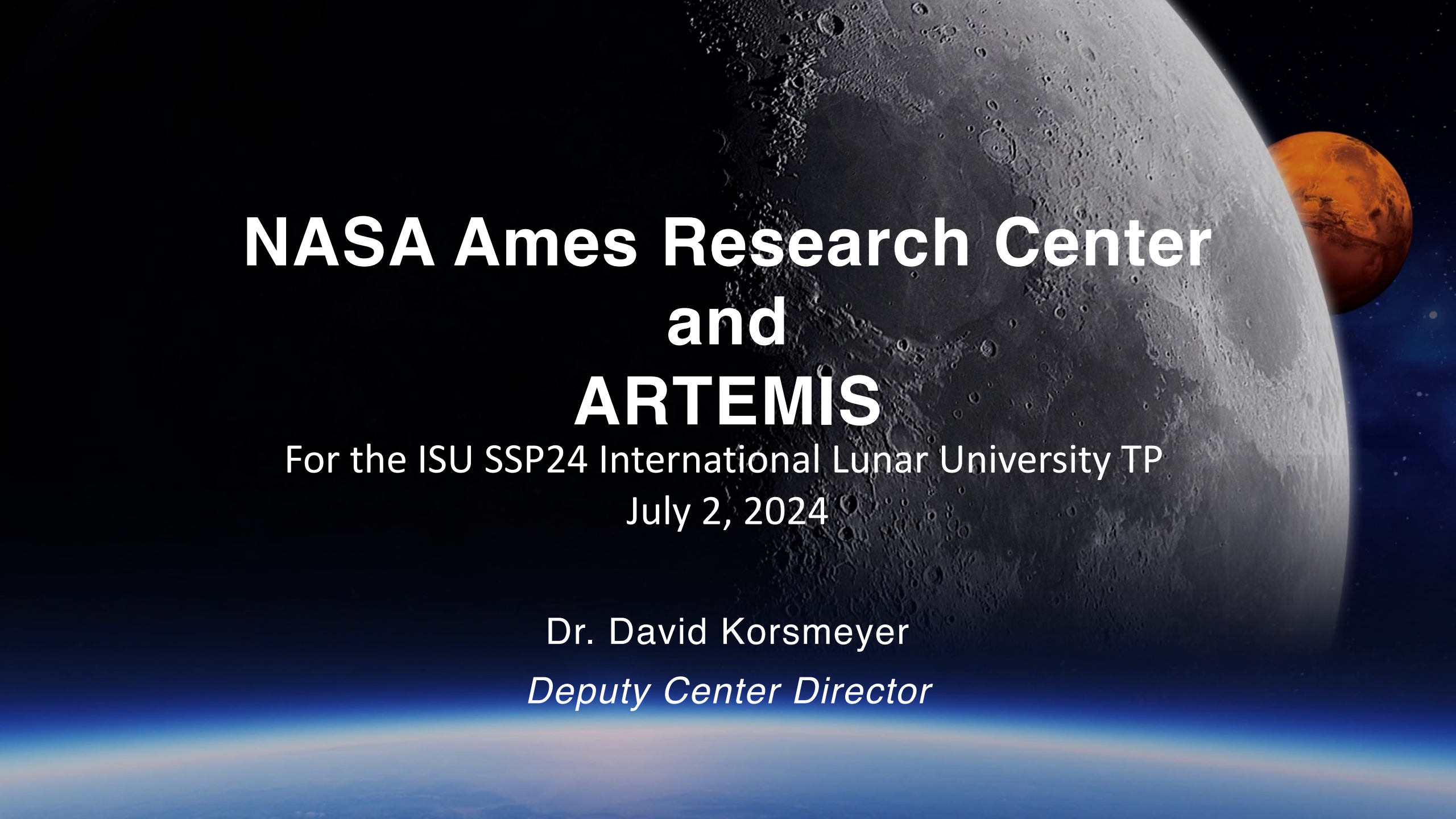


NASA Ames Research Center and ARTEMIS

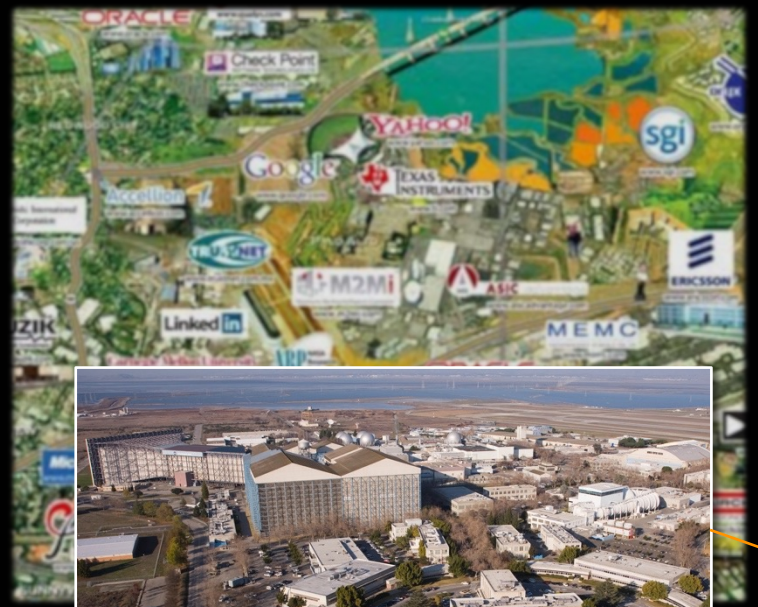
For the ISU SSP24 International Lunar University TP

