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Space Administration

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SPACE LAUNCH SYSTEM (SLS) PROGRAM MISSION PLANNER'S GUIDE (MPG) EXECUTIVE OVERVIEW

REVISION AND HISTORY PAGE

Status	Version No.	Change No.	Description	Release Date
Released	1		Initial Release of SLS DRD 1406OP-040A for SLS Critical Design Review (CDR), MSFC 4511 Concurrence on file • Space Launch System Program (SLSP) Mission Planner's Guide Executive Overview developed from the Outer Loop Design Analysis Cycle evolvability study	08/22/14

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

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this Space Launch System (SLS) Mission Planner's Guide (MPG) Executive Summary is to provide future payload developers/users with insight to potential SLS mission capabilities within and beyond earth orbit. While the SLS MPG Executive Summary focus is on detailing delivery capability to payload destination including performance, interfaces, and constraints, some additional design insight is provided on vehicle elements (e.g., Upper Stages, adapters, fairings) that significantly affect payload accommodation through all mission phases. Initial missions of SLS planned for the 2017 to 2021 timeframe use a SLS Block 1 configuration capable of delivering 70t to Low Earth Orbit (LEO) that has a relatively mature design capable of accommodating the Orion Multi Purpose Crew Vehicle (MPCV). However, options to fly an un-crewed mission using a 5m Expendable Launch Vehicle (ELV) derived fairing on a Block 1 vehicle are also possible during this timeframe. In addition, the Marshall Space Flight Center (MSFC) is continuing to evolve SLS capability beyond the Block 1 configuration in order to provide a 130t or greater LEO capability in the post-2021 timeframe.

Therefore, this SLS MPG Executive Summary serves as a communication tool between NASA, industry, and the scientific community for understanding the conceptual development status of planned SLS mission capabilities. It is intended for this information to promote two-way dialogue between developers and users to most efficiently evolve SLS mission/payload capabilities. Those requiring additional mission planning information in the form of the full Mission Planner's Guide or detailed technical interchange are encouraged to contact Mr. Steve Creech, Deputy Manager SLS Spacecraft Payload Integraton & Evolution (steve.creech@nasa.gov).

1.2 Scope

This document is in response to SLS Program Plan and Spacecraft Payloads Integration and Evolution (SPIE) program requirements It includes evolution of the SLS configuration and associated Ground Systems Development and Operations (GSDO) Program capabilities required to deliver 130t or more of payload to LEO.

1.3 Change Authority/Responsibility

The NASA Office of Primary Responsibility (OPR) for this document is XP50/SPIE.

Changes to this document shall be controlled at the OPR level using processes defined by the OPR.

2.0 DOCUMENTS

Reserved.

3.0 SLS OVERVIEW

Scheduled for a first launch in 2017, the NASA Space Launch System will support a new era of human space exploration as the country's first exploration-class launch vehicle since Saturn V last flew in 1972. NASA is developing the SLS in parallel with two other NASA exploration systems – the Orion Program, and the GSDO Program. The Orion 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 flight of SLS in 2017, the vehicle will evolve, eventually reaching a full capability of delivering more than 130t to LEO. While SLS was created to enable human space exploration, the vehicle, in both its initial and evolved configurations, will also provide a robust capability for science and other missions of national importance. This wide range of exploration mission capture is shown in Figure 3-1.

