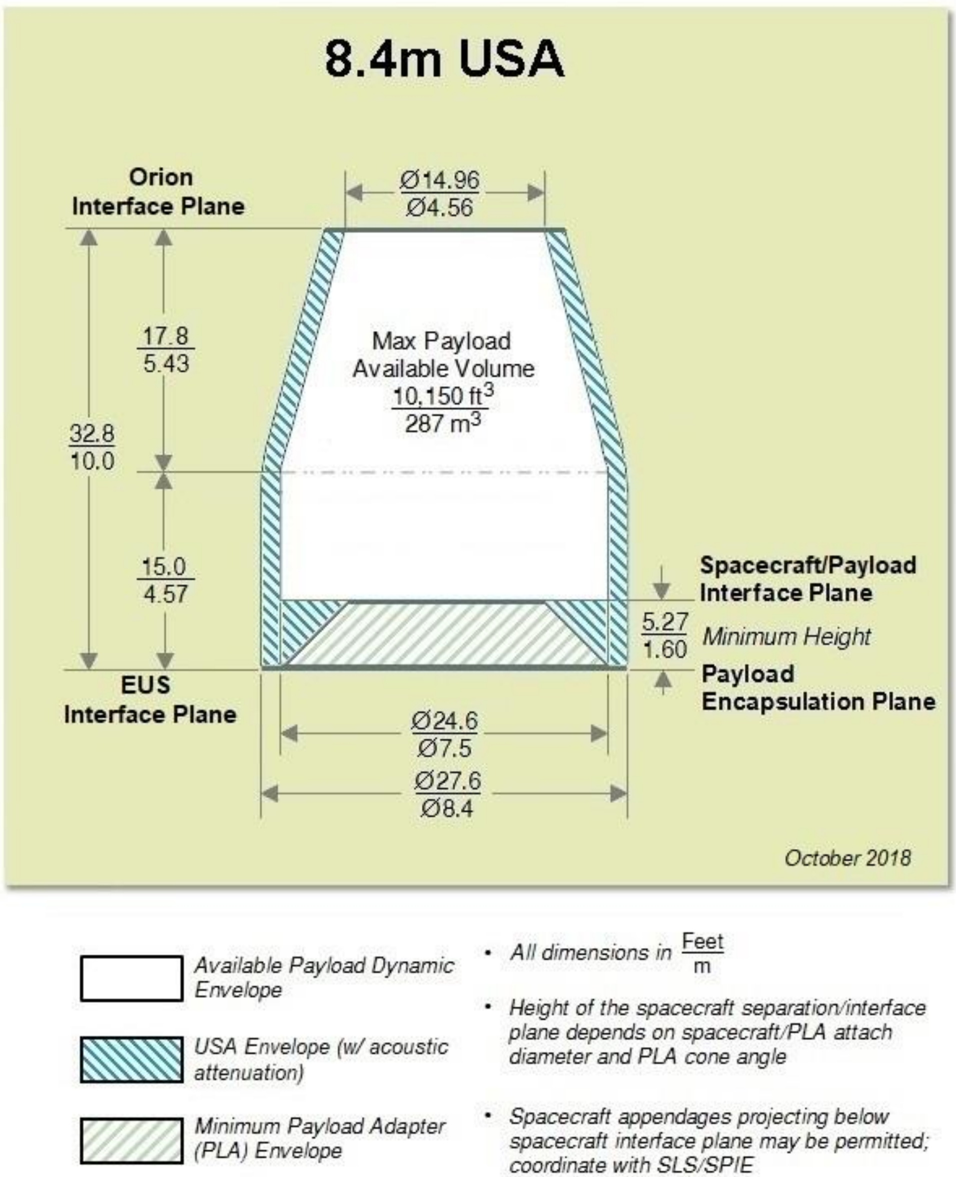


Figure 6-11. Composite Universal Stage Adapter (USA)

Figure 6-12 depicts a USA concept of operations based on Orion docking/extraction of a large CPL (i.e., Orion CPL), as well as that for a self-propelled CPL (i.e., Independent CPL). It assumes that once on orbit and post Orion separation from the USA, the USA jettisons in a canister fashion (in contrast to typical jettison in sectors) to support CPL separation. Canister-style jettison results in the upper 85 percent of the USA structure, with the Orion SA still attached, being jettisoned as a single, circumferential ring. The non-separable 15 percent of the USA structure remains with the EUS; its height is at or less than the PLA separation plane to maximize CPL separation by Orion, or separation as an independent CPL.

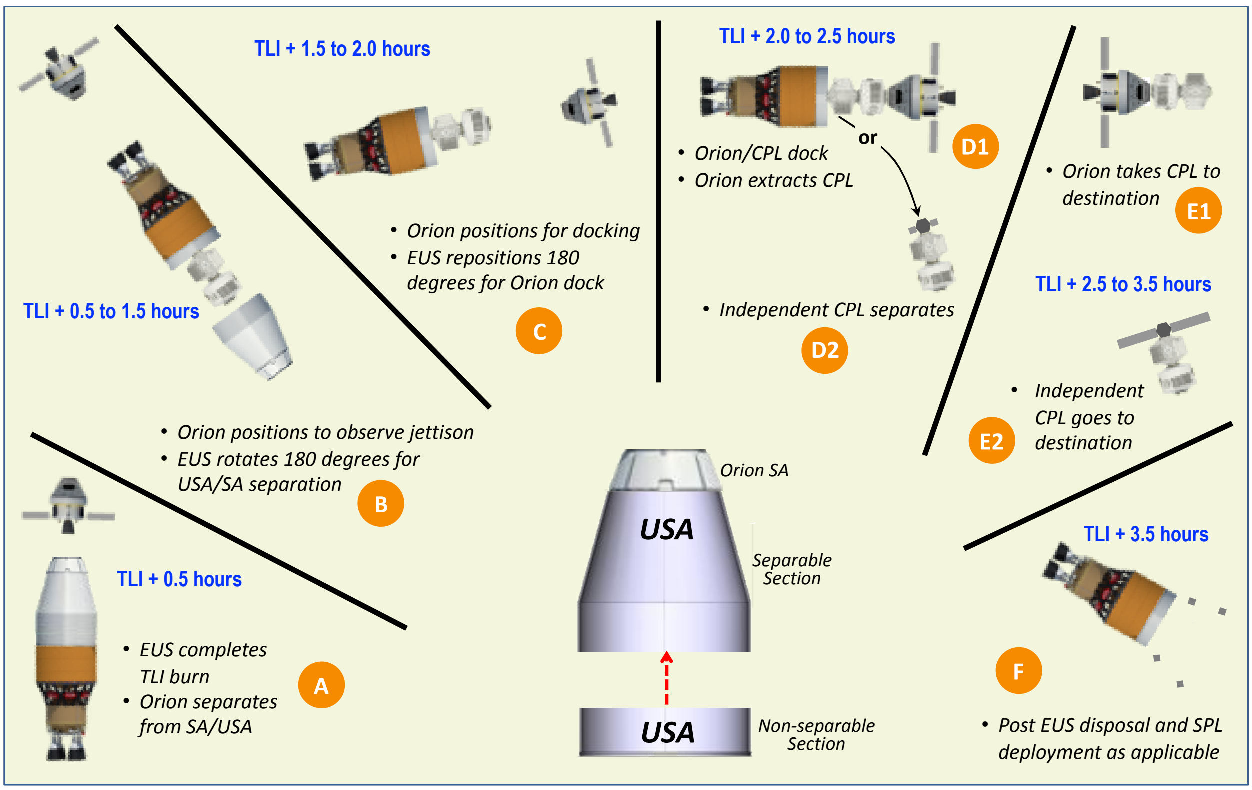


Figure 6-12. Representative USA Concept of Operations

6.4 SLS PLA Accommodations for PPL and CPL

Selection of an appropriate PLA interface, and any associated support equipment, should be coordinated with the SPIE office as early as possible within the SLS payload integration process. When possible, all SLS spacecraft/payload developers should define their initial interface and accommodation needs using the SLS Accommodation Demand Model Input Template (ADMIT) survey found in Appendix B.

6.4.1 CPL and PPL Mechanical Interfaces

Similar to ELVs, the mechanical interface between the SLS Block 1B/2 launch vehicle and a PPL or CPL is provided by SLS as a mission dependent PLA, consisting of up to three components, as shown in Figure 6-13:

- Payload Attach Fitting (PAF): a structural/service interface to the 8.4 m-class diameter SLS EUS Forward Adapter. The PAF is configured with a Payload Separation System (PSS) to accommodate various spacecraft/payload interfaces as needed.
- Payload Separation System (PSS): a spacecraft/payload structural separation interface mounted on a PAF. Depending on the interface diameter required, the PSS can support a variety of COTS PSS (e.g., D1666 or 1666VS) or larger, new-development PSS (e.g., PSS4394) as needed.
- Payload Interface Adapter (PIA): an optional structural/service interface between the PAF and PSS available to maximize diameter and/or height available based on specific spacecraft/payload needs

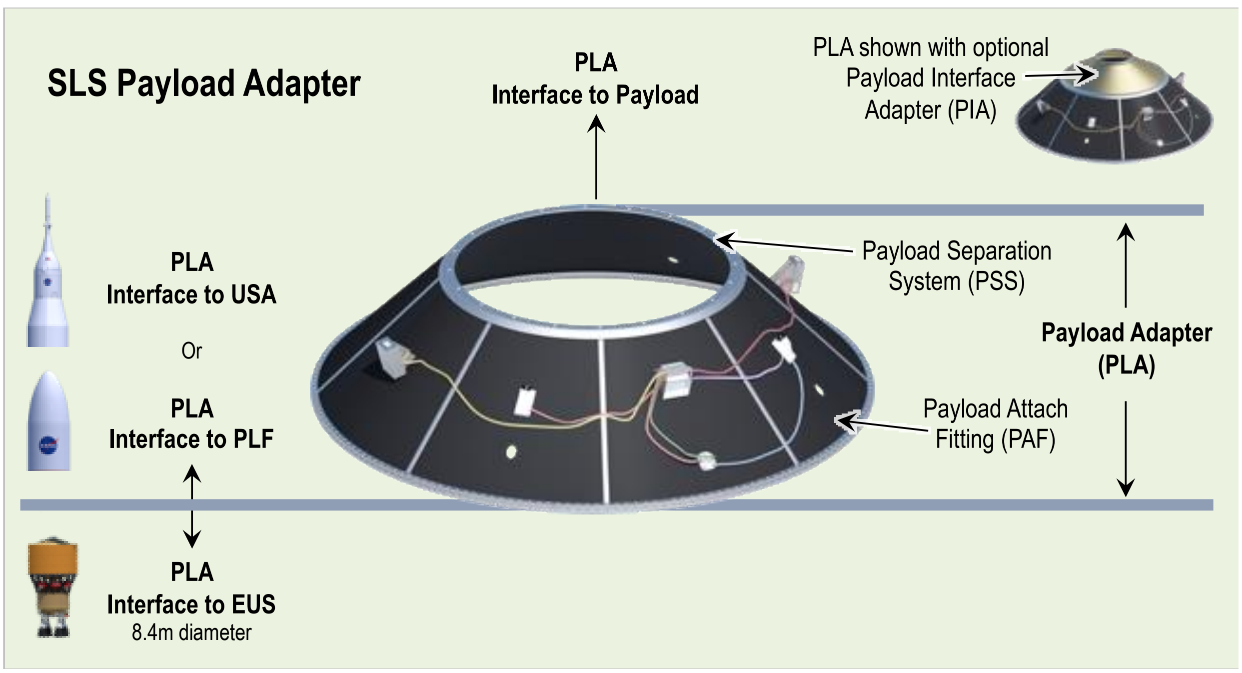


Figure 6-13. SLS Block 1B/2 Payload Adapter (PLA)

The SLS Block 1B/2 PAF is constructed of composite sectors with horizontal and vertical joints. Payload mass accommodation can be increased or decreased depending on the number of composite plies used and the amount of resource access (connector and bracket support interfaces) needed. Depending on the spacecraft/payload interface diameter required, the composite PAF sectors can also be lengthened or shortened as well. In general, PLAs that are shorter, and/or do not require a PIA, will have a lower mass compared to those that do. It is anticipated that a variety of SLS PLA designs will be required over time as spacecraft/payload interfaces are better-defined in order to take best advantage of the unique performance capability SLS offers.

This flexible SLS Block 1B/2 PLA approach allows use of a family of components to provide a required interface, height and volume for specific spacecraft/payloads. Example PLA applications to various potential SLS Block 1B/2 payload configurations is detailed in Figure 6-14.

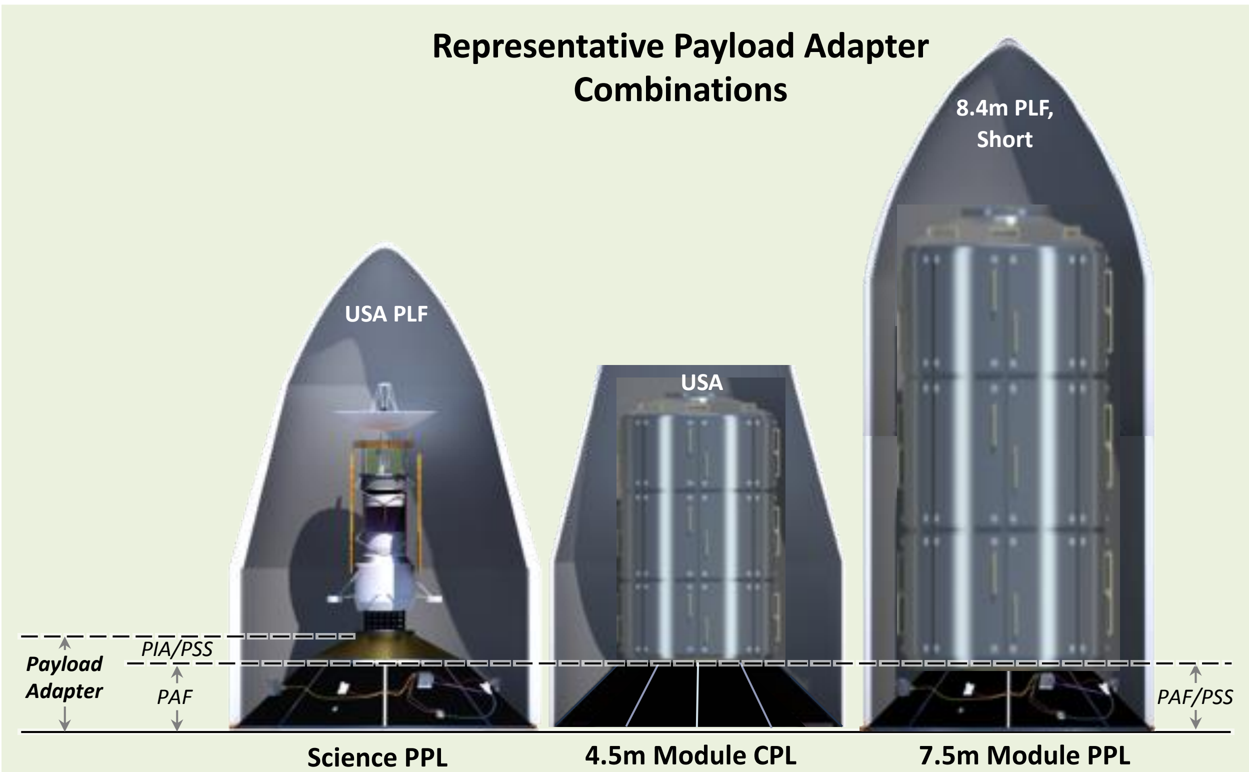
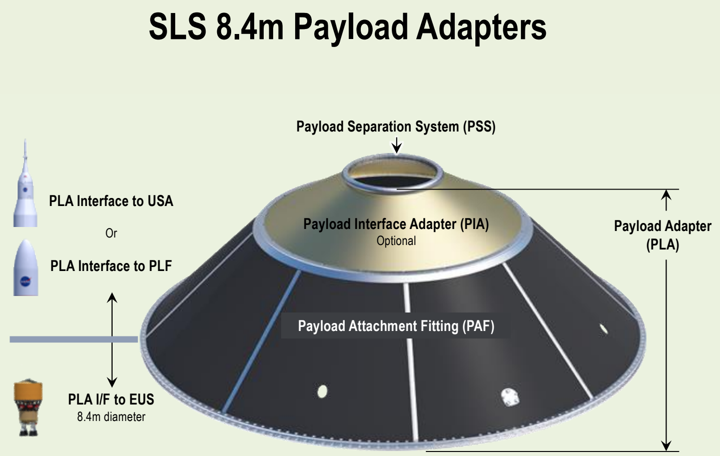
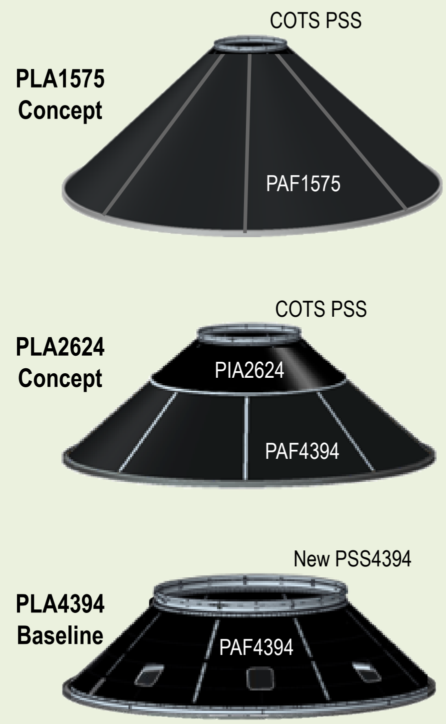


Figure 6-14. Representative PLA Configurations for CPL and PPL

Figure 6-15 provides the physical characteristics of three representative SLS Block 1B 8.4m PLAs. All current SLS PLA designs interface to the EUS at the bottom and utilize the same base cone angle (~45 degrees). As SLS is an 8.4 m-class diameter launch vehicle, in comparison to 5 m-class ELVs, it is generally more efficient to provide a spacecraft/payload-to-PLA interface diameter greater than 13.1 ft (4 m). Hence, the baseline PLA for initial SLS Block 1B flights will be the PLA4394. Other PLA concepts shown are provided for reference only to demonstrate accommodation commonality with current 5 m-class diameter ELV payload interfaces if needed.





PLA Concept	PLA Interface								
	Diameter To PIA		Diameter To PSS		Diameter To Payload		Height to PSS (1)		Payload Lift
	in	mm	in	mm	in	mm	in	mm	
PLA1575	NA	NA	62.0	1,575	65.6	1,666	130.0	3,302	(2)
PLA2624	173.0	4,394	103.3	2,624	103.3	2,624	115.8	2,940	(2)
PLA4394	NA	NA	173.0	4,394	173.0	4,394	82.3	2,089	(2)

Notes: (1) Total PLA height varies based on PSS type chosen
(2) Max 19,842 lb (9.0 t) payload capability on Block 1B PLA (crew configuration)

Figure 6-15. 8.4 m Payload Adapters (PLAs)

PLA4394 Baseline. This SLS provided PLA represents a two-piece (PAF4394 + PSS4394) configuration capable of supporting up to 19,842 lbm (9.0 t) of payload. A new PSS4394 currently under development will accommodate a PPL/CPL interface of 173 in (4,394 mm) in diameter. This configuration represents the shortest PLA and therefore maximizes available payload height within the USA or PLF compared to other PLAs shown. PLA4394 provides an accommodation similar to that shown in Figure 6-14 as "4.5m Module CPL." Due to the proximity of the PLA to the upper oxygen tank dome of the EUS, a "keep out zone" within the interior of the PLA must be maintained. For the PLA4394, the CPL has the potential of "intruding" as much as 14.5 in (368 mm) in the downward direction from the PAF/PSS interface plane: use of this PLA volume must be evaluated on case-by-case basis. PLA4394 center of gravity (CG) offsets applicable to CPL mass ranging from 9,546 lb (4.33 t) to 19,842 lb (9.00 t) include the following:

- SLS Launch and Ascent - an axial (+x) CG offset of 132 in (3353 mm) from the PAF/PSS interface plane and a lateral CG offset (y-z) of 5 in (127 mm) from the nominal centerline
- SLS/Orion Rendezvous & Proximity Operations – no axial CG offset constraint from the PAF/PSS interface plane and a lateral (y-z) CG offset of 10 in (254 mm) from the nominal centerline

A "heavy" variant of the PLA4394 could support up to 89,580 lb (~40 t) Block 1B PPL accommodation shown in Figure 6-14 as "7.5 Module PPL".

