SLS Mission Planners Guide (MPG) Overview

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Introduction

- **Objective**
  - Provide a summary overview of draft SLS Mission Planners Guide (MPG)

- **Outline**
  - Section 1-2: Purpose and Scope
  - Section 3: SLS Configuration Overview
  - Section 4: SLS Mission Design
  - Section 5: Environments
  - Section 6: Launch Vehicle Interfaces
  - Section 7: KSC Payload Launch Facilities

- **Approach**
  - "Inner Loop" (SLS Program) uses its Design Analysis Cycle (DAC) to develop Exploration Mission 1 (EM-1) for first flight in 2017
  - "Outer Loop" (SLS Evolvability) uses SLS DAC data to establish potential performance of SLS Block upgrades
  - Outer Loop analysis based on Inner Loop data provides the basis for the current version of this MPG Overview

SLS Mission Planners Guide Section 1-2

1: PURPOSE
2: SCOPE

Mission Planners Guide

- **Serves as a information resource between NASA, industry, and the scientific community for understanding potential range of SLS mission capture**

- **Promotes two-way dialogue between developers and users to most efficiently evolve SLS mission/payload capabilities**

- **Those requiring additional mission planning information contact Mr. Steve Creech, SLS Assistant Program Manager, Strategy and Partnerships (steve.creech@nasa.gov)**

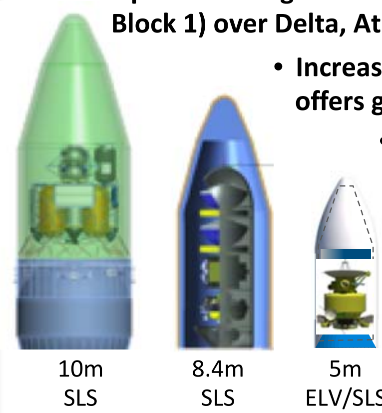
SLS Mission Planners Guide Section 3

SLS CONFIGURATION OVERVIEW

SLS Performance and Mission Capture Benefits

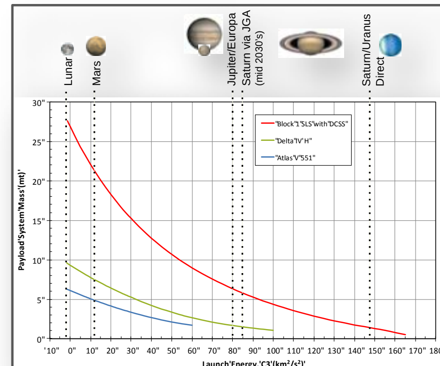
Increased Mass/Volume Payload to Orbit

- **Up to 5 times greater mass to orbit capability (SLS Block 1) over Delta, Atlas and Falcon**
  - **Increases payload mass margins and offers greater propellant loads**
    - **Accommodates a range of existing (5m) and new (8.4m-10m) fairings**
      - **Up to 6 times greater payload volume over current launch vehicles**



Larger Interplanetary Science Payloads

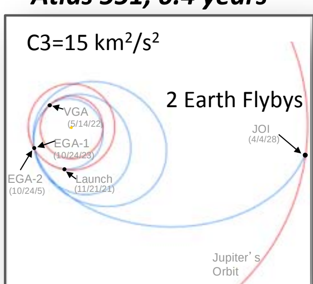
- **3 to 4 times the mass to destination over ELVs**
- **Single launch of larger payload reduces payload complexity**
  - Asteroid Redirect Mission
  - Mars Sample Return
  - Jupiter Europa Orbiter
  - Saturn/Titan Sample Return
  - Ice Giant Exploration
  - Outer Planet Sample Return
  - Large Telescopes
  - In-Space Infrastructure



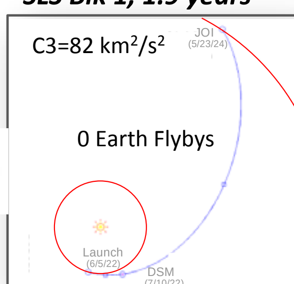
Shorter Transit Times to Destination

- **Europa Clipper flight time reduced 70% over Atlas 551**
- **Longer launch window provides more mission margin**
- **Significantly reduced cost for each year of transit reduced**

Atlas 551, 6.4 years

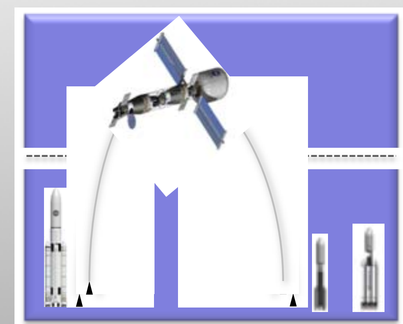


SLS Blk 1, 1.9 years



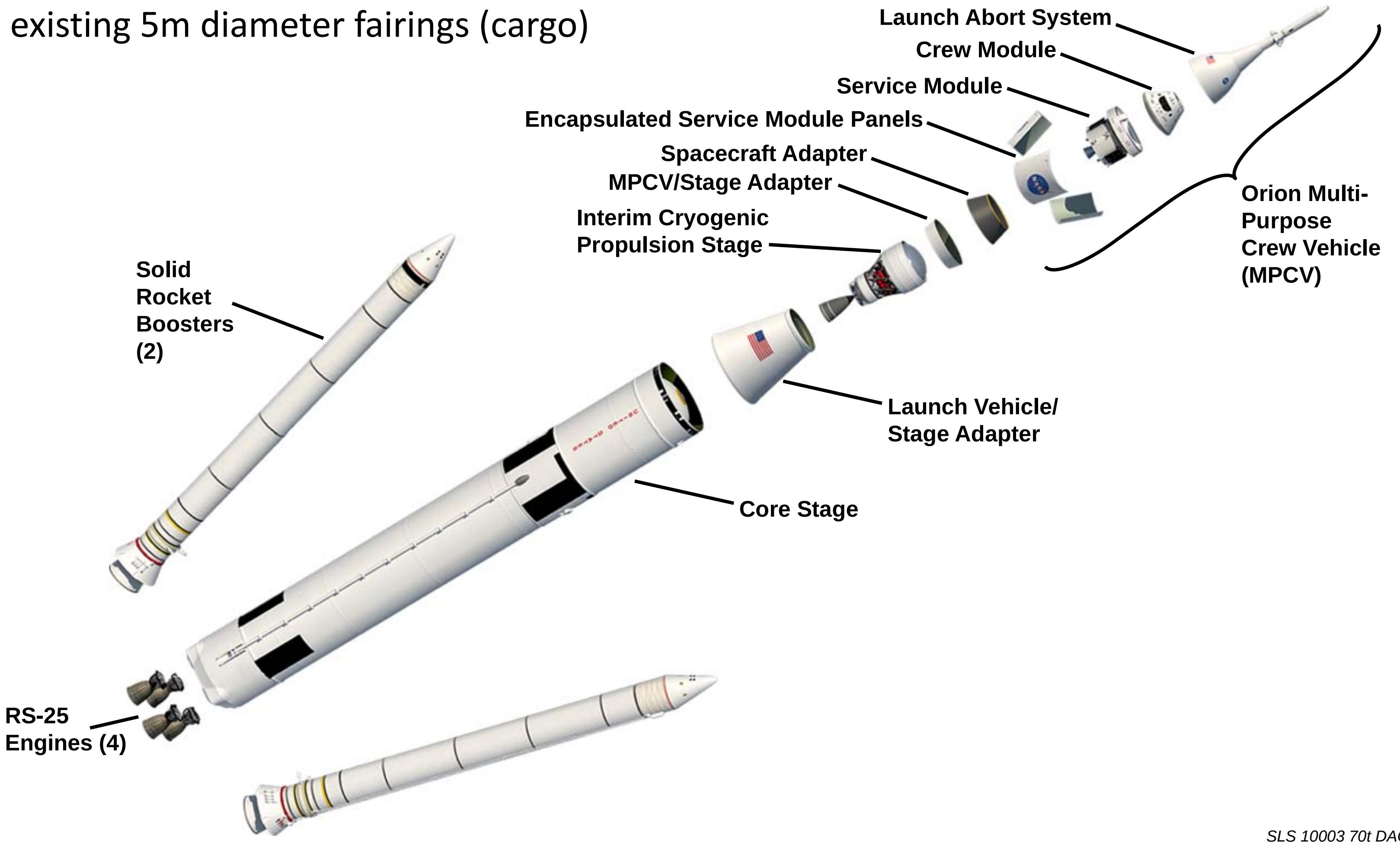
Enhanced Reliability and Safety

- **Additional volume simplifies orbital operations (less orbital assembly for large spacecraft)**
- **Significantly less time in Earth Orbit reduces propellant boil-off**
- **Eliminates Earth flyby nuclear safety concern**