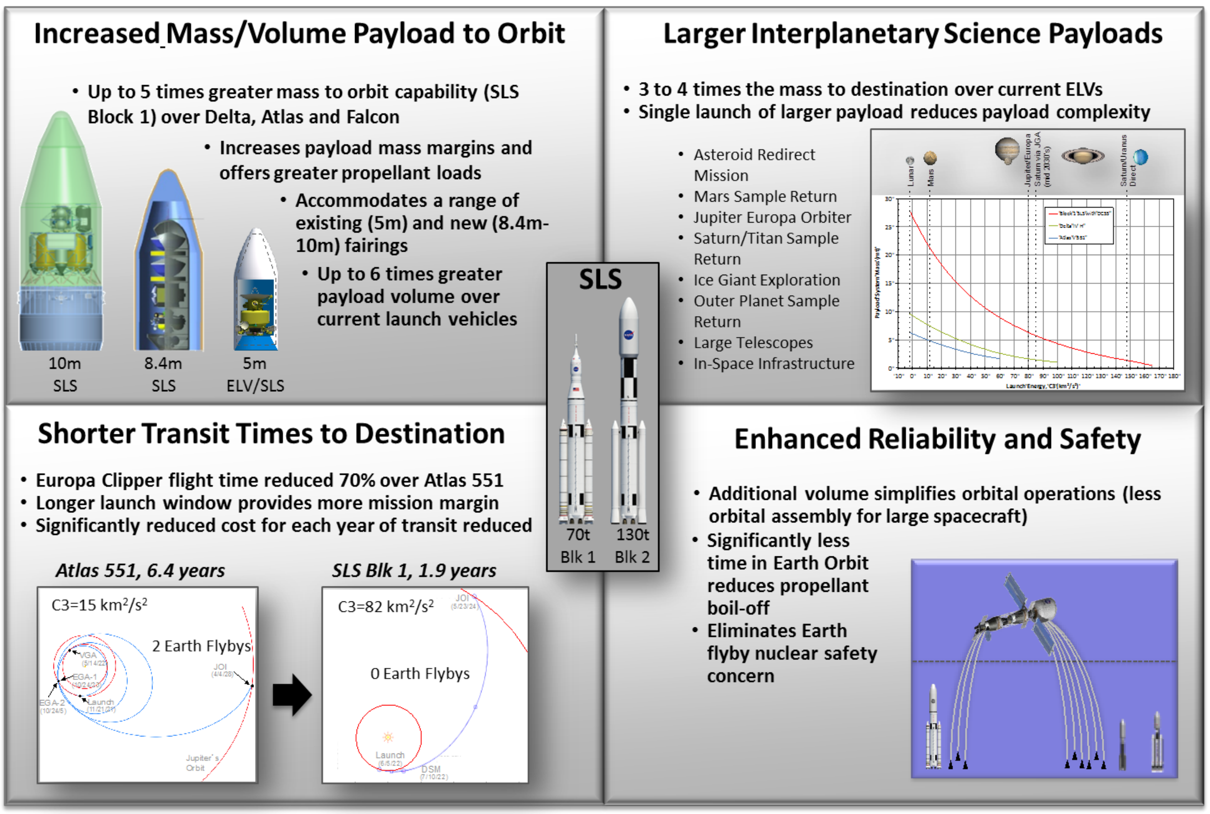


Figure 3-1. SLS Performance and Mission Capture Benefits

3.1 SLS Block 1 (70t) Vehicle Configuration

The SLS architecture was developed based on best meeting exploration requirements by minimizing life-cycle costs, enabling challenging missions to deep space, maintaining critical skills and transitioning the workforce 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, and Liquid Oxygen (LOX)/Liquid Hydrogen (LH2) propellant infrastructure. Figure 3-2 provides an overview of the initial SLS Block 1 configuration that will first fly with the Orion in 2017.

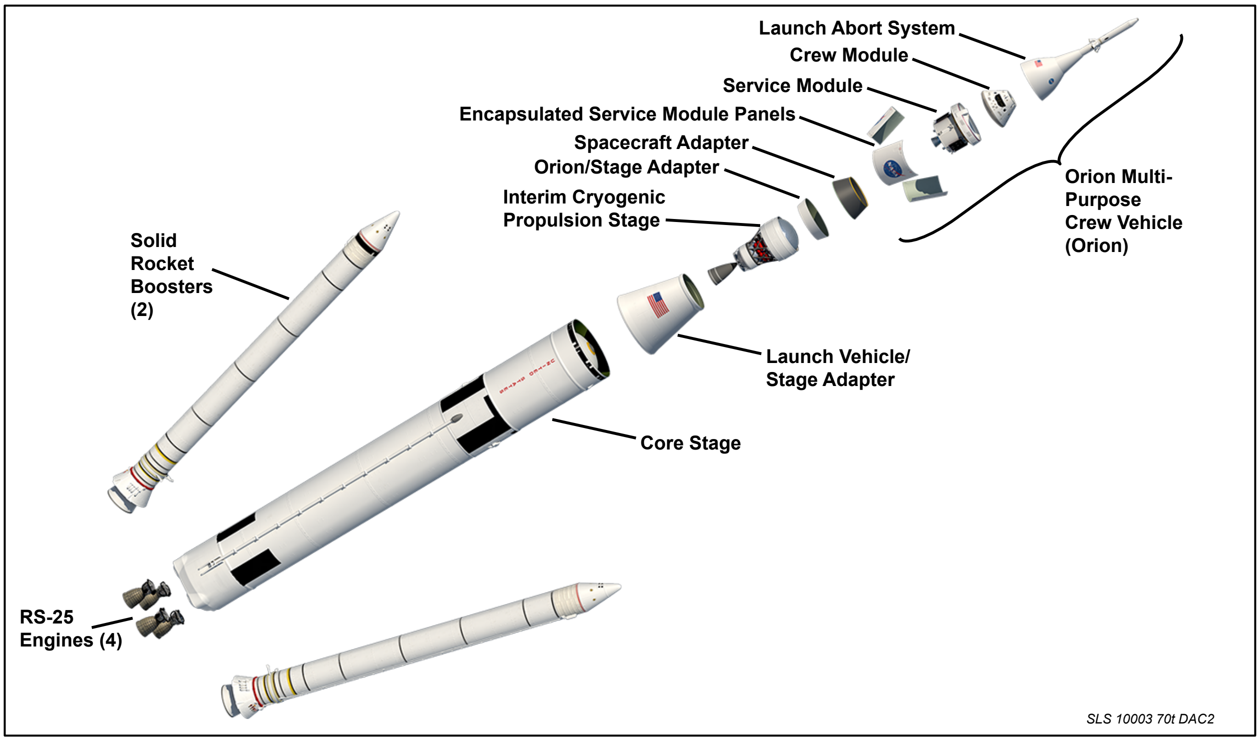


Figure 3-2. SLS Block 1 70t Initial Configuration (Crewed version)

3.2 SLS Post Block 1 (105t/130t) Vehicle Configurations

While the SLS Program is currently focused on the first SLS flight in 2017, early development work has already begun for the evolution of SLS beyond the 70t Block 1 configuration in order to ensure support is “built-in” to the Block 1 design for future capabilities. Reaching/exceeding the full 130t SLS LEO capability will require at least two new developments: a new Upper Stage and an Advanced Booster. The Block 1 configuration of the Core Stage will be used as-is for evolved configurations. This commonality-based strategy will reduce the cost of evolving SLS capabilities by maintaining similar interfaces to flight hardware and ground systems as was used for Block 1. Figure 3-3 provides a representational concept of a post Block 1 130t configuration that would fly with Orion or cargo payloads in the post 2021 timeframe.