PLA1575 Concept (reference only). Figure 6-15 represents a two-piece (PAF1575 + COTS PSS) PLA concept. This PLA1575 can provide an ELV-like PSS spacecraft/payload interface accommodation of 65.6 in (1,666 mm) in diameter. Currently it is the tallest PLA concept and therefore reduces available payload height within the USA or PLF compared to other PLAs.

PLA2624 Concept (reference only). Figure 6-15 illustrates a three-piece (PAF2624 + PIA2624 + COTS PSS) PLA concept using a PIA to decrease the Baseline PLA4394 spacecraft/payload interface diameter without having to design and/or procure a unique PLA. This configuration is also represented in Figure 6-14 as "Science PPL". PIAs might also be employed in a purely cylindrical configuration to provide additional clearance above the PAF for CPL intrusion as needed (e.g., payload docking/hatch or propulsion systems). If additional spacecraft/payload mass accommodation is needed, a new, two-piece (PAF2624 + COTS PSS) PLA2624 would result in a lower mass PLA, therefore providing additional spacecraft/payload performance.

6.4.2 CPL and PPL Electrical Interfaces

Ground Services. As shown in Figure 6-16, a number of ground power and data services are provided to the EUS, with potential distribution to payloads via the PLA.

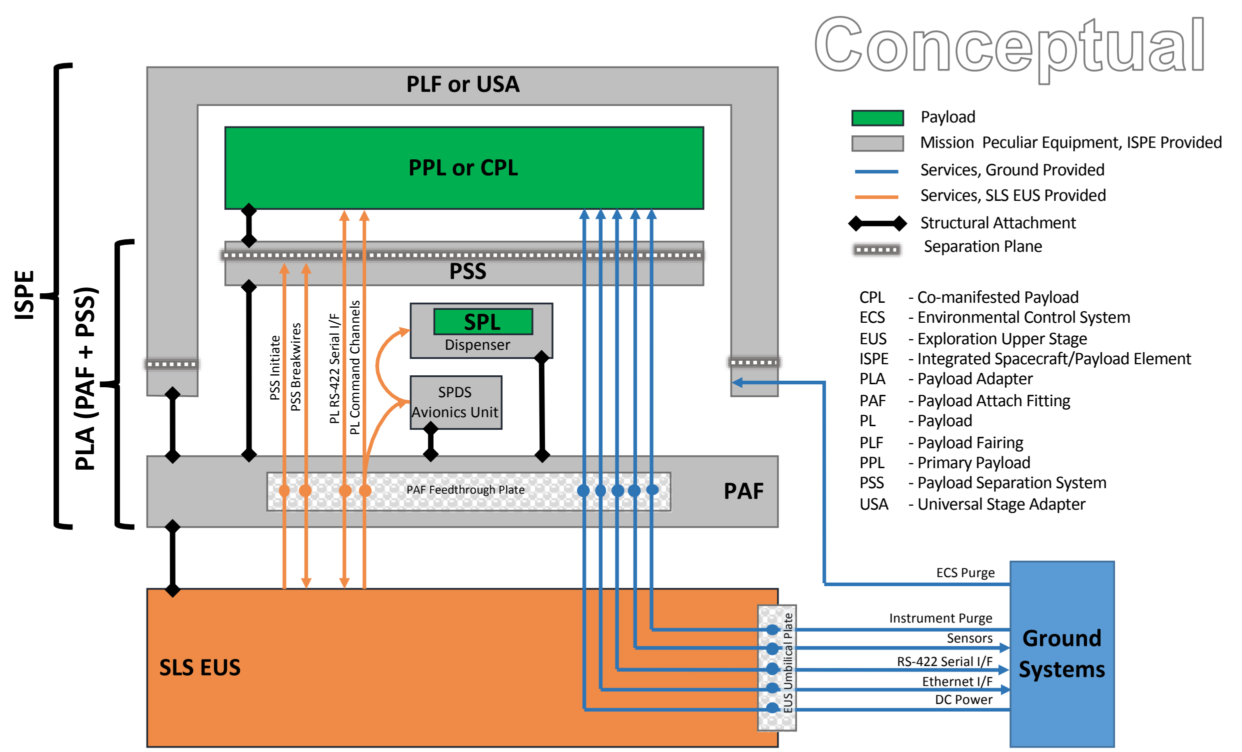


Figure 6-16. Conceptual Payload Adapter (PLA) Accommodations for Block 1B/2

For each service, multiple, redundant pairs, or multiple connectors are available. This interface/service would typically be available to CPL and PPL once the encapsulated payload is integrated with the EUS in KSC's VAB (although facilities and services are maybe available as an option before then) until EUS separation from ML T-0 umbilicals at launch. Ground services provided through ML T-0 umbilicals include:

- Exploration Ground System's (EGS) provided air and nitrogen bulk purges for compartment conditioning
- Optional EGS-provided instrument purge (low volume for sensitive equipment)
- 68 twisted shielded pairs for sensors and sensor excitation (Note 1)
- 2 x RS-422 serial data cables (Note 1)
- 2 x Ethernet data cables (Note 1)
- Up to 24 power cables (rated to 126 VDC, 14 A) (Note 1)

Note 1: Available for use by spacecraft/payload provided electrical ground support equipment in the Mobile Launcher Payload User Room.

Flight Services. These data services are distributed from the EUS via the PLA to the spacecraft/payload. This interfaces/services are available to CPL or PPL starting with EUS separation from ML T-0 umbilicals at launch and end with separation from PAF umbilicals during payload jettison, post-EUS insertion burn. Flight services include:

- Separation or pyrotechnic signals for spacecraft use
- Dual redundant RS-422 interfaces for interleaved health and status downlinking and limited commanding to spacecraft
- 14 command channel interfaces that can provide discrete commanding

Payload developers should note the EUS has no provision to provide electrical power to payloads post-liftoff. However, as an optional service, electrical power could be provided to payloads at the PAF interface using payload-provided batteries mounted by SLS on the PLA. This additional mass would be considered part of the total payload mass allocation.

6.5 SLS OSA and PLA Accommodations for SPL

SLS can accommodate SPLs, based on availability of excess capacity after accommodating: Orion (Block 1), or Orion and a CPL (Block 1B/2) for crewed missions, or PPL for cargo missions (Block 1B/2). In general, SPL accommodations range from 6U (unit) to 27U-class CubeSats, or the equivalent volume. Options for accommodating larger volumes are also being considered. For SPLs with mission requirements that include separation from SLS, deployment begins post-TLI after:

- Orion separation from ICPS (Block 1 crew missions) and ICPS disposal initiation
- Orion/CPL separation from EUS (Block 1B/2 crew missions) and EUS disposal initiation
- PLF/PPL separation from EUS (Block 1B/2 cargo missions) and EUS disposal initiation

Secondary payloads interface to the Block 1 OSA or Block 1B/2 PLA via the Secondary Payload Deployment System (SPDS). The SPDS provides a standard SPL interface via a COTS dispenser, dispenser/SPL support structure, Avionics Unit and cable harnesses for deployment signal and access to battery charging via the upper stage (provided by KSC ground services). Once Orion, or Orion/CPL, or PLF/PPL has separated from the upper stage and the upper stage has completed its disposal burn, SPLs can be deployed. To comply with SLS Program requirements for functional failure tolerance, the SPDS design implements two identical independent discrete circuits to preclude inadvertent dispenser activation. The SPDS includes:

- Structural interfaces via a provided 6U or 12U dispenser (27U dispensers would be limited to SLS Block 1B/2)
- Dispenser provided environmental interfaces for thermal, bonding/grounding, electromagnetic compatibility, venting, shock, random vibration and load conditions
- Dispenser provided electrical power and data connectors (these connect to the SPDS avionics unit via cables during ground and flight operations)

SLS Block 1 will accommodate the SPDS on the inner surface of the OSA as shown in Figure 6-17. SLS Block 1B/2 will accommodate the SPDS on the outer surface of the PLA, as shown in Figure 6-18.

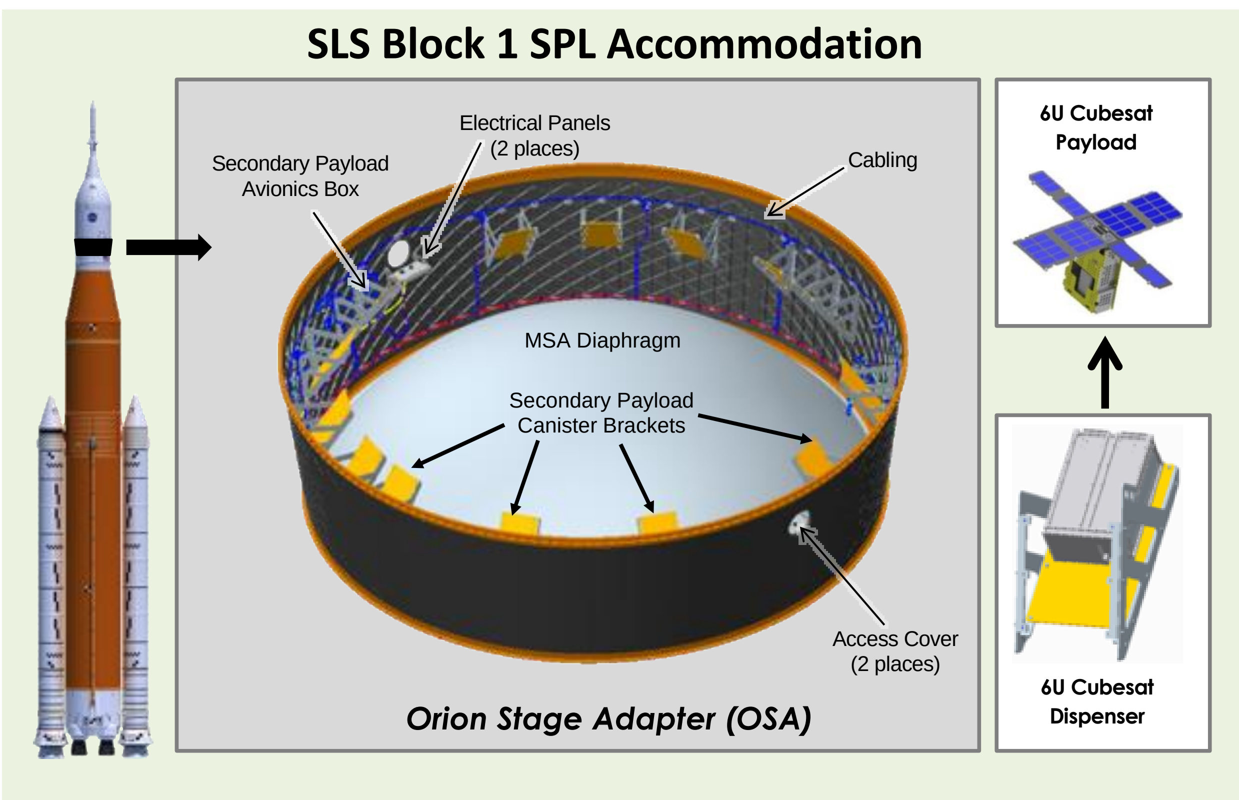


Figure 6-17. Orion Stage Adapter (OSA) to Integrated Secondary Payload (SPL) Interface

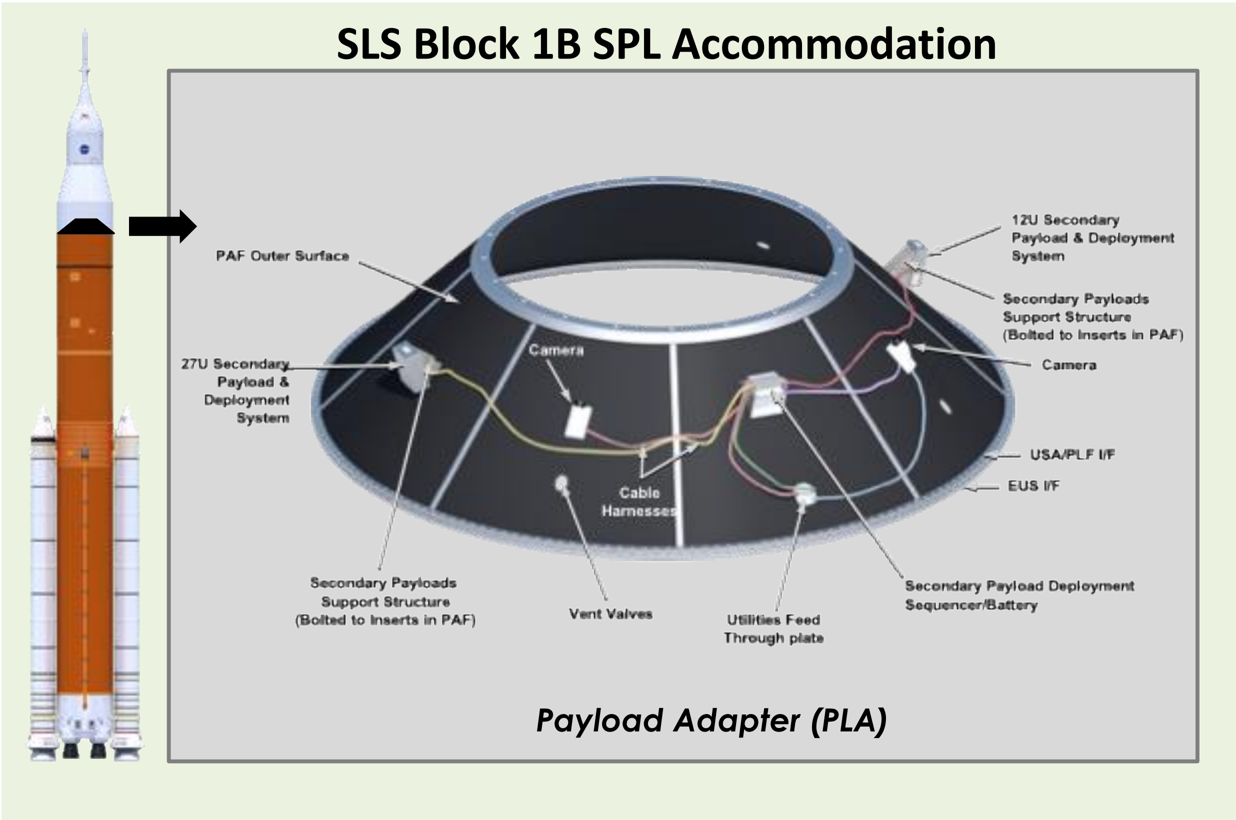


Figure 6-18. SLS Block 1B/2 Payload Adapter (PLA) Accommodation of SPLs

6.5.1 SPL Mechanical Interfaces

The primary structural interface for an SPL is to an SLS-specified COTS dispenser. This dispenser provides the SPL a means for SLS integration, protection during launch and ascent, and deployment from the SLS. The SPDS can accommodate either a 6U, 12U or up to a 27U dispenser; the SPL must stay within allowed physical provisions for its associated dispenser. The SLS Block 1 OSA can physically accommodate up to 17 SPLs radially. The SLS Block 1B/2 can physically accommodate either one 27U SPL or a combination of 6U or 12U SPLs on each PLA sector. A maximum of 7 PLA sector locations could be made available on a flight by flight basis.

Physical provisions include the dimensional orientation of the payload inside the dispenser; maximum allowable dimensions, volume and mass; and the CG envelope. Figure 6-19 depicts the SPL dimensional orientation. Table 6-1 provides the dimensions, volume and mass numbers for both 6U and 12U dispensers (27U COTS dispensers are currently under development). Figure 6-20 provides the payload CG datum within the dispenser. Table 6-2 provides the CG envelope numbers for 6U and 12U dispensers. Based on the maximum allowable payload mass for a 6U dispenser (Table 6-1), an ejection rate of 3.9+/-0.2 feet/sec (1.2+/- 0.06 m/sec) is anticipated.

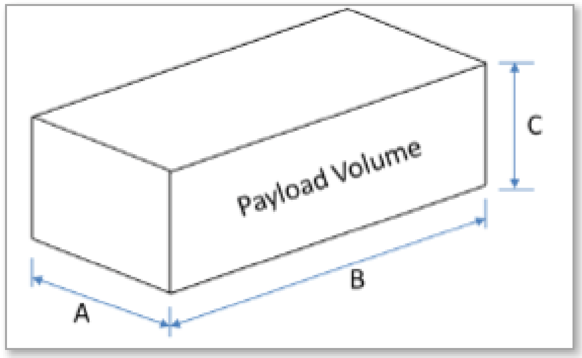


Figure 6-19. Secondary Payload (SPL) Envelope Dimensional Depiction

Table 6-1. Secondary Payload (SPL) Maximum Dimensions

Dispenser	A		B		C		Volume		Mass	
	in	mm	in	mm	in	mm	in^3	mm^3	lbm	kg
6U	9.41	239.00	14.41	366.00	4.45	113.00	603.41	9,884,562	30.86	14.00
12U	9.41	239.00	14.41	366.00	8.90	226.00	1206.82	19,769,124	44.73	20.29

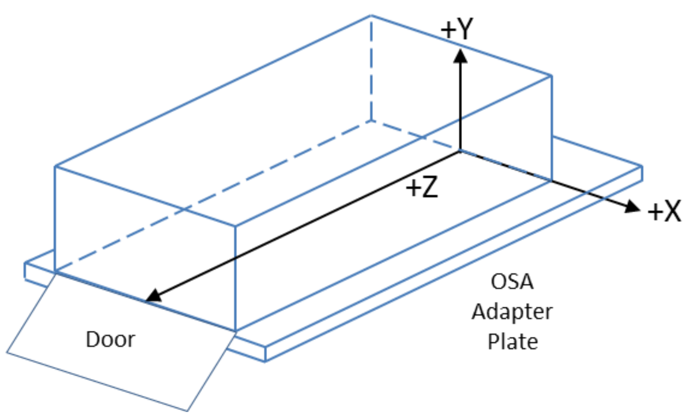


Figure 6-20. SPL Center of Gravity (CG) Envelope within Dispenser

Table 6-2. SPL Center of Gravity (CG) Envelope

Parameters	Units	6U		12U	
		Min.	Max.	Min.	Max.
Center of Mass, X	in (mm)	-1.57 (-40)	+1.57 (+40)	-1.57 (-40)	+1.57 (+40)
Center of Mass, Y	in (mm)	+0.39 (+10)	+2.76 (+70)	+2.17 (+55)	+4.92 (+125)
Center of Mass, Z	in (mm)	+5.24 (+133)	+9.17 (+233)	+5.24 (+133)	+9.17 (+233)

The integrated SPL/dispenser unit will interface with SLS for structural support (Block 1 OSA or Block 1B/2 PLA) during launch and early flight phases. The SPDS will provide the cable connectors and wire types that interface the integrated dispensers with the OSA or PLA support brackets. The integrated SPL/dispenser unit must be within the allowed mass and CG provisions of the OSA or PLA. Mass margin provisions for vibration isolation, thermal protection, etc. are an option and must be discussed with the SPIE office. The combined SPL/dispenser unit CG envelope is the same as shown in Table 6-2. The integrated SPL/dispenser unit will contribute to the combined loads as part of the encapsulated payload. These loads will be analyzed as part of flight/mission planning.

An option exists to fly multiple, larger than 27U SPLs mounted in a manner similar to the Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) mounted on or above the SLS PLA. This approach can provide additional deployment flexibility and efficiency for larger SPLs as well as accommodate an entire payload ring or even stacked rings. This accommodation could be flown in tandem with a larger CPLs depending on mission performance and USA/PLF volume height available. The potential for this type of accommodation on SLS is currently being evaluated.

6.5.2 SPL Electrical Interfaces

In general, there is no capability for battery charging to SPLs during SPL encapsulation, during VAB operations, or at the pad. However, the SPDS itself receives battery charging capability via a drag-on cable connector prior to rollout to the launch pad. Generally, the last opportunity for users to charge SPL batteries will be in standalone KSC facilities prior to vehicle stacking. SPL battery charging in the VAB via a drag on cable may be possible on a case-by-case basis as requested by the user. SPLs must remain powered off from handover to EGS at KSC until post-deployment from the SLS upper stage. The SPDS Avionics Unit (AU) is programmed prior to flight with the predetermined sequence and timing for each SPL deployment. When the SPDS avionics unit receives the signal from the upper stage (post-disposal initiation), two identical independent power circuits are closed, initiating the SPL deployment sequence. The SPL may then be powered up after it is deployed.

