National Aeronautics and Space Administration

Returning to the Moon: NASA's Artemis Missions

Parul Agrawal
Engineering Project Manager
NASA Ames Research Center

ARTEMIS

PERSONAL INFORMATION

- Project Manager for Orion (Multi-Purpose Crew Vehicle) operations at NASA Ames Research Center since 2018
  - Orion is one of the elements of NASA's Artemis program with objective to land the first woman and next man on Moon by 2024
- Project Manager for Science mission proposals
- Prior to current role, I spent 11 years in Entry Systems division designing, developing and testing heatshield materials and systems. I had the opportunity to work on many different projects at NASA.
  - Mission concept studies to send probes to Ice giants
  - Thermal analysis of Entry vehicles
  - Asteroid entry on Earth and their break-up

ARTEMIS

Twin sister of Apollo and goddess of the Moon in Greek mythology, Artemis is the torch-bringer personifying our path to the Moon. During the next era of human exploration, we will discover life-saving, Earth-changing science and technology along the way.

NASA’s goal is to land the first woman and first person of color on the Moon and return them safely to Earth. When the Artemis astronauts land on the lunar surface, they will step into the future, bringing all of humanity with them.

Why Artemis?

DISCOVER

With Artemis, we're building on more than 50 years of exploration experience to reignite America's passion for discovery

VIPER

Volatiles Investigating Polar Exploration Rover

Locate concentrations of water ice that could eventually be harvested to sustain human exploration on the Moon, Mars — and beyond. VIPER represents the first resource mapping mission on another celestial body.

DISCOVER

With Artemis, we're building on more than 50 years of exploration experience to reignite America's passion for discovery

VIPER

Volatiles Investigating Polar Exploration Rover

Locate concentrations of water ice that could eventually be harvested to sustain human exploration on the Moon, Mars — and beyond. VIPER represents the first resource mapping mission on another celestial body.

ISRU

In-situ resource utilization

- Propellant material mining
- Material synthesis for 3-D Printing on the Moon

For sustainability on the Moon and future human missions to Mars.

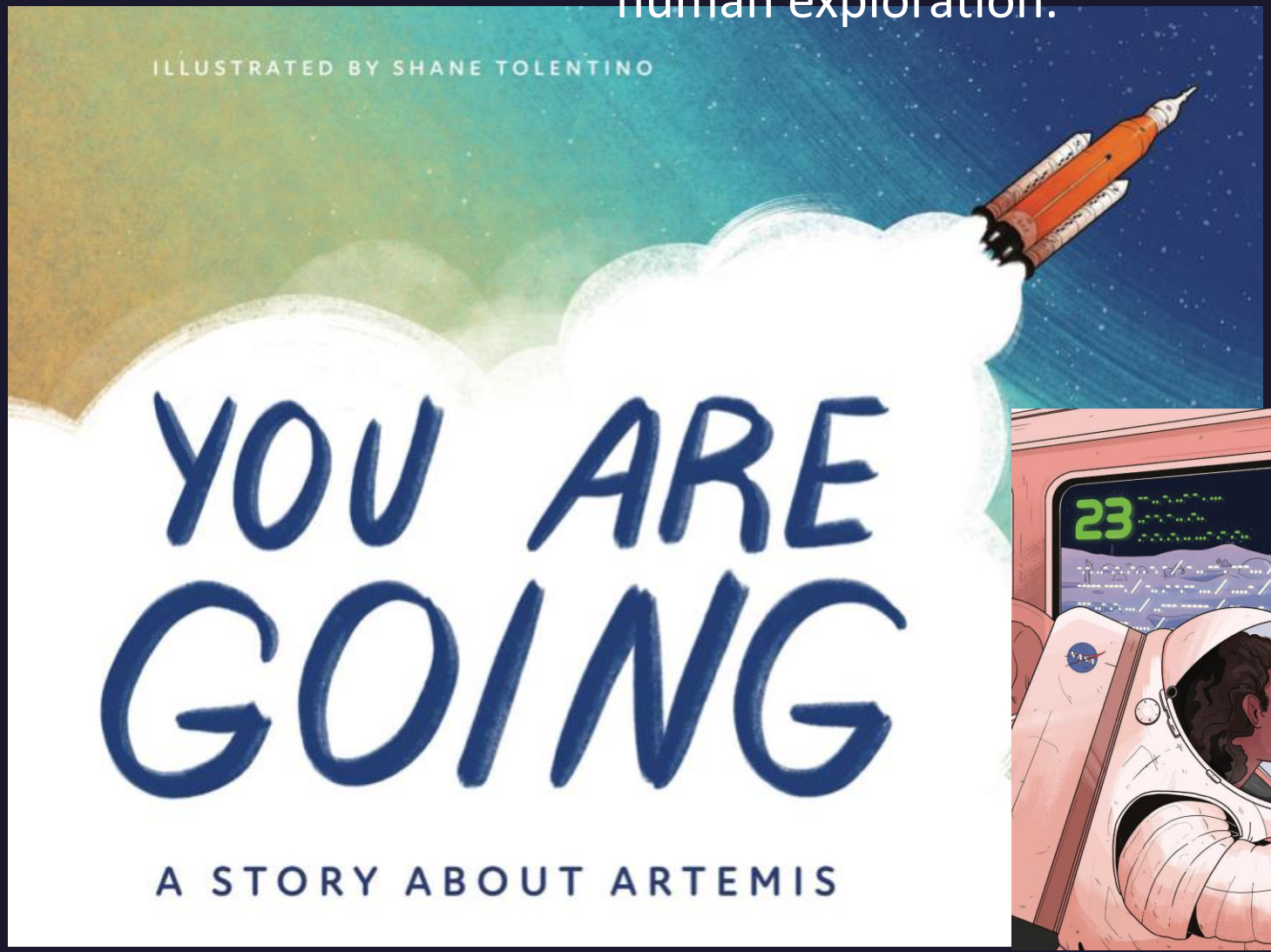
OPPORTUNITY

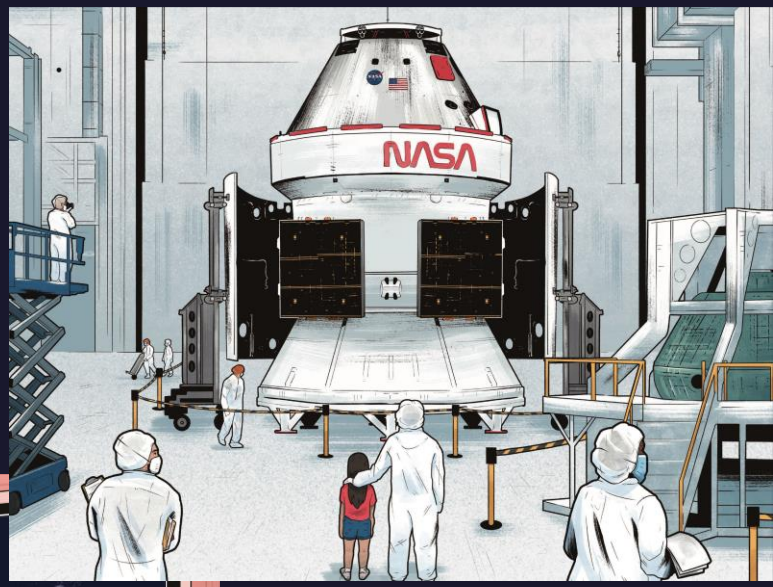
Artemis missions **enable a growing lunar economy** by fueling new industries, supporting job growth, and furthering the demand for a skilled workforce.