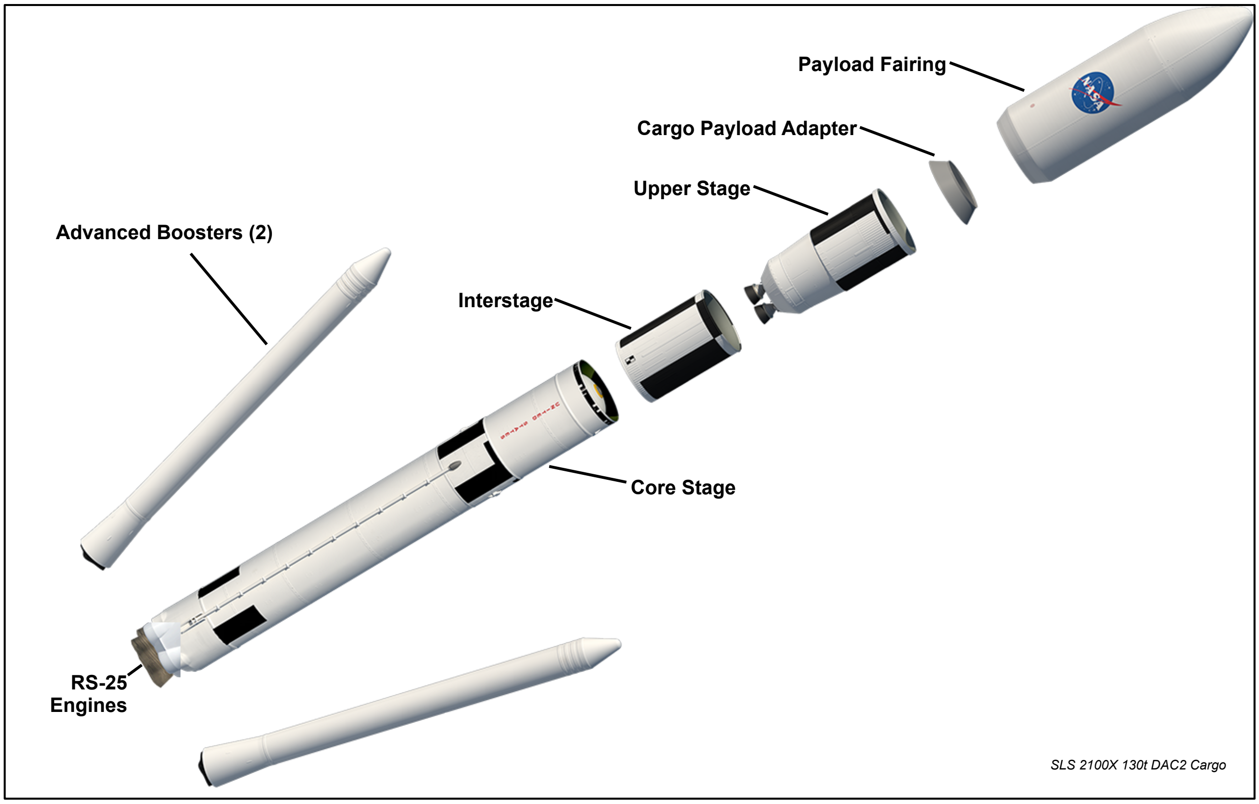


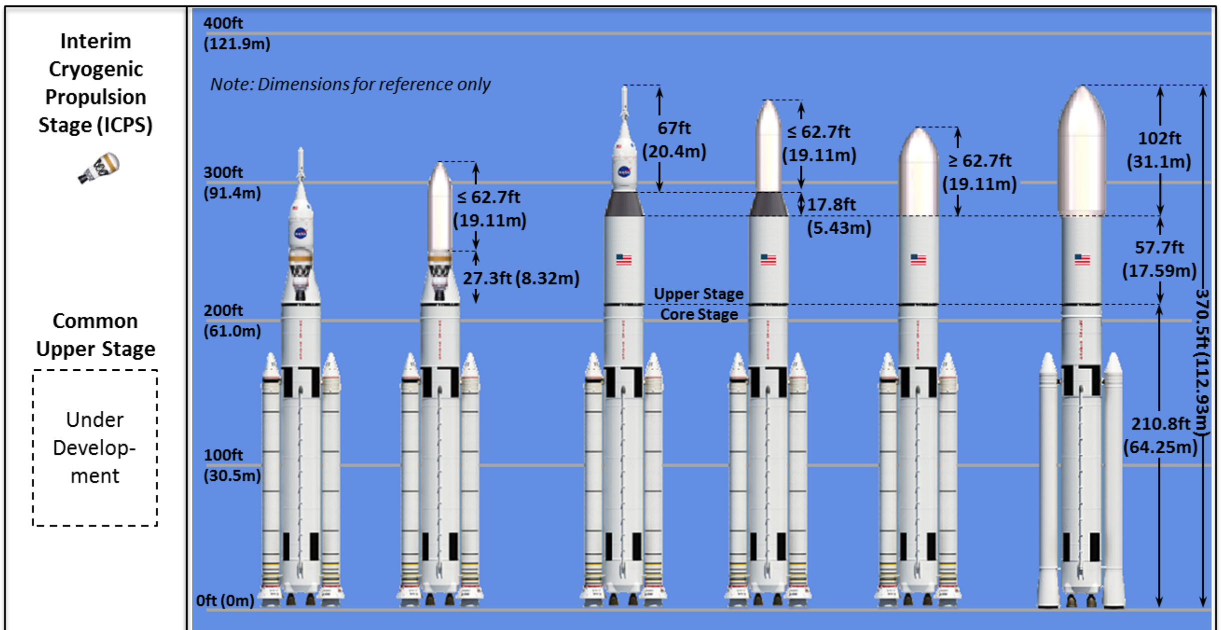
Figure 3-3. Post SLS Block 1 SLS 130t Evolved Concept

