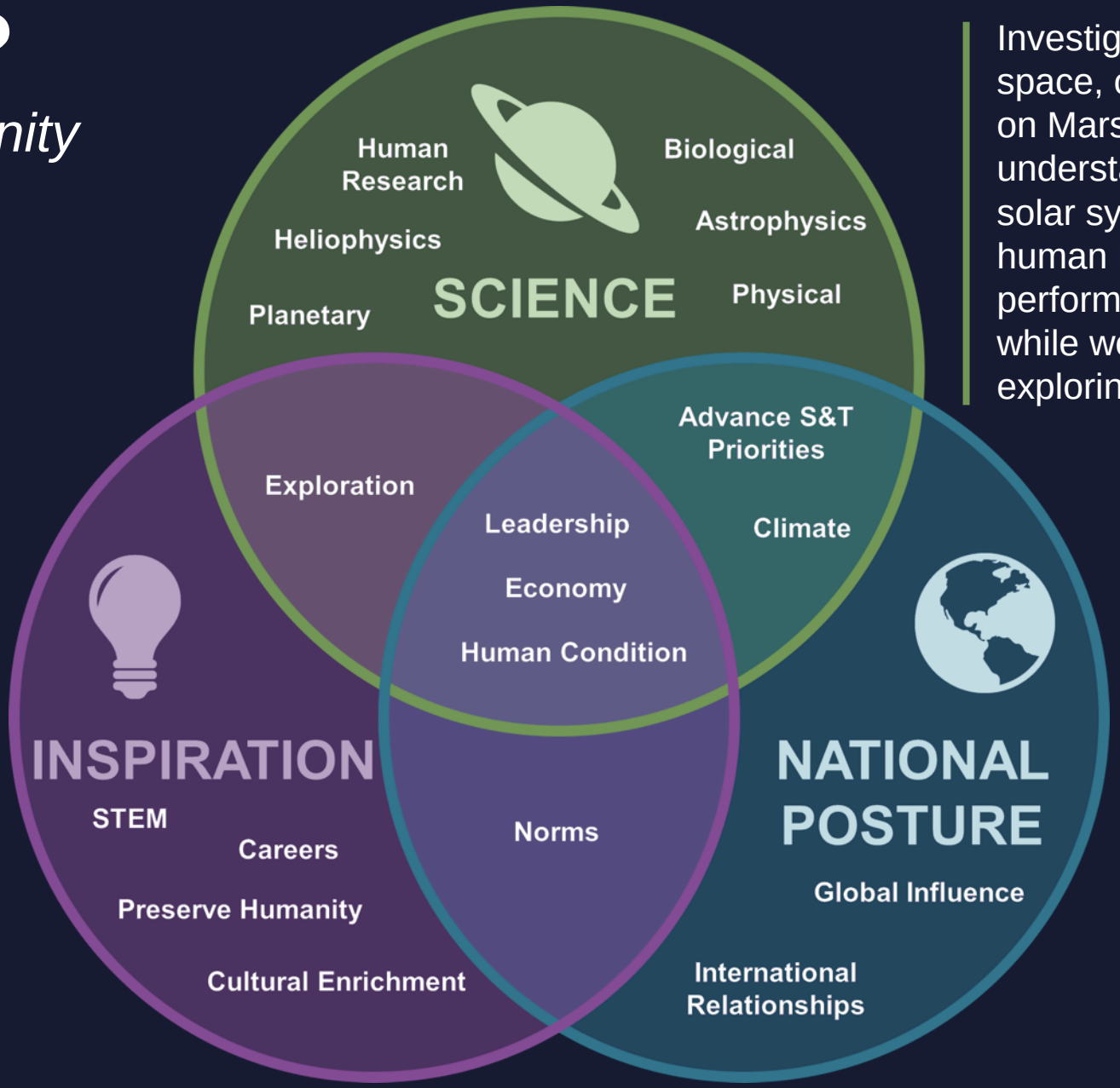
HUMAN LANDING SYSTEM

Lisa Watson-Morgan
Program Manager

Why Go?

Benefits to Humanity



Investigations in deep space, on the Moon, and on Mars will enhance our understanding of the solar system, Earth, the human body, and how to perform new operations while we are out there exploring.

Accepting audacious challenges and succeeding through perseverance and tenacity in the face of adversity motivates current and future generations to dare mighty things.

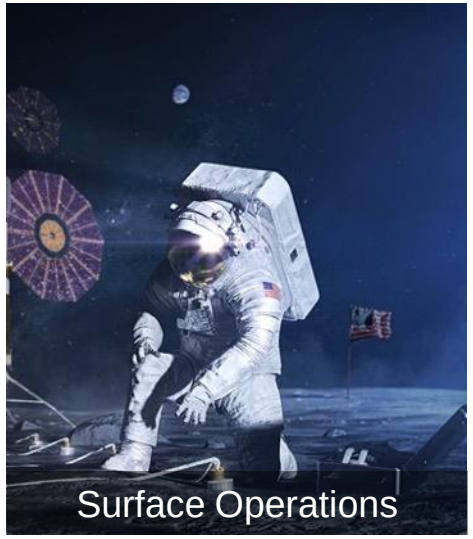
What we choose to do, how we do those things, and who we do them with greatly impacts our place in the world today, our quality of life, and our possibilities for the future.

