National Aeronautics and Space Administration

NASA'S SPACE LAUNCH SYSTEM: PAYLOAD OPPORTUNITIES FOR LUNAR EXPLORATION, SCIENCE MISSIONS

October 25, 2019

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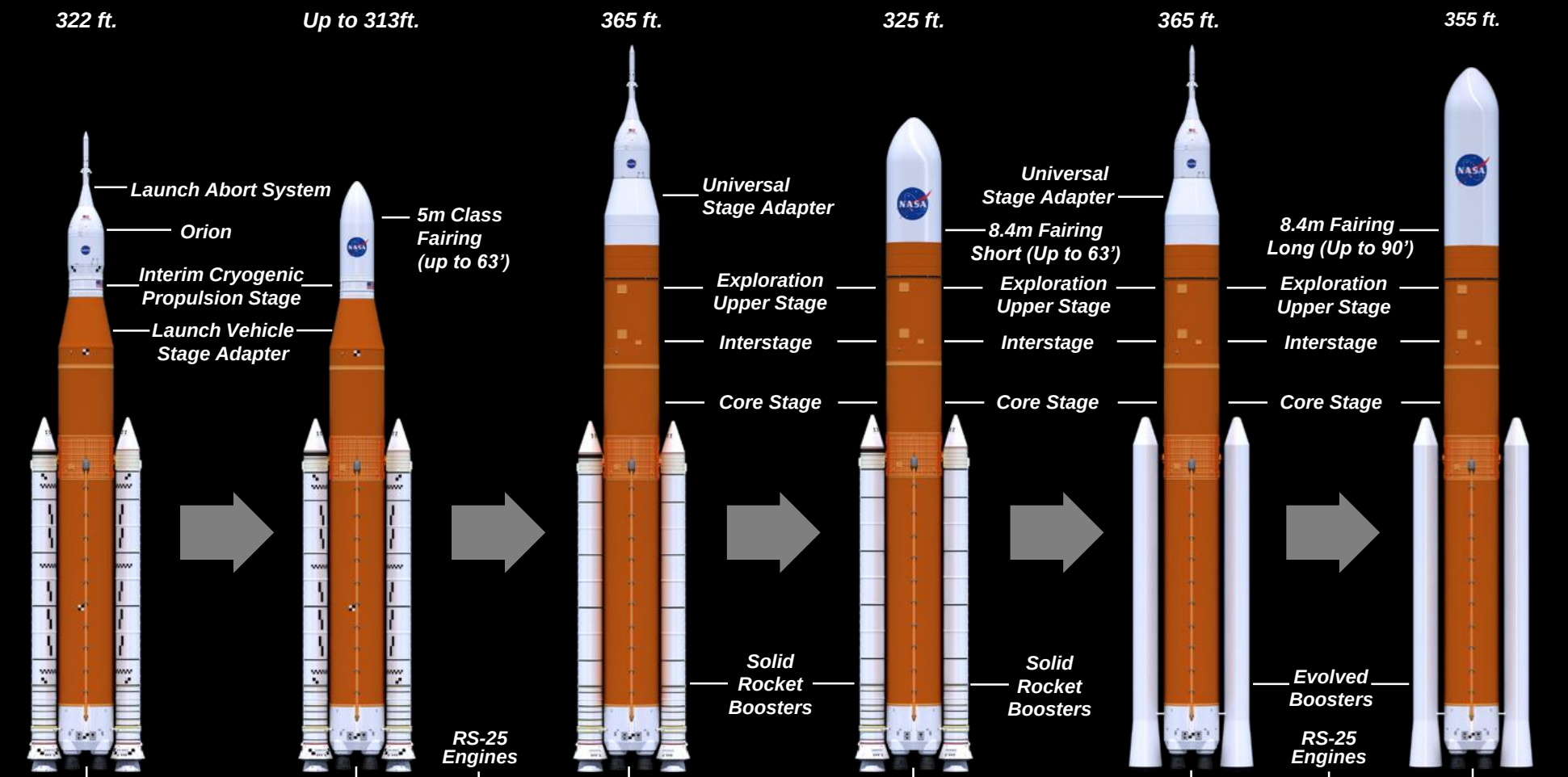
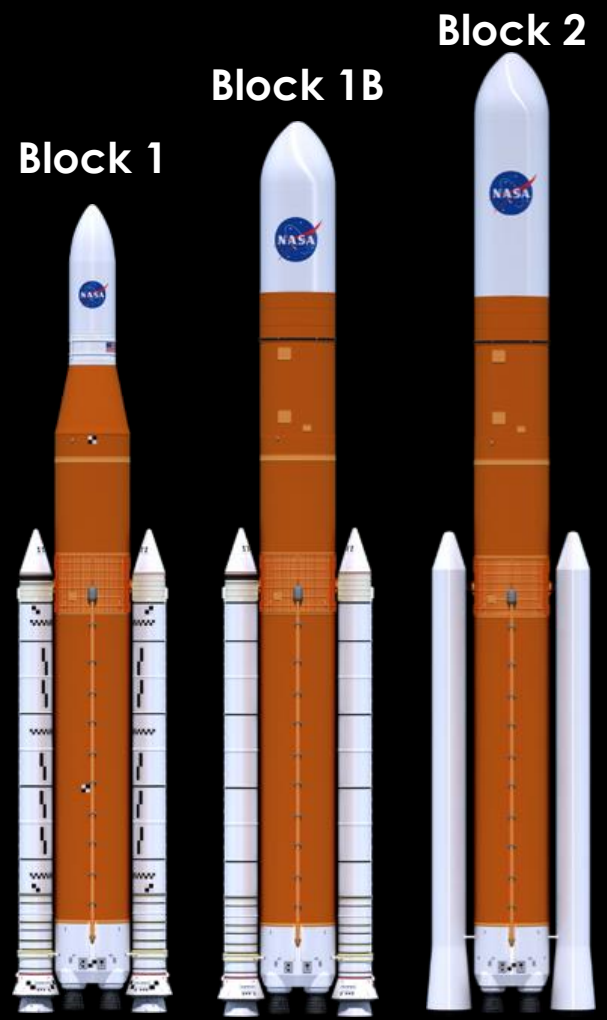
NASA's Space Launch System