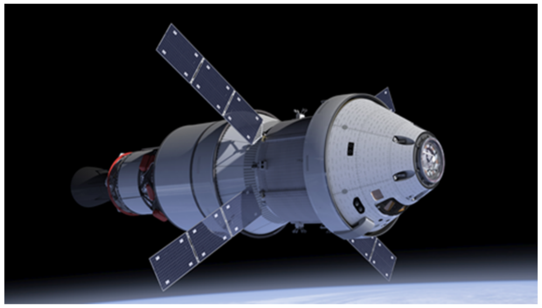
SLS Block 1 Configuration: 70t Crew Mission

- **Focus of Exploration Mission-1 (EM-1) Flight in 2017**
  - Core Stage (tankage and engines derived from Shuttle)
  - Uses existing Upper Stage (derived from Delta-IV)
  - Uses 5 segment RSRMs (derived from Shuttle)
  - Uses existing 5m diameter fairings (cargo)



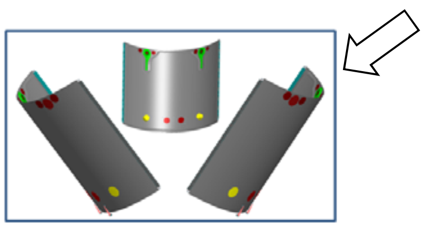
SLS 10003 70t DAC2

Block 1 Payload Overview
SLS DAC3 PoD Configuration



Injected Payload

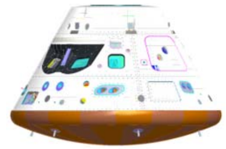
Launch Abort System (LAS)



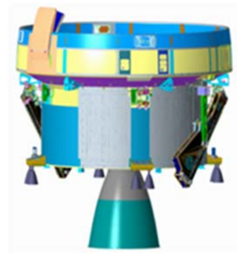
Tri-Sector Fairing Deployment

Crew Module

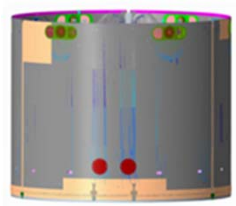
Same part as above/right
Shown twice for clarity



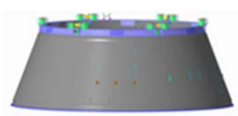
Crew Module



European Service Module



Encapsulated Service Module Panels



Spacecraft Adapter (SA)

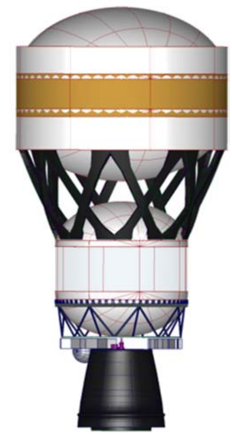
MPCV Stage Adapter

Same part as above/right
Shown twice for clarity

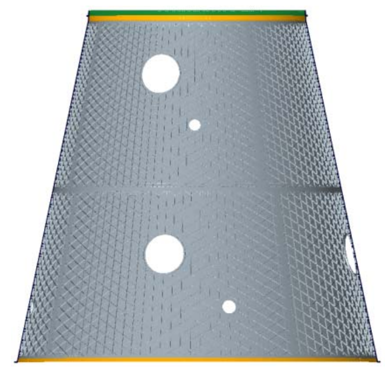
SLS Block 1

Same part as below/left
Shown twice for clarity

MPCV Stage Adapter (MSA)

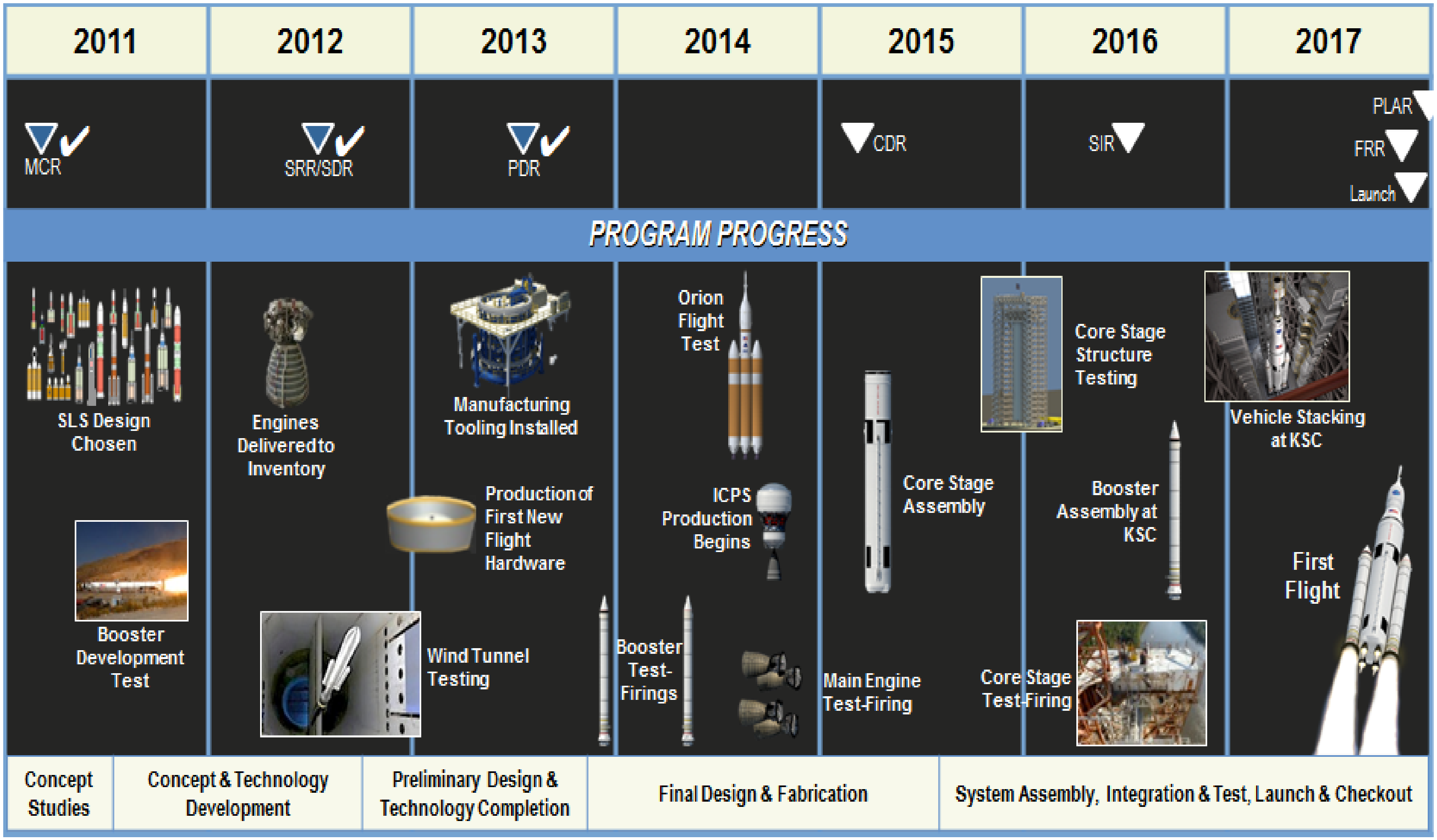


Interim Cryogenic Propulsion Stage (ICPS)