The integrated SPL/dispenser-to-AU interface is an electrical interface that initiates the deployment sequence via a discrete signal between the AU sequencer and each SPL dispenser by means of two pigtail cables, in order to receive an activation signal from the dispenser and for ground charging of the SPL batteries. GSE connections are depicted in Figure 6-21. Only SPL systems using Lithium-ion 18650 rechargeable batteries can be charged at KSC prior to launch. SPLs will be delivered to KSC and inhibited from performing any functions until 15 seconds after deployment to minimize risk of hazardous operations during integration, launch and post-deployment.

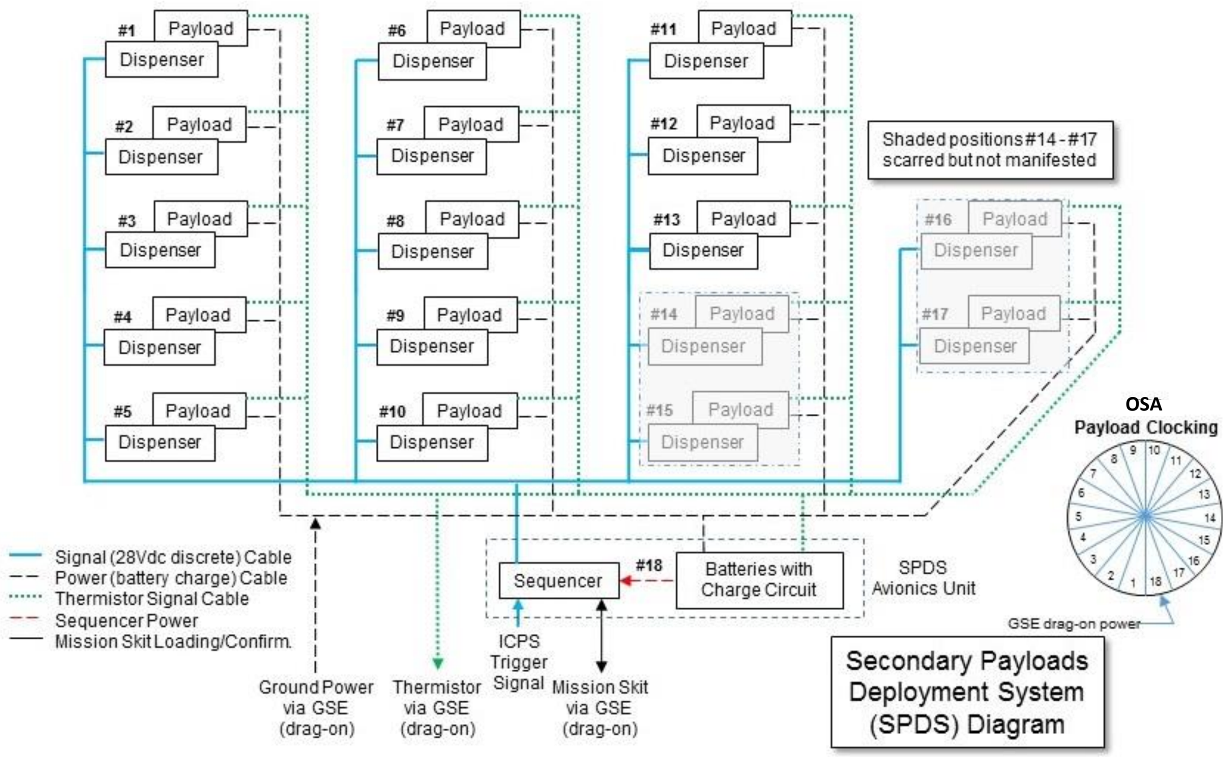


Figure 6-21. Representative SPDS Avionics Unit SPL Interface (Block 1/EM-1)

The AU has a battery life of up to 10 days after activation of the sequencer on-orbit. The sequencer activation is delayed until post-TLI and near completion of the upper stage disposal maneuver. SPLs using rechargeable batteries should be designed to support a launch no less than 180 days (nominal) after the last recharge. Approximately five minutes after the upper stage end-of-mission is complete (within eight hours from launch), the SPLs commence launching from OSA or PLA mounted dispensers.

7.0 KENNEDY SPACE CENTER (KSC) PAYLOAD LAUNCH FACILITIES

All SLS blocks will launch from KSC in Florida. The EGS Program is responsible for coordination with all programs and projects for maintenance and operation of all vehicles and spacecraft/payload processing, integration and launch facilities that the SLS Program utilizes. KSC facilities include payload processing facilities available to commercial and U.S. government users. This section outlines the processing, integration and launch facility capabilities available to SLS users, as shown in Figure 7-1. Payload processing and launch facilities include: the Space Station Processing Facility (SSPF), Multi Payload Processing Facility (MPPF), Payload Hazardous Servicing Facility (PHSF) and Launch Complex 39, which includes the VAB, Launch Pad B and the Launch Control Center.

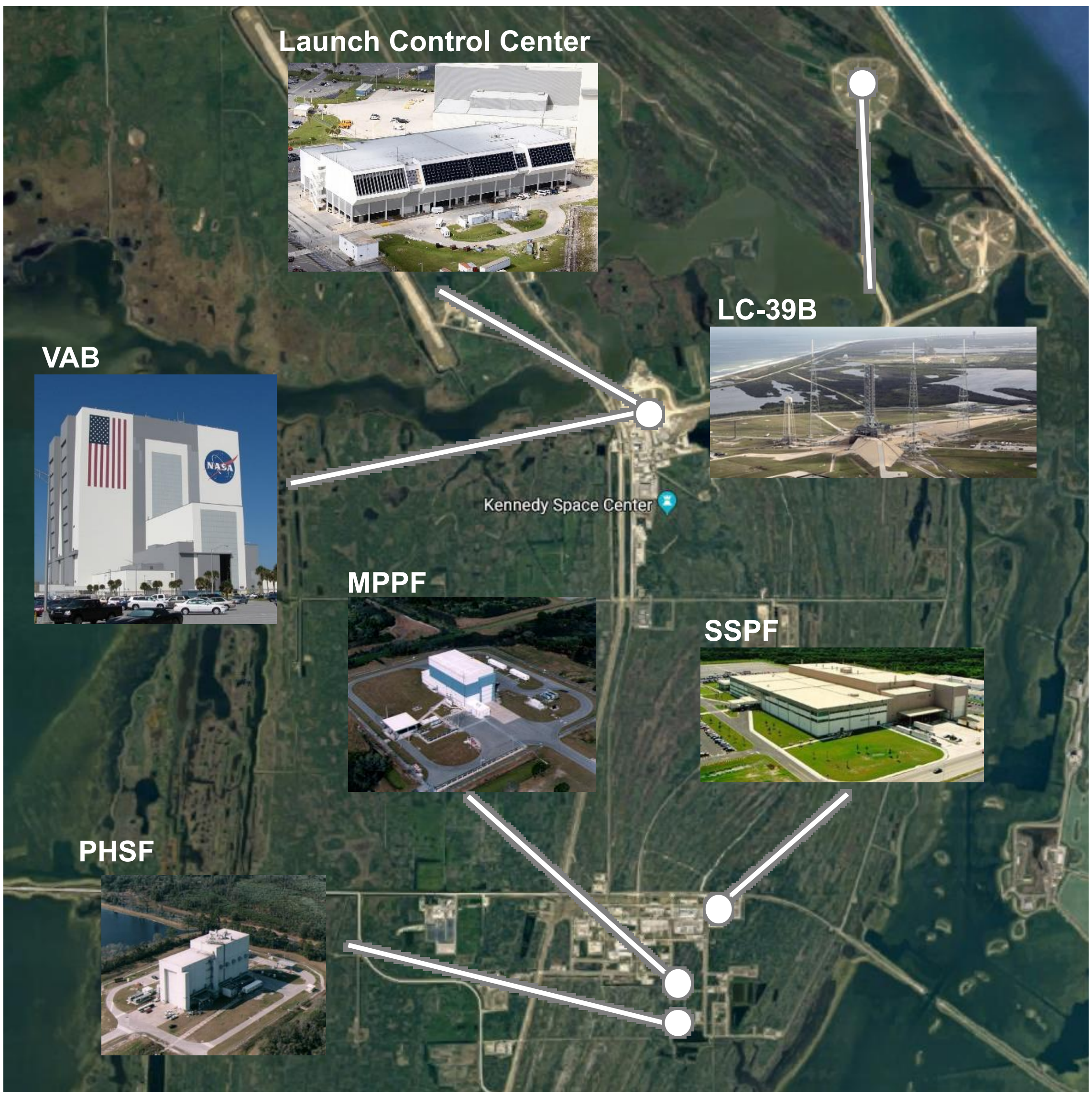


Figure 7-1. Aerial Overview of Kennedy Space Center (KSC) Payload Processing and Launch Facilities

7.1 Space Station Processing Facility (SSPF)

The SSPF, shown in Figure 7-2, is available for SLS spacecraft/payload processing prior to encapsulation as an optional service (negotiated separately with EGS). In the past, it was used for processing International Space Station (ISS) and other space shuttle payloads.

Figure 7-2. Space Station Processing Facility (SSPF)

The SSPF consists of an administrative area, intermediate high bay (I-bay) area and high bay (HB) area with an adjoining air lock. The three-story structure is 457,000 ft^3 (42,457 m^3) and is used to support pre-launch activities, such as receiving, handling and assembly of spacecraft hardware. In addition, the SSPF can be utilized to conduct testing for proper configuration and verifying critical systems and system interfaces. The HB area is used as the main processing area for horizontally processed payload and flight elements. The eight footprints in the HB are designated payload processing areas. Facility services in the HB are provided at each footprint through stub-ups recessed in the floor for interconnection to payload GSE that will be used for testing or processing of payloads. Support equipment elements in the HB are: launch package integration stands, air-bearing equipment, cargo element work stands, and portable servicers. All stands are designed to be movable, therefore the HB system configuration may vary with each mission. The I-bay will be the main area for experiment and rack processing. Experiments will be brought into the I-bay and processed for integration into racks that will be integrated with flight elements. Flight elements enter the HB through an airlock located at the west end of the SSPF. The airlock prevents contamination of the HB CWA when moving payload elements or payloads in and out of the HB. The airlock is able to accommodate the payload canister, in the horizontal position, on the transporter. All vehicles and equipment must be visibly clean prior to entry into the air lock.

This facility is suitable for nonhazardous processing, with the exception of anhydrous ammonia (NH3) and assembly of payloads and spacecraft. Without a waiver and additional controls, the facility is not suitable for hazardous payload processing due to its proximity to inhabited buildings and the explosive and safety quantity distance requirements. Figure 7-3 depicts the floor plan of the SSPF. Tables 7-1 and 7-2 detail specific resources available.

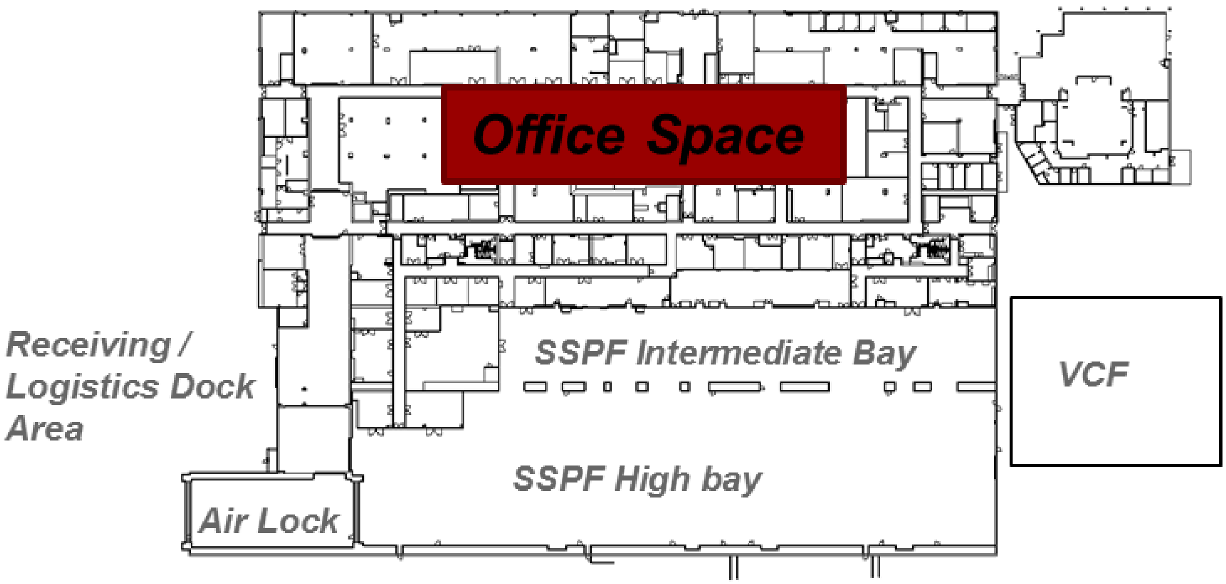


Figure 7-3. Space Station Processing Facility (SSPF) Floor Plan

The online processing areas are located in the I-bay and HB of the SSPF. The HB is rated as a Class 1, Division 2, Groups C and D area, with a motorized steel vertical door 49.5 ft (15.1 m) high and 42 ft (12.8 m) wide. The HB floor is capable of supporting very heavy loads. It also has seismically isolated sections, making it suitable for extremely precise measurements. The floor is very smooth to facilitate the use of air-bearing pallets, which can enable effortless movement of large flight elements and stands. The floor is conductive, which helps to reduce the risk of inadvertent electrostatic discharge.

The SSPF provides access platforms on each work stand parallel to the ground. These fixed personnel platforms are on each side of the stand. In addition, mobile stairs are attached to these stands to allow for ease of personnel and equipment transfer to the work stand. There is also the option to erect scaffolding at the end of each work stand to allow continuous access around the flight element. There is also a Removable Overhead Access Platform (ROAP), which provides 180° access to payloads above the payload fittings.

A test conductor console is provided in the SSPF. This console provides operational intercommunications among facilities and video control and monitoring. There are multi-system racks located in each control/user room, allowing an interface between users in bay areas and specific off-line processing areas. Also, there is a Test, Control and Monitoring System (TCMS) provided in those control rooms, which support utilization and re-supply. Lastly, the Command and Data Handling System (C&DHS) verifies the functional interface compatibility of experiments and racks. Through a set of program test sets and processors, this provides an integrated simulation of the flight along with command, data and timing requirements.

Table 7-1. SSPF Capability Overview

Resource	High Bay	Intermediate Bay	Air Lock
Clean Work Area	Level 4, Class 100,000	Level 4, Class 100,000	Level 5, Class 300,000
Temperature	71 (+/-6) °F [21.7 (+/- 3.3) °C]	71 (+/-6) °F [21.7 (+/- 3.3) °C]	71 (+/-6) °F [21.7 (+/- 3.3) °C]
Relative Humidity	60% max. continuous	60% max. continuous	60% max. continuous
Usable Floor Space	105 ft x 436 ft (32.00 m x 132.89 m)	50 ft x 338 ft (15.24 m x 103.02 m)	46 ft x 108 ft (14.02 m x 32.92 m)
Ceiling Height	61.5 ft (18.75 m)	30 ft (9.14 m)	61.5 ft (18.75 m)
Door Dimensions (H x W)	49.5 ft x 42 ft (15.1 m x 12.8 m)	N/A	49.5 ft x 42 ft (15.1 m x 12.8 m)
Crane Type	Bridge	Bridge	Bridge
Crane Capacity	(2) 30 ton (27.2 t)	(2) 5 ton (4.5 t)	15 ton (13.6 t t)
Crane Hook Height	50 ft (15.24 m)	25 ft (7.62 m)	50 ft (15.24 m)

Table 7-2. SSPF Resource Overview

Resource	Description
Power	• Four 60 Hz power floor clusters per HB footprint • HB power can be provided in a 208Y/120 V 3-phase configuration with 60 or 100 A, also 480 V, 100 A 3-phase power can be supplied • Eight 60 Hz power floor clusters located in the IB with 208/120 V, 100 A 3-phase configuration • 60 Hz power interface is usually supplied through alternating current (AC) electrical power carts. For planning purposes, use of these power carts by the customer should be requested through the Launch Site Support and Requirements Document (LSSRD) and coordinated with the manager of the facility • 400 kVA Uninterruptible Power Supply (UPS) provides 480 V at 60 Hz power, which can be used at five 100 A receptacles in HB and at one 100 A receptacle in I-bay • Portable UPS are also available upon request and can provide 18 and 65 kVA 208 V at 60 Hz and 10 kVA 480 V at 50 Hz • In control rooms, single-phase 120 VAC at 60 Hz is distributed • 120/208 VAC, 30 A three-phase power is supplied by under-floor receptacles • Each offline processing area contains single phase, 60 Hz, 120 V power receptacles
Liquids & Gases	• GHe and GN2 are provided to footprint mechanical panels in HB, I-bay and GSE fluid areas, where pressures can be controlled through separate valves for 50, 750, 3,000 and 6,000 psi • Compressed air provided at 125 psi (Level 4 CWA compliant) and is available in each HB footprint • Air-handling system in online processing areas can complete four air changes in the HB per hour (non-laminar) • GO2 and purge system, which provides service capability at HB footprints 3 and 5, with a pressure of 2,400 psi (max of 6,000 psi) • LN2 used for low-temperature cooling is supplied from a port located at the east wall of the I-bay. It is provided at 80 psi at a temperature of -345° F at a flow rate of 500 gallons per minute • Chilled water for transporting waste thermal energy away from payload elements and experiments is provided at 43° F at 55 psi with a flow rate of 10 gallons per minute for panels in the I-bay and 60 gallons per minute for stubs in the HB
Propellant & Gas Sampling Services	• Vapor Containment Facility (ammonia plant) can handle 1,200 lbm flowing, with 6,000 lbm in storage • Environmental counters are located in each footprint of the HB and I-bay • Integrated Environmental Monitoring System provides capability to ensure cleanliness requirements are met with fixed sensor points located within the bay areas

Environmental counters are located in each footprint in the HB and I-bay to monitor and track particle counts and relative humidity.

The HB has two 30-ton (27.2 t) cab-operated electrical bridge cranes with a 50 ft (15.24 m) hook height. The I-bay has two pendant-operated 5-ton (4.5 t) electrical bridge cranes with a 25 ft (7.62 m) hook height. The airlock has one pendant-operated 15 ton (13.6 t) electrical bridge crane with a 50 ft (15.24 m) hook height. The hardware inspection area has one pendant-operated 5 ton (4.5 t) electrical bridge crane with a 25 ft (7.62 m) hook height.

This facility contains approximately 140,000 ft^2 (13,006.4 m^2) for nearly 1,000 employees, 25 conference areas, 16 offline processing rooms, two chemical labs, two dark rooms, and nine control rooms, located on raised floor areas. Also included are a Multi-Layer Insulation (MLI) sewing room, Vapor Containment Facility (VCF) to house NH3, flight crew room (final checkpoint for all flight crew equipment), foam cutting room (custom-cut foam for hardware elements), food processing room (for storing and processing crew food packages), and a waste processing room (for processing of post-flight waste containers).

The Closed Circuit Television (CCTV) system provides color, closed-circuit video surveillance and recording of payload processing activities from operational areas. Portable cameras are available for floor-level monitoring. The cameras can be remotely controlled from the control and user rooms. Interfaces are available at each HB footprint for customer-provided cameras. Monitors are located in the user and control rooms and various other locations.

The SSPF also has about 20 offline laboratories. A typical offline lab will provide the same capabilities as the online areas. Biology labs provide deep freezers, fume hoods and other laboratory equipment and support services.

7.2 Multi Payload Processing Facility (MPPF)

The MPPF, shown in Figure 7-4, is available for SLS spacecraft/payload processing as an optional service (negotiated separately with EGS). This facility has been used for processing space shuttle and Launch Services Program (LSP) payloads. The MPPF is a steel frame building covered with insulated metal siding and contains a high bay, low bay and equipment airlock. The high bay and low bay meet requirements of Level IV class 100,000 CWA and the equipment airlock meets a Level V class 300,000 CWA. The high bay is the main processing area and contains three areas that can be used as workstations. The low bay will be used for processing smaller payloads; the equipment airlock will be used for equipment staging and preparation for entry into the high bay. Connected to the north wall of the MPPF is a two-story metal structure. The first floor contains the electrical/mechanical room, the Test and Assembly Inspection Record (TAIR) station, an air shower and additional support rooms. The second floor consists of the UPS and heating, ventilation and air conditioning (HVAC). Connected to the south wall of the MPPF is the Annex, which holds administrative offices and two Payload Operation Control Centers (POCCs). Currently, the MPPF serves as the pre-flight and post-flight processing location for the Orion spacecraft.