Artemis: A Foundation for Deep Space Exploration


Space Launch System


Orion spacecraft


Human Landing Systems


Surface Operations

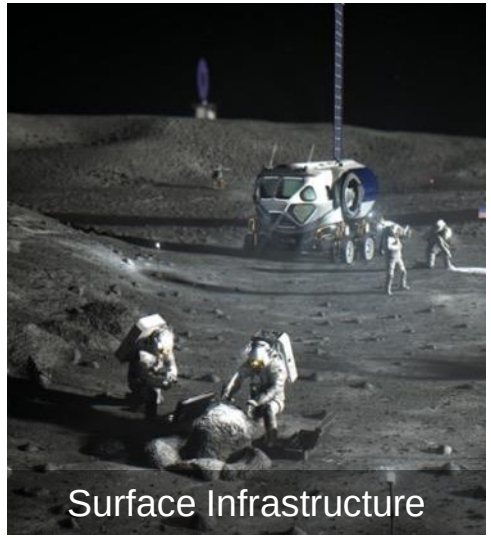

Gateway


Exploration Ground Systems


Space Communications & Navigation


Surface Mobility


Spacesuits


Surface Infrastructure

Artemis I

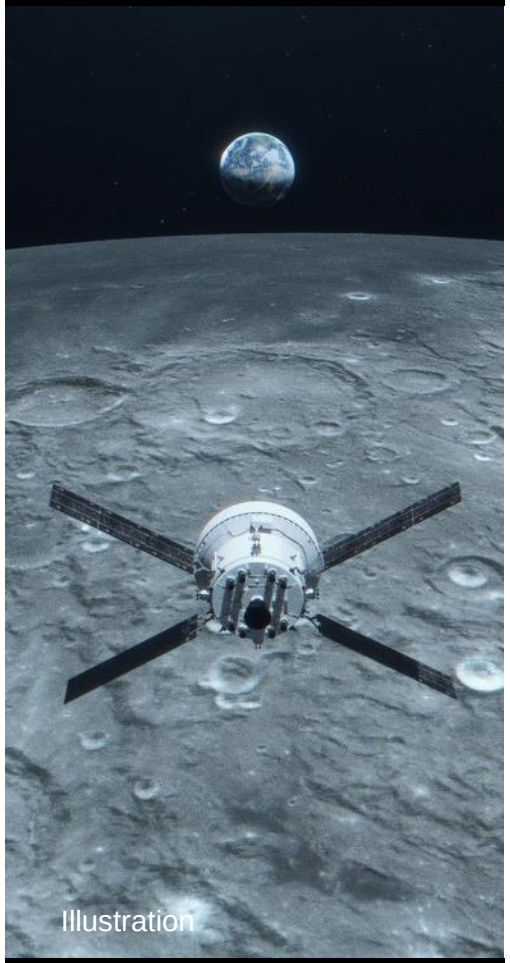
Uncrewed flight test

COMPLETE

SLS, Orion, EGS

Artemis II

Crewed flight test



SLS, Orion, EGS

Artemis III

Crewed surface expedition

SLS, Orion, EGS, HLS

Artemis IV

Gateway assembly, crewed sustaining lander expedition

SLS, Orion, EGS, HLS, Gateway *(PPE/HALO, I-HAB)*

Artemis V

Crewed mobile surface exploration, Gateway expansion

SLS, Orion, EGS, HLS, LTV, Gateway (*ESPRIT, Canadarm3*)

LANDING

humans and cargo on the lunar surface

- Developed by U.S. industry, based on NASA requirements
- Carries crew and cargo to the lunar surface and returns crew to lunar orbit
- Serves as a habitat on the lunar surface for early Artemis missions
- Houses equipment for surface activities including moonwalks, sample collection, and scientific experiments

STARSHIP

Human Landing System (HLS)

NASA is working with SpaceX to develop its Starship Human Landing System for use on:

- Artemis III - the mission that will put the next two Americans on the surface of the Moon
- Artemis IV - which meets an extended set of requirements such as docking with Gateway for crew transfer, more mass to the surface, and longer mission durations

SpaceX will perform an uncrewed demonstration mission prior to the crewed Artemis III mission.

Image Credit: SpaceX

Starship Human Landing System (HLS) Artemis III Concept of Operations

Crew board Starship from Orion

Crew board Orion from Starship

Near Rectilinear Halo Orbit (NRHO)

HLS propellant fill

Fast trans-lunar injection (TLI)

