National Aeronautics and Space Administration

NASA'S SPACE LAUNCH SYSTEM: ENABLING ARTEMIS AND TRANSFORMATIVE SCIENCE MISSIONS

September 26, 2019

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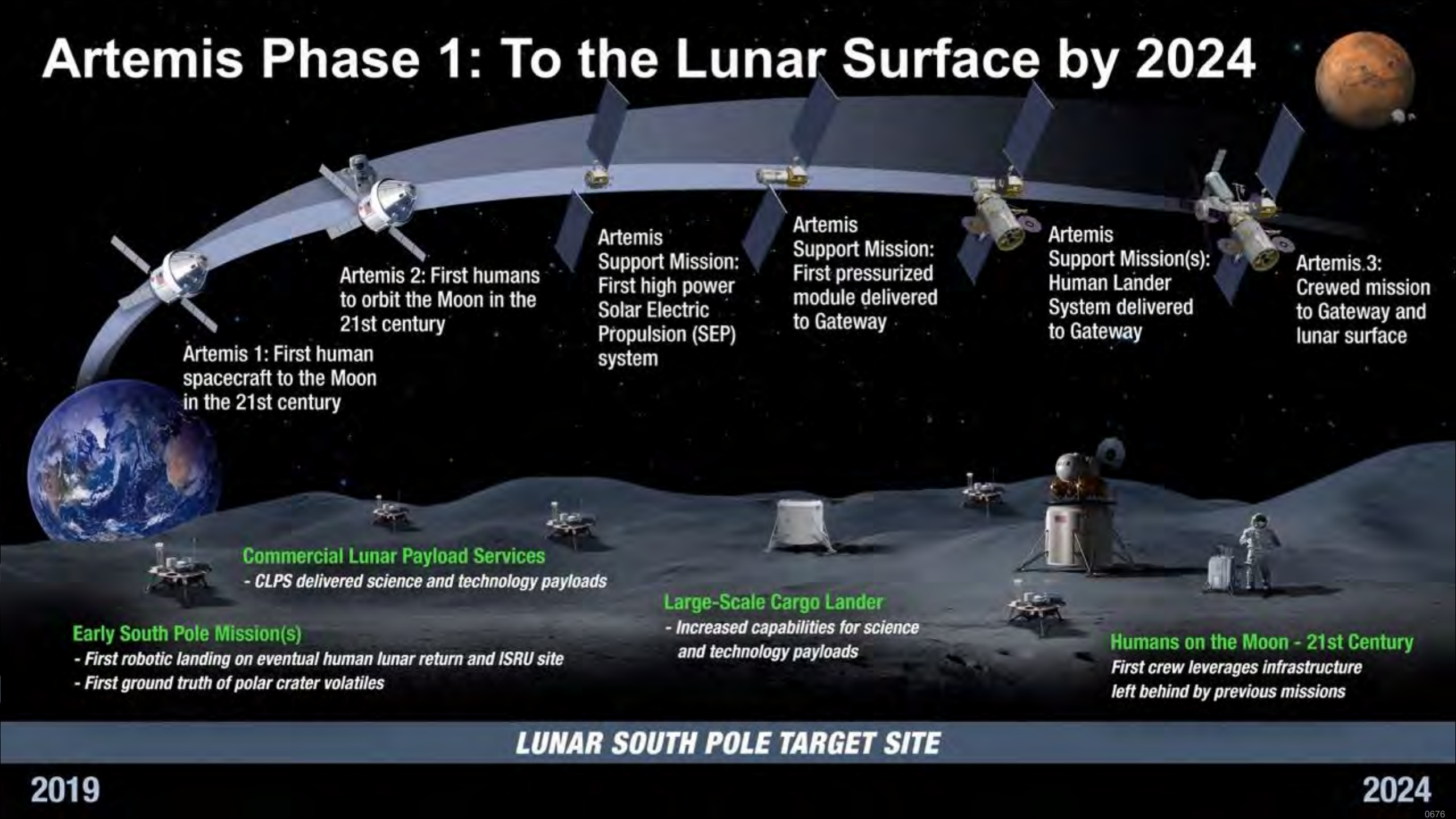
NASA's Space Launch System