July 2, 2024

Dr. David Korsmeyer

Deputy Center Director

NASA Centers



Ames Research Center



Glenn Research Center



HQ



Goddard Space Flight Center



Langley Research Center





Marshall Space Flight Center



Armstrong Flight Research Center



Jet Propulsion Laboratory

Johnson Space Center



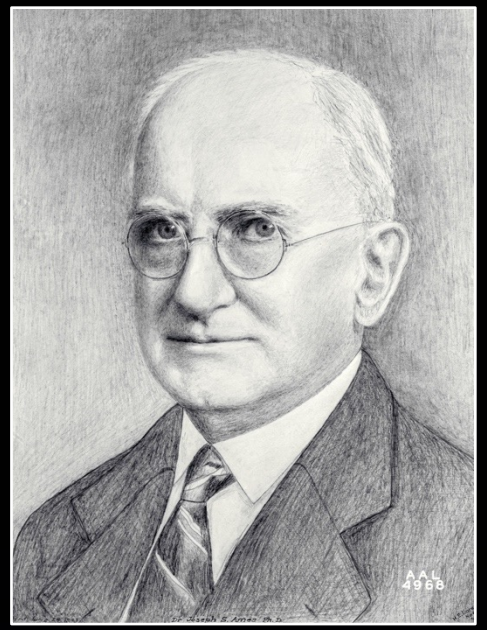
Stennis Space Center

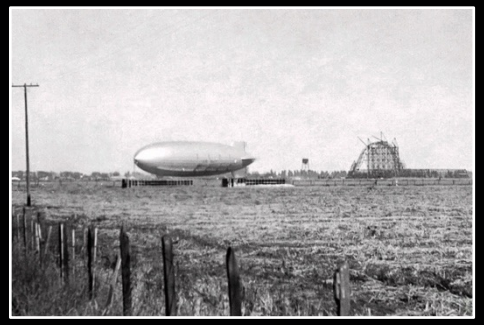


Kennedy Space Center

Ames Aeronautical Laboratory

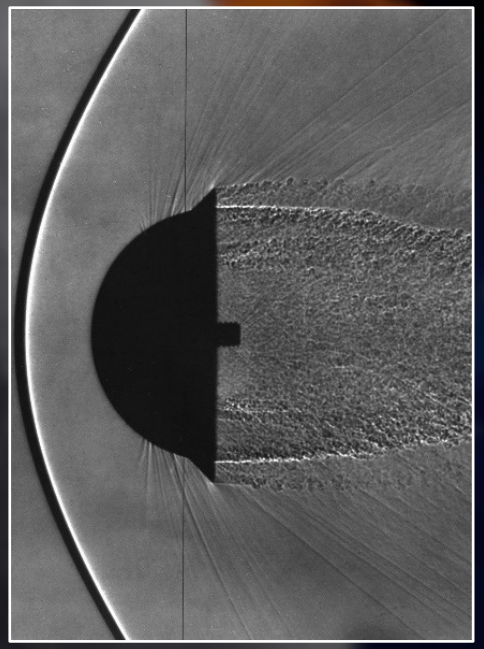
NACA's Second Laboratory

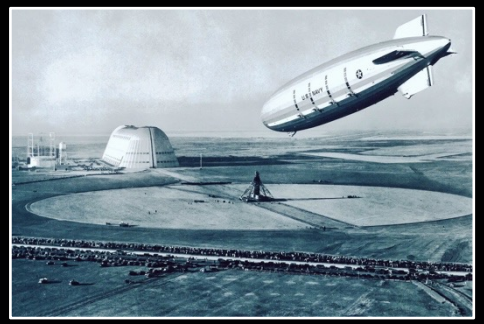


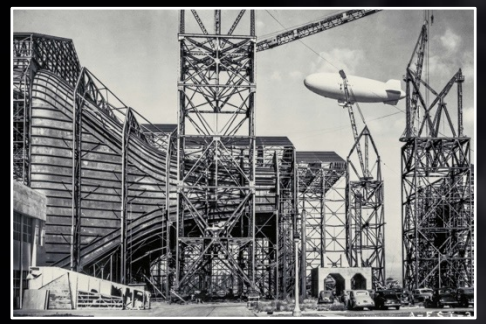










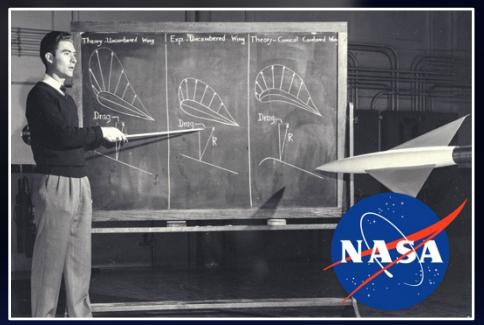












1915 1917 1939 1941 1946 1958

"Langley Memorial Aeronautical Laboratory"
Langley Research Center (LaRC)

"Ames Aeronautical Laboratory"
Ames Research Center (ARC)

"Aircraft Engine Research Laboratory"
Glenn Research Center (GRC)

"Muroc Flight Test Unit"
Armstrong Flight Research Center (AFRC)

Ames Today



Occupants (FY23)

~1,300 civil servants; ~1,900 on-site contractors
~5,800 NRP workforce
~700 students (OSTEM, Pathway, NRP(CMU) & Chabot SCC)

Real Property

~1,900 acres; 400 acres security perimeter
5M building ft²
Airfield with ~9,000 and 8,000 ft. runways

Budget (FY23)

~$1B (includes reimbursable/EUL)

Ames' 85 Years of Innovation

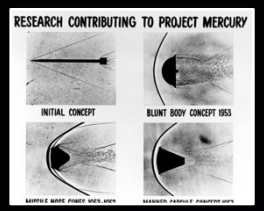

1955


Launch Escape System (1963)

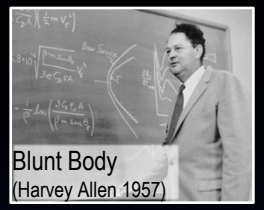


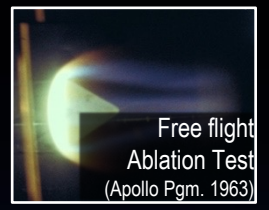
1957

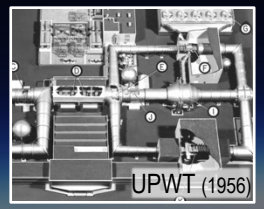

Lifting Body (M2F1 1965)