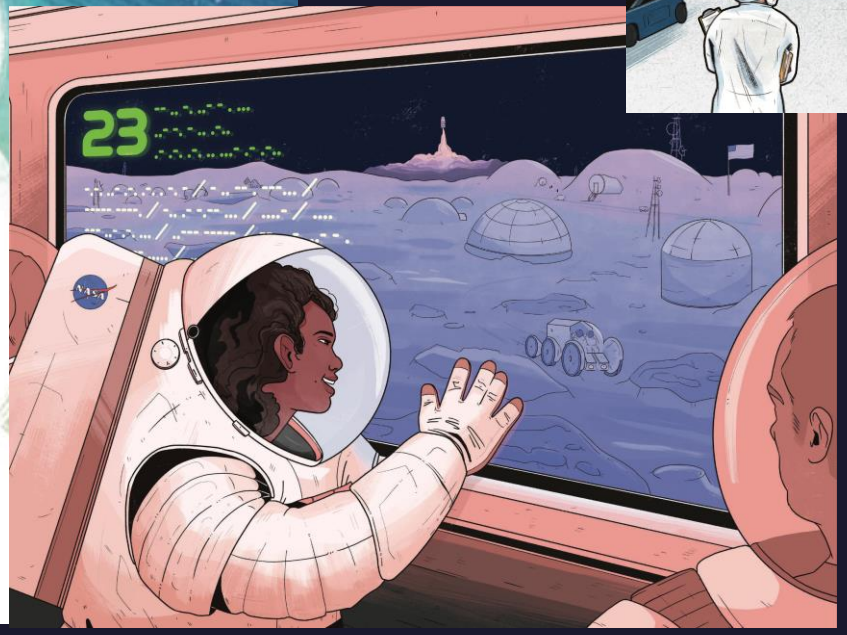
ARTEMIS

INSPIRATION

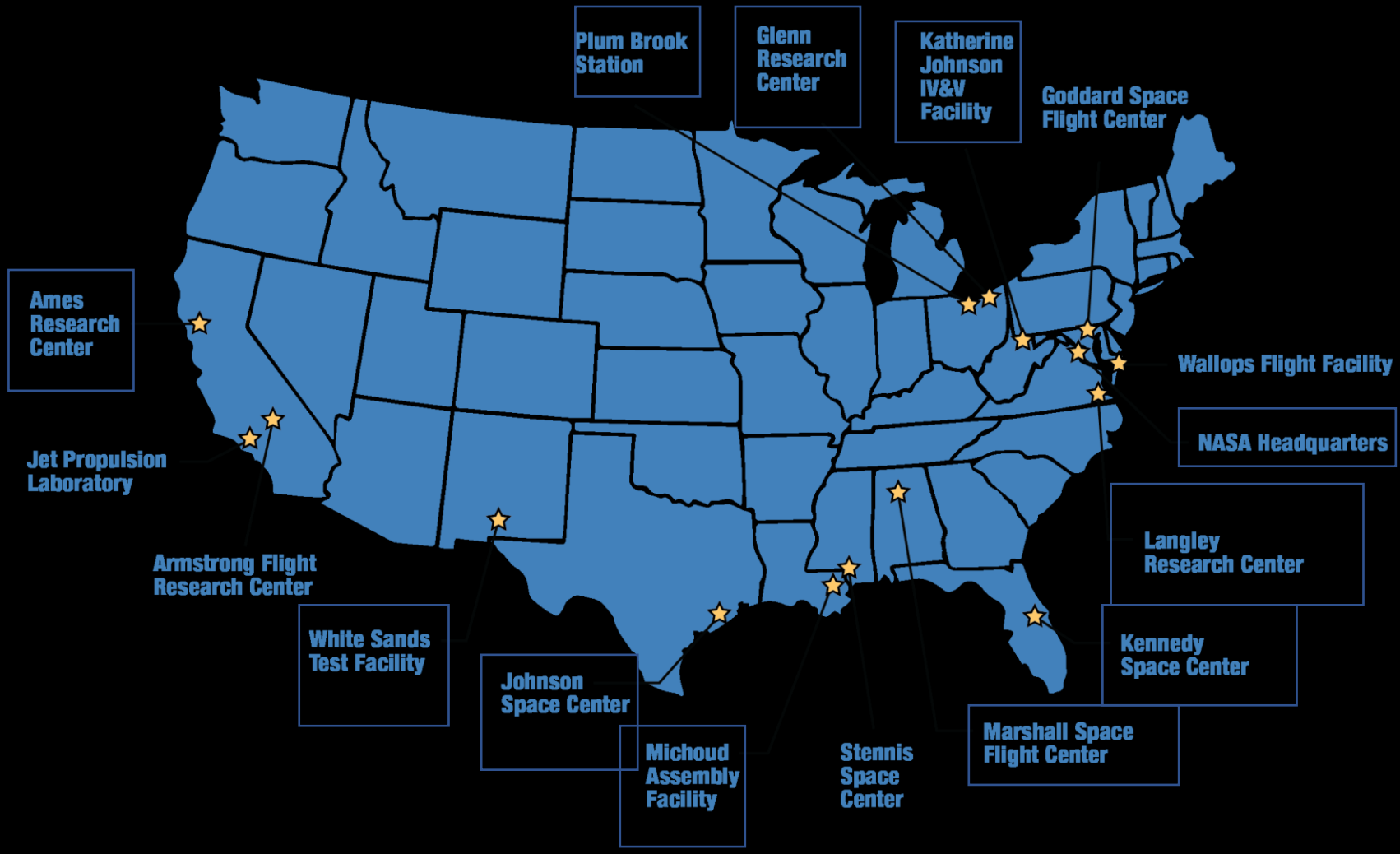
With Artemis missions, NASA will land an inspirational crew on the Moon, using innovative technologies to expand human exploration.