Figure 7-4. Multi Payload Processing Facility (MPPF)

The MPPF consists of an administrative area, high bay processing area with adjoining airlock, and shop area. The airlock and three high bay servicing areas share a common transport aisle. A Level 4, Class 100,000 CWA, the facility serves as a Payload Processing Facility (PPF) and/or a Hazardous Processing Facility (HPF), depending on customer requirements. Figure 7-5 depicts the floor plan of the MPPF.

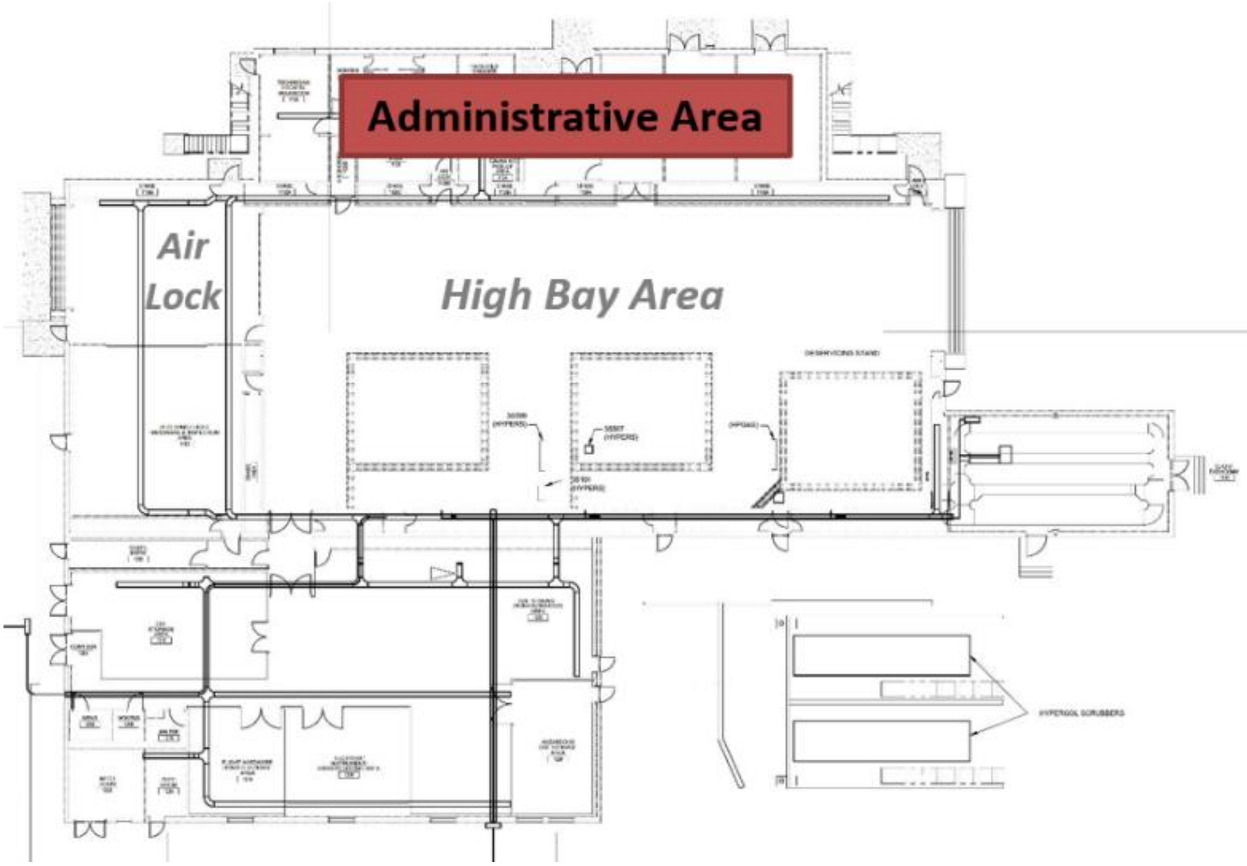


Figure 7-5. MPPF Floor Plan

The high bay is rated as a Class 1, Division 2, Group C area, capable of processing hazardous commodities including high-pressure gas, hypergolic materials, ammonia, oxygen and fluorocarbon coolant. The associated facility infrastructure includes a motorized 46 ft high x 30 ft wide (14.0 m x 9.1 m) segmented vertical door, air-bearing compatible high bay floor and an electrostatic discharge mitigation system.

Each of the three footprints in the MPPF high bay provides up to 480V/100A facility power, ground, HVAC, GN2, gaseous helium (GHe), compressed air and high/low pressure manifold venting. Hypergolic and ammonia-contaminated gasses may be vented into a facility scrubber. Operational Intercommunication Systems-Digital (OISD) communications, UPS, fire detection, CCTV and WiFi are also available.

Detailed facility information is outlined in Tables 7-3 and 7-4.

Table 7-3. MPPF Capability Overview

Resource	High Bay	Air Lock
Clean Work Area	Level 4, Class 100,000	Level 5, Class 300,000
Temperature	71 (+/-6) °F [21.7 (+/- 3.3) °C]	71 (+/-6) °F [21.7 (+/- 3.3) °C]
Relative Humidity	55% max. continuous	55% max. continuous
Usable Floor Space	132 ft x 60 ft (40.2 m x 18.9 m)	39 ft x 28 ft (11.9 m x 8.5 m)
Ceiling Height	62 ft (18.9 m)	20 ft (6.1 m)
Door Dimensions (H x W)	46 ft x 30 ft (14.0 m x 9.1 m)	15 ft x 20 ft (4.6 m x 6.1 m)
Crane Type	Bridge	N/A
Crane Capacity	20 ton (18.1 t)	N/A
Crane Hook Height	49 ft (14.9 m)	N/A

Table 7-4. MPPF Resource Overview

Resource	Description
Power	• In high bay, 120V, 30 A single-phase power provided at 60 Hz, 120/208 V, 30 A three-phase power at 60 Hz, and 480V, 100 A three phase power at 60 Hz • In low bay, 120/208V, 30 or 100 A three-phase power at 60 Hz can be supplied • Airlock can provide identical power capabilities to the low bay • South end of high bay contains several 120/208 V, 100 A receptacles that automatically switch over to UPS units during air conditioning failure
Liquids & Gases	• Air enters the MPPF through HEPA filters mounted in the ceilings of the high bay, low bay, equipment airlock and TAIR station, and is guaranteed class 5,000 air at the filter discharge for the air conditioning and reheat systems • Conditioned air handling system in online processing areas is capable of at least eight complete air changes in the high bay per hour (non-laminar flow) • Two air compressors supply regulated compressed air to both high bay and airlock, through 5 micron filters; compressed air can be provided at 90 or 125 psi • GHe is supplied through a regulating panel located on the south side of the building. The gas is available through outlets in both the high bay and equipment airlock at 750 psi and 3000 psi • GN2 is supplied from the industrial area (6,000 psi) system. The connection to this system is located on the south side of the building. A GN2 regulating panel filters the GN2 to 10 microns and regulates the GN2 down to 750 psi and 3,000 psi to outlets available in the high bay and airlock
Propellant & Gas Sampling Services	• Breathing air (Self Contained Atmospheric Protective Ensemble and Supplied Air Respirators) connections are available in each of the high bay servicing areas • Hypergolic vents are located on the south wall of the high bay

The high bay has one 20-ton (18.1 t), cab-operated, electrical bridge crane with a 49 ft (14.9 m) hook height. The MPPF is a work area. There is no planned office space at this location due to planned hazardous operations. Office space, if desired, must be arranged at other locations. The administrative area provides space for the facility Access Control Monitor (ACM) as well a change-out room with access to the high bay for related work.

The CCTV system provides color, closed-circuit video surveillance and recording of payload processing activities from operational areas. There are currently five cameras in the system.

7.3 Payload Hazardous Servicing Facility (PHSF)

The Payload Hazardous Servicing Facility (PHSF), shown in Figure 7-6, is expected to be used as a standard service to encapsulate spacecraft/payloads within the USA or PLF. The facility is an 18,813 ft^2 (1,747.8 m^2) steel frame building covered with insulated metal siding. It contains a hazardous operations service bay and airlock. This service bay also meets the requirements of a Level 4, class 100,000 clean room, and can be used as a PPF and/or an HPF. A one-story, concrete block structure is connected to the southwest wall of the PHSF and contains an equipment airlock, an air shower, a utilities and operations control room, an electrical/mechanical room and several support rooms. Another one-story, concrete block structure is connected to the north wall of the PHSF service bay and contains the communication room. When used as a PPF, the processing flow may include installation of solar panels, antennas and other items by the spacecraft/payload builder. When used as an HPF, the processing flow may include propellants (e.g., hypergols). Other functions of the PHSF as an HPF include hazardous system tests and checkout, build-up and mating of a payload to a solid-propellant upper stage motor, propellant system leak tests and other potentially explosive or hazardous operations. The facility can be used to process expendable launch vehicle payloads that have planetary protection cleanliness requirements or that carry nuclear material. The PHSF high bay also provides SLS payload fairing encapsulation capability, as needed.

Figure 7-6. Payload Hazardous Servicing Facility (PHSF)

Figure 7-7 depicts the PHSF and surrounding support facilities. Detailed information regarding facility capabilities are outlined in Table 7-5 and Table 7-6, as well as the section below.

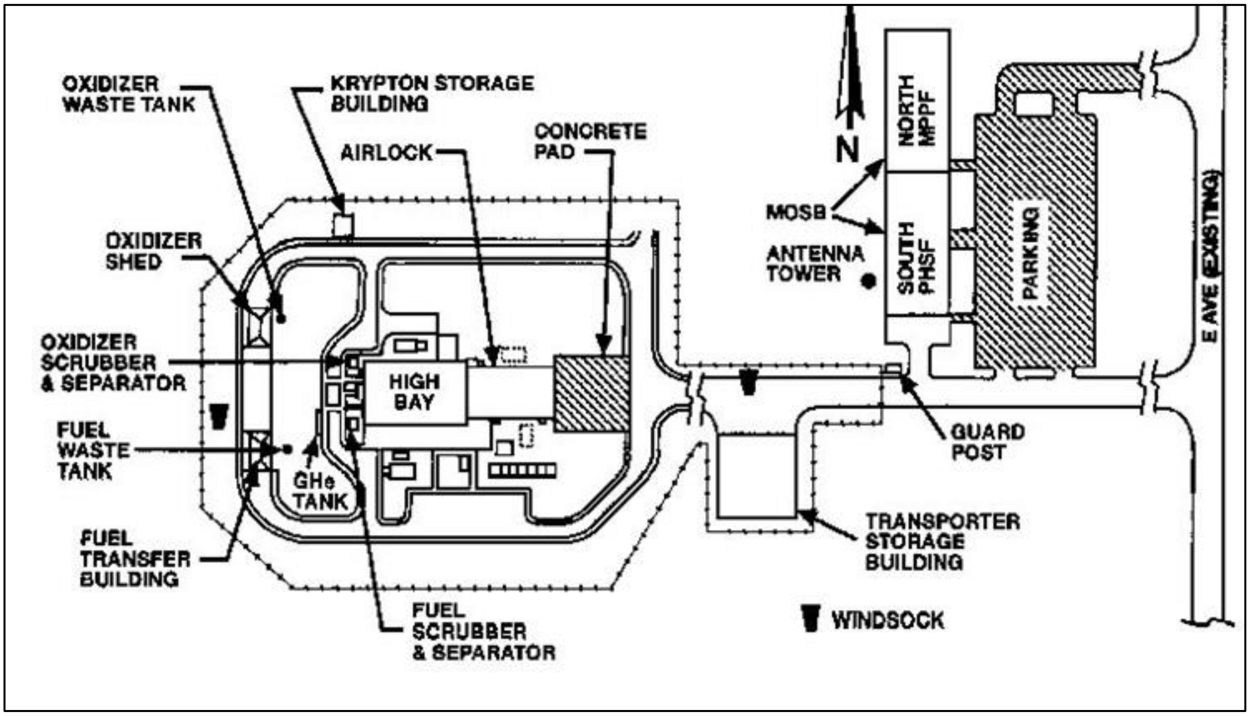


Figure 7-7. PHSF and Surrounding Facilities

Table 7-5. PHSF Capability Overview

	High Bay	Air Lock
Clean Work Area	Level 4, Class 100,000	Level 5 Class 300,000
Temperature	71 (+/- 6) °F	71 (+/- 6) °F
Relative Humidity	60% maximum	60% maximum
Usable Floor Space	107 ft x 60 ft	85 ft x 50 ft
Ceiling Height	95 ft (28.96 m)	90 ft (27.43 m)
Door Dimensions	75 ft x 35 ft	75 ft x 35 ft
Crane Type	Bridge	Bridge
Crane Capacity	50 ton (45.3 t)	15 ton (13.6 t)
Crane Hook Height	74.5 ft (22.71 m)	72.5 ft (22.10 m)

Table 7-6. PHSF Resource Overview

Resource	Description
Electrical/ Power	• 120 V at 20 or 30 A in single phase at 60 Hz • 208 V at 30 A with single phase at 60 Hz • 208 Y/ 120 V at 30, 60, 100 A (3-phase) at 60 Hz • 480 V at 100 or 200 A (3-phase) at 60 Hz • Backup power supplied by 1000 kw diesel generator • 300 kVA UPS unit that supplies 480/208/120 V power
Gases/ Liquids	• Two air compressors located in electrical/mechanical room supply compressed air to the service bay and airlock. Outlets have 5-micron filters and air is available at 90 psi at 185 ft^3/ min (CFM) and at 125 psi with flow of 325 CFM • GHe is supplied via tube trailer or multi-pack K-bottle racks. Both sources are available through outlets on the west end at pressures of 50 psi, 1,000 psi, 3,000 psi and 3,800 psi • GN2 is supplied from unfiltered 4,800 psi system. Connection and regulating panel are located in west end of the building. Panel filters GN2 to 10 microns and regulates GN2 down to 50 psi, 750 psi and 3,000 psi • Breathing air is supplied by external source (mobile tube bank or portable K-bottles) at 2,400 psi. It is passed through 10-micron filter and is regulated at 100 psi • HEPA filters are mounted in the ceilings of the service bay, airlock and equipment airlock. At the filter, discharge is guaranteed class 5,000 air for the air conditioning and reheat systems. These systems allow temperature to be maintained within 6° F of 71° F with a maximum humidity of 60 percent • With spacecraft present in the service bay, air is exchanged at a minimum of seven times per hour and at least four times per hour in the airlock
Propellant & Gas Sampling Services	• Regulated breathing air for Propellant Handlers Ensemble (PHE) operations is available from four 0.375 in (9.525 mm) quick-disconnect couplings on the service bay west wall • Hypergol vents are located on service bay west wall • Propellant waste drain system is a non-storage system used in event of a spill. The system consists of two trench drains in center of a sloped floor, 20 ft x 40 ft (6.1 m x 12.2 m) with a 2 in (51 mm) slope per 10 ft (0.3 m). • There is an ammonia vapor vent pipe on west wall of the service bay. Approximately 110 ft (33.5 m) of 4 in (102 mm) diameter high-density

	polyethylene vent pipe extends vertically from the exterior side of penetration to above the service bay roof

Mission Operations Support Building (MOSB) is located at entrance of PHSF complex. The one-story steel building has an insulated metal siding exterior. It is 2,209 sq. ft and consists of several office areas with cubicles available. Also, there are three conference rooms, which seat 30, 20, and 46 people. On the south end of the building there are two payload control rooms and are separated by a rollup door. These rooms serve as a ground station for checkout and testing of the customer's spacecraft located in the service bay. There is a Propellant Handlers Ensemble (PHE) change room on the northwest side of the building which is only accessible from the outside. This room contains lockers and the necessary equipment for PHE operation change. Room 148 is MIL-71 Ground Station which serves as the testing area for the spacecraft's telemetry system. The room contains all of the electrical power interfaces and communication interfaces to support Electrical Ground Support Equipment (EGSE). The EGSE is deployed for the spacecraft testing phase prior to launch. The room contains desks and phones for approximately three to four testing personnel. Control rooms in the MOSB can be used to monitor activities in the PHSF.

The airlock has a 15-ton (13.6 t) bridge crane that operates on twin runway girder rails in an east-west direction. The effective east-west travel of the hoist (hook centerline to wall) is to a point 17 ft, 5 in (5.3 m) from the east wall, and 12 ft, 11 in (3.9 m) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 4 f, 9.5 in (1.5 m) from the north wall and 4 ft, 5 in (1.3 m) from the south wall. The maximum hook height is 72.5 ft (22.1 m).

The service bay has two 50-ton (45.4 t) bridge cranes that operate on twin runway girder rails in an east-west direction. The nominal hook height for each of the cranes is 74.5 ft (24.3 m). Both crane hooks are outfitted with a debris shield to protect payloads from any possible overhead debris falling from the crane.

The effective east-west travel of the west crane hoist (hook centerline to wall) is to a point 31 ft, 5 in (9.5 m) from the east wall, and 13 ft, 9 in (4.2 m) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 6 ft, 5 in (2 m) from the north and south walls. The effective east-west travel of the east crane hoist (hook centerline to wall) is a point 11 ft, 2 in (3.4 m) from the east wall, and 34 ft, 3 in (10.4 m) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 11 ft (3.3 m) from the north wall and 9 ft, 10 in (2.9 m) from the south wall.

CCTV provides closed-circuit video surveillance of payload processing from operational areas (PHSF Rooms 116 and 117) to control and monitor areas in the payload control rooms and in the facility control room in the MOSB. Also, four monitors are located in the PHSF security room 110. There are eight pan-and-tilt CCTV cameras. Four are in the PHSF and two each (one portable and one fixed) are in the fuel transfer building and oxidizer shed. These cameras and pan-and-tilt units are hazard-proof.

Sliding doors on the east and west sides allow payload access to the facility high bay. When the facility is used for payload processing, 30 to 40 people occupy the building during operations and work from temporary offices inside the MOSB.

7.4 Launch Complex 39

The following section describes Launch Complex 39 consisting of the Vehicle Assembly Building, Mobile Launcher, Crawler-Transporter, Pad B and the Launch Control Center.

7.4.1 Vehicle Assembly Building (VAB)

The VAB, shown in Figure 7-8, supports vertical integration and stacking of the encapsulated payload to the upper stage, and where applicable, the encapsulated payload to Orion. It consists of a main transfer aisle, low bay and four high bays that can support various customers and unique launch configurations. The VAB contains multiple cranes that can be used for lifting, stacking and mating various launch components. The SLS vehicles will be stacked in High Bay 3, which has the capability of accessing different locations around the launch vehicle using multiple fixed platforms. Similarly, receipt, inspection, checkout and final integration can be performed in the facility. The VAB contains weather/lightning protection and security.

Figure 7-8. Vehicle Assembly Building (VAB)

The low bay consists of eight checkout cells, low bay transfer aisle and four shop/processing areas, designated as areas K, L, M and N. The low bay transfer aisle is capable of receiving, staging, inspecting and transferring flight hardware components. The high bay area consists of six tower sections, noted as towers A, B, C, D, E and F, and four assembly areas, noted as HB1, HB2, HB3 and HB4. The high bays provide the capability for stacking, mating, integrating, servicing and final checkout of flight hardware components. HB1 and HB3 are located on the east side of the VAB and HB2 and HB4 are located on the west side. The east and west side high bays are separated by a transfer aisle, which is used for staging, lifting, stacking and integrating hardware prior to lifting into one of the high bays for final assembly. Figure 7-9 depicts the VAB floor plan; Table 7-7 details available resources.

HB3 has the capability to provide 360° access to the outer mold line of the encapsulated spacecraft/payload through the use of multiple fixed and moving platforms within the high bay.

Access to the payload can be provided through doors within the base of the fairing. Specific access requirements will be developed during the planning stage of each mission.

The VAB provides interfaces to the ML and access to flight hardware. VAB systems that support the ML include ECS, pneumatics, handling and access, and the Ground Cooling Subsystem (GCS).