Artemis Phase 1: To the Lunar Surface by 2024



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SLS LIFT CAPABILITIES

FOUNDATION FOR A GENERATION OF DEEP SPACE EXPLORATION

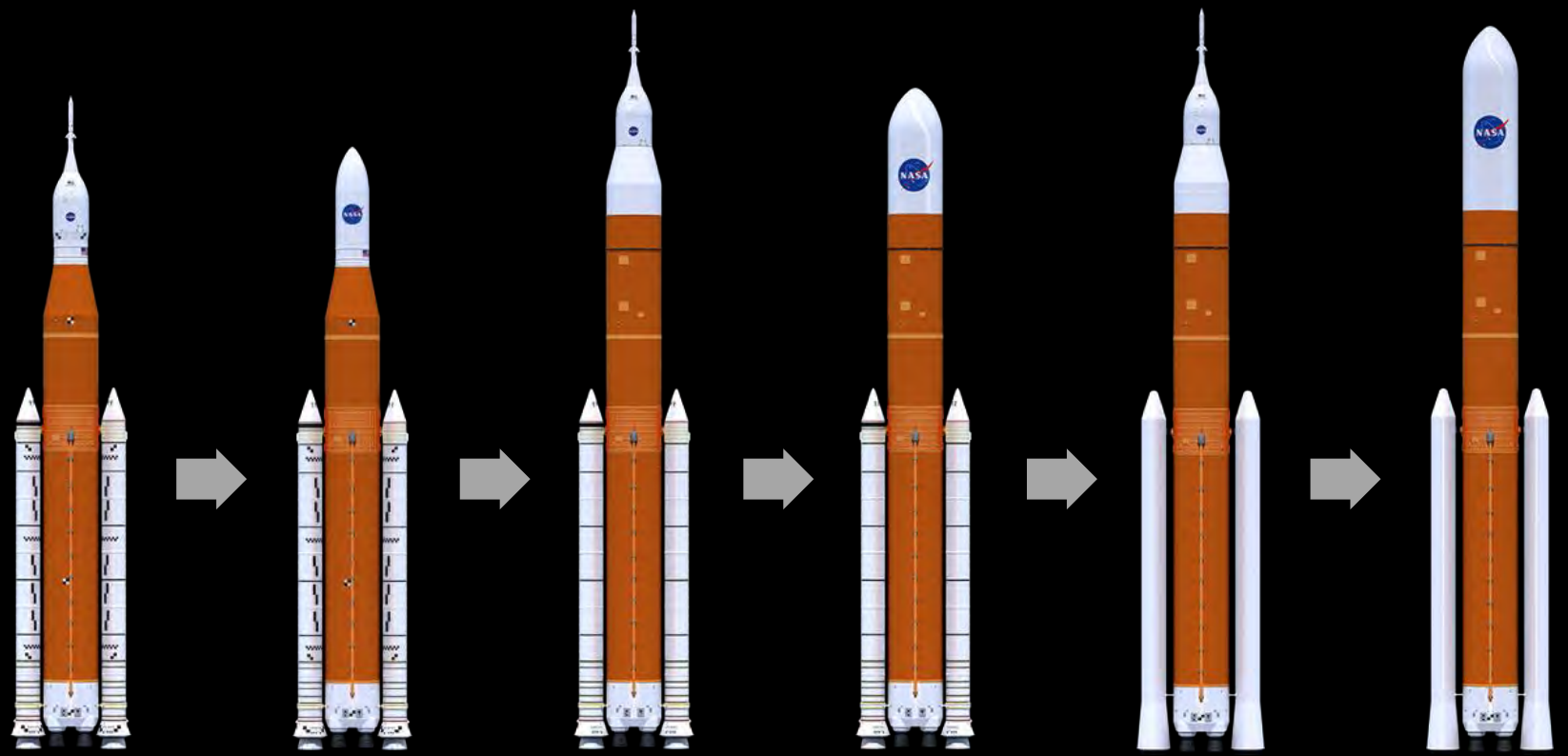
	SLS Block 1 Crew	SLS Block 1 Cargo	SLS Block 1B Crew	SLS Block 1B Cargo	SLS Block 2 Crew	SLS Block 2 Cargo
Payload to LEO	95 t (209k lbs)	95 t (209k lbs)	105 t (231k lbs)	105 t (231k lbs)	130 t (287k lbs)	130 t (287k lbs)
Payload to TLI/Moon	> 26 t (57k lbs)	> 26 t (57k lbs)	34–37 t (74k–81k lbs)	37–40 t (81k–88k lbs)	> 45 t (99k lbs)	> 45 t (99k lbs)
Payload Volume	N/A**	9,030 ft^3 (256m^3)	10,100 ft^3 (286m^3)**	18,970 ft^3 (537 m^3)	10,100 ft^3 (286m^3)**	34,910 ft^3 (988 m^3)
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