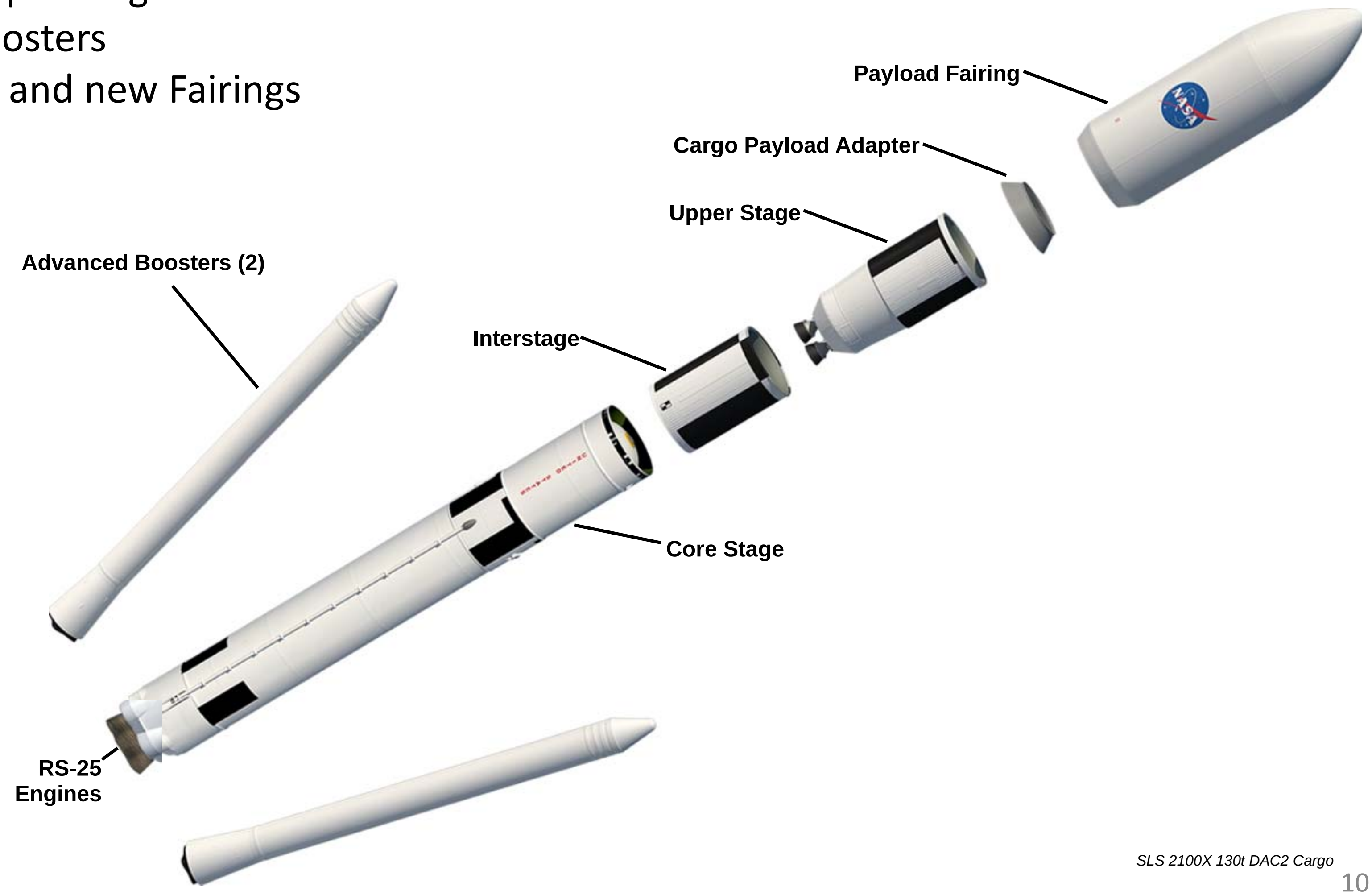
Launch Vehicle Stage Adapter (LVSA)

SLS Block 1 (70t to LEO) Development



SLS Post Block 1 Configuration: 105/130t Cargo

- **Ultimate evolutionary goal post SLS Block 1 EM-1 and EM-2 flights**
  - Minimal changes to Block 1 Core Stage
  - New Upper Stage
  - New Boosters
  - Existing and new Fairings



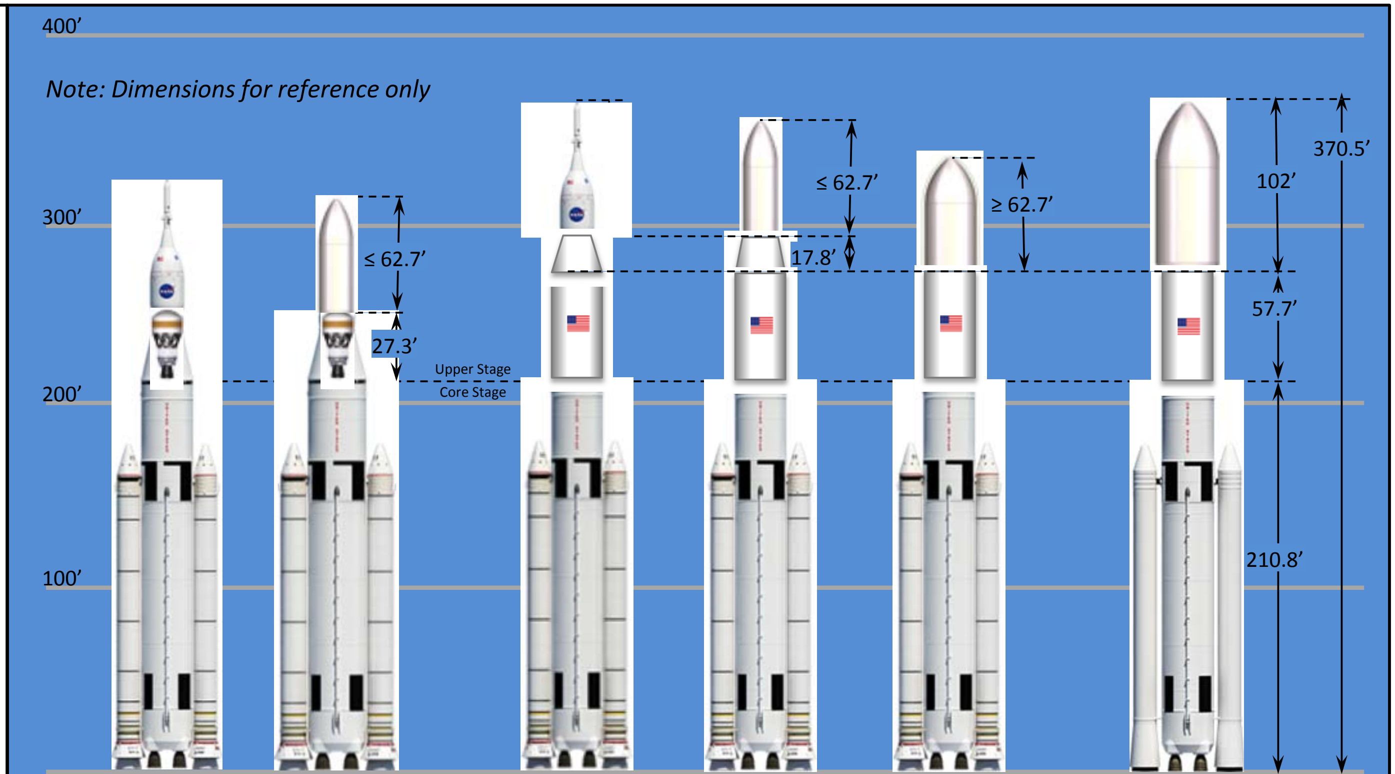
SLS 2100X 130t DAC2 Cargo

SLS Evolvability Point of Departure Concepts

Interim Cryogenic Propulsion Stage (ICPS)

Upper Stage (US)