Blunt Body
(Harvey Allen 1957)


Free flight Ablation Test
(Apollo Pgm. 1963)


UPWT (1956)


Steerable parachute (1963)

1940 2020

Ames' 85 Years of Innovation


1955


Launch Escape System (1963)


Pioneer (1972)

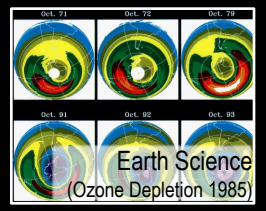

Viking (1975)


Galileo (1989)

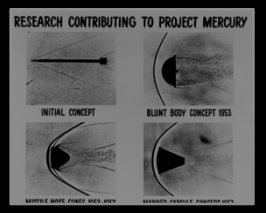

1957


Lifting Body (M2F1 1965)


Airborne Science (ER2 1970)

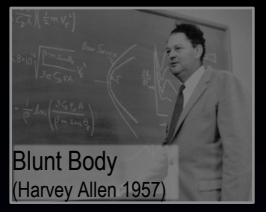

Earth Science (Ozone Depletion 1985)


Earth Science Project Office (1987-)






XV-15 (1980)

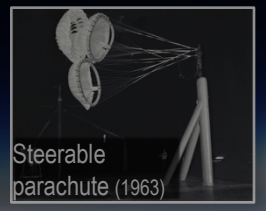

Blunt Body (Harvey Allen 1957)

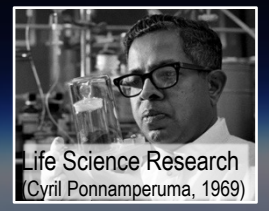

Free flight Ablation Test (Apollo Pgm. 1963)


Reusable Surface Insulation Lost Tile Test (Shuttle Pgm. 1976)


PICA (1980s)


UPWT (1956)


Steerable parachute (1963)


Life Science Research (Cyril Ponnamperuma, 1969)


Cray-2 (1987)

1940 2020

Ames' 85 Years of Innovation





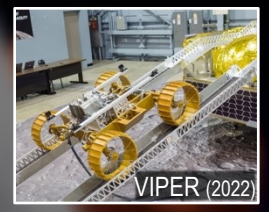






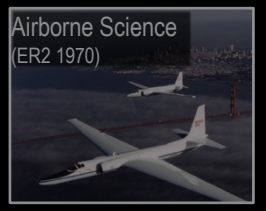


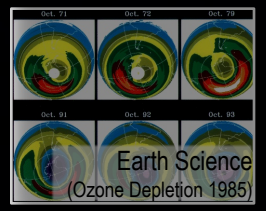










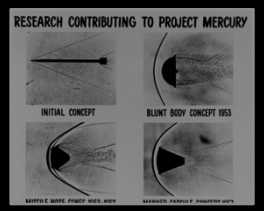
















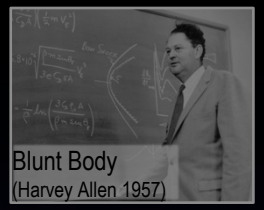






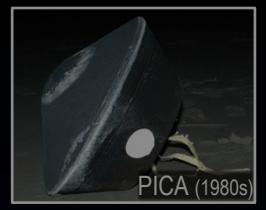










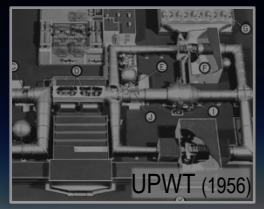


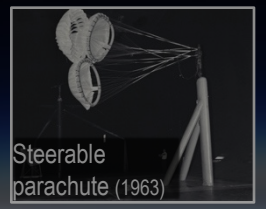


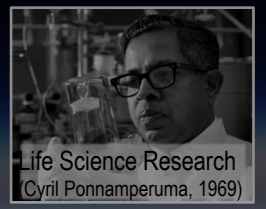




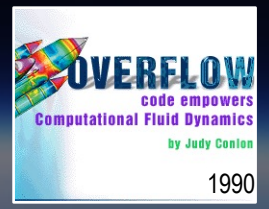


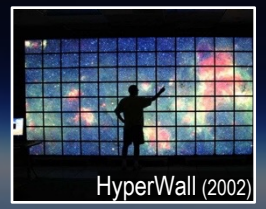


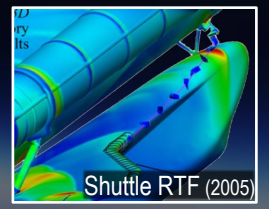














1940 2020

What Does NASA Ames Do?

Aeronautics Research







Transform Aviation through R&D

Space Operations





Launch and Space Operations

Deep Space Exploration Sys.









Moon to Mars Exploration

Science





Understand the Sun, Earth, and Universe

Space Technology





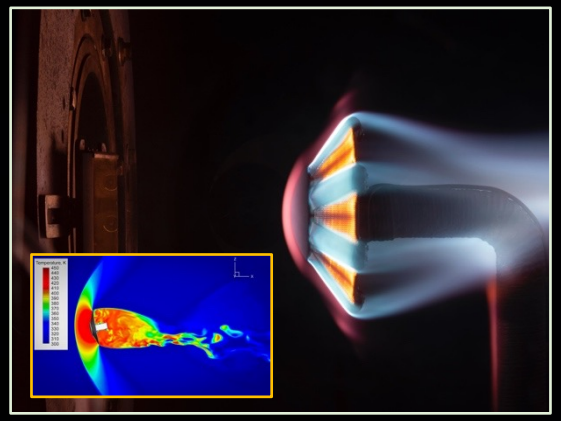
Develop and transfer revolutionary technologies