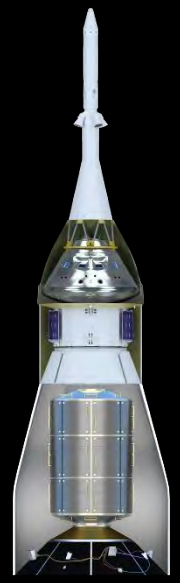
NASA'S SPACE LAUNCH SYSTEM

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

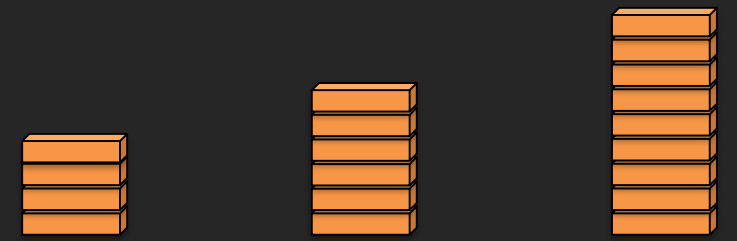


Orion with Co-Manifested Payloads

*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



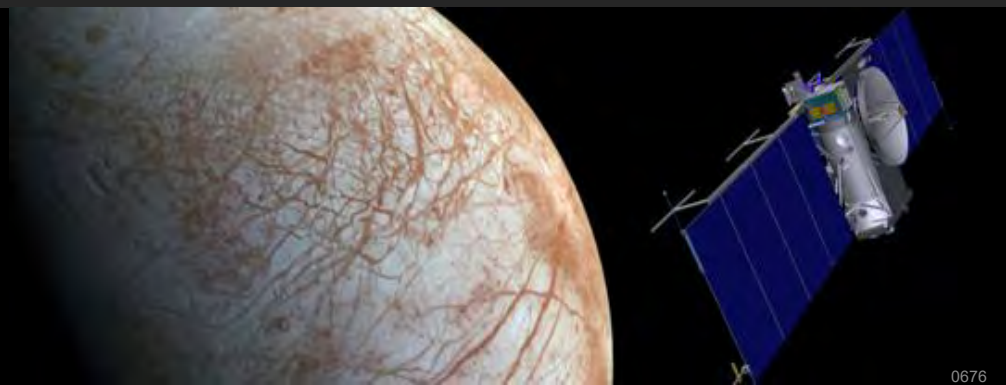
Contemporary Heavy Lift

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



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ARTEMIS 1 SOLID ROCKET BOOSTERS COMPLETE

- ✓All 10 motor segments complete
- ✓Preparing to deliver forward, aft assemblies

ARTEMIS 1 ENGINES COMPLETE

✓Artemis 1: Four flight engines delivered to Michoud

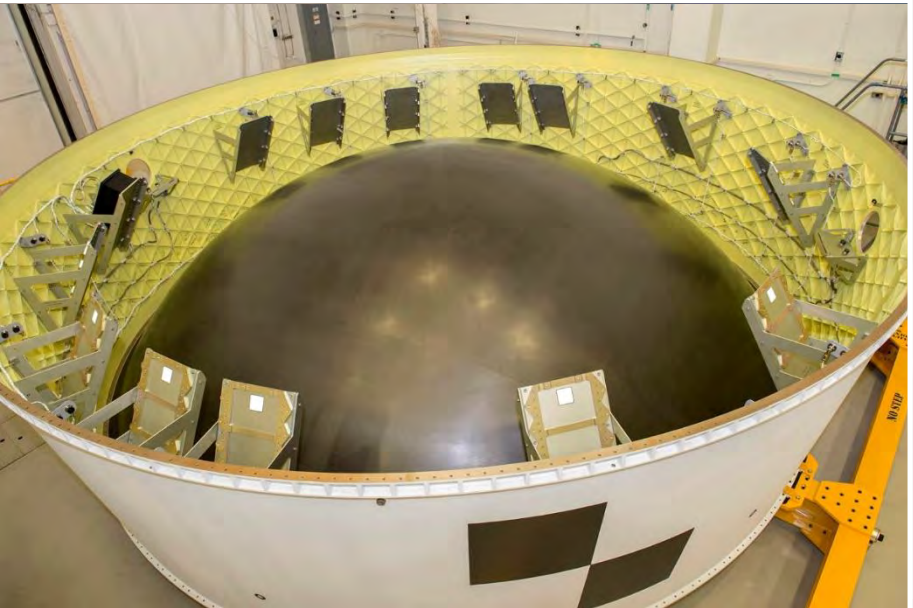
✓Nine-test Retrofit 1B hot-fire test series complete