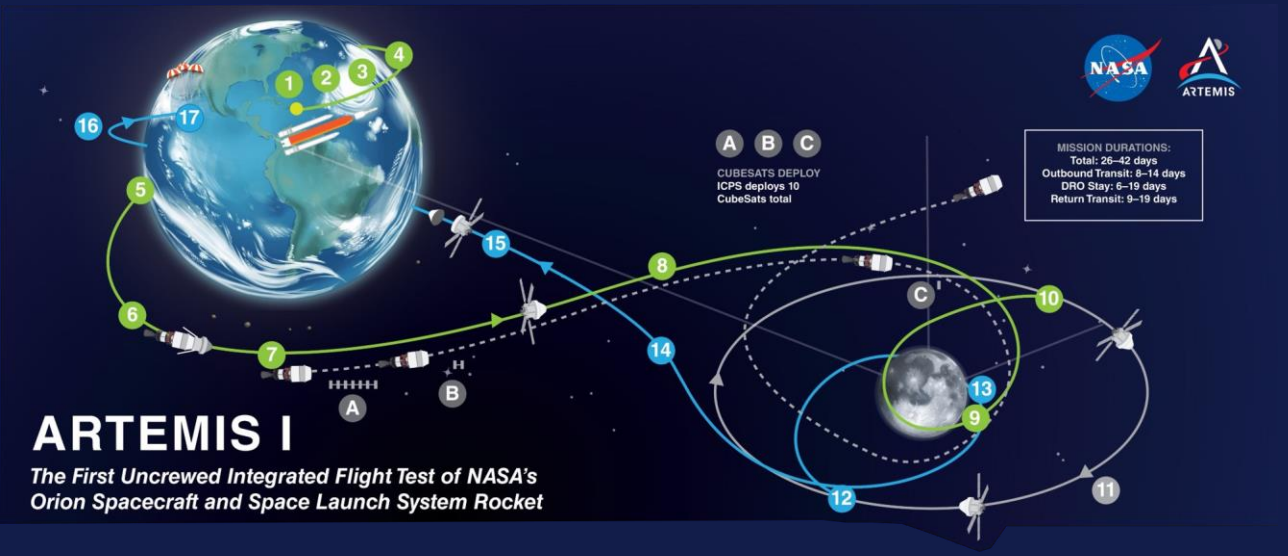




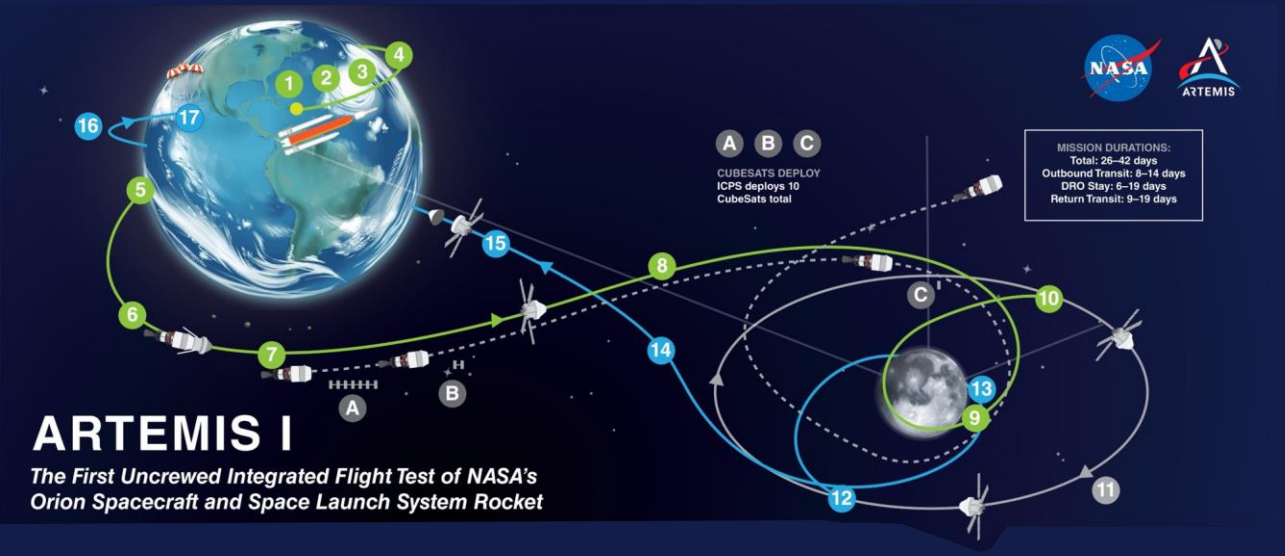
Key Artemis Contributions by NASA Centers



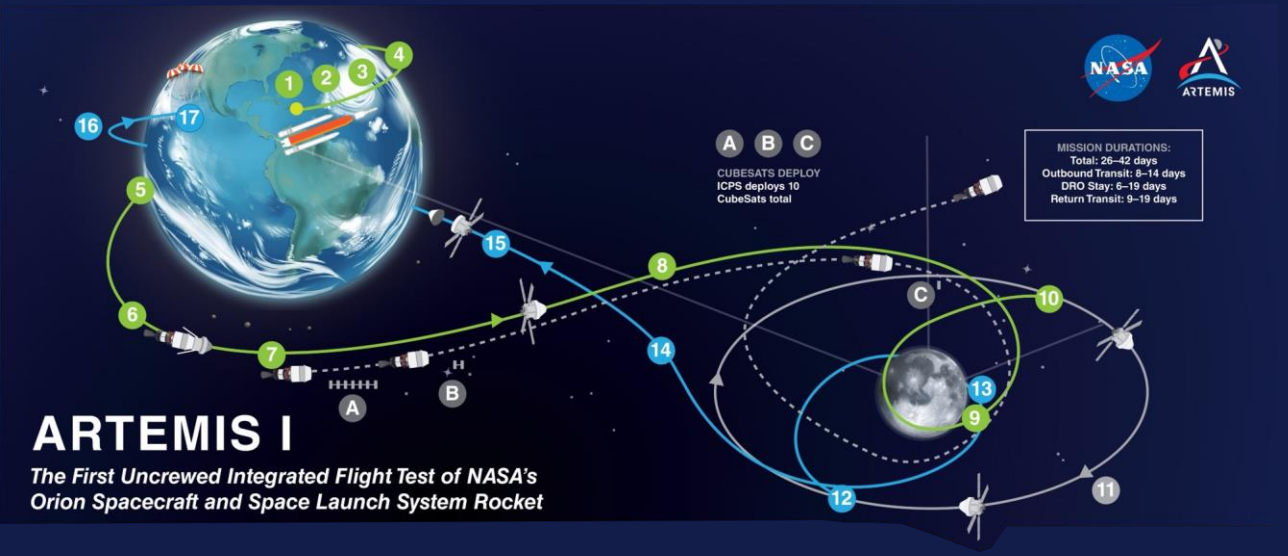
HOW WE GET THERE!