Under Development



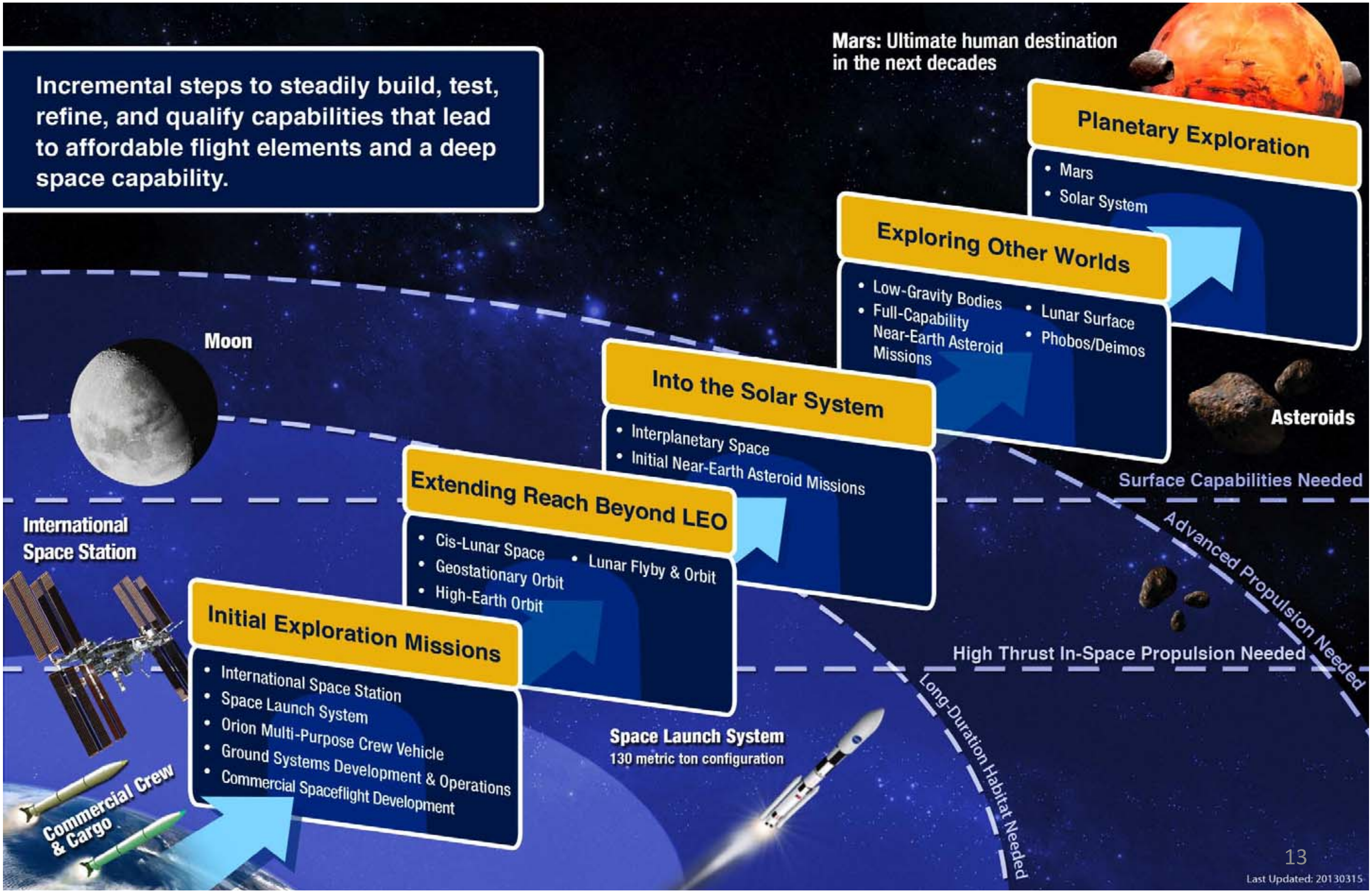
SLS Configuration	Block 1 (70t LEO Class)		Block 1B (105t LEO Class)			Block 2B (130t LEO Class)
Vehicle ID	10003	10500	28000	27500	27000	25000A/26000A/26001A
Core	8.4m Common Core		8.4m Common Core			8.4m Common Core
Booster	5 Segment Shuttle Booster		5 Segment Shuttle Booster			Advanced Booster
Upper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

Revision: 2-21-14

SLS Mission Planners Guide Section 4

4.1: MISSION TRAJECTORIES
4.2: MISSION PERFORMANCE

NASA's Capabilities Driven Framework



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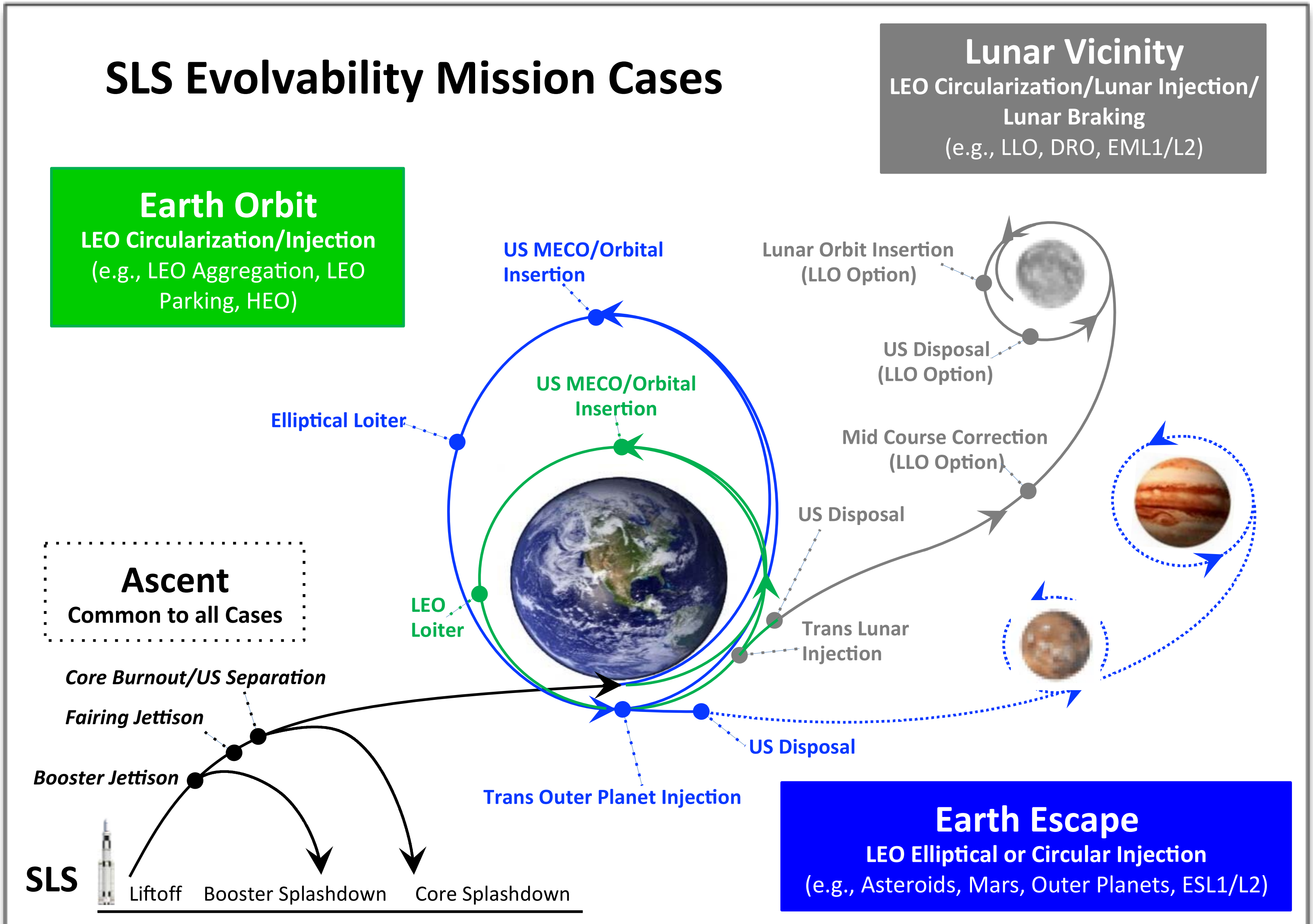
SLS Evolvability Mission Cases



