National Aeronautics and Space Administration

DEEP SPACE EXPLORATION SYSTEMS

Heritage Capabilities Enabling Deep Space Human Exploration Missions

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70th IAC

SPACE LAUNCH SYSTEM - ORION - EXPLORATION GROUND SYSTEMS

Introduction

SPACE LAUNCH SYSTEM

ORION

GROUND SYSTEMS

Ground Systems Processing Facilities at KSC

Operations and Checkout (O&C) Building

Rotation Processing and Surge Facility

Multi-Payload Processing Facility

Vehicle Assembly Building

Left: Apollo Command and Service Module in O&C (1960s)
Right: Orion Crew and Service Module in O&C (2019)

Ground Systems Facilities in the U.S.A.

– Michoud Assembly Facility (New Orleans)

– B-1/B-2 Test Stand (Stennis)

– Plum Brook Station (Glenn)

– Lunar Landing Research Facility (Langley)

B-1/B-2 Test Stand with Saturn 1-C Test Stage (1960s) and Artemis Core Stage Pathfinder (2019)

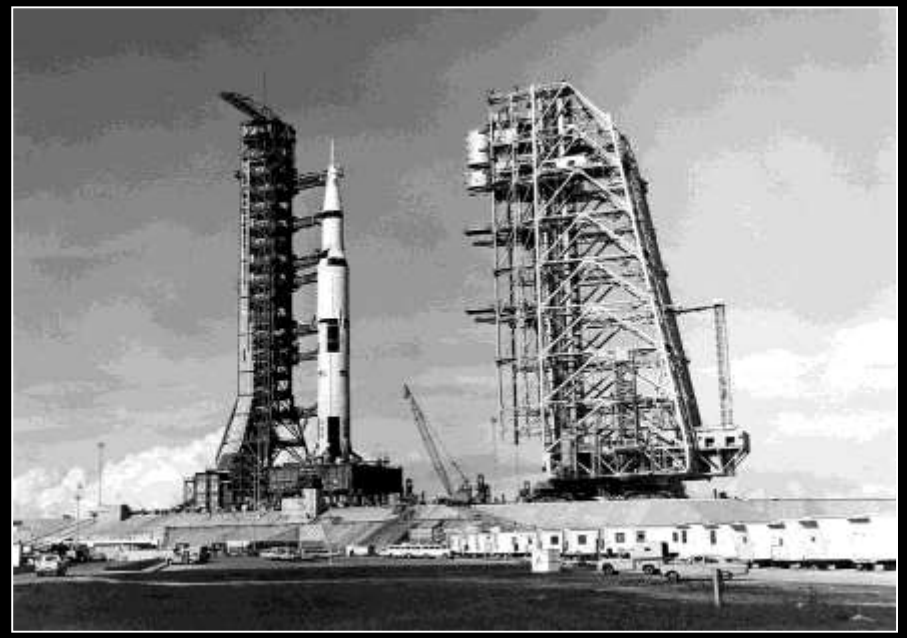
Ground Systems Launch and Mission Ops

– Space Launch Complex 39B (KSC)

– Launch Control Center (KSC)

– Mission Control Center (JSC)

– Huntsville Ops Support Center (MSFC)



Space Launch Complex 39B for Apollo (1969), Shuttle (2009) and Artemis (2019)

Transportation and Logistics Systems

Pegasus Barge | Super Guppy | Crawler Transporter

Crawler Transporter

Pegasus Barge Arrives at KSC with SLS Core Stage Pathfinder (2019)

Super Guppy

Launch Vehicle Flight Systems

- Boosters
- RS-25 Engines
- Interim Cryogenic Propulsion Stage (ICPS)
- RL-10 Engine

Heritage Hardware from Space Shuttle to be used on Space Launch System (SLS) – Block 1 configuration shown