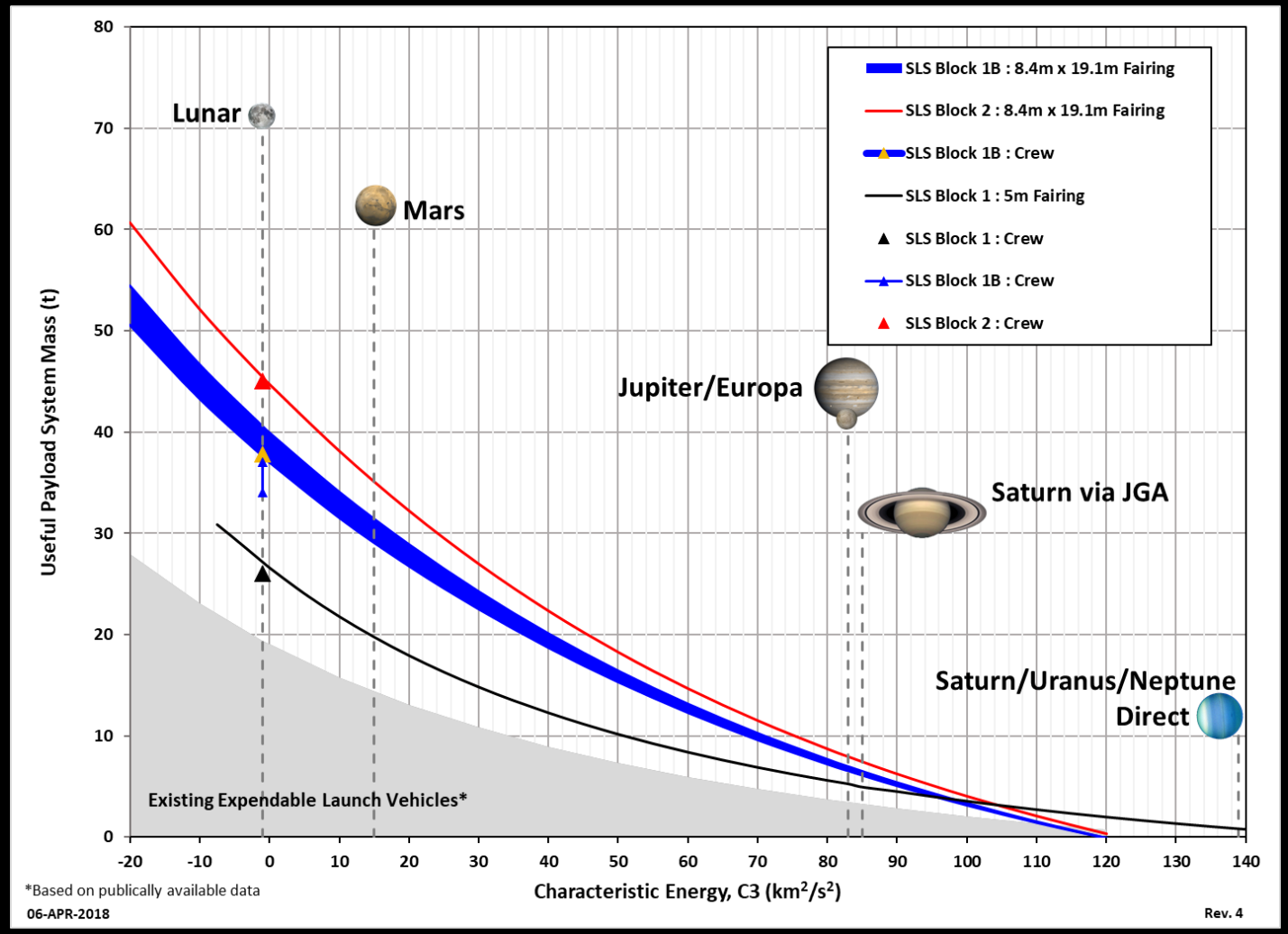
SLS EVOLVABILITY

FOUNDATION FOR A GENERATION OF DEEP SPACE EXPLORATION



SLS C3 PERFORMANCE

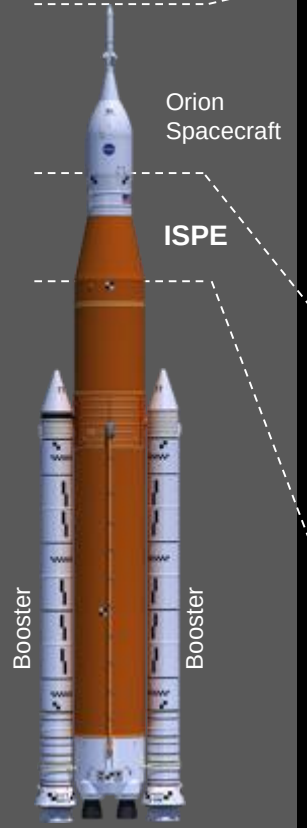


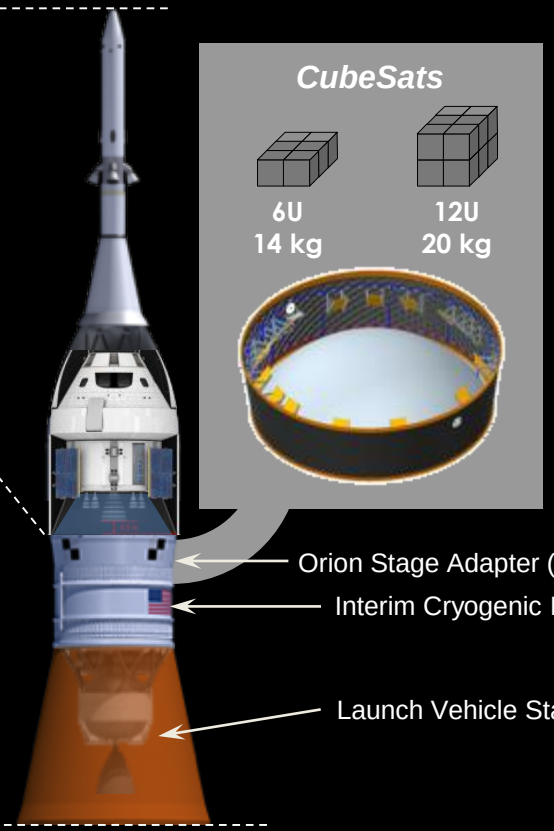


SLS performance is optimized for lunar destinations (C3=-0.99 km²/s²)

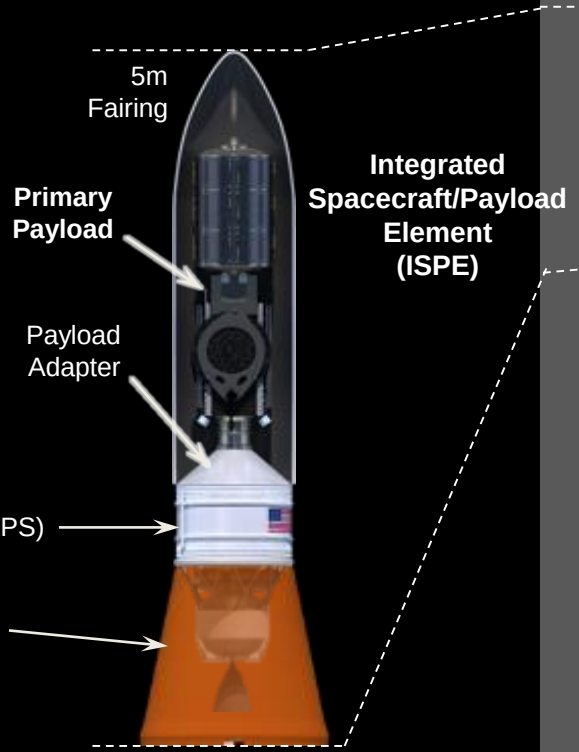
BLOCK 1 PAYLOAD ACCOMMODATIONS

SLS Block 1 Crew



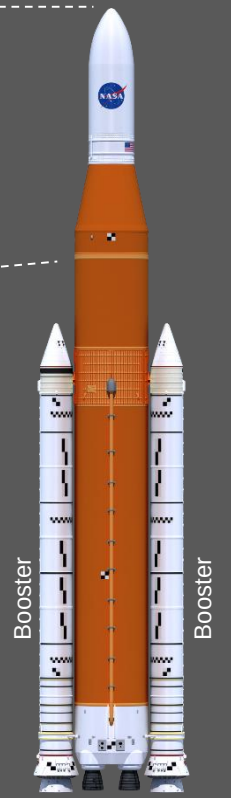


Up to 17 places ≤ 12U

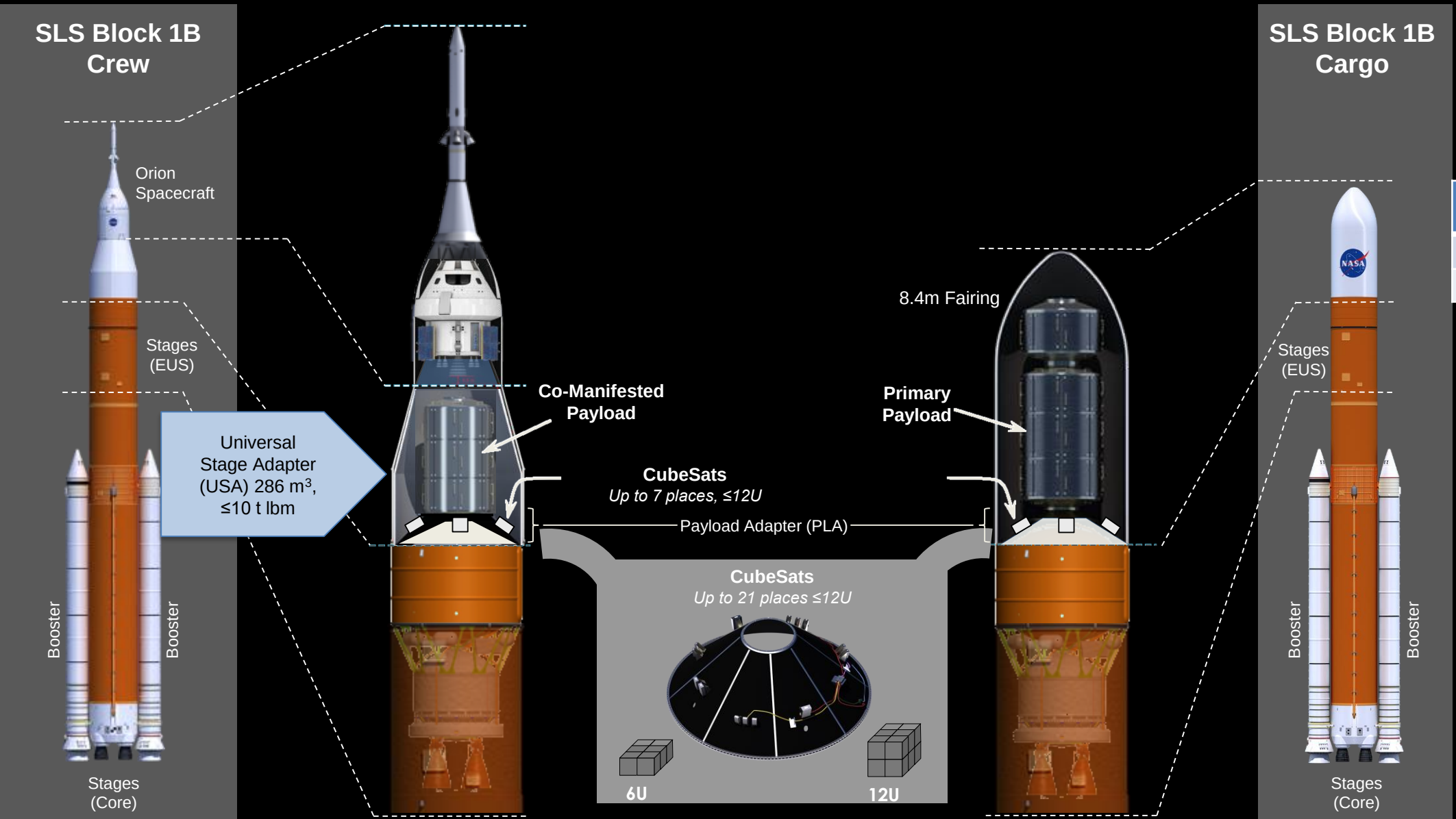


229 m³ available volume

SLS Block 1 Cargo



BLOCK 1B PAYLOAD ACCOMMODATIONS



Fairing diameter x length	Available volume
8.4 m x 19.1 m	621 m^3
8.4m x 27.4 m	988 m^3