ARTEMIS 1 INTERIM CRYOGENIC PROPULSION STAGE COMPLETE

✓Artemis 1 flight article delivered to EGS

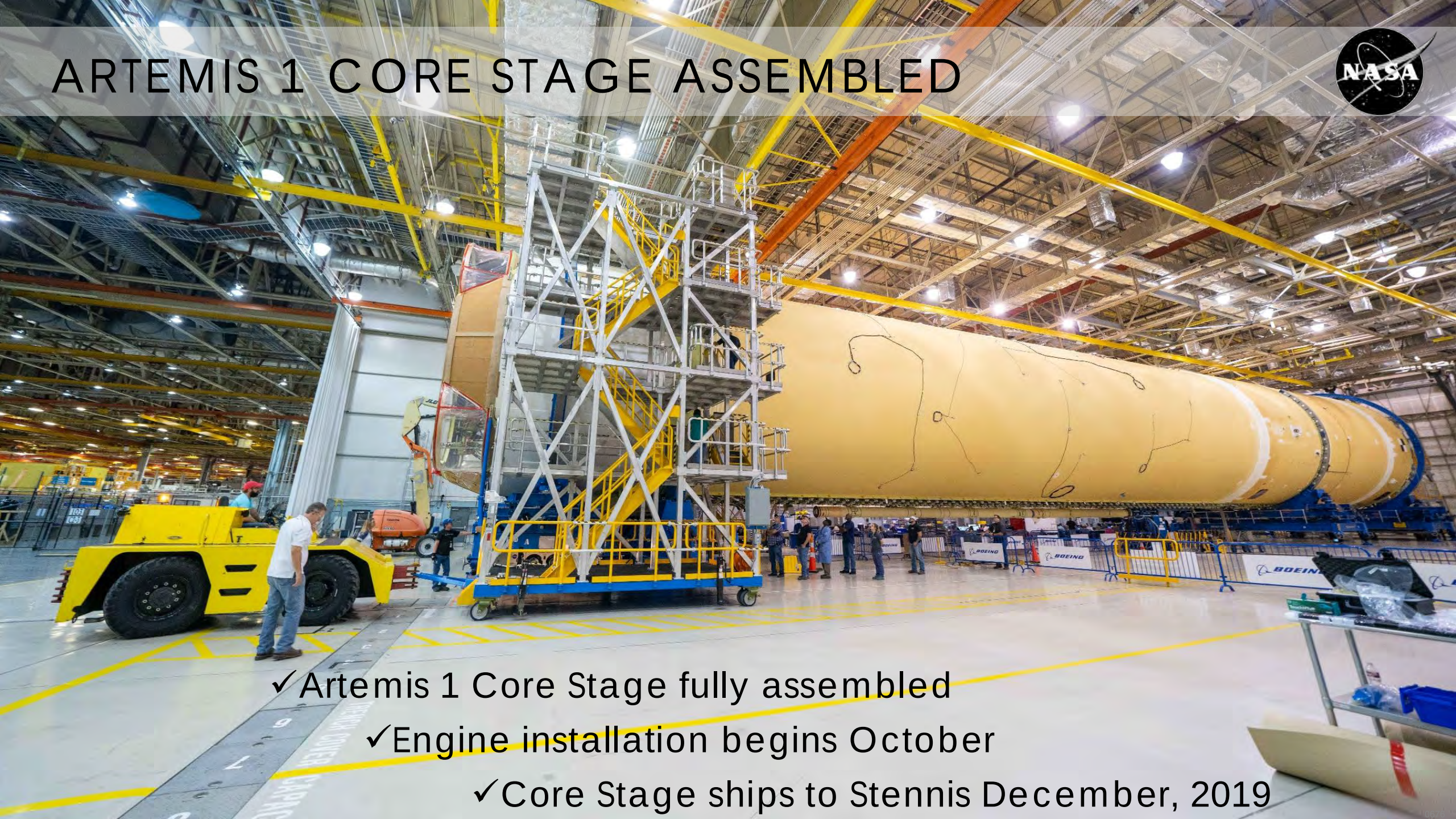
✓ Stored in Space Station Processing Facility at KSC

