



SPACE LAUNCH SYSTEM (SLS) MISSION PLANNER'S GUIDE

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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 assessment. Like ELV Programs, once approved to fly on SLS, specific payload requirements will be defined in unique documentation. 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. The SLS Block 1 configuration will be flown once to test and validate key components of the Orion/SLS system for recurring SLS Block 1B flights. Therefore, SLS Block 1 data may be used as a basis for some SLS Block 1B payload accommodations, associated environments, and flight availability; this will be clearly indicated in the SLS MPG where applicable. This SLS MPG will be updated as needed to reflect newly-baselined capabilities as the SLS Block 1B payload specific performance to destination, interfaces, and operational constraints mature.

Representative capabilities described within the SLS MPG are purely representative and are not necessarily indicative of Agency 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). 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 on a formal Change Request (CR). Proposed changes to this document shall be submitted via a CR to the ESD Control Board (ECB) for disposition. All such requests will adhere to the ESD Configuration Management Process defined in ESD 10005, ESD Configuration and Data Management Plan.

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2.0 DOCUMENT

2.1 Applicable Documents

The SLS Mission Planner's Guide is for reference only. Therefore, there are no applicable documents.

2.2 Reference Documents

The following documents contain supplemental information to guide the user in the application of this document.

MIL-STD-461F	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (10 December 2007)
NASA-STD-4003A	Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment (Baseline, 02-05-2013)
NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft (Baseline, 11-30-2016)
NP-2015-08-2018-HQ	NASA's Mission to Mars
NPD 2570.5	NASA Electromagnetic Spectrum Management (July 2011)
SLS-SPEC-159	Cross-Program Design Specification for Natural Environments (DSNE) (Revision D, November 4, 2015)
SLS-SPIE-HDBK-005	Space Launch System (SLS) Secondary Payload User's Guide (Baseline, February 6, 2015)

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3.0 SLS OVERVIEW

Scheduled for first launch in the 2018 timeframe, the NASA Space Launch System will support enhanced human space exploration by launching over 70 t or 154,000 lbm of payload to Low Earth Orbit (LEO), and then going beyond LEO for the first time in over 40 years. This capability is greater than any other contemporary launch vehicle and more than twice the payload capability of the Space Shuttle. NASA is developing the SLS in parallel with two other NASA exploration systems – the Orion Program and the Ground Systems Development and Operations (GSDO) Program. The Orion spacecraft is designed to carry astronauts on exploration missions into deep space. The GSDO Program is converting the facilities at NASA's Kennedy Space Center (KSC) into a next-generation spaceport capable of supporting launches by multiple types of vehicles.

Following the first flights of SLS, the vehicle will evolve over time to be capable of delivering significantly more payload to LEO and beyond. While SLS was specifically created to enable human space exploration, the vehicle will provide unique payload lift, volume, and operational flexibility for science and other missions of national importance. The benefits of these unique performance capabilities are shown in Figure 3-1.

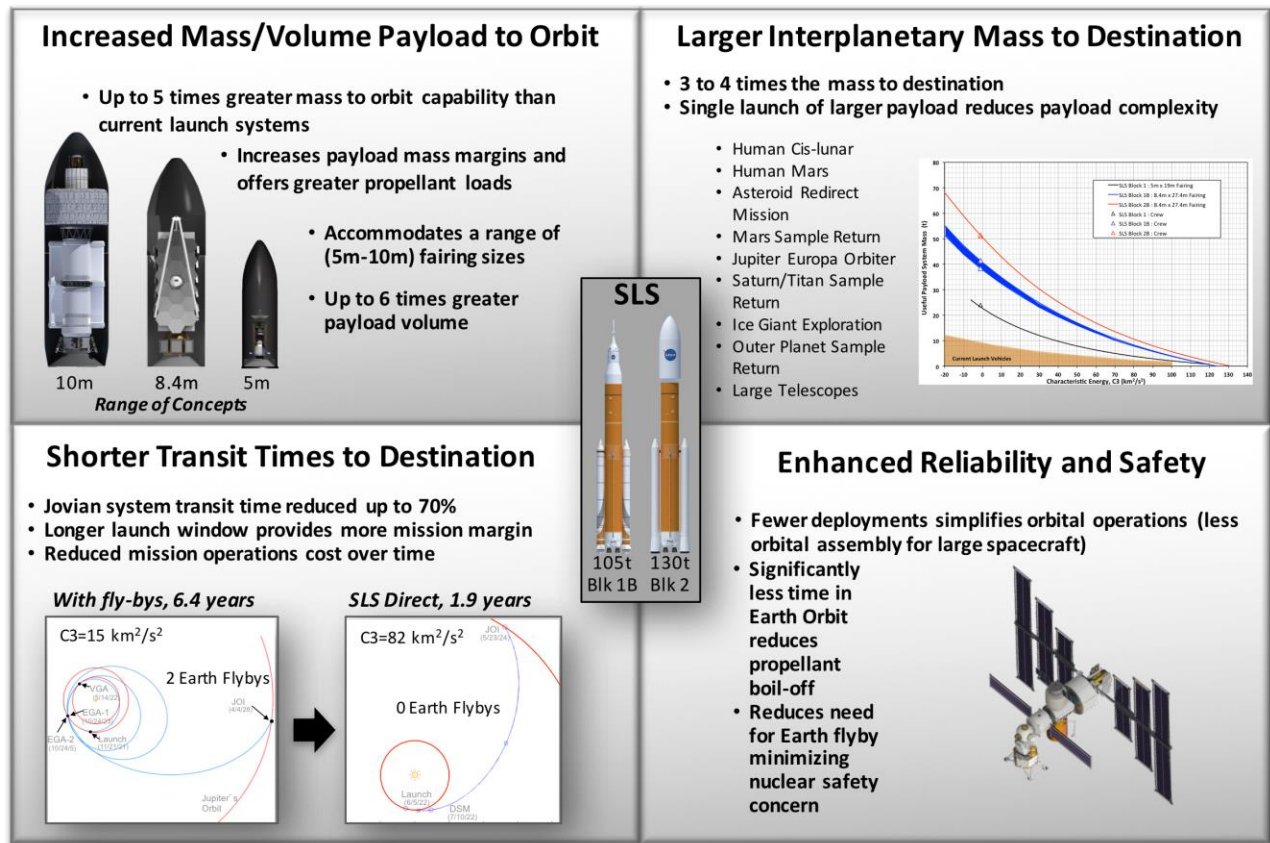


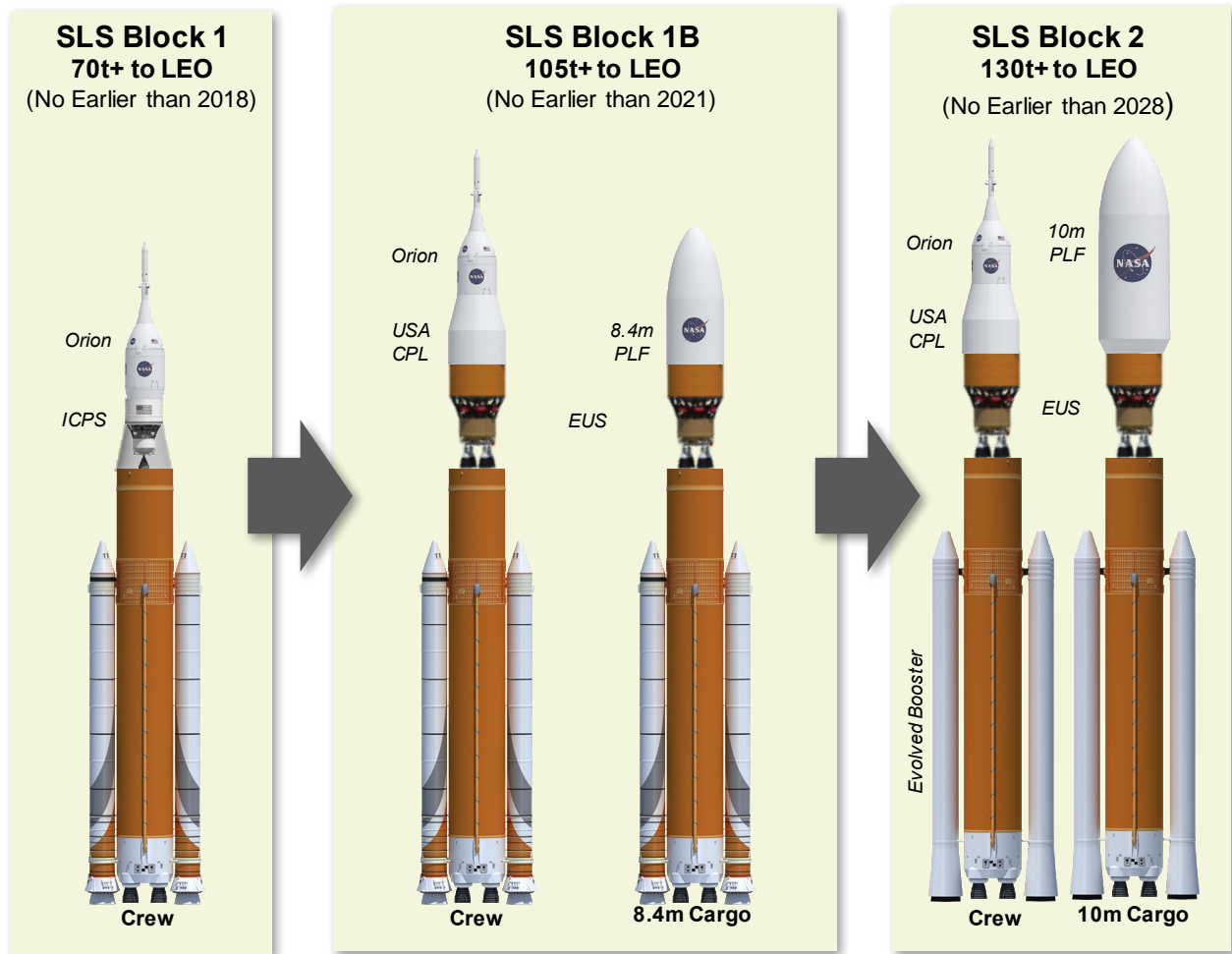
Figure 3-1. SLS Performance and Mission Capture Benefits

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3.1 SLS Block Configuration Descriptions

To achieve the performance necessary to ultimately deliver 130 t, or 287,000 lbm, payloads to LEO in support of future human lunar and Mars missions, three configurations or “Blocks” of phased vehicle development are envisioned for SLS. These are shown in Figure 3-2.



ICPS - Interim Cryogenic Propulsion Stage USA - Universal Stage Adapter CPL - Co-manifested Payload EUS - Exploration Upper Stage PLF - Payload Fairing

Figure 3-2. SLS Block Configurations

SLS Block 1 will provide a 70 t, or 154,000 lbm, payload delivery capability to LEO. This initial SLS test flight will accommodate an uncrewed Orion and a number of Secondary Payloads (SPL). Its purpose is to test SLS launch capabilities and Orion’s ability for safe translunar crew return; this is planned to be available no earlier than 2018 on Exploration Mission-1 (EM-1).

SLS Block 1B will utilize a new Exploration Upper Stage (EUS) to meet a 105 t, or 232,000 lbm, payload delivery goal to LEO. The crew version can accommodate Orion and a combination of Co-manifested Payload (CPL) and SPL using the Universal Stage Adapter (USA). The cargo version

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can accommodate a range of 8.4 m diameter Payload Fairings (PLF) and SPL. The first flight of Block 1B planned to be available no earlier than 2021.

SLS Block 2 utilizes the EUS and replaces the Block 1 Solid Rocket Boosters (SRB) with new Evolved Boosters (EB) to meet a 130 t, or 287,000 lbm, payload delivery goal to LEO. The crew version can accommodate Orion and a combination of CPL and SPL using the USA. The cargo version can accommodate a range of 8.4 – 10 m diameter PLFs and SPL. It is planned to be available no earlier than 2028.

SLS evolution from Block 1 to Block 1B is not backwards compatible; once the Block 1B configuration is in service, Block 1 will no longer be supported. Similarly, when NASA moves from a Block 1B to Block 2 configuration, all missions will use the Block 2 configuration and Block 1B will no longer be supported. Each of these SLS Block configurations may include unique equipment depending on spacecraft or payload accommodated such as payload fairings, adapters, attach fittings, separation systems, and services. For the purposes of this MPG, “spacecraft” refers to specialized payload such as Orion or science/instrument carrier, and “cargo” refers to SLS delivery missions that do not fly the Orion spacecraft.

SLS block configurations support an architecture development approach that minimize life cycle program costs, enables deep space missions, maintains critical skills, and transitions existing infrastructure effectively. The Shuttle-derived design takes advantage of resources established for the Space 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/LH₂) propellant infrastructure.

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.

- +X_{SLS} points aft down the vehicle axis.
- +Y_{SLS} points to the centerline of the right-hand (RH) booster.
- +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 +Y_{SLS} side of the launch vehicle) when looking at SLS with the Mobile Launcher Tower beyond. In rendered views of the vehicle, the – Y_{SLS} booster features a black band below the nose cone.

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3.3 SLS Block 1B Vehicle Configuration

While the SLS Program prepares for the single SLS test flight (Block 1 configuration), development work has already begun for evolution to the SLS Block 1B configuration. The development of the Exploration Upper Stage (EUS) will be required in order to reach and exceed the Block 1B SLS LEO capability of 105 t or 232,000 lbm. The Block 1 configuration of the Core Stage will be used with only minor subsystem changes for Block 1B. 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 3-4 details the Block 1B configuration that would fly with Orion as early as 2021. Figure 3-5 details the Block 1B Cargo configuration.

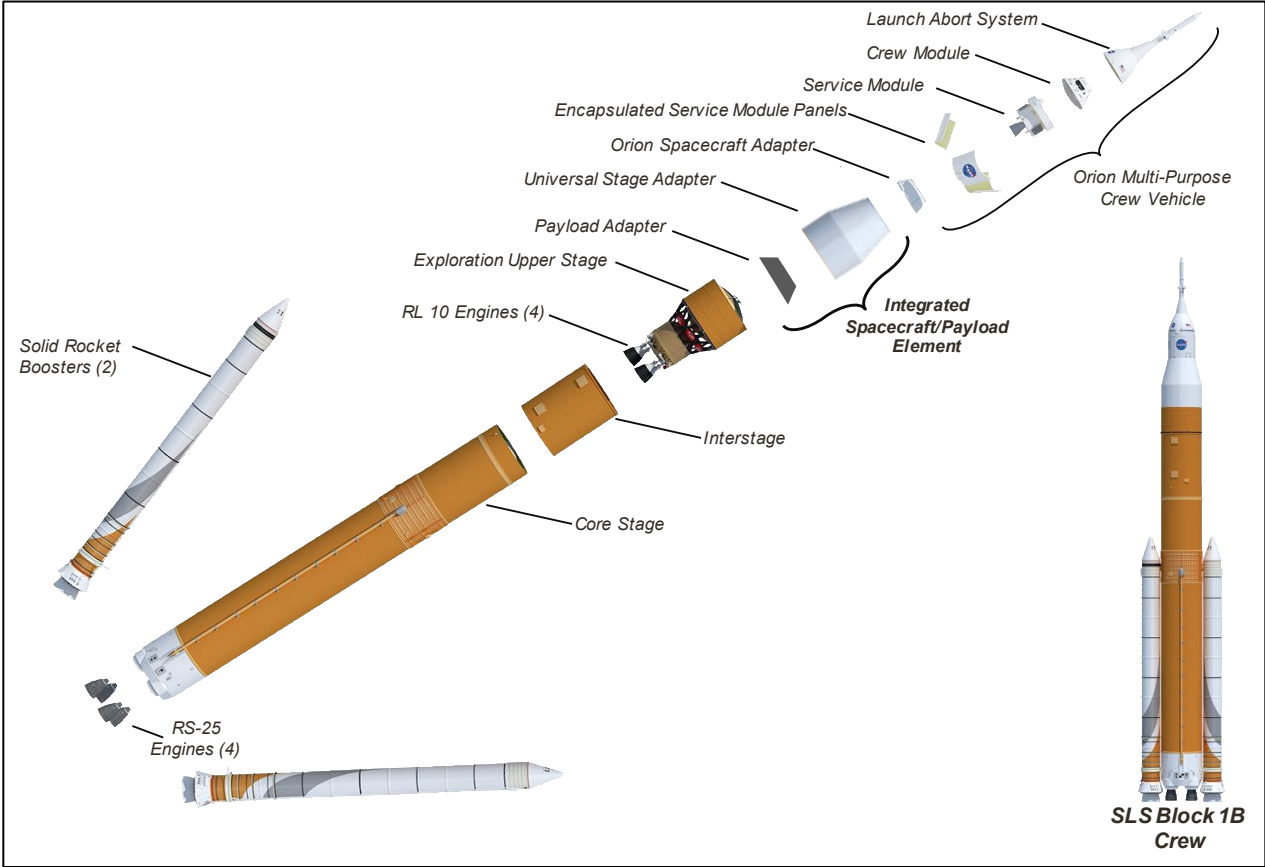


Figure 3-4. SLS Block 1B Crew Configuration

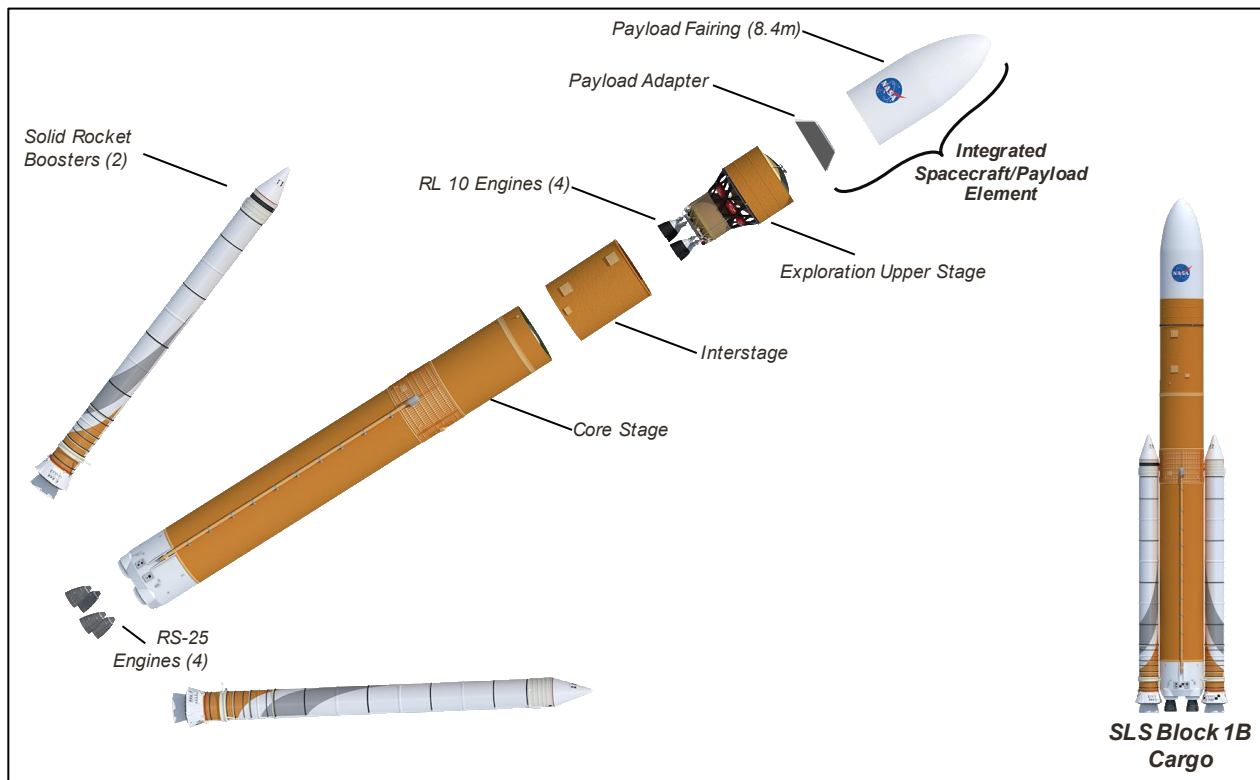


Figure 3-5. SLS Block 1B Cargo Configuration

3.3.1 SLS Block 1B 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 27.5 ft (8.4 m) diameter, 200 ft (61 m) tall stage forms the rocket's structural backbone. The Core Stage will hold the LOX/LH₂ propellants for the vehicle's RS-25 main engines. These human-rated engines support the SLS goal of safety, with a record of 100 percent mission success for the engines over 135 flights (over 400 successful engine in-flight burns) and have accumulated over 1 million seconds of ground hot-fire experience.

3.3.2 SLS Block 1B Solid Rocket Boosters

The majority of the thrust at launch for SLS will come from a pair of Solid Rocket Boosters (SRB), also of Space Shuttle Program heritage. The SLS Program is upgrading the Boosters from the four-segment version flown on the Shuttle to a more-powerful five-segment Booster. Shuttle heritage hardware and design includes forward structures, metal cases, aft skirt, and thrust vector control elements. The upgraded hardware and expendable design includes the solid rocket motor, avionics, and asbestos-free insulation.

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3.3.3 SLS Block 1B Exploration Upper Stage (EUS)

The Exploration Upper Stage (EUS) shown in Figure 3-6 is being developed to provide both ascent/circularization and in-space transportation for payloads. Four RL10-C3 LOX/LH₂ engines power the stage. On-board batteries provide electrical power while a passive thermal control system minimizes cryogenic propellant boil-off during the EUS lifetime. It interfaces to the SLS Core Stage via an 8.4 m diameter Interstage. The 8.4 m diameter EUS Forward Adapter interfaces to the payload element composed of a Payload Adapter/Universal Stage Adapter (USA). This payload element then provides a standard interface for Orion while providing encapsulation of Co-manifested Payloads or Secondary Payloads. For non-crewed missions, the EUS Forward Adapter provides an interface for various Payload Adapter/PLFs.

Note: for the purposes of this SLS MPG common names of stages, adapters, and fairings will include the diameter in meters (e.g., 8.4m PLF); this is compliant with international naming conventions.

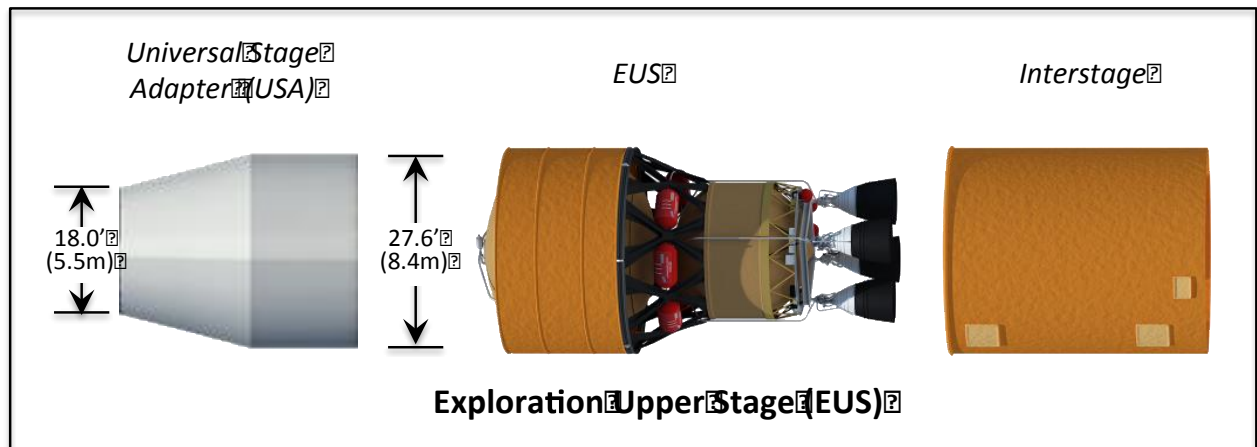


Figure 3-6. SLS Exploration Upper Stage (EUS)

3.4 SLS Block 2 Vehicle Configuration

Figure 3-7 details the SLS Block 2 vehicle configuration with the cargo version shown. The crew version would be similar with the Orion/USA/Payload Adapter taking the place of the PLF/Payload Adapter. The development of an Evolved Booster to replace the existing SRBs will be required in order to reach and exceed the Block 2 SLS LEO capability of 130 t, or 287,000 lbm, as early as 2028. This configuration would also take advantage of future developments in technology while providing unique enabling capabilities for human Mars missions.

3.4.1 SLS Block 2 Core Stage

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

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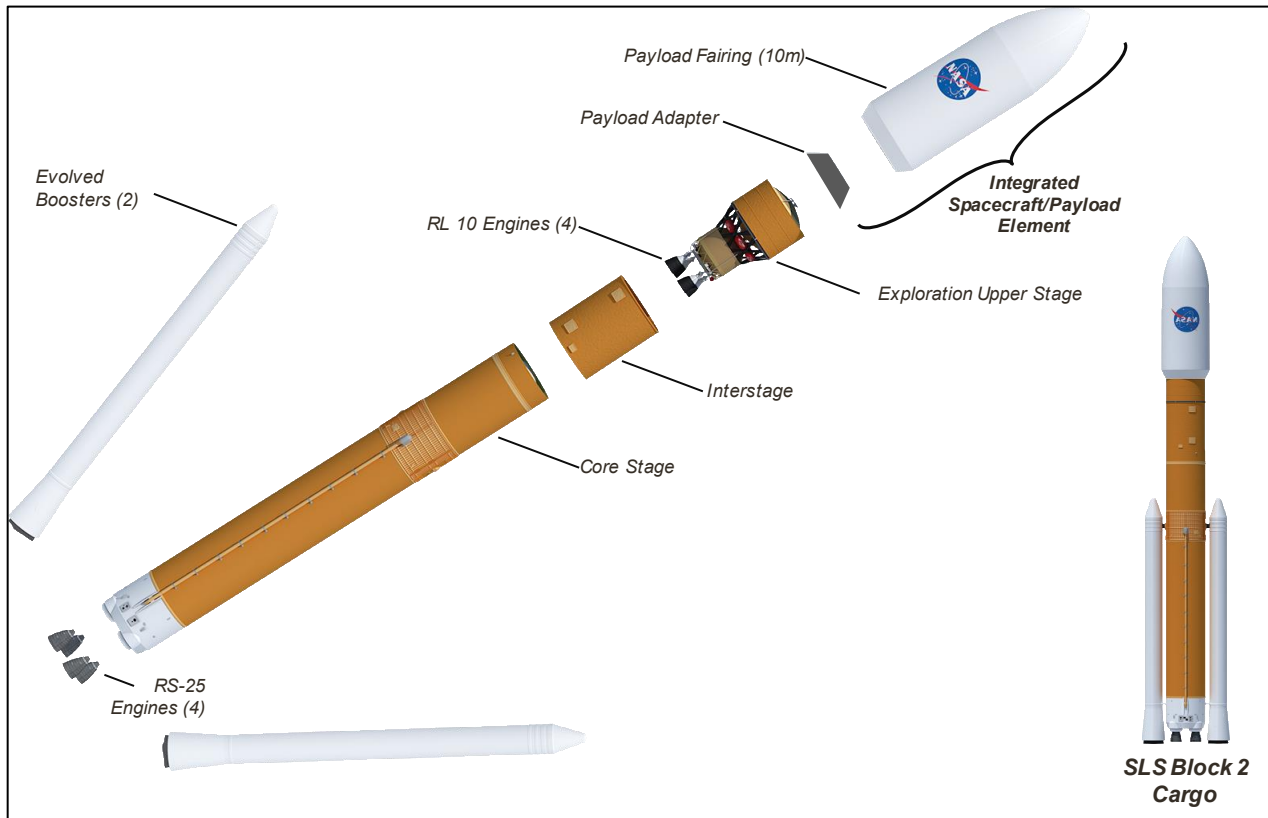


Figure 3-7. SLS Block 2 Cargo Configuration

3.4.2 SLS Block 2 Evolved Boosters

The five segment SRBs would be replaced with Evolved Boosters that provide significantly improved performance over that of the Block 1B configuration.

3.4.3 SLS Block 2 Exploration Upper Stage (EUS)

The EUS 8.4m Forward Adapter would be capable of accommodating either an Orion and Co-Manifested Payloads using a Payload Adapter/USA or Payload Adapter PLF. Currently Block 2 will accommodate 8.4 and 10 m diameter PLFs of varying lengths.

3.5 Initial SLS Development Timeline

The development timeline and progress to date for initial SLS launch (EM-1) and test of SLS and its associated ground infrastructure no earlier than 2018 is shown in Figure 3-8.

EM-2 will build on this development and flight test approach by adding a new EUS, USA or PLF, and Payload Adapter to create a SLS Block 1B for launch as early as 2021.

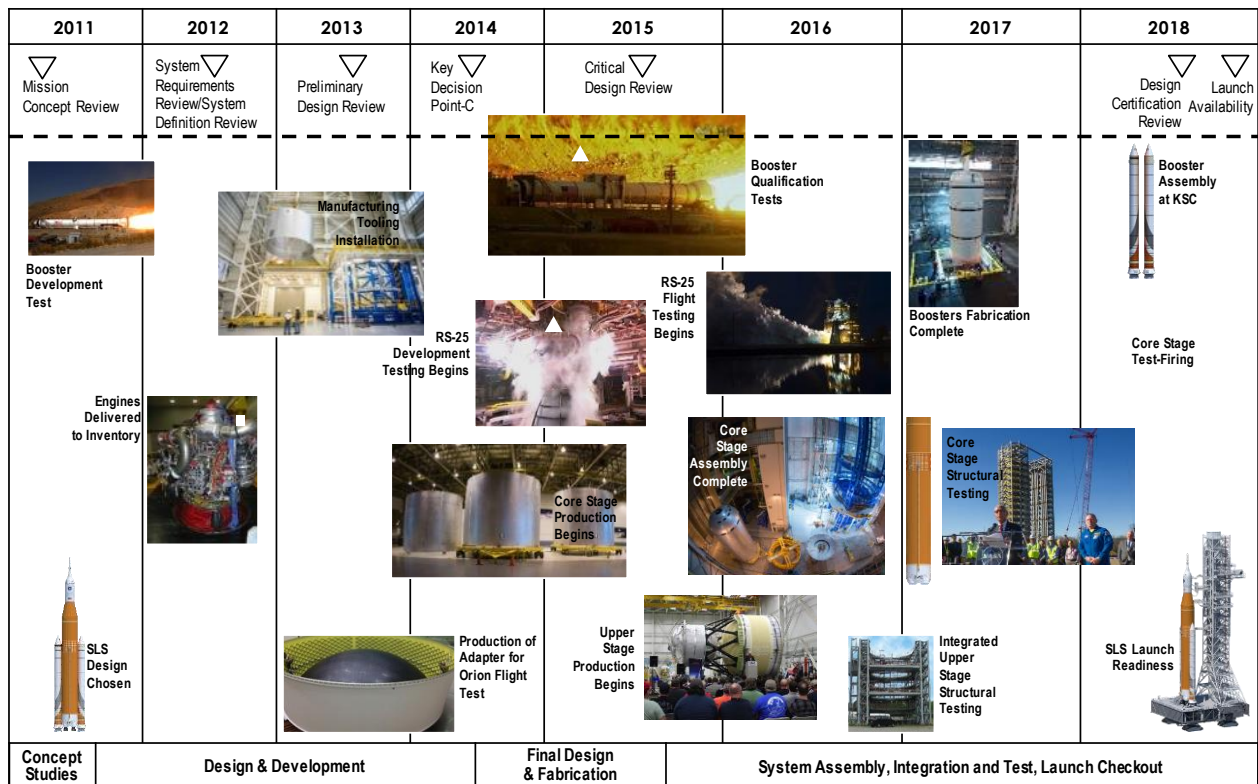


Figure 3-8. SLS Development Timeline and Progress in Support of First Flight (EM-1)

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4.0 SLS MISSION DESIGN AND PERFORMANCE

4.1 Mission Trajectories and Performance Options

NASA's Journey to Mars passes through three thresholds, each with increasing challenges as humans move farther from Earth as shown in Figure 4-1.