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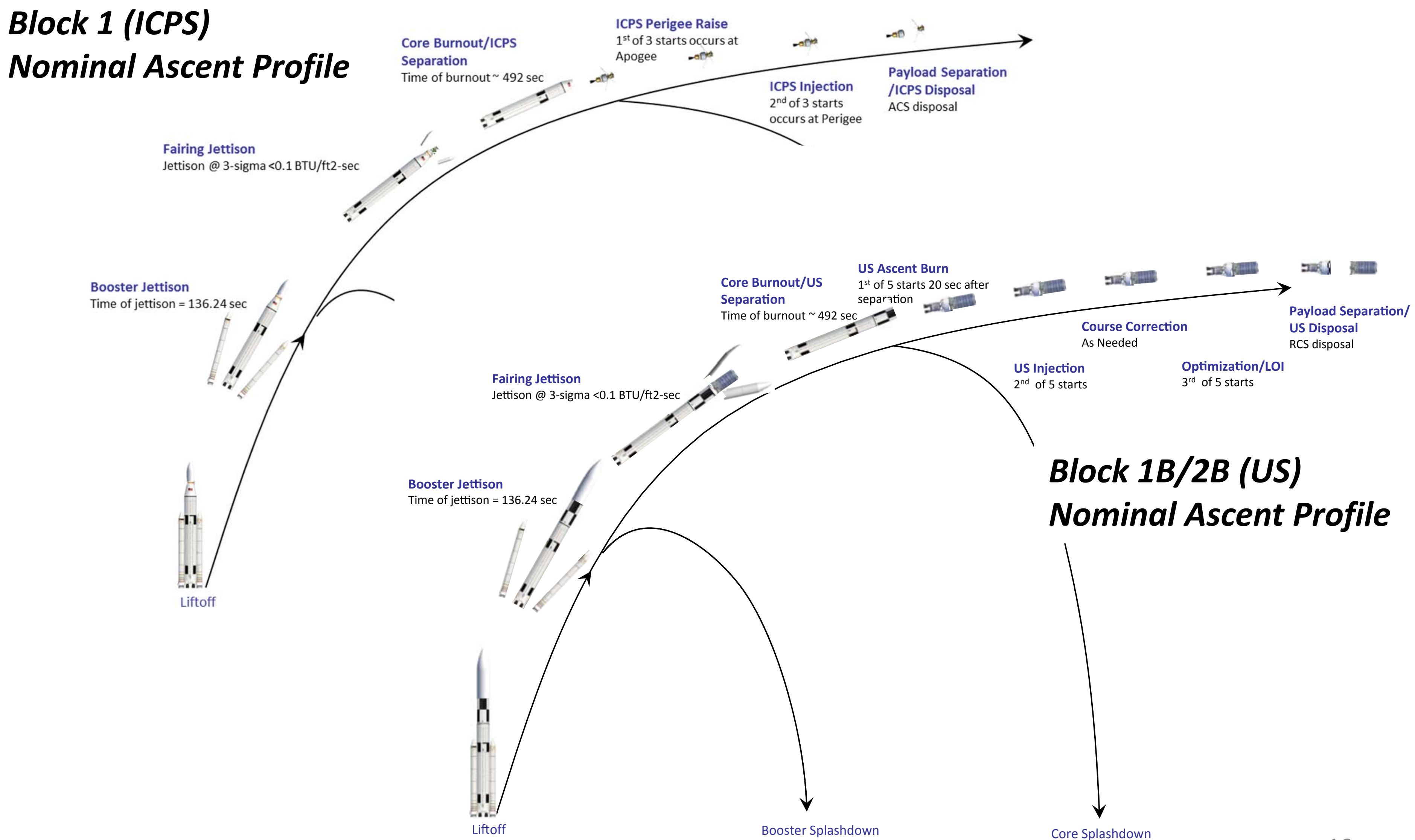
Ascent Profiles

- **SLS launch to spacecraft separation**
  - Block 1 ICPS is strictly an in-space stage, and can perform 3 engine starts
  - Block 1B US is ascent as well as in-space burns, and can perform ≥3 engine starts
- **Ascent communications and tracking use standard KSC range services**
- **Command and telemetry through TDRS S-band**
- **Core Stage must burn out with a ballistic trajectory and avoid landmasses on impact**
- **Fairing separation jettisoned when the free molecular heating rate drops below 0.1 BTU/ft2 sec**

Ascent Profiles



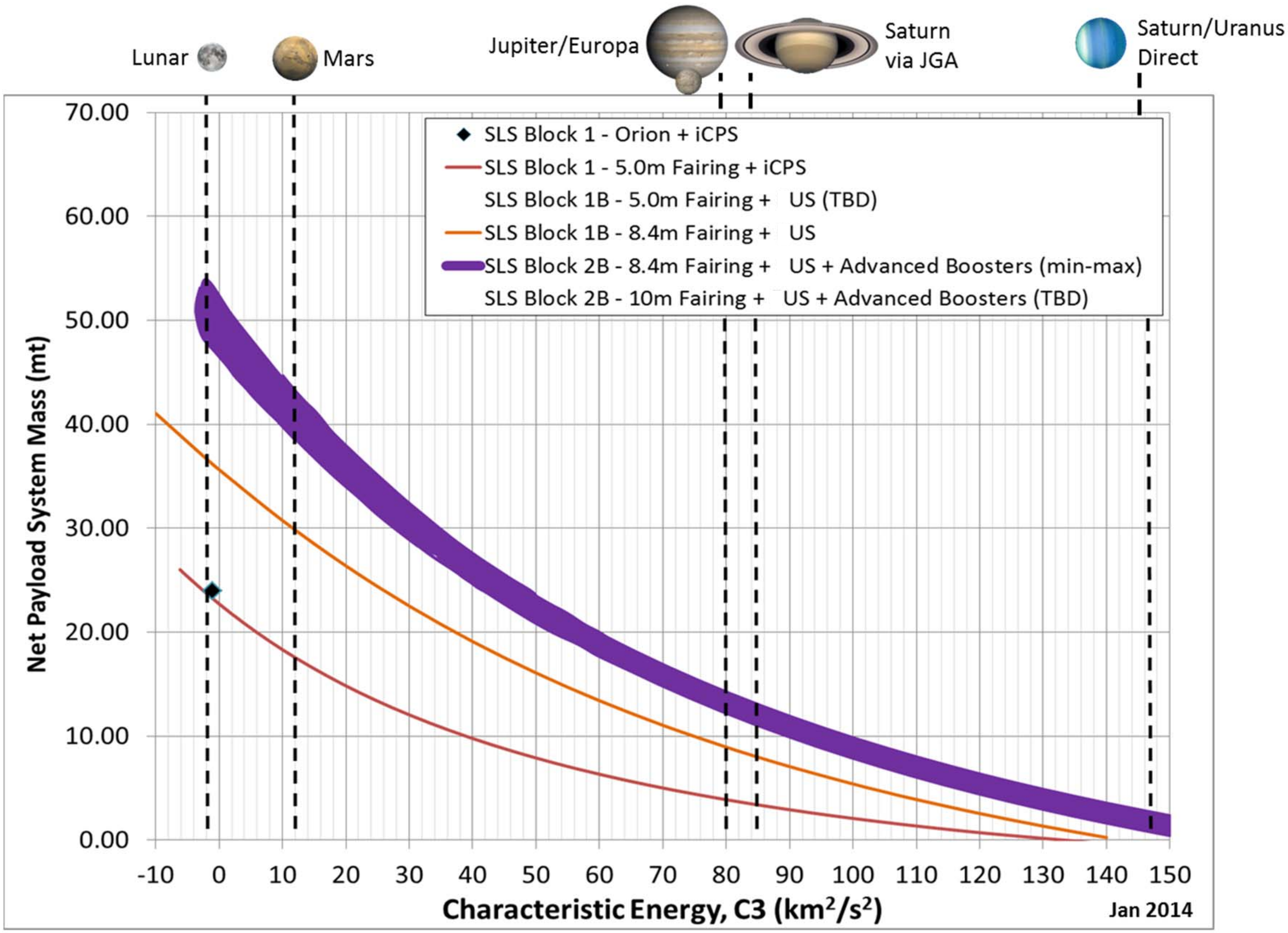
Key Mission Performance Definitions

- **SLS Mission Performance Groundrule**
  - Performance data has appropriate margins built in for mass growth allowance, flight performance reserve, and program managers reserve