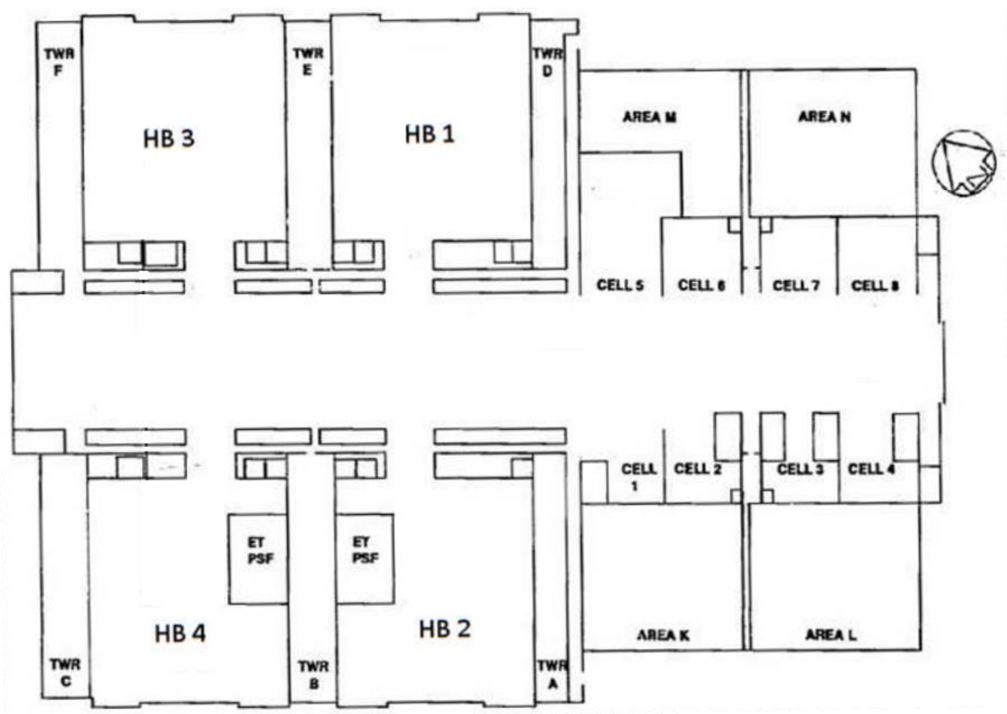


Figure 7-9. Vehicle Assembly Building (VAB) Floor Plan

Table 7-7. VAB Resource Overview

Resource	Description
Electrical/ Power	• Power enters at 13.8 kV, stepped down as needed to 480 VAC • Distributed throughout the facility and feeds end-user equipment at voltage levels of 480/277 or 208/120 with either single or three phase
Gases/ Liquids	• Provide compressed air at 125 psi • GN2 is supplied to high and low bays at pressure of 6,000 psi. Gas is distributed from High Pressure Gas Storage Building to Tower D, and then distributed to towers A, B, C, E, and F • GHe will be brought in on a tube bank when required • Conditioned air purge can be provided to the launch vehicle and payload on the ML in the VAB through umbilicals on the ML tower; temperature ranges

	of this purge depend on the final ECS configuration but nominally range from 65-85° F

This facility has the capability to provide the following services: Spaceport Command and Control System (SCCS), Kennedy Integrated Test System (KITS), KSC Network (KNET), Operational Information System (OIS), Telephone, Paging and Area Warning System (PAWS), Operational Television (OTV) and Radio Frequency and Telemetry Station (RFTS).

The VAB high bays have a 250 and 325 ton (227 and 295 t) bridge cranes that operate on common support rails. The 250 ton crane is located on the east side while the 325 ton crane is on the west side of the VAB. Due to this configuration, the 325 ton crane does not have access to the extreme east side of HB1 or HB3, and the 250 ton crane does not have access to the extreme west side of HB2 or HB4. The maximum hook height (to the VAB floor) for all of these cranes is 462.5 ft (140.9 m).

The transfer aisle has a 175 ton (159 t) bridge crane that operates in the north and south directions only. The maximum hook height (to the VAB floor) for this crane is 160 ft 3 in (48.8 m).

Payload customer access will be provided within the VAB via EGS-supplied GSE and cleanrooms of ISO 8 classification. Cleanrooms ensure that planetary protection and contamination prevention will not be compromised. EGS can accommodate up to two access doors (each with a cleanroom entry way) for customers to access their payload. However, number and location will vary according to mission. The EGS Program has identified areas on the PLF and USA where doors may be located. This door map will serve as the customer's template to use when designing and implementing door locations.

7.4.2 Mobile Launcher (ML)

The ML consists of the Mobile Launcher Base (MLB) and an integrated Mobile Launcher Tower (MLT), providing all of the service interfaces needed to physically integrate, test, service and launch the integrated SLS vehicle, including the encapsulated payload. While SLS and the ML are in the VAB, platforms provide access for mating all umbilicals on the MLT with the integrated vehicle; limited access is provided for last-minute payload closeout operations. Also, access will be provided to the Orion Crew Module (CM) via the Crew Access Arm (CAA) and to the base of the launch vehicle. The first ML will accommodate SLS Block 1 configurations while a second ML is being developed to support SLS Block 1B configurations. Figure 7-10 shows a ML configuration for SLS Block 1B.

The ML uses the Orion Service Module Umbilical (OSMU) and EUS Umbilical (EUSU), located on the MLT, to provide propellants, ground commodities, electrical, purges and access to Orion and the EUS. Provisions for PPL, CPL and SPL ground services will be routed through the SLS EUS Forward Adapter via the EUSU.

The ML is allocated to support SLS and Orion operations. It will support multiple Orion configurations and SLS blocks with scarring for extensibility. The ML consists of equipment and infrastructure used to physically stabilize, integrate, test, service, transport and launch the integrated stack. See Table 7-8 details available ML resources.

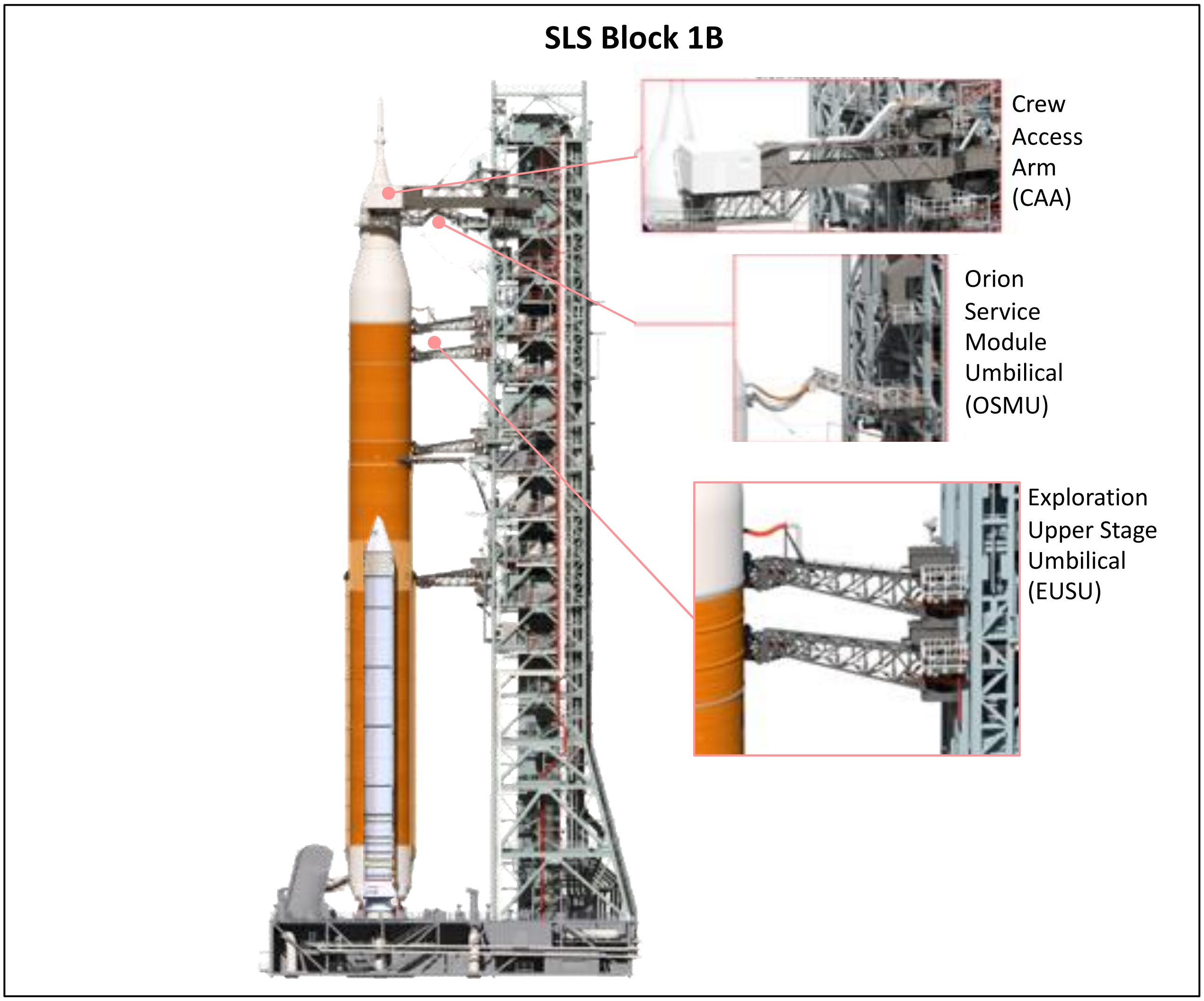


Figure 7-10. Mobile Launcher (ML) Resources

Table 7-8. ML Resource Overview

Resource	Description
Electrical/ Power	• Power provided through VAB, CT and pad • MLB provides voltage levels of 480/288 or 208/120 with either single or three phase • MLT provides the same voltage levels as MLB in addition to being capable of providing 120 V single phase • Both MLB and MLT provide grounding/lightning protection and are Class 1, Division 2-compliant, with the exception of pressurized spaces • Two 275 kW UPS units are available in static auto tie, providing AC voltage levels of 480 or 208/120 in either single or three phase
Gases/ Liquids	• Compressed air can be provided at 125 psi with a flow of 88 CFM • Conditioned air purge can be provided to launch vehicle and payload on MLB in VAB high bay, during rollout on CT, and at the pad through umbilicals on MLT. Flow rates depend on facility capabilities

The ML has the capability to provide the following Command, Control, Communication and Range (C3R) services: SCCS, KNET, OIS, PAWS, T&CD and Operational Television (OTV).

The Payload User Room is designed for payload ML operations that require close proximity to the payload. The room will serve as umbilical interface room for payload connections to EGS. EGS will provide transportation of payload customer GSE to the Payload User Room and will set up the room. The User Room will include space for all racks, cabling and other GSE as well as space for GN2 purge carts. The Payload User Room can accommodate up to three customers and one table per customer, and additional furniture and office supplies. Space to allow for troubleshooting will also be provided. At all times, the room will retain a positive pressure to ensure that the room is Class I Division II-compliant so customers will not have to make all of their GSE explosion-proof. The room will be staffed during electrical ground support equipment (EGSE) installation, connection, configuration and checkout. Additionally, the support room will be staffed during initial umbilical connection and EGS circuit connection and verification. Payload Test Operations will be accommodated as required. Additionally, after launch the room will be de-configured, and EGSE and purge carts will be removed.

7.4.3 Crawler-Transporter (CT)

The Crawler-Transporter (CT), shown in Figure 7-11, is diesel-powered and capable of transporting the ML with a vehicle stack along the crawlerway between the VAB and the launch pad. The CT lifts its load by lowering via the jacking, equalization and leveling (JEL) system, allowing it to drive under the ML. In addition to raising or lowering the height of the CT, the JEL system also keeps the ML level while transporting the enormous SLS stack on the ML. This system is critical for keeping the integrated vehicle nearly level to avoid any unnecessary loads on the vehicle structure.

Figure 7-11. Crawler-Transporter

The Shuttle era CT system was modified to carry the heavier SLS rocket, ML, and allow for an extended operation period. The CT comprises a variety of systems, which include JEL lifting cylinders, propulsion, braking, steering, generators, computers and controls. The CT interfaces with the ML at four structural pickup points that raise, lower and level the element. The CT will provide electrical power to the MPPUs during rollout for in-transit ECS purging. Additional power is available for ML electrical loads during rollout. Table 7-9 details CT resources available.

Table 7-9. CT Resource Overview

Resource	Description
Electrical/ Power	• Provide voltage levels of 480/277, three-phase power at 60 Hz to ML and vehicle while they are being transported
Gases/ Liquids	• ISO Class 8 conditioned air purge of 65-85° F (18 to 29° C) can be provided to the launch vehicle and payload on ML while in transit through umbilicals on MLT

7.4.4 Pad B

Launch Complex 39B (LC-39B), or pad B, shown in Figure 7-12, is a human-rated space launch complex encompassing 57,289 ft^2 (5,322.3 m^2) that provides the services required for each launch. The launch pad facilities at LC-39B work in conjunction with the ML and the Launch Control Center (LCC) to provide the necessary support to conduct launch operations. All pad B services are provided to the vehicle through the ML, except lightning protection. The facilities at LC-39B include cryogenic propellant storage and servicing equipment, electrical systems, a flame trench and flame diverters, HVAC, weather data instrumentation and lightning protection. Table 7-10 details available resources.

Figure 7-12. Launch Complex 39B (LC-39B)

Table 7-10. Pad B Resource Overview

Resource	Description
Electrical/ Power	• Electrical distribution system supplied by three 13.8 kV feeders, two of which are backed up by generators at an emergency power plant • Distributed voltage levels of 480/277 or 208/120 with either single or three-phase as required • Two 275 kVA UPS units are available in static auto-tie configuration, capable of providing AC voltage levels at 480 or 208/120 in single or three-phase configuration
Gases/ Liquids	• Compressed air can be provided at 125 psi • ISO 8 conditioned air purge of 65-85° F (18 to 29° C) with humidity ratio of 37 grains per pound) can be provided to launch vehicle and payload on the ML at the pad through umbilicals on MLT • GHe and GN2 are supplied at nominal pressure of 6,000 psi and if needed 10,000 psi can be provided via mobile compressed gas trailer • GO2 can be provided at pressure of 6,000 psi through mobile compressed gas trailer • Breathing air can be supplied at 6,000 psi via fixed storage vessels

The ML systems utilized at LC-39B include ECS, Kennedy Ground Control System, Ignition Overpressure/Sound Suppression (IOP/SS), GCS, Hazardous Gas Leak Detection (HGLD), pneumatics, weather (Wx), Sensor Data Acquisition Subsystem (SDAS), cryogenics and Ground Special Power (GSP). This facility has the capability to provide the following services: SCCS, KITS, OIS, PAWS, T&CD, OTV, Broadband Cable Distribution System (BCDS) and Photo Optical Control System II (POCS II).

7.4.5 Launch Control Center

The Launch Control Center shown in Figure 7-13, is a four-story building attached to the southeast corner of the VAB. The Launch Control Center is used to control operations interfaces with the launch vehicle and spacecraft/payload. Available communication and network capabilities include the checkout system in the firing rooms (FRs), RF antennas used to collect telemetry, weather radar and radar antennas used to skin-track launch vehicles. The U.S. Air Force provides vehicle tracking and telemetry resources, weather forecasting, control of nearby air- and sea-space, and flight-termination capabilities. Incoming and outgoing communications feeds through the Launch Control Center and various areas within KSC are provided via the Communications Distribution and Switching Center (CD&SC).

Figure 7-13. Launch Control Center

Firing Room (FR) 1, also known as the Young-Crippen Firing Room, will control all SLS launch operations. FR 4 provides the capability for spacecraft control rooms prior to and during launch. There are four smaller control rooms that can be expanded to accommodate teams of differing sizes. Rooms can be configured to support specific needs, allowing teams to bring in their own equipment. Secure access will be provided to each of the rooms, along with access to NASA communications infrastructure and electrical services, including UPS.

7.5 Payload Processing and Encapsulation

The EGS Program provides complete vehicle integration and launch services for the SLS launch vehicle and spacecraft/payload. A system of facilities, equipment and personnel trained in launch vehicle and integration and launch operations is in place.

Payloads are manufactured/assembled at the payload provider's manufacturing facility and arrive at KSC in customer-provided shipping containers or by aircraft. Any support required for off-loading at KSC can be negotiated during development of the LSSRD. Upon arrival at KSC, the spacecraft and associated GSE will be delivered to an assigned PPF or HPF for standalone processing. EGS provides transportation, handling and security for the spacecraft and customer-supplied GSE from arrival through delivery to appropriate processing facility and then delivery to the VAB. The payload will be quiescent during transport between KSC facilities. The standalone processing performed by the payload customer includes all activities from receiving and inspection through final testing and checkout of spacecraft prior to PLA and payload mating and encapsulation. The actual operations that each payload will undergo during this customer processing phase varies according to mission. Any GSE that the payload will require during this processing phase will be provided by the payload customer. Standalone processing will be conducted prior to turnover of the spacecraft/payload to EGS.

Following the completion of payload processing activities either at the manufacturer or at a KSC integration facility, the payload will be turned over to EGS for encapsulation, beginning the offline processing phase. Any hazardous processing, such as hypergol fueling or ordnance installation, will be completed offline in the PHSF. Any fueling GSE will be provided by the payload customer. Integration of the payload to SLS hardware is performed in this phase. Activities performed by EGS during this phase include mating of spacecraft/payload to PLA and interface testing, potential removal of customer GSE, system performance testing and encapsulation. Lastly, after encapsulation, EGS will transport the mated ISPE to the VAB.

Upon arrival at the VAB, the ISPE (typically transported on a KAMAG) will enter the VAB via the transfer aisle. The EGS Program leads the operations for stacking and integrating the ISPE onto the SLS vehicle. The ISPE is lifted by overhead crane from the transporter, which is secured in the transfer aisle, and placed on the SLS vehicle, which is staged on the ML in HB 3. The ISPE is attached and secured to the SLS ICPS or EUS prior to any umbilicals being connected or any integrated tests being performed. At this time, customer personnel, supported by EGS, will set up the Payload User Room and the required GSE will be position in the Payload User Room. The payload EGSE must be compatible with the Payload Accommodation Subsystem (PAS). Following the stacking of the payload, testing of the integrated SLS with the payload and ML will be performed. This will, at minimum, consist of an interface verification test. Upon completion of the integrated test and checkout, rollout operations will be executed, followed by pad operations. Rollout preparations include final closeouts of the payload and PLF/USA and any preparations for monitoring the payload and GSE during the SLS and ML rollout to the pad.

Pad operations take place when the ML is connected to the launch pad. Once those interfaces are mated, checkouts of the vehicle to ground systems are conducted to ensure all interfaces are functional. This usually consists of a health check of the payload to ensure interfaces were not affected during rollout. This leads up to launch operations. The SLS vehicle, ML, pad, Payload User Room and LCC are now activated. Power-up of ground systems and flight vehicle ensues, followed by loading of cryogenic fuels and monitoring of launch commit criteria (LCC). Final launch countdown is initiated. During liftoff, the ML umbilicals are retracted. Payload element data systems must be compatible with the EGS Launch Control System (LCS) for ground processing and launch countdown monitoring. Figure 7-14 shows a representative operational flow for the SLS Block 1 cargo launch vehicle and payload. Figure 7-15 shows a representative operational flow for an SLS Block 1B crew vehicle and CPL. Figure 7-16 shows a representative operational flow for an SLS Block 1B cargo launch vehicle and PPL.