ARTEMIS 1 STAGE ADAPTERS STATUS



- ✓ Orion Stage Adapter delivered to EGS
- ✓ Launch Vehicle Stage Adapter in final processing

ARTEMIS 1 CORE STAGE ASSEMBLED



✓Artemis 1 Core Stage fully assembled

✓Engine installation begins October

✓Core Stage ships to Stennis December, 2019

CORE STAGE STRUCTURAL TESTING

CORE STAGE STRUCTURAL TESTING

B-2 STAND READY FOR GREEN RUN

- ✓B-2 stand renovated, ready for Green Run
- ✓Crews maneuvering Pathfinder
- ✓Stage controller, Green Run application software in progress


NASA

REMAINING STEPS TO FINAL INTEGRATION

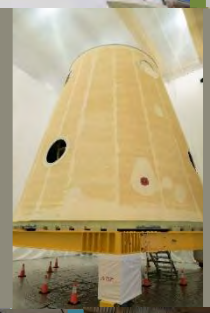
BOOSTERS: Deliver forward & aft assemblies, ship motor segments; crews maneuvering pathfinders in RPSF



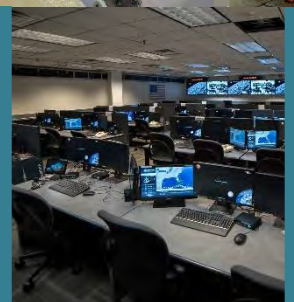

CORE STAGE: Engine installation, shipping to SSC, Green Run test campaign, shipping to KSC



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


ORION PROGRESS TOWARD ARTEMIS 1

EXPLORATION GROUND SYSTEMS PROGRESS TOWARD ARTEMIS 1

ARTEMIS I Mission Priorities

A flight test that will enable NASA to fly crew to the Moon and back on Artemis II:

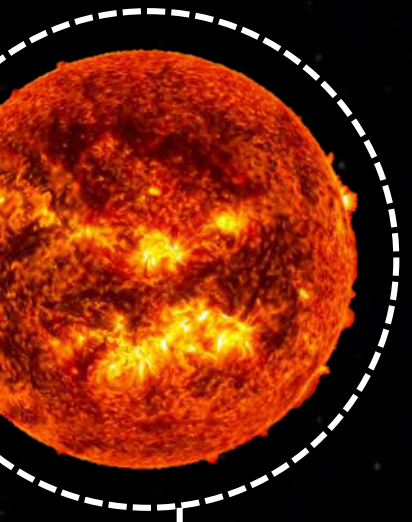
1. **Demonstrate Orion heatshield at lunar entry velocities**
2. **Operate Systems in Flight Environment**
3. **Retrieve Spacecraft**
4. **Complete Remaining Objectives**: Perform residual mission in the absence of system failures and conduct all mission content as planned

ARTEMIS 1

FULL SYSTEMS CHECKOUT PRIOR TO CREWED MISSIONS

ARTEMIS I SECONDARY PAYLOADS

SMALLSATS TO BE DEPLOYED FROM THE ORION STAGE ADAPTER



SUN

- CuSP (Southwest Research Institute)

MOON

- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- OMOTENASHI (JAXA)
- LunIR (Lockheed Martin)
- EQUULEUS (JAXA)

ASTEROID

- NEA Scout (NASA)

EARTH-MOON

- ArgoMoon (ESA/ASI)