- **<u>LEO or LEO Net Payload</u> is defined as encompassing the spacecraft or cargo element mass delivered on-orbit**
  - Does not include an upper stage or adapter mass

- **<u>Payload System Mass</u> is defined as encompassing the mass of both the spacecraft/cargo and any associated vehicle adapter(s) required**
  - SLS Performance is given in terms of Net Payload System Mass

Earth Escape Performance



SLS Mission Planners Guide Section 5

ENVIRONMENTS

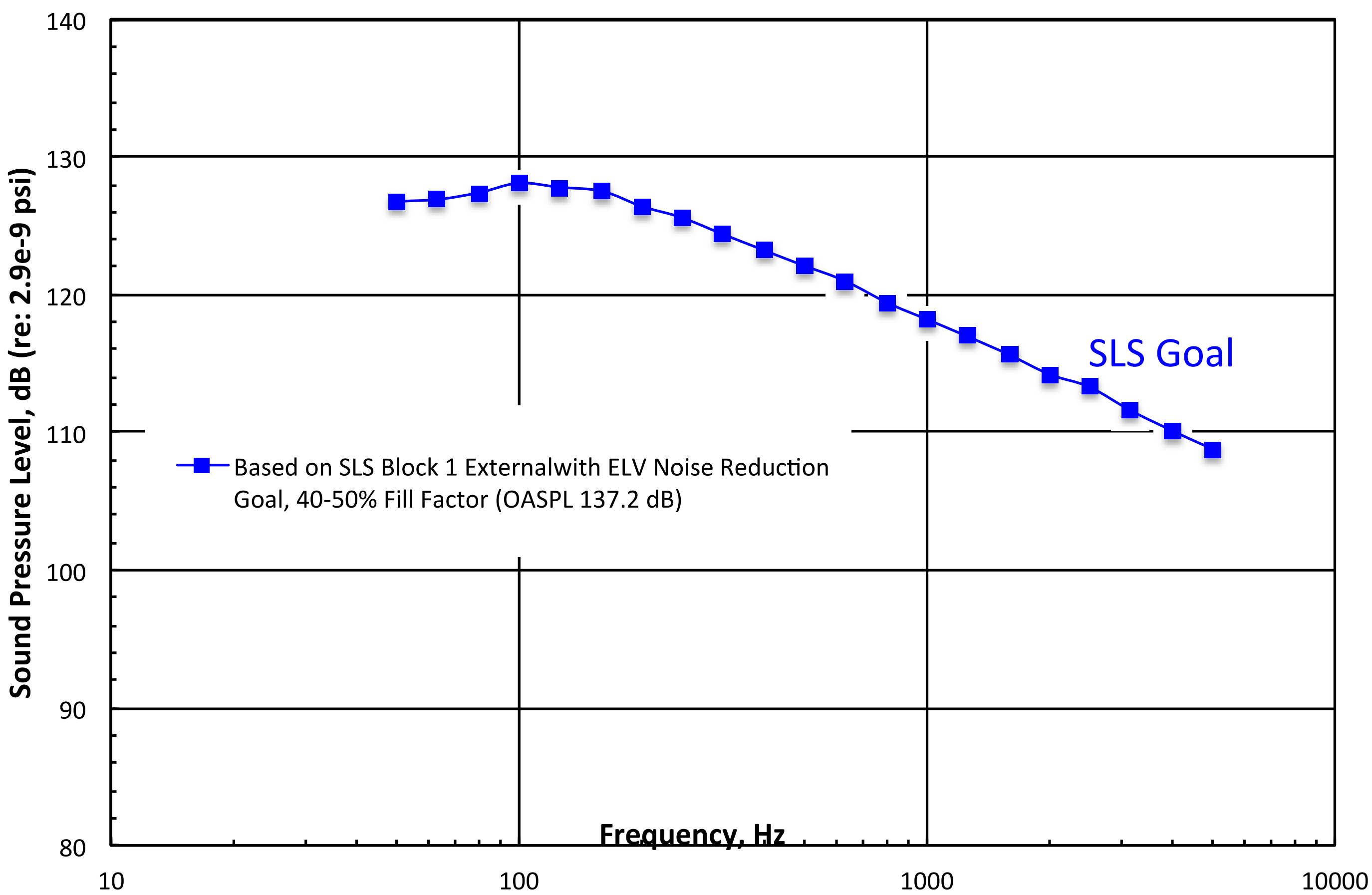
Payload Loads Environment

- **Current payload acceleration estimates:**

	Lift off	Transonic	Max Q*Alpha	Max G, Boost	Max G, Core
Axial Acceleration, g	2.75	2.00	2.50	3.25	3.50
Lateral Acceleration, g	0.75	0.75	0.50	0.30	0.25

- **Vehicle dynamic coupled loads analysis can be performed to generate more specific environments once payload and adapter concepts are more mature**

Payload Acoustic Environment



Shock Environment

- **Sources of shock environment at the payload/launch vehicle interface**
  - Booster separation
  - Core stage/upper stage separation
  - Fairing separation
  - Payload/adapter separation

- **Similar to ELVs, shock levels due to booster and core stage/upper stage separation are highly attenuated through the vehicle structure before reaching the payload/vehicle interface**

- **Shock levels due to fairing and payload/adapter separation are characteristically the primary drivers due to proximity with payload/adapter levels being the higher**

- **SLS cargo vehicles as a goal will utilize existing ELV fairings and payload adapters**

- **Shock levels for ELV fairing and payload/adapter separation events are readily available in ELV Payload Planners Guides**

Payload Ascent Thermal Environment

- **Payloads will be protected from aerodynamic heating through the application of external TPS and attenuation of heating by the fairing walls and internal acoustic protection system**

- **Current estimates of aerodynamic heating are consistent with those of other ELV**

- **Internal heat flux will be no greater than 0.1 BTU/ft^2-sec typical of current ELV**

- **Payload fairing is not jettisoned until the *external* heat flux drops below 0.1 BTU/ft2-sec**

Payload Ascent Venting Environment

- **SLS fairings can be vented during the ascent phase by proper implementation of vent doors to insure an acceptable depressurization rate of the payload compartment**

- **Specific venting scheme designs will depend on the mission trajectory and payload depressurization rate requirement**

Payload Ascent Contamination Environment

- **Typical sources of ascent contamination include: molecular outgassing, NVR redistribution, particle redistribution, fairing separation, booster separation, core stage separation, and upper stage reaction control system**

- **Except for booster & core stage separation contamination sources, environments will be consistent with current industry available fairing provisions, cleanliness procedures and deposition requirements**

- **Since the payload is fully encapsulate by the fairing far forward of the sources, booster and core stage separation system potential debris contamination products will not pose a threat to the spacecraft**

Payload Other Ascent Environments

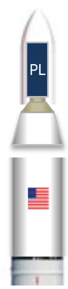
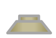
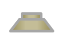
- **Other ascent environments under evaluation to be made available in the future:**
  - Radiation and EMC --- TBD
  - Vibrations --- TBD