Ames Core Competencies

Air Traffic Management



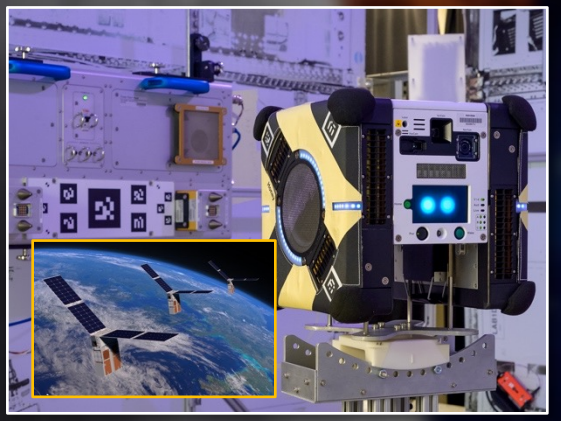
Entry Systems



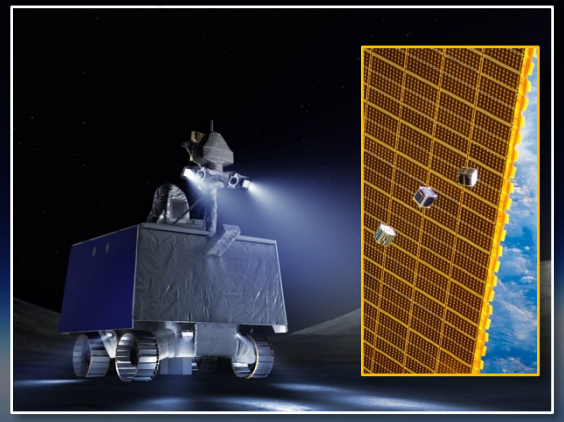
Advanced Computing & IT



Intelligent / Adaptive Systems



Cost-Effective Space Missions



Aerosciences



Astrobiology & Life Science

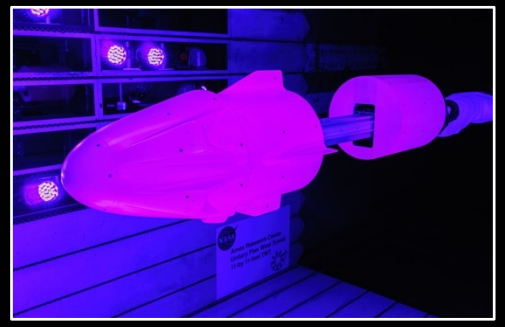


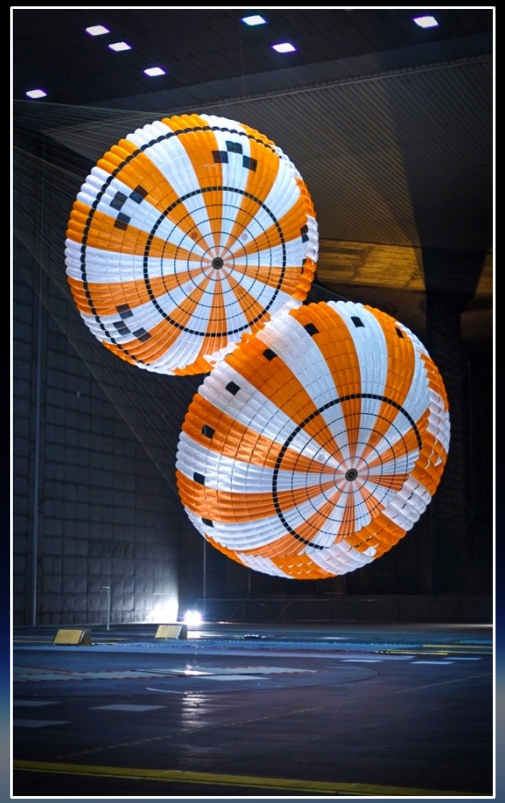
Space & Earth Sciences



Ames' Major Research Facilities