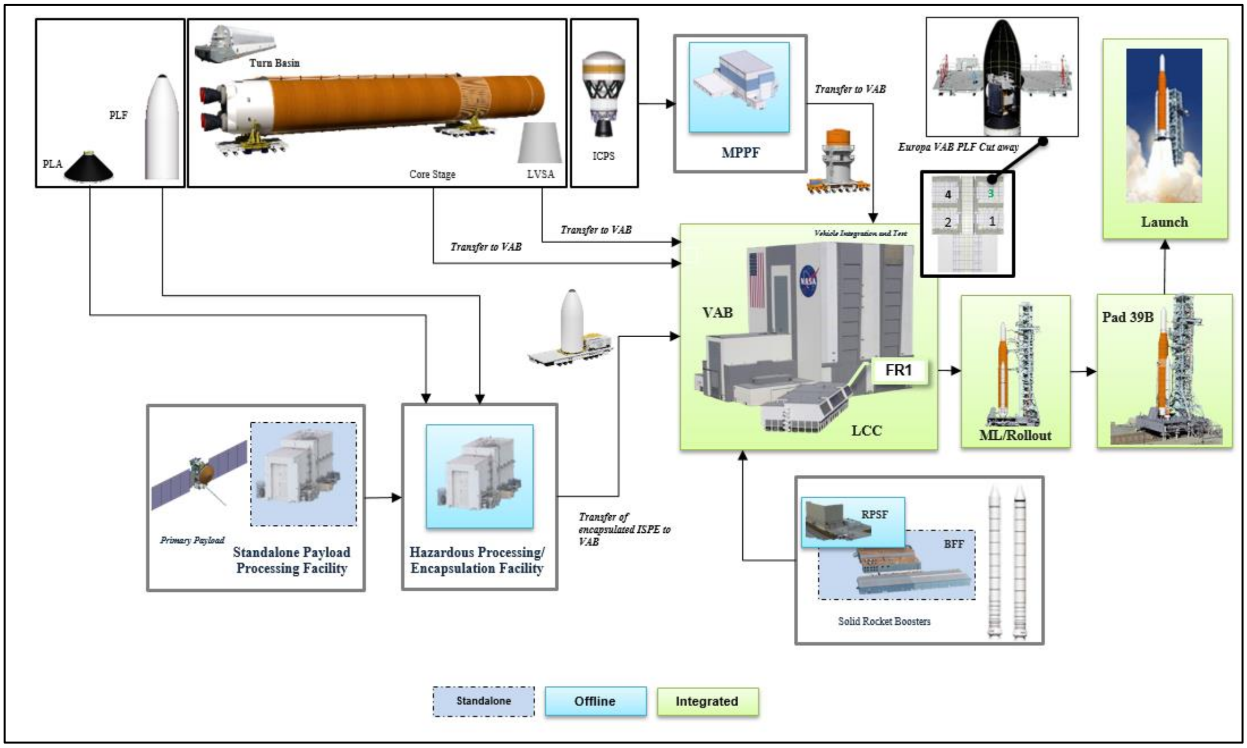


Figure 7-14. Representative SLS Block 1 Cargo Payload Operational Flow

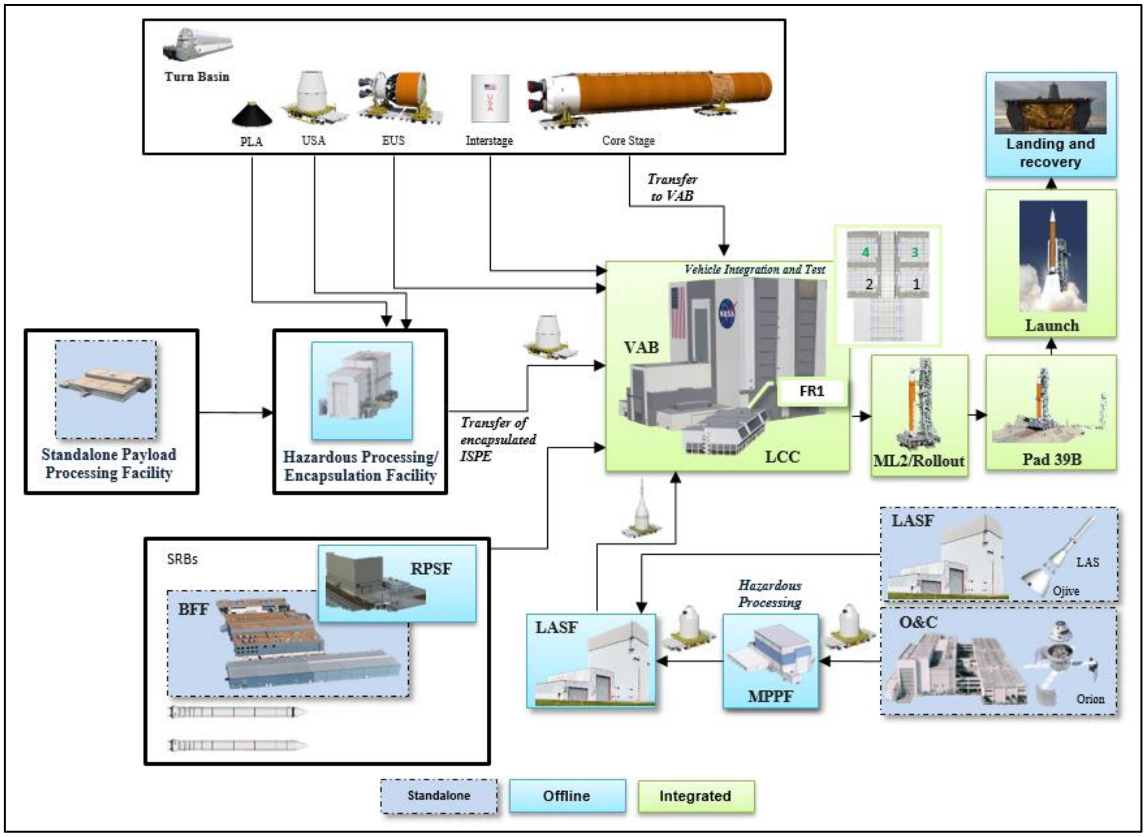


Figure 7-15. Representative SLS Block 1B Crew Payload Operational Flow

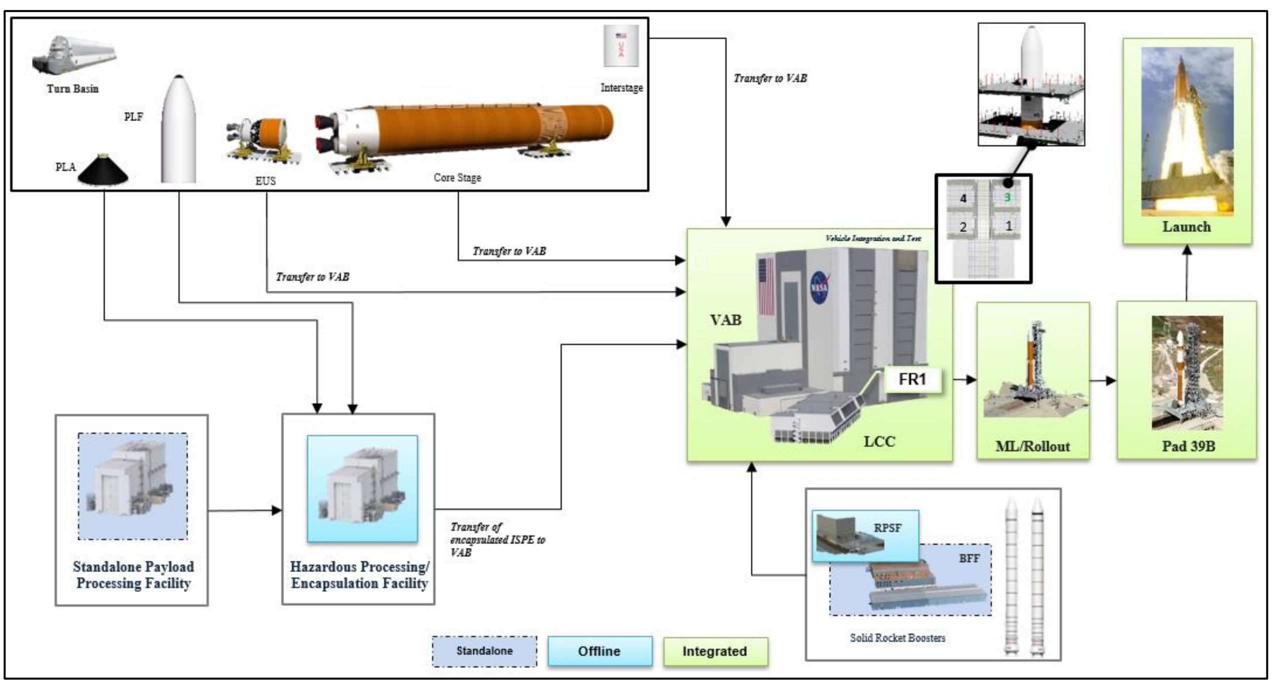


Figure 7-16. Representative SLS Block 1B Cargo Payload Operational Flow

For all of the various payload elements, the same basic processing phases will be followed for payload encapsulation at the PPF. Figure 7-17 shows this process for a CPL encapsulated by a canister USA in an offline processing facility, but the process would be similar for PPL encapsulated by a sectored fairing.

Prior to payload arrival, the USA Canister or PLF sectors are delivered to the PPF where they are inspected and prepared for payload encapsulation. The USA or PLF is debagged, cleaned and inspected, then placed on GSE for assembly and rotation operations. Encapsulation operations begin with the placement of the transportation pallet assembly in the encapsulation area and the installation of the PLA. The payload is then configured for encapsulation and mated to the PLA. Payload-specific integrated checkouts may be performed upon the completion of this procedure per the manufacturer's requirements. The USA or PLF sectors are positioned and configured for encapsulation in the PPF HB. The USA or PLF is then mated to the PLA and the encapsulated payload is prepared for transportation from the PPF to the VAB. The payload transporter is equipped with an ECS capable of providing a conditioned air purge to the payload in transit. This allows for positive pressure, humidity and temperature control for encapsulated payloads up to 65,000 lbm (29,483 kg). Once in the VAB, the temporary ECS is disconnected and an integrated lift is used to move the encapsulated payload from the transportation pallet to the top of the integrated vehicle stack, where it is mated with the EUS.

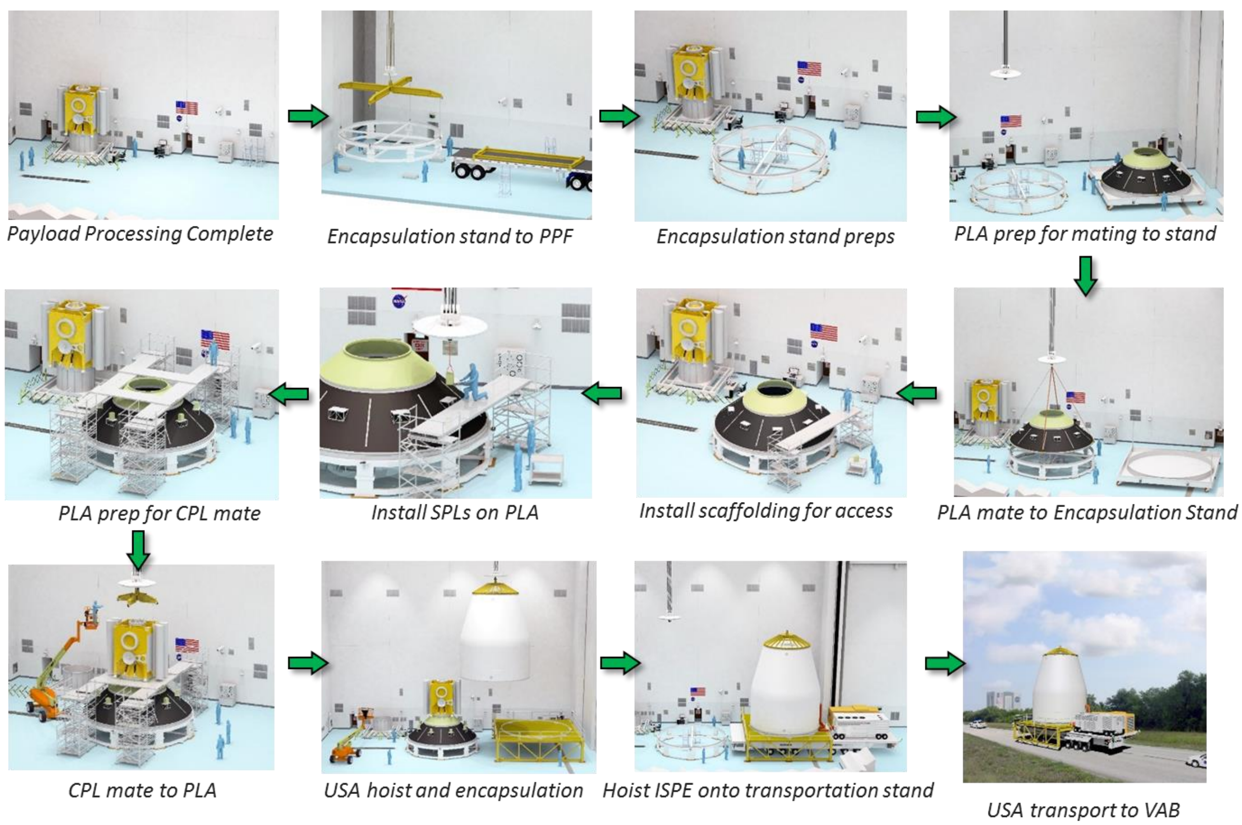


Figure 7-17. Payload Encapsulation Operational Flow (USA Example)

7.6 Standard vs. Non-Standard Payload Ground Services

Listed below is a synopsis of services that EGS provides to customers during the integration and processing operations. Standard services are not limited to this list:

- Provide personnel, services, hardware, equipment, documentations, analyses and facilities to support mission planning, launch vehicle production, payload integration and launch
- Provide all range and safety documents for payload customer to complete
- Facilitate the range and safety integration process
- Provide an adapter and technical support for a mechanical interface compatibility verification test at assigned processing facility
- Provide transportation for the customer's spacecraft container and all GSE
- Provide ISO 8 cleanroom integration space for the payload and GSE prior to launch
- Support customer's hazardous operations
- Provide GSE to support physical mating of payload to PLA, perform encapsulation and integration of encapsulated system to the launch vehicle
- Process the launch vehicle and test electrical interfaces
- Provide conditioned air into fairing during ground processing
- Provide two access doors in the PLF/USA at pre-designed locations
- Supply internet drops in customer processing facility
- Supply electrical outlets in customer processing facility
- Provide generators to customer processing facility
- Provide security to customer processing facility
- Provide all administrative items (chairs, desks, copiers, phones, filing cabinets, tables, etc.)
- Ensure processing facility maintains humidity, temperature and particulate described in designated facility section
- Supply cranes in processing facility
- Supply contamination prevention garments
- Provide propellant loading gases, hypergols
- Provide transportation equipment
- Provide facility equipment
- Provide processing services such as battery disposal, calibration, decontamination, sample analysis, thermal analysis, etc.

Additional services that are not considered typical, but are still feasible are described as Non-Standard Services (NSS). These are services that are out-of-scope of current architecture capability and/or budget baseline. Below is a list of example NSS, but they are not limited to this list:

- Extra cleanliness requirements otherwise specified by facility description (i.e. ISO 7)
- Special facility environment requirements otherwise specified by facility description
- Special purge requirements otherwise specified by facility description
- Transportation requirements such as oversized loads or high-vibration sensitivity
- Handling guidelines not mentioned in facility description (RF restrictions, height restrictions)
- Training services

- Facility reconfiguration to meet requirements
- Direct payload interaction with LCS for pre-integration testing and launch support
- Gases or commodities not mentioned in facility breakdown
- Utilizing KSC personnel for pre-integration processing (alignments, machine, non-destructive evaluations)
- Work time policy conflicting with KSC guidelines
- Tool control plan that conflicts with KSC guidelines
- Safety restrictions
- RF attenuation/exposure monitoring
- Alternative personnel protection requirements
- Access door location on the conical section of the PLF or USA
- Power provided to the payload during rollout

8.0 SLS SPACECRAFT/PAYLOAD INTEGRATION AND MANAGEMENT

Exploration Systems Development (ESD), a division within NASA's Human Exploration and Operations Mission Directorate (HEOMD), is responsible for management and integration of the Orion, SLS and EGS Programs. ESD is responsible for manifesting all spacecraft/payloads to be launched on SLS. The SLS Program is responsible for launch vehicle integration for all SLS missions. As part of the SLS Program, the SPIE office has the responsibility for spacecraft/payload integration into SLS throughout the lifecycle of a mission. EGS supports the SLS Program by performing launch site processing of the payload and mission-dependent equipment, including assessment and allocation of ground-related analytical requirements, as well as actual physical hardware processing. The Flight Operations Directorate (FOD) supports the SLS Program by managing integrated flight operations and flight rules including those for the payload.

8.1 SLS, EGS and Spacecraft/Payload Responsibilities

Clear communication between the SLS, EGS and spacecraft/payload is essential to flight success. SLS and EGS have established procedures and interfaces to delineate areas of responsibility and authority between SLS, ground systems and spacecraft/payloads. Based on lessons learned from other programs, such as EELVs, ISS, and the Space Shuttle Program, the SLS - spacecraft/payload integration process is planned to be compatible with spacecraft/payload developer-defined milestones whenever possible. Therefore, this process could formally start with the spacecraft/payload's Systems Requirements Review (SRR), or equivalent, and end with spacecraft/payload encapsulation, launch and deployment. The actual integration process and schedule can be tailored to meet SLS, EGS and spacecraft/payload requirements for each flight. Spacecraft/payload developers are encouraged to interact with SPIE and EGS as early as possible during the concept development phase. Early interaction facilitates mission and vehicle feasibility/compatibility analysis as well as schedule milestone discussion that will identify preferred flight and accommodation approaches.

8.1.1 SLS Program Responsibilities

The SLS Program is responsible for design, manufacture and integration of the launch vehicle. As part of the SLS Program, SPIE manages not only the development of spacecraft/payload accommodation hardware, but also manages the integration of the spacecraft/payload into SLS including: flight, ground and range safety; and electrical, mechanical, environmental and electromagnetic compatibilities. Other responsibilities of the SPIE office include guidance system integration, mission analysis, software design and ground and flight operations support.

SPIE will assign a Payload Integration Manager (PIM) to serve as the single spacecraft/payload point of contact for all integration activities for each spacecraft/payload on a specific mission. The PIM, representing the spacecraft/payload to the vehicle, will ensure the spacecraft/payload receives needed analytical, physical, and operations resources during all phases of integration and implementation. The SLS Program coordinates with the EGS Program to support payload ground activities and EGS Program integration activities including SLS Program representation to ensure cross-program integration.

8.1.2 EGS Program Responsibilities

The EGS Program will perform payload integration for payloads flown on the SLS launch vehicle by physically integrating the payload and SLS flight hardware at the launch site for processing. This function includes evaluation of payload ground requirements, performing coordination to meet these requirements, KSC-wide physical integration activities and SLS ISPE hardware processing at the launch site. The EGS Program coordinates with the SLS Program to support payload ground activities and SLS Program integration activities including EGS Program representation to ensure cross-program integration.

EGS is responsible for spacecraft/payload physical encapsulation and integration onto SLS, launch site processing, launch control, range safety and ground requirements assessment/validation that will be executed as identified in mission-specific documents as applicable. EGS will assign a Launch Site Integration Manager (LSIM) to act as the launch site ground system point of contact for payload. In coordination with the SLS PIM, the EGS LSIM will engage with the spacecraft/payload during all phases of its development and integration, including initial feasibility assessments and applicable payload life cycle reviews.

8.1.3 Spacecraft/Payload Responsibilities

In order to ensure initial compatibility with SLS and overall mission feasibility, SLS encourages the spacecraft/payload developer to define its needs with SPIE as early in the process as possible. The SLS Accommodations Demand Model Input Template (ADMIT) survey shown in Appendix B is a short spacecraft/payload questionnaire that can be used as a guide to initial dialog and evaluation between SLS and a potential spacecraft/payload developer. Typical information includes, but is not limited to, desired launch date; principal points of contact; trajectory requirements; mechanical and electrical interfaces; thermal and dynamic environments; physical access; propulsion systems; batteries, transmitters and receivers; electro-explosive devices; non-electrical ordnance and release devices; contamination requirements and orbit injection conditions.

After initial feasibility and interest for SLS accommodation is established, the spacecraft/payload defines its required SLS interfaces and accommodations. Typically, this is done through development of a unique spacecraft/payload "launch vehicle" Interface Requirements Document (IRD), or equivalent. If the spacecraft/payload does not have this type of documentation, the PIM and LSIM, will help the spacecraft/payload document its accommodation and service requirements.

Once formally manifested by ESD, the spacecraft/payload will be responsible for supporting SLS integration activities and participating in associated reviews in a phased manner to ensure safe and successful integration as detailed in Table 8-1. Unless otherwise noted, the SLS PIM and/or EGS LSIM will help develop documentation and represent the spacecraft/payload at other NASA required mission reviews not shown in Table 8-1. Opportunities for spacecraft/payload involvement in these other reviews will be arranged on a "by exception basis" by the PIM/LSIM.