SLS Mission Planners Guide Section 6

LAUNCH VEHICLE INTERFACES

SLS Offers Numerous Fairing Options

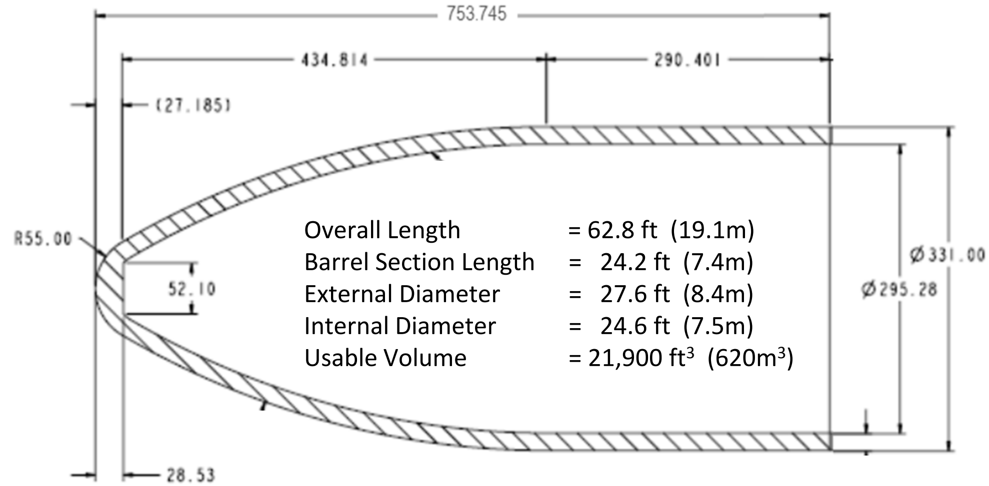
- **SLS accommodates 5m, 8.m and 10m Diameter Fairings depending on mission need**
  - POD Configurations shown as reference

	 **SLS Block 1** **5m** (10500)	 **SLS Block 1B** **5m** (27500)	 **SLS Block 1B** **8.4m** (27000)	 **SLS Block 2B** **10m** (25000A) (26000A) (26001A)
Payload	 **Existing 5m Class** • Outer: 5.1m to 5.4m dia by ≤19.1m long • Inner: 4.6m dia PL envelope • Up to 300 m^3 PL volume	 **Existing 5m Class** • Outer: 5.1m to 5.4m dia by ≤19.1m long • Inner: 4.6m dia PL envelope • Up to 300 m^3 PL volume	 **SLS 8.4m** • 8.4m dia x ≥19.1m* • 7.5m dia PL envelope • 620 m^3 PL volume ** Barrel section can be added as needed*	 **SLS 10m** • 10m dia x 31.1m • 9.1m dia PL envelope • 1800 m^3 PL volume
	 Existing 5m Adapters	 Existing 5m Adapters	 SLS CPA 8.4m	 SLS CPA 10m

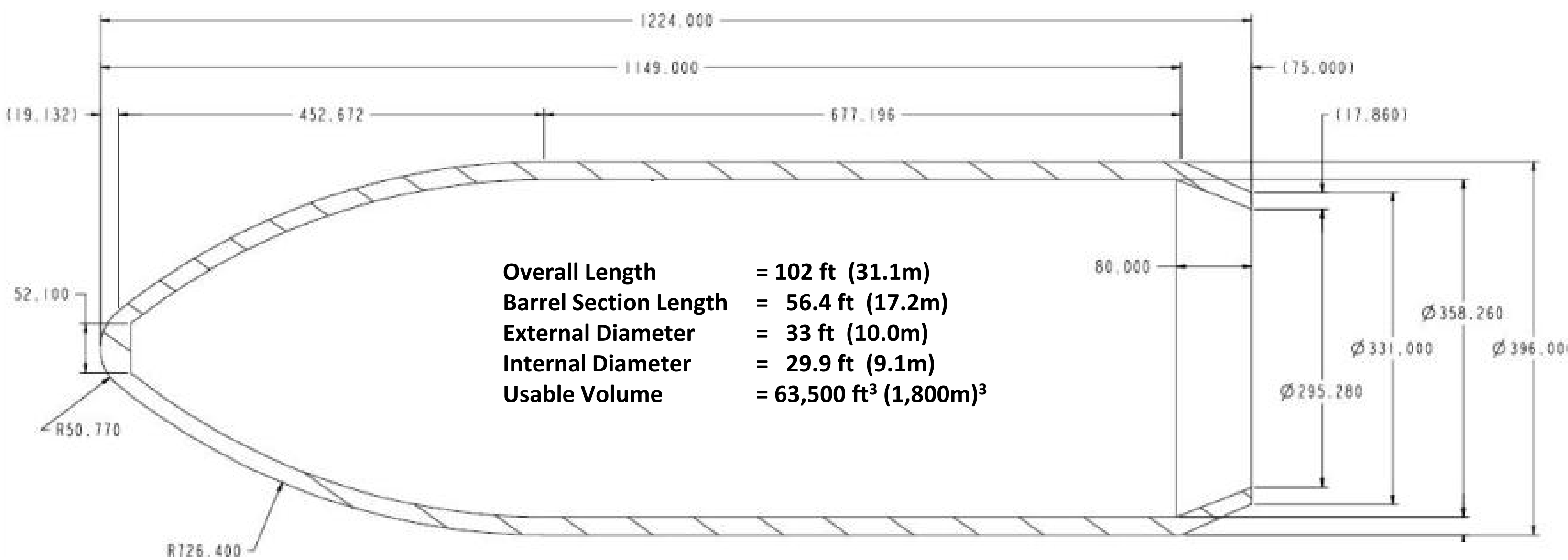
Revised 2-21-14

POD 8.4m and 10m Diameter Fairings

Additional Barrel Sections Can be Added to the 8.4m Fairing



Overall Length = 62.8 ft (19.1m)
Barrel Section Length = 24.2 ft (7.4m)
External Diameter = 27.6 ft (8.4m)
Internal Diameter = 24.6 ft (7.5m)
Usable Volume = 21,900 ft^3 (620m^3)