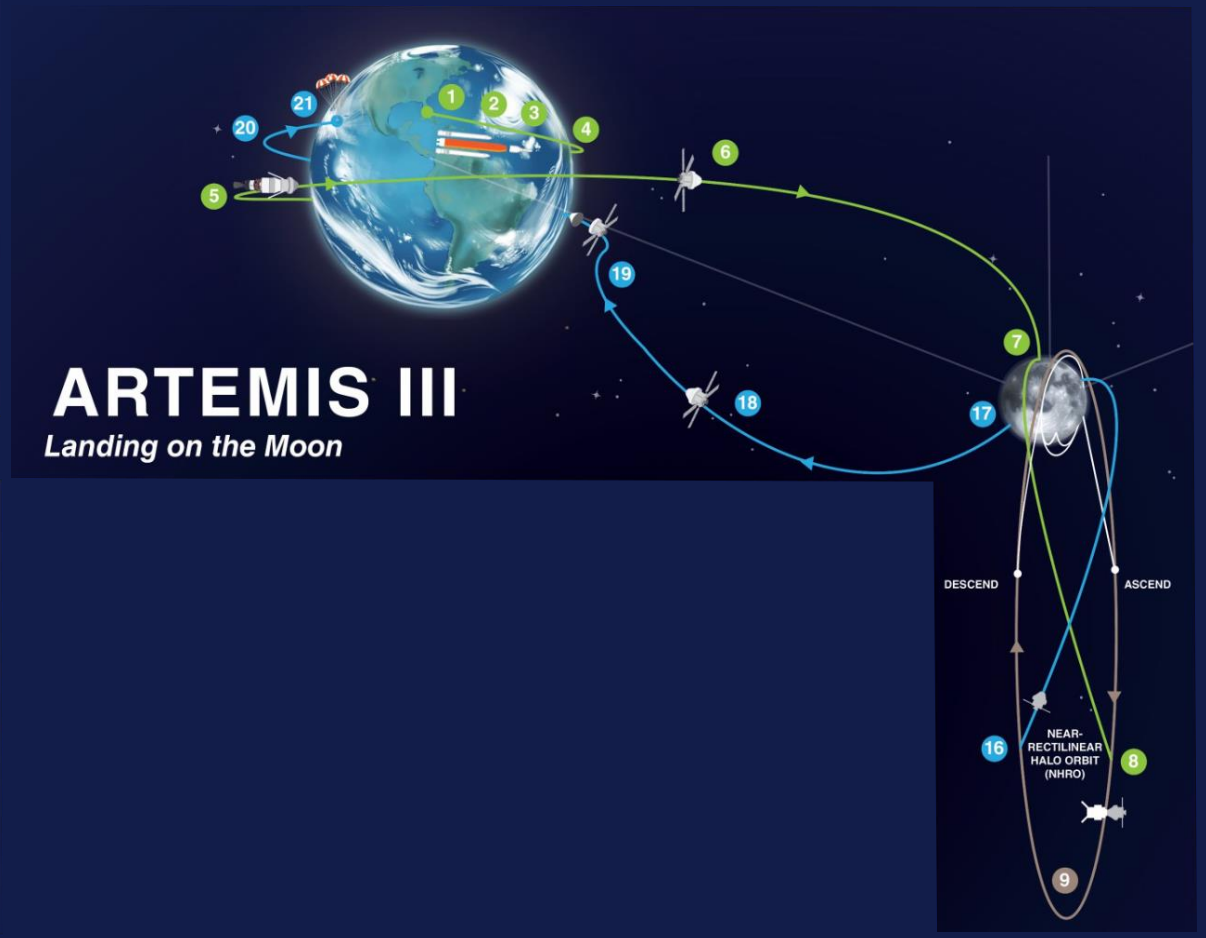


HOW WE GET THERE!



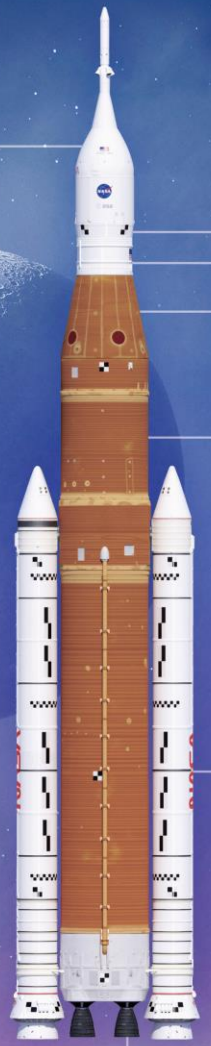
HOW WE GET THERE!





Space Launch System

ARTEMIS I MOON ROCKET



ORION SPACECRAFT

An uncrewed Orion spacecraft will venture thousands of miles beyond the Moon, paving the way for future flights with astronauts.

ORION STAGE ADAPTER

The adapter carries small satellites to deep space where they conduct world-class science for pennies on the dollar.

INTERIM CRYOGENIC PROPULSION STAGE (ICPS)

One RL10 engine provides 24,750 pounds of thrust to send Orion to the Moon.

LAUNCH VEHICLE STAGE ADAPTER

The adapter connects the 27.5-foot diameter core stage to the 16.5-foot diameter ICPS and partially encloses the ICPS in-space stage.

CORE STAGE

The 212-foot tall core stage holds 733,000 gallons of propellant to power four RS-25 engines for eight minutes, sending the rocket soaring to space at 17,000 miles per hour.

SOLID ROCKET BOOSTERS

Each 17-story-tall booster generates 3.6 million pounds of thrust, providing 75 percent of total thrust during the SLS rocket's first two minutes of flight.

FOUR RS-25 ENGINES

As the most efficient engines ever built, the engines provide a total of two million pounds of thrust for launch and ascent to space.

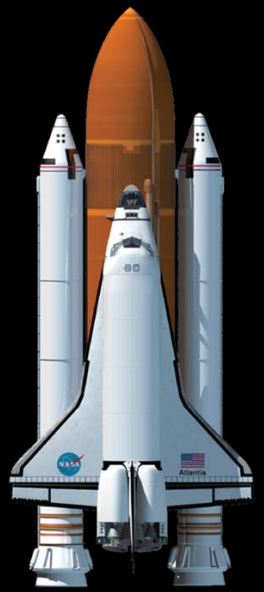
NASA'S SPACE LAUNCH SYSTEM (SLS) is the only rocket built to send more than **59,525** pounds to deep space.

www.nasa.gov/sls

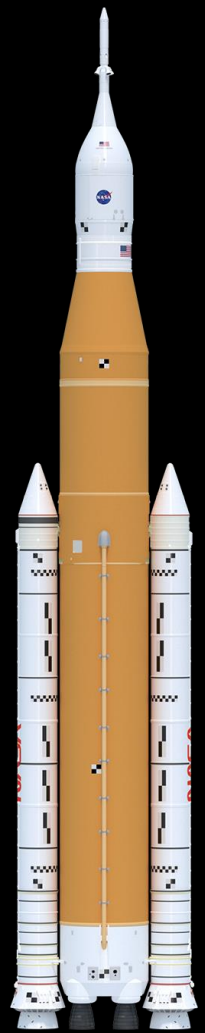
Once in space, need **24,750 pounds** of thrust to send Orion to the Moon!

Total of **5.6 Million pounds** of thrust to lift 59,525 pounds from the Earth's surface, escape gravity.

STATUE OF LIBERTY
305 ft.



SPACE SHUTTLE
184 ft.



SLS / ORION Block I
322 ft.

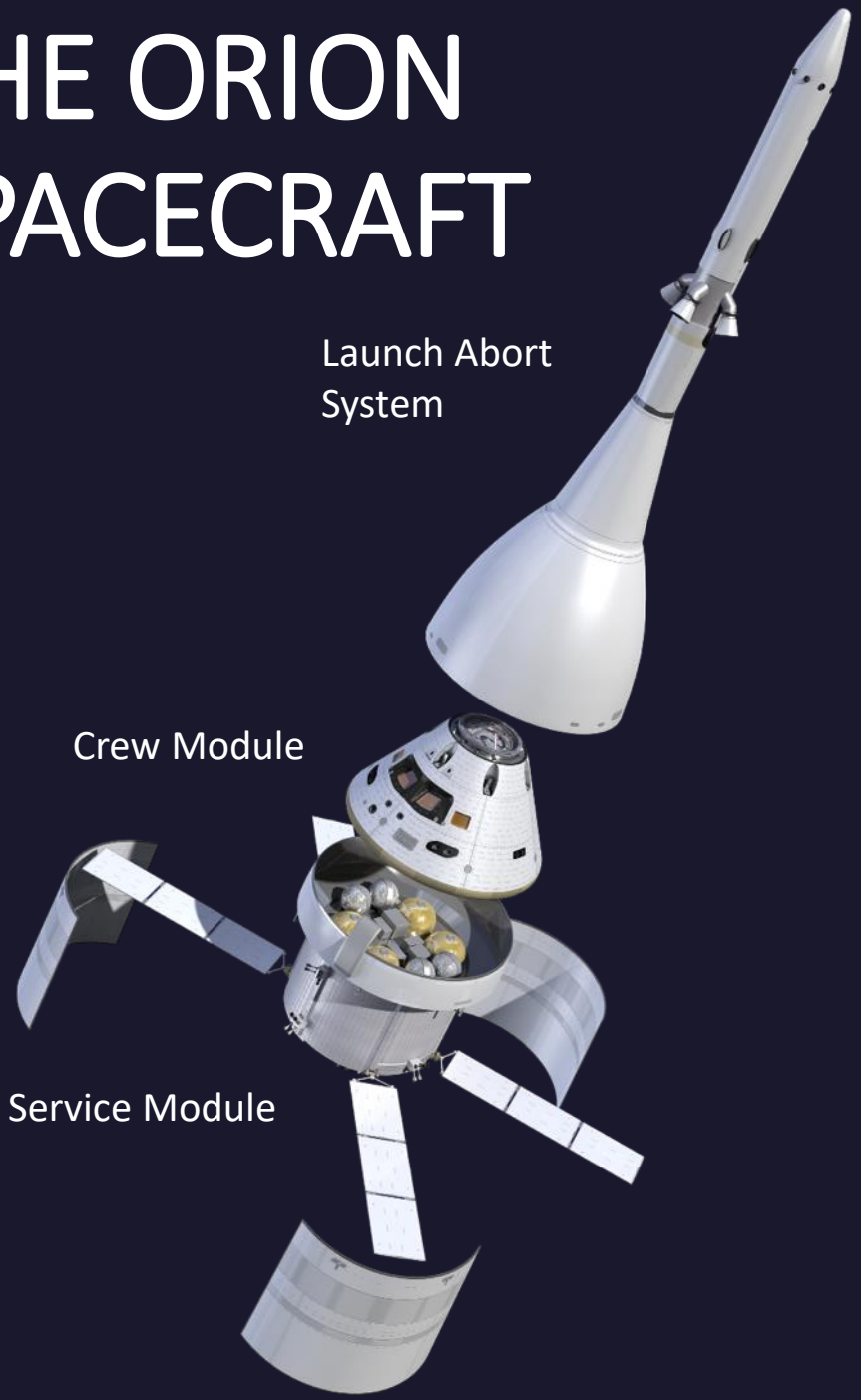
SLS / ORION Block II
364 ft.