SLS ENABLES LUNAR, MARTIAN MISSIONS

ARTEMIS

CubeSats

Smallsat access to deep space, propulsive capabilities

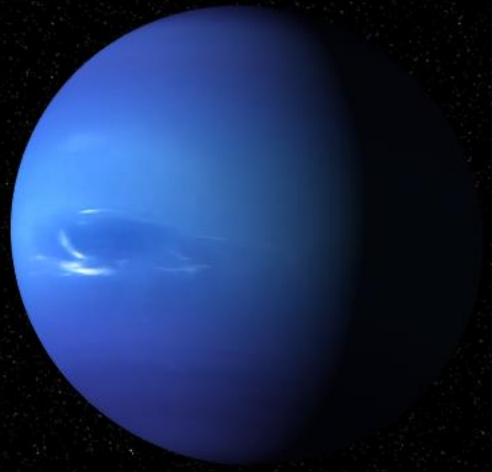
Orion with short-duration hab module

286 m^3
10 t lbm capability

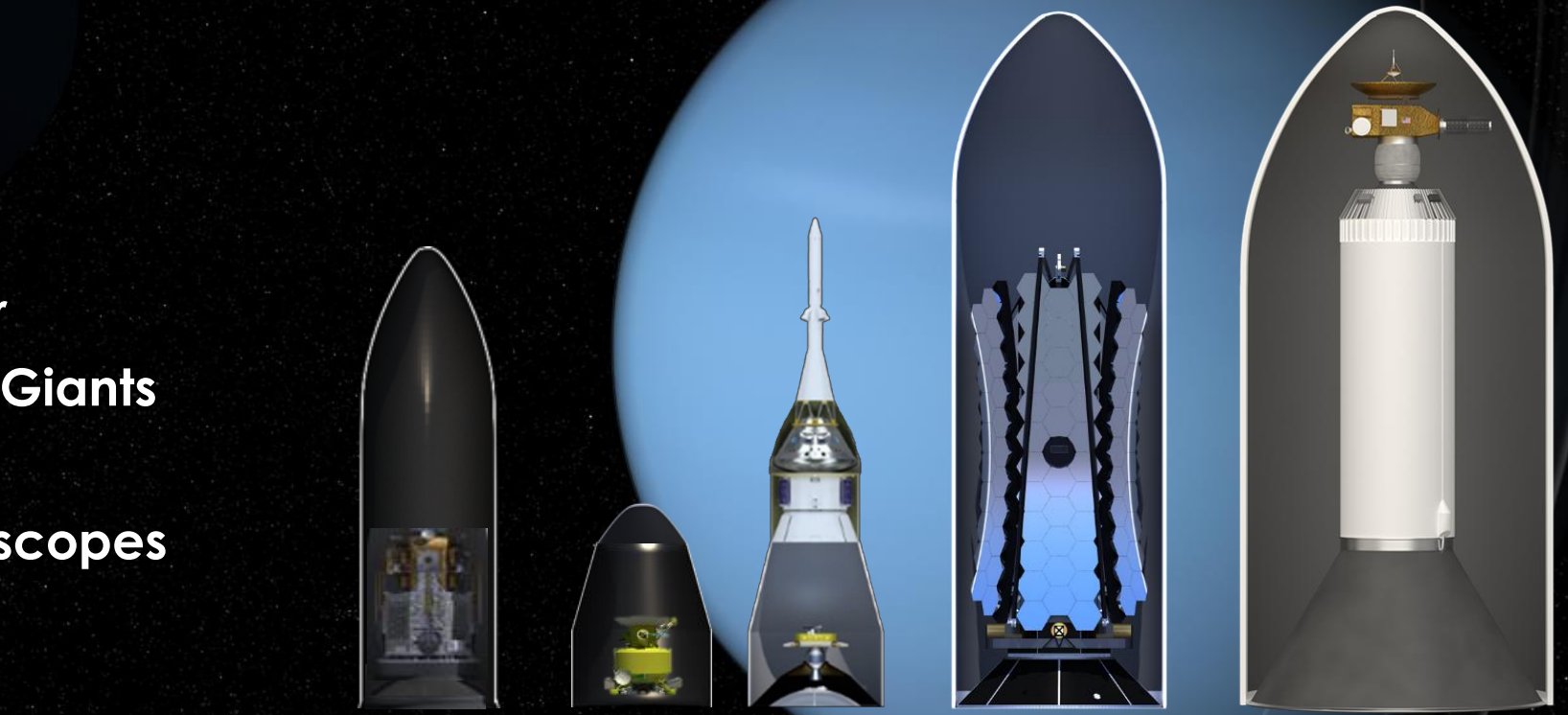
10m fairing w/notional Mars payload

1,320 m^3
>45 t lbm capability

SLS ENABLES SCIENCE MISSIONS



- **Europa Clipper and Lander**
- **Dual spacecraft to the Ice Giants**
- **Interstellar probe**
- **Large-aperture space telescopes**