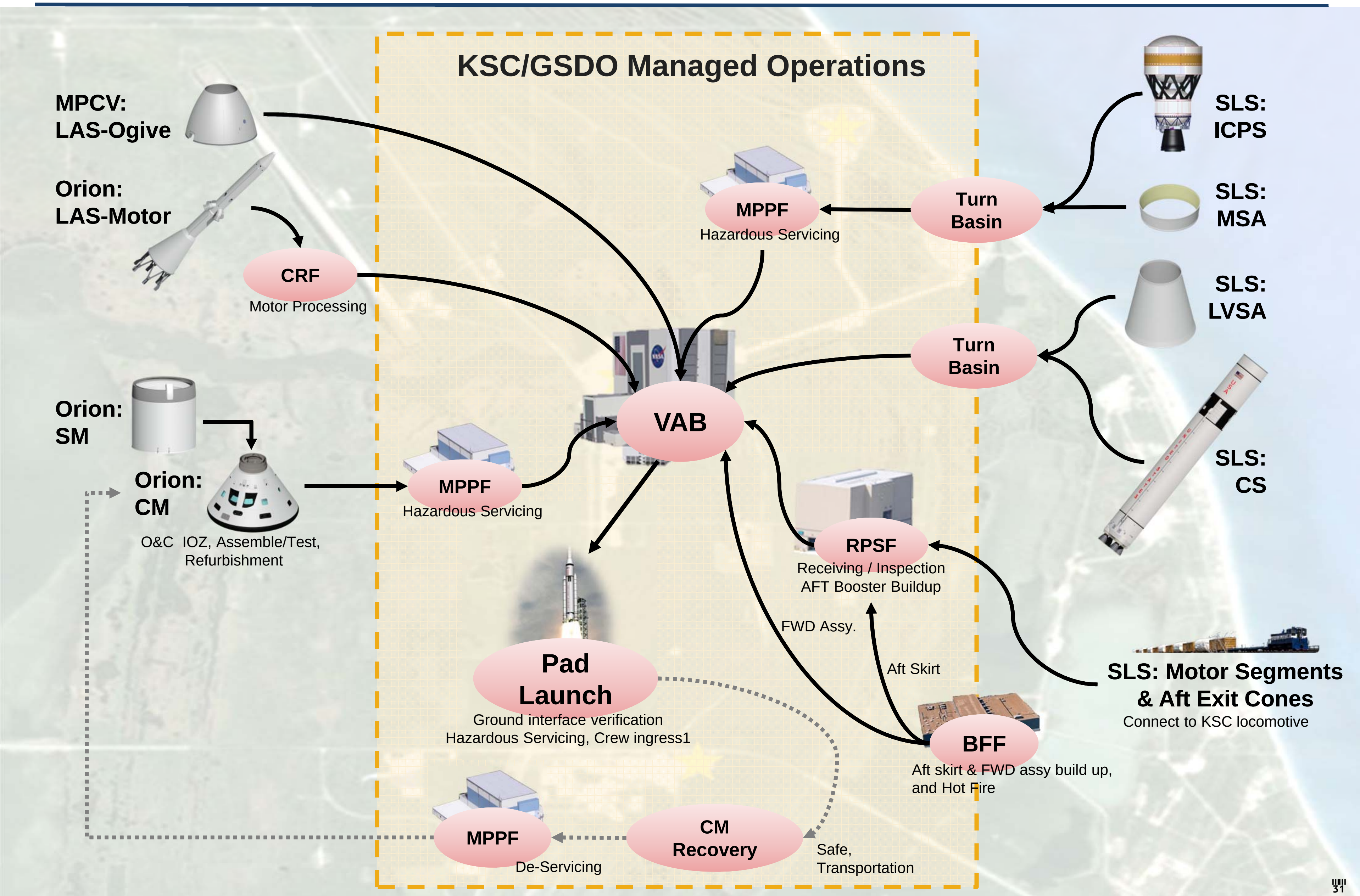


Overall Length = 102 ft (31.1m)
Barrel Section Length = 56.4 ft (17.2m)
External Diameter = 33 ft (10.0m)
Internal Diameter = 29.9 ft (9.1m)
Usable Volume = 63,500 ft^3 (1,800m)^3

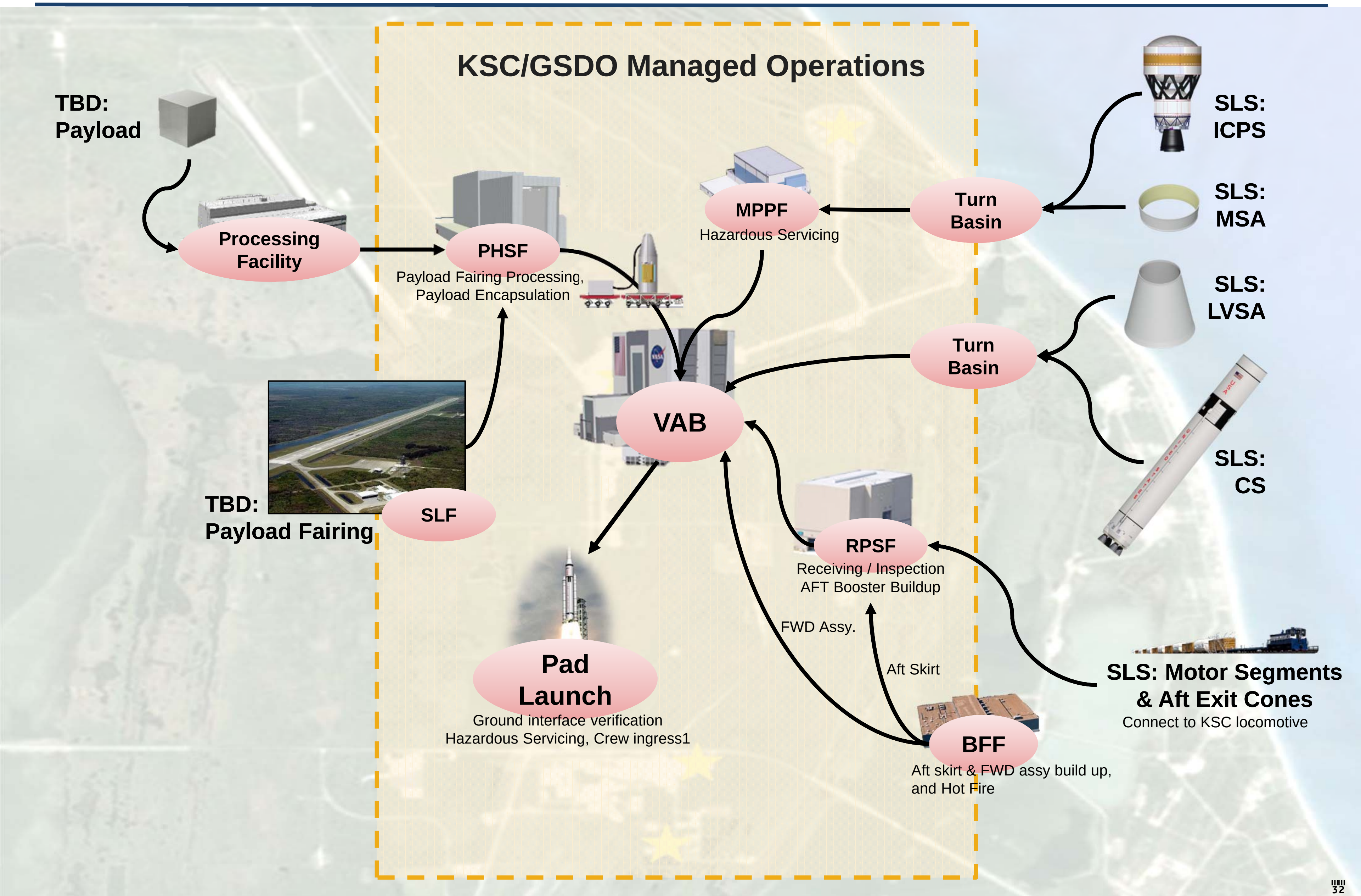
SLS Mission Planners Guide Section 7

KSC PAYLOAD LAUNCH FACILITIES

EM-1 SLS Block 1 Crew Operational Flow



EM-1 SLS Block 1 Payload Operational Flow



KSC/GSDO Facility Overview

Space Station Processing Facility (SSPF)
- High Bay, Intermediate Bay, Air Lock
- Level4/5 Clean Work Area
- Door Dimensions (H x W): 49.5’ x 42’
- Cranes: (2) 30 t / (2) 5 t / (1) 15 t
- Hook Height: 50’ / 25’ / 50’
- Ammonia Servicing, Compressed Air, GHe, GN2

Mobile Launcher (ML)
- Service Interfaces for SLS Vehicle (Umbilicals, Access Arms)
- Compressed Air
- Environmental Control System

Payload Hazardous Servicing Facility (PHSF)
- High Bay, Air Lock
- Level4/5 Clean Work Area
- Door Dimensions (H x W): 75’ x 35’
- Cranes: (1) 50 t / (1) 15 t
- Hook Height: 74.5’ / 72.5’
- Compressed Air, GHe, GN2
- Hypergolic Vent System
- PHE Breathing Air

Crawler Transporter (CT)
- Transports ML with Integrated Vehicle
- Environmental Control System

Vehicle Assembly Building (VAB)
- (4) High Bays, (4) Low Bay Areas, Transfer Aisle
- Cranes: (2) 250 t / (2) 325 t / (1) 175 t
- Hook Height: 462.5’ / 462.5’ / 160.25’
- Compressed Air, GHe, GN2
- 360° Access to OML of Launch Vehicle

Launch Complex 39B (LC-39B)
- Human-Rated Space Launch Complex
- Clean Pad Approach
- Compressed Air, GHe, GN2, GO2, LH2, LO2
- Environmental Control System

Launch Control Center (LCC)
- “Brain” of LC-39
- Controls Operations Interfaces with Launch Vehicle and Spacecraft

SLS Mission Planners Guide

SUMMARY AND NEXT STEPS

Summary and Next Steps

- **SLS Program (Inner Loop) continues to develop the 2017 vehicle**
- **SLS Evolvability (Outer Loop) continues to assess SLS Program results and incorporate those into Block upgrade performance studies**
- **A formal SLS Mission Planners Guide will be available after the next synch between Inner and Outer Loop is completed**
- **This overview also provides insight to better understand needed mission enabling technology investments for SLS Block upgrades**
  - Users are invited to continue the discussion involving potential SLS utilization and related performance improvements that can increase SLS mission capture