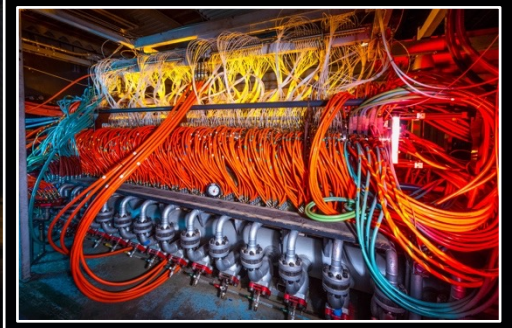
Wind Tunnels





Arc Jet Complex







Simulators







Supercomputing



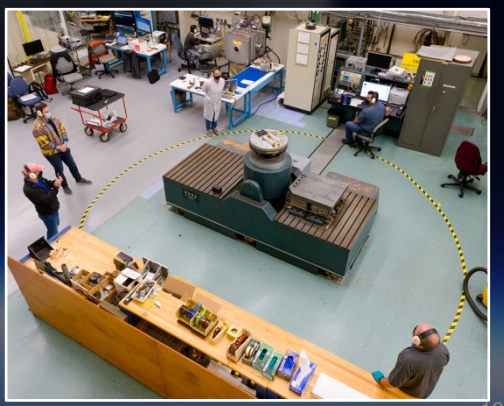


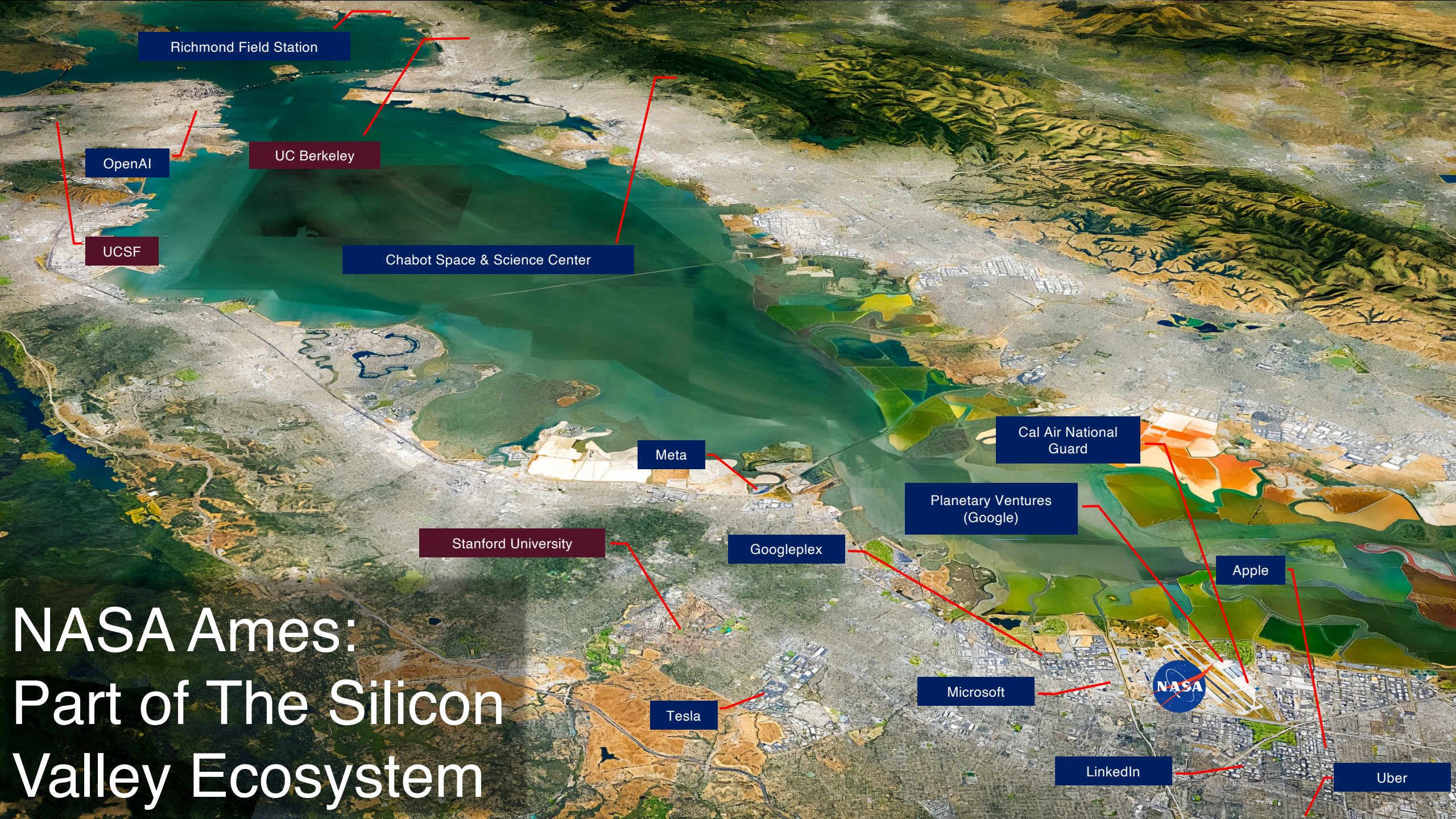


Laboratories







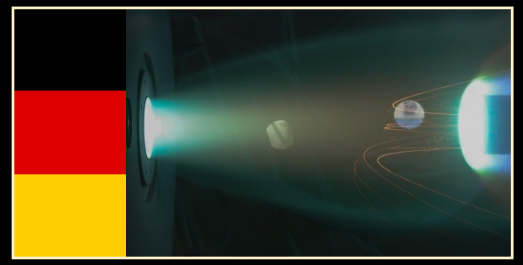


NASA Ames: Part of The Silicon Valley Ecosystem

Ames' Partnerships

International

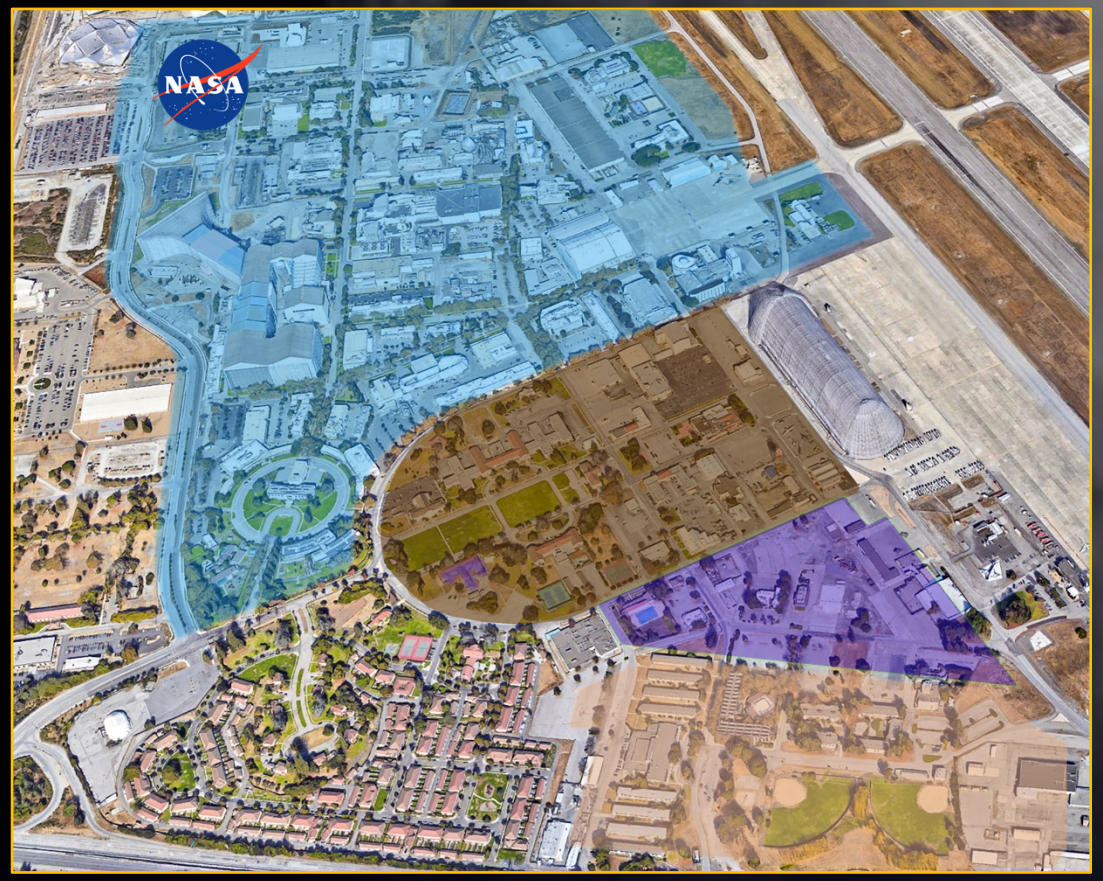






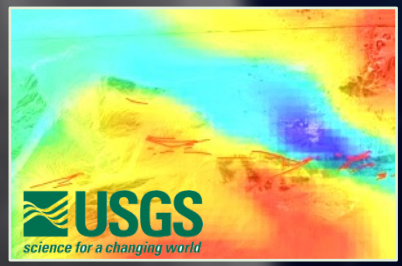