Robotic Payloads to the outer solar system

Orion with Co-manifested Science Missions

Large-Aperture Space Telescopes

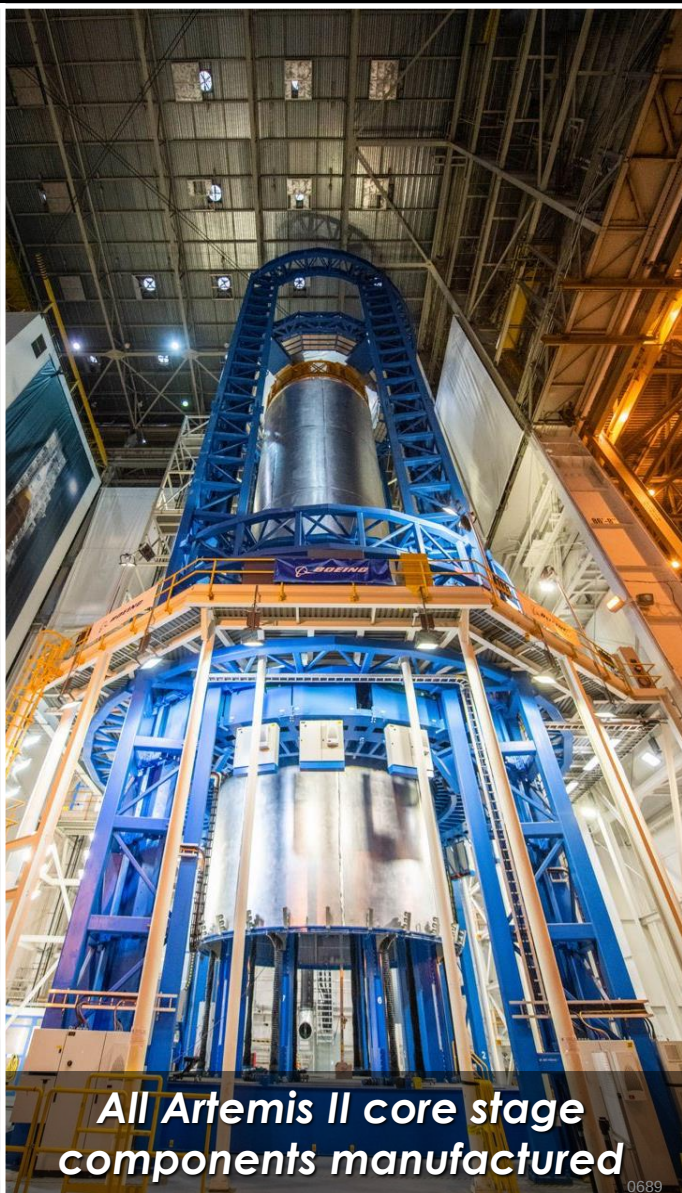
Interstellar Probe

SLS PROGRESS TOWARD ARTEMIS I: FLIGHT ARTICLES

SLS PROGRESS TOWARD ARTEMIS II & BEYOND

Five RL-10s complete

All booster motor segments cast; seven complete



All Artemis II core stage components manufactured

Two RS-25s complete, controllers green run

Payload adapter manufacturing demonstration article

LVSA, OSA, ICPS panels machined

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MORE TECHNICAL INFORMATION

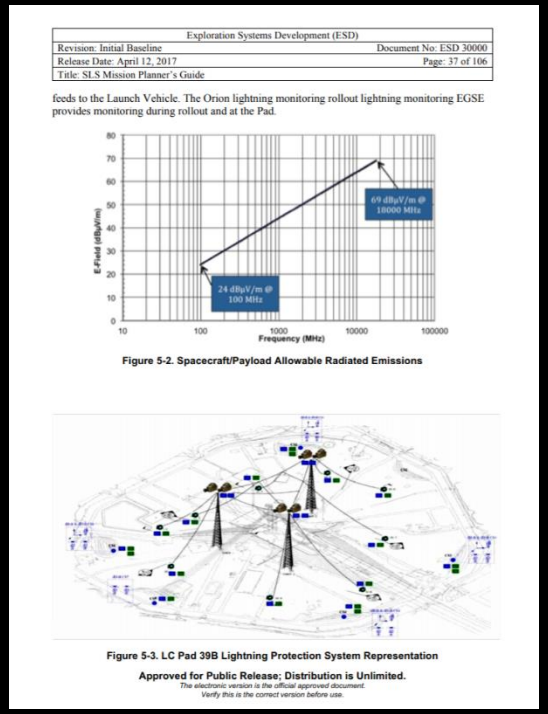
SLS MISSION PLANNER'S GUIDE

- **SLS Mission Planner's Guide (ESD 30000)**
  - Google or email: NASA-slspayloads@mail.nasa.gov
  - –www.nasa.gov/opportunities for payload opportunities and announcements


National Aeronautics and Space Administration

SPACE LAUNCH SYSTEM (SLS)
MISSION PLANNER'S GUIDE

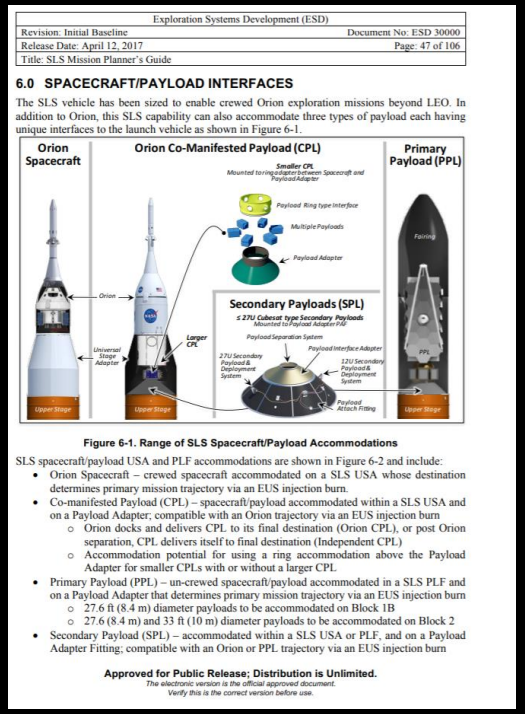
ESD 30000
REVISION A
RELEASE DATE: TBD



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



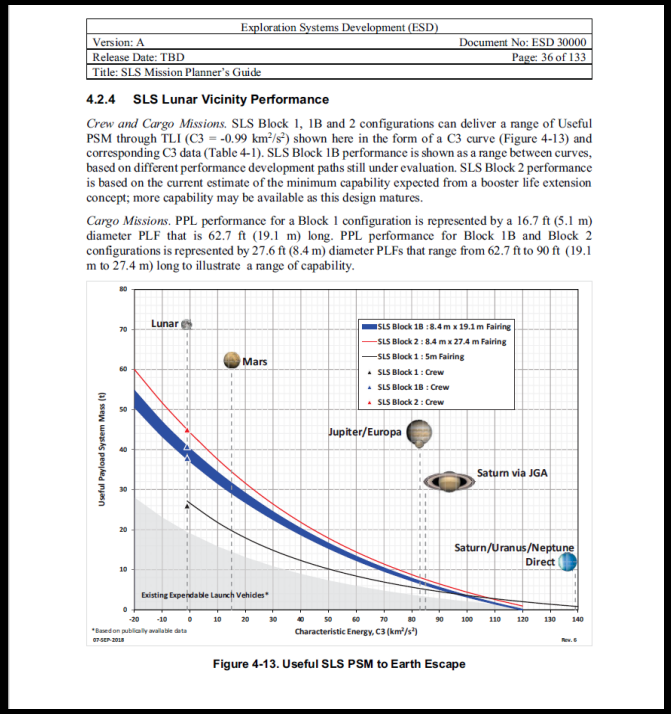
6.0 SPACECRAFT/PAYLOAD INTERFACES

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



4.2.4 SLS Lunar Vicinity Performance

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

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

Figure 4-13. Useful SLS PSM to Earth Escape


ARTEMIS
www.nasa.gov
@NASA_SLS
NASASLS
youtube.com/nasa
@explorenasa
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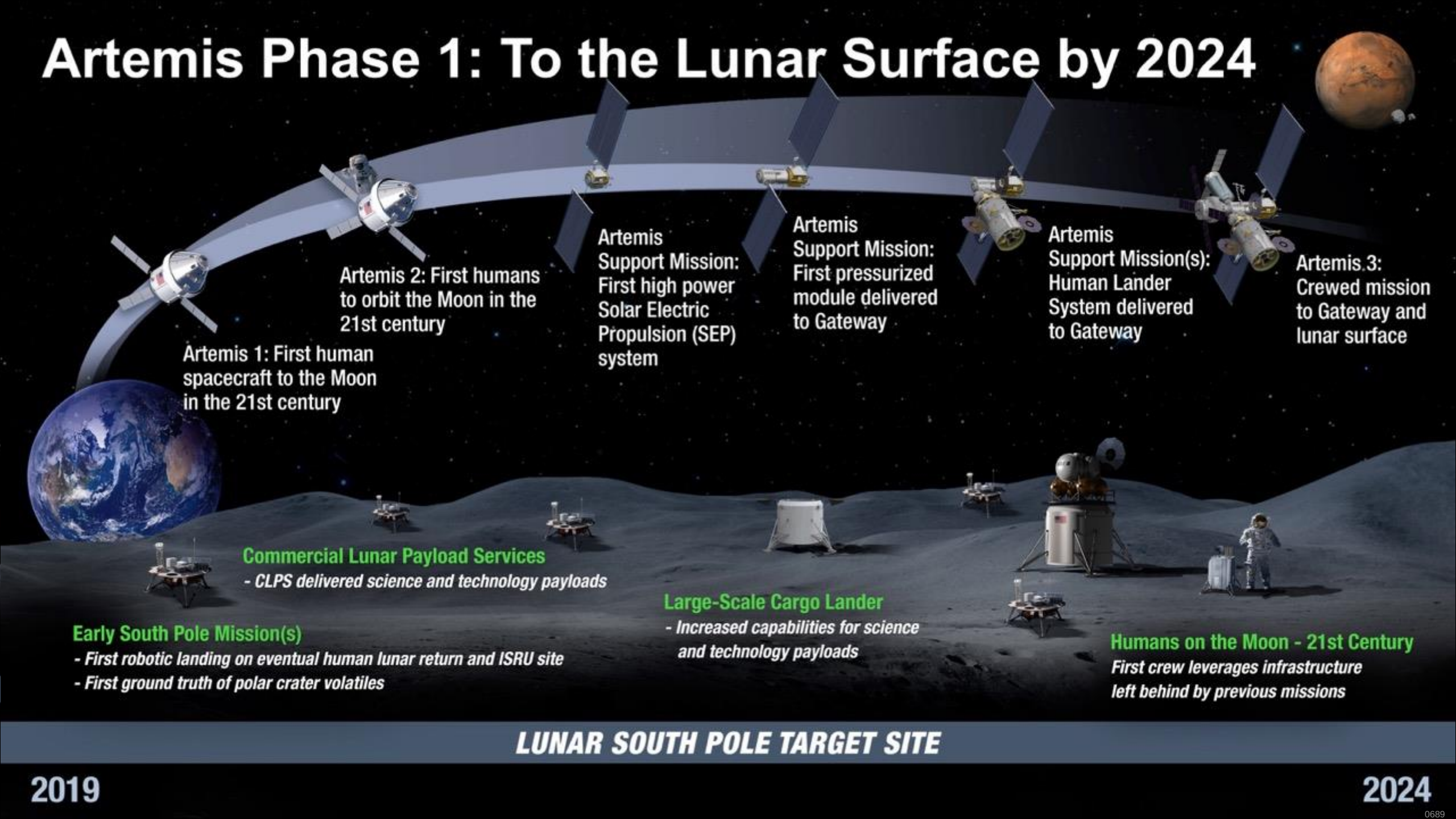
BACKUP