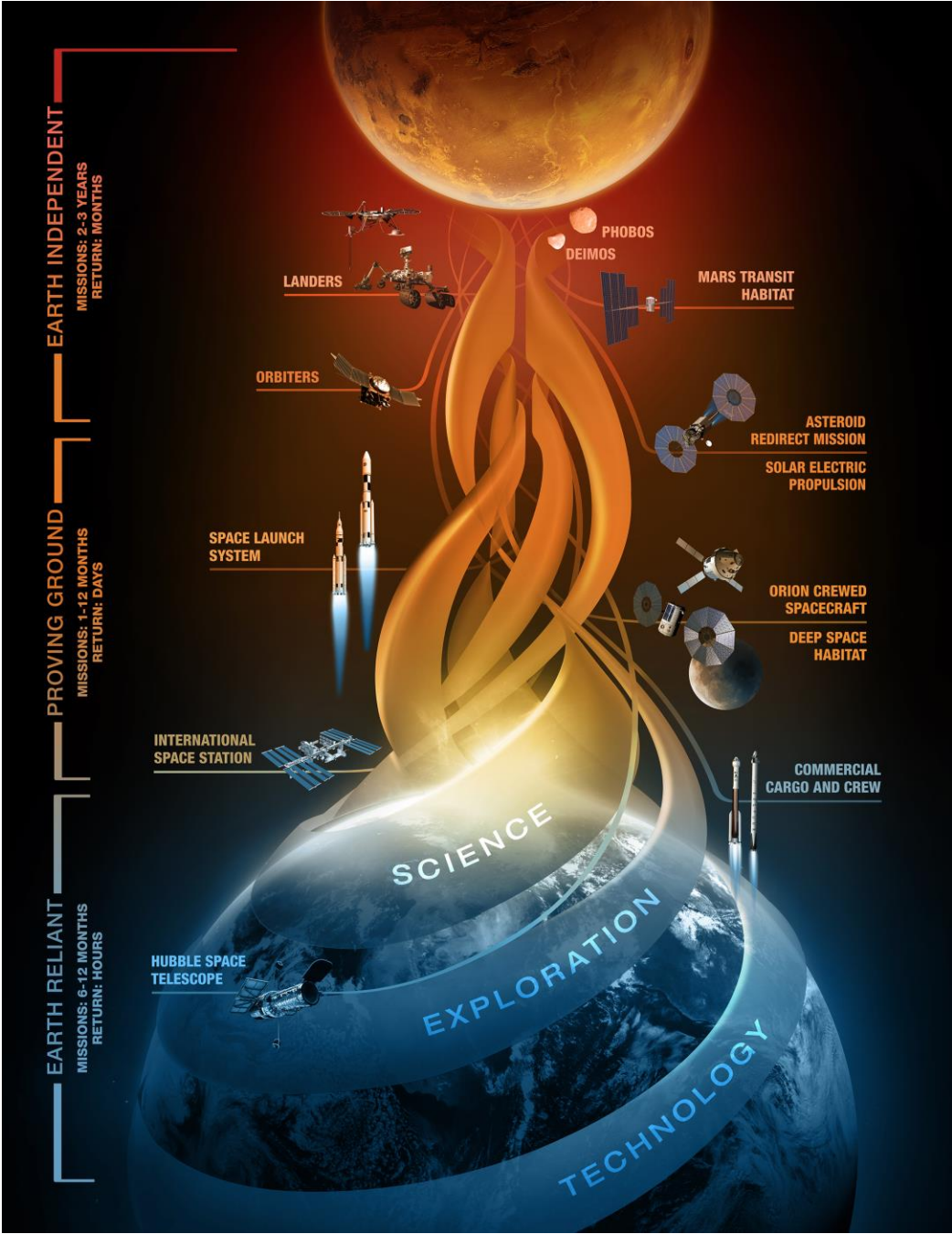


Figure 4-1. Three Phases of NASA's Journey to Mars

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Earth Reliant exploration is focused on research aboard the International Space Station. On the space station, we are testing technologies and advancing human health and performance research that will enable deep-space, long-duration missions.

- Human health and behavioral research
- Advanced communications systems
- Material flammability tests
- Extravehicular operations
- Mars mission class environmental control and life support systems
- 3-D printing
- Material handling tests for in-situ resource utilization demonstrations

In the Proving Ground, NASA will learn to conduct complex operations in a deep space environment that allow crews to return to Earth in a matter of days. Primarily operating in cislunar space, NASA will advance and validate capabilities required for human exploration of Mars.

- A series of Exploration Missions, starting with EM-1, the first integrated test of SLS and Orion, anticipated in 2018
- The Asteroid Redirect Robotic Mission in 2020 that will collect a large boulder from a near-Earth asteroid, then ferry it to the Proving Ground and the Asteroid Redirect Crew Mission that will allow astronauts to investigate and sample the asteroid boulder
- An initial deep-space habitation facility for long-duration systems testing Autonomous operations, including rendezvous and docking and state of the art information technology solutions
- Concepts to minimize resupply needs through reduction, reuse, and recycling of consumables, packaging, and materials
- Other key operational capabilities required to become Earth Independent

Earth Independent activities build on what we learn on International Space Station and in cislunar space to enable human missions to the Mars vicinity, including the Martian moons, and eventually the Martian surface. With humans on Mars, we will be able to advance science and technology in ways only dreamed of with current robotic explorers. Future Mars missions will represent a collaborative effort among NASA and its partners—a global achievement that marks a transition in humanity's expansion as we go to Mars not just to visit, but to stay.

- Living and working within transit and surface habitats that support human life for years, with only routine maintenance
- Harvesting Martian resources to create fuel, water, oxygen, and building materials
- Leveraging advanced communication systems to relay data and results from science and exploration excursions with a 20-minute delay

Figure 4-2 describes nominal SLS Flight Destinations that support the three phases of the Journey to Mars: Earth Orbit, Lunar Vicinity, and Earth Escape.

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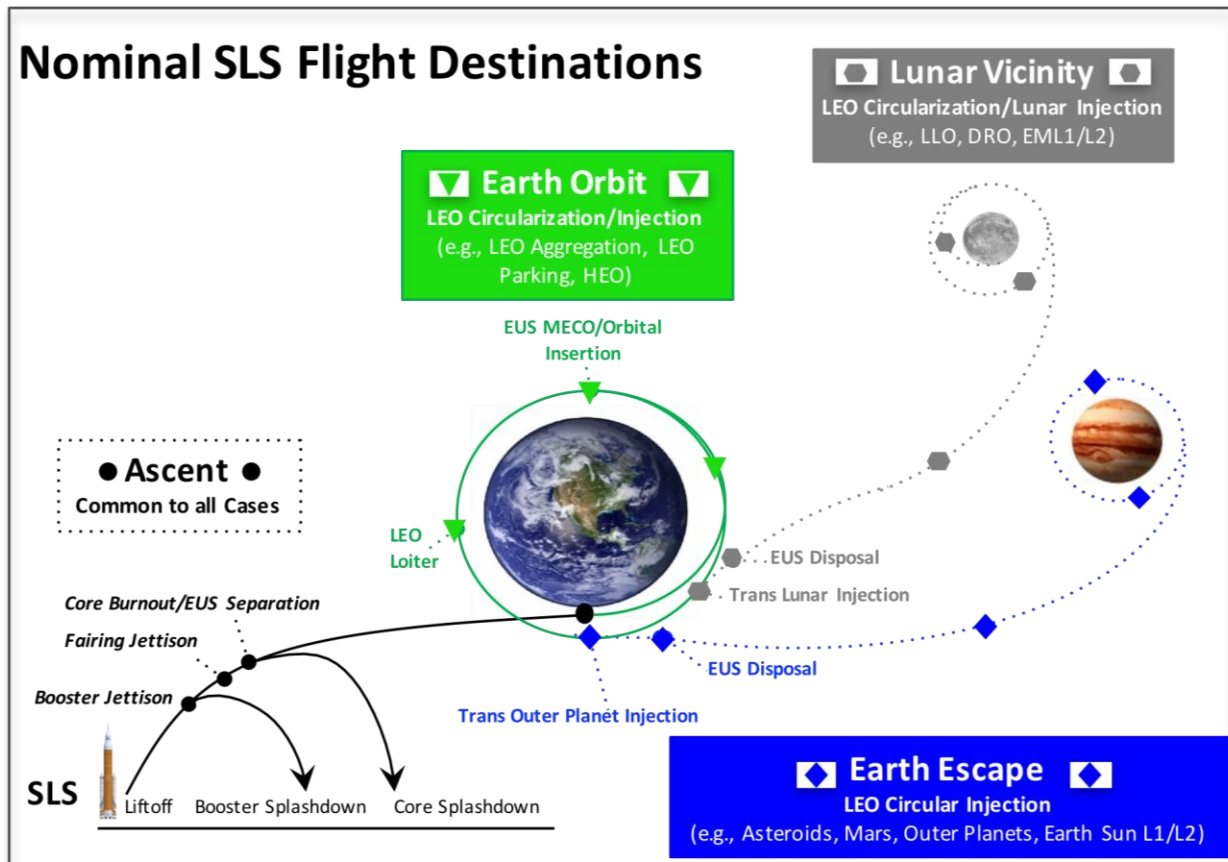


Figure 4-2. Nominal SLS Flight Destinations

4.1.1 Nominal Ascent Profile

The nominal ascent profile for a SLS Block 1B configuration is shown in Figure 4-3. The Block 1B EUS is used during ascent through Earth's atmosphere as well as to provide necessary in-space injection burns. The EUS can perform a number of engine starts, one of which is reserved for ascent. While this ascent profile is representative for all mission cases shown in Figure 4-2, a representative lunar injection of $C3 = -2.0 \text{ km}^2/\text{s}^2$ is also shown to provide a reference for altitude and velocity that could be provided for spacecraft/payload on a lunar trajectory.

Ascent profile geometries will vary based on several factors to 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 EUS drive the altitude and velocity vector at Core Stage burnout.

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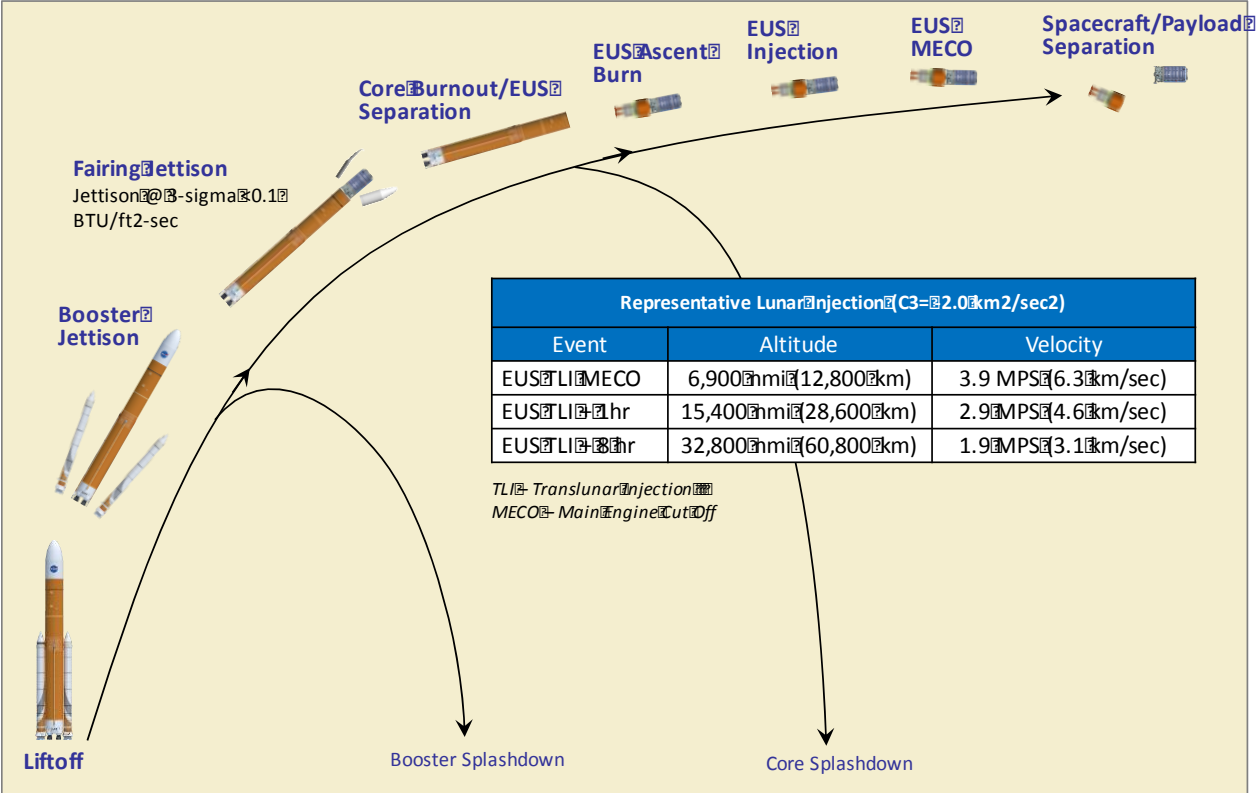


Figure 4-3. Nominal SLS Block 1B Ascent Profile

Note that unique ascent maneuvers 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 $0.1 \text{ BTU/ft}^2\text{-sec}$ ($1,136 \text{ W/m}^2$). Should the mission require a depressed trajectory, the fairing may be carried beyond the staging event and jettisoned during the EUS burn. Separation of the Boosters, and then later Core Stage separation, 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 2,000 nm (3,700 km).

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; the amount of 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. Crew mission payloads separate from EUS after Orion and USA have separated and obtained a safe distance; depending on mission requirements this can occur approximately from 5 to 8 hours from launch. Cargo mission payloads

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can separate from EUS post PLF separation; depending on mission requirements this can occur approximately from 1 to 8 hours from launch.

For LEO delivery 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 these missions, the payload spends limited time in LEO before the EUS initiates a Translunar Injection (TLI) burn. Figure 4-4 details a representative SLS Block 1B Lunar Fly-by mission profile, Near Rectilinear Halo Orbit (NRHO) where EUS performs a final portion of the ascent burn prior to injecting itself and its payload into LEO.

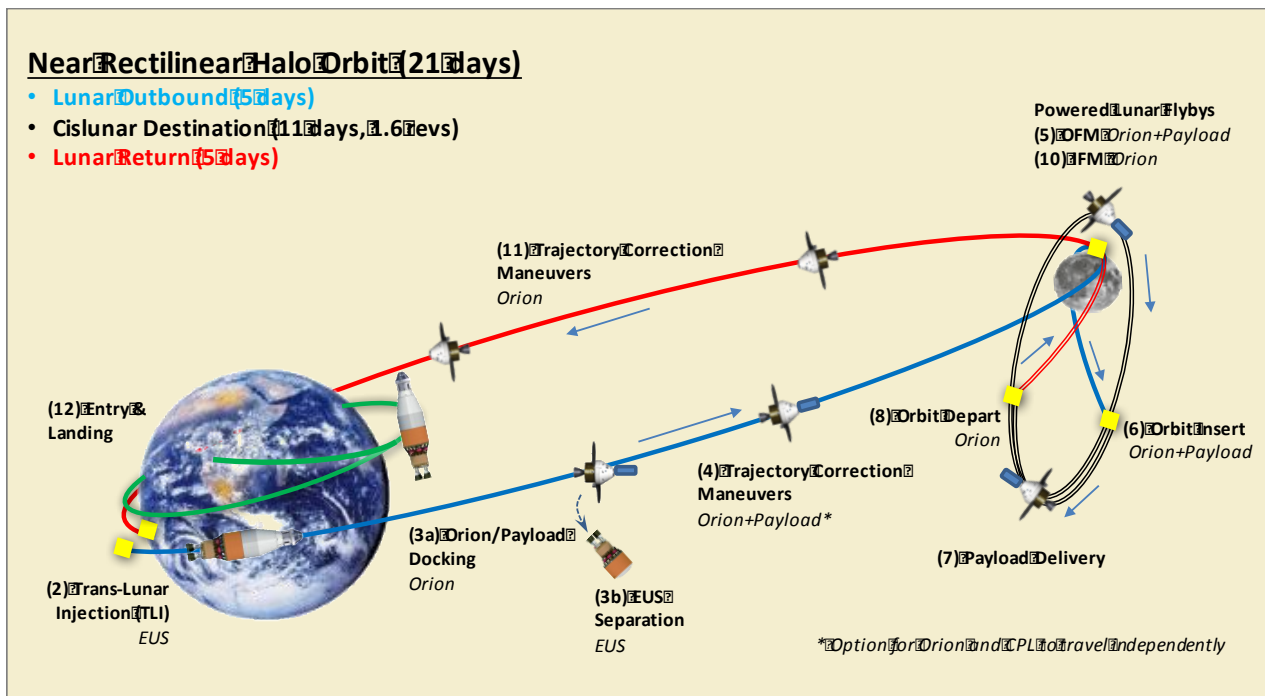


Figure 4-4. Representative SLS Block 1B Lunar Fly-by Mission Profile (NRHO)

The EUS can loiter in LEO for a predetermined amount of time before performing its final burn. The amount of time in orbit is dependent upon the mission's propulsive needs balanced against the degree of propellant boil off incurred in the orbit. The EUS then performs an injection burn to initiate a lunar transfer orbit. Crew mission payloads then separate from EUS after Orion and USA have separated and obtained a safe distance; depending on mission requirements this can occur approximately from five to eight hours from launch. Cargo mission payloads can separate from EUS post PLF separation; depending on mission requirements this can occur approximately from one to eight hours from launch.

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4.1.4 Earth Escape

Earth Escape missions are shown in Figure 4-2. After ascent and PLF separation, the SLS EUS performs the final portion of the ascent burn and injects itself and the associated payload into a circular or elliptical orbit. The EUS can loiter in this orbit for a predetermined amount of time before performing its final burn. Time in orbit is dependent upon propellant load balanced against the degree of propellant boil off incurred in the orbit. The EUS then performs an injection burn to initiate escape from Earth's gravitational influence. Depending on mission requirements this can occur anytime from one to eight hours from 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 4-5.

- Injected Mass at LEO (IMLEO)
 - Includes upper stage dry mass, unused upper stage fuel on-orbit, and Payload System Mass
- Payload System Mass (PSM)
 - Cargo configuration payload capability (fairing dependent)
 - $PSM = IMLEO - \text{Upper Stage Burnout Mass}$
 - Includes mass of spacecraft/payload and associated payload adapters required to interface to upper stage
- Useful Payload System Mass (Useful PSM*)
 - $\text{Useful PSM} = PSM - \text{Program Manager's Reserve (PMR)}$
 - 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)

Performance relative to spacecraft/payload delivery in conjunction with Crew missions (e.g., Co-manifested Payload) is handled differently than typically for ELV flights due to the addition of the Universal Stage Adapter. See Section 4.2.5 for CPL performance definitions.

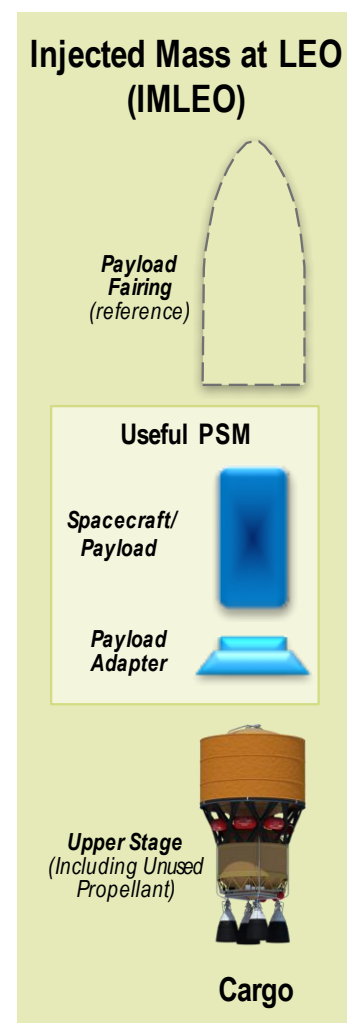


Figure 4-5. Mass Delivery Definition for Cargo Configurations

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4.2.2 SLS Performance Margin and Reserve Approach

Since SLS Block 1B and 2 configurations are still in development, all performance estimates include appropriate SLS vehicle performance reserves. These margins/reserves are detailed below and not available to payload (e.g., Useful PSM does not include any Program Manager's Reserve).

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 Program Manager's Reserve will be maintained throughout the development of SLS to ensure performance will meet the program goals despite potential increases in SLS inert mass or if the performance of its propulsion systems is lower than expected. In addition to these development phase margins, *Flight Performance Reserve (FPR)* is carried as an operational margin. This performance allocation is held in reserve by the vehicle to account for day-to-day variation in launch environments and the allowable variation in hardware performance. Payload performance predictions given in this document do not need to be decreased further to account for these margins.

4.2.3 SLS Earth Orbit Performance

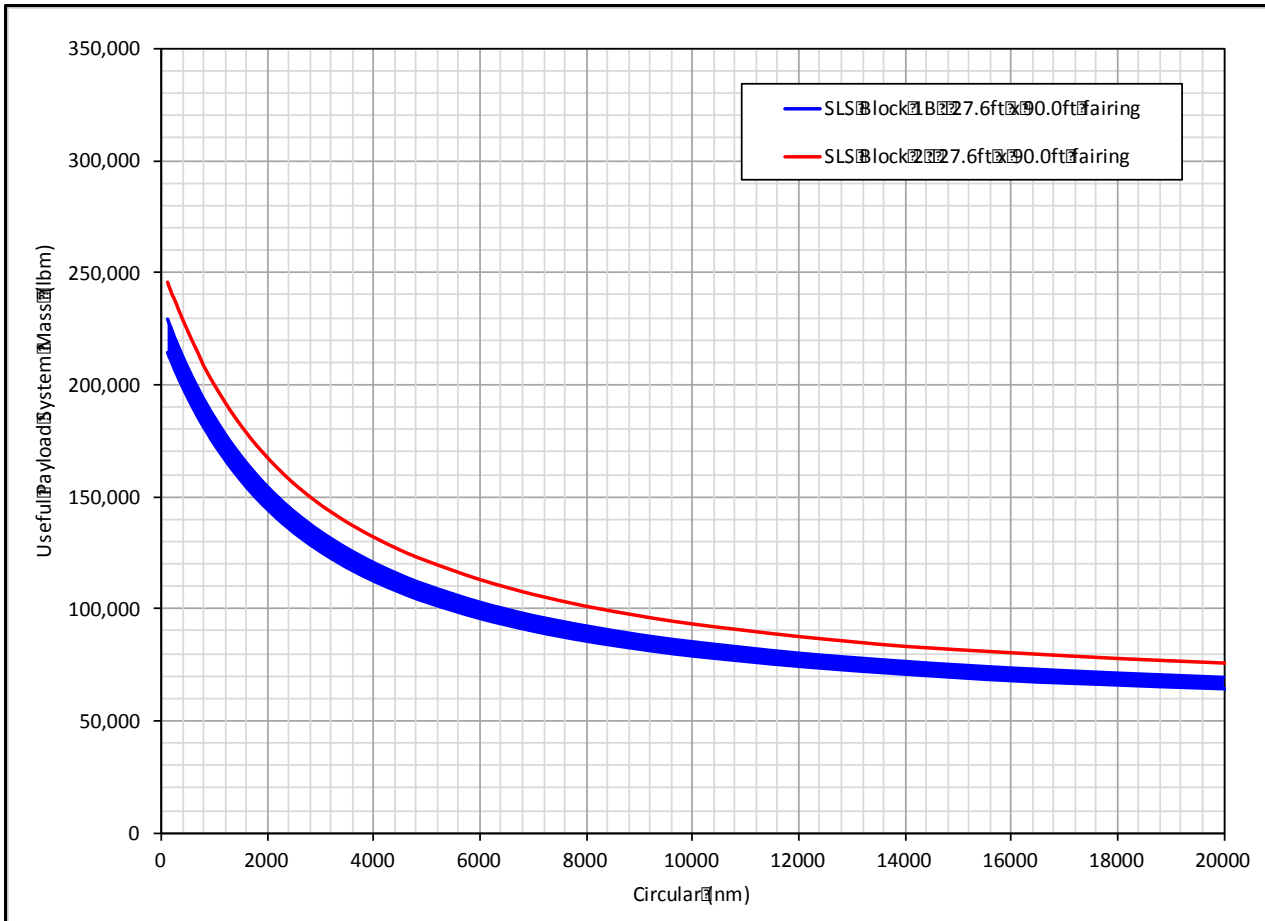
SLS Block 1B/2 performance to various Earth orbits is given in the Figures 4-6, 4-7, 4-8, 4-9, and 4-10. Unless otherwise noted, all orbits are to 28.5 degree inclination and are based on a 27.6 ft (8.4 m) diameter PLF that is 90 ft long (27.6 m); this is also known as the SLS 8.4m Long PLF. Since Core Stage disposal locations have not been 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 for more details.

Useful Payload System Mass to Circular Earth Orbits for Block 1B/2 configurations for an 8.4m Long PLF are shown in Figure 4-6 (English) and Figure 4-7 (metric). Both minimum and maximum performance cases are shown for Block 1B representing initial performance (minimum) and the performance goal (maximum) based on current configuration development studies. These are based on using the 8.4m Long PLF to establish a minimum performance for Block 1B (shorter fairings would increase performance available to payloads). SLS Block 2 performance is based on the current estimate of the minimum performance Evolved Booster concept using a representative PLF, in this case an 8.4m Long PLF.

Useful Payload System Mass to Elliptical Earth Orbits for Block 1B/2 configurations for an 8.4m Long PLF are shown in Figure 4-8 (English) and Figure 4-9 (metric). Propellant is offloaded from the EUS to maximize payload lift capability. Both minimum and maximum performance cases are shown for Block 1B representing initial performance (minimum) and the performance goal (maximum) based on current configuration development studies. SLS Block 2 performance is based on the current estimate of the minimum performance Evolved Booster concept.