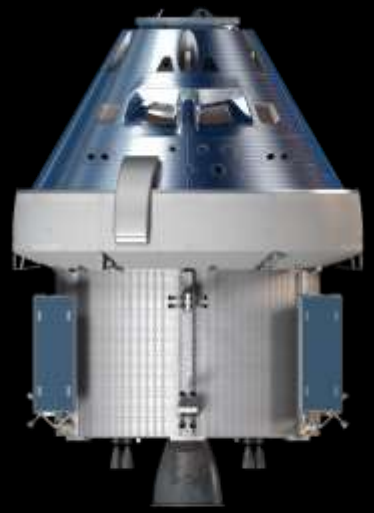
Spacecraft Flight Vehicle Systems

– Crew Module
– ECLSS

– Service Module
– Engines

Automated Transfer Vehicle – Solar Arrays

Apollo



Orion

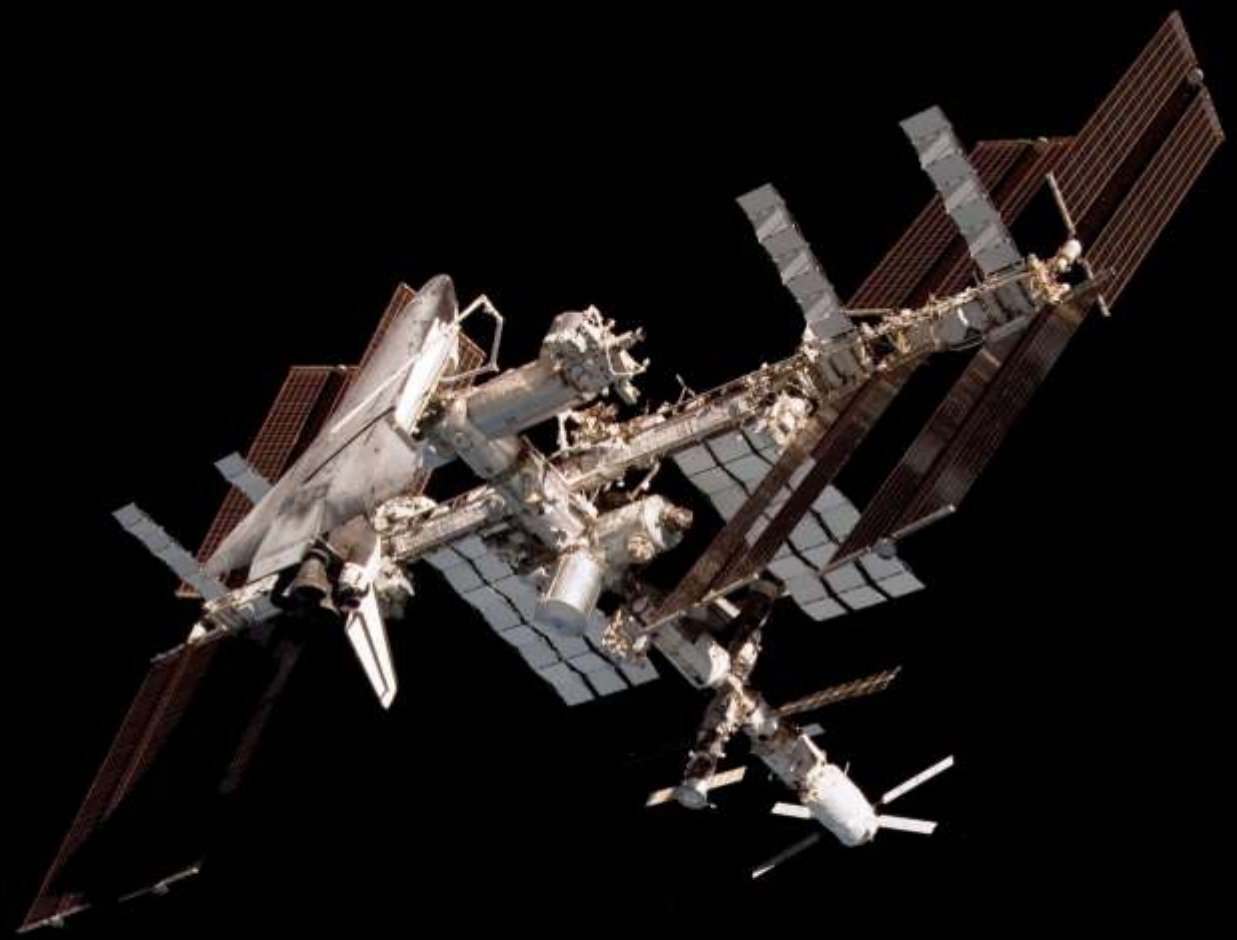
Space Shuttle – Orbital Maneuvering System Engines and RS-25 Engines