Table 8-1. SLS Spacecraft/Payload Integration and Management Process* (1 of 3)

Milestone	Lead	Definition	Typical Products
Mission Concept Definition (Early as needed) **MCR** Mission Concept Review	SLS	Vehicle capabilities, vehicle interfaces and requirements	SLS MPG Accommodations Demand Model Input Template (ADMIT) survey
	SP	Early known spacecraft/payload requirements and service requirements	Draft of spacecraft/payload interface requirements document (IRD) or completed SLS-provided Service Request. CAD, definition of interface, finite element models, math models, trajectories, constraints, mass properties, physical access, thermal models, launch service requirements, communications and network plans, etc.
	SLS	Early mission integration analysis	Feasibility studies
		Initial integrated concept of operations based on spacecraft/payloads mission	Draft concept of operations
		Bi-lateral agreement defining services, data requirements and schedules mutually agreed upon by all parties	Draft Payload Integration Agreement (PIA)
SP SRR Systems Requirement Review or equivalent	ESD	Spacecraft/payload is manifested on SLS	Official manifesting document from ESD
	SLS	Bi-lateral agreement defining services, data requirements and schedules mutually agreed upon by all parties	Signed (baseline) PIA
		Provide a draft SLS-SP Interface Control Document (ICD) from initial inputs from the spacecraft/payload and initial vehicle interface definition. Early evaluation of mission feasibility, mission design, unique requirements and unique hardware to support spacecraft/payload’s milestone reviews	Draft ICD
	SP	Participate/support Phase 0 Safety Review	List of potential flight and ground payload hazards
	SLS	Final integrated concept of operations based on spacecraft/payloads mission	Baseline concept of operations
SPIR 1 Spacecraft/Payload Integration Review (~3 months prior to SP PDR)	SLS	Provide a baselined SLS-SP ICD from initial inputs from the spacecraft/payload and initial vehicle interface definition. Corresponding verification plan will accompany the ICD and describe the verification requirements and methods spacecraft/payload must show for compliance	Baselined ICD with verification plans. Defined PLA interface and other mission-specific hardware required
		Perform an integrated system-level evaluation of SLS and spacecraft/payload hardware design	Results provided to spacecraft/payload
LSIR 1 Launch Site Integration Review	EGS	Architectural studies have been completed, concept of operations has been confirmed, preliminary payload requirements have been identified and preliminary NSS have been identified	Internal EGS Program assessments to ensure EGS can accommodate the payload/spacecraft by providing the necessary services and meeting levied ground processing requirements
		Risks have been identified and mitigation strategies appear reasonable	Presented to payload
SP PDR Preliminary Design Review or equivalent	SLS-SP	Provide additional or updated inputs to the SLS-SP ICD	Baseline SLS-SP ICD
	SP	Inputs to LSSRD, Operations and Maintenance Requirements and Specifications (OMRS) and LCC	Draft Assembly and Installation Drawings, service request, requirement development, procedures, GSE requirements, LCC, etc.
		Inputs to range safety documentation	Hazards and debris characteristic data
		Participate/support Phase 1 Safety Review	Descriptions of flight and ground safety-critical subsystems, payload operations and interfaces. Preliminary hazard analysis with hazard causes and potential control strategy identified

**Assumes appropriate documentation is available at spacecraft/payload reviews and that spacecraft/payload review schedule supports integrated product (analysis, etc.) development prior to mission reviews. SPIE is responsible for ensuring Spacecraft/payload coordination with EGS Program and FOD.*

Table 8-1. SLS Spacecraft/Payload Integration and Management Process* (2 of 3)

Milestone	Lead	Definition	Typical Products
SPIR 2 (~ 3 months prior to SP CDR)	SLS	Based on updated results, perform an integrated system-level evaluation of SLS vehicle and spacecraft/payload hardware design including ground operations	Results provided to spacecraft/payload
LSIR 2	EGS	Baselined requirements have been identified, preliminary launch site payload processing and service requirements are in work, NSS have been baselined and requirements requiring verification have been identified	Preliminary (preliminary) LSSRD
		Action items from previous LSIR have been closed	LSIR package
		Risks have been identified and mitigation strategies appear reasonable	Presented to spacecraft/payload
SP CDR Critical Design Review or equivalent	SLS-SP	Provide additional or updated inputs to the SLS-SP ICD	Update the SLS-SP ICD.
	SP	Flight Operation inputs	Flight operation products such as flight rules, burn sequences for CPLs, procedures, rendezvous and prox ops needs, etc.
		Participate/support Phase 2 Safety Review	Products defining the payload flight and ground safety requirements and processes that drive payload component and pre-deploy timeframe flight and ground hazard analysis. Trajectory analysis needed for recontact assessments (CPLs and secondary payloads)
		Matured inputs to LSSRD, Operations & Maintenance Requirements & Specifications and Launch Commit Criteria	Matured Assembly and Installation Drawings, service request, requirements, procedures, GSE requirements, launch commit criteria, etc.
LSIR 3	EGS	Finalized requirements have been identified, baselined Launch Site Payload processing and service requirements, finalized Non-Standard services and support requirements, and verification and validation of requirements have been solidified.	Baselined LSSRD.
		Actions from previous LSIR have been closed.	LSIR Package
		Program Requirements Document (PRD) is in development	Draft PRD
		Risks have been identified; mitigation strategies appear reasonable	Presented to payload
SPIR 3 (~3 months prior to SP SIR)	SLS	Based on updated results, perform an integrated system-level evaluation of SLS vehicle and spacecraft/payload hardware design including ground operations	Results provided to spacecraft/payload
SP SIR System Integration Review	SP	Ensures that spacecraft/payload system is ready to be integrated	Documents spacecraft/payload integration facilities, support personnel and integration plans and procedures are ready
Spacecraft/Payload Verification Complete	SP	Verification Compliance Deliverables	Closed Detailed Verification Objectives (DVO)
		Participate/support Phase 3 Safety Review	Final assessment products including flight and ground payload safety requirements and processes that drive payload component and pre-deploy timeframes
		Flight Operation inputs	Operations inputs such as flight displays, mission simulations, and customer procedures
**Assumes appropriate documentation is available at spacecraft/payload reviews and that spacecraft/payload review schedule supports integrated product (analysis, etc.) development prior to mission reviews. SPIE is responsible for ensuring Spacecraft/payload coordination with EGS Program and FOD.*			

Table 8-1. SLS Spacecraft/Payload Integration and Management Process* (3 of 3)

Milestone	Lead	Definition	Typical Products
SPIR 4	SLS	Perform an integrated system-level evaluation of SLS vehicle and spacecraft/payload hardware design including ground operations	Results provided to the vehicle for final integration
LSIR 4	EGS	Requirements, services and commitments are finalized; LSSRD will not require any significant changes; EGS compliance with payload customer requirements has been verified; all To Be Determined (TBDs) and To Be Resolved (TBRs) in LSSRD have been resolved	Final LSSRD
		PRD has been sent to suppliers for commitment	Baselined PRD
		Actions from previous LSIR have been closed	LSIR board package
		Residual risks have been deemed acceptable	Presented to payload
GOR	EGS	Forum for coordinating launch site activities and resolving operational issues and concerns	Ground flow activities, operational timeline modifications for mission-unique spacecraft/payload operational considerations, LSSRD definition for launch site facilities and GSE, hazardous operations with the range, and ground test requirements.
Spacecraft/Payload Pre-Ship Review	SP SLS EGS	Remaining safety requirement closeout	Updated descriptions of safety-critical subsystems, operations and interfaces. Completed flight hazard analysis. Listing of approved waivers to safety requirements. Safety verification tracking log that identifies open safety verification methods, status and expected closure
		Final flight operation inputs	Participating in launch countdown and mission simulations as appropriate, and provide final customer procedures
		Updates to Launch Site Support Requirements Document, OMRS and LCC	Updates to final assembly and installation drawings, service request, procedures, GSE requirements, LCC, etc.
		Formal approval for shipment of PL and MDE to KSC	Products listed above
FRR Flight Readiness Review	SLS	Final assessment of SLS, spacecraft/payload system and launch facility readiness	Closure of all open paperwork and risks to flight and ground systems, ER and Western landing and recovery
**Assumes appropriate documentation is available at spacecraft/payload reviews and that spacecraft/payload review schedule supports integrated product (analysis, etc.) development prior to mission reviews. SPIE is responsible for ensuring Spacecraft/payload coordination with EGS Program and FOD.*			

8.2 Spacecraft/Payload Integration Documentation

The products listed in this section define required spacecraft/payload services, interfaces and analysis to support all phases of the integration process. Based on the complexity of a specific spacecraft/payload, additional information may be required.

The representative SLS-Spacecraft/Payload Integration Schedule shown in Figure 8-1 defines the launch-minus integration documents and milestones required between the spacecraft/payload and the SLS Program. Each spacecraft/payload will have a unique integration schedule based on the relative complexity of their system. For more complex spacecraft/payloads, the formal process could begin when manifested as early as 48 months prior to launch (e.g., PPL or CPL). For less complex spacecraft/payloads, the process can nominally begin as late as 36 months prior to launch (e.g., SPL). SPIE, EGS and spacecraft/payload will negotiate and agree to the overall integration schedule.

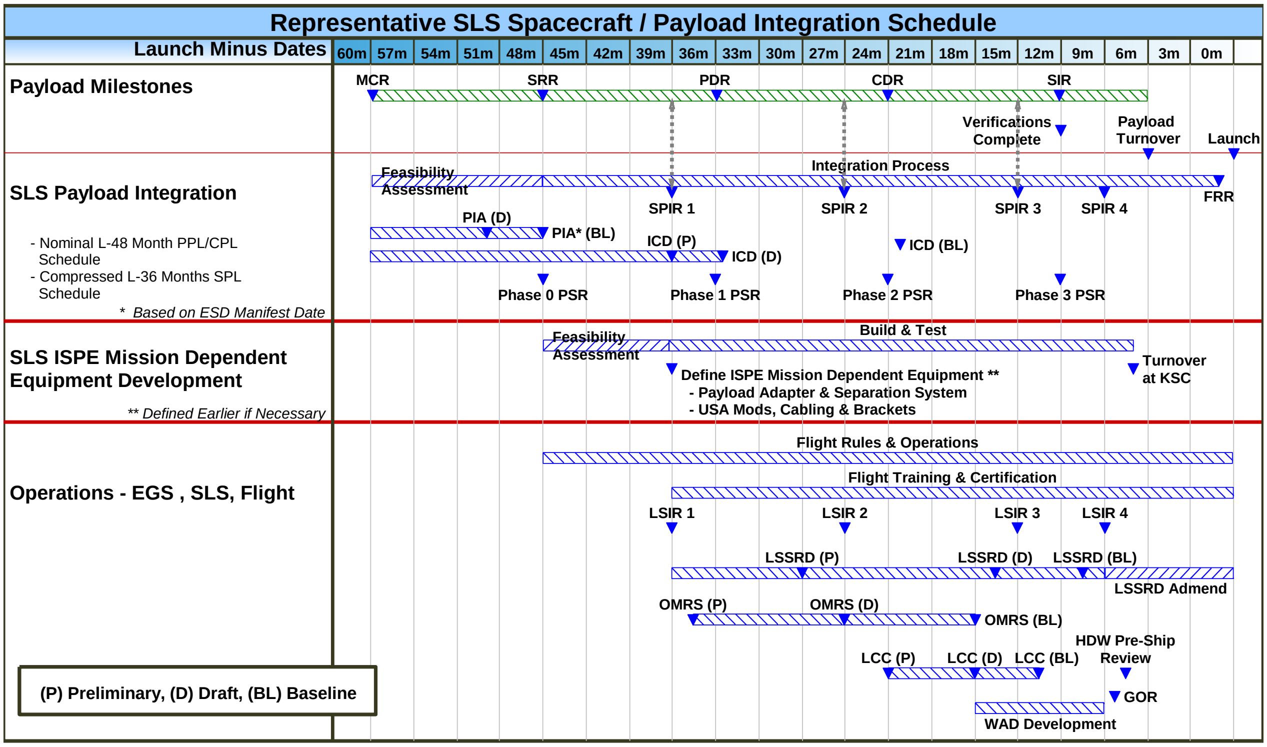


Figure 8-1. Representative SLS/EGS Spacecraft/Payload Integration Schedule

8.2.1 Payload Integration Agreement (PIA)

The PIA, or an equivalent programmatic agreement, establishes and implements all management and programmatic integration requirements between the spacecraft/payload and SLS. The PIA defines SLS and the spacecraft/payload roles and responsibilities, interfaces, standard services, any non-standard services, deliverable exchanges and the overall schedule for successful integration and launch. The PIA is developed by the PIM and coordinated with the spacecraft/payload, with revisions negotiated and agreed to by all parties as needed. SPIE will work with ESD, ESG and the spacecraft/payload early in the development process to develop a draft PIA using the spacecraft/payload IRD or equivalent document; all parties will agree to a draft of the document prior to formal manifesting. When ESD manifests the spacecraft/payload on SLS, the PIA will be baselined. Baselining the PIA formally starts the SLS-spacecraft/payload integration process.

8.2.2 Payload Unique Interface Control Document (ICD)

The SLS payload unique ICD defines the interface and requirements between SLS and EGS, and the spacecraft/payload for a specific mission. The ICD is the agreed upon design solution that controls and defines each side of an interface (SLS or spacecraft/payload) for hardware, GSE, software and environment compatibility. It identifies required modifications to or new design of ISPE Mission Dependent Equipment such as the USA, PLA, and associated cabling and bracketry. The PIM develops ICD in coordination with the spacecraft/payload. As part of this payload unique

ICD, a verification plan will provide one-to-one mapping of spacecraft/payload requirements to a particular compliance method for all phases of operations (e.g., ground processing, lift-off, in-flight, SLS separation events). The verification plan provides instructions and guidelines to verify safety and interface compatibility of the as-built SLS vehicle and spacecraft/payload hardware and software. The success criteria and methods of verification will be in the form of Detailed Verification Objectives (DVO), outlining the type or proof required for closeout (e.g., test, analysis, demonstration, inspection, similarity, and/or validation of records).

8.2.3 Payload Unique Safety Requirements Document (SRD)

A SLS safety representative establishes the safety policy and requirements applicable to SLS spacecraft/payload for a specific mission in the payload unique SRD. Its typical scope starts at payload delivery at the launch site and continues through ascent until end of the Orion mission (for Co-Manifested Payloads and Secondary Payloads on an Orion mission), or until upper stage disposal (for Primary Payloads and Secondary Payloads on an uncrewed mission). For the ground processing phase, the payloads must also comply with identified ground processing hazard requirements as identified in this document. Verification results of these payload ground and flight processing/operations hazards will be reviewed at the relevant phase Payload Safety Reviews.

8.2.4 Payload Unique Launch Site Support and Requirements Document (LSSRD)

The EGS payload unique LSSRD provides an overview of spacecraft/payload requirements for each individual payload such as facility footprints, lifting hardware, Ground Support Equipment (GSE) required, payload specific processing phases, and standard/non-standard services needed. The EGS lead for the mission-specific LSSRD development will be the LSIM who will work with the payload developer. Generally, there are three phases of payload-specific LSSRD development: Preliminary LSSRD no later than Launch-36 months that contains the complete requirements known up to that point (will be continually updated until ready for baselining); Baseline LSSRD typically by Launch-24 months that contains final Non-Standard Service (NSS) requests, as well as the requirements and commitments known up to that point (revisions to this baseline version may occur through Launch-12 months); and the As-Flown LSSRD published after launch which incorporates any support and/or requirement changes that occurred after the Baseline LSSRD. The EGS Program and the spacecraft/payload approves the baselined version of the LSSRD; this version provides the basis to develop the EGS Program Requirements Document that is used to obtain commitments from suppliers to provide ground support requested.

8.2.5 Program Requirements Document (PRD)

A PRD is developed and comprised of a collection of payload support requirements related to products, commodities, and services, required to perform payload processing, test, and operations. These support requirements may include propellants, fluids and gases, commodity purity testing, ordnance storage and handling, security services, etc. The payload specific PIA, ICD, PSR, and LSSRD are utilized to develop the PRD. The PRD support requirements will then be communicated to the proposed suppliers to obtain payload support commitments.

8.2.6 Payload Operations & Maintenance Requirements Specifications (OMRS)

Any spacecraft/payload ground operations or integration task required after hardware turnover to EGS at KSC not documented through a PRD or in released engineering products will be documented through an OMRS. Payload OMRS will communicate detailed ground processing requirements to be implemented via work instructions in Work Authorization Documents (WADs) and application software to support launch processing activities such as integrated testing, servicing, operations, maintenance, launch countdown and recovery (as applicable). OMRS may be used for operations and maintenance (O&M) requirements for provided GSE unless O&M requirements are documented in manuals or other released engineering documents.

8.2.7 Payload Launch Commit Criteria (LCC)

LCC represent a single authoritative requirement source to verify the launch configuration supports mission objectives while maximizing launch probability and mission success, and ensuring the safety of ground personnel and flight crew safety. Inputs will be gathered via the SLS PIM and coordinated with EGS. Inputs will be used to support the development of Ground & Flight Application Software (GFAS), as a source of identifying credible anomalies for launch team simulation training models, and to help define the necessary launch countdown response/safing steps in emergency or contingency operations.

8.2.8 Payload Flight Operations Timelines, Flight Rules and Procedures

The PIM will assist the spacecraft/payload in documenting flight operations related planning and requirements development activities. This will include identifying nominal and off nominal payload operations during SLS ascent, orbit, injection, payload separation, and upper stage disposal maneuvers as well as post upper stage disposal in the case of applicable Secondary Payloads. These results will be used as inputs to develop relevant payload timelines, Flight Rules, certifications, and associated procedures to support related mission training and ground console activities. They will be evaluated with support from FOD and presented at applicable reviews (e.g., Flight Operations Review) and incorporated in other documents (e.g., OMRS) as needed by the PIM on behalf the spacecraft/payload.

8.3 SLS-Spacecraft/Payload Integration Process and Milestones

The SLS integration process has been developed to efficiently mesh with the spacecraft/payload's schedule. This schedule (reference Figure 8-1) should be compatible with the spacecraft/payload's milestone reviews (e.g., SRR, PDR, etc.), and, at a lower level, by the hardware and trajectory/mission target definition receivables and deliverables. The integration process will formally start post-ESD manifesting, with a baseline PIA between SPIE and the spacecraft/payload developer. The SLS integration process has been developed to effectively mature the integrated system through a series of system-level analyses and evaluations, each more rigorous than the previous. Throughout the integration process, with the support of the SLS PIM and EGS LSIM, the spacecraft/payload will participate in the working group and review activities described below.

8.3.1 Spacecraft/Payload Early Integration Studies

SLS encourages the spacecraft/payload to establish a dialogue with SPIE as early as possible to evaluate mission feasibility and design, unique requirements and unique hardware to support the spacecraft/payload's milestone reviews. SPIE will establish a point of contact for the spacecraft/payload in coordination with EGS until a PIM is formally designated. Prior to a manifest decision, the SPIE office will arrange for regular spacecraft/payload working group or technical interchange meetings (TIMs) to focus on special topics to drive initial information required for spacecraft/payload and SLS integration planning. SPIE will arrange for these meetings to be held at regular intervals (e.g., monthly, quarterly, semi-annually) to define accommodation points of departure, as well as update the spacecraft/payload and SLS management on overall status. Findings from these meetings are used by the spacecraft/payload developer to support development of their SLS IRD, and by SPIE to support development of a draft PIA. Figure 8-1 shows this to nominally begin at L-60 months for PPL/CPL; in reality it will depend on the spacecraft/payload's level of design maturity and readiness to engage with SLS.

8.3.2 Spacecraft/Payload Integration Reviews (SPIR)

SLS SPIE SPIRs ensure feasibility/compatibility of the spacecraft/payload to SLS ISPE accommodations and operational requirements and are aligned to spacecraft/payload lifecycle reviews (e.g., PDR, CDR, etc.). While SPIR 1 through 4 are shown as an example, the number and timing of these may vary based on spacecraft/payload, SLS, and mission requirements.

SPIR 1 will showcase the results of SLS system level vehicle and spacecraft/payload analyses for the mission. This will include defined vehicle accommodations such as the Payload Adapter, USA or PLF, as well as design environments identified during early integration activities. SPIR 1 results will be documented in a preliminary version of the SLS-Spacecraft/Payload ICD. SPIR 2 will review status of a more mature system, identifying interface changes on either side of the vehicle interface (SLS or spacecraft/payload). SPIR 2 results will be documented in a draft of the SLS-Spacecraft/Payload ICD. SPIR 3 will review the results of an "as-built" integrated system level evaluation of the SLS and spacecraft/payload hardware design. SPIR 3 results will be documented in a baselined version of the SLS-Spacecraft/Payload ICD. A final SPIR (represented by SPIR 4) will review integrated verification data from the spacecraft/payload and SLS hardware such as the Payload Adapter, USA, or PLF. Successful SPIR 4 results will support having an effective spacecraft/payload Pre-Ship Review prior to EGS handover and acceptance.