Artemis Phase 1: To the Lunar Surface by 2024



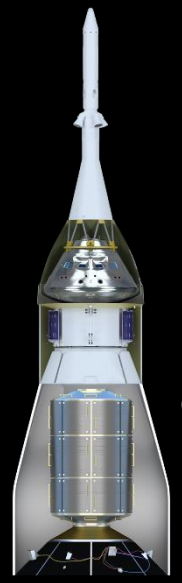
NASA'S SPACE LAUNCH SYSTEM

UNIQUE CAPABILITY FOR HUMAN AND ROBOTIC EXPLORATION

VOLUME

- Block 1B: **Double the volume** of any contemporary heavy lift vehicle
- **Only vehicle** that can carry the Orion and a co-manifested payload to the Moon

8.4 m x 27.4 m fairing with large-aperture telescope

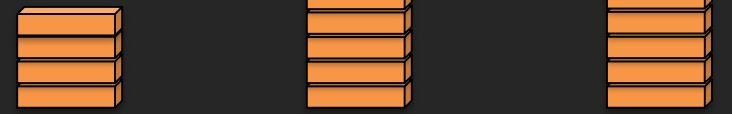


Orion with Co-Manifested Payloads

**Not to scale*

MASS

- Block 1B: Can launch **50% more mass** than any contemporary launch vehicle
- Block 2: Mars-enabling capability of **greater than 45 metric tons** to Trans Lunar Injection



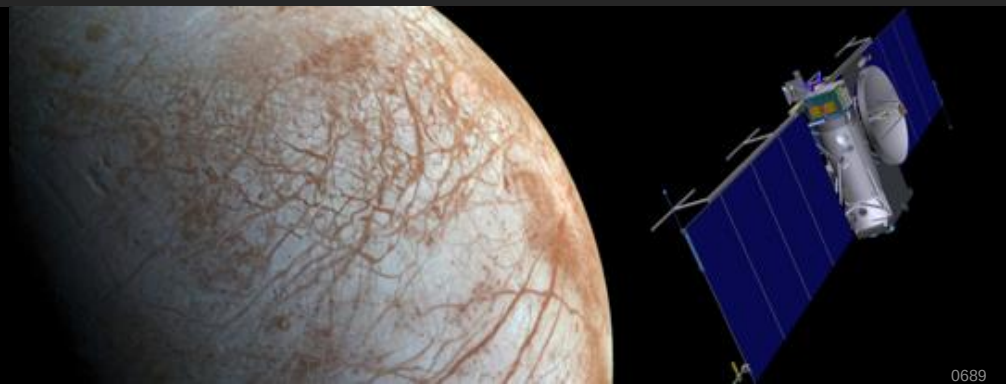
Contemporary Heavy Lift

SLS Block 1B

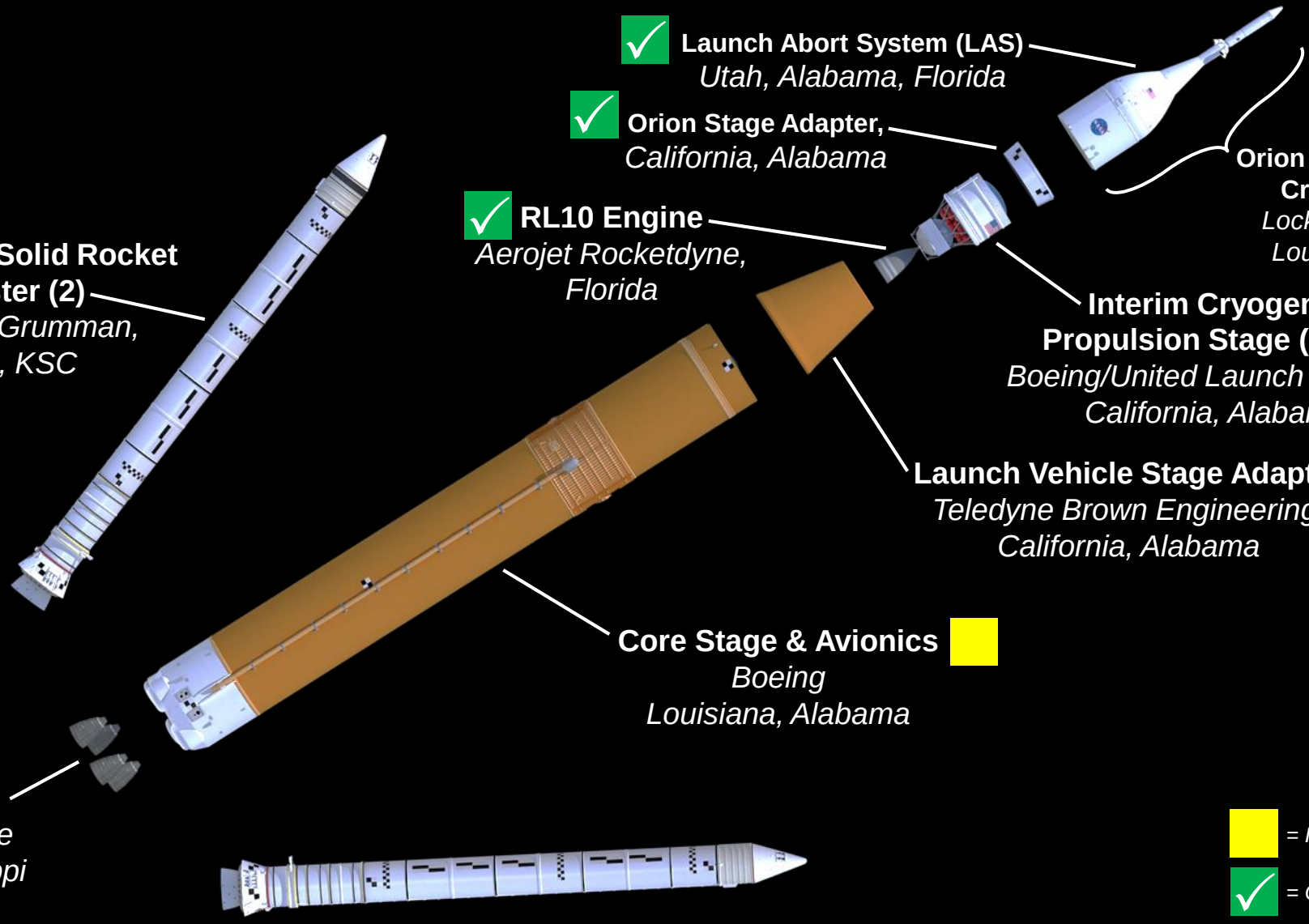
SLS Block 2

DEPARTURE ENERGY

- **Reduce transit times by half or greater** to the outer solar system
- Enables larger payloads to **deep space destinations**



SLS BLOCK 1 CONFIGURATION



✓ **Launch Abort System (LAS)**
Utah, Alabama, Florida

✓ **Orion Stage Adapter,**
California, Alabama

Orion Multi-Purpose Crew Vehicle
Lockheed Martin, Louisiana, KSC

✓ **RL10 Engine**
Aerojet Rocketdyne, Florida

✓ **5 Segment Solid Rocket Booster (2)**
Northrop Grumman, Utah, KSC

Interim Cryogenic Propulsion Stage (ICPS) ✓
Boeing/United Launch Alliance, California, Alabama