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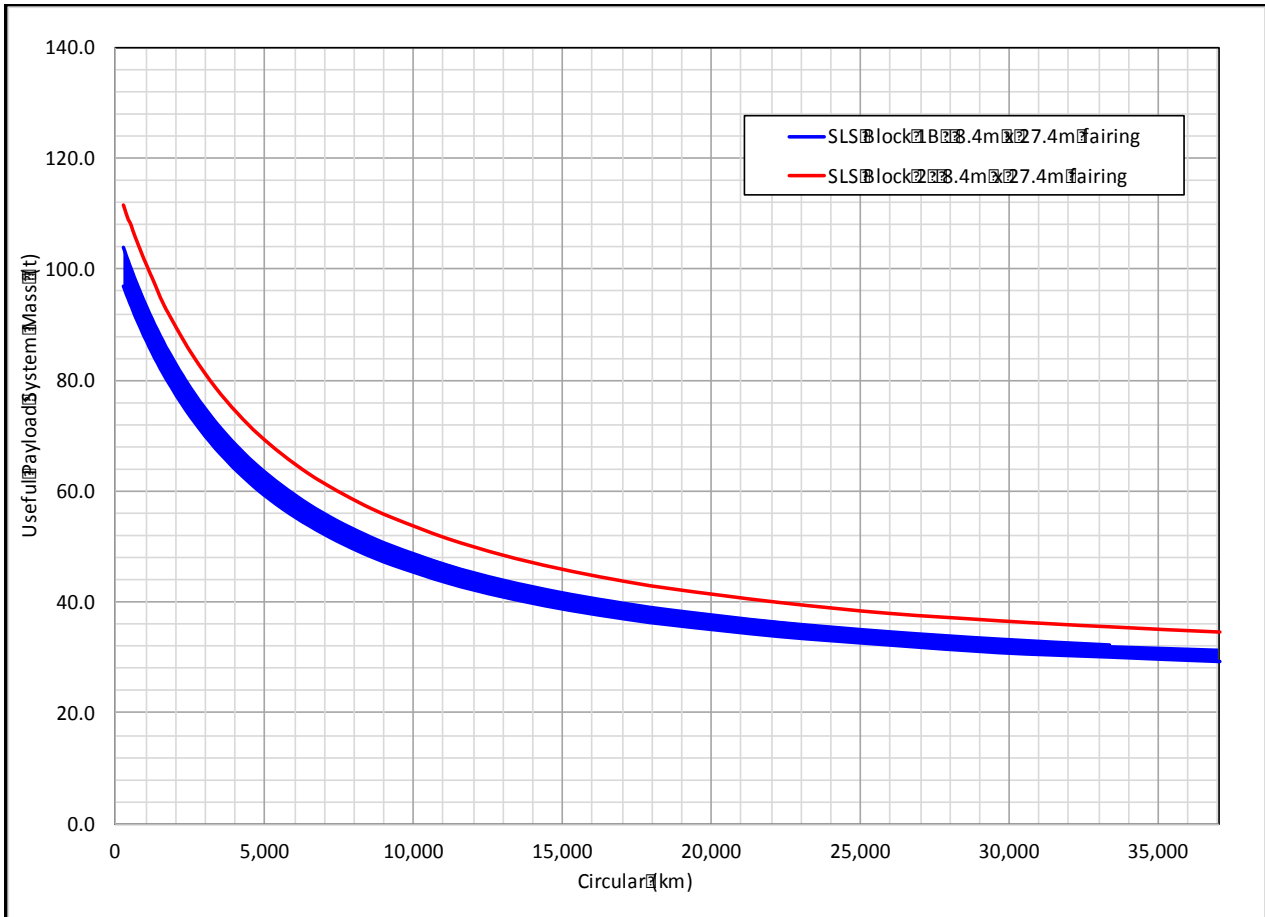


Apogee (nm)	SLS Block 1B 8.4m Dia. Fairing (lbm)		Apogee (nm)	SLS Block 1B 8.4m Dia. Fairing (lbm)		Apogee (nm)	SLS Block 2 8.4m Dia. Fairing (lbm)		Apogee (nm)	SLS Block 2 8.4m Dia. Fairing (lbm)	
	Min.	Max.		Min.	Max.		Min.	Max.			
	250	207204		221922	38764		1400	160344		171751	185548
300	204479	219005	35721	1600	154587	165583	179084	6000	95765	103027	113291
350	201836	216176	32767	1800	149310	159956	173196	7000	90181	97105	106715
400	199274	213432	29907	2000	144523	154816	167819	8000	85730	92387	101436
500	194373	208186	24431	2200	140054	150103	162931	9000	82111	88547	97129
600	189748	203235	219256	2400	135982	145769	158358	10000	79120	85339	93517
700	185376	198556	214342	2600	132226	141773	154181	12000	74473	80299	87931
800	181234	194123	208987	3000	125534	134654	146743	14000	71005	76546	83552
900	177307	189919	204591	3500	118435	127107	138861	16000	68006	73654	80650
1000	173576	185928	200410	4000	112448	120744	132221	18000	66186	71357	78147
1200	166646	178502	192635	4500	107342	115321	126500	20000	64439	69488	76122

Figure 4-6. Useful PSM to Circular Earth Orbits (8.4m Long PLF, English)

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Apogee (km)	SLS Block B 8.4m Dia. Fairing (t)		SLS Block B 8.4m Dia. Fairing (t)		Apogee (km)	SLS Block B 8.4m Dia. Fairing (t)		Apogee (km)	SLS Block B 8.4m Dia. Fairing (t)		Apogee (km)	SLS Block B 8.4m Dia. Fairing (t)	
	Min.	Max.	Min.	Max.		Min.	Max.		Min.	Max.			
	463	94.0	100.7	108.3		2593	72.7		77.9	84.2		9260	46.7
556	92.7	99.3	106.9	2963	70.1	75.1	81.2	11112	43.4	46.7	51.4		
648	91.6	98.1	105.6	3334	67.7	72.6	78.6	12964	40.9	44.0	48.4		
741	90.4	96.8	104.3	3704	65.6	70.2	76.1	14816	38.9	41.9	46.0		
926	88.2	94.4	101.8	4074	63.5	68.1	73.9	16668	37.2	40.2	44.1		
1111	86.1	92.2	99.5	4445	61.7	66.1	71.8	18520	35.9	38.7	42.4		
1296	84.1	90.1	97.2	4815	60.0	64.3	69.9	22224	33.8	36.4	39.9		
1482	82.2	88.1	94.8	5556	56.9	61.1	66.6	25928	32.2	34.7	37.9		
1667	80.4	86.1	92.8	6482	53.7	57.7	63.0	29632	30.8	33.4	36.6		
1852	78.7	84.3	90.9	7408	51.0	54.8	60.0	33336	30.0	32.4	35.4		
2222	75.6	81.0	87.4	8334	48.7	52.3	57.4	37040	29.2	31.5	34.5		

Figure 4-7. Useful PSM to Circular Earth Orbits (8.4m Long PLF, metric)

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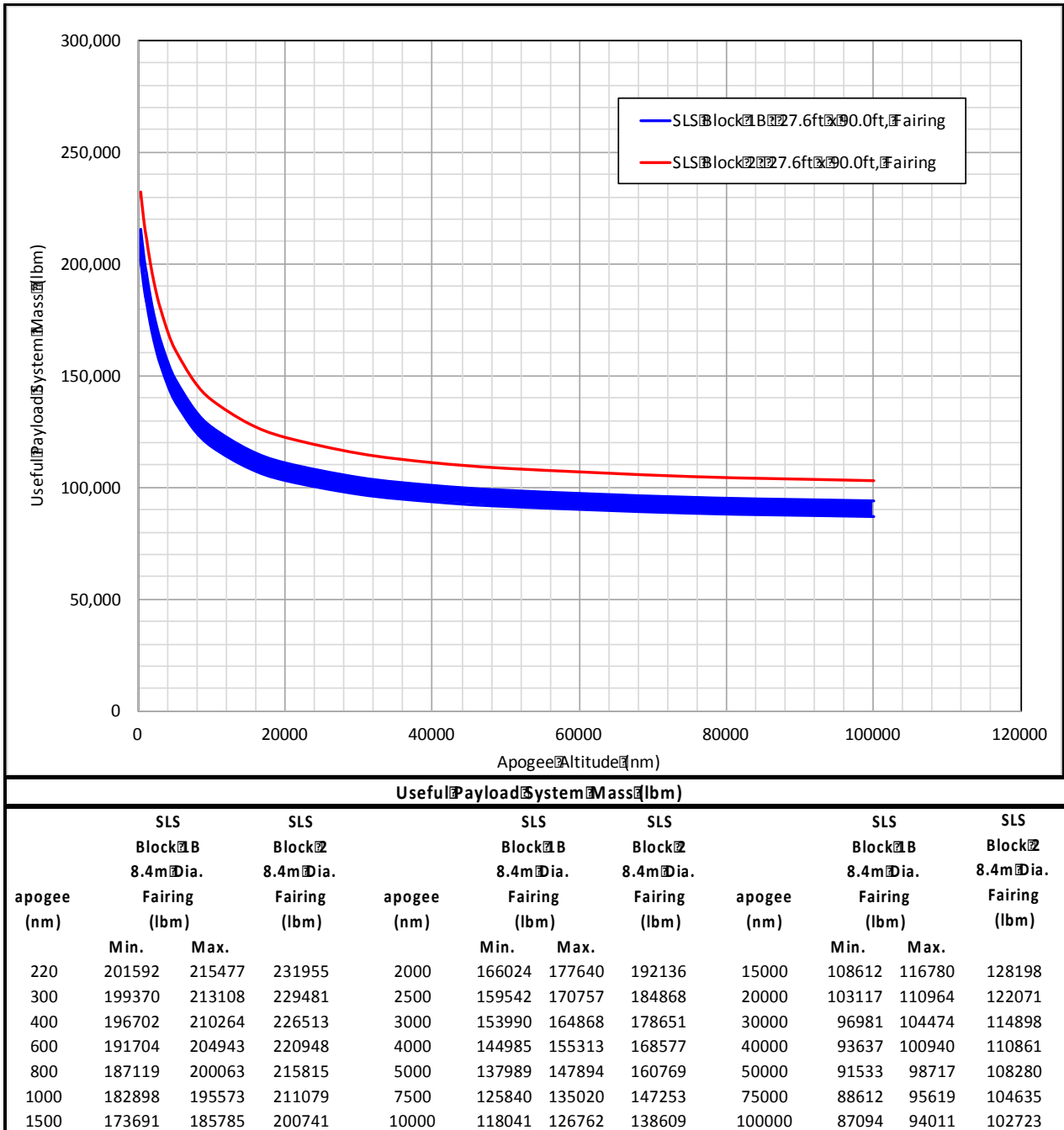


Figure 4-8. Useful PSM to Elliptical Earth Orbits (8.4m Long PLF, English)

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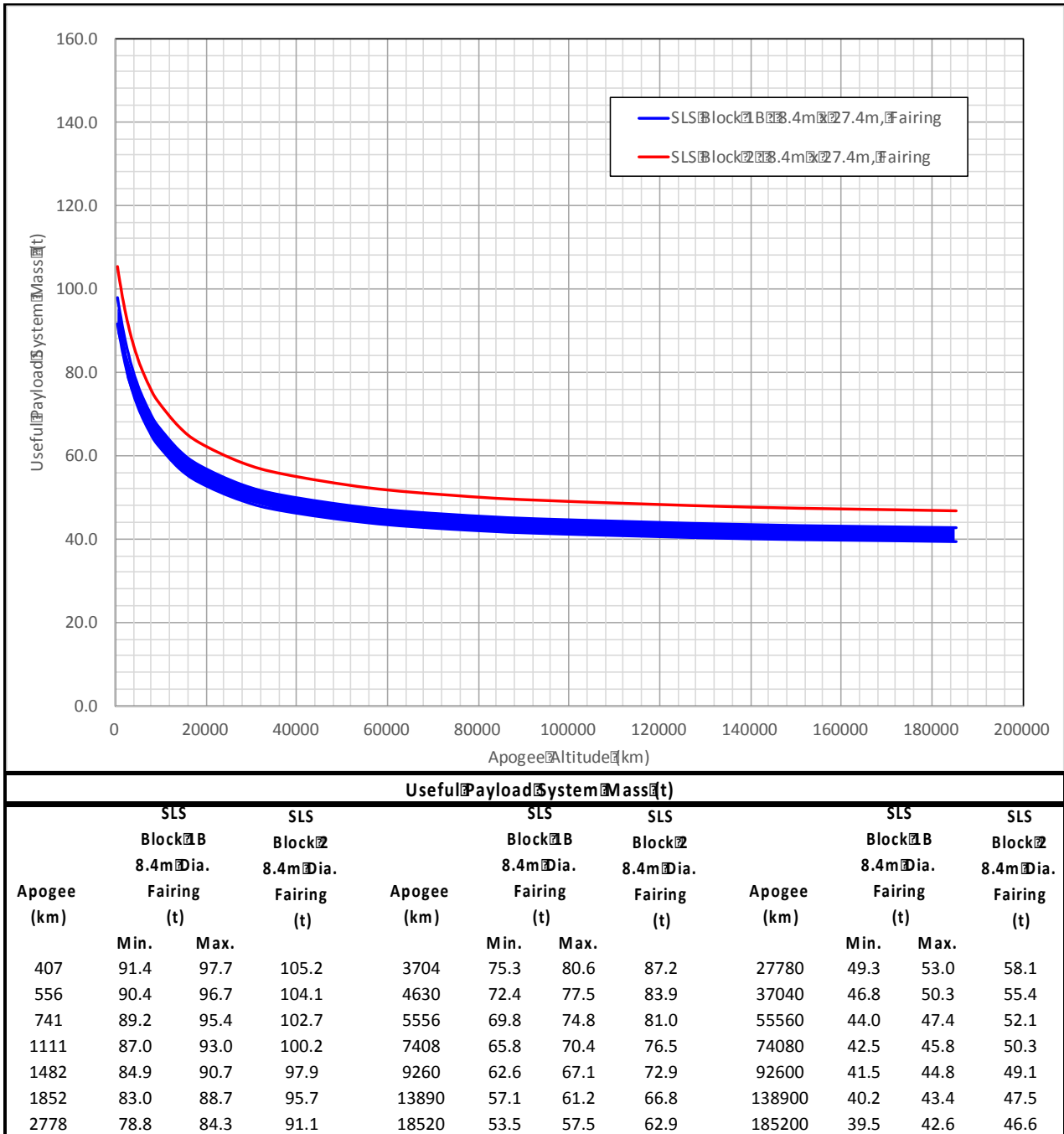


Figure 4-9. Useful PSM to Elliptical Earth Orbits (8.4m Long PLF, metric)

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4.2.4 SLS Lunar Vicinity Performance

SLS Block 1B/2 configurations can deliver a range of Useful Payload System Mass through TLI ($C3 = -0.99 \text{ km}^2/\text{s}^2$) shown here in the form of a C3 curve (Figure 4-10) and corresponding C3 data (Table 4-1). SLS Block 1B performance is shown as multiple curves based on different performance development paths still under evaluation. SLS Block 2 performance is based on the current estimate of the minimum performance Evolved Booster concept; more capability may be available as this design matures. Primary Payload performance for Block 1B and Block 2 configurations is represented by a 27.6 ft (8.4 m) diameter PLF that is 90 ft. (27.4 m) long PLF for planning purposes. The performance for a 33 ft (10 m) diameter PLF is still under evaluation at this time.

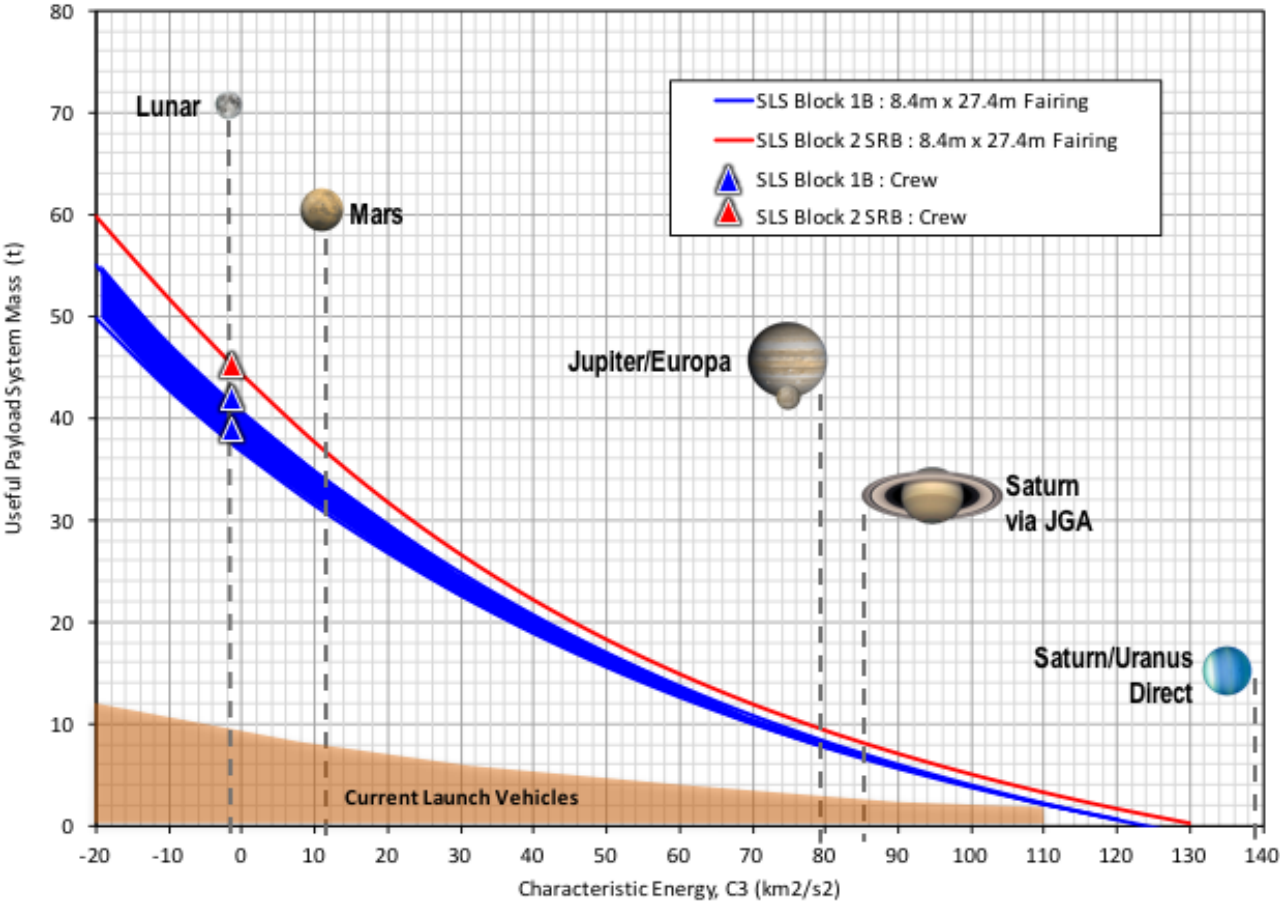


Figure 4-10. Useful SLS Block 1B and 2 PSM to Earth Escape

Table 4-1. Useful PSM to Earth Escape

C3 Actual (km ² /s ²)	Block 1B 8.4m x 27.4m Fairing				Block 2 8.4m x 27.4m Fairing		
	Min. Payload		Max. Payload		C3 Actual (km ² /s ²)	Payload	
	(t)	(lb)	(t)	(lb)		(t)	(lb)
-20	49.9	109,915	55.2	121,596	-20	59.8	131,882
-10	42.8	94,401	47.4	104,519	-10	51.8	114,100
-0.99	37.3	82,240	41.3	91,125	-0.99	45.0	99,229
0	36.7	80,996	40.7	89,755	0	44.3	97,677
10	31.5	69,336	34.9	76,844	10	37.6	82,951
20	26.8	59,055	29.6	65,251	20	31.7	69,973
30	22.6	49,836	24.9	54,901	30	26.6	58,637
40	18.9	41,615	20.7	45,696	40	22.1	48,777
50	15.6	34,308	17.0	37,534	50	18.2	40,206
60	12.6	27,819	13.8	30,315	60	14.9	32,742
70	10.0	22,055	10.9	23,934	70	11.9	26,220
80	7.7	16,927	8.3	18,284	80	9.3	20,501
83	7.0	15,501	7.6	16,717	83	8.6	18,923
90	5.6	12,357	6.0	13,271	90	7.0	15,464
100	3.8	8,275	4.0	8,810	100	5.0	11,010
110	2.1	4,620	2.2	4,830	110	3.2	7,055
120	0.6	1,339	0.6	1,269	120	1.6	3,531
130					130	0.2	377

SLS Block 1B/2 can simultaneously transport Orion and Orion Co-manifested Payloads using Universal Stage Adapters to LEO or TLI destinations as needed.

Table 4-2 shows estimated SLS Block 1B/2 CPL Mass available to destination; this represents the sum of the spacecraft/payload mass and associated Payload Adapter mass accommodated within the USA for crewed mission. SLS Block 1B performance is shown as either “Threshold” or “Objective” based on different Block 1B performance development paths under evaluation. SLS Block 2 performance is based on an estimate of CPL Mass to destination using the lower range of Evolved Booster concept performance. CPL performance to destination capability will be refined and updated as 1B/2 Block configuration performance capability matures. Values provided should be used for initial user assessments only.

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Table 4-2. Block 1B/2 Co-manifested Mass available to Destination

For Planning Purposes Only

Destination	Block 1B Co-manifested Payload Mass			
	Initial		Goal	
	lbm	t	lbm	t
LEO*	44,092	20.0	-	-
TLI (C3 = -0.99)	12,125	5.0	22,046	10.0

Destination	Block 2 Co-manifested Payload Mass	
	lbm	t
LEO*	44,092	20.0
TLI (C3 = -0.99)	44,092	20.0

* CPL density and volume available will be LEO constraints, not CPL mass

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 Long PLF payload flights is given in Figure 4-10. An interim circular orbit of 100 nm (185 km) altitude is assumed prior to C3 injection. Specific data points for each set of curves are provided in Table 4-1.

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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. Current environments shown have been established through evaluation of using Commercial Off the Shelf (COTS) Expendable Launch Vehicle (ELV) 5 m diameter PLFs analyzed on SLS vehicles. Since definition of environments for 8.4 m diameter USA and PLF accommodations are currently under development, the environments shown in this section should be understood as goals for 8.4 m diameter and larger spacecraft/payloads. More definition of expected ground and flight environmental conditions can be found in SLS-SPEC-159, Cross-Program Design Specification for Natural Environments (DSNE).

5.1 Pre-Launch Environments

5.1.1 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. During encapsulation in the Payload Hazardous Servicing Facility (PHSF) the temperature and relative humidity are shown in Table 5-1. During ground transport from the PHSF to the Vehicle Assembly Building (VAB) at KSC, conditioned air with a mass flow rate of 185 lbm/min (84 kg/min) at 65-85 °F (18-29 °C) can be provided. During rollout from the VAB to the Pad 39B conditioned air with a mass flow rate of 85 lbm/min (39 kg/min) at 65-85 °F (18-29 °C) can be provided. Purge temperatures are not controllable to specific values within the available range. Once the mating operations have been completed, a continuous purge is established through a T-0 Environmental Control System (ECS) Umbilical. The capabilities available to the payload while in the VAB are shown in Table 5-2. These tables represent maximum capabilities that can be provided.

More specific environments can be provided once a payload and its heat dissipation characteristics are defined and the applicable fairing configuration established. These analyses will also take into account effects from internal fairing radiation, terrestrial environments and environmental purge systems. USA thermal environments for Co-manifested Payloads and Secondary Payloads will be established as the configuration matures. A fairing internal distribution system will deliver the conditioned air/gas throughout the fairing venting to the atmosphere through one-way flapper doors ensuring positive pressure. It should be noted that GN2 is available at the Pad for local purge of spacecraft/payload elements if required; details will be worked with spacecraft/payload customers on a case by case basis.

Table 5-1. Payload Hazardous Servicing Facility Temperature & Humidity

	High Bay	Air Lock
Temperature	71 °F (± 6°), 21.7 °F (± 14°)	71 °F (± 6°), 21.7 °F (± 14°)
Relative Humidity	60% maximum	60% maximum

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Table 5-2. OSMU ECS Capability at VAB and Pad 39B

Location	Medium	Mass Flow Rate	Temperature
VAB	Conditioned Air	235 lbm/min (107 kg/min)	65-85 °F (18-29 °C)
Rollout	Conditioned Air	185 lbm/min (84 kg/min)	65-85 °F (18-29 °C)
Pad	Conditioned Air	235 lbm/min (107 kg/min)	65-85 °F (18-29 °C)
	Gaseous Nitrogen/Conditioned Air	100 lbm/min (45 kg/min)	65-85 °F (18-29 °C)

5.1.2 Electromagnetic Compatibility (EMC)

During ground operations, the SLS vehicle will be subject to illumination by radars, communications, and tracking systems. These emitters are significant contributors to the Radio Frequency (RF) Electromagnetic Environment (EME).

5.1.2.1 Pre-Launch RF Electromagnetic Environment (EME)

The RF EME that is present during pre-launch and launch operations are given in Table 5-3 and Figure 5-1 below.

Table 5-3. Launch Processing and 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

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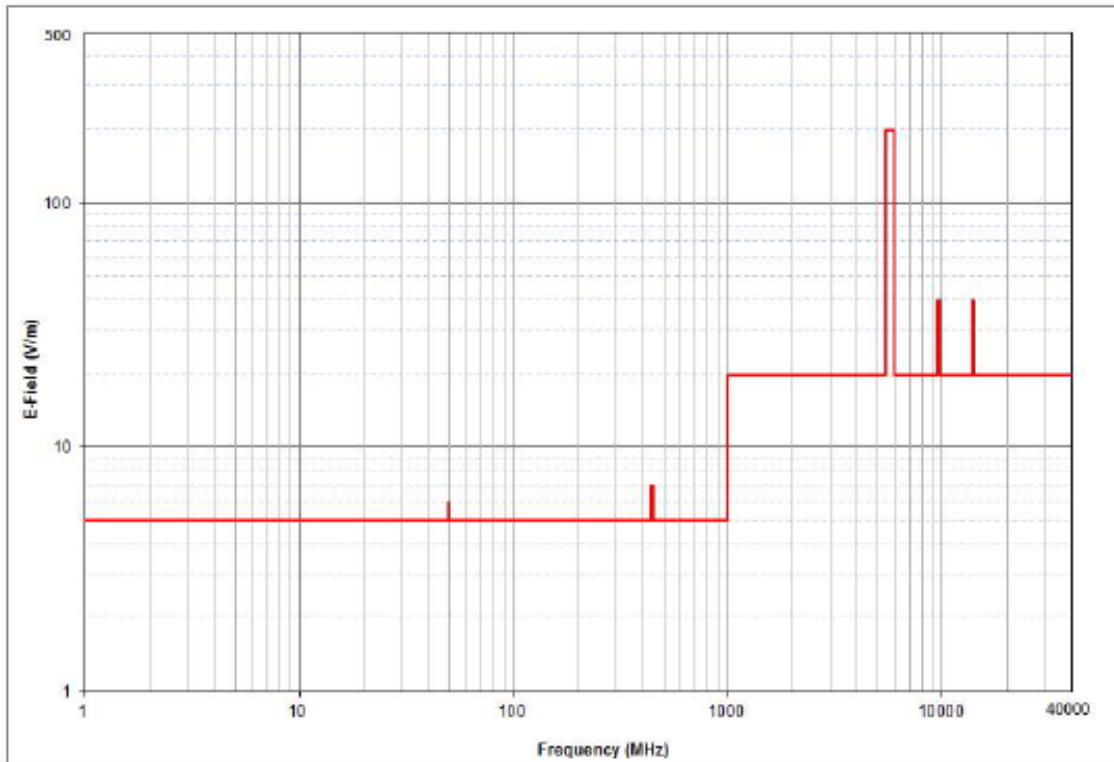


Figure 5-1. Launch Processing and Launch RF EME (Peak Environment)

5.1.2.2 Spacecraft/Payload Allowable Emissions

The maximum allowable spacecraft/payload radiated emissions at the vehicle separation plane are provided in Figure 5-2 below. This requirement was tailored from MIL-STD-461F RE102-3, from 100 MHz and 18 GHz, for use on the SLS Program. It is also a Spacecraft/Payload responsibility to ensure that the communications with to/from their PPL, CPL or SPL does not interfere with SLS or Orion frequencies per NPD 2570.5, NASA Electromagnetic Spectrum Management.

5.1.2.3 Lightning Mitigation

Weather related conditions and events at the LC-39B Pad are recorded and measured continuously. Lightning direct effects are mitigated by a lightning protection catenary wire system. Energy from a nearby lightning strike can couple into launch vehicle and spacecraft/payload cable. Operational controls and shielding will be in place to provide a limited level of protection as well as sensor data from the launch site for comparison against payload retest levels. Additional measures beyond these capabilities will be the responsibility of the payload. An illustration of the LC Pad 39B is given in Figure 5-3 below. The Mobile Launcher portion of the weather subsystem monitors, records and transmits 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 rollout lightning monitoring EGSE provides monitoring during rollout and at the Pad.

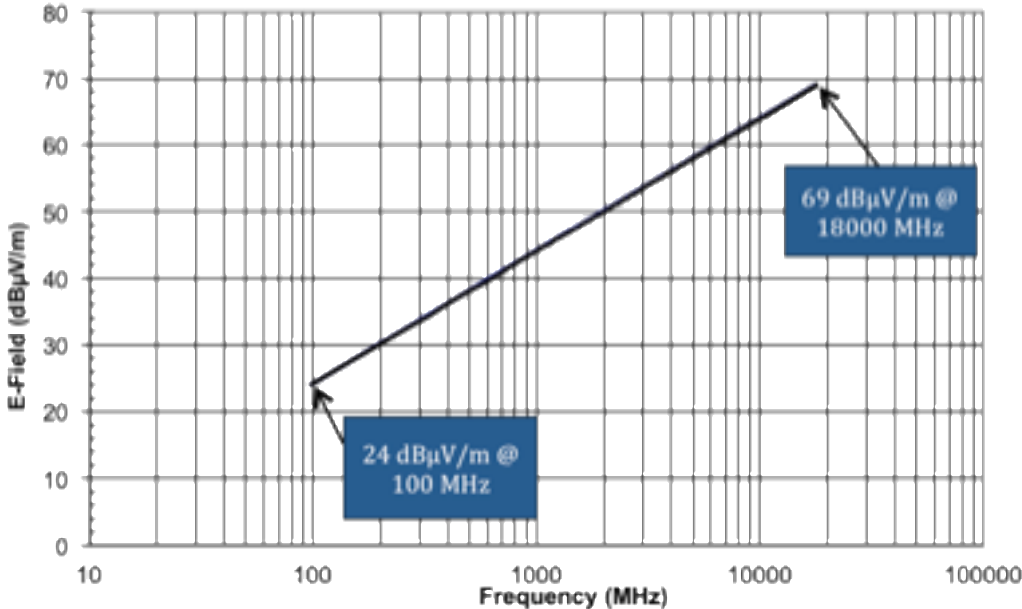


Figure 5-2. Spacecraft/Payload Allowable Radiated Emissions

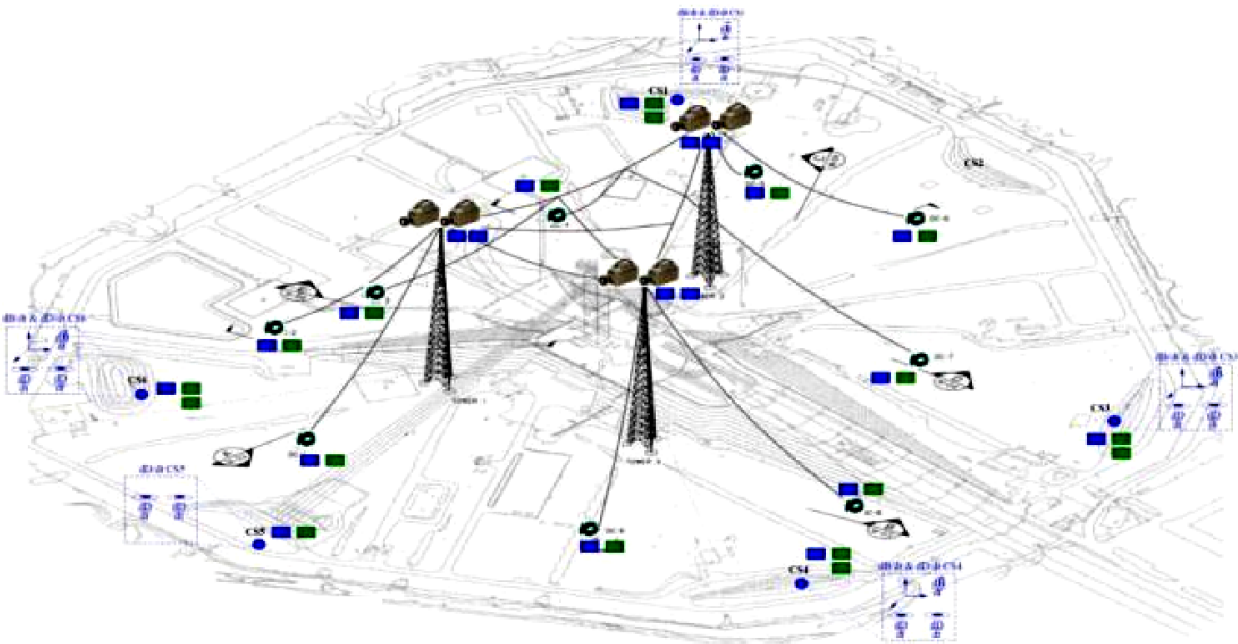


Figure 5-3. LC Pad 39B Lightning Protection System Representation

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5.1.2.4 Electrical Bonding Requirement

The spacecraft/payload must be equipped with an accessible point to achieve an electrical bond with the launch vehicle interface. The launch vehicle interface will provide a conductive path for bonding the spacecraft/payload to the launch vehicle. If the payload has intentional transmitters or receivers, or can be affected by intentional transmitters or receivers, the spacecraft/payload interface must be capable of achieving a Class R electrical bond in accordance with NASA-STD-4003A, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment. If the payload uses launch platform electrical power, the spacecraft/payload interface must be capable of achieving a Class H electrical bond in accordance with NASA-STD-4003A, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment. If the payload does not require either a Class R or Class H electrical bond, the spacecraft/payload interface must be capable of achieving a Class S electrical bond in accordance with NASA-STD-4003A, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment.

5.1.3 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. A comprehensive Contamination Control Plan will be written to identify these requirements and procedures. Contamination-critical hardware surfaces will be visually inspected to verify established contamination and nonvolatile residue (NVR) criteria are met. Additional verification techniques shown below can be provided on a mission-unique basis:

- 1) Particulate Obscuration—Tape lift sampling
- 2) Nonvolatile Residue (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 Class standards. Spacecraft/payload outgassing control within the SLS USA (which is a shared compartment with Orion and EUS) and PLF will follow Standard Materials and Processes Requirements for Spacecraft, NASA-STD-6016.