Earth Orbit

Storage depot launch

Propellant aggregation

HLS Starship launch

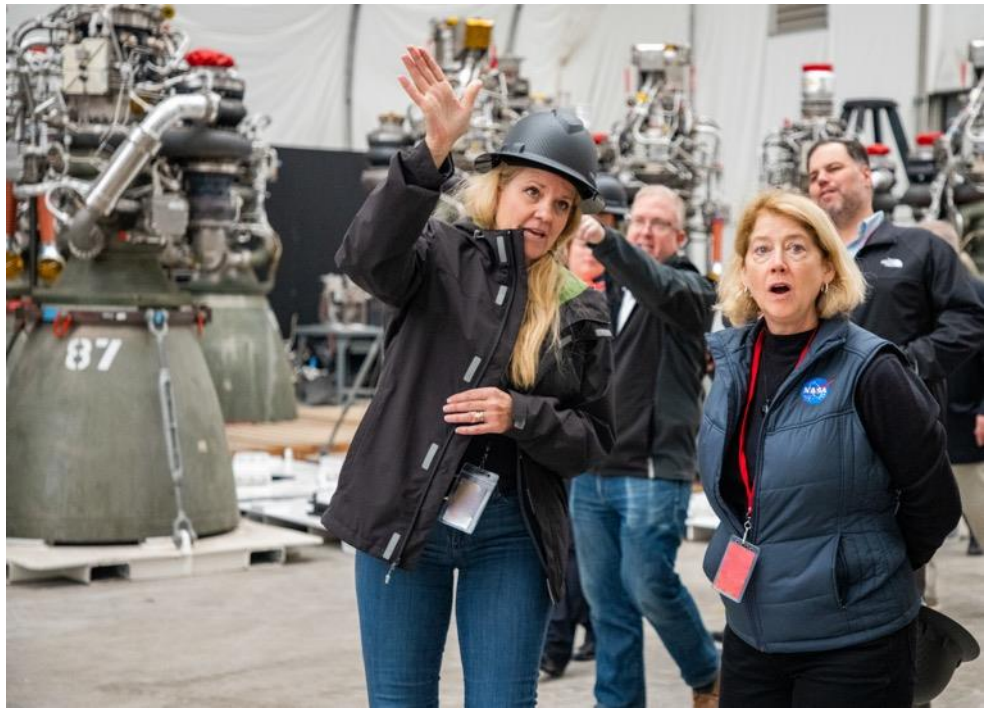
Loiter in NRHO

Artemis III launch

Surface expedition

Crew returns in Orion


SPACEX


87

SN8 Launch

SN15 Landing

Booster 7 Static Fire

Ship 24 + Booster 7 Wet Dress

BLUE MOON

Human Landing System (HLS)

NASA awarded Blue Origin a contract to develop a human landing system built to meet NASA's plans for regularly occurring, long-term access to the lunar surface.

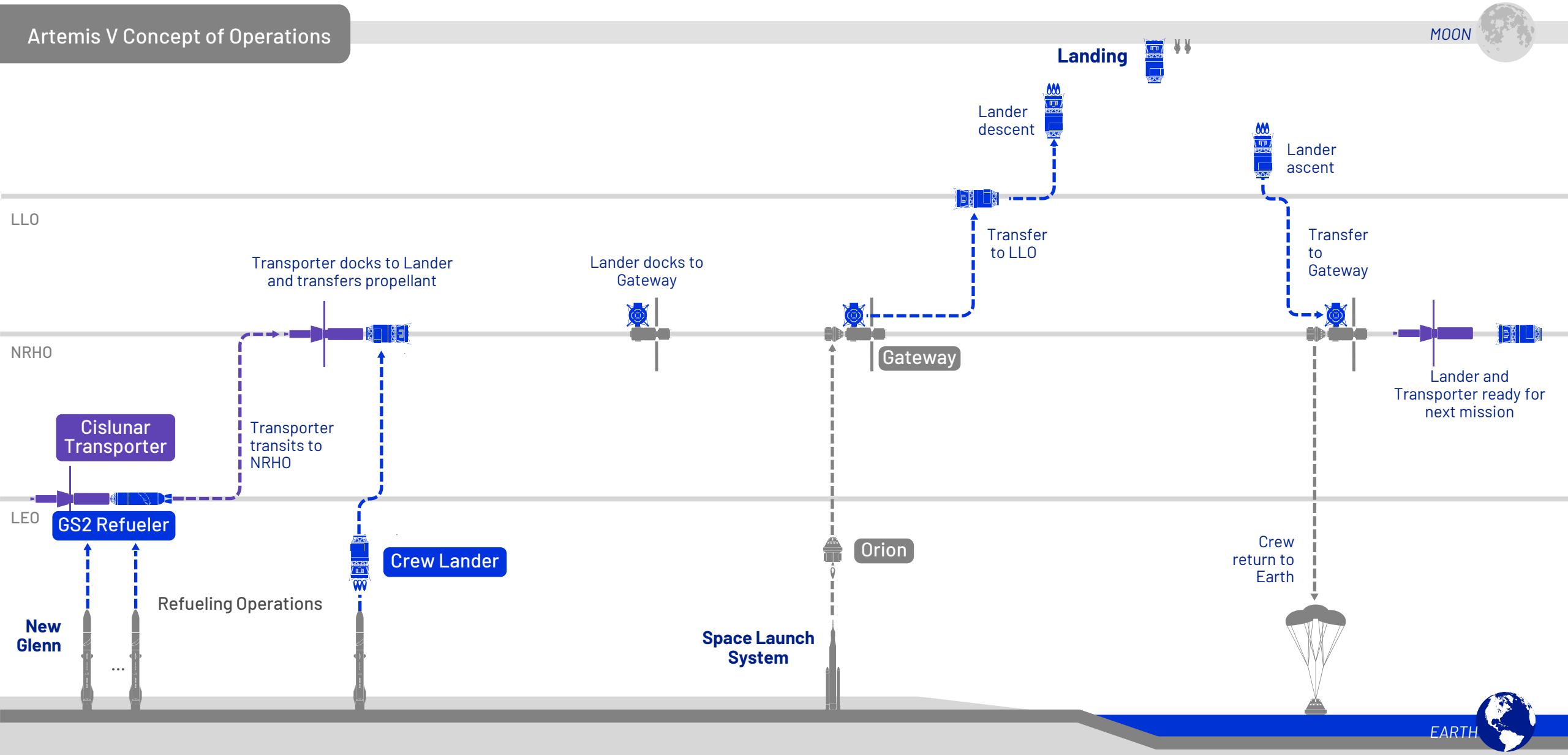
The contract includes one uncrewed demonstration mission and one crewed demonstration mission (Artemis V).