Launch Vehicle Stage Adapter
Teledyne Brown Engineering, California, Alabama ✓

Core Stage & Avionics ■
Boeing
Louisiana, Alabama

✓ **RS-25 Engine (4)**
Aerojet Rocketdyne
California, Mississippi

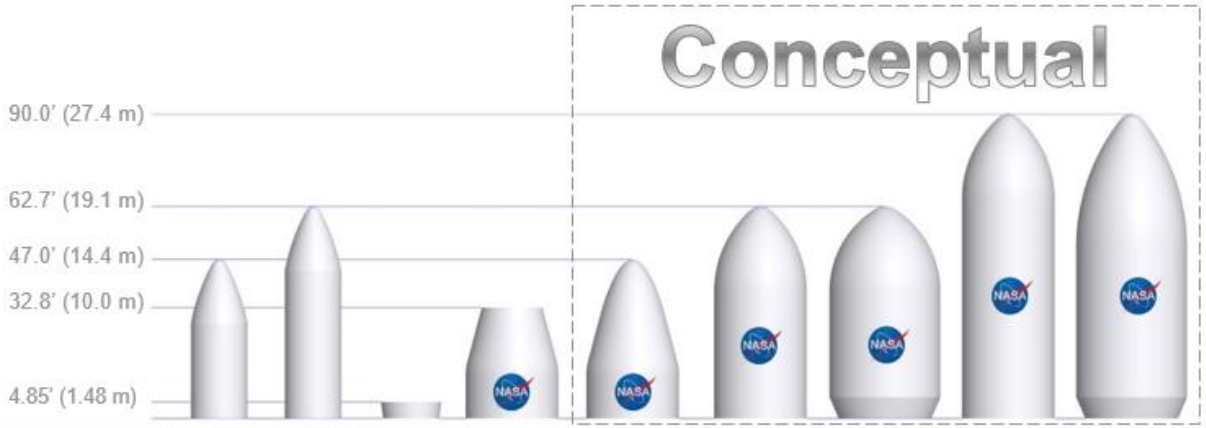
■ = *In Progress*

✓ = *Completed*

UNMATCHED VOLUME FOR PAYLOADS

Block 1

Block 1B



Enclosure	5.1m PLF	5.1m PLF	OSA	8.4m USA	8.4m USA PLF	8.4m PLF, Short	10m PLF Short	8.4m PLF, Long	10m PLF Long
Payload Type	5m PPL	5m PPL	5m SPL	8.4m CPL	8.4m PPL	8.4m PPL	10m PPL	8.4m PPL	10m PPL
Length	47.0 ft	62.7 ft	4.85 ft	32.8 ft	47.2 ft	62.7 ft	62.7 ft	90 ft	90 ft
	14.3 m	19.1 m	1.48 m	10.0 m	14.4 m	19.1 m	19.1 m	27.4 m	27.4 m
Diameter	16.7 ft	16.7 ft	17.7 ft	27.6 ft	27.6 ft	27.6 ft	33.0 ft	27.6 ft	33.0 ft
	5.1 m	5.1 m	5.4 m	8.4 m	8.4 m	8.4 m	10.0 m	8.4 m	10.0 m
Internal Diameter	15.1 ft	15.1 ft	16.7 ft	24.6 ft	24.6 ft	24.6 ft	29.9 ft	24.6 ft	29.9 ft
	4.6 m	4.6 m	5.1 m	7.5 m	7.5 m	7.5 m	9.1 m	7.5 m	9.1 m
Available Volume	5,358 ft³	8,118 ft³	516 ft³	10,100 ft³	11,260 ft³	21,930 ft³	32,470 ft³	34,910 ft³	46,610 ft³
	151.7 m³	229.9 m³	14.6 m³	286.0 m³	319 m³	621 m³	919 m³	988 m³	1,320 m³
Potential Availability *(No Earlier Than)*	COTS	COTS	2020	2024	2025	2025	2029	2029	2029

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

Block 2

ARTEMIS I

The first uncrewed, integrated flight test of NASA's Orion spacecraft and Space Launch System rocket, launching from a modernized Kennedy spaceport

1 LAUNCH
SLS and Orion lift off from pad 39B at Kennedy Space Center

2 JETTISON ROCKET BOOSTERS
Solid rocket boosters separate

3 JETTISON LAUNCH ABORT SYSTEM (LAS)
The LAS is no longer needed, Orion could safely abort

4 CORE STAGE MAIN ENGINE CUT OFF (MECO) and separation

5 ENTER EARTH ORBIT
Perform the perigee raise maneuver

6 EARTH ORBIT
Systems check and solar panel adjustments

7 TRANS LUNAR INJECTION (TLI) BURN
Burn lasts for approximately 20 minutes

8 INTERIM CRYOGENIC PROPULSION STAGE (ICPS) SEPARATION
The ICPS has committed Orion to TLI

9 OUTBOUND TRANSIT
Requires several attitude maneuvers

10 OUTBOUND TRAJECTORY CORRECTION (OTC) BURNS
As necessary adjust trajectory for Lunar flyby to DRO

11 OUTBOUND POWERED FLYBY (OPF)
62 miles from the Moon; targets DRO insertion

Heliocentric Disposal precludes re-contact

12 ORBIT INSERTION
Enter Distant Retrograde Orbit for next 6-23 days

13 DISTANT RETROGRADE ORBIT (DRO)
Orbit Maintenance burns and solar panel adjustments; 38,000 nmi from the surface of the Moon

14 DRO DEPARTURE
Leave DRO and start return to Earth

15 RETURN POWER FLY-BY (RPF)
RPF burn prep and return coast to Earth initiated

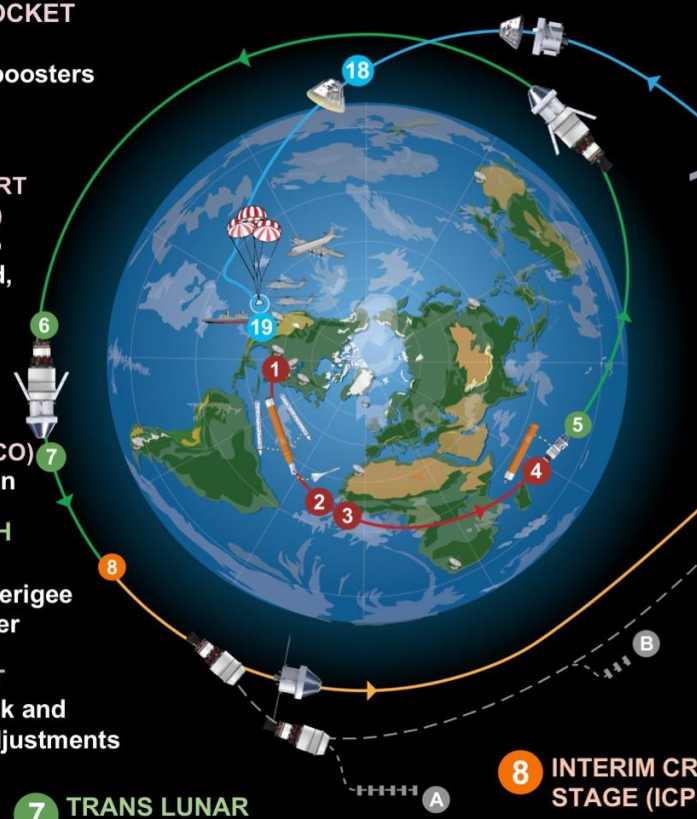
16 RETURN TRANSIT
Return Trajectory Correction (RTC) burns as necessary to aim for Earth's atmosphere; travel time 3-11 days

17 FINAL RETURN TRAJECTORY CORRECTION (RTC) BURN
Precision targeting for Earth entry

18 ENTRY INTERFACE (EI)
Enter Earth's atmosphere

19 SPLASHDOWN
Pacific Ocean landing within view of the U.S. Navy recovery ships

A B C D
CUBESATS DEPLOY
ICPS deploys 13 CubeSats total



Launch | Earth Orbit | Trans Lunar | Lunar Orbit | Trans Earth | Earth Re-entry | Payload Orbit/Disposal

Total distance traveled: 1.3 million miles – Mission duration: 26-42 days – Re-entry speed: 24,500 mph (Mach 32) – 13 CubeSats deployed