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5.2 Launch and Flight Environments

5.2.1 Spacecraft/Payload Design Loads

Spacecraft/payload accelerations are estimates from ongoing SLS analysis. Analysis ground rules and assumptions limit the ascent vehicle steady state axial acceleration to a maximum of 5g and a lateral acceleration to 3g. These values are not intended to be used for payload design. More mature Block 1B vehicle steady state values should be appropriately used. 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 max lateral load factors tend to be lower for high max axial load factors and vice versa. Notional design load factors for Block 1B payloads are shown in Table 5-4; the goal is to stay within a load factor box comparable to other ELVs. Payload cantilevered fundamental mode frequencies are assumed to be a minimum of 8 Hz lateral and 15 Hz axial to ensure applicability of the design load factors. Mission unique vehicle dynamic coupled load analyses will provide time consistent (and Orion compatible when applicable) spacecraft/payload primary and secondary structure loads, accelerations, and deflections. As a specific mission's design matures, these analyses are used to support spacecraft/payload and adapter design, test planning, and verification of minimum margins of safety.

Table 5-4. Examples of SLS Block 1B Payload Combined Load Factors

Event		Lateral Accelerations	Axial Accelerations
Liftoff	min	0	-1.5
	max	2	-1.5
Ascent - Transonic	max	2	2.25
Booster Phase - Max G	max	0.5	3.25
Core Stage Phase - Max G	max	0.5	4.1

5.2.2 Acoustics

The spacecraft/payload is exposed to an acoustic environment from Core Stage ignition throughout the ascent phase of flight, until the vehicle is out of the atmosphere. Two portions of flight have significantly higher acoustic levels than the others. The highest acoustic level occurs from solid rocket ignition during liftoff. The other significant level occurs during the transonic portion of flight. The acoustic level inside the PLF or USA will vary slightly with different spacecraft/payload depending on its acoustic absorption properties and the payload fill factor. A range of acoustic mitigation systems to provide various levels of noise reduction are available depending on payload needs. Acoustic levels can be mitigated within limits by adding more acoustic foam, for example. The current goal for SLS Block 1B PLF and USA internal acoustic environments is shown in Figure

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5-4 and Table 5-5. The internal acoustic environment represents a 95 percent probability with a 50 percent confidence level, a 60 percent fill effect, and blanketed section.

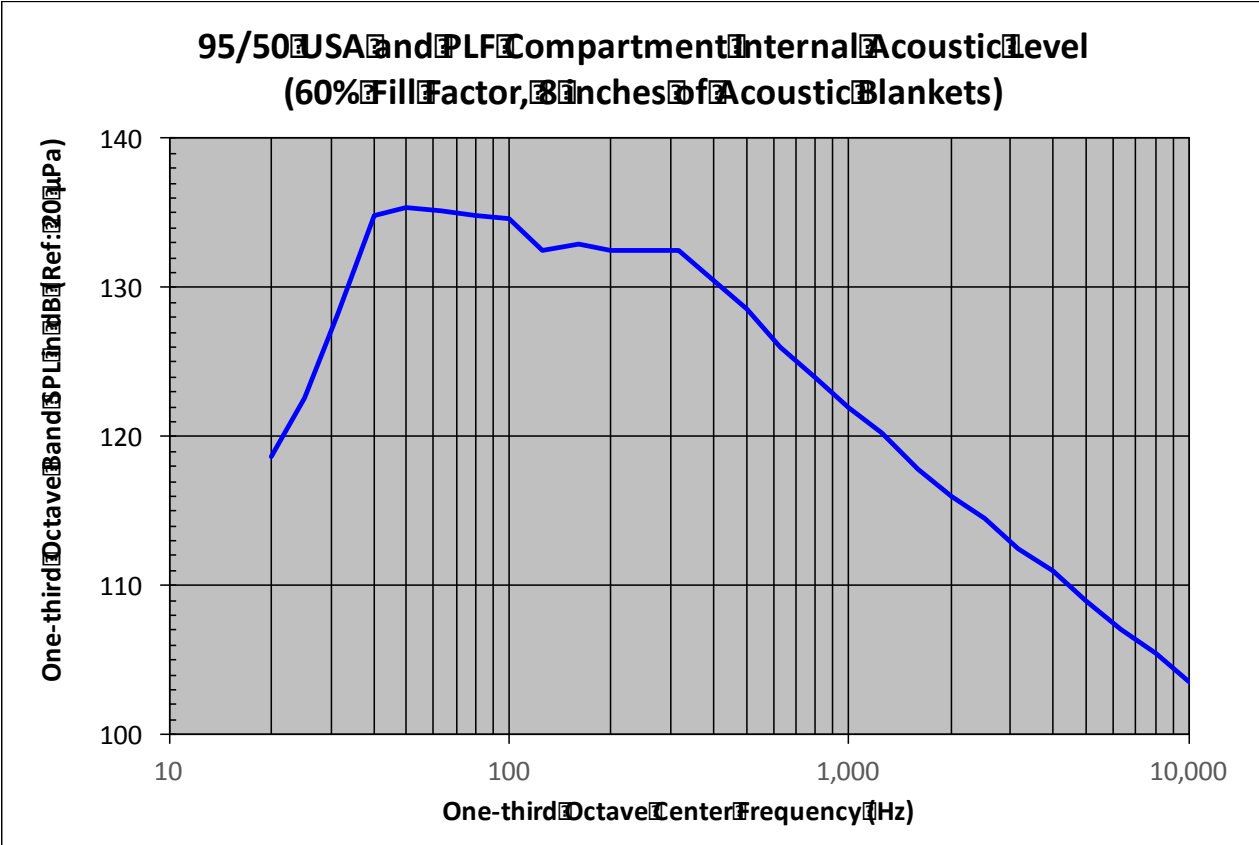


Figure 5-4. SLS Block 1B USA and PLF Internal Acoustic Environment

Table 5-5. Examples of SLS Block 1B Payload Combined Load Factors

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

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5.2.3 Vibration

5.2.3.1 Random Vibration

The random vibration environment is derived from acoustically induced vibration and mechanically induced vibration. For the Primary Payload, located in a fairing, the dominant environment causing vibration to the payload will be from the fairing internal acoustics environment. The Primary Payload mechanically induced vibration path would be through the payload adapter. Because this vibration will be attenuated through the vehicle joints and through mass attenuation, this level will be low and enveloped by the fairing internal acoustic field. For the Secondary Payloads located in an SLS stage adapter, acoustically induced vibration depends on the payload mass, SLS stage adapter structure, and external acoustic environment of the SLS launch vehicle configuration. USA vibration environment will be established as the configuration matures and specific system analyses are performed.

5.2.3.2 Vehicle Dynamics (Low Frequency Sinusoidal Vibration)

The payload will experience transient environments during flight. These transients are generally characterized by short duration (generally less than five seconds) with a time-varying amplitude. This low frequency transient environment is a result of the launch vehicle/payload responding at their fundamental modes of vibration during events such as engine ignition, launch release, engine overpressure, staging, wind buffeting, etc. Vehicle dynamics criteria are not to be used for design of the payload primary structure, but it can be used as design aid for payload secondary structures/components. This low frequency transient criterion is generally verified by analyses and can be tailored by coupled loads analyses data. The USA vehicle dynamics environment for CPLs and SPLs will be established as the configuration matures and specific system analyses are performed.

5.2.4 Shock

Pyrotechnic shock events during SLS flight that could affect payloads are the PLF jettison, the upper stage separation from the Core Stage, and the spacecraft/payload separation. Because the system for upper stage separation from the Core Stage is located far from the spacecraft/payload, the shock is highly attenuated by the time it reaches the spacecraft/payload and does not produce a significant shock at the interface. This is also true for the PLF and for separation of the SLS SRBs from the Core Stage. Separation devices for the SLS Payload Adapter are located closer to the spacecraft/payload, and the shock at the interface is much larger. The spacecraft separation device located at the top of the Payload Adapter is typically closest to the spacecraft/payload to upper stage interface and generally produces the highest shock. The SLS goal is to utilize current ELV fairings and spacecraft/payload separation systems, where applicable. Those corresponding driving 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. USA separation shock levels for CPLs will be established as the configuration matures.

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5.2.5 Thermal

Aerodynamic heating on the fairing external surface results in an internal time-dependent radiant heating environment around the spacecraft/payload before fairing jettison. Fairings use cork on the external surface to minimize fairing skin temperatures. The spacecraft/payload thermal environment is further attenuated by the acoustic suppression system that is utilized for fairing barrel sections and the lower portion of the respective nose cones. Current maximum internal composite fairing skin temperature is expected to be 145 °F (63 °C) at launch ramping to 155 °F (68 °C) at 120 seconds and remaining at 155 °F (68 °C) until fairing separation for insulated fairing surfaces with an emissivity of 0.9 (reference Figure 5-6). The fairing is typically jettisoned during the Core Stage burn when the free molecular heating rate drops below 0.1 BTU/ft²-sec (1,136 W/m²).

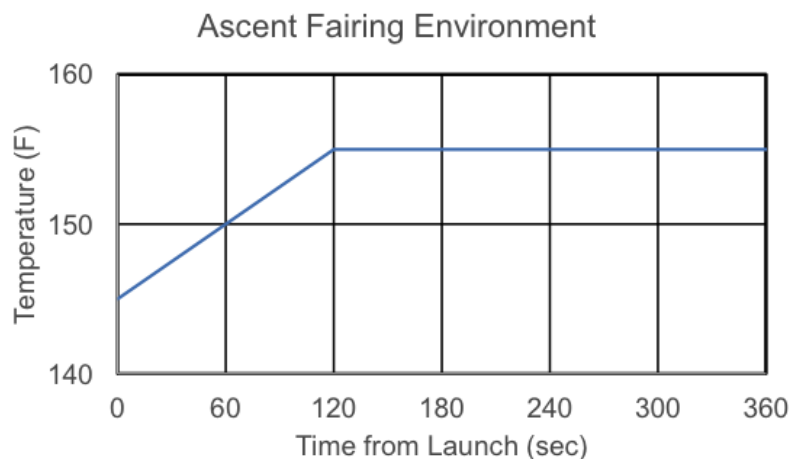


Figure 5-6. SLS PLF Internal Ascent Temperature (Block 1 Reference)

While this is based on Block 1 vehicle configuration data, preliminary Block 1B trajectories and fairing external aerothermal environments show them to be in family with the Block 1 data; more specific environments will be provided once a payload is defined and the applicable fairing configuration established. The effects the components/surfaces aft of the payload fairing may impose on the ascent thermal payload fairing environment are not included in the shown environments but will be considered in future releases of this document. USA internal skin ascent temperature levels for CPL will be established as the configuration matures. These analyses will take into account internal fairing radiation, terrestrial environments, ascent aerodynamic-heating, and on-orbit environmental characteristics

5.2.6 Static Pressure (Fairing Venting)

SLS payload fairings will be vented during the ascent phase by proper implementation of vent doors to insure a proper depressurization rate of the payload compartment. Venting scheme designs will depend on the mission trajectory and payload depressurization rate across 5, 8.4, and 10 m diameter fairings. Payload pressurization rate requirements can be evaluated once specific payload and fairing configurations are defined and mission trajectories established. USA internal pressure time

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histories for CPL will be established as the configuration matures and specific system analyses are performed.

5.2.7 SLS Contamination Control

USA cleanliness levels provided for co-manifested payloads and PLF cleanliness levels for Primary Payloads will similar to ELVs; this goal will be validated as these configurations mature. Additional launch vehicle hardware cleanliness levels may be specified to meet mission-unique requirements as they are defined. The limits of molecular and fractional particle obscuration deposition on spacecraft/payload surfaces from all launch system sources will be established by future analyses. These deposition limits are verified by vehicle class analyses. Launch system ground contamination sources were addressed in Section 5.1.3. Launch system ascent contamination sources include: molecular outgassing, Non-Volatile Residue (NVR) redistribution, particle redistribution, fairing separation, Booster separation, Core Stage separation, and upper stage reaction control system.

Mission-unique verification analysis will be performed to verify spacecraft/payload contamination requirements beyond those stated above and to verify the above requirements for mission or vehicle designs not anticipated by the system specification. Mission-unique contamination analysis incorporates thermal, trajectory, and configuration data. These analyses will draw heavily on the appropriate class analysis. Since the spacecraft/payload is fully encapsulated by the Payload Fairing, Booster and Core Stage separation system potential debris and contamination products will not pose a threat to the spacecraft/payload. Due to containment approaches employed by existing fairing separation systems, spacecraft/payload contamination from this system is expected to be negligible.

During ascent, particles may be released from launch vehicle surfaces due to the vibro-acoustic environment, and migrate to spacecraft/payload surfaces. Depositions will be small because the exposed launch vehicle hardware surfaces within the payload compartment will be cleaned and verified to future specified criteria before encapsulate.

5.2.8 Launch and On-Orbit Electromagnetic Capability

SLS spacecraft/payload conductive equipment will be electrically bonded to the SLS vehicle structure (e.g., the Payload Adapter) in accordance with NASA-STD-4003. Class R and/or H bonds will be applicable to equipment installed on SLS. The resistance requirements of Class R and Class H bonds are 2.5 milliohms and 100 milliohms respectively. This electrical bonding approach combined with SLS surface treatments and associated test/analysis will mitigate triboelectrification hazards to the integrated spacecraft/payload/vehicle.

During launch and flight operations the SLS vehicle will be subject to illumination by ground-based and on-orbit transmitters all around the world. These emitters are significant contributors to the Radio Frequency (RF) Electromagnetic Environment (EME). The Launch RF EME is provided in the Pre-Launch Environments Section 5.2.1.2. The On-Orbit RF EME is provided in Table 5-5 and Figure 5-7, below. The maximum allowable spacecraft/payload radiated emissions during flight operations is the same as that during pre-launch operations and is given in the Pre-Launch Section, 5.1.2.1.

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Table 5-6. 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
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

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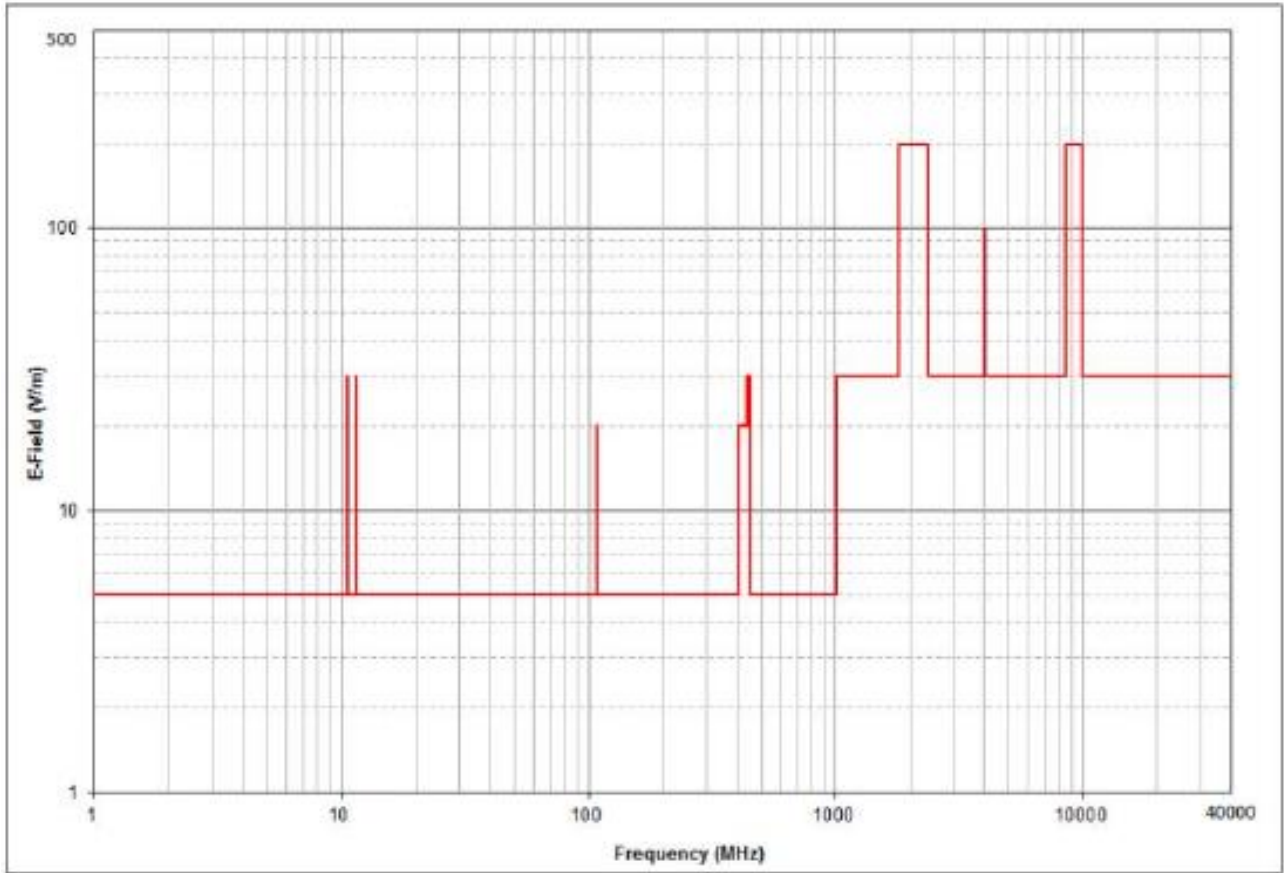


Figure 5-7. On-Orbit RF EME (Peak Environment – 57° Inclination)

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6.0 SPACECRAFT/PAYLOAD INTERFACES

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

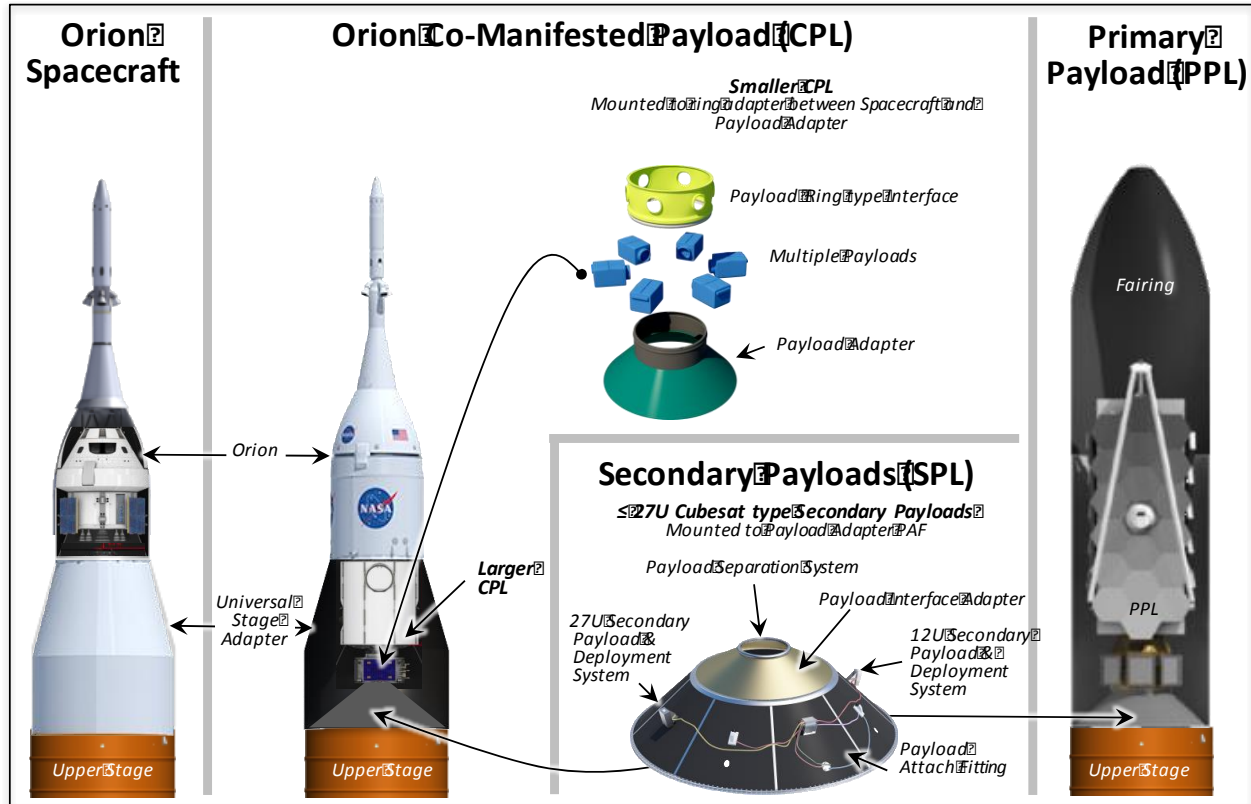


Figure 6-1. Range of SLS Spacecraft/Payload Accommodations

SLS spacecraft/payload USA and PLF accommodations are shown in Figure 6-2 and include:

- Orion Spacecraft – crewed spacecraft accommodated on a SLS USA whose destination determines primary mission trajectory via an EUS injection burn.
- Co-manifested Payload (CPL) – spacecraft/payload accommodated within a SLS USA and on a Payload Adapter; compatible with an Orion trajectory via an EUS injection burn
 - Orion docks and delivers CPL to its final destination (Orion CPL), or post Orion separation, CPL delivers itself to final destination (Independent CPL)
 - Accommodation potential for using a ring accommodation above the Payload Adapter for smaller CPLs with or without a larger CPL
- Primary Payload (PPL) – un-crewed spacecraft/payload accommodated in a SLS PLF and on a Payload Adapter that determines primary mission trajectory via an EUS injection burn
 - 27.6 ft (8.4 m) diameter payloads to be accommodated on Block 1B
 - 27.6 (8.4 m) and 33 ft (10 m) diameter payloads to be accommodated on Block 2
- Secondary Payload (SPL) – accommodated within a SLS USA or PLF, and on a Payload Adapter Fitting; compatible with an Orion or PPL trajectory via an EUS injection burn

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- Multiple locations available on Payload Adapter Fitting for $\leq 27U$ sized Cubesats
- Minimizes impacts to the overall flight and ground systems architecture and does not jeopardize crew safety or primary mission objectives

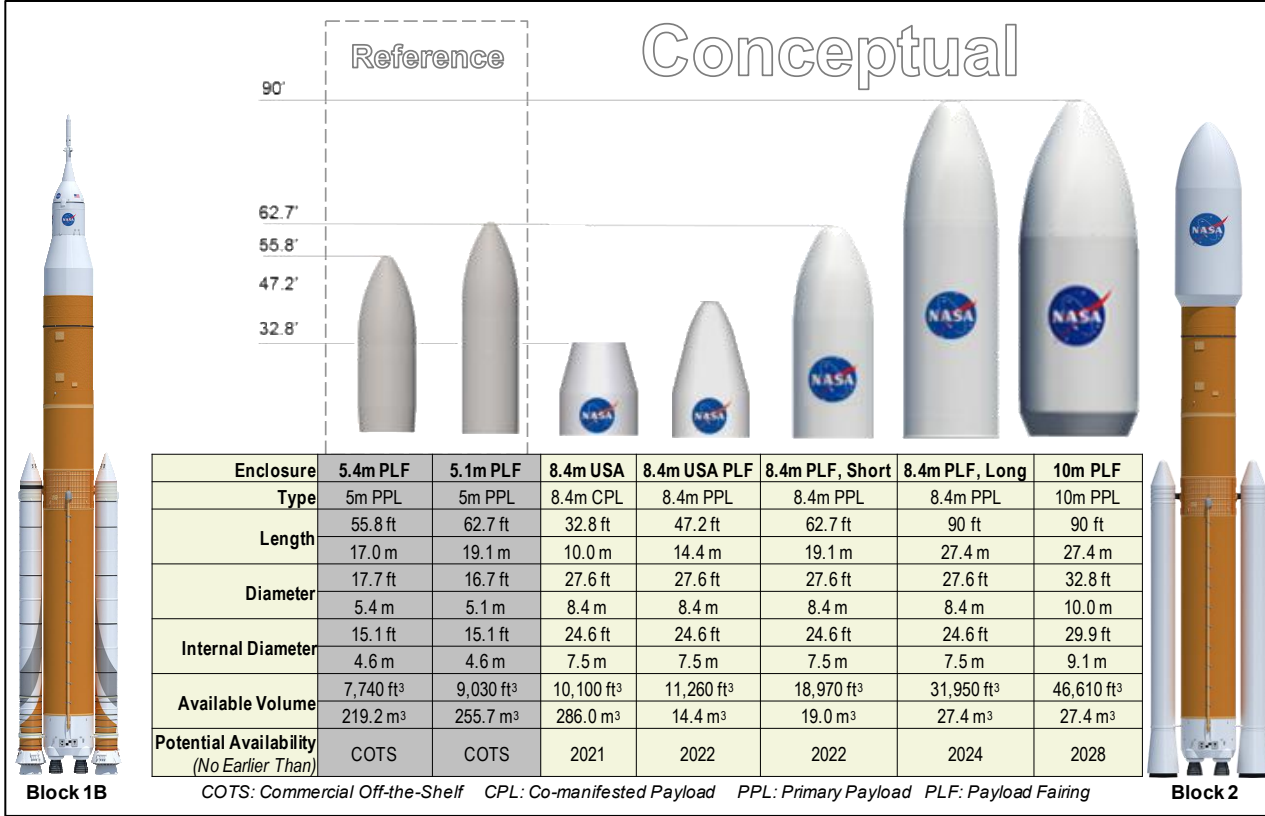


Figure 6-2. Range of Potential Payload SLS Fairings and Stage Adapter Concepts

The two 5m PLFs are shown for reference and represent the largest (in volume and length) COTS fairings available at this time. The SLS USA is required to accommodate Orion on all Block 1B/2 flights. The USA volume, which is larger than that provided by the largest available 5 m PLF, allows payload to be co-manifested with Orion on every crew flight if needed. This early availability of USA also provides the option of adding a nose cone to convert the USA into an 8.4m PLF if needed prior to the availability of a purpose-built PLF. Regarding the 8.4 m Short and Long PLF concepts, the “short” is equivalent in height to today’s tallest ELV fairings and the “long” is the tallest fairing length that can be accommodated within existing launch site encapsulation facilities. These lengths are representative of the total range of 8.4 m PLFs under consideration and not meant to imply a particular design implementation at this time. The 10m PLF concept is currently envisioned to support Mars class exploration flights as well as large volume payloads like telescopes.

6.1 SLS to Orion Spacecraft

Early Exploration Missions are focused on crew transport to the lunar vicinity. Therefore, initial crew oriented flights will deliver Orion on a trajectory around the moon to test critical launch vehicle and spacecraft systems. The USA will accommodate Orion at the Orion Spacecraft Adapter (SA) interface as shown in Figure 6-3. The SLS Block 1B/2 USA provides the transition from the 27.6 ft (8.4 m) diameter EUS to the 18 ft (5.5 m) diameter SA (reference Figure 3-6). Upon Orion separation from SLS, the Orion SA remains attached to the USA and remains attached to it once the USA is jettisoned from the EUS to support CPL and/or SPL operations.

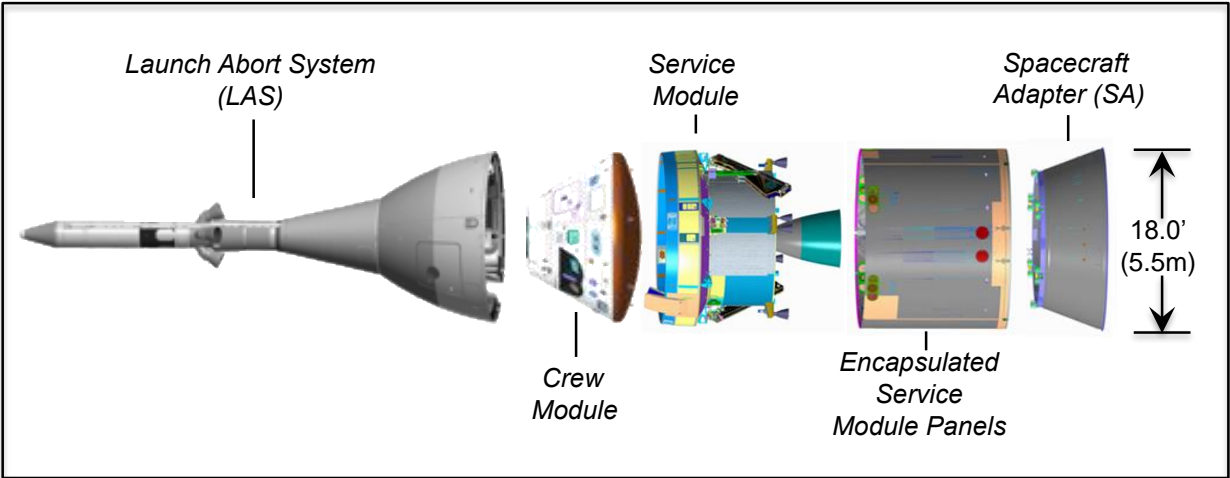
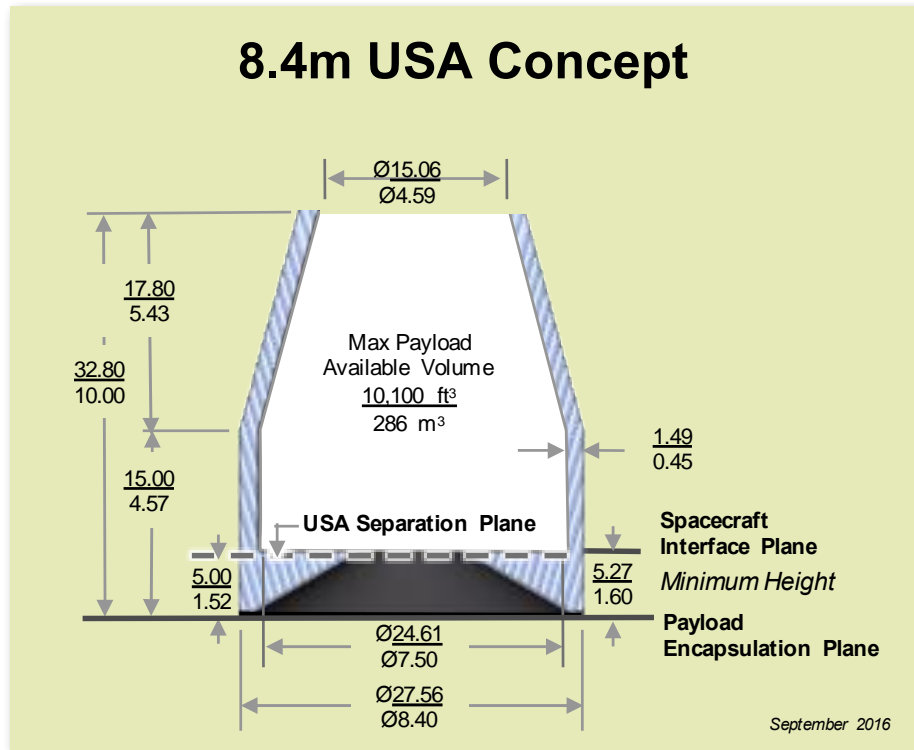


Figure 6-3. SLS to Orion Interfaces for Crewed Missions

6.2 SLS to Co-manifested Payloads

The Block 1B/2 configurations use the enhanced performance of the EUS which provides the potential of flying large or small CPLs (and potentially SPLs) within the USA during Orion missions. Figure 6-4 provides the available dynamic envelope for the 27.6 ft (8.4 m) diameter composite USA; this volume is equivalent to that offered by the Space Shuttle Payload Bay. This stage adapter offers installation of differently sized access doors as needed and an interior surface compatible with acoustic treatments to meet environmental requirements.