Orion solar array testing at Plum Brook Station

Conclusions

Observed Themes:
– Transportation and Logistics
– Infrastructure
– Launch Vehicle Systems
– Spacecraft Systems

Leveraging heritage systems has both advantages and disadvantages.

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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

A B C D
CUBESATS DEPLOY
ICPS deploys 13 CubeSats total

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

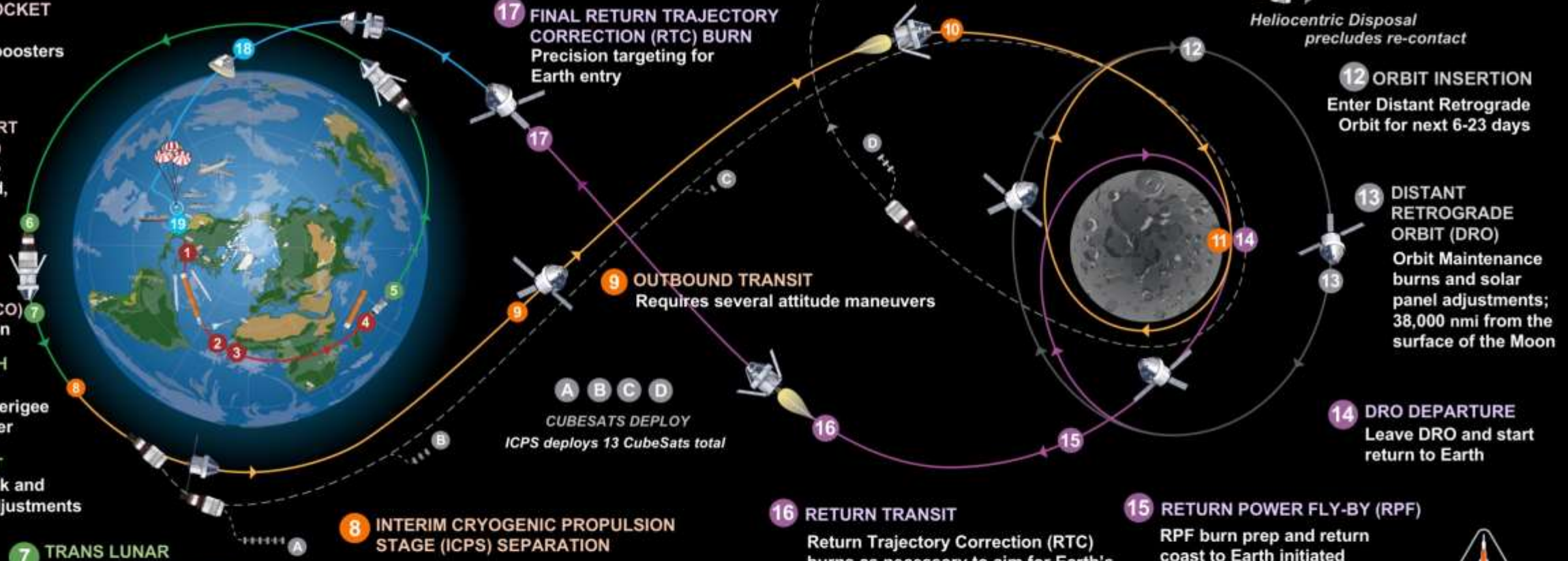
15 RETURN POWER FLY-BY (RPF)
RPF burn prep and return coast to Earth initiated