8.3.3 Payload Safety Reviews (PSRs)

PSRs will be phased over time and require information to perform analysis efforts that include, but are not limited to, payload handling and physical processing hazards, RF interference, ascent hazard, debris characteristics for input to unique range safety data, joint loads and environments, payload recontact analysis (nominal mission scenarios), etc. The spacecraft/payload will be required to participate in these and support data requests from the Payload Safety Review Panel (PSRP). Flight and ground safety requirements will be documented in the SRD and will form the basis of verification according to the corresponding DVO. See Table 8.1 for a more detailed list of typical data shared at PSRs.

8.3.4 Launch Site Integration Reviews (LSIRs)

EGS Program LSIRs have been developed to align with the payload's milestone review schedule (PDR, CDR, etc.). The processes build upon and apply best practices and lessons learned to reduce program and technical risk while improving mission success. Iterations of these reviews (LSIR 1-LSIR 4) will be held in parallel with external program reviews. LSIRs ensure feasibility and compatibility of the payload with EGS ground operations as the integration process matures. Prior to arrival of flight equipment for processing at KSC, all related EGS facilities, support equipment (such as GSE) and ground systems will be readied for receiving and processing flight hardware and software. Incoming support equipment (GSE) must go through an acceptance process for use at KSC.

LSIR 1 will demonstrate EGS's capability to support the Payload Customer during its processing at KSC. This will also be a review of preliminary payload requirements and Non-Standard Services (NSS). LSIR 2 will be a review of the baselined requirements and support services. LSIR 3 will serve as a review of the finalized requirements. The Baselined LSSRD will be a reviewable document and the PRD will be in development. Lastly LSIR 4 will review all finalized commitments, ensure that the PRD has been sent to suppliers, and the Final LSSRD will be available for review. LSIR 4 will ensure EGS compliance with Payload Customer requirements have been verified and any residual risks have been deemed acceptable for Customer processing at KSC.

8.3.5 Spacecraft/Payloads Verification Complete

After completion of the spacecraft/payload's hardware and software build and testing, the spacecraft/payload will submit to SPIE all verification compliance deliverables, including test verified models, analysis, etc. through the DVO process. There may be cases where verification will need to remain open until after the spacecraft/payload has been shipped to KSC and fully integrated into the vehicle by EGS. The spacecraft/payload will provide a listing of any approved waivers to engineering and safety requirements. SPIE will maintain a safety verification tracking log that identifies open safety verification methods, status and expected closure. This information will provide inputs to conduct a successful Pre-Ship Review.

8.3.6 Ground Operations Review (GOR)

The EGS Program GOR provides a forum for coordinating launch site activities and resolving operational issues and concerns. Topics include, but are not limited to, ground flow activities, timeline modification for mission-unique spacecraft/payload operational considerations, LSSRD definition for launch site facilities and GSE, hazardous operations and ground test requirements.

8.3.7 Pre-Ship Review

The Pre-Ship Review is conducted at the spacecraft/payload facility prior to shipment of the payload hardware to the launch site and typically after successful completion of all flight and ground system element verifications. After completion of spacecraft/payload hardware and testing, spacecraft/payload will submit their verification compliance deliverables, test-verified models, analyses to the respected external program through their DVO process. SPIE, with EGS participation, will perform Pre-Ship Reviews for payload and mission dependent equipment using integrated deliverables. A successful PSR serves as formal approval for shipment of payload hardware and mission dependent equipment to KSC for turnover and acceptance

8.3.8 Flight Readiness Review (FRR)

The Flight Readiness Review (FRR) process will certify readiness for flight in the form of approved Certificate of Flight Readiness (CoFR). A sequence of CoFR reviews will be conducted prior to final rollout of SLS to the pad consisting of organizational, Element, Program and ESD Pre-FRRs which will culminate in the Agency FRR. The Agency FRR will provide a final pre-launch assessment of the integrated SLS-spacecraft/payload system and launch facility readiness, including open work and risks to the readiness of flight and ground systems, the ER and Western landing and recovery, network assets, personnel, and procedures necessary to perform launch through landing and recovery operations. The sequence of CoFR reviews will ensure that the spacecraft/payload, SLS systems, facilities, GSE and all supporting organizations are ready and committed to support final launch preparations, countdown and launch. SPIE will represent the spacecraft/payload during this sequence of CoFR related reviews.

APPENDIX A
ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACM	Access Control Monitor
ADMIT	Accommodation Demand Model Input Template
AU	Avionics Unit
BL	Baseline
BCDS	Broadband Communication Distribution System
BTU	British Thermal Unit
C	Celsius
C3	Characteristic Energy (km^2/s^2)
C3R	Command, Control, Communication and Range
CAA	Crew Access Arm
CAD	Computer-Aided Design
CCAFS	Cape Canaveral Air Force Station
CCTV	Closed Circuit Television
CDR	Critical Design Review
CD&SC	Communications Distribution and Switching Center
CG	Center of gravity
CM	Crew Module
COTS	Commercial Off The Shelf
CPL	Co-manifested Payload
CR	Change Request
CT	Crawler-Transporter
CWA	Clean Work Area
C&DHS	Command and Data Handling System
D	Draft
DCSS	Delta Cryogenic Second Stage
DRO	Distant Retrograde Orbit
DVO	Detailed Verification Objective
ECS	Environmental Control System
EELV	Evolved Expendable Launch Vehicle
EGS	Exploration Ground Systems
EGSE	Electrical Ground Support Equipment
ELV	Expendable Launch Vehicle
EM	Exploration Mission

EMC	Electromagnetic Capability
EME	Electromagnetic Environment
ER	Eastern Range
ESD	Exploration Systems Development
ESPA	EELV Secondary Payload Adapter
EUS	Exploration Upper Stage
EUSU	Exploration Upper Stage Umbilical
F	Fahrenheit
FOD	Flight Operations Directorate
FPR	Flight Performance Reserve
FR	Firing Room
FRR	Flight Readiness Review
ft	Foot (Feet)
ft/sec	Feet per Second
ft^2	Square Feet
ft^3	Cubic Feet
GCS	Ground Cooling System
GFAS	Ground & Flight Application Software
GHe	Gaseous Helium
GN2	Gaseous Nitrogen
GO2	Gaseous Oxygen
GOR	Ground Operations Review
GSE	Ground Support Equipment
HazGas	Hazardous Gas
HB	High Bay
HEPA	High-Efficiency Particulate Air
HEOMD	Human Exploration and Operations Mission Directorate
HPF	Hazardous Processing Facility
HVAC	Heating, ventilation, and air conditioning (HVAC)
ICD	Interface Control Document
ICPS	Interim Cryogenic Propulsion Stage
IMLEO	Injected Mass at Low Earth Orbit
in	Inch
IOP	Ignition Overpressure
IRD	Interface Requirements Document
I_{sp}	Specific Impulse
ISO	International Organization for Standardization

ISPE	Integrated Spacecraft and Payload Element
ISS	International Space Station
JEL	Jacking, Equalization and Leveling
kg	Kilogram
KITS	Kennedy Integrated Test System
km	Kilometer
KNET	KSC Network
KSC	Kennedy Space Center
kVA	kilovolt amperes
lbm	Pounds Mass
LC	Launch Complex
LCC	Launch Commit Criteria
LCS	Launch Control System
LEO	Low-Earth Orbit
LH_2	Liquid Hydrogen
LOX	Liquid Oxygen
LSIM	Launch Site Integration Manager
LSIR	Launch Site Integration Reviews
LSP	Launch Service Program
LSSRD	Launch Site Support and Requirements Document
LV	Launch Vehicle
LVSA	Launch Vehicle Stage Adapter
m	Meter
m/s	Meters per Second
m^3	Cubic Meters
MAX	Maximum
MCR	Mission Concept Review
MDE	Mission Dependent Equipment
MECO	Main Engine Cut-Off
MGA	Mass Growth Allowance
Min	Minute
MIN	Minimum
ML	Mobile Launcher
MLB	Mobile Launcher Base
MLI	Multilayer Insulation
MLT	Mobile Launch Tower
MOSB	Mission Operations Support Building

MPE	Maximum Predicted Environment
MPG	Mission Planner's Guide
MPPF	Multi Payload Processing Facility
MPPU	Mini Portable Purge Units
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
nm	Nautical Mile
NRHO	Near Rectilinear Halo Orbit
NSS	Non Standard Service
NVR	Non-Volatile Residue
OIS	Operational Information System
OML	Outer Mold Line
OPR	Office of Primary Responsibility
OMRS	Operations and Maintenance Requirements Specifications
OSA	Orion Stage Adapter
OISD	Operational Intercommunication Systems-Digital
OSMU	Orion Service Module Umbilical
OTV	Operational Television
P	Preliminary
PAF	Payload Attach Fitting
PAS	Payload Accommodation Subsystem
PAWS	Paging and Area Warning System
PDR	Preliminary Design Review
PHSF	Payload Hazardous Servicing Facility
PIA	Payload Integration Agreement
PIA	Payload Interface Adapter
PIM	Payload Integration Manager
PLA	Payload Adapter
PLF	Payload Fairing
PMR	Program Manager's Reserve
POCS II	Photo Optical Control System II
PPL	Primary Payload
PPF	Payload Processing Facility
PRD	Program Requirements Document
psi	Pound per square inch
PSM	Payload System Mass
PSR	Payload Safety Review

PSS	Payload Separation System
RH	Right Hand
RF	Radio Frequency
RFTS	Radio Frequency and Telemetry Station
ROAP	Removable Overhead Access Platform
RSRM	Reusable Solid Rocket Motor
SA	Spacecraft Adapter
SCCS	Spaceport Command and Control System
sec	Second
SI	Second Stage Engine Cut-off
SECO	International System of Units
SIR	System Integration Review
SLS	Space Launch System
SM	Science Mission
SP	Spacecraft/payload
SPDS	Secondary Payload Deployment System
SPIR	Spacecraft/Payload Integration Review
SPL	Secondary Payload
SPIE	Spacecraft/Payload Integration & Evolution
SRD	System Requirements Document
SRB	Solid Rocket Booster
SRR	Systems Requirement Review
SRS	Shock Response System
SS	Sound Suppression
SSPF	Space Station Processing Facility
t	Metric Tons
TAIR	Test and Assembly Inspection Record
T&CD	Timing and Countdown Subsystem
TLI	Trans-Lunar Injection
UPS	Uninterruptible Power Supply
USA	Universal Stage Adapter
VAB	Vehicle Assembly Building
VAC	Volts Alternating Current
VCF	Vapor Containment Facility
W	Watt
WAD	Work Authorization Document

APPENDIX B
ACCOMMODATION DEMAND MODEL INPUT TEMPLATE (ADMIT) SURVEY

Completing the ADMIT survey is the first step in defining requirements, interface details, and preliminary safety data for spacecraft/payload that could be manifested on SLS. If a spacecraft/payload unique Interface Requirements Document (IRD) or equivalent already exists, it may replace an ADMIT response if the needed data is contained there. It is understood that a specific response to some ADMIT questions may not be possible due to mission/design maturity. Other information or constraints considered pertinent by the spacecraft/payload should also be included in addition to an ADMIT response. Spacecraft/payload ADMIT survey and/or IRD responses can be submitted to NASA-slspayloads@mail.nasa.gov. A representative from the SLS SPIE office will contact you to discuss your spacecraft/payload requirements in greater detail.

1.0 GENERAL INFORMATION

1.1 Spacecraft/Payload Designation

Provide the name of the spacecraft/payload, including definition of any acronyms used.

1.2 Contact information

Provide the name of the spacecraft/payload sponsoring organization. Provide names and contact information, including mailing address, email address, and telephone number for the Principal Investigator and Project Manager.

1.3 Proprietary data restrictions

Identify any systems that have proprietary data restrictions, as well as the rationale behind the proprietary designation.

1.4 International Partnerships

Identify the names and nationalities of any spacecraft/payload partners or participants that are based outside of the United States.

2.0 SPACECRAFT/PAYLOAD CHARACTERISTICS

2.1 SLS Spacecraft/Payload Type

Choose one: SLS Primary Payload, SLS Co-manifest Payload, SLS Secondary Payload

2.2 General Mission Description

Provide a general description of the spacecraft/payload and its systems, including mass properties and overall envelope dimensions. Provide any sketches/renderings if available. Describe the destination and mission / goals.

2.3 Development Schedule Planning

Provide the current spacecraft/payload development schedule planning (e.g., estimated dates for MCR, SRR, PDR, CDR, estimated launch date, etc.).

2.4 Physical Characteristics

Provide mass, dimensions, any access requirements for different ground processing phases at different facilities at KSC.

2.5 Propulsion Systems

Describe the propulsion systems used by the spacecraft/payload. For each propellant, provide the type, quantity, and loading timeline. Define any pressure and temperature constraints.

2.6 Other Fluid Systems

Describe the characteristics for all other spacecraft/payload fluids (gases, pneumatics, hydraulics, etc.). For each fluid, provide the fluid name, quantity of each fluid, and loading timeline. Define any pressure and temperature constraints.

2.7 Internal Volumes

Describe any spacecraft/payload internal volumes and identify whether these volumes are pressurized or vented during flight.

2.8 Power Systems

Describe the electrical power supply systems used by the spacecraft/payload.

- Describe battery systems used. Description should include battery type, quantity, battery location, charging approach and any environmental or handling constraints.
- Describe the number and size of any solar arrays in the launch configuration.
- If the spacecraft/payload incorporates any other power systems, describe them here.

2.9 RF Transmitters and Receivers

Describe the numbers and types of RF transmitters and receivers. Describe general operational timeline including on-pad, ascent, and on-orbit operations for the RF systems.

2.10 Other Systems

Describe any deployable systems used during the ascent/on-orbit phase. Describe any laser systems employed. Describe any radioactive devices contained on the spacecraft/payload, including type and quantity of material. Describe any pressure vessels employed, and their location on the spacecraft. Describe any explosive devices installed (pyros, separation system, etc.). Describe any unique features that may pose a hazard to crew or ground personnel or require specific processing environments or constraints (temperature, shock, vibration, or acoustic). If the spacecraft/payload will be flying as part of a crewed mission, list any systems planned to activate prior to Orion separation.

2.11 Contamination Control / Planetary Protection

Describe any contamination control requirements or planetary protection constraints during processing and ascent.

3.0 MISSION PARAMETERS

3.1 Mission Description

Describe the overall mission, destination, mission timeline, and objectives. Include separation targets, desired launch times and dates, launch window, and trajectory.

3.2 Spacecraft/Payload Constraints

List any spacecraft/payload constraints on the mission parameters (e.g., sun angle constraints, telemetry, eclipse, maximum angular acceleration, spin rates, or other constraints).

4.0 INTERFACE REQUIREMENTS TO SLS

4.1 Mechanical Interfaces and Access

Identify the preferred Payload Adapter including anticipated separation system and identify whether it will be spacecraft/payload provided or SLS provided. Describe any access required post encapsulation including planned location on spacecraft/payload and timeline for access).

4.2 Ground Electrical/Fluid Interfaces

Describe what electrical, signal, data or fluid needs are required through the mobile launch tower umbilical.

4.3 Flight Command and Data Interface

Describe any ascent flight commands or data telemetry needs from the vehicle.

5.0 HANDLING AND PROCESSING

5.1 Transportation and Arrival requirements

Describe any transport / arrival support requirements. Include a high level transportation plan and who is providing the service to what location.

5.2 Spacecraft Ground Environment

Describe the ECS/GN2 Purge during encapsulation, transport to/from VAB, in VAB, and On-Pad as well as spacecraft/payload Purge Outage requirements. List any Air Impingement Limits and Verification requirements. Specify any Contamination Control / Planetary Protection requirements or concerns.

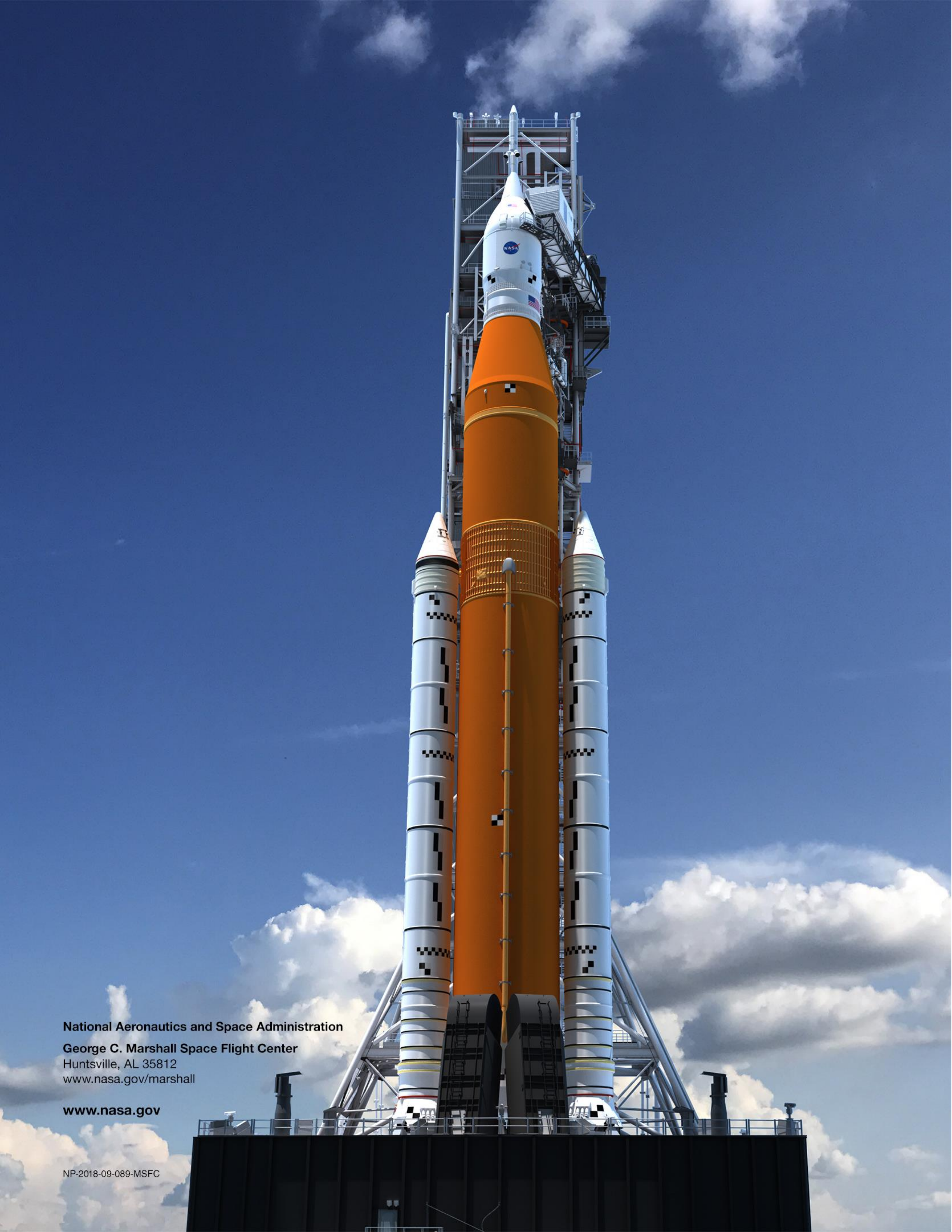
5.3 Launch Site Ground Processing & Operations

- Describe high level Processing Facility requirements, including the planned approach for spacecraft buildup at KSC or at private facility, as well as dwell time and processing timeline. Include an Operations Flow Chart, detailed sequence of operations, and all spacecraft related launch site activities.
- Identify any hazardous processes such as fueling or ordinance installation. If fueling is involved identify the type of the fuel utilized.
- Describe any test you will need to conduct at KSC (i.e. Structural test, fit test, etc.). Specify any Ground Support Equipment that will be utilized and its electrical power needs.

- Additional Services – Identify any other services or requirements not previously mentioned. This could include but is not limited to sensitive security concerns that are specific to the spacecraft, power being supplied during rollout, power being supplied at VAB or Pad, power required during launch/ascent, communications/data requirements, purge requirements, thermal requirements, cleanliness requirements, unique mounting requirements, or defining any necessary post encapsulation access requirements.

5.4 Flight Operations

- Prelaunch– describe the location of the spacecraft/payload operations control center and describe any mission critical interface requirements.
- Launch thru spacecraft/payload Separation– describe the uplink requirements, describe the downlink requirements, and describe the systems activated prior to spacecraft/payload separation.
- Post-spacecraft/payload Separation– describe the spacecraft/payload tracking station and describe any acquisition assistance requirements.



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