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| <div style="border: 1px solid black; width: 60px; height: 20px; margin-bottom: 5px;"></div> <p>Available Payload Dynamic Envelope</p> <div style="background: repeating-linear-gradient(45deg, transparent, transparent 2px, blue 2px, blue 4px); width: 60px; height: 20px; margin-bottom: 5px;"></div> <p>Fairing Envelope (w/acoustic attenuation)</p> <div style="background-color: black; width: 60px; height: 20px;"></div> <p>Minimum Payload Adapter Envelope</p> | <ul style="list-style-type: none"> • All dimensions in $\frac{\text{Feet}}{\text{m}}$ • Height of the spacecraft separation/interface plane depends on spacecraft/PAF attach diameter and PAF cone angle • Spacecraft appendages projecting below spacecraft interface plane may be permitted; coordinate with SLS/SPIE |
|---|---|

Figure 6-4. Composite Universal Stage Adapter Concept

Figure 6-5 depicts a USA concept of operation based on Orion docking/extraction of large CPL or Orion and CPL independent flight. It assumes that once on orbit and post Orion separation from USA, the USA separates in a “canister” fashion (in contrast to “sectors” as fairings typically do). This results in the upper 85 percent of the USA structure with the Orion SA still attached jettisoned as a single, circumferential ring. The non-separable 15 percent of the USA structure remains with the EUS; its height is less than the Payload Adapter separation plane to maximize Co-manifested Payload extraction by Orion, or separation as an independent CPL.

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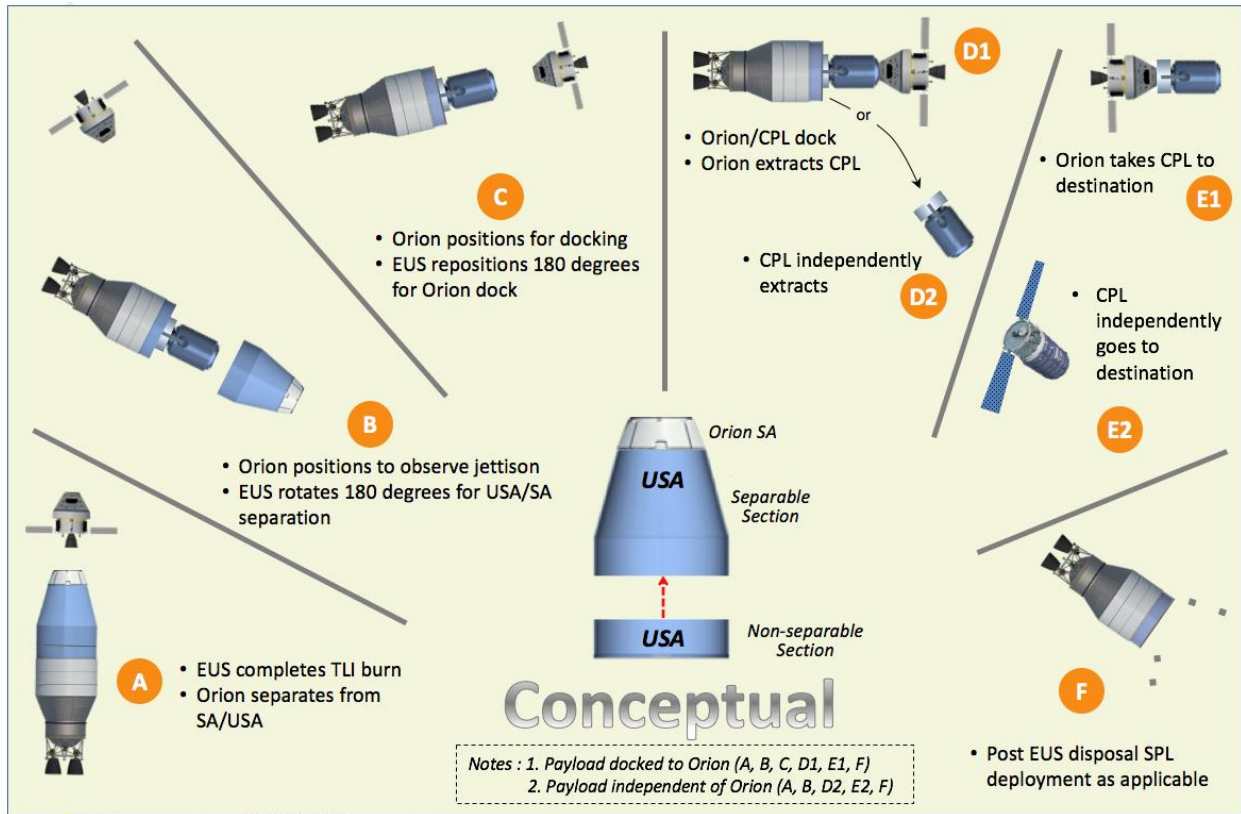


Figure 6-5. USA Representative Concept of Operations

6.3 SLS to Secondary Payloads

SLS can accommodate SPLs based on availability of performance and volume remaining after Primary (within the PLF) and Co-manifested Payload (within the USA) are accommodated. SPL accommodations range from 6 U to 27 U CubeSat class or the equivalent volume. For SPLs that desire separation from the EUS, SPL deployment begins after Orion/CPL separation or PPL separation, and EUS disposal initiation (reference Figure 6-5).

6.4 SLS to Primary Payload

Primary Payloads launched on SLS are protected by a PLF that shields them from the external environment and contamination during ground operations, launch, and ascent phases. Payload fairings typically incorporate hardware to control thermal, acoustic, electromagnetic, and cleanliness environments for the payload. Ground services can provide the fairing conditioned air, fueling/draining, power and command/telemetry relay, standard access door locations. Ground services and may also provide additional payload access to the encapsulated payload while in the VAB or nitrogen purge at the pad as option 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.

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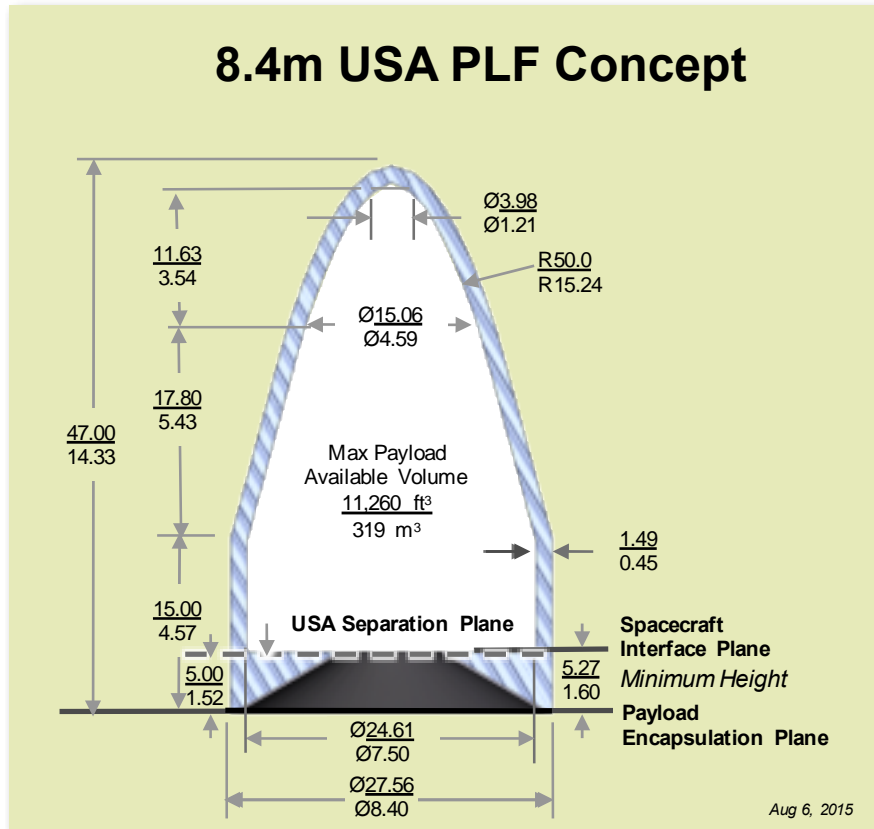
SLS can accommodate a wide variety of fairings ranging from existing Expendable Launch Vehicles (ELV) 5 m PLFs to SLS 8.4 m/10 m PLF design concepts. The internal fairing envelopes shown in the following sections define the available payload dynamic envelope relative to the payload separation plane. All SLS fairing/stage adapter envelopes are still in the conceptual design stage. SLS is currently in the process of identifying (with the user community's help) preferred fairing diameters and lengths to best accommodate potential exploration missions. Therefore, potential users should only use the following information for initial feasibility assessment. For the latest information on payload fairing accommodations users should contact the SLS SPIE office directly.

6.4.1 8.4 m Diameter Fairings

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

Adding a nosecone to the USA creates a composite 47 ft (14.4 m) long USA PLF that could be potentially available earlier than a purpose-built, 8.4 m PLF to support near term, non-Orion flights. The available USA derived PLF dynamic 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.

Figure 6-7 depicts the current concept of operations for the USA PLF. It assumes that after ascent and 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 the EUS during the injection burn. The height of this non-separable portion is less than the Payload Adapter interface plane to maximize Co-manifested Payload extraction by Orion, or separation for independent flight.



- | | |
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| <p> Available Payload Dynamic Envelope</p> <p> Fairing Envelope (w/acoustic attenuation)</p> <p> Minimum Payload Attach Fitting Envelope</p> | <ul style="list-style-type: none"> • All dimensions in $\frac{\text{Feet}}{\text{m}}$ • Height of the spacecraft separation/interface plane depends on spacecraft/PAF attach diameter and PAF cone angle • Spacecraft appendages projecting below spacecraft interface plane may be permitted; coordinate with SLS/SPIE |
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Figure 6-6. Composite 8.4m USA PLF Concept

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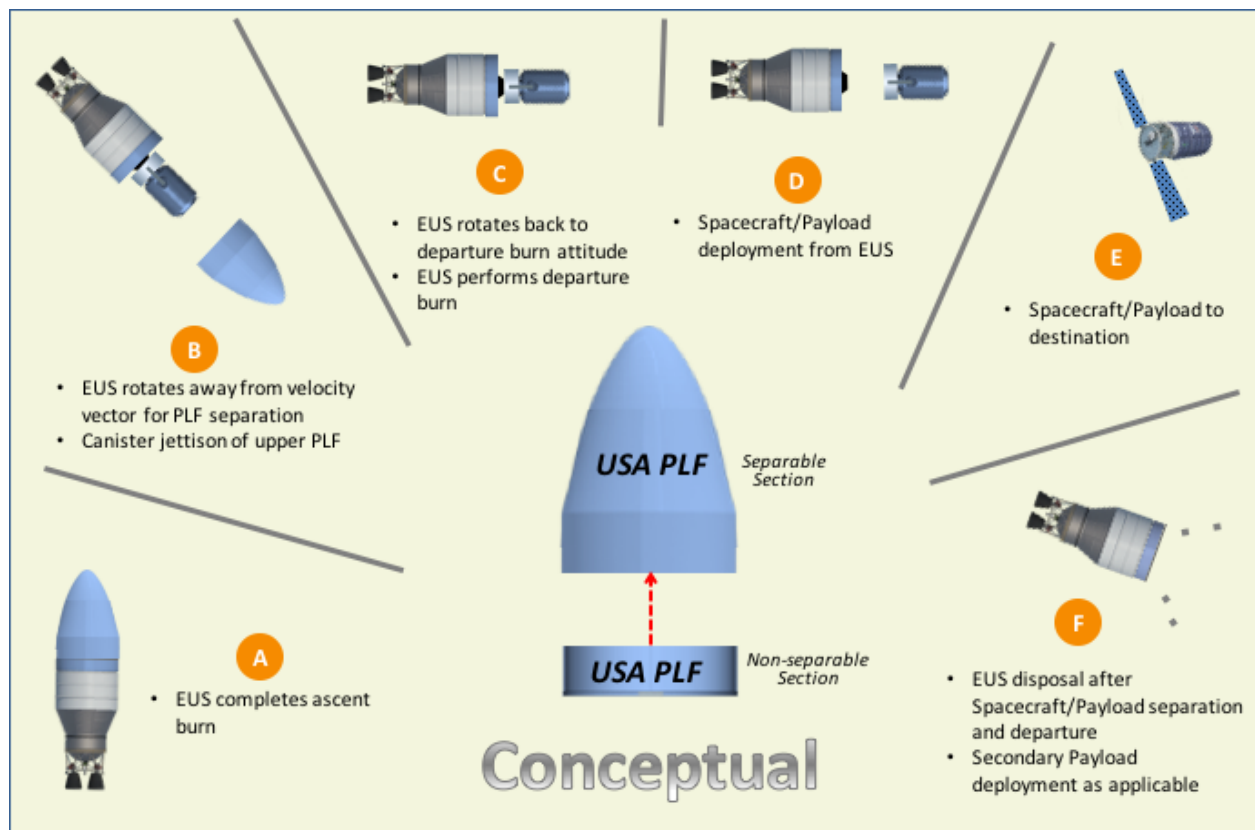


Figure 6-7. Composite 8.4m USA PLF Concept of Operations

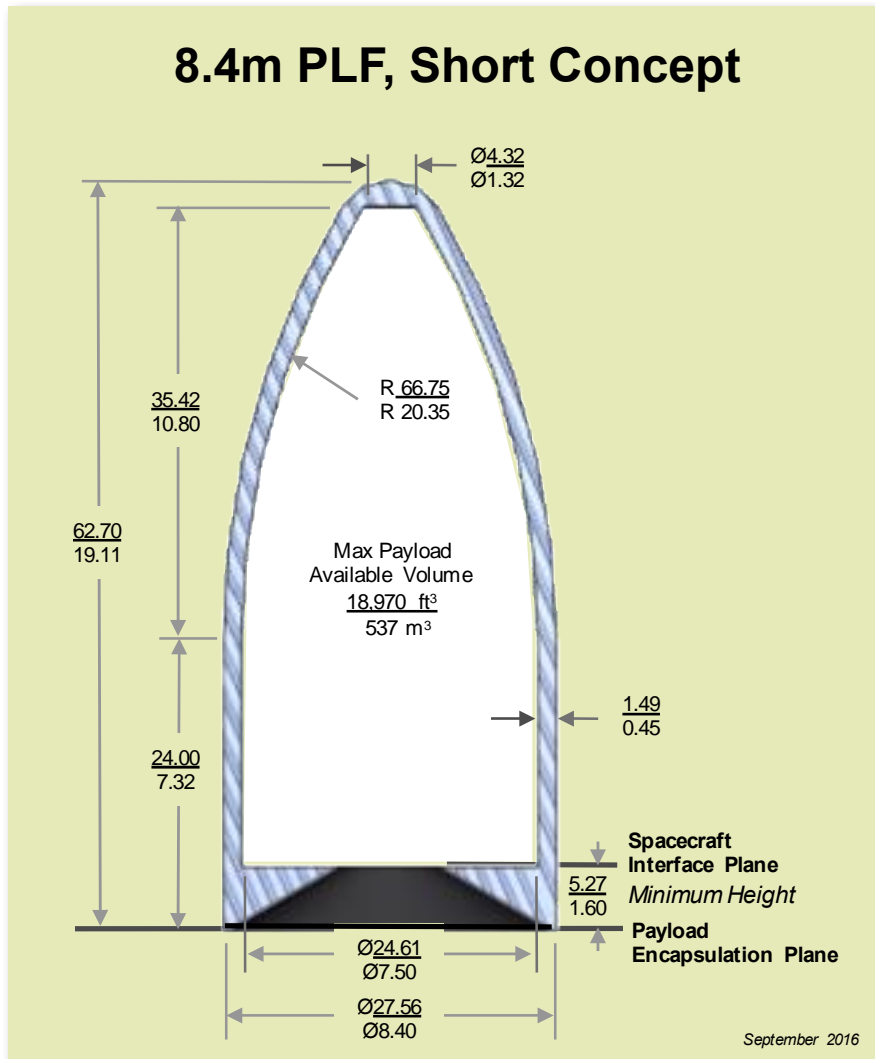
Figures 6-8 and 6-9 provide the available dynamic envelope for the Short and Long 8.4 m diameter composite PLF concepts. These fairings jettison using traditional “sectors” versus the “canister” approach employed on USA PLF. Sectors are jettisoned during ascent (prior to LEO or direct insertion by the EUS).

The current Short 8.4 m diameter PLF concept represents the maximum length possible based on current ceiling height constraints of KSC’s Payload Hazardous Servicing Facility; 63 ft (19 m). Potential exists for longer PLFs by lengthening the cylindrical section as needed. The current maximum PLF length of 90 ft (27 m), represented in this case by the Long 8.4m PLF, is constrained by the door/ceiling height of Cape Canaveral Air Force Station’s (CCAFS) 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/length combinations. Therefore, potential users are encouraged to work with SPIE to define the feasibility of specific spacecraft/payload PLF diameter and length needs as soon as possible.

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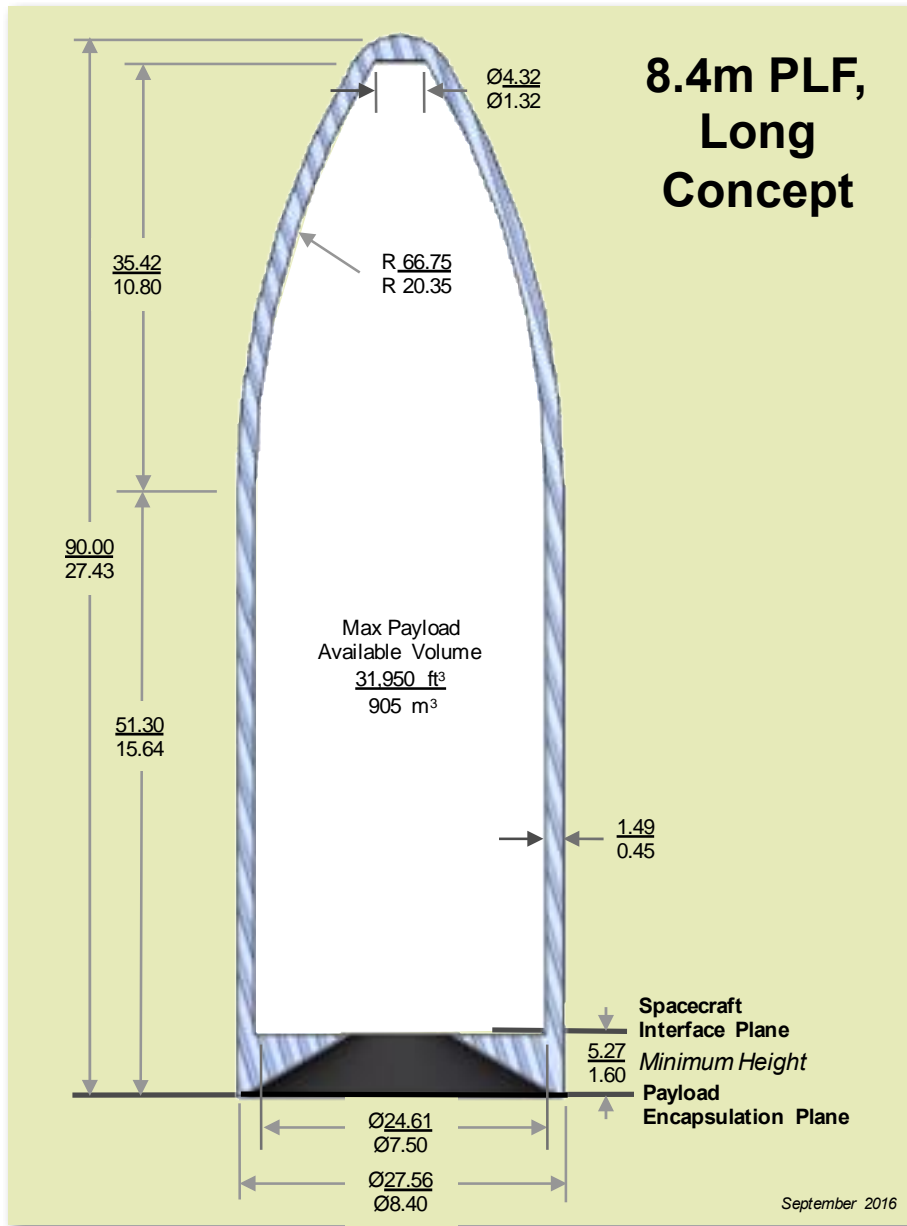
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|--|---|
| <p> Available Payload Dynamic Envelope</p> <p> Fairing Envelope (w/acoustic attenuation)</p> <p> Minimum Payload Adapter Envelope</p> | <ul style="list-style-type: none"> • All dimensions in $\frac{\text{Feet}}{\text{m}}$ • Height of the spacecraft separation/interface plane depends on spacecraft/PAF attach diameter and PAF cone angle • Spacecraft appendages projecting below spacecraft interface plane may be permitted; coordinate with SLS/SPIE |
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Figure 6-8. Composite 8.4 m PLF, Short Concept

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


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|--|---|
| <p> Available Payload Dynamic Envelope</p> <p> Fairing Envelope (w/acoustic attenuation)</p> <p> Minimum Payload Adapter Envelope</p> | <ul style="list-style-type: none"> • All dimensions in $\frac{\text{Feet}}{\text{m}}$ • Height of the spacecraft separation/interface plane depends on spacecraft/PAF attach diameter and PAF cone angle • Spacecraft appendages projecting below spacecraft interface plane may be permitted; coordinate with SLS/SPIE |
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Figure 6-9. Composite 8.4 m PLF, Long Concept

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6.4.2 10m Diameter Fairings

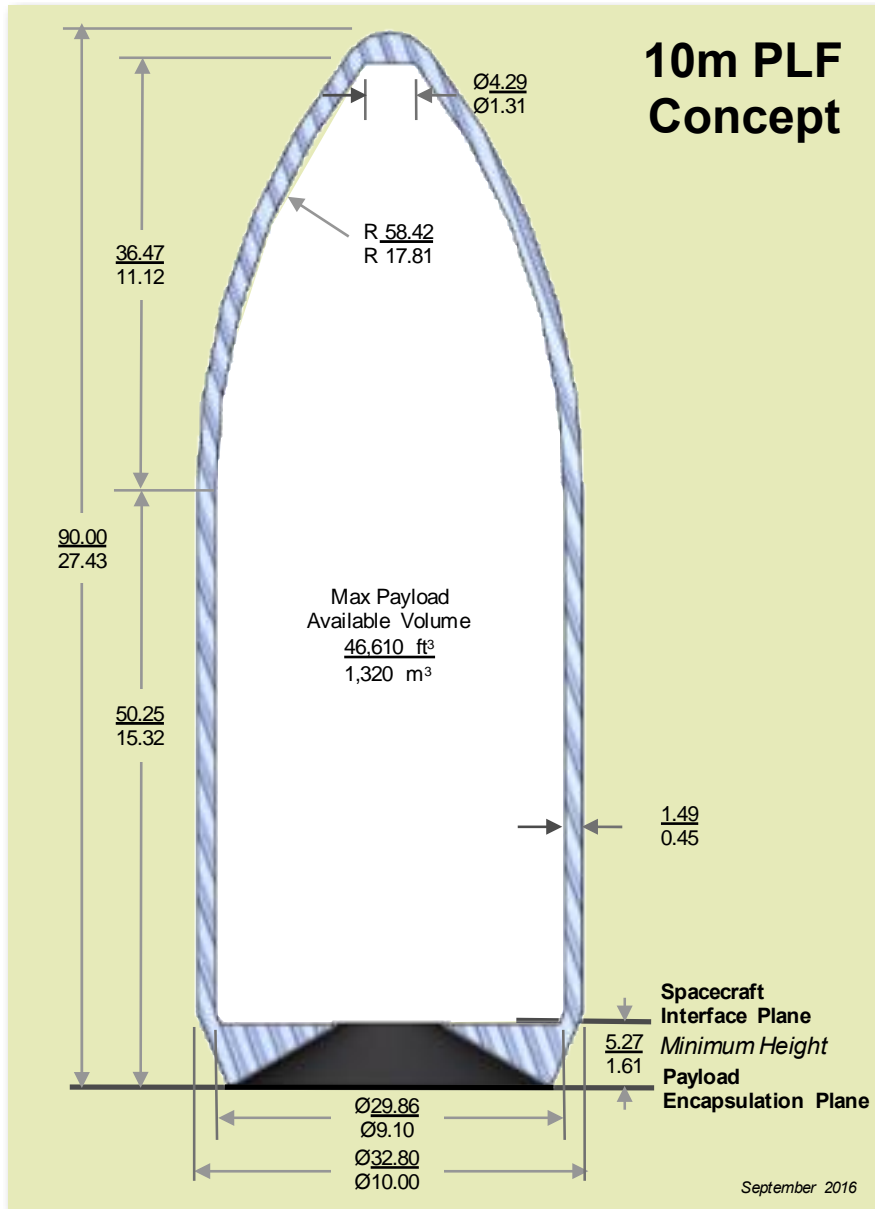
Once SLS transitions to the Block 2 configuration using the enhanced performance of an 8.4 m diameter EUS and Evolved Boosters, potential accommodation of larger diameter PLFs in the 33 ft (10 m) class may be possible.

The current 10 m diameter PLF concept represents the maximum length possible based on door width and door/ceiling height constraints of CCAFS's largest encapsulation facility. Figure 6-10 provides the available dynamic envelope for this 10 m PLF. Potential exists for shorter 10 m PLFs by shortening the cylindrical section as needed. A 10 m PLF that is 63 ft (19 m) long 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/length combinations. Therefore, potential users are encouraged to work with SPIE to define the feasibility of specific spacecraft/payload PLF diameter and length needs as soon as possible.

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


-  Available Payload Dynamic Envelope
 -  Fairing Envelope (w/acoustic attenuation)
 -  Minimum Payload Adapter Envelope
- All dimensions in $\frac{\text{Feet}}{\text{m}}$
 - Height of the spacecraft separation/interface plane depends on spacecraft/PAF attach diameter and PAF cone angle
 - Spacecraft appendages projecting below spacecraft interface plane may be permitted; coordinate with SLS/SPIE

Figure 6-10. Composite 10 m PLF Concept

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6.5 SLS Payload Adapter Accommodations for CPL and PPL

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

Payload Adapter provided resources and interfaces available to PPL, CPL and SPL during ground and flight operations are shown in Figures 6-11 (Crew vehicle) and 6-12 (Cargo vehicle). Ground services can be provided to payload integrated within the USA or PLF volume via the PAF Utilities Feed-Through Plate. This includes the potential for a unique ECS purge of the USA (non-standard service). Once the encapsulated payload is integrated to the EUS in the Vehicle Assembly Building, these ground resources are then routed through the EUS Umbilical Plate. After umbilical separation on the pad at lift-off, EUS provides flight resources on a mission dependent basis.