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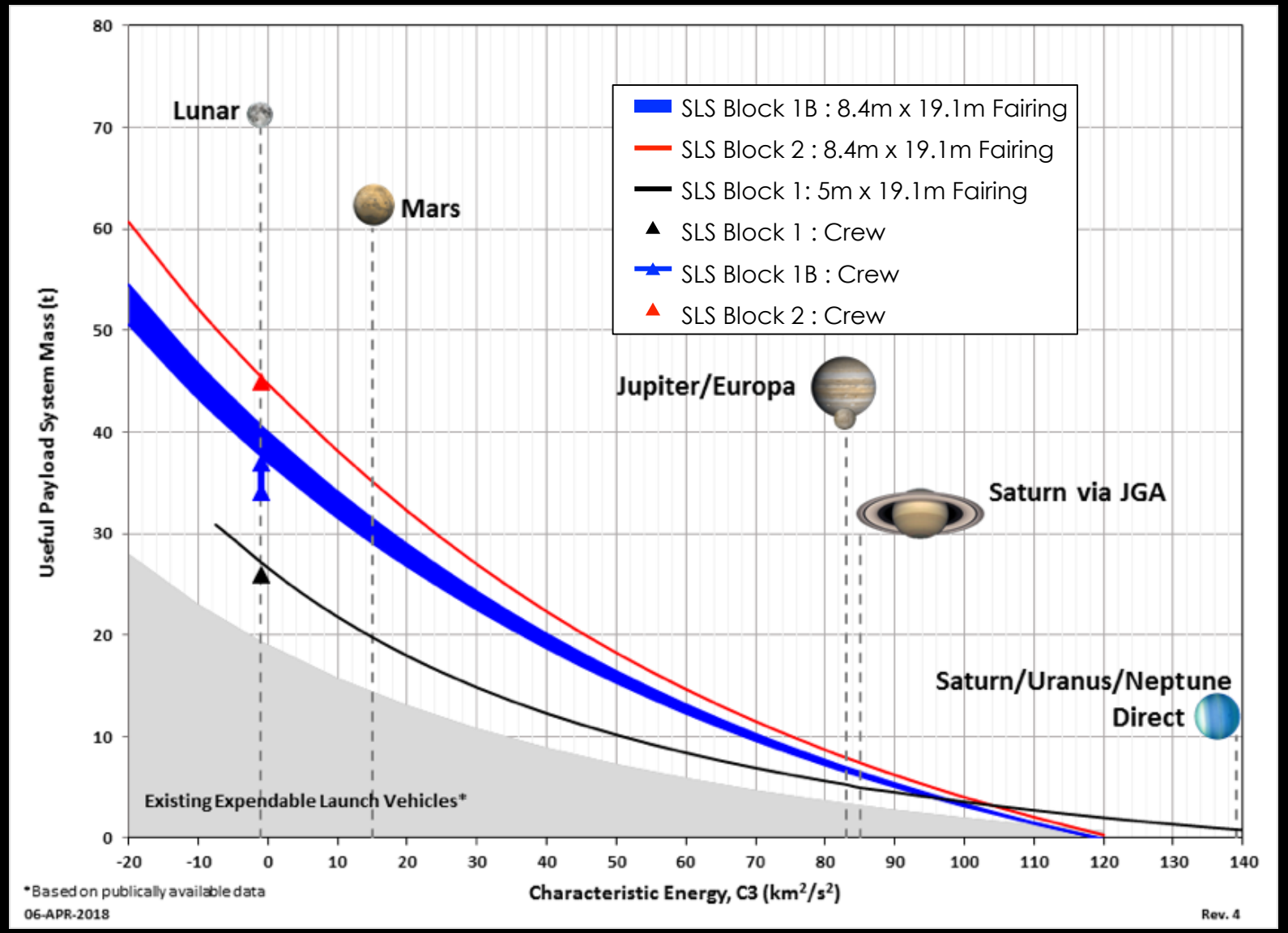
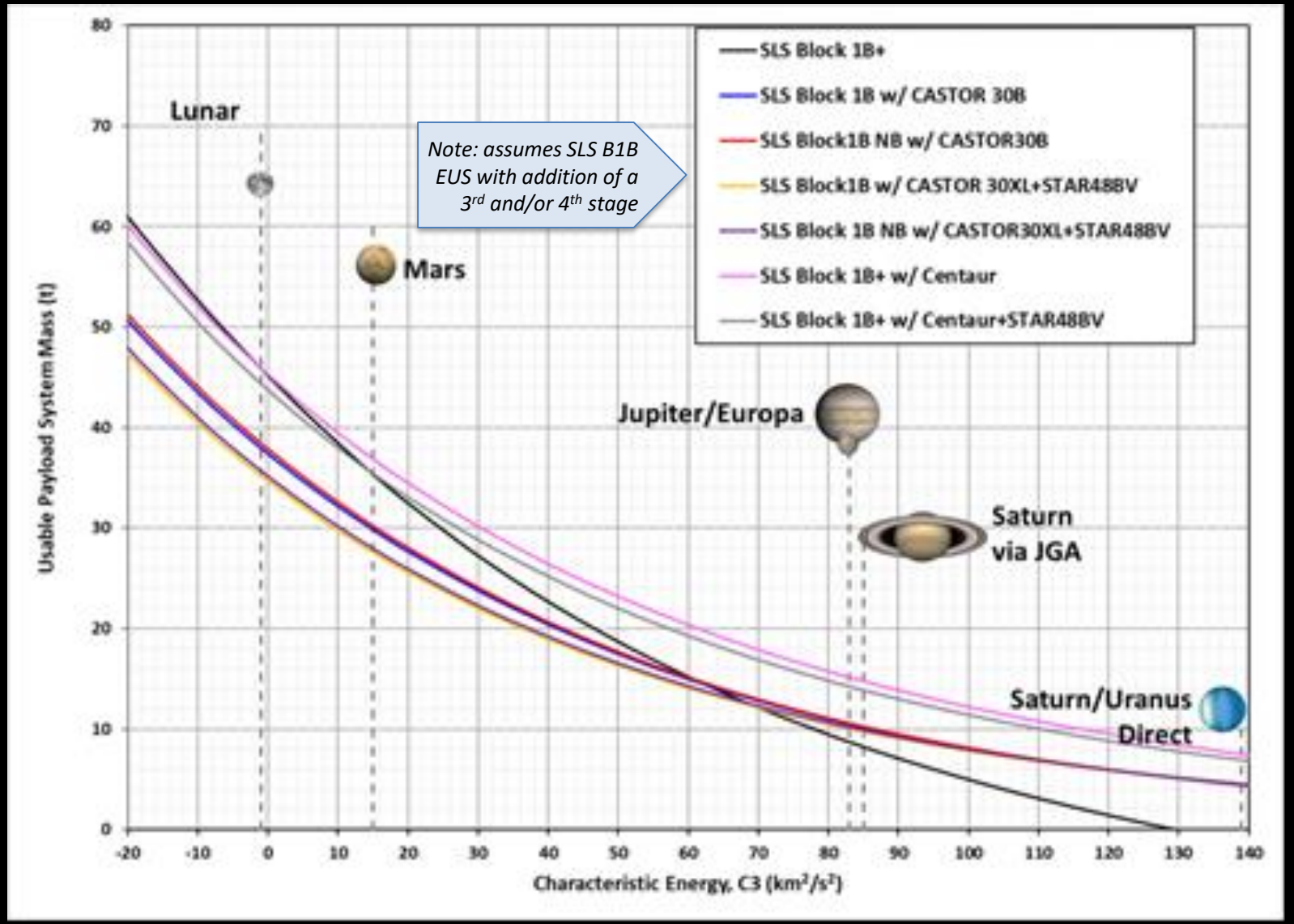
ARTEMIS I
FULL SYSTEMS CHECKOUT PRIOR TO CREWED MISSIONS

SLS MASS TO DESTINATIONS



SLS MASS TO DESTINATIONS



REMAINING STEPS TO FINAL INTEGRATION

BOOSTERS: Deliver forward & aft assemblies, ship motor segments; crews maneuvering pathfinders in RPSF




CORE STAGE: Engine installation, shipping to SSC, Green Run test campaign, shipping to KSC

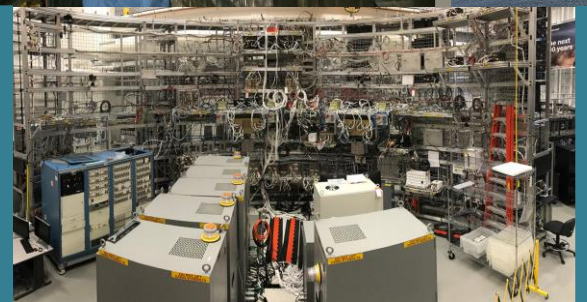


LAUNCH VEHICLE STAGE ADAPTER: Install DFI, quick disconnects & cable runs; final checkout; shipping

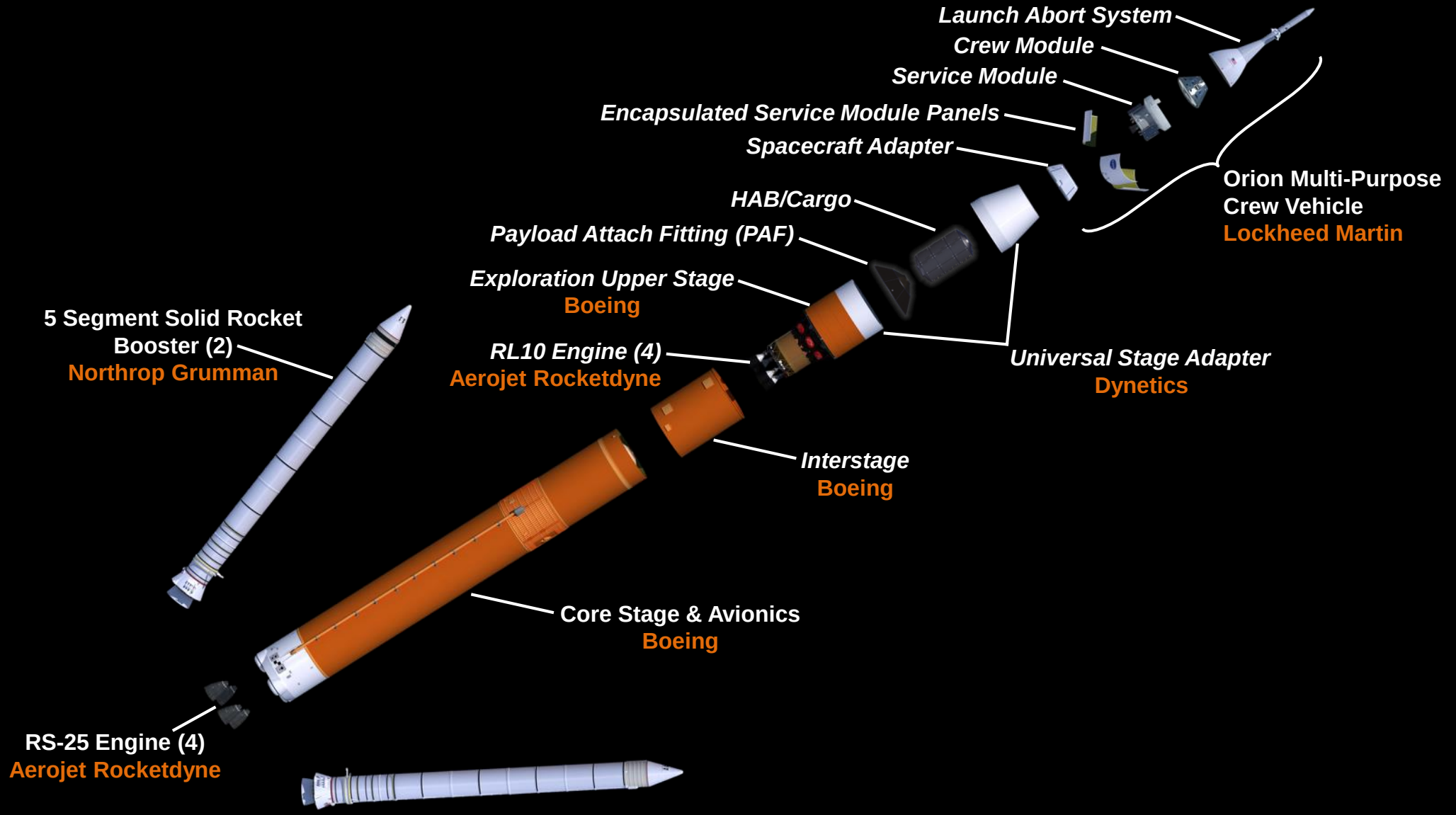



SYSTEMS ENGINEERING & INTEGRATION: DCR, flight software delivery, Software Integration Lab (SIL) certification, CoFR, training