The team's architecture consists of **Blue Origin's** Blue Moon lander and **Lockheed Martin's** Cislunar Transporter as well as:

- **Draper** - guidance software and analysis on the lunar lander; developing pilot simulator and training system
- **Boeing** - active docking adapter for the integrated lander; engineering design; mission support operations
- **Astrobotic** - cargo accommodation system; landing sensor maturation; mission operations
- **Honeybee Robotics** - motion control systems and robotics

Image Credit: Blue Origin

Artemis V Concept of Operations



PHASES	Systems Deployment and Refueling Operations	Initial Lunar Orbit Operations	Descent	Surface	Ascent	Return to Lunar Orbit Ops	Post-Mission Ops

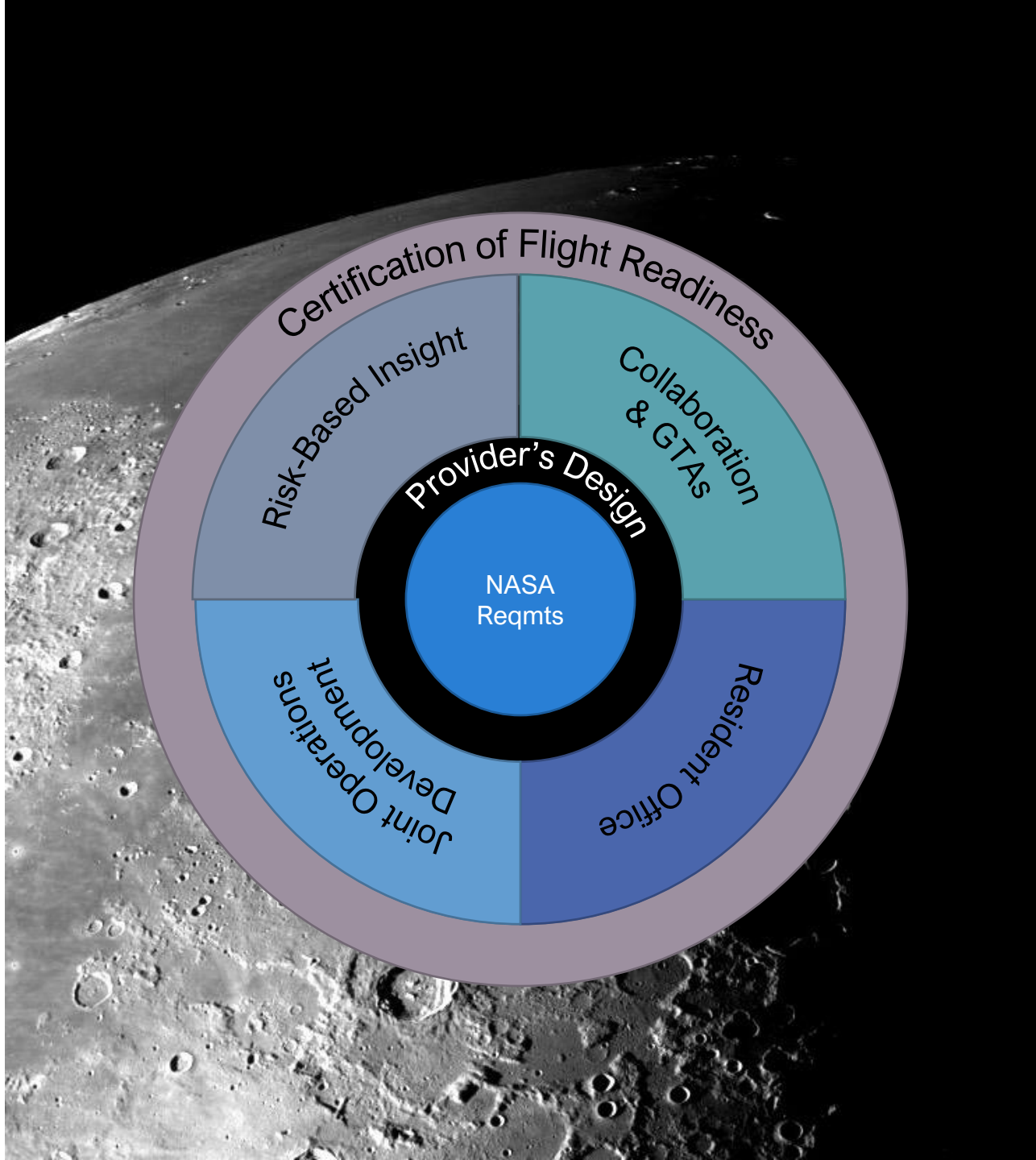
Insight

- Risk based focusing on targeted areas of program concern
- Ensures HLS resources are applied efficiently, and that Providers are not overly burdened by excessive insight activity in low risk areas