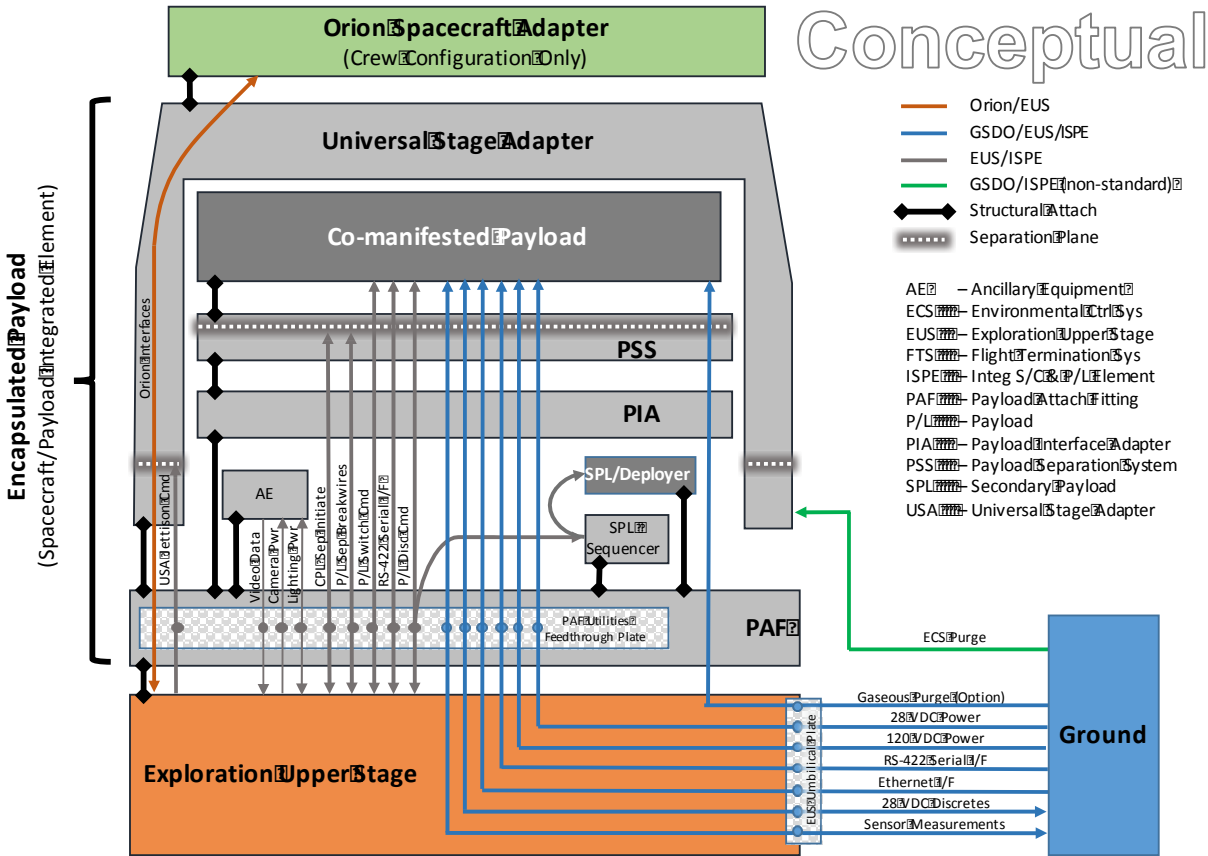


Figure 6-11. Conceptual Payload Adapter Accommodations for Crew Vehicle (USA)

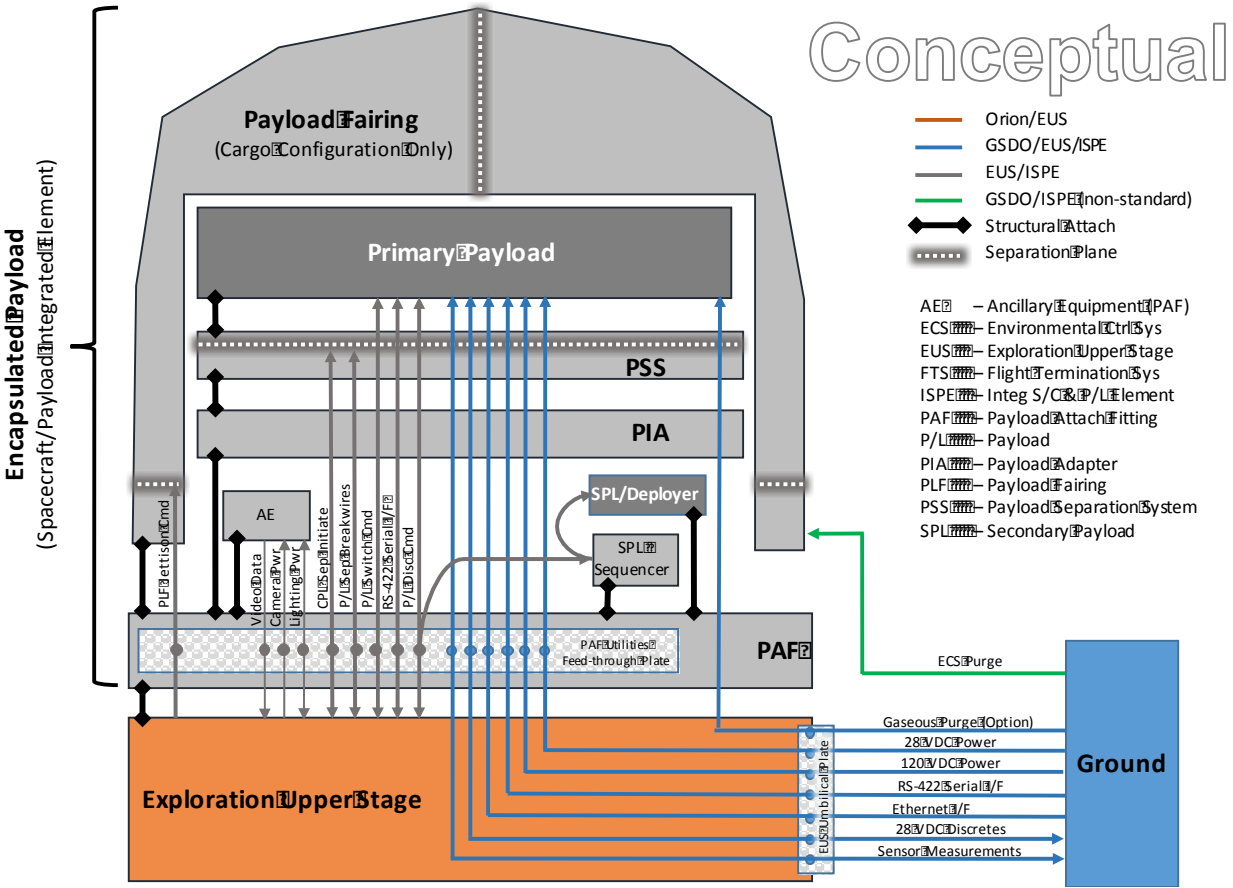


Figure 6-12. Conceptual Payload Adapter Accommodations for Cargo Vehicle (PLF)

6.5.1 CPL and PPL Mechanical Interfaces

Similar to ELVs, the mechanical interface between SLS launch vehicle and a Primary or Co-manifested Payload is provided by a mission dependent Payload Adapter consisting of up to three components assembled in various configurations as shown in Figure 6-13:

- Payload Attach Fitting (PAF) - structural/service interface to the SLS EUS Forward Adapter. The PAF can be configured with a Payload Interface Adapter and/or Payload Separation System to accommodate different spacecraft/payload interfaces as needed.
- Payload Interface Adapter (PIA) – optional structural/service interface between the PAF and spacecraft/payload available to maximize available volume/height. It accommodates a Payload Separation System.
- Payload Separation System (PSS) –structural separation interface for a spacecraft/payload mounted on the PAF or PIA. It supports a variety of COTS PSS (e.g., D1666 or 1666VS).

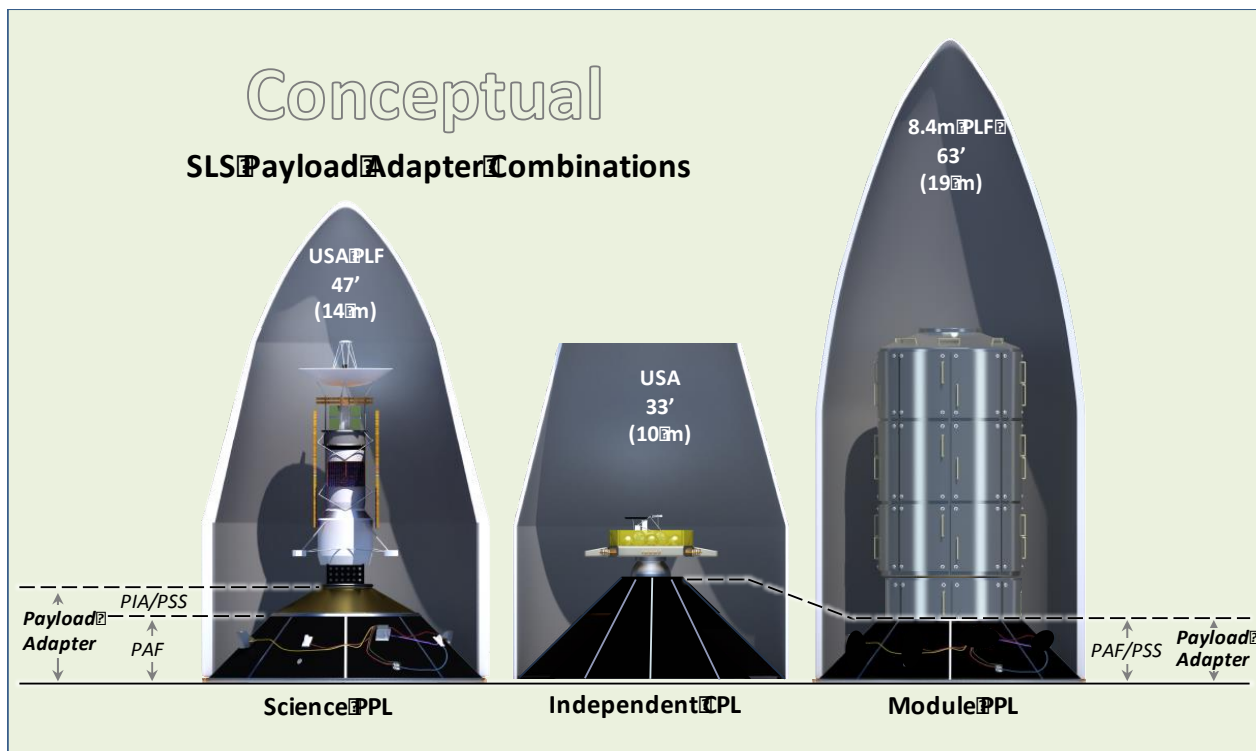


Figure 6-13. Potential SLS Mechanical Interface Configurations for CPL and PPL

This flexible SLS Block 1B Payload Adapter approach allows use of different components to provide a required interface, height, and volume for the spacecraft/payload. Figure 6-14 describes four representative SLS Block 1B 8.4 m Payload Adapter concepts available to be used for initial payload planning and sizing purposes.

Concept 1 represents a single composite cone Payload Adapter configuration capable of supporting up to a 22,046 lbm (10.0 t) of payload; this would support a mission similar to the “Independent CPL” shown in Figure 6-13. It also provides an example of a typical, COTS PSS spacecraft/payload accommodation of 62.0 in (1575 mm).

Concept 2 and 3 are similar in using a PAF geometry equivalent to the base of Concept 1, but shorter. The composite nature of this design allows the option of incorporating more or less composite plies depending on a load ranging from 22,046 lbm (10.0 t) to 88,185 lbm (40.0 t). The “Module PPL” in Figure 6-13, represents either of these 2 concepts.

Concept 4 represents a three-piece Payload Adapter configuration capable of supporting up to a 22,046 lbm (10.0 t) of payload. It provides an equivalent PSS diameter interface to Concept 1, but at a shorter overall height due to a shallower PIA cone angle as compared to that of the PAF. This concept supports a mission similar to the “Science PPL” shown in Figure 6-13.

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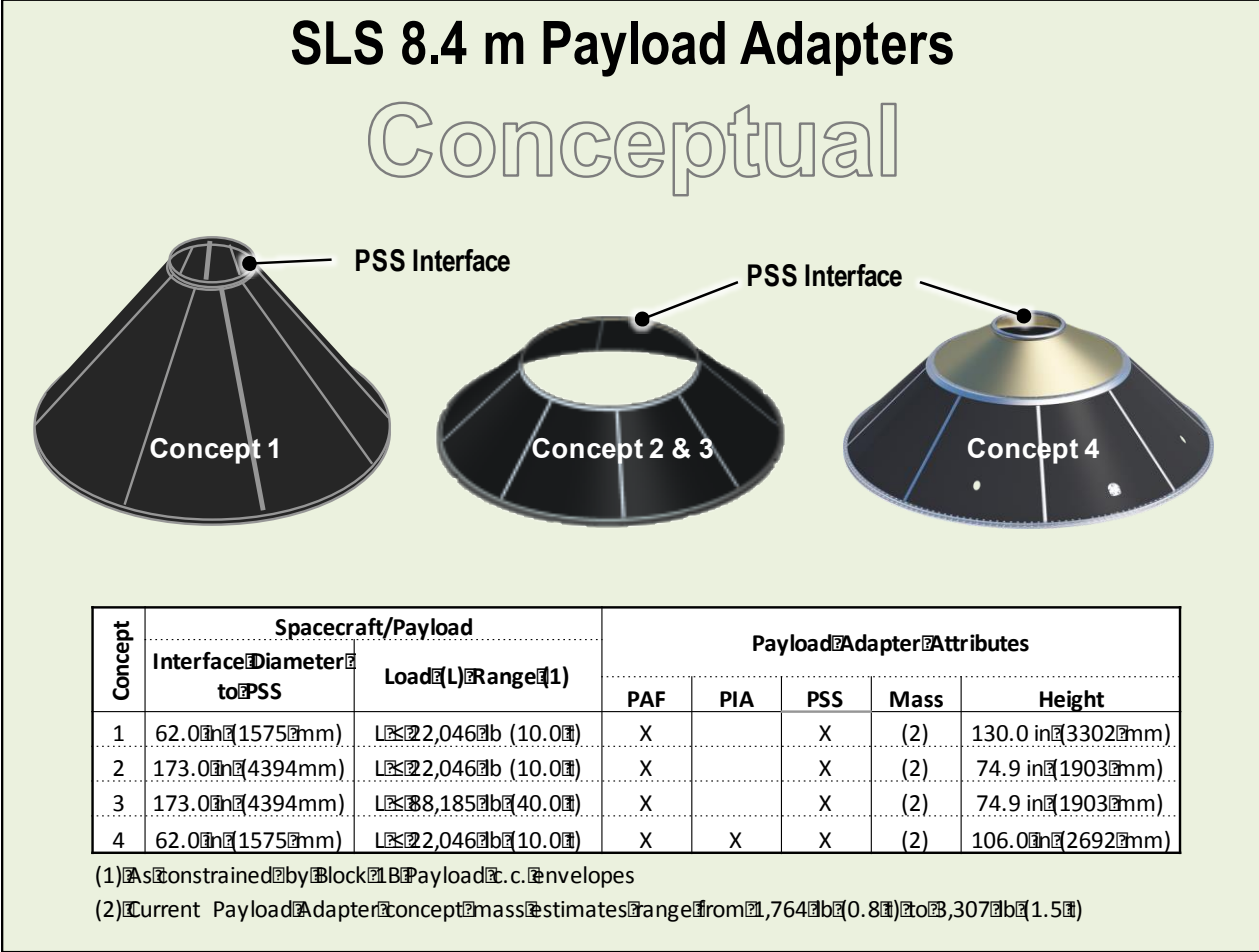


Figure 6-14. 8.4 m Payload Adapter Concepts

The SLS Block 1B PAF is constructed of composite sectors with horizontal and vertical joints. These sectors can be individually customized to enhance performance (more or less composite plies) and/or resource access (connector and bracket support interfaces). In order to best meet unique spacecraft/payload mission requirements (e.g., performance to destination, height within the USA, interface diameter), the composite PAF sectors can be lengthened/shortened to provide a custom spacecraft/payload interface at an efficient mass. In general, Payload Adapters 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 Payload Adapter designs will be required over time as spacecraft/payload interfaces are better defined to take advantage of the unique performance capability of SLS.

As shown in Figure 6-1, an option exists to fly multiple, smaller CPLs mounted to a payload ring similar to the Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) mounted above the SLS Payload Adapter. This approach can provide additional deployment flexibility and efficiency for smaller CPLs as well as accommodate an entire payload ring or number of stacked rings. This accommodation could be flown in tandem with a larger CPL depending on

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mission performance and USA/PLF volume height available. The potential for this type of accommodation on SLS is currently being evaluated.

6.5.2 CPL and PPL Electrical Interfaces

As shown in Figure 6-11 and 6-12 a number of ground power and data services are provided to the EUS with potential distribution to payloads via the Payload Adapter. For each service, multiple, redundant pairs or multiple connectors are available. This interface/service can be available to CPL and PPL starting with payload encapsulation (although facilities/service are available before that time as an optional service) and ending at EUS pad umbilical separation at launch.

Flight data services are distributed from the EUS via the Payload Adapter to the spacecraft/payload. They include multiple, redundant pairs for commands and data as well pyro initiation for USA/PLF jettison and spacecraft/payload separation. Redundant breakwires are provided to confirm spacecraft/payload separation from SLS. This interface/service can be available to CPL and PPL starting with EUS pad umbilical separation at launch and ending at PAF umbilical separation during payload jettison post EUS insertion burn. As a note, the EUS provides no electrical power provision to payloads post lift-off. 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 PAF if desired; this additional mass would be considered as part of the total Payload Mass.

6.6 SLS Payload Adapter Accommodations for SPL

SLS Block 1B/2 will accommodate the Secondary Payload Deployment System (SPDS) on the outer surface of the Payload Adapter PAF as shown in Figure 6-15. The SPDS provides a standard SPL interface via a COTS Dispenser, Dispenser SPL Support Structure, Avionics Unit, and cable harness for deployment signal and access to battery charging from EUS/ground services. Once CPL or PPL has separated from the EUS and the EUS has completed its disposal burn SPL 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.

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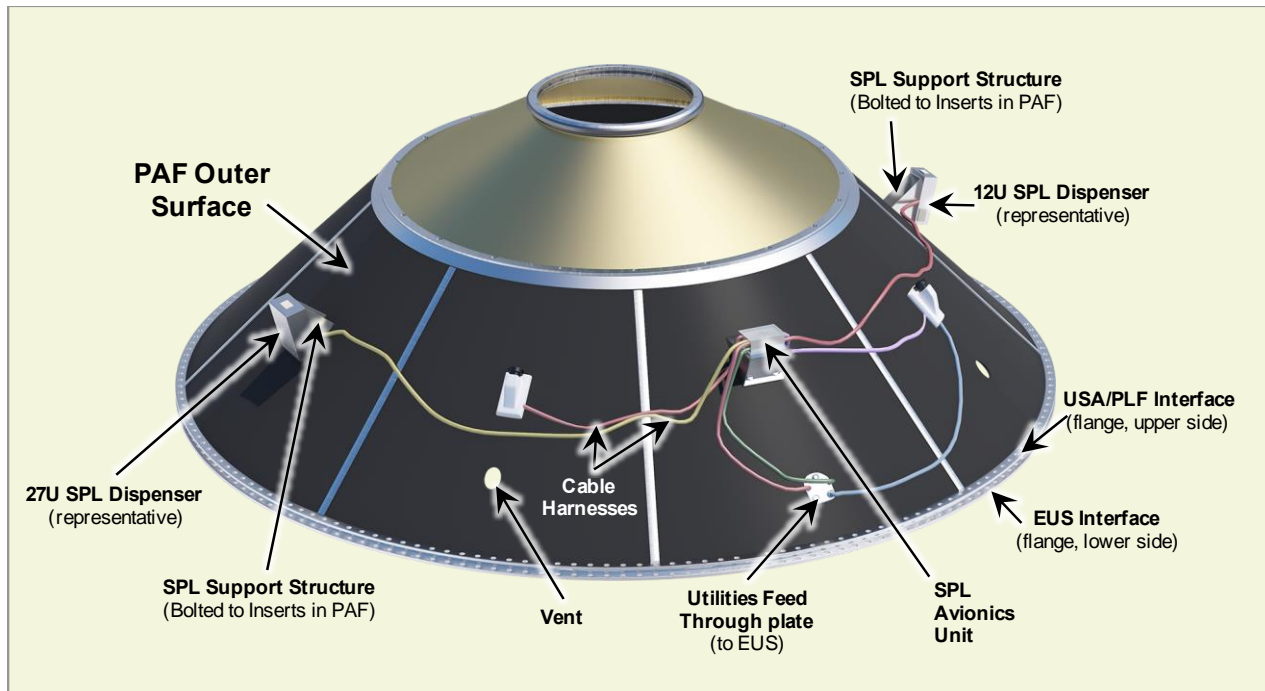


Figure 6-15. 8.4 m Payload Adapter PAF Accommodation of SPL

6.6.1 SPL Mechanical Interfaces

The primary structural interface for a SPL is to an SLS Dispenser. This Dispenser provides the SPL a means for SLS integration, protection during launch/ascent and deployment from the launch vehicle. The SPDS can accommodate either a 6U (unit), 12U or 27U size Dispenser; the SPL must stay within allowed physical provisions for its associated Dispenser.

Physical provisions include the dimensional orientation of the payload inside the Dispenser, maximum allowable dimensions, volume, and mass, and the center of gravity envelope. Figure 6-16 depicts the SPL dimensional orientation. Table 6-1 provides the dimensions, volume, and mass numbers for both 6U and 12U Dispensers (27U Dispensers are currently under development). Figure 6-17 provides the payload center of gravity within the Dispenser, and Table 6-2 provides the center of gravity 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.

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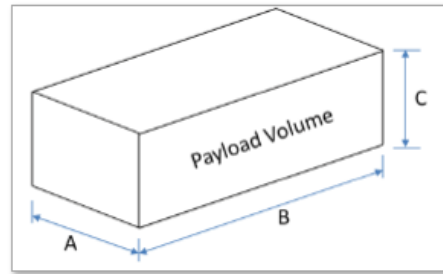


Figure 6-16. Payload Envelope Dimensional Depiction

Table 6-1. Payload 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

Table 6-2. Payload Center of Gravity 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)

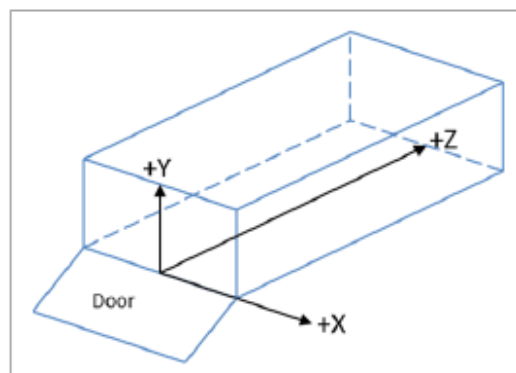


Figure 6-17. Payload C.G. Envelope within Dispenser

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The integrated SPL/Dispenser unit will interface with a SLS PAF for structural support during launch and early flight phases. The SPDS will provide the cable connectors and wire types that interface the integrated Dispenser with the PAF support bracket. The integrated SPL/Dispenser unit must be within the allowed mass and center of gravity provisions of the PAF. Currently the 6U Dispenser mass is 10.78 lbm (4.89 kg) and the 12U Dispenser mass is 13.27 lbm (6.02 kg); the 27U Dispenser mass is still in development. For the integrated payload and 6U Dispenser, there exists a mass margin of 16.36 lbm (7.42 kg). Mass margin provisions for vibration isolation, thermal protection, etc. are an option and must be discussed with the SPIE office. The combined Secondary Payload/Dispenser unit center of gravity envelope is the same as shown in Table 6-2. The integrated Secondary Payload / 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

6.6.2 SPL Electrical Interfaces

While the SPDS receives, battery charging capability via a drag-on cable connector prior to roll-out to the launch pad, there is currently no capability for battery charging to SPLs during encapsulation, or pad operations. The last opportunity for users to charge SPL batteries will be in the VAB; therefore, SPLs will remain powered off from VAB roll-out until post-deployment from the SLS vehicle. The SPDS Avionics Unit is programmed prior to flight with the pre-determined sequence and timing for each SPL deployment. When the SPDS Avionics Unit receives the signal from the EUS (post disposal initiation), two identical independent power circuits are closed which initiates the SPL deployment sequence. The SPL is then powered upon deployment.

6.7 Ground Equipment Interfaces

6.7.1 Spacecraft/Payload Console

This section is reserved.

6.7.2 Power

Kennedy Space Center (KSC) provides several types of electrical power at the payload processing facilities as well as at the launch complex for payload customer use. Alternating Current (AC) power is used for basic facility power as well as end-user equipment power. The processing and launch facilities outlined in Section 7.1 also include Uninterruptible Power Supply (UPS) units that can be utilized for critical operations.

6.7.3 Liquids and Gases

All chemicals used will be in compliance with requirements restricting ozone-depleting chemicals.

- **Gaseous Helium (GHe)** – At Launch Complex 39, GHe is available within the VAB during final payload closeout activities, as well as at Pad B.
- **Gaseous Nitrogen (GN2)** – At Launch Complex 39, GN2 is available within the VAB during final payload closeout activities, as well as at Pad B.
- **Gaseous Oxygen (GO2)** – At Launch Complex 39, GO2 is available at Pad B.

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6.7.4 Propellant and Gas Sampling

This section is reserved.

6.7.5 Work Platforms

High Bay 3, within the Vehicle Assembly Building (VAB), 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.

6.8 Range and System Safety Interfaces

The Range element provides RF surveillance, meteorology and tracking for launches from the KSC. The upgraded Winds Towers at LC-39 will provide real-time weather measurements for all customers launching from the Pad 39B. All other range functions are integral parts of the Eastern Range (ER) Architecture and support all customers at KSC and the ER.

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7.0 KSC PAYLOAD LAUNCH FACILITIES

The SLS will launch from KSC in Florida. The GSDO Program is responsible for the coordination with all center programs and project for maintenance and operation of all vehicle and spacecraft/payload processing, integration, and launch facilities to be utilized by the SLS Program. KSC facilities include payload processing facilities available to commercial and U.S. government users. This section outlines the processing, integration, and launch facility capabilities that are available to SLS customers as shown in Figure 7-1: Space Station Processing Facility (SSPF), Multi Payload Processing Facility (MPPF), Payload Hazardous Servicing Facility (PHSF), and Launch Complex 39 which includes the Vehicle Assembly Building (VAB), Launch Pad B and the Launch Control Center (LCC).



Figure 7-1. Aerial Overview of KSC Facilities

7.1 Space Station Processing Facility

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

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

The Space Station Processing Facility (SSPF) consists of an administrative area, intermediate high bay (I-bay) area and high bay (HB) area with an adjoining 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 existing inhabited buildings and the explosive and safety quantity distance requirements. Figure 7-3 depicts the floor plan of the SSPF.

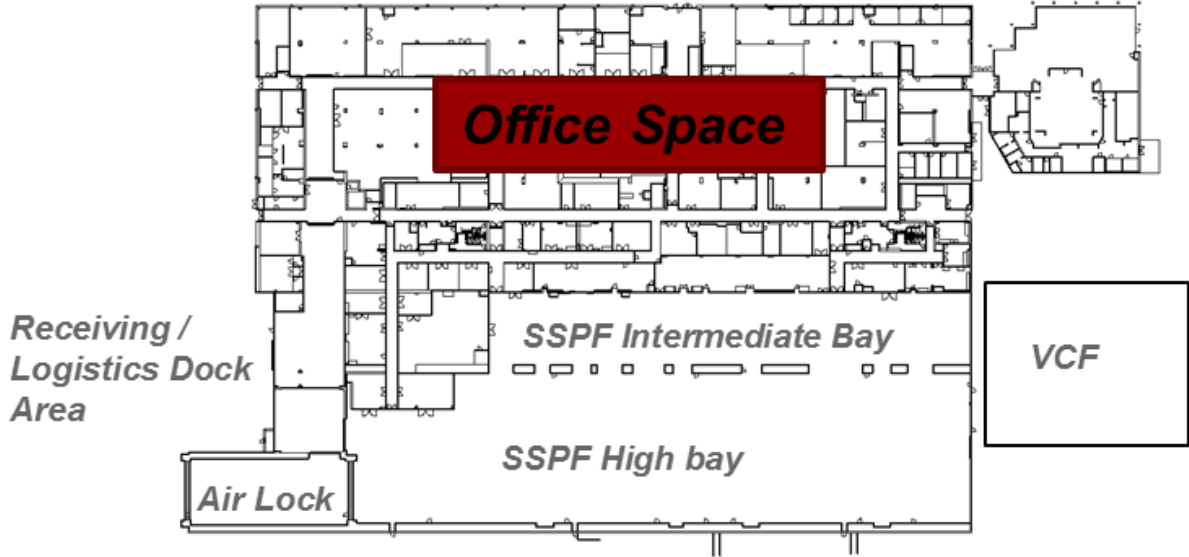


Figure 7-3. SSPF Floor Plan

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The online processing areas are located in the I-bay and HB of the SSPF. The high bay 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 high bay floor is capable of supporting very heavy loads. It also has sections, which are seismically isolated, thus making it suitable for extremely precise measurements. The floor is very smooth in order 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 (ESD).

Each footprint in the SSPF high bay provides up to 480V/100A of power, facility ground, chilled water, gaseous nitrogen (GN2), gaseous helium (GHe), high and low pressure venting, Operational Intercommunication Systems-Digital (OISD) communications, and compressed air. Detailed information regarding facility capabilities are outlined in Table 7-1 and the section below. The building also was designed to accommodate a set of changing requirements. New footprint capabilities can easily be added via the tunnels underneath the high bay.

Table 7-1. SSPF Capability Overview

	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	55% max. continuous	55% max. continuous	55% max. continuous
Usable Floor Space	105 ft x 362 ft (32.00 m x 110.34 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 metric ton)	(2) 5 ton (4.5 metric ton)	15 ton (13.6 t metric ton)
Crane Hook Height	50 ft (15.24 m)	25 ft (7.62 m)	50 ft (15.24 m)

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Air Handling – The air handling system in the online processing areas is capable of a minimum of four complete air changes in the high bay per hour, and can hold the temperature and humidity within strict specifications. The system runs at the capacity needed to keep the room at a 100,000 clean work area (CWA) specification.

Ammonia Servicing – the Vapor Containment Facility (VCF), an ammonia plant to the east of the I-bay, serves the facility. The plant can handle 1,200 lbm (544 kg) flowing, with 6,000 lbm (2,721 kg) in storage. Ammonia lines are brought into the high and intermediate bays on the east end, and built-in and portable environmental monitoring equipment is available.

Compressed Air – The SSPF can provide compressed air at 125 psi (8.6 bars).

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

Cranes – The HB has two 30-ton (27.2 metric ton) 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 metric ton) electrical bridge cranes with a 25 ft (7.62 m) hook height. The air lock 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 metric ton) electrical bridge crane with a 25 ft (7.62 m) hook height.

Electrical Service – This facility is outfitted with 480 V, three-phase power at 60 Hz, and can be reconfigured to meet customer requirements. The SSPF has redundant connections to the power grid as well as a backup generator. Also, battery uninterruptible power is provided through a combination of built-in facility systems and portable UPS units.

Gaseous Helium – GHe is provided to footprint mechanical panels in the HB, I-bay, and the GSE fluids area. There are control panels around the perimeter of the areas that isolate the gas. Pressures can be controlled through separate valves for 50, 750, 3,000 and 6,000 psi (3.45, 51.7, 206.8 and 413.7 bar). The lines are 1 by 0.095 in (2.54 by 0.24 cm), 1 by 0.095 in (2.54 by 0.24 cm), ¾ by 0.065 in (1.91 by 0.17 cm), and ½ by 0.072 in (1.27 by 0.18 cm), respectively.

Gaseous Nitrogen – GN2 is provided to footprint mechanical panels in the HB, the I-bay, and the GSE fluids area. There are control panels around the perimeter of the areas that isolate the gas. Pressures can be controlled through separate valves for 50, 750, 3,000 and 6,000 psi (3.45, 51.7, 206.8 and 413.7 bar). The lines are 1¼ by 0.049 in (3.175 by 0.125cm), 1¼ by 0.049 in (3.175 by 0.125 cm), 1 by 0.095 in (2.54 by 0.24 cm), and ½ by 0.072 in (1.27 by 0.18 cm), respectively.

Office Space – This facility contains approximately 140,000 ft² (13,006.4 m²) 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 anhydrous ammonia; 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).

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Potable Water – Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Temperature and Humidity Control – The environmental conditions are kept at 71 (+/- 6 degrees) degrees F (21.7 +/- 3.3 degrees C). Offline lab areas also are available with additional controls for air conditioning monitoring. The lab areas require the temperature to be 72 °F (22.2 °C) (+/- 2 degrees). Relative humidity for the facility is 55 percent max continuous; humidity in offline lab areas is maintained between 35 and 50 percent.

Video Camera/Recorders – 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 high bay 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 all of the 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

The Multi Payload Processing Facility (MPPF) shown in Figure 7-4 is available for SLS spacecraft/payload processing as an optional service (negotiated with KSC separately). This facility has been used for processing Space Shuttle and Launch Services Program payloads. 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 isle. A Level 4, Class 100,000 clean work area, 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.