3.3 SLS Block Configuration Descriptions

To achieve the performance necessary to deliver 130t payloads to LEO, in support of future human lunar and Mars missions, the Block 1 SLS will require additional performance. SLS evolvability studies since SLS PDR have focused on evolving the SLS Block 1 performance by adding:

- An Upper Stage that increases SLS LEO delivery from 70t to 105t (or more); this configuration is known as SLS Block 1B
- An Upper Stage and Advanced Boosters that increase SLS LEO delivery from 105t to 130t (or more); this configuration is known as SLS Block 2B

For the purposes of the SLS MPG, the SLS Block 1 crew configuration (with the Orion) is considered part of the SLS Program Preliminary Design Review (PDR) Baseline while the SLS Block 1 cargo configuration (with 5m fairing), Block 1B crew/cargo configurations, and Block 2B cargo configurations are considered SLS Evolvability Point of Departure (POD) concept configurations. Figure 3-4 provides an overview of current SLS POD evolution configurations in comparison to the SLS Block 1 crewed configuration. For the purposes of this document the following mass delivery definitions are used. *Injected Mass at LEO* (IMLEO) is defined as the sum of Payload System mass, upper-stage dry mass, and unused upper-stage fuel once on-orbit. *Payload System Mass (PSM)* is defined as encompassing the mass of both the spacecraft/cargo and any associated vehicle adapter(s) required. It equals Injected Mass minus Stage Burnout Mass (PSM = IMLEO – mbo). *Net Payload System Mass* equals Payload System minus Manager's Reserve (Net PSM = PSM – Man Reserve). *Net Payload* is defined as encompassing the spacecraft or cargo element mass delivered on-orbit (i.e., does not include an upper stage or adapter mass). Figure 3-5 illustrates these mass delivery definitions for a notional system. Section 6.0 has descriptions of the payload adapters.



SLS Configuration	Block 1 (70t LEO Class)		Block 1B (105t LEO Class)			Block 2B (130t LEO Class)
Vehicle ID	10003	10500	28000	27500	27000	25000A/26000A/26001A
Core	8.4m Common Core		8.4m Common Core			8.4m Common Core
Booster	5 Segment Shuttle Booster		5 Segment Shuttle Booster			Advanced Booster
Upper Stage	ICPS		Common Upper Stage			Common Upper Stage
Payload	Orion	5m Payload	Orion	5m Payload	8.4m Payload	10m Payload

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Figure 3-4. SLS Block 1, 1B, and 2B POD Vehicle Configurations

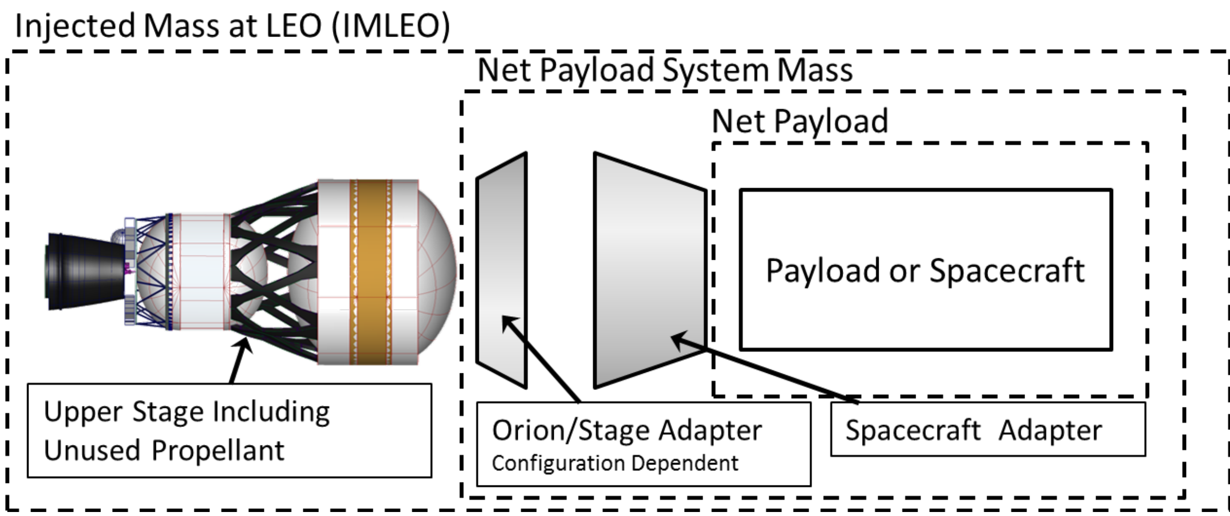

Figure 3-5. Mass Delivery Definitions for Notional System

4.0 SLS MISSION DESIGN AND PERFORMANCE

4.1 Mission Trajectories and Performance Options

NASA's Capabilities Driven Framework approach matches evolving SLS performance to different categories of crewed and un-crewed NASA exploration missions as shown in Figure 4-1 (SLS is shown in lower, middle part of graphic).