Collaboration

- Personnel that are assigned to work with the Provider and part of their team
- Accomplish tasks that are specified by the Provider, and deliverable to the Provider as in-line work

NASA maintains ultimate authority on certification of flight readiness.



Human Landing System Program Office

Marshall Space Flight Center

HQ

Program Executive
Nantel Suzuki

LP01

Program Manager, Dr. Lisa Watson-Morgan
Deputy Program Manager, Kent Chojnacki
Associate Program Manager, Dr. Don Krupp
Associate Program Manager-JSC, Lisa Hammond
Program/Management Analyst, Heather Hall
Secretary, Melissa Walden

External Interfaces
Gateway – Jon Olansen
Launch Services Program – Amanda Mitskevich
Orion – Howard Hu
SLS – John Honeycutt
EGS – Shawn Quinn
EVA & Surface Mobility – Lara Kearney

Procurement Support
Office Chief, Anita Ayers, PS50
Team Lead, Stacey Hadavi, PS53

Program TA
Chief Engineer, Rene Ortega
Deputy Chief Engineer, Angela Olstad, Chance Garcia, Kris McDougal (detail)
Chief Safety Officer, John Crisler
Deputy Chief Safety Officer, Wade Bostick, Chris Cowart
Chief Health and Performance Officer, Jonathan Dory
Deputy Chief Health and Performance Officer, Ryan Johns

LP03

Program Planning & Control Office
Manager, Davey Jones
Deputy Manager, Joe Matus

LP10

Systems Engineering & Integration Office
Manager, Kent Chojnacki (acting)
Deputy Manager, Tom Percy
Lead System Engineer, Tara Polsgrove
Deputy Lead System Engineer, Michelle Garn

LP20

Mission Systems Management Office
Manager, Bill Jacobs
Tech Manager: Larry Gagliano
Management Integration Lead: Daryl Woods
Contracting Represenative: Kevin Flynn

LP30

Space Vehicle Systems Office
Manager, Leo Barreda
Deputy Manager, Jim Stott

JSC

Crew Compartment Office
Manager, Nikki Williams
Deputy Manager, Mike Rapley

KSC

Lander Ground Operations Office
Manager, Khoa Vo
Deputy Manager, Tracy Gill

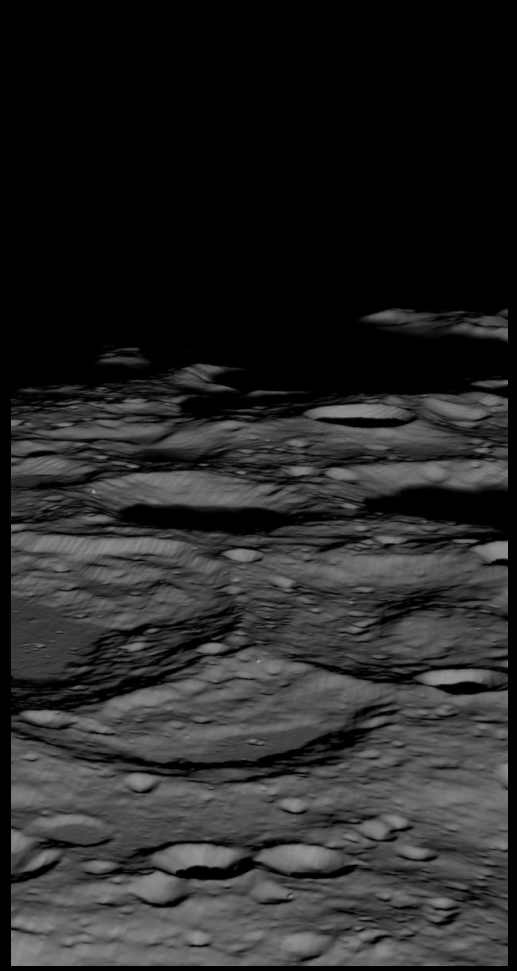
JSC

Lander Flight Operations Office
Manager, Cori Kerr
Deputy Manager, Christie Bertels
Lead Flight Director, Ron Spencer
Crew Office, Raja Chari