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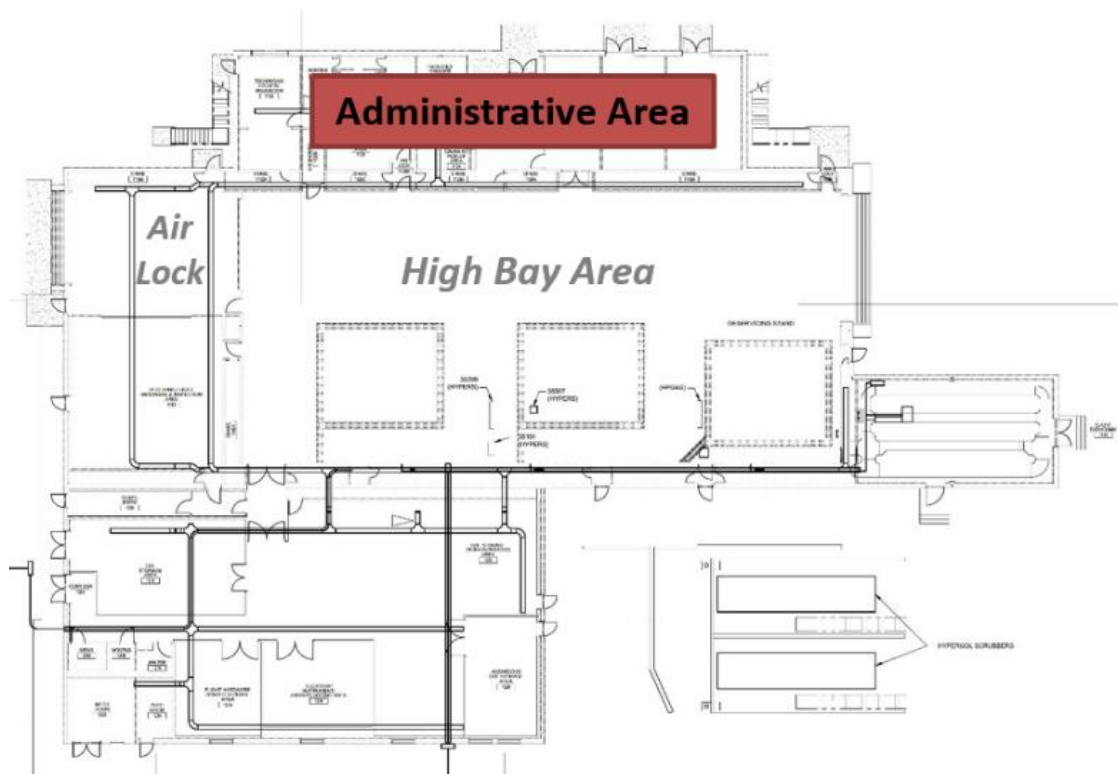


Figure 7-5. MPPF Floor Plan

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 (ESD) mitigation system for the reduction of ESD damage.

Each of the 3 footprints in the SSPF high bay provides up to 480V/100A facility power, ground, HVAC, gaseous nitrogen (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 Table 7-2.

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Table 7-2. MPPF Capability Overview

	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 metric ton)	N/A
Crane Hook Height	49 ft (14.9 m)	N/A

Air Handling – The conditioned air handling system in the online processing areas is capable of a minimum of four complete air changes in the highbay per hour, and can hold the temperature, humidity and particulate filtration within specifications for a 100,000 clean work area (CWA).

Breathing Air – BAir (SCAPE / SAR connections) available in each of the high bay servicing areas to support hazardous processing operations.

Compressed (shop) Air – 90 psi (6.2 bars) to 125 psi (8.6 bars).

Cranes – The high bay has one 20-ton (18.1 metric ton), cab-operated, electrical bridge crane with a 49 ft (14.9 m) hook height.

Electrical Service – 120V / 240V / 480V, three-phase power at 60 Hz, and can be reconfigured to meet customer requirements.

Gaseous Helium –available from highbay South wall at pressures of 750 psi (51.7 bars), 3,000 psi (206.8 bars), and 5,600 psi (386.1 bars) maximum.

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Gaseous Nitrogen – available from highbay South wall at pressures of 750 psi (51.7 bars), 3,000 psi (206.8 bars), and 5,600 psi (386.1 bars) maximum.

Hypergolic Vent System – Hypergolic vents are located on the south wall of the high bay. Vapors are piped into the respective fuel or oxidizer separators, and then the effluent travels into the hypergolic scrubber system and is vented. Aspirated (vacuumed) hypergolic liquids are retained in the aspirator, and vapors are exhausted through the hypergolic vents.

Office Space – The MPPF is a work area. There is no planned office space at this location due to planned hazardous operations. Offline space 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.

Potable Water – Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Temperature and Humidity Control – The environmental conditions are kept at 71 (+/- 6 degrees) degrees F (21.7 +/- 3.3 degrees C). Relative humidity for the facility is 55 percent max continuous.

Uninterruptible Power Supply (UPS) – UPS is available at the facility; however, it is utilized by critical ground systems. Any potential use of the UPS would need to be coordinated so as not to impact existing systems.

Video Camera/Recorders – The Closed Circuit Television (CCTV) system provides color, closed-circuit video surveillance and recording of payload processing activities from operational areas. There are currently 5 cameras in the system.

7.3 Payload Hazardous Servicing Facility

The Payload Hazardous Servicing Facility (PHSF) shown in Figure 7-6 is planned to be used to encapsulate spacecraft/payload within the USA or PLF as a standard service. It is an 18,813 ft² (1,747.8 m²) steel frame building covered with insulated metal siding, which contains a hazardous operations service bay and air lock. This service bay also meets the requirements of a Level 4, class 100,000 clean room, and can be used as a payload processing facility and/or a hazardous processing facility. 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); 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 carry nuclear material. The PHSF high bay also provides SLS payload fairing encapsulation capability as needed.

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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 7-3 and the section below.

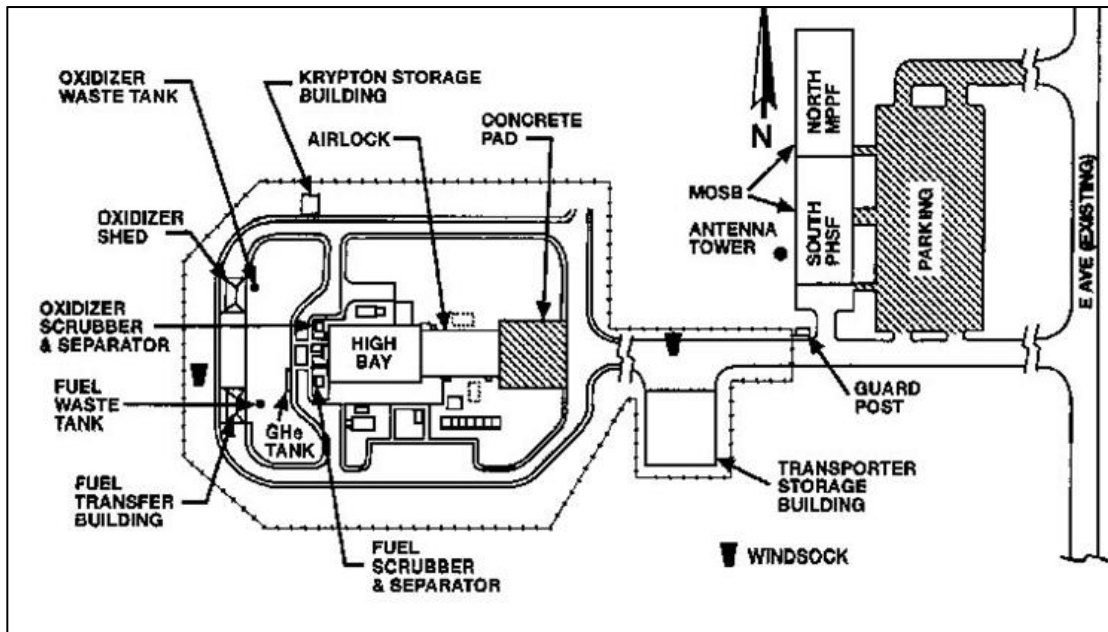


Figure 7-7. PHSF and Surrounding Facilities

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Table 7-3. PHSF Capability Overview

	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	60% maximum	60% maximum
Usable Floor Space	107 ft x 60 ft (32.6 m x 18.3 m)	85 ft x 50 ft (25.9 m x 15.2 m)
Ceiling Height	95 ft (28.96 m)	90 ft (27.43 m)
Door Dimensions (H x W)	75 ft x 35 ft (22.86 m x 10.67 m)	75 ft x 35 ft (22.86 m x 10.67 m)
Crane Type	Bridge	Bridge
Crane Capacity	50 ton (45.3 metric ton)	15 ton (13.6 metric ton)
Crane Hook Height	74.5 ft (22.71 m)	72.5 ft (22.10 m)

Compressed Air – Two air compressors supply regulated compressed air to the PHSF service bay and the air lock, the outlets are equipped with 5-micron filters. The PHSF can provide 90 psi (6.2 bars) at 185 ft³ per minute (5.24 m³ per minute) and 150 psi (10.3 bars) at 325 ft³ per minute (9.2 m³ per minute).

Control Rooms – Control Rooms in the Mission Operations Support Building can be used to monitor activities in the PHSF.

Cranes – The air lock has a 15-ton (13.6 metric ton) 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 metric ton) bridge cranes which 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.

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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 meters) from the east wall, and 34 feet, 3 inches (10.4 meters) from the west wall. The effective north-south travel of the hoist (hook centerline to wall) is 11 feet (3.3 meters) from the north wall, and 9 feet, 10 inches (2.9 meters) from the south wall.

Electrical Service – This facility is outfitted with 480 volts, three-phase power at 60 hertz, and can be reconfigured to meet customer requirements.

Gaseous Helium – GHe can be provided by mobile compressed gas trailer for pressures up to 6,000 psi (413.7 bars) or by K-bottles for up to 2,200 psi (151.7 bars) based on user requirements.

Gaseous Nitrogen – The Gaseous nitrogen (GN2) system is supplied from the unfiltered Industrial Area at 6,000 psi (413.8 bars) A GN2 regulating panel, also located at the west end of the building, filters the GN2 to 10 microns and regulates the GN2 down to 50 psi (3.4 bars), 750 psi (51.7 bars), and 3,000 psi (206.9 bars). The GN2 (Grade B, MIL-P-27401C) is available in both the PHSF service bay and air lock.

Hypergolic Vent System – Hypergolic vents are located on the west wall of the service bay. Vapors are piped into the respective fuel or oxidizer separators, and then the effluent travels into the hypergolic scrubber system and is vented. Aspirated (vacuumed) hypergolic liquids are retained in the aspirator, and vapors are exhausted through the hypergolic vents.

PHE Breathing Air – Regulated breathing air for Propellant Handlers Ensemble (PHE) operations is available from four 9.525 millimeter (3/8 inch) quick disconnect couplings on the west wall of the service bay. The PHSF can provide 65 psi (4.5 bars) and 120 psi (8.3 bars).

Potable Water – Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Temperature and Humidity Control – Air enters the PHSF through High-Efficiency Particle Air (HEPA) filters mounted in the ceilings of the service bay, air lock and equipment air lock, and is guaranteed class 5,000 air at the filter discharge for the air conditioning and reheat systems. These systems maintain temperatures of 71 (+/- 6) °F (21.7 +/- 3.3 °C), with a maximum relative humidity of 60 percent. Volumetric air change is exchanged a minimum of four times per hour, with positive pressure maintained at all times. These systems maintain temperatures of 71 (+/- 6) °F (21.7 +/- 3.3 °C), with a maximum relative humidity of 60 percent.

Uninterruptible Power Supply (UPS) – There are two UPS units in the PHSF. An 80 KVA 480v system and a 100 KVA 120/208v system supply power to all the explosion-proof receptacles in the high bay and air lock.

Video Camera/Recorders – 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 Mission Operation Support Building.

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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.

The PHSF is currently used by Boeing to perform hazardous payload processing for the Checkout, Assembly and Payload Processing Services (CAPPS) contract on expendable launch vehicle (ELV) payloads. Sliding doors (owned and maintained by Boeing) 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 Multi-Operations Support Building.

7.4 Payload Launch Complex 39

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

7.4.1 Vehicle Assembly Building

The Vehicle Assembly Building (VAB) shown in Figure 7-8 supports integration and stacking of the encapsulated payload to the EUS, 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. It has the capability of accessing different locations around the launch vehicle using multiple fixed platforms within High Bay 3. 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, lowbay 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 check out 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 of the VAB. 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.

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

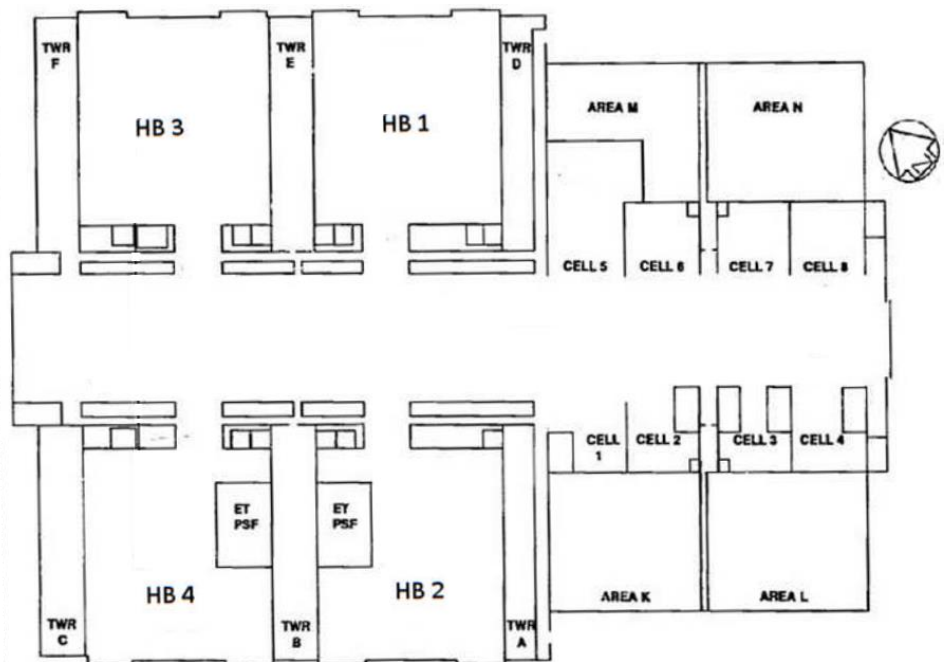


Figure 7-9. VAB Floor Plan

Compressed Air – The VAB can provide compressed air at 125 psi (8.6 bars).

Command, Control, Communications, and Range – This facility has the capability to provide the following C3R 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), Radio Frequency and Telemetry Station (RFTS)

Cranes – The VAB high bays have a 250 and 325 ton (227 and 295 metric ton) 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 32 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 metric ton) 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).

Electrical Service – Power enters the VAB at 13.8 kV and is stepped down as needed to 480 volts alternating current (VAC) at the various unit substation transformers. It is then distributed throughout the facility and ultimately feeds end user equipment at voltage levels of 480/277 or 208/120 with either single or three phase as required.

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Environmental Control System – A conditioned air purge can be provided to the launch vehicle and spacecraft/payload on the ML in the VAB high bay through umbilicals on the ML Tower:

- Cleanliness Class 100,000 (ISO Class 8)
- Temperature 65-85 °F (18-29 °C); temperature ranges are dependent upon final ECS configuration
- Humidity ratio 37 grains-per-pound (81.6 grains-per-kilogram) of dry air
- Flow rate 235 lbm/min (1.77 kg/sec)

Gaseous Helium – Gaseous helium (GHe) is supplied to the high bays and low bays at a pressure of 6,000 psi (413.7 bars). GHe is distributed from the High Pressure Gas Storage Building to Tower D, where it is then distributed to Tower A, B, C, E, and F.

Gaseous Nitrogen – Gaseous nitrogen (GN₂) is supplied to the high bays and low bays at a pressure of 6,000 psi (413.7 bars). GHe is distributed from the High Pressure Gas Storage Building to Tower D, where it is then distributed to Tower A, B, C, E, and F.

Potable Water – Potable water requires filtration to pass testing to be in compliance with the federal government standard is available in this facility.

7.4.2 Mobile Launcher

The Mobile Launcher (ML) shown in Figure 7-10 for SLS Block 1B consists of the Mobile Launch Base (MLBM) and an integrated Mobile Launch 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 in the VAB, platforms are used to provide access for mating of all umbilicals on the MLT with the integrated vehicle; limited access is provided for last minute payload closeout operations. While at the Pad, limited access may be available for the integrated vehicle and payloads as an optional service.

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 the Orion and EUS. Provisions for PPL, CPL, and SPL ground services will be routed through the SLS EUS Forward Adapter via the EUSU.

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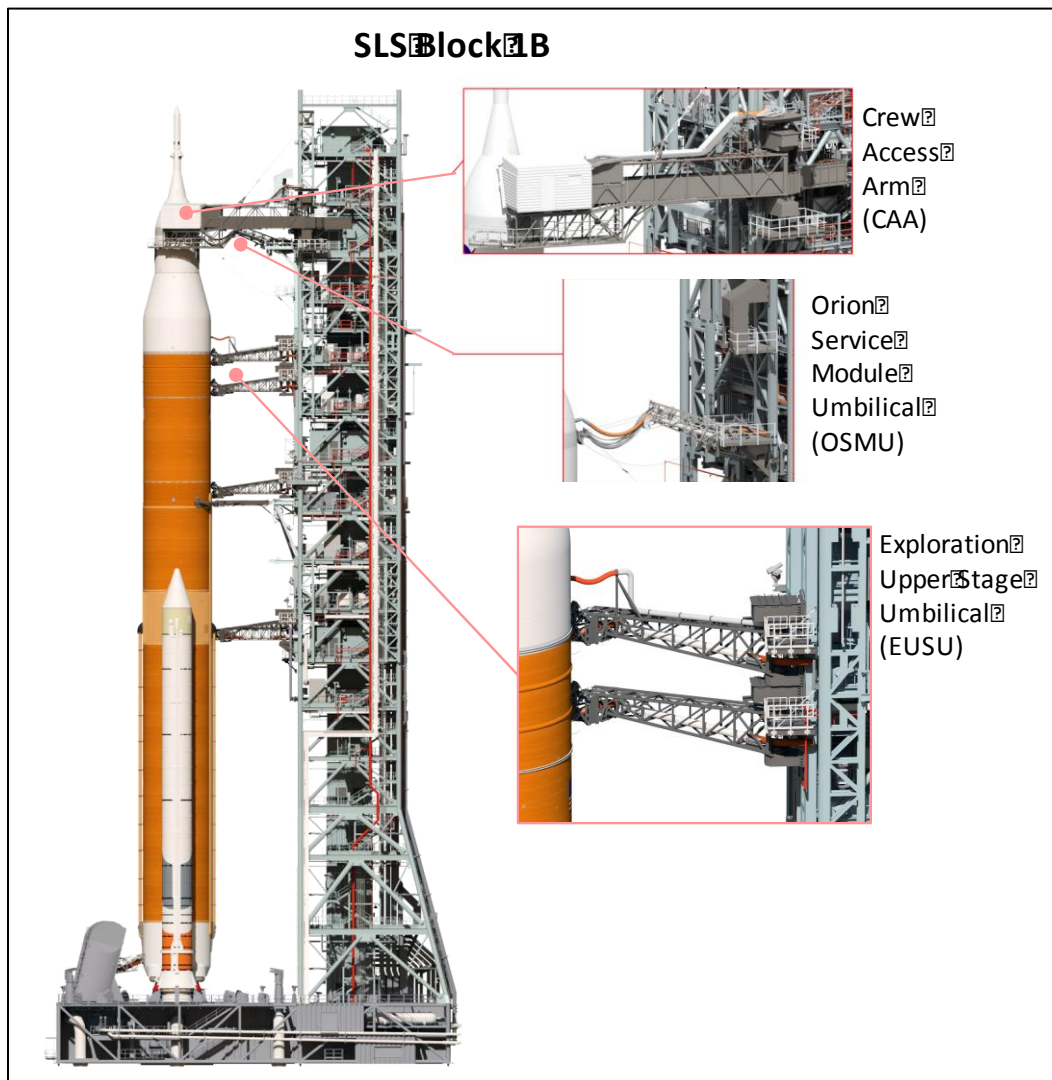


Figure 7-10. Mobile Launcher (ML)

Compressed Air – The ML can provide compressed air at 125 psi (8.6 bars), +/-5 psi with a flow of 88 standard ft³ per minute (2.5 m³ per minute) per compressor.

Command, Control, Communications, and Range – The ML has the capability to provide the following C3R services: Spaceport Command and Control System (SCCS), KSC Network (KNET), Operational Information System (OIS), Telephone, Paging and Area Warning System (PAWS), Timing and Countdown Subsystem (T&CD), Operational Television (OTV).

Electrical Service – Power is provided to the MLBM and MLT through the VAB, Crawler Transporter (CT) and Pad. The MLBM then provides voltage levels of 480/277 or 208/120 with either single or three phase as required. The MLT provides voltage levels of 480/277 or 208/120 with either single or three phase as required, or 120-volt single phase. Both the MLBM and MLT

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provide grounding/lightning protection and are Class 1, Div 2 compliant, except for pressurized spaces.

Environmental Control System – A conditioned air purge can be provided to the launch vehicle and spacecraft/payload on the ML in the VAB high bay, during rollout on the CT, or at the Pad through umbilicals on the ML Tower. Flow rates will be dependent on facility capabilities.

Potable Water – Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Uninterruptible Power Supply (UPS) – Two 275 kW units are available in a static auto tie configuration, providing AC voltage levels of 480 or 208/120 with either single or three phase as required.

7.4.3 Crawler-Transporter

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. 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 during transport. 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

Electrical Service – The CT is capable of providing voltage levels of 480/277, three-phase power at 60 hertz to the ML and vehicle while they are being transported.

Environmental Control System – A conditioned air purge can be provided to the launch vehicle and spacecraft/payload on the ML while in transit through umbilicals on the ML Tower:

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- Cleanliness Class 100,000 (ISO Class 8)
- Temperature 65-85 °F (18-29 °C); temperature ranges are dependent upon final ECS configuration
- Humidity ratio 37 grains-per-pound (81.6 grains-per-kilogram) of dry air
- Flow rate 185 lbm/min (1.39 kg/sec)

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 ft² (5322.3 m²) that provides the services required for each launch. The launch pad facilities at LC-39B work in conjunction with the ML and the LCC to provide the necessary support to conduct launch operations. All Pad B services are provided to the vehicle through the ML, excluding 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.



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

The ML systems utilized at LC-39B include ECS, KGCS, Ignition Overpressure/Sound Suppression (IOP/SS), GCS, Hazardous Gas Leak Detection, Pneumatics, Weather (Wx), Sensor Data Acquisition Subsystem (SDAS), Cryogenics, and Ground Special Power (GSP).

Compressed Air – Pad B can provide compressed air at 125 psi (8.6 bars).

Command, Control, Communications, and Range –This facility has the capability to provide the following C3 services: Spaceport Command and Control System (SCCS), Kennedy Integrated Transmission System (KITS), Operational Intercommunication System (OIS), Telephone, Paging and Area Warning System (PAWS), Timing and Countdown Subsystem (T&CD), Operational Television (OTV), Broadband Cable Distribution System (BCDS), and Photo Optical Control System II (POCS II).

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Electrical Service – The electrical distribution system at LC-39B is supplied by three 13.8 kV feeders, two of which are backed up by generators at the emergency power plant. It is then distributed throughout the complex at voltage levels of 480/277 or 208/120 with either single or three phase as required.

Environmental Control System – A conditioned air purge can be provided to the launch vehicle and spacecraft/payload on the ML at Pad B through umbilicals on the ML Tower:

- Cleanliness Class 100,000 (ISO Class 8)
- Temperature 65-85 °F (18-29 °C); temperature ranges are dependent upon final ECS configuration
- Humidity ratio 37 grains-per-pound (81.6 grains-per-kilogram) of dry air
- Flow rate availability is still under evaluation

Gaseous Helium – Gaseous helium (GHe) is supplied to LC-39B at a nominal pressure of 6,000 psi (413.7 bars). If needed, 10,000 psi (689.5 bars) can be provided via mobile compressed gas trailer.

Gaseous Nitrogen – Gaseous nitrogen (GN₂) is supplied to LC-39B at a nominal pressure of 6,000 psi (413.7 bars). If needed, 10,000 psi (689.5 bars) can be provided via mobile compressed gas trailer.

Gaseous Oxygen – Gaseous oxygen (GO₂) can be provided at LC-39B at a nominal pressure of 6,000 psi (413.7 bars) via mobile compressed gas trailer.

Breathing Air - can be supplied at LC-39B at a nominal pressure of 6,000 psi (413.7 bars) via fixed storage vessels.

Potable Water – Potable water tested and verified to be in compliance with the federal government standard is available in this facility.

Uninterruptible Power Supply (UPS) – Two 275 kVA units are available in a static auto tie configuration, providing AC voltage levels of 480 or 208/120 with either single or three phase as required.

7.4.5 Launch Control Center

The Launch Control Center (LCC) shown in Figure 7-13 is a four-story building attached to the southeast corner of the VAB that is the electronic “brain” of LC-39. This facility 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 (FR), RF antennas used to collect telemetry, weather radar, and radar antennas used to skin-track launch vehicles. The U.S. Air Force provides TEL-4, SCAN, and flight-termination capabilities. Incoming and outgoing communications feeds through the LCC and various areas within KSC are provided via the Communications Distribution and Switching Center (CD&SC).

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Figure 7-13. Launch Control Center (LCC)

Firing Room 1, also known as the Young-Crippen Firing Room, will control all SLS launch operations. Firing Room 4 provides the capability for spacecraft control rooms prior to and during launch. There are four smaller control rooms that can be expanded as required to accommodate teams of differing sizes. Rooms can be configured to support specific team 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 uninterruptible power supply.

7.5 Payload Processing and Encapsulation

GSDO 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. Figure 7-14 shows a representational operations flow for Block 1B SLS launch vehicle and payload. Payloads are manufactured/assembled at the payload provider's manufacturing facility and arrive at KSC. Following the completion of payload processing activities either at the manufacturer or at an optional KSC integration facility, the payload will be turned over to KSC/GSDO for encapsulation and launch integration operations.

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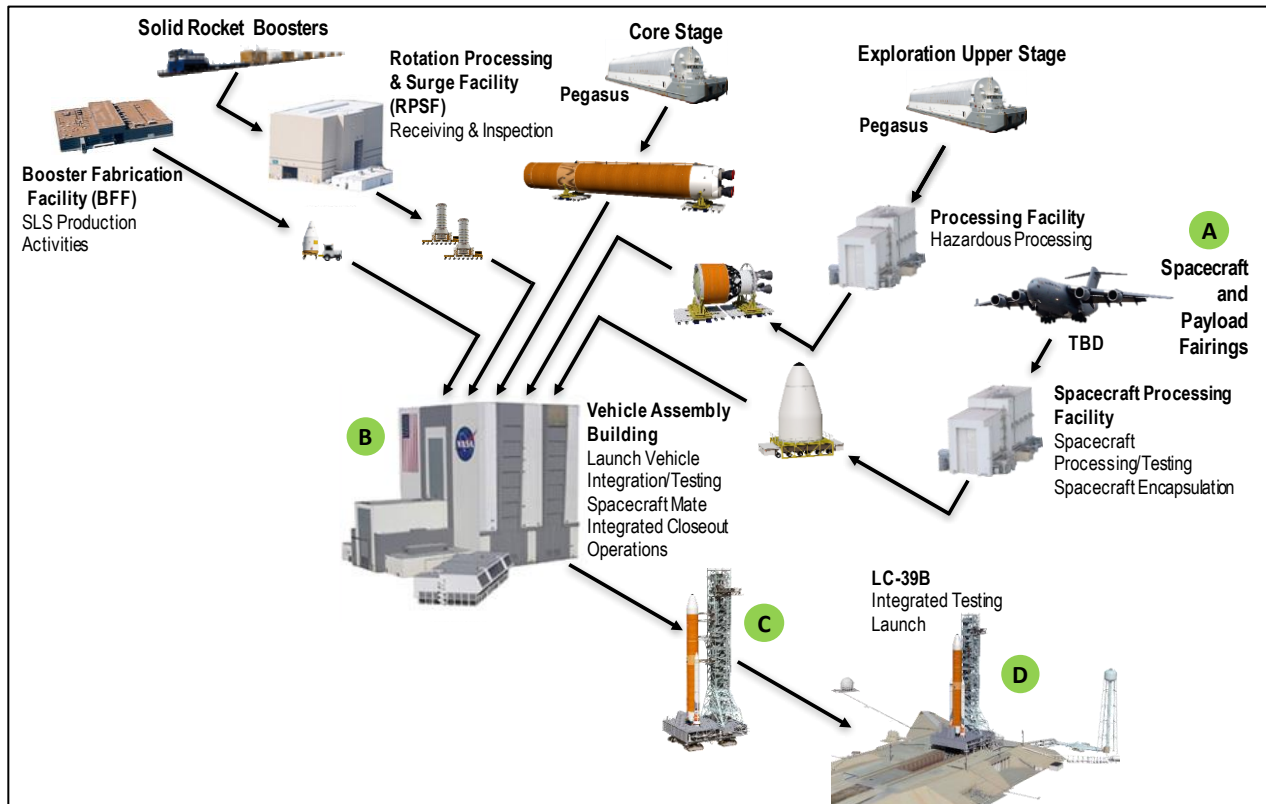


Figure 7-14. Representative Block 1B SLS Payload Operational Flow (A-B-C-D)

For all of the various payload elements, the same basic processing phases will be followed for payload encapsulation at the payload processing facility. Figure 7-15 shows this process for a CPL encapsulated by a canister USA, 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 payload processing facility, where they are inspected and prepared for payload encapsulation. The USA or PLF is debagged, cleaned, and inspected, and 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 Payload Adapter. Payload is then configured for encapsulation and mated to the Payload Adapter. 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 payload processing facility high bay. The USA or PLF is then mated to the Payload Adapter and the encapsulated payload is prepared for transportation from the payload processing facility to the VAB. The payload transporter is equipped with an Environmental Control System (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.