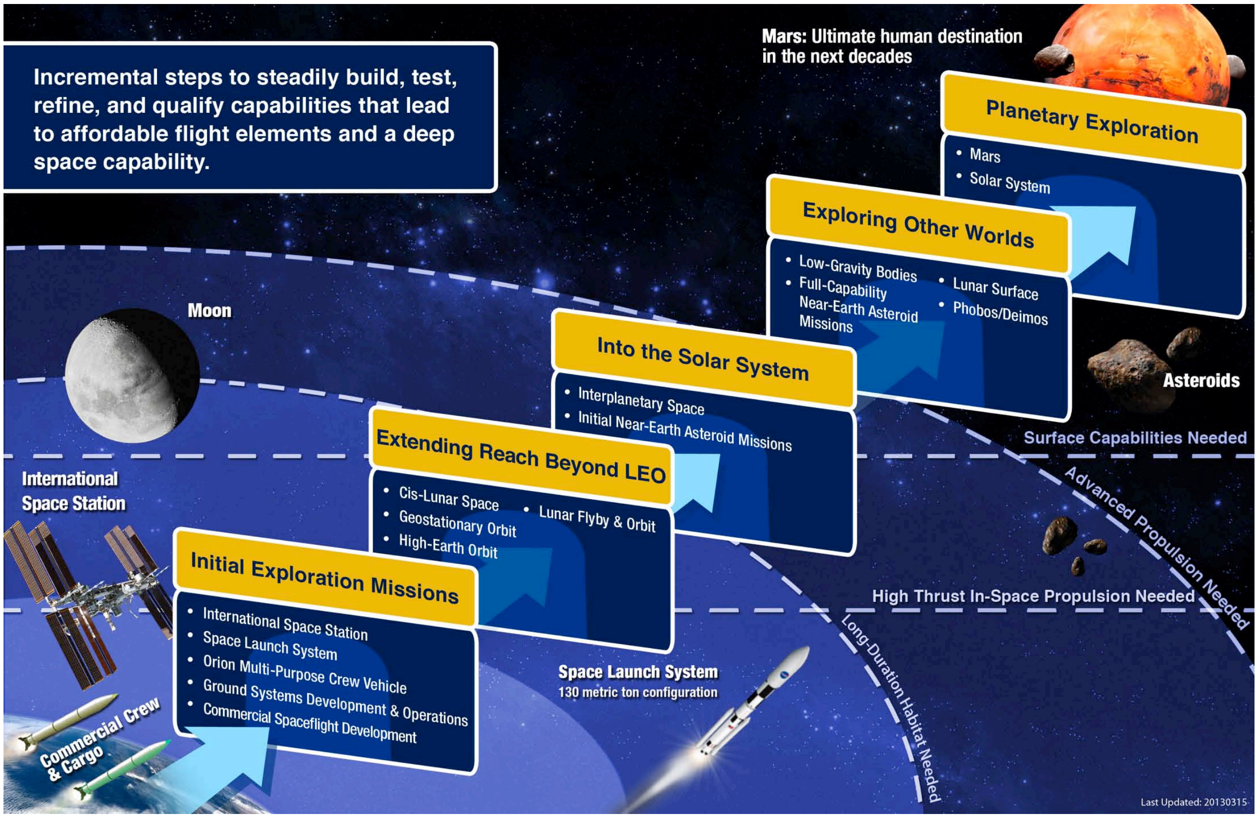

Figure 4-1. NASA Capabilities Driven Framework to Space Exploration

Specific Design Reference Missions (DRM) have been defined in the Exploration Systems Development Concept of Operations document and by NASA's cross-agency Human Architecture Team (HAT) in ongoing studies that are represented in Figure 4-1. This is one of the reasons why the SLS architecture evolves over time – to deliver crew, cargo and science to the widest possible array of mission destinations using performance capabilities represented in efficient Block upgrades. Figure 4-2 provides a summary of the three SLS "mission cases" that envelope current NASA DRMs: Earth Orbit, Lunar Vicinity, and Earth Escape.