SATURN 5
363 ft.

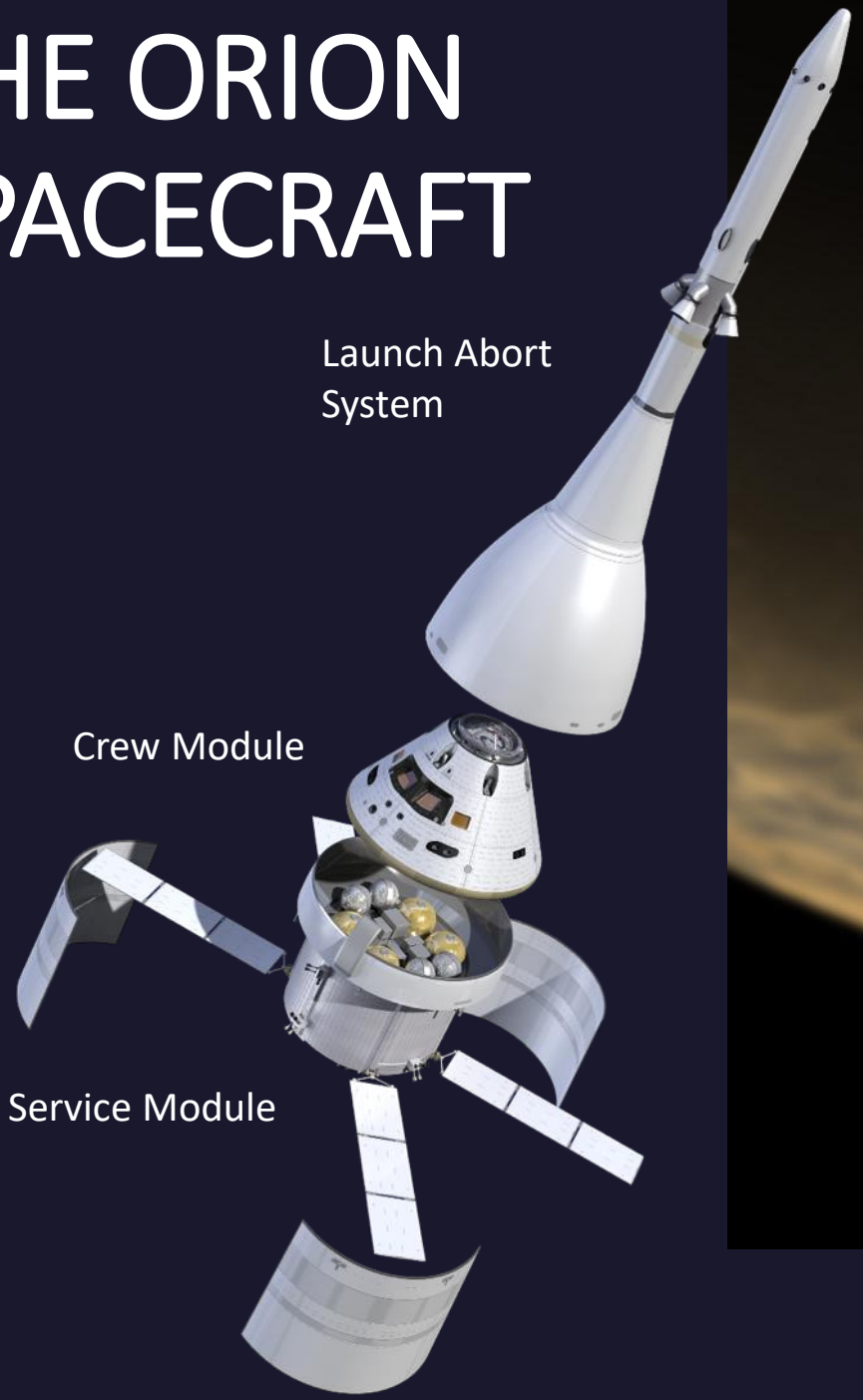

SLS

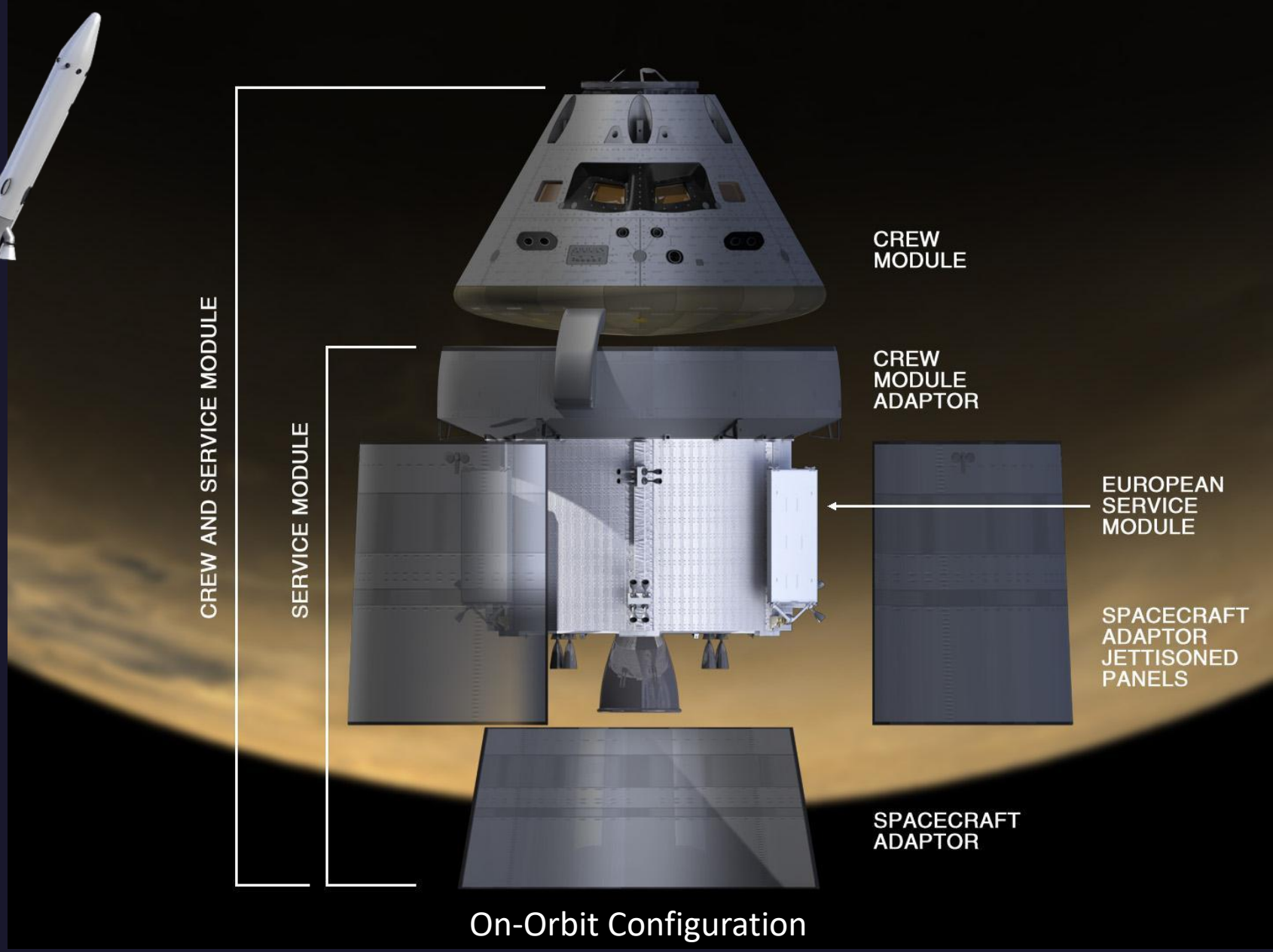
EGS

THE ORION SPACECRAFT



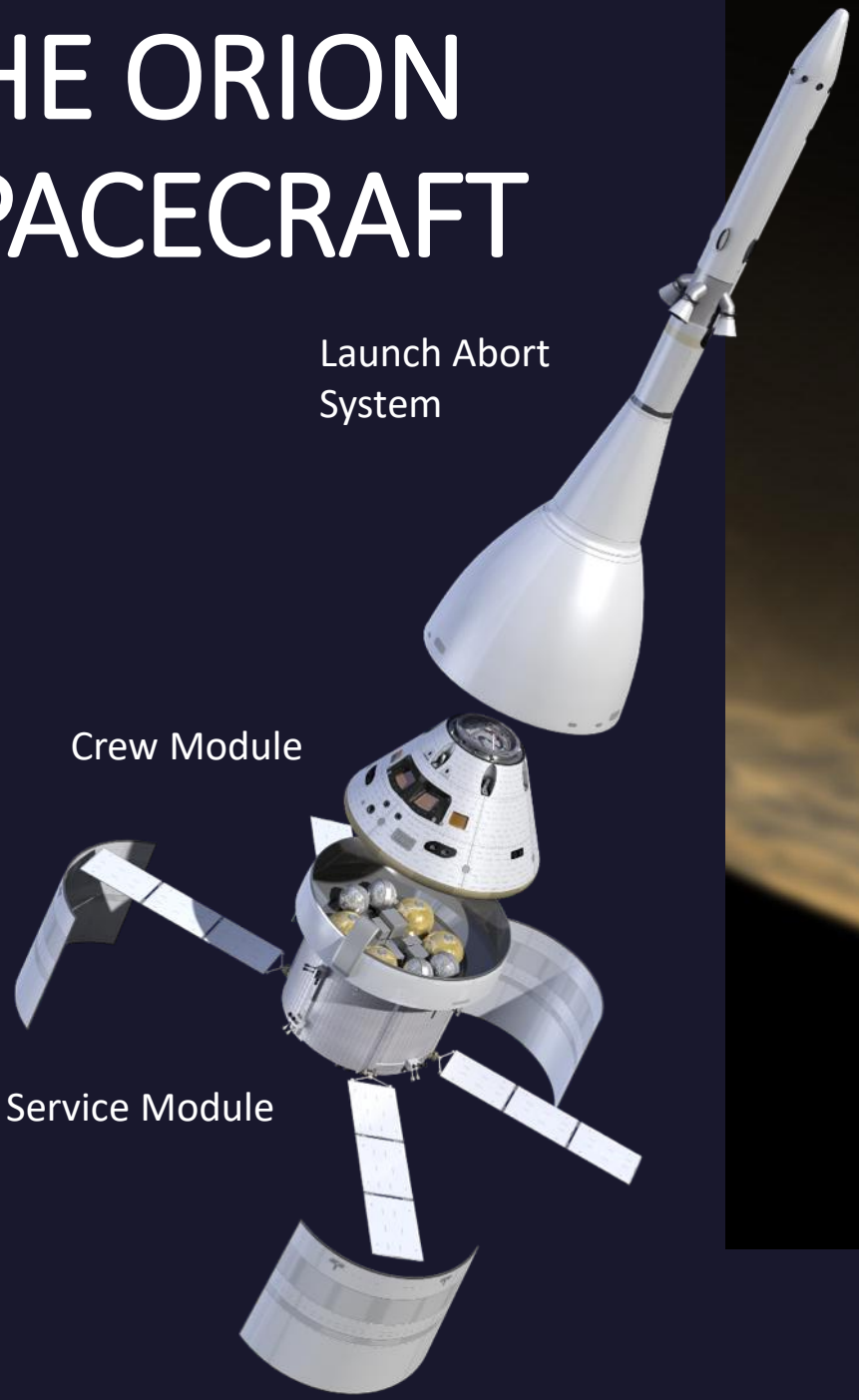
THE ORION SPACECRAFT

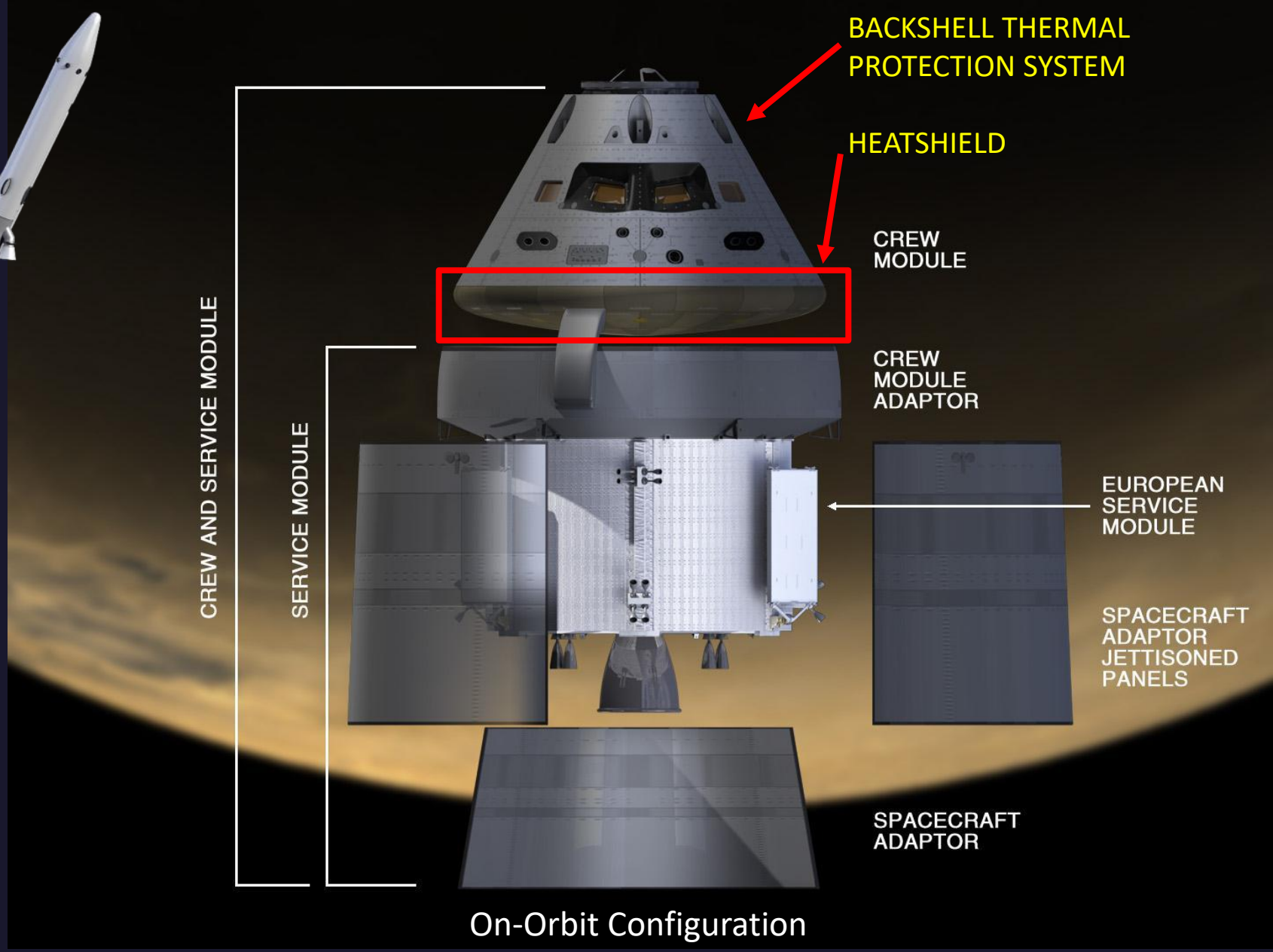




On-Orbit Configuration

THE ORION SPACECRAFT





On-Orbit Configuration

Artemis I Payloads

Science and technology investigations and demonstrations paving the way for future, deep space human exploration

Moonikin Campos

The Moonikin is a male-bodied manikin previously used in Orion vibration tests. Campos will occupy the commander's seat inside and wear an Orion Crew Survival System suit