Inter-Agency





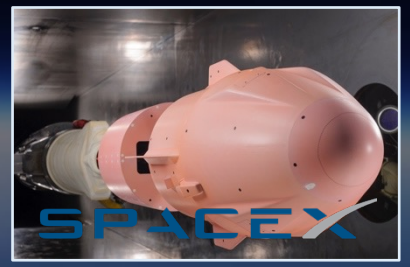


Commercial









Academic

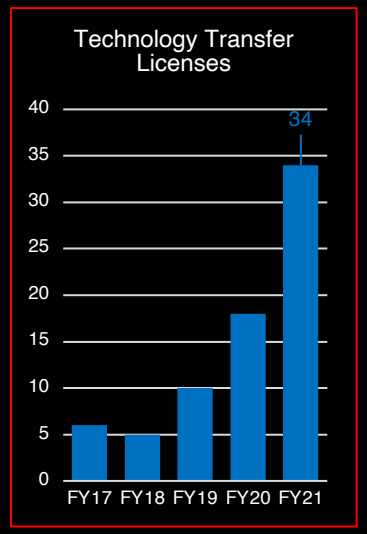


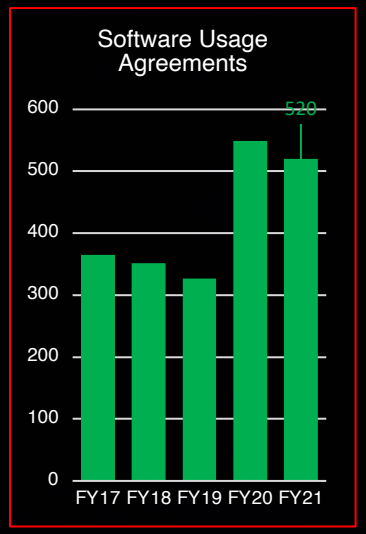


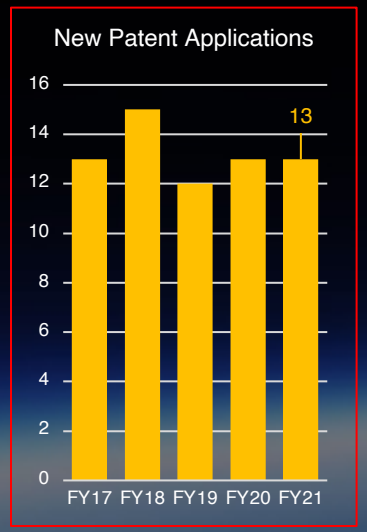

NASA Research Park
Planetary Ventures
California Air National Guard
Berkeley Science Center
USGS
Carnegie Mellon University
CMU
Mountain View Housing Venture
NASA
SILICON VALLEY
AMES RESEARCH CENTER