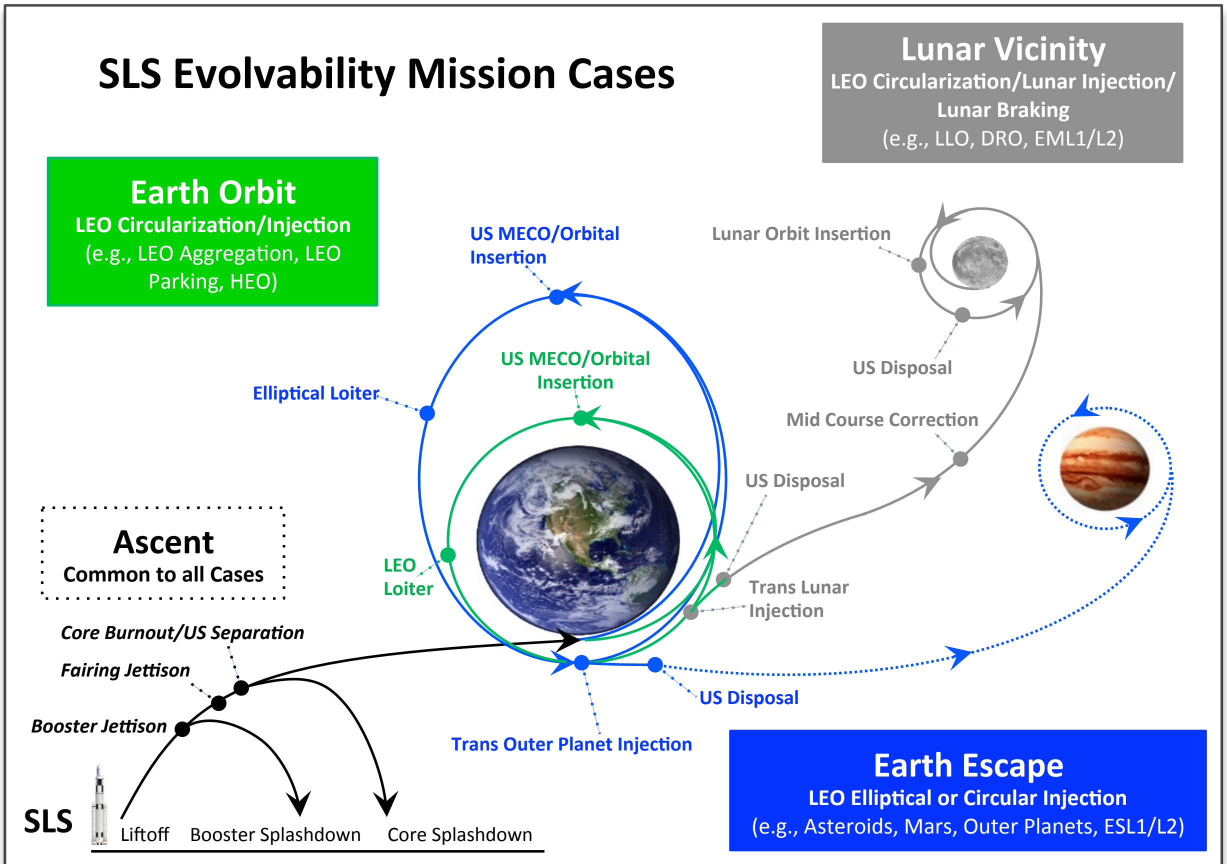

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Figure 4-2. SLS Evolvability Mission Cases

The payload delivery to Earth escape for a range of characteristic energy, or C3, for SLS Block 1 cargo and SLS Block 1B/2B configurations is given in Figure 4-3 (run date: January, 2014).

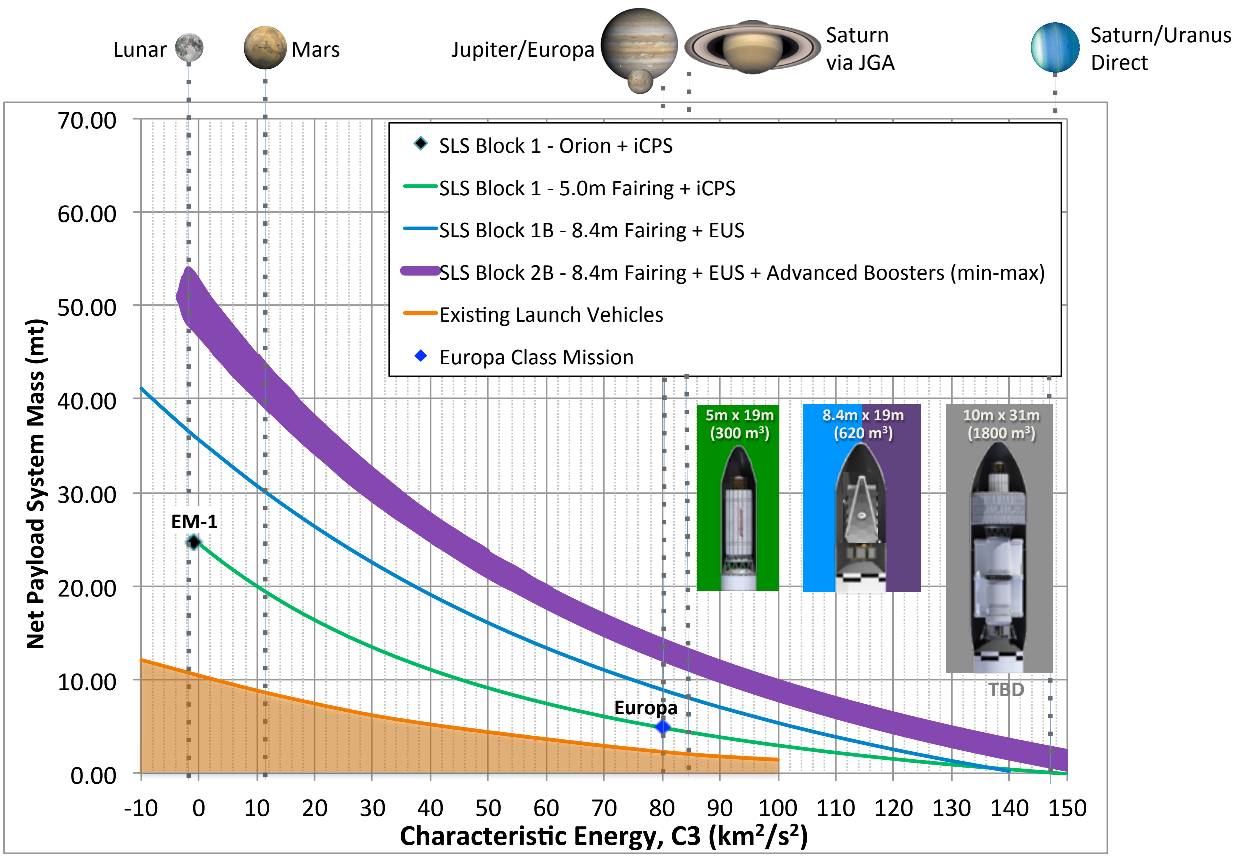

Figure 4-3. Net Payload System Mass to Earth Escape

5.0 ENVIRONMENTS

The SLS payload environment is similar to those found in expendable launch vehicles. Payload environments that will be modeled and potentially mitigated by mission include: Pre-launch thermal, radiation and electromagnetics, SLS contamination and cleanleness environments; and launch and flight loads, acoustics, shock, thermal, static pressure, contamination, radiation and electromagnetics, and vibration environments.