Radiation Sensors
There will be three types of sensors, including the ESA Active Dosimeters, Hybrid Electronic Radiation Assessor, and the Radiation Area Monitor.

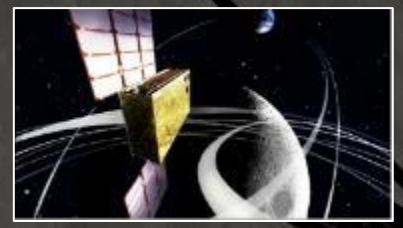
MARE
Radiation shielding Personal Protection Equipment (radiation vest) for astronauts.

Crew Interface Technology Payload (CITP)
Creates an interactive experience between Orion and the public during the mission

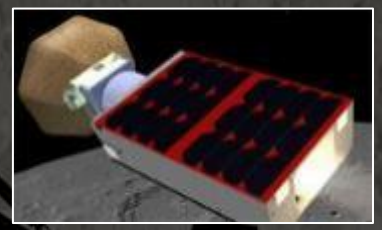
Bio-Experiment-1
Battery-powered life sciences payload for biology research beyond low-Earth orbit (LEO)

ArgoMoon

LunaH-Map



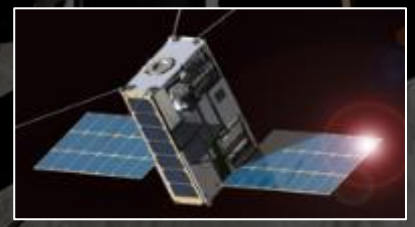
EQUULEUS