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



ARTEMIS

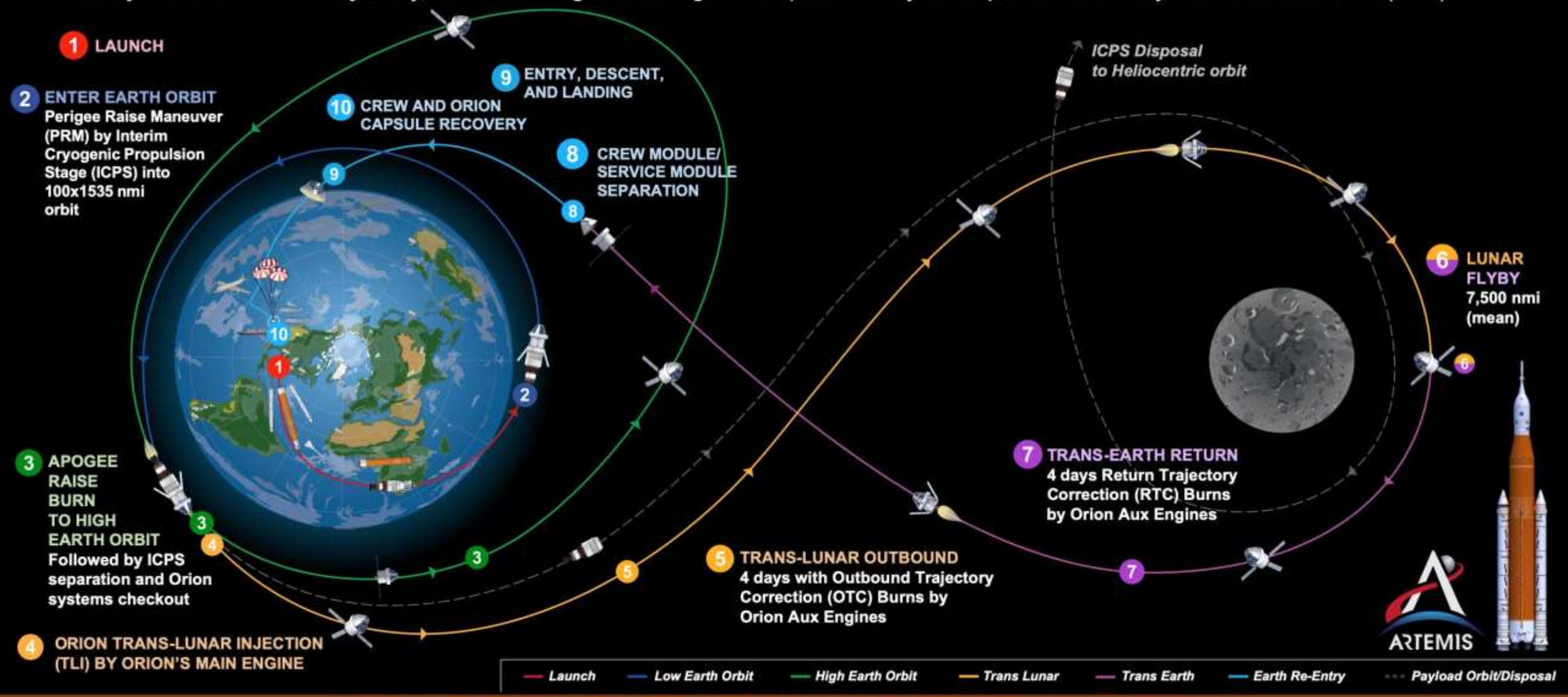
Launch — Earth Orbit — Trans Lunar — Lunar Orbit — Trans Earth — Earth Re-entry — Payload Orbit/Disposal

ARTEMIS I

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

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 insertion orbit | 28.5 deg inclination

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