6.0 LAUNCH VEHICLE INTERFACES

6.1 Payload Fairings

A spacecraft or cargo payload launched on a SLS is protected by a fairing which shields it 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 typically provide the fairing conditioned air (or nitrogen purge as a unique service), fueling/draining, power and command/telemetry relay, standard access door locations and may also be tailored to provide additional payload access to the encapsulated payload.During vehicle ascent fairings protect the payload from aerodynamic, acoustic, and thermal loads and are jettisoned when free molecular heating rate drops below 0.1 British Therman Unit (BTU)/ft2 sec. Although no specific fairing designs have been finalized at this time, three SLS POD classes of fairing (5m, 8.4m, and 10m diameters) have been identified to support payload delivery performance analysis to LEO. This does not imply that SLS fairings are limited to these three configurations. Rather the SLS can accommodate a variety of existing (5m diameter) and new fairings (8.4m and 10m diameter) based on defined requirements. A summary of SLS POD fairing and adapter combinations is shown in Figure 6-1.

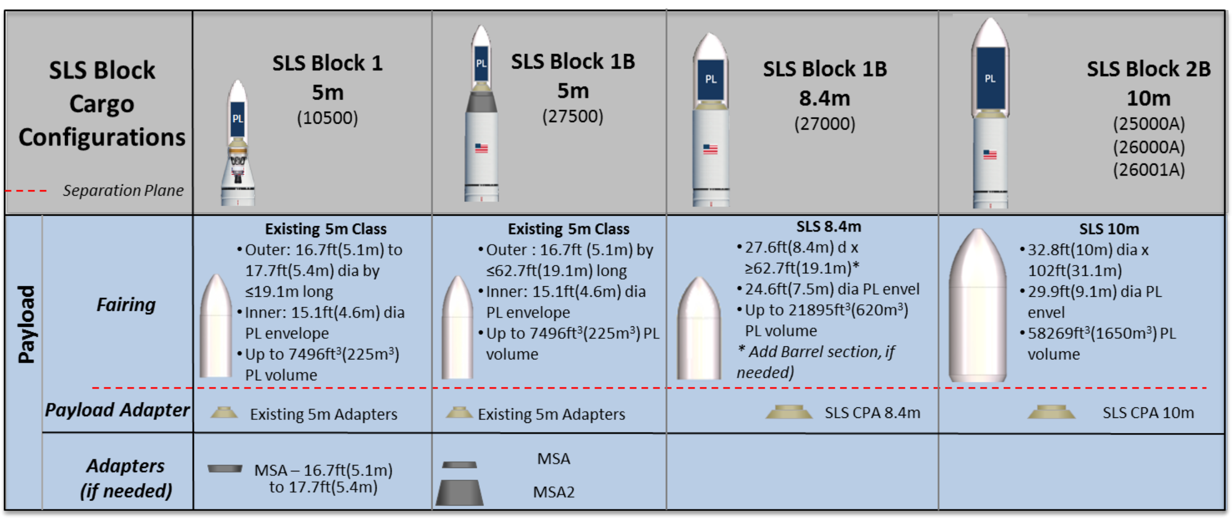

Figure 6-1. SLS Fairing Point-of-Departure Concepts

6.2 Mechanical Interface/Payload Adapters

Typically existing 5m diameter adapters are available from ELV providers to provide the primary interface between the payload and launch vehicle. These adapters (e.g., Payload Attach Fittings, Payload Adapters) provide mounting provisions for the separation springs, support the interfacing components for electrical connectors between the launch vehicle and spacecraft, and support additional mission-unique hardware as needed. Electrical bonding is provided across all mechanical interface planes associated with these adapters. These adapters are designed to allow the spacecraft to be best oriented to meet mission requirements. Reference applicable ELV user guides for more information.

The structural adapter equivalent for SLS is known as a Cargo Payload Adapter (CPA) for 8.4m and 10m payloads. Figure 6-2 shows two types of these adapters that could be used on SLS. It is anticipated that a variety of 8.4m and 10m SLS CPAs will be required; these will range from SLS provided to user provided, depending how to most efficiently accommodate spacecraft requirements.

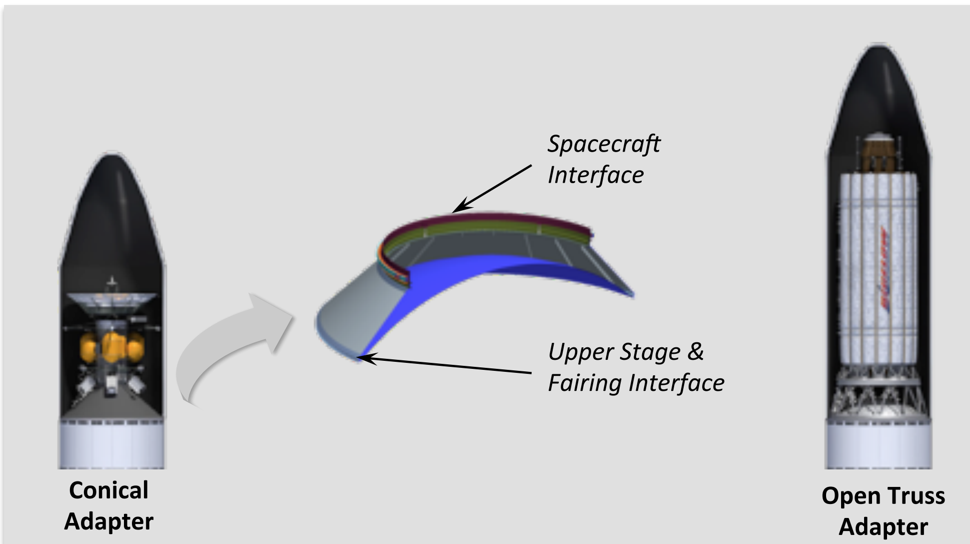

Figure 6-2. Representative Cargo Payload Adapter

6.3 Electrical Interfaces

Provisions can be made to accommodate unique spacecraft electrical and telemetry requirements including range safety.