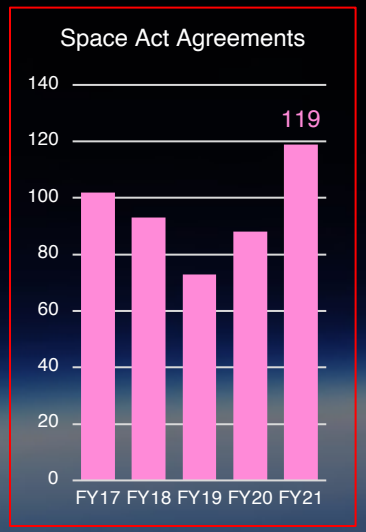
Ames' Technology Transfer

Metrics

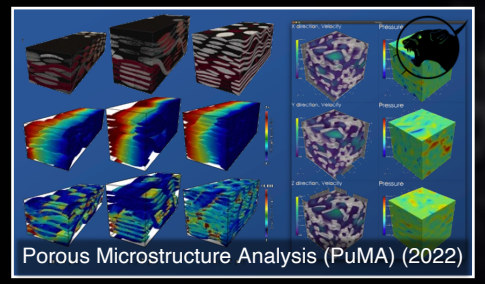


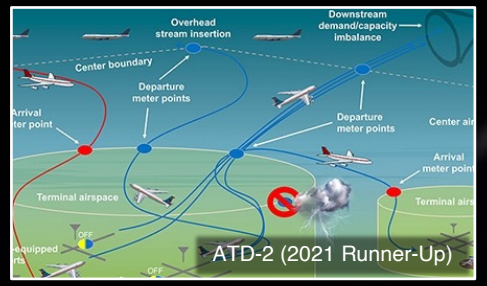






Software of the Year



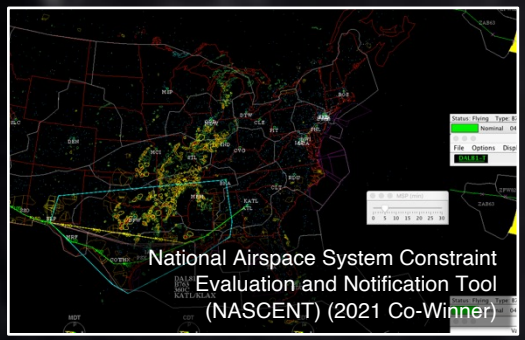




In the Past 10 years:
- 7 Winners, 3 Runner ups

Invention of the Year



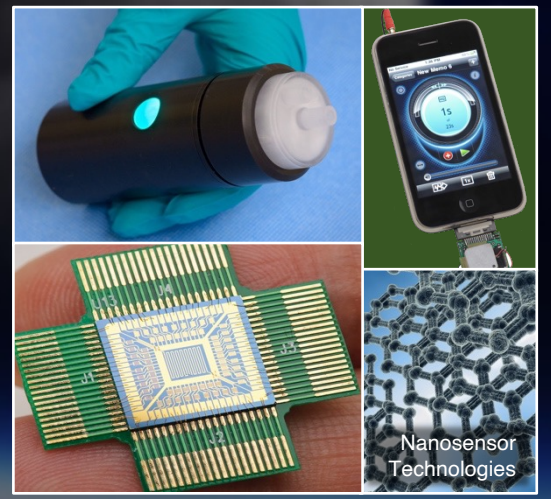




In the Past 10 years:
- 5 Winners, 1 Co-winner, 1 Runner up

Patents






ARTEMIS
Enabling Deep
Space Human
Exploration
ARTEMIS
NASA

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

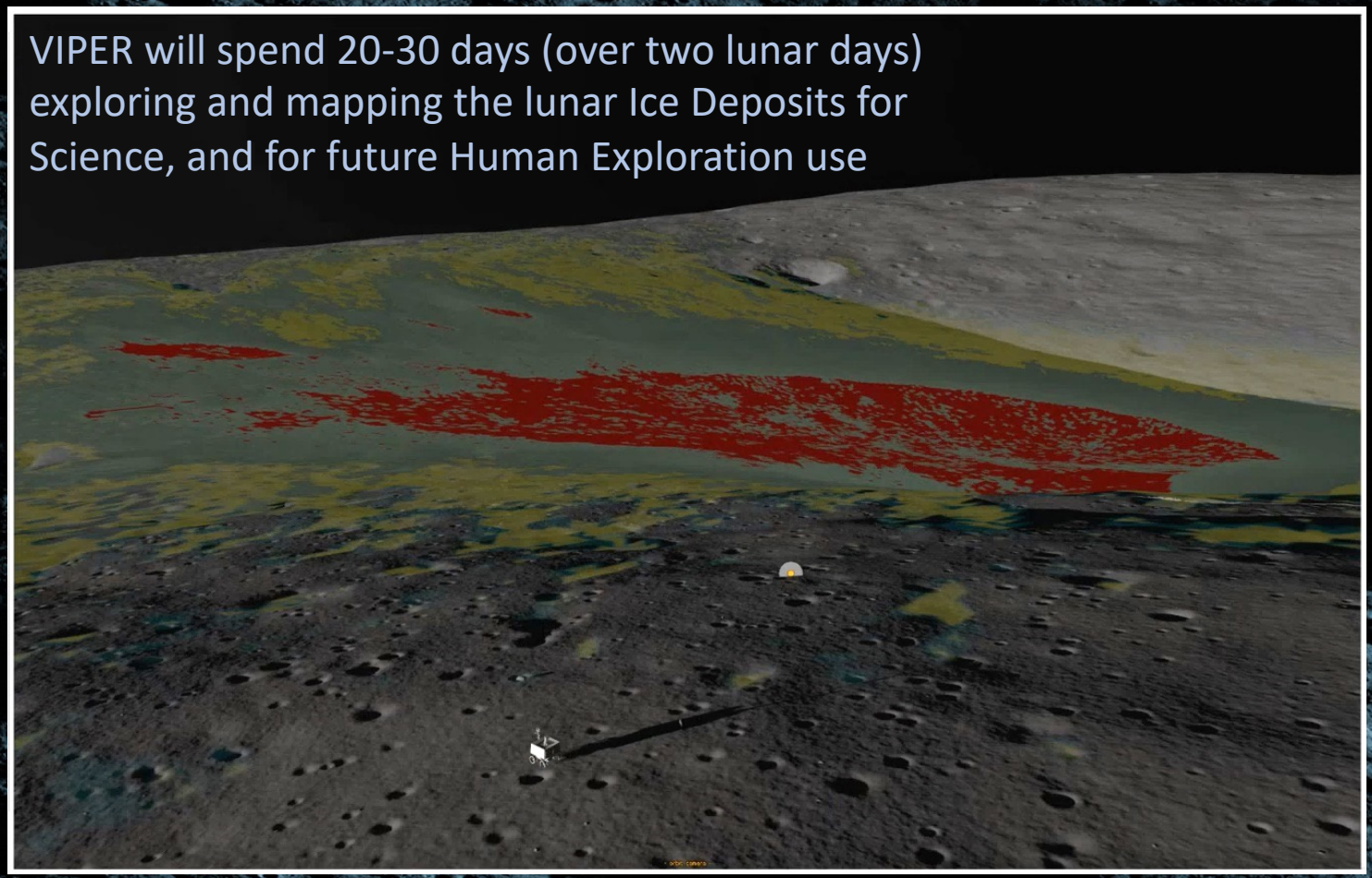
VIPER Mission: Exploring Ice Region at Lunar Pole

VIPER



Ames manages the VIPER Mission
- PM, PI, Instrument leads, Software and Ops
- JSC is the Rover hardware lead and developer
- KSC provides a key instrument

VIPER will spend 20-30 days (over two lunar days) exploring and mapping the lunar Ice Deposits for Science, and for future Human Exploration use