Follow the missions
@NASAARTEMIS

HLS Uncrewed Demo

SpaceX Starship



2024

Artemis III

SpaceX Starship

2025

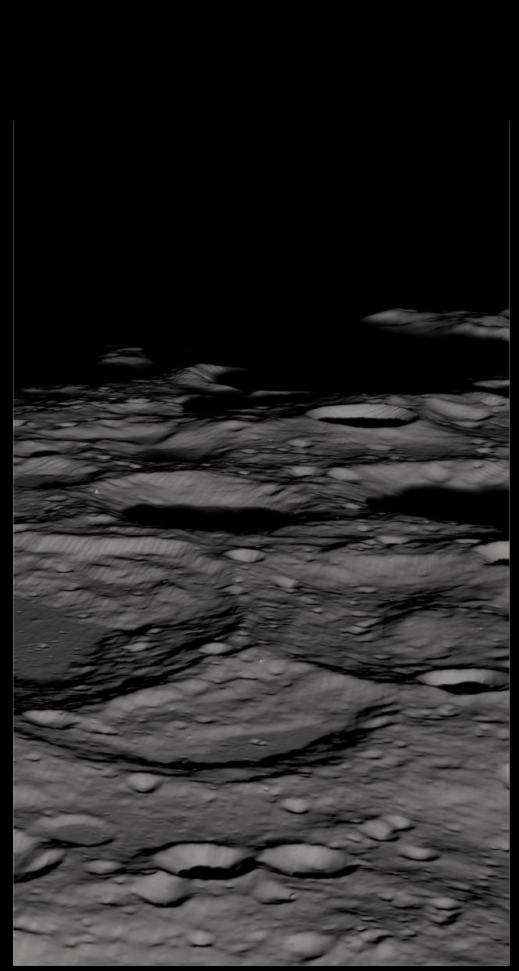
Artemis IV

SpaceX Starship

2028

HLS Uncrewed Demo

Blue Origin
Blue Moon



2028

Artemis V

Blue Origin
Blue Moon

2029

STARSHIP

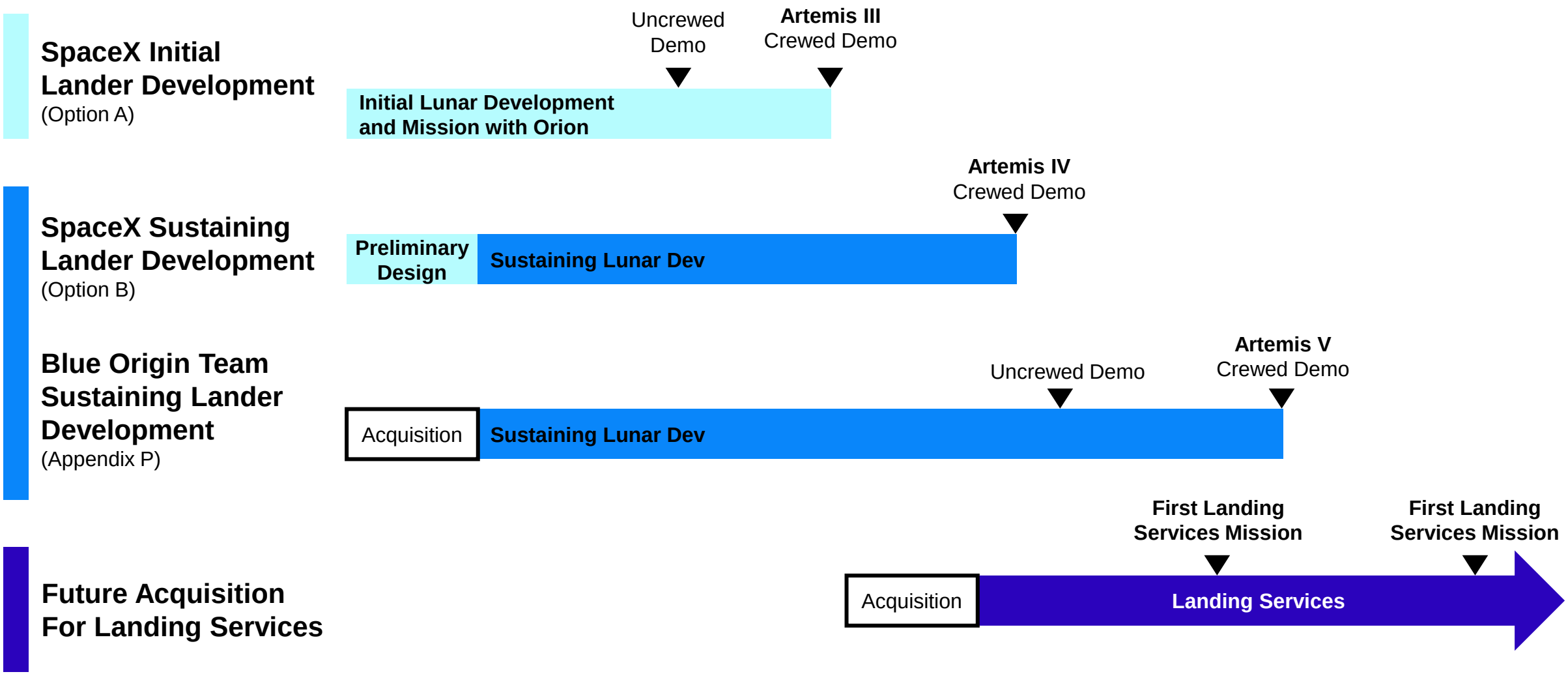
Human Landing System (HLS)

NASA has awarded two contracts to SpaceX:

- Option A – develop its HLS Starship for use on Artemis III, the mission that will put the next two Americans on the surface of the Moon
  - Uncrewed Lunar Landing Demonstration
  - Artemis III
- Option B – further develop its HLS Starship to an extended set of requirements
  - Artemis IV

Image Credit: SpaceX

Human Landing System Acquisition Approach



Human Landing System (HLS) Procurement Path

DESIGN STUDIES, RISK REDUCTION, AND EARLY DEVELOPMENT

Initial Lander Studies & Risk Reduction (Appendix E) *2019-2020*
- Aerojet Rocketdyne
- Blue Origin
- Boeing
- Dynetics
- Lockheed Martin
- Masten Space Systems
- Northrop Grumman
- OrbitBeyond
- Sierra Nevada Corporation
- SpaceX
- SSL

Initial Lander Early Development (Appendix H Base Period) *2020-2021*
- Blue Origin Federation
- Dynetics
- SpaceX

Sustaining Lander Studies & Risk Reduction (Appendix N) *2021-*
- Blue Origin
- Dynetics
- Lockheed Martin
- Northrop Grumman
- SpaceX

FULL DEVELOPMENT AND DEMONSTRATION

SpaceX Uncrewed Lunar Demo-A

SpaceX Crewed Lunar Demo-A

Initial Lander Development & Demonstration (Appendix H Option A) *2021-* — *SpaceX*

SpaceX Crewed Lunar Demo-B

Evolution from Initial to Sustaining Lander (Appendix H Option B) *2022-* — *SpaceX*

Parallel efforts to develop sustaining landers for delivering humans and human-class cargo

Blue Origin Uncrewed Lunar Demo

Blue Origin Crewed Lunar Demo

Sustaining Lander Development & Demonstration (Appendix P) *2023-* — *Blue Origin*

RECURRING TRANSPORTATION SERVICES

Landing Services

(Future task order procurement for delivering humans and human-class cargo)

- Contract Completed
- Contract In Execution
- Future Contract
- Lunar Demo Flight

www.nasa.gov/nextstep

Axiom Extravehicular Mobility Unit (AxEMU)

- The spacesuit that will be worn by the first woman on the Moon during the Artemis III mission
- Built on the heritage of NASA's xEMU design and the agency's decades of spacesuit research and development
- Incorporates the latest technology, enhanced mobility, and added protection from hazards at the Moon

Image: Axiom Space Extravehicular Mobility Unit (AxEMU) spacesuit prototype

Artemis I

MISSION COMPLETE:

The Artemis I mission launched on November 16, 2022, and the Orion spacecraft successfully splashed down on December 11, 2022.

FIRSTS:

- Uncrewed integrated flight test of the Space Launch System (SLS) rocket, Orion spacecraft, and Exploration Ground Systems (EGS) at Kennedy Space Center
- Demonstration of Orion heatshield at lunar re-entry conditions

NEW ELEMENTS:

- SLS rocket Block 1 configuration
- Orion crew spacecraft
- Mobile Launcher 1 and upgraded ground systems

THE ARTEMIS II CREW

The Artemis II crew represents thousands of people working tirelessly to bring us to the stars. This is their crew. This is our crew. This is humanity's crew.