6.4 Ground Equipment Interfaces

Ground equipment interfaces include spacecraft console, power, liquids and gases, propellant and gas sampling, and work platforms.

6.5 Range and System Safety Interfaces

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

7.0 KSC PAYLOAD PROCESSING AND ENCAPSULATION

The Space Launch System (SLS) will launch from Kennedy Space Center (KSC) in Florida. The Ground Systems Development and Operations (GSDO) Program operating out of KSC is responsible for the maintenance and operation of all vehicle and spacecraft processing, integration, and launch facilities. KSC facilities include payload processing facilities available to commercial and U.S. government users as shown in Figure 7-1: Space Station Processing Facility (SSPF), Payload Hazardous Servicing Facility (PHSF), Vehicle Assembly Building (VAB), Launch Complex 39 and the Launch Control Center (LCC).

Figure 7-1: Aerial Overview of KSC Facilities

Ground Systems Development and Operations (GSDO) program provides complete vehicle integration and launch services for the SLS launch vehicle and payload. A system of facilities, equipment, and personnel trained in launch vehicle and spacecraft integration and launch operations is in place. Payloads are manufactured at the payload provider’s manufacturing facility, which may be at the launch site or off-site. Following the completion of manufacturing activities, or upon arrival at KSC, the payload will be turned over to KSC GSDO for final processing and launch integration. For all of the various payload elements, the same basic processing phases will be followed for KSC offline encapsulation activities at the PHSF as shown in Figure 7-2.

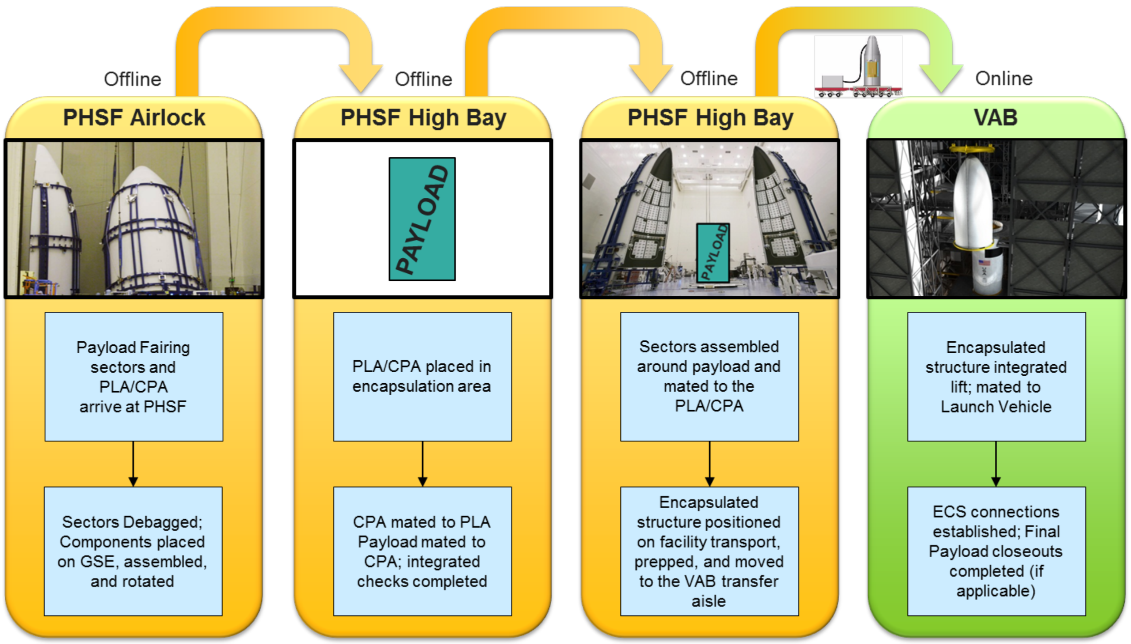

Figure 7-2. Payload Encapsulation Concept of Operations

Prior to payload arrival, the SLS fairing sectors are delivered to the PHSF, where they are inspected and prepared for payload encapsulation. The sectors are debagged, cleaned, and inspected, and then placed on GSE for assembly and rotation operations. Encapsulation operations begin with the placement of the payload adapter in the encapsulation area. Payload is then configured for encapsulation and mated to the adapter. Payload-specific tests may be performed upon the completion of this procedure per the manufacturer's requirements. The fairing sectors are positioned and configured for encapsulation in the encapsulation high bay. The fairing is then mated to the CPA and the encapsulated payload is configured for transportation. The encapsulated payload is then transported from the PHSF to the VAB transfer aisle and mated to the upper stage. 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 pounds.

APPENDIX A
ACRONYMS AND ABBREVIATIONS

BTU	British Thermal Unit
CPA	Cargo Payload Adapter
DRM	Design Reference Mission
ECS	Environmental Control System
ELV	Expendable Launch Vehicle
ER	Eastern Range
ft	Foot/feet
GSDO	Ground Systems Development and Operations
HAT	Human Spaceflight Analysis Team
IMLEO	Injected Mass at Low Earth Orbit
KSC	Kennedy Space Center
LCC	Launch Control Center
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
LOX	Liquid Oxygen
MPCV	Multipurpose Crew Vehicle
MPG	Mission Planner's Guide
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
OPR	Office of Primary Responsibility
PCB	Program Control Board
PDR	Preliminary Design Review
PHSF	Payload Hazardous Servicing Facility
POD	Point of Departure
PSM	Payload System Mass
SLS	Space Launch System
SLSP	Space Launch System Program
SPIE	Spacecraft Payloads Integration and Evolution
VAB	Vehicle Assembly Building