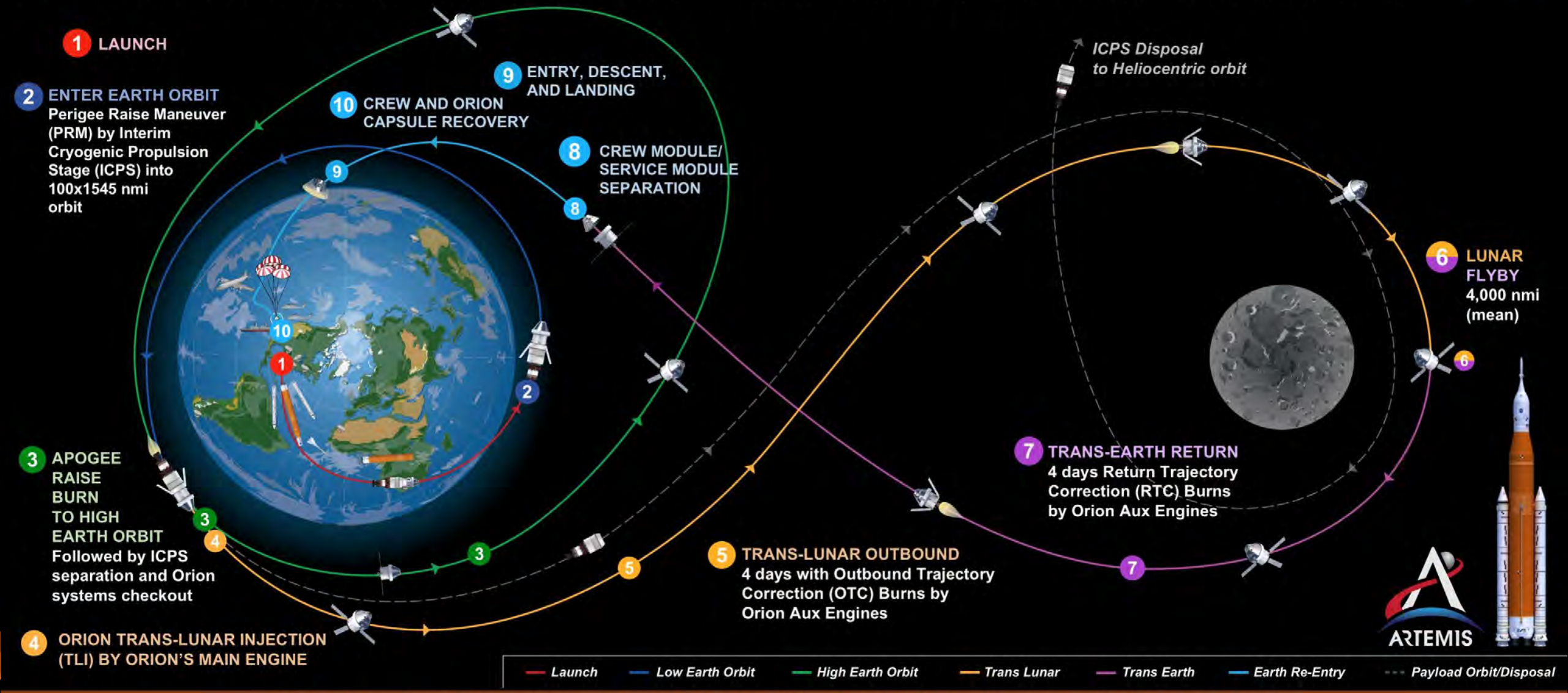
...AND MORE

- Biosentinel (NASA)
- Cislunar Explorers (Cornell University)
- CU-E^3 (University of Colorado Boulder)
- Team Miles (Miles Space)

**Request for proposals for 6U and 12U CubeSat payloads for Artemis 2 open Until November 1, 2019*

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

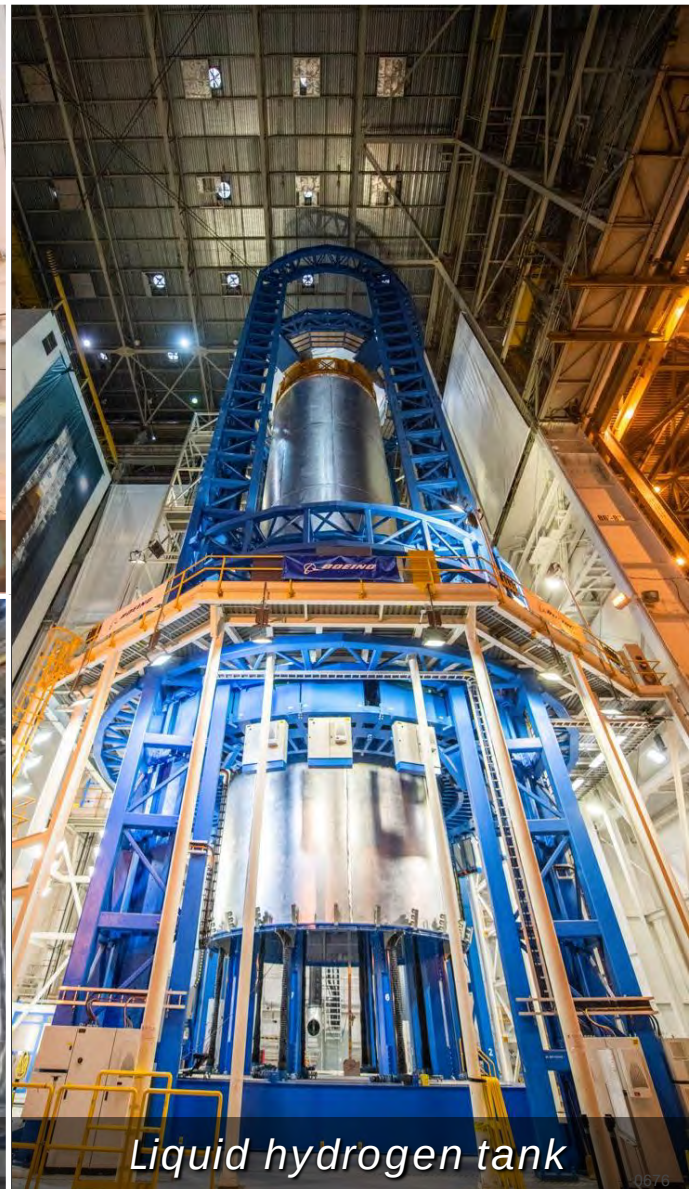
4 astronauts | Mission duration: 10 Days | Re-entry speed: 24,500 mph (Mach 32)