SLS BLOCK 1B CONFIGURATION



THIRD FLIGHT AND BEYOND

Five RL-10s complete

Booster processing

Payload adapter manufacturing demonstration article

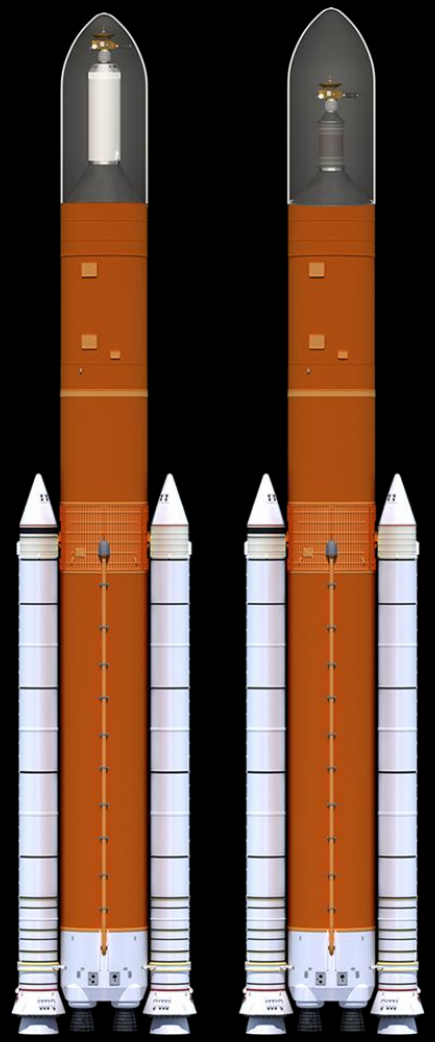
RS-25 HIP-bonded main combustion chamber

Tooling for USA

EUS weld confidence articles

Additively manufactured pogo accumulator

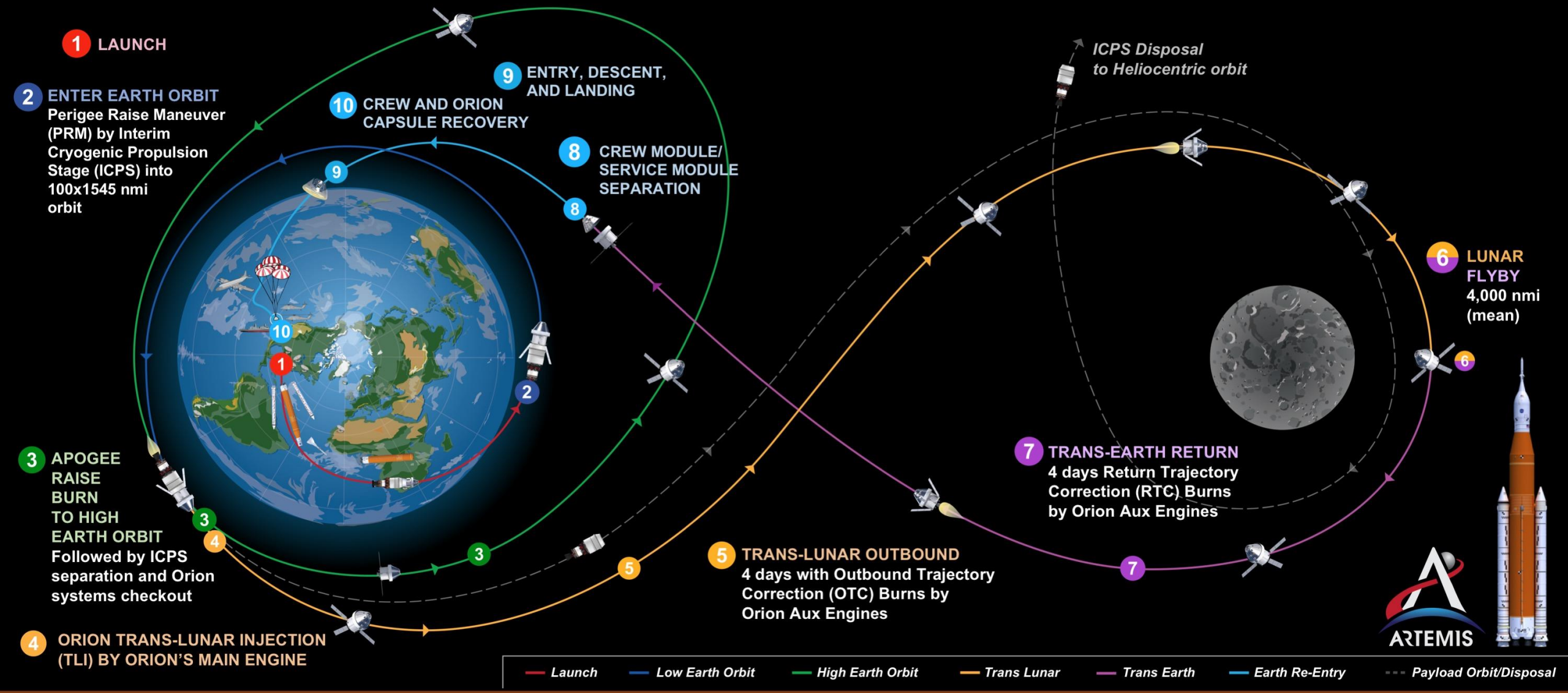
SLS CAN ENABLE BREAKTHROUGH SCIENCE MISSIONS



- **SLS is America's heavy-lift vehicle for strategic human exploration and scientific missions**
- **Manufacturing is complete for the first flight; SLS is nearing the integration phase**
- **SLS has a flexible architecture and an evolvable upgrade path**
- **Discussions with the science community are ongoing to determine how SLS can enable breakthrough science missions, such as sending a probe to interstellar space**

ARTEMIS II

Crewed Hybrid Free Return Trajectory, demonstrating crewed flight and spacecraft systems performance beyond Low Earth Orbit (LEO)



SLS Configuration (Block 1) with Human Rated ICPS | 15x1200 nmi (27.8x2222.4 km) insertion orbit | 28.5 deg inclination

4 astronauts | Mission duration: 10 Days | Re-entry speed: 24,500 mph (Mach 32)

SLS LIFT CAPABILITIES

FOUNDATION FOR A GENERATION OF DEEP SPACE EXPLORATION

	SLS Block 1 Crew	SLS Block 1 Cargo	SLS Block 1B Crew	SLS Block 1B Cargo	SLS Block 2 Crew	SLS Block 2 Cargo
Payload to LEO	95 t (209k lbs)	95 t (209k lbs)	105 t (231k lbs)	105 t (231k lbs)	130 t (287k lbs)	130 t (287k lbs)
Payload to TLI/Moon	> 26 t (57k lbs)	> 26 t (57k lbs)	34–37 t (74k–81k lbs)	37–40 t (81k–88k lbs)	> 45 t (99k lbs)	> 45 t (99k lbs)
Payload Volume	N/A**	9,030 ft³ (256m³)	10,100 ft³ (286m³)**	18,970 ft³ (537 m³)	10,100 ft³ (286m³)**	34,910 ft³ (988 m³)
Maximum Thrust	8.8M lbs	8.8M lbs	8.8M lbs	8.8M lbs	11.9M lbs	11.9M lbs

Low Earth Orbit (LEO) represents a typical 200 km circular orbit at 28.5 degrees inclination

Trans-Lunar Injection (TLI) is a propulsive maneuver used to set a spacecraft on a trajectory that will cause it to arrive at the Moon. A spacecraft performs **TLI** to begin a lunar transfer from a low circular parking orbit around Earth.

The numbers depicted here indicate the mass capability at the Trans-Lunar Injection point.

** Not including Orion/Service Module volume