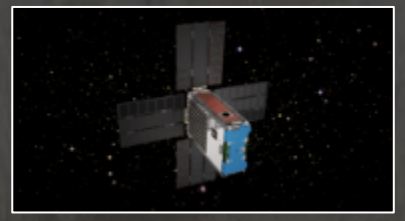
OMOTENASHI

LunIR

Near-Earth Asteroid Scout (NEA Scout)



Lunar IceCube



BioSentinel

Team Miles

CuSP

A SAFE RETURN

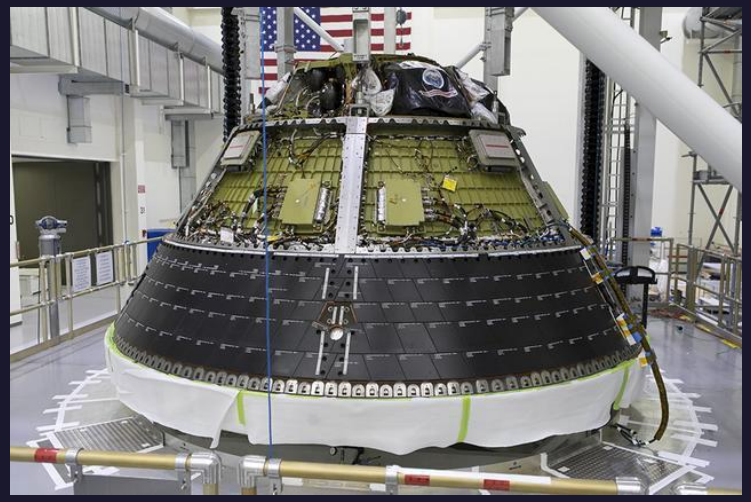
A SAFE RETURN

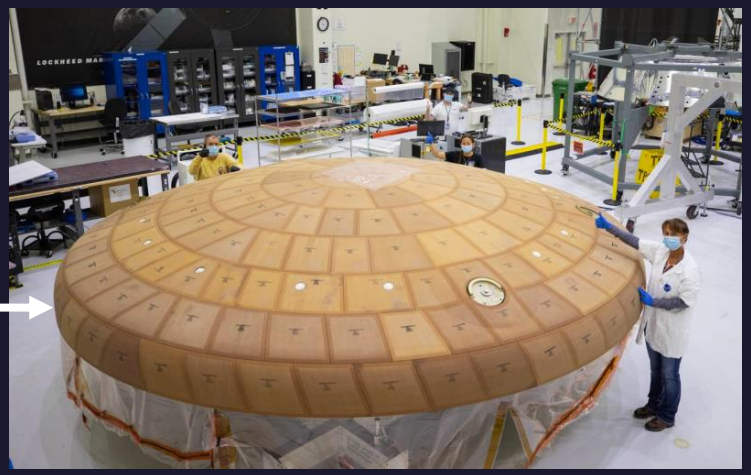
Survive Extreme Heating!

The capsule must survive external **temperatures as high as 5,000 ºF**! That's half the surface temperature of the Sun!!!!

Our heat shield technology helps keep the inside of the capsule (where the humans will live!) in the mid-70 ºF

This is the largest ablative heatshield in the world at **16.5 ft in diameter!**





A SAFE RETURN

Put on the Brakes!