Jeremy Hansen
Mission Specialist
Canadian Space Agency Astronaut

Reid Wiseman
Commander
NASA Astronaut

Victor Glover
Pilot
NASA Astronaut

Christina Hammock Koch
Mission Specialist
NASA Astronaut

THE ARTEMIS II CREW

NASA Astronauts

REID WISEMAN
Commander

VICTOR GLOVER
Pilot

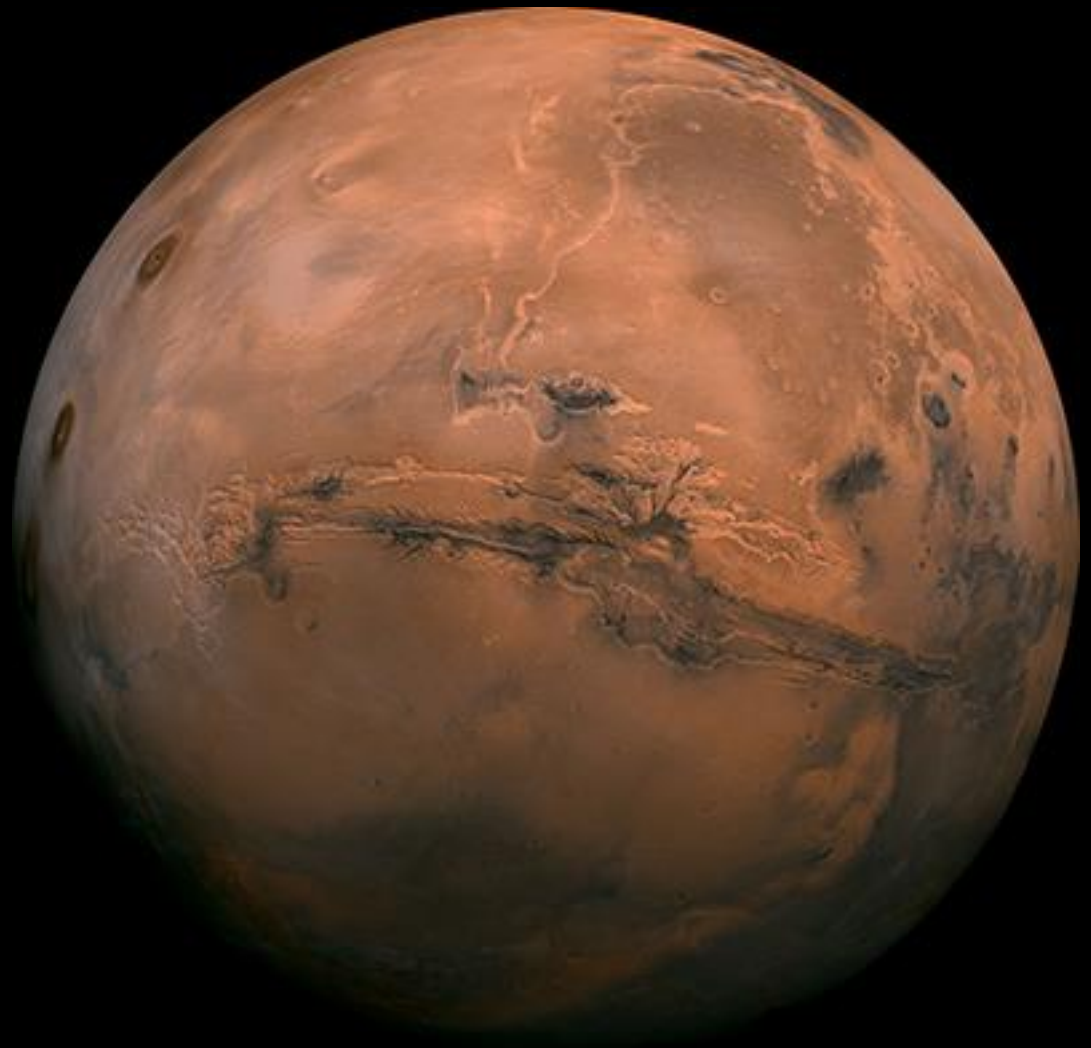
CHRISTINA HAMMOCK KOCH
Mission Specialist

Canadian Space Agency Astronaut

JEREMY HANSEN
Mission Specialist

The Artemis II crew represents thousands of people working tirelessly to bring us to the stars. This is their crew. This is our crew. This is humanity's crew.


ARTEMIS
Lunar surface infrastructure
A sustainable environment to live and work on the lunar surface



Notional Human Spaceflight Strategy for Integrated Research and Testing for Mars Mission Readiness

FIRST MISSIONS TO MARS

●●●●

OPERATIONAL VALIDATED CREW HEALTH & PERFORMANCE

Mission Verification & Validation

ARTEMIS LUNAR-BASED ANALOGS

●●●○

MICROGRAVITY / PARTIAL GRAVITY

DEEP SPACE RADIATION

EXPLORATION MEDICAL CAPABILITY

EXTENDED MISSIONS

Risk mitigation of integrated hazards

Human systems validation

LOW-EARTH ORBIT RISK REDUCTION

●●○○

MICROGRAVITY / 1G TRANSITIONS

GENE / MICROGRAVITY INTERACTIONS

CROP PRODUCTION

TEST NEW SYSTEMS

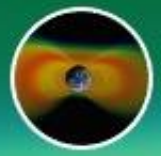
INTEGRATED SIMULATIONS

Risk mitigation of single hazards

Risk mitigation of integrated and simulated hazards

GROUND-BASED RESEARCH

●○○○



SPACE RADIATION SIMULATION

BEDREST

ISOLATION ANALOGS

ANALOG FIELD TESTS

CREW HEALTH AND PERFORMANCE SYSTEM FORMULATION

TIME → GROUND & ISS | LEO COMMERCIALIZATION | ARTEMIS BASECAMP | FIRST MISSION TO MARS

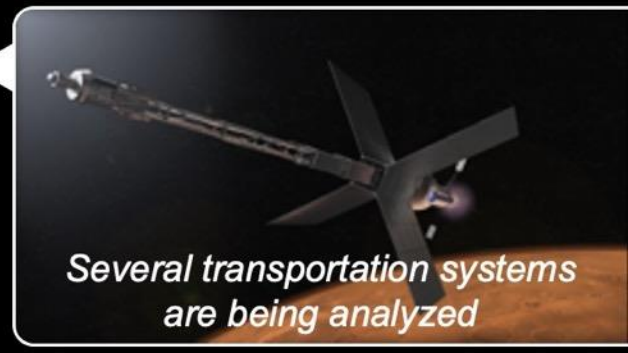
One of Several Potential Concepts for a First Human Mission to Mars

Illustrating the minimum suite of elements needed for a “light exploration footprint”.

TRANSIT HABITAT AND TRANSPORTATION STAGE

Supports four crew on the two to three-year mission to Mars

Two crew remain in orbit while two crew visit the Mars surface



Several transportation systems are being analyzed

1 PRE-DEPLOYED CARGO

2 PRE-DEPLOYED MARS ASCENT VEHICLE

3 CREW AND PRESSURIZED ROVER