SLS PROGRESS TOWARD ARTEMIS 2

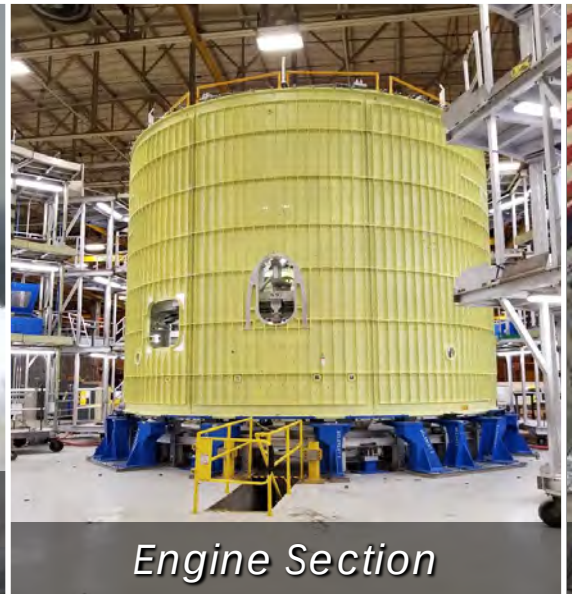

All booster motor segments cast


Forward skirt


Liquid oxygen tank


Liquid hydrogen tank


Two RS-25s complete, controllers green run


Engine Section


LVSA, OSA panels

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 ENABLES SCIENCE MISSIONS

- Discussions with the science community are ongoing to determine how SLS can enable breakthrough science missions
- Missions being evaluated include Europa Clipper and Lander, space-based solar power, large-aperture telescopes, an interstellar probe mission and others