Orion is equipped with 11 parachutes that are deployed to **slow the vehicle from 325 mph to 20 mph** for a soft landing in the ocean.

A SAFE RETURN

ARTEMIS-1 Successes!

SUCCESSFUL LAUNCH OF MOST POWERFUL ROCKET IN THE WORLD

ORION HEADED TO THE MOON

ORION IN DISTANT RETROGRADE ORBIT
CAPTURES MOON TRANSIT IN FRONT OF EARTH

ARTEMIS-1 Successes!

SUCCESSFUL RECOVERY IN THE PACIFIC OCEAN

QUESTIONS?

VALUABLE LUNAR SCIENCE

- Study of Planetary Processes
- Understanding Volatile Cycles
- Impact History of Earth-Moon System
- Record of the Ancient Sun
- Fundamental Lunar Science
- Platform to Study the Universe

LUNAR SURFACE SCIENCE OBJECTIVES

Mission Needs Drive Design

LOW EARTH RETURN

3 HOURS
3,000°F
17,500 MPH
250 MILES

LUNAR RETURN

3 DAYS
5,200°F
24,700 MPH
240,000 MILES

MARS RETURN

9 MONTHS
6,200°F
26,800 MPH
39,000,000 MILES

**Numbers are averages*

Artemis: a Foundation for Deep Space Exploration


Space Launch System


Orion spacecraft


Human Landing System


Surface Operations

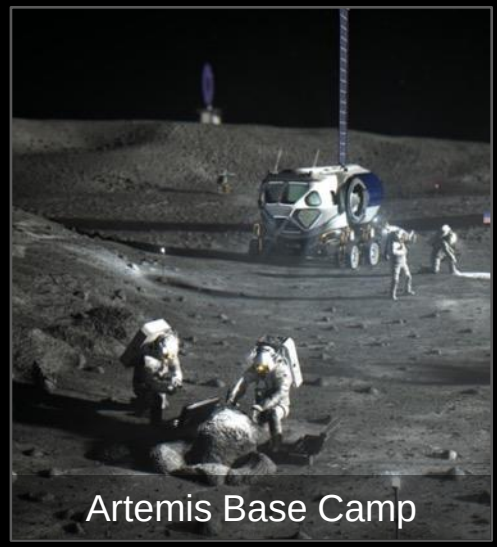

Gateway

Exploration Ground Systems

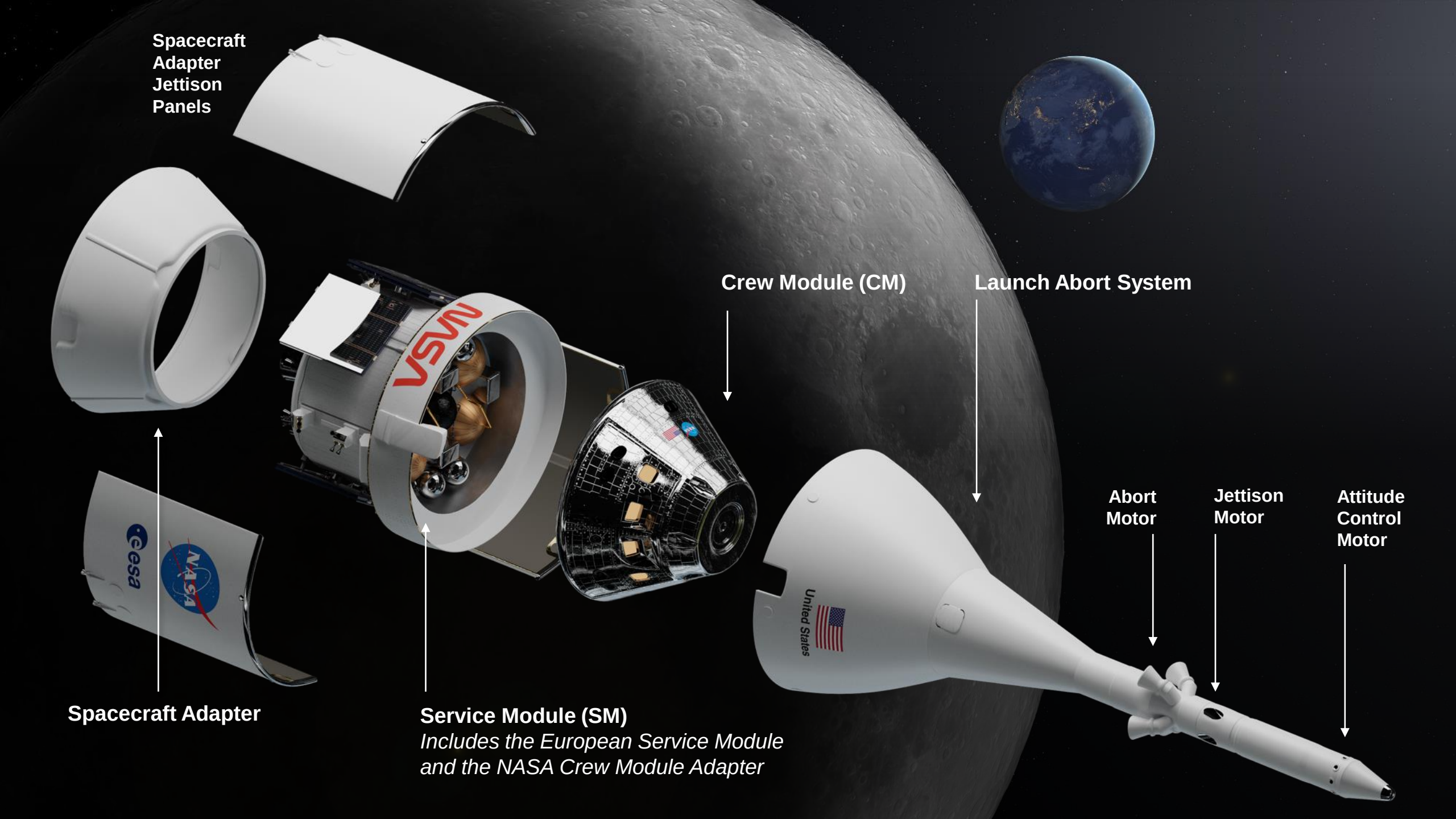

Space Communications & Navigation


Surface Mobility


Space Suits


Artemis Base Camp

ORION


Spacecraft Adapter Jettison Panels
Crew Module (CM)
Launch Abort System
Abort Motor
Jettison Motor
Attitude Control Motor
Spacecraft Adapter
Service Module (SM)
Includes the European Service Module and the NASA Crew Module Adapter

Orion Quick Facts

Performance	
Number of crew	4
Mission Duration	up to 21 days

Height	
Crew module + service module	26 ft.
Orion stack (launch abort system + crew module + service module)	67 ft.
SLS Block 1 Configuration (Orion + SLS stack)	322 ft.

Trans-Lunar Insertion Mass	
Artemis I	53,000 lbs.
Artemis II	58,000 lbs.

Post-Trans Lunar Insertion Mass	
Artemis I	51,500 lbs.
Artemis II	57,000 lbs.
Usable Propellant	19,000 lbs.

Gross Liftoff Weight	
Artemis I	72,000 lbs.
Artemis II	78,000 lbs.

Total Change in Velocity (ΔV) with Fully Loaded Propellant Tank	
Artemis I	53,000 lbs.
Artemis II	58,000 lbs.