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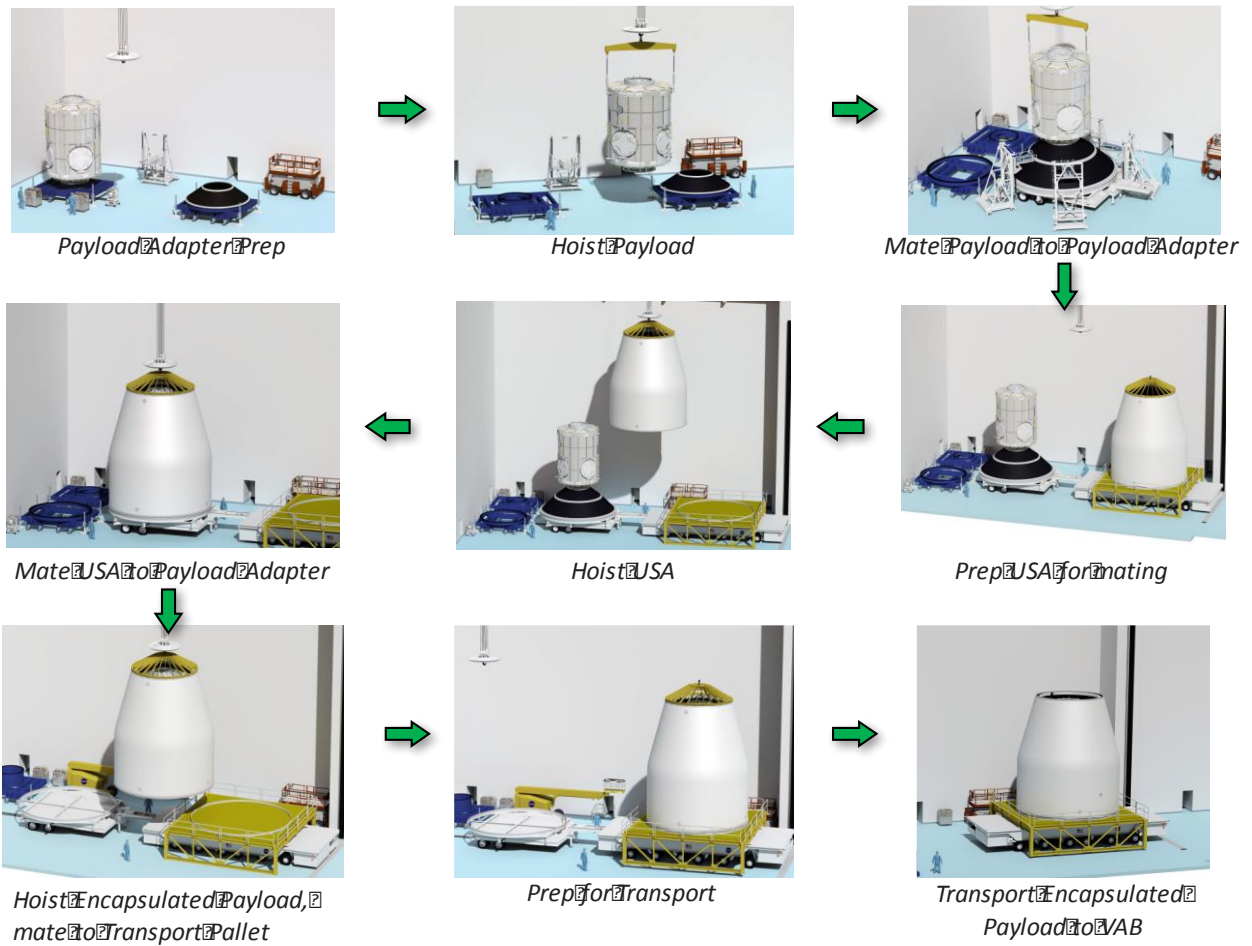


Figure 7-15. Payload Encapsulation Operational Flow (USA Example)

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8.0 SLS SPACECRAFT/PAYLOAD INTEGRATION AND MANGEMENT

Exploration Systems Development Division (ESD) is a division within NASA's Human Exploration and Operations (HEO) Mission Directorate responsible for management and integration of Orion, SLS and GSDO Programs. ESD is responsible for manifesting all spacecraft/payloads to be launched on SLS. The SLS Program has the responsibility to perform 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.

8.1 SLS - Spacecraft/Payload Integration Management

Clear communication between the SLS and spacecraft/payload is essential to flight success. SLS has established procedures and interfaces to delineate areas of responsibility and authority between the SLS and spacecraft/payloads. Based on lessons learned from other programs such as EELVs, ISS, and Space Shuttle, the SLS - spacecraft/payload integration process is planned to be phased around spacecraft/payload developer defined milestones. This process formally starts with the spacecraft/payload's Systems Requirements Review (SRR), or equivalent, and ends with spacecraft/payload encapsulation, launch, and separation. The actual integration process and schedule is flexible and can be tailored to meet SLS and spacecraft/payload requirements for each flight. Spacecraft/payload developers are encouraged to interact with SPIE as early as possible during their concept development cycle. This early interaction facilitates mission and vehicle feasibility/compatibility analysis that will identify preferred flight and accommodation approaches.

The following sections describe the integration responsibilities, documentation, and process for a SLS spacecraft/payload (SP); it is also summarized in Table 8.1.

8.1.1 SLS Responsibilities

SLS 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, electrical, mechanical, environmental, and electromagnetic compatibilities; guidance system integration; mission analysis; software design; and ground and flight operation support.

SPIE will assign a Payload Integration Manager (PIM) to serve as the single spacecraft/payload point of contact for all related integration activities for each specific spacecraft/payload making up the specific mission. The PIM, representing the spacecraft/payload to the vehicle will ensure the spacecraft/payload receives needed analytical and physical resources during all phases of integration and implementation. In addition, the PIM supports the spacecraft/payload in supporting all requirements and reviews as part of the integration process.

SPIE also coordinates with the GSDO Program and Flight Operations Directorate (FOD) on behalf of the spacecraft/payload. GSDO is responsible for spacecraft/payload physical encapsulation and integration onto the SLS, launch site processing, launch control, and range safety. FOD is responsible for managing integrated flight operations.

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

Milestone	Provider	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)
	SP	Early known spacecraft/payload requirements and service requirements	Draft of spacecraft/payload 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
	SLS	Initial Integrated Concept of Operations based on spacecraft/payloads mission	Draft Concept of Operations
	SLS	Bi-lateral agreement defining services, data requirements and schedules mutually agreed by all parties	Draft Payload Integration Agreement (PIA)
SP SRR System 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 by all parties	Signed (baseline) PIA
	SLS	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 Interface Control Document (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 payload adapter interface and other mission specific hardware required.
	SLS	Perform an integrated system level evaluation of SLS and spacecraft/payload hardware design	Results provided to spacecraft/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 Launch Site Support Plan, Operations & Maintenance Requirements & Specifications and Launch Commit Criteria	Draft Assembly and Installation Drawings, service request, procedures, GSE requirements, launch commit criteria, etc.
	SP	Inputs to Range Safety documentation	Hazards and debris characteristic data
	SP	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
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
*Assumes appropriate material is available at spacecraft/payload reviews and that spacecraft/payload review schedule supports integrated product (analysis, etc.) development prior to integrated mission reviews. NOTE: SPIE is responsible for SP coordination with Ground Systems Development and Operations (GSDO) Program and FOD.			

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

Milestone	Provider	Definition	Typical Products
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 proxy ops needs, etc.
	SP	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)
	SP	Final inputs to Launch Site Support Plan, Operations & Maintenance Requirements & Specifications and Launch Commit Criteria	Final Assembly and Installation Drawings, service request, procedures, GSE requirements, launch commit criteria, etc.
GOR Ground Operations Review	GSDO	Forum for coordinating launch site activities and resolving operational issues and concerns	Ground flow activities flow, operational timeline modifications for mission-unique spacecraft/payload operational considerations, LSSP definition for launch site facilities and ground support equipment, hazardous operations with the Range, and ground test requirements
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 SP system is ready to be integrated	Documents SP integration facilities, support personnel, and integration plans and procedures are ready for integration
Spacecraft/Payload Verification Complete	SP	Verification Compliance Deliverables	Closed Detailed Verification Objectives (DVO)
	SP	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
	SP	Flight Operation inputs	Operations inputs such as flight displays, mission simulations, and customer procedures
FIR Flight Integration Review	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
Spacecraft/Payload Handover and Acceptance Review	SP	Remaining Safety Requirement Closeout	Updated descriptions of safety-critical subsystems, operations and interfaces. Completed flight Hazard Analysis and appropriate. Listing of approved waivers to safety requirements. Safety verification tracking log that identifies open safety verification methods, status, and expected closure
	SP	Final Flight Operation Inputs	Participating in launch countdown and mission simulations as appropriate, and provide final customer procedures
	SP	Updated to Launch Site Support Plan, Operations & Maintenance Requirements & Specifications and Launch Commit Criteria	Updates to Final Assembly and Installation Drawings, service request, procedures, GSE requirements, launch commit criteria, etc.
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, Eastern Test Range and Western landing and recovery
<p>*Assumes appropriate material is available at spacecraft/payload reviews and that spacecraft/payload review schedule supports integrated product (analysis, etc.) development prior to integrated mission reviews. NOTE: SPIE is responsible for SP coordination with Ground Systems Development and Operations (GSDO) Program and FOD.</p>			

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8.1.2 Spacecraft/Payload Responsibilities

In order to ensure initial compatibility with SLS and overall mission feasibility, SLS encourages the spacecraft/payload to define their particular needs with SPIE as early in the process as possible. The SLS Accommodations Demand Model Input Template (ADMIT) shown in Appendix B is a short spacecraft/payload survey 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 interface, electrical interface, thermal environment, physical access, dynamic environment, propulsion systems, batteries, transmitters and receivers, electro explosive devices, non- electrical ordinance 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. In the case where the spacecraft/payload does not have this type of documentation, the PIM will help the spacecraft/payload document their 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.

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.

8.2.1 Payload Integration Agreement (PIA)

The PIA is a bilateral agreement between SLS and the spacecraft/payload for establishing and implementing all management and technical integration requirements. The PIA defines SLS and the spacecraft/payload roles & responsibilities, specific interfaces, standard services, any non-standard services, deliverable exchanges, and the overall schedule for successful integration and launch. The PIA is developed and coordinated by the PIM with revisions negotiated and agreed to by all parties as needed.

The representative SLS-Spacecraft/Payload Integration Schedule shown in Figure 8-1 defines the launch-minus integration activities between the spacecraft/payload and SLS. Each spacecraft/payload will have a unique integration schedule based on the relative complexity or simplicity of their system. For more complex spacecraft/payloads the process could begin as early as 60 months prior to launch (e.g., PPL or CPL). For less complex spacecraft/payloads, the process can begin as late as 12 months prior to launch (e.g., SPL). Schedule revisions will be negotiated and agreed to by all parties as needed.

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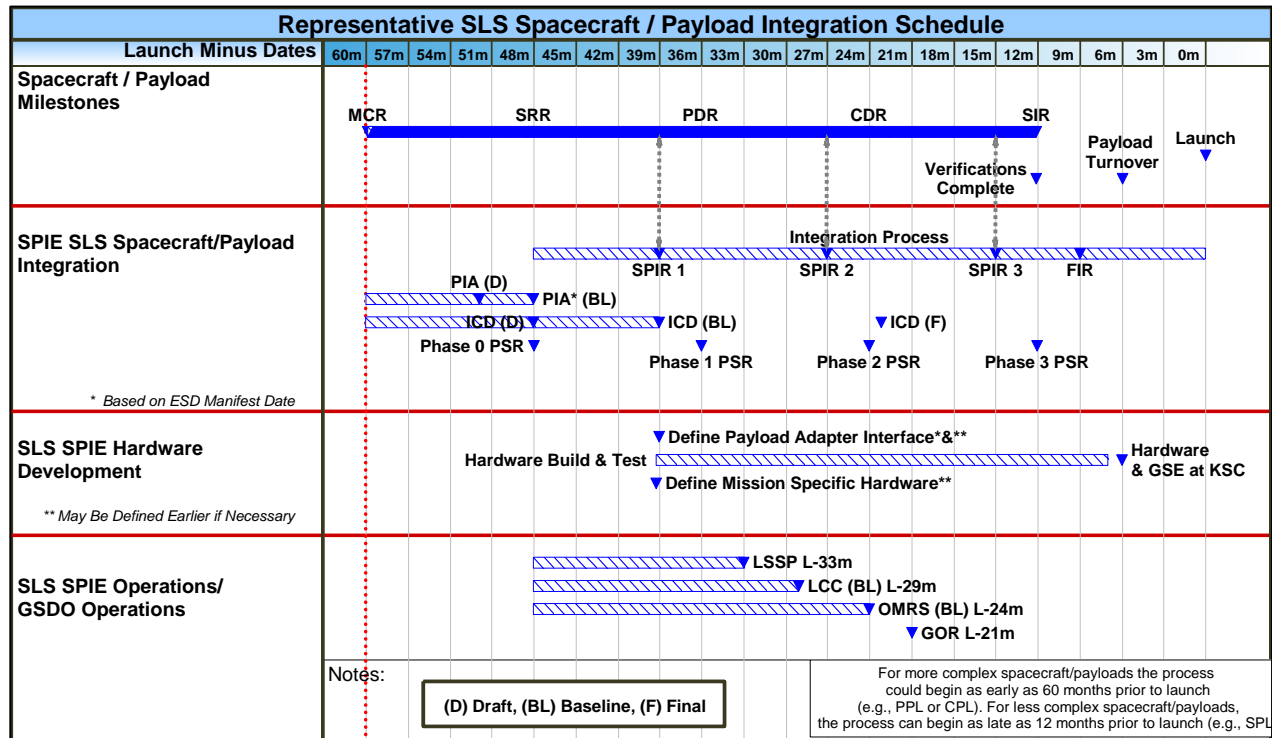


Figure 8-1. Representative SLS-Spacecraft/Payload Integration Schedule

SPIE will work with the spacecraft/payload early in their development process to develop a draft PIA using the spacecraft/payload IRD or equivalent document for all parties to agree to prior to formal manifesting. The PIA will then be signed (baselined) after the spacecraft/payload has been manifested by SLS by ESD. This signing of the PIA formally starts the SLS-spacecraft/payload integration process.

8.2.2 SLS-Spacecraft/Payload Interface Control Document (ICD)

The ICD defines the interface and requirements between SLS, GSDO, Orion (as applicable) and the spacecraft/payload. The ICD is the agreed to design solution that controls and defines each side of an interface (SLS or spacecraft/payload) for hardware, environment and software compatibility. SLS performance, interfaces, and services are documented in Sections 4, 5, 6 & 7 of this SLS Mission Planner's Guide. The ICD is developed and coordinated by the PIM.

As part of the ICD, there will be a verification plan that provides a 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). It provides instructions and guidelines to verify safety and interface compatibility of as-built SLS vehicle & 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 close out (e.g., test, analysis, inspection, etc.).

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8.2.3 Spacecraft/Payloads Launch Site Support Plan (LSSP)

The LSSP provides an overview of spacecraft processing, summarizes organization responsibilities and documents support requirements to be provided at the launch site. The PIM will support the spacecraft/payload in the providing inputs required to create the LSSP. The LSSP is developed by GSDO with the coordination by the PIM.

8.2.4 Spacecraft/Payloads Launch Commit Criteria (LCC)

The spacecraft/payload LCC inputs will be gathered by SPIE and coordinated with GSDO. These inputs will be used to support the development of Ground & Flight Application Software (GFAS) development, as a source of identifying credible anomalies for launch team simulation training models, and for helping define the necessary launch countdown response/safing steps in emergency and/or contingency situations. The PIM will support the spacecraft/payload in providing the inputs required to create the LCCs.

8.2.5 Spacecraft/Payload Operations & Maintenance Requirements Specification (OMRS)

Any spacecraft/payload flight integration and ground operations tasks required after handover to GSDO at KSC will be documented in the form of an OMRS coordinated by the PIM. The spacecraft/payload OMRS will communicate detailed ground processing requirements to be implemented via work instructions in the Work Authorization Documents (WADs) and application software to support launch processing activities such as integrated testing, servicing, operations, maintenance, and launch countdown.

8.3 SLS-Spacecraft/Payload Integration Process and Milestones

The SLS integration process has been developed to effectively mesh with the spacecraft/payload's schedule. This schedule (reference Figure 8-1) is generally driven by the spacecraft/payload's milestone reviews (e.g., SRR, PDR, etc.) and to a lower level by the hardware and trajectory/mission target definition receivables and deliverables. The integration process will formally start post ESD manifesting with signing of the PIA between SPIE and the spacecraft/payload. The SLS integration process has been developed to effectively mature the integrated system through a series of system level analyses/evaluation each more mature than the previous. Throughout the integration process, 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, mission design, unique requirements and unique hardware to support spacecraft/payload's milestone reviews. SPIE will establish a point of contact for the spacecraft/payload until the PIM is formally designated. Prior to a signed (baseline) PIA, SPIE will arrange for regular spacecraft/payload working group or technical interchange meetings to focus on special topics to drive out 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,

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quarterly, semi-annually) to define accommodation points of departure as well as update spacecraft/payload and SLS management on overall status. Findings from these meetings are used by the spacecraft/payload to support development their SLS IRD and by SPIE to support development of a draft PIA.

8.3.2 Spacecraft/Payload Integration Review 1 (SPIR 1)

Approximately three months before the spacecraft/payload PDR or equivalent, SLS will conduct an initial formal review that will ensure feasibility/compatibility of the spacecraft/payload with SLS and ground operations. This review will be the result of SLS system level vehicle and spacecraft/payload analyses for the appropriate mission. During this review, SLS will define vehicle accommodations such as the Payload Adapter, USA or PLF, and ground support systems, as well as design environments identified during early integration activities. At this review, spacecraft/payloads will provide SLS any additional requirements not already given to SLS for accommodations and services needed. SLS will use the data provided to perform an integrated system level evaluation of the SLS and spacecraft/payload hardware design for a designated flight and provide the results to the spacecraft/payload before their next milestone review such as CDR. See Table 8.1 for a more detailed list of typical data to be shared at this review. After SPIR 1, this information will be documented in a baselined SLS-Spacecraft/Payload ICD.

8.3.3 Spacecraft/Payload Integration Review 2 (SPIR 2)

Approximately three months before the spacecraft/payload's CDR or equivalent, SLS will conduct a second formal review to communicate a more mature system identifying interface changes on either side of the vehicle interface (SLS or spacecraft/payload). Again, SPIE will use this new agreed to data to perform an integrated system level evaluation of the SLS and spacecraft/payload hardware design for a designated flight and provide the results to the spacecraft/payload before their next milestone review. After SPIR 2, SPIE will take this information and update the SLS-Spacecraft/Payload ICD.

8.3.4 Spacecraft/Payload Integration Review 3 (SPIR 3)

Approximately three months before the spacecraft/payload's System Integration Review (SIR) or equivalent, SLS will conduct a third formal review to communicate interface changes on either side of the vehicle interface (SLS or spacecraft/payload). SPIE will use this new data provided to perform an "as-built" integrated system level evaluation of the SLS and spacecraft/payload hardware design for a designated flight and provide the results to the spacecraft/payload. After SPIR 3, SPIE will take any new information and update the SLS-Spacecraft/Payload ICD as needed.

8.3.5 Additional SLS-Spacecraft/Payload Reviews

Additional reviews will be conducted by SPIE if necessary due to changes throughout the integration process. After each the SLS-Spacecraft/Payload ICD will be updated accordingly. The representative integration schedule in Figure 8-1 shows three specific SPIRs but the number of these reviews can be tailored for each spacecraft/payload as required.

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8.3.6 Payload Safety Reviews (PSR)

Flight and ground safety requirements will be documented in the SLS-Spacecraft/Payload ICD and will need to be verified according to the corresponding DVO. The spacecraft/payload will be required to participate and support data requests from the Payload Safety Review Panel (PSRP). 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, radio frequency interference, ascent hazard and debris characteristics for input to a unique Range Safety data, joint loads and environments, and payload recontact analysis (nominal mission scenarios), etc. See Table 8.1 for a more detailed list of typical data to be shared at PSRs.

8.3.7 Ground Operations Review (GOR)

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

8.3.8 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 their 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 SLS by GSDO. The spacecraft/payload will provide a listing of any approved waivers to safety requirements. SPIE will maintain a safety verification tracking log that identifies open safety verification methods, status, and expected closure.

8.3.9 Flight Integration Review (FIR)

Three months after the spacecraft/payload has submitted all of their verification compliance deliverables, SPIE will perform a FIR using the integrated verification data from the spacecraft/payload and SLS hardware such as the Payload Adapter, USA or PLF. A successful FIR will serve as the approval for a spacecraft/payload to ship to KSC for spacecraft/payload handover and acceptance.

8.3.10 Flight Readiness Review (FRR)

The FRR will be conducted within seven days of launch and prior to final rollout of SLS to the pad. It will provide a final prelaunch assessment of the integrated SLS-spacecraft/payload system and launch facility readiness that includes addressing open work and risks to the readiness of the flight and ground systems, the Eastern Test Range and Western landing and recovery, network assets, personnel, and procedures necessary to perform launch through landing and recovery operations. FRR will ensure that spacecraft/payload, SLS systems, facilities, GSE, and all supporting organizations are ready and committed to support the final launch preparations, countdown and launch. SPIE will represent the spacecraft/payload during this review.

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APPENDIX A ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ADMIT	Accommodation Demand Model Input Template
AB	Evolved Booster
B/L	Baseline
BCDS	Broadband Communication Distribution System
BTU	British Thermal Unit
C	Celsius
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	Centimeter
CPL	Co-manifested Payload
CPSM	Co-manifested Payload System Mass
CR	Change Request
CT	Crawler Transporter
CWA	Clean Work Area
D	Draft
DAC	Design Analysis Cycle
DCSS	Delta Cryogenic Second Stage
DRM	Design Reference Missions
DVO	Detailed Verification Objectives
ECS	Environmental Control System
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
EM	Exploration Mission
EMC	Electromagnetic Capability
ER	Eastern Range
ESD	Exploration Systems Development Division
ESPA	EELV Secondary Payload Adapter
EUS	Exploration Upper Stage

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F	Fahrenheit
F	Final
FIR	Flight Integration Review
FIR-F	Flight Integration Review-Final
FR	Firing Rooms
FPR	Flight Performance Reserve
FRR	Flight Readiness Review
ft	Foot (Feet)
ft/sec	Feet per Second
ft ²	Square Feet
ft ³	Cubic Feet
GCS	Ground Cooling System
GG	Gas Generator
GHe	Gaseous Helium
GN ₂	Gaseous Nitrogen
GO ₂	Gaseous Oxygen
GOR	Ground Operations Review
GR&A	Ground Rules and Assumptions
GSDO	Ground Systems Development and Operations
GSE	Ground Support Equipment
HazGas	Hazardous Gas
HB	High Bay
HEPA	High-Efficiency Particulate Air
HEO	Human Exploration and Operations
ICD	Interface Control Document
ID	Identification
IMLEO	Injected Mass at Low Earth Orbit
in	Inch
IOP	Ignition Overpressure
IR	Infrared
IRD	Interface Requirements Document
I _{sp}	Specific Impulse
ISPE	Integrated Spacecraft and Payload Element
ISS	International Space Station
JEL	Jacking, Equalization and Leveling
JGA	Jupiter Gravity Assist

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Kg	Kilogram(s)
KITS	Kennedy Integrated Test Transmission System
km	Kilometer(s)
KNET	KSC Network
KSC	Kennedy Space Center
lbm	Pounds Mass
LC	Launch Complex
LCC	Launch Control Center
LCC	Launch Committee Criteria
LEO	Low Earth Orbit
LH ₂	Liquid Hydrogen
LOX	Liquid Oxygen
LSSP	Launch Site Support Plan
LV	Launch Vehicle
m	Meter
m/s	Meters per Second
m ³	Cubic Meters
Max	Maximum
MCR	Mission Concept Review
ME	Main Engine
MECO	Main Engine Cut Off
MGA	Mass Growth Allowance
min	Minute
ML	Mobile Launcher
MLBM	Mobile Launch Base
MLI	Multilayer Insulation
MLT	Mobile Launch Tower
MPG	Mission Planners Guide
MPPF	Multi-Payload Processing Facility
MPS	Miles per Second
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
nm	Nautical Mile
NPR	NASA Procedural Requirements
NRHO	Near Rectilinear Halo Orbit
NVR	Non-Volatile Residue

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OSMA	Office of Safety & Mission Assurance
OIS	Operational Information System
OML	Outer Mold Line
OPR	Office of Primary Responsibility
OMRS	Operations and Maintenance Requirements Specifications
OSA	Orion Stage Adapter
OIS	Operational Intercommunication Systems-Digital
OSMU	Orion Service Module Umbilical
OTV	Operational Television
PAF	Payload Attachment Fitting
PAWS	Paging and Area Warning System
PDR	Preliminary Design Review
PHSF	Payload Hazardous Servicing Facility
PIA	Payload Integration Agreement
PIA	Payload Interface Adapter
PLI	Propellant Liner Insulation
PLF	Payload Fairing
PMR	Program Manager's Reserve
POCS II	Photo Optical Control System II
POD	Point of Departure
PPL	Primary Payload
Psi	Pound per square inch
PSM	Payload System Mass
PSR	Payload Safety Review
PSS	Payload Separation System
RCS	Reaction Control System
RH	Right Hand
RF	Radio Frequency
RFTS	Radio Frequency and Telemetry Station
RSRMV	Five-segment Reusable Solid Rocket Motor
PSVP	Payload Specific Verification Plan
S&MA	Safety and Mission Assurance
SCCS	Spaceport Command and Control System
Sec	Second(s)
SIR	System Integration Review
SLS	Space Launch System

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SLSP	Space Launch System Program
SP	Spacecraft/payload
SPDS	Secondary Payload Deployment System
SPEC	Specification
SPIE	Spacecraft / Payload Integration and Evolution Office
SRD	System Requirements Document
SRB	Solid Rocket Booster
SRR	Systems Requirement Review
SSPF	Space Station Processing Facility
t	Metric Tons
T&CD	Timing and Countdown Subsystem
TDRS	Tracking and Data Relay Satellite
TLI	Trans Lunar Injection
TPS	Thermal Protection System
UPS	Uninterruptible Power Supply
US	Upper Stage
USA	Universal Stage Adapter
VAB	Vehicle Assembly Building
VAC	Volts Alternating Current
VCF	Vapor Containment Facility
W	Watt
WAD	Work Authorization Document

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APPENDIX B ACCOMMODATION DEMAND MODEL INPUT TEMPLATE (ADMIT)

Completing an SLS Accommodation Demand Model Input Template (ADMIT) is the first step in assessing potential feasibility of SLS accommodation for a specific spacecraft/payload. ADMIT, MSFC Form 4664, is accessible as a PDF fill-in via NASA Electronic Forms (NEF):

<https://publicforms.nasa.gov/documents/11002/11052/M4664.pdf/d158e6f5-b47e-4af5-878b-25a7157be468>

Fill in ADMIT as completely as possible and email to NASA-slspayloads@mail.nasa.gov. A representative from the SLS SPIE office will contact you to discuss your requirements in greater detail.

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SLS ACCOMMODATION DEMAND MODEL INPUT TEMPLATE (Continued)

PAYLOAD NAME:	KEY CONTACT/SPONSOR:
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KENNEDY SPACE CENTER (KSC) REQUIREMENTS

REQUIREMENTS (Cleanliness levels, access requirements, unique test and checkout [T-C/O] requirements, power, environment, temperature):

- | | | | |
|---|--|------------------------------|------------------------------|
| <input type="checkbox"/> CLEANLINES LEVEL | <input type="checkbox"/> ACCESS REQUIREMENTS | <input type="checkbox"/> VAB | <input type="checkbox"/> PAD |
| <input type="checkbox"/> UNIQUE TEST AND CHECKOUT | <input type="checkbox"/> POWER | VOLTS | |
| <input type="checkbox"/> TEMPERATURE | <input type="checkbox"/> ENVIRONMENT | | |

LAUNCH AND FLIGHT OPERATIONS

PRELAUNCH

• LOCATION OF SPACECRAFT OPERATIONS CONTROL CENTER:

• MISSION-CRITICAL INTERFACE REQUIREMENTS:

LAUNCH THROUGH SPACECRAFT SEPARATION

• SPACECRAFT UPLINK REQUIREMENTS:

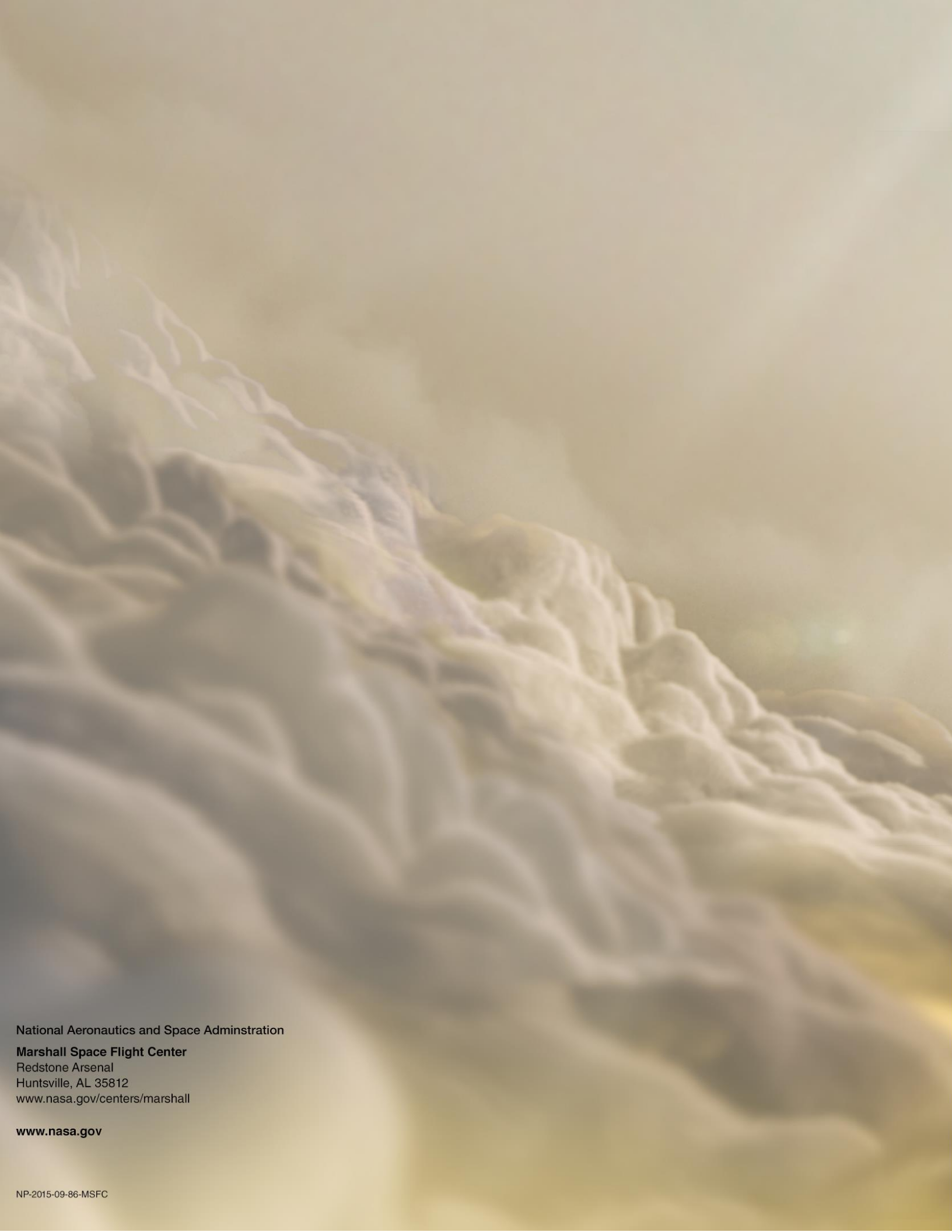
• SPACECRAFT DOWNLINK REQUIREMENTS:

• SYSTEMS ACTIVATED PRIOR TO PAYLOAD SEPARATION:

POST-SPACECRAFT SEPARATION

• SPACECRAFT TRACKING STATION:

• SPACECRAFT ACQUISITION ASSISTANCE REQUIREMENTS:



National Aeronautics and Space Administration

Marshall Space Flight Center

Redstone Arsenal

Huntsville, AL 35812

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