CubeSats

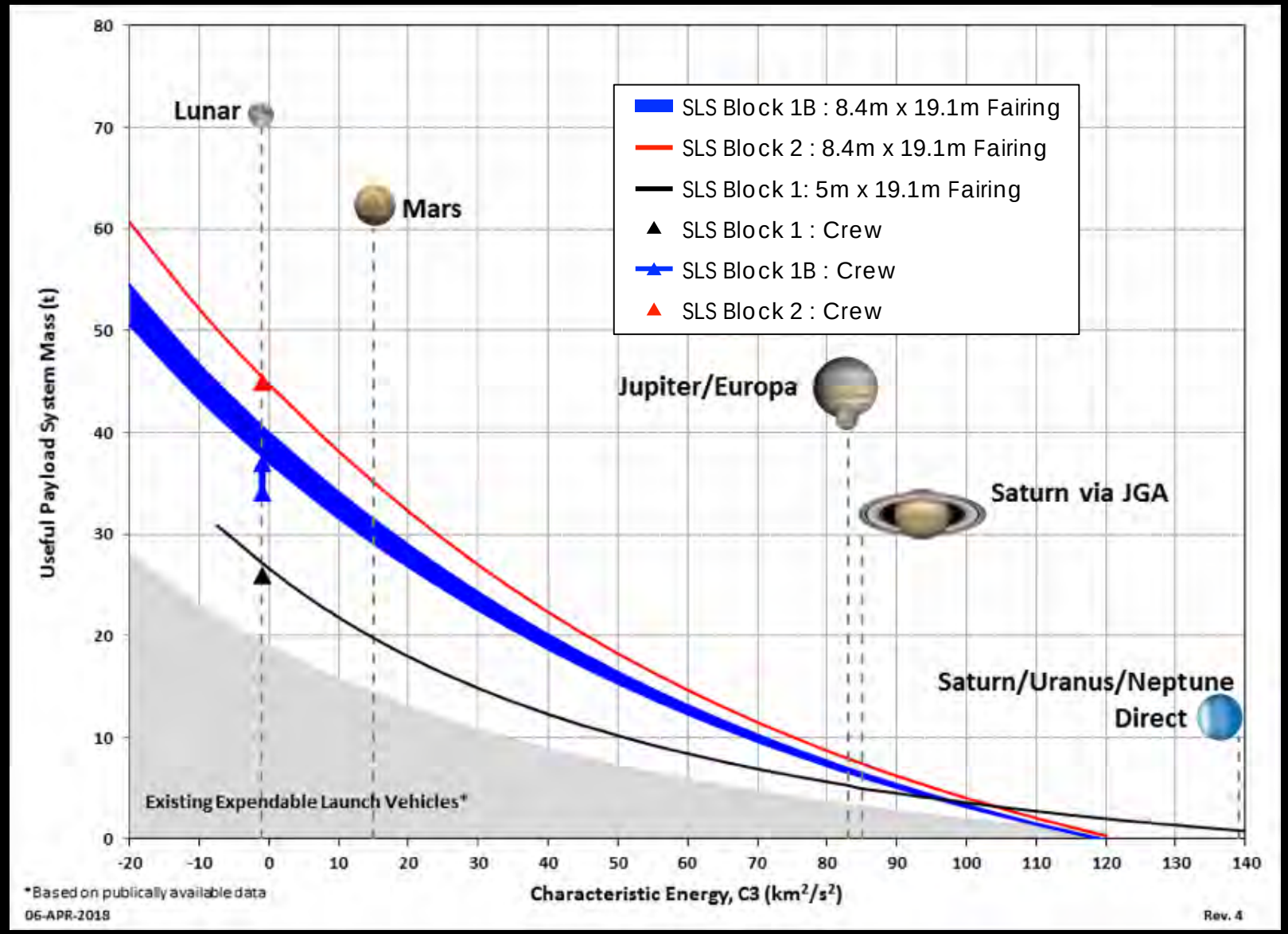
Science Payloads

Orion with Co-manifested Science Missions

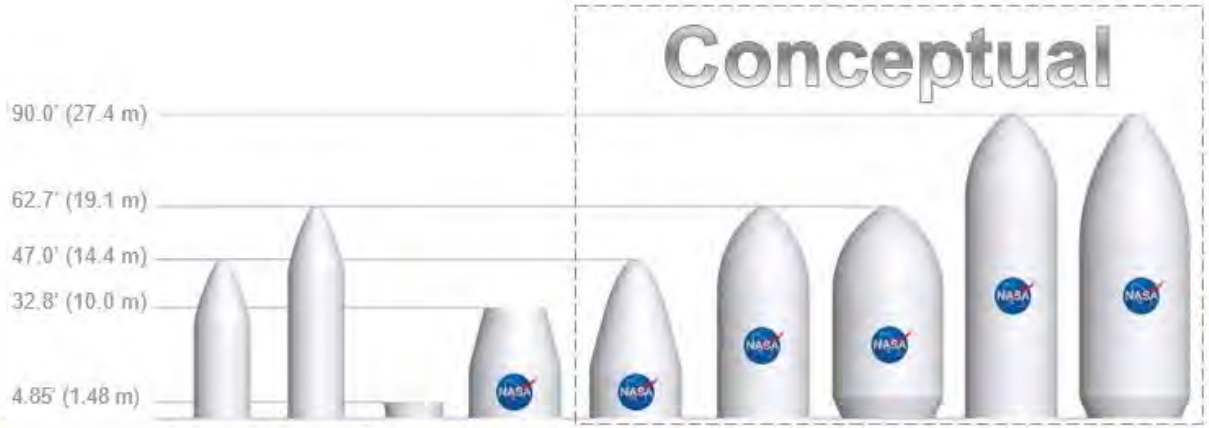
Large-aperture space telescopes

Interstellar probe precursor mission

SLS MASS TO DESTINATIONS



UNMATCHED VOLUME FOR PAYLOADS



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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