Screenshot from the VIPER Traverse Planning tool /M. Shirley



Artemis I: 2022

Uncrewed Flight Test

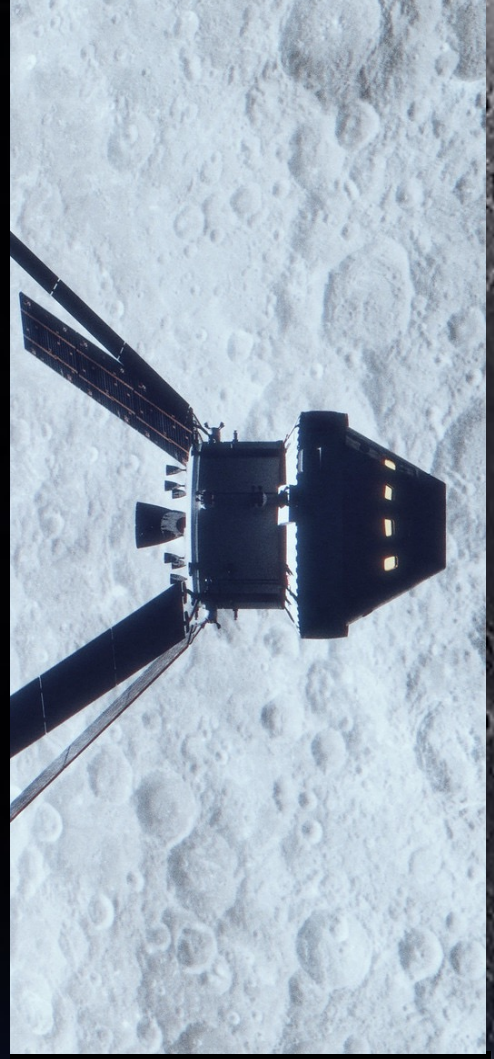
Space Launch System & Orion Spacecraft



VIPER: 2025+

Robotic Rover

Ice Exploration and Prospecting



Artemis II: 2025+

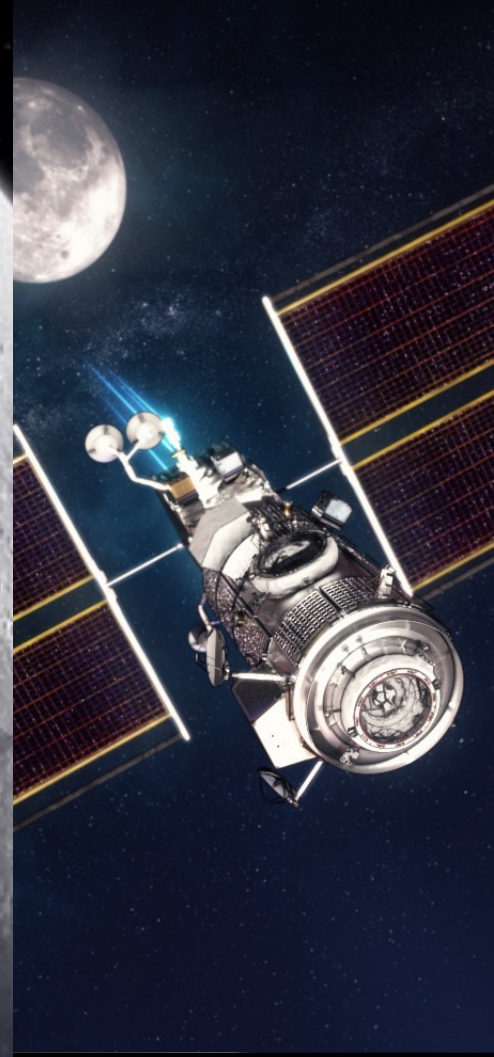
Crewed Flight Test

Space Launch System & Orion Spacecraft



SpaceX Uncrewed Demo

Starship Demonstration to the lunar surface



Gateway: 2026+

A lunar orbiting Crewed outpost

Exploration Campaign & Segments

LEO AND EARTH ANALOGS

SUSTAINED LUNAR EVOLUTION

HUMAN LUNAR RETURN

EXPLORATION, EXCURSIONS AND EVALUATION

ARTEMIS RESEARCH & LONG-DURATION MARS ANALOGS

HUMANS TO MARS

ISS AND COMMERCIAL LEO PLATFORMS

COMMERCIAL CARGO

SLS BLOCK 1

ORION

NEAR-TERM ARTEMIS MISSIONS

SLS BLOCK 1B

Global & Regional Site Diversity

Mobile Assets Meet Crew Where Possible

SLS BLOCK 2

A Campaign, Not Just A Demonstration Mission

Expanded Objectives Similar to Lunar

GATEWAY

Increased Crew Size & Longer Durations in Micro-gravity

TRANSIT HABITAT AND MARS TRANSIT

COMMUNICATIONS RELAYS

SURFACE HABITAT

HUMAN LANDING SYSTEM

LOGISTICS LANDER

Nuclear Surface Power

MARS ASCENT VEHICLE

Habitation Systems

PRESSURIZED ROVER

Partial Gravity Operations

Mobile Expedition Duration / Mobile Exploration Range

PRESSURIZED ROVER

LUNAR TERRAIN VEHICLE

In-Situ Resource Utilization

MARS TERRAIN VEHICLE

Autonomous Robotics Systems & Contingency Crew Transportation

Segments – Defined more by emerging objective satisfaction emphasis than time

Campaign – Matures based upon reconnaissance, discovery, progress and partners

Evolved Lunar Capabilities Feed Forward to Expanded Mars Campaign Objectives

Lunar Surface Evolution

Increased Science Capability

Increased Payload/Cargo Return

Increased Economic Opportunity

Increased Duration & Population

Ames for Artemis: Exploration Campaign & Segments

LEO AND EARTH ANALOGS

SUSTAINED LUNAR EVOLUTION

HUMAN LUNAR RETURN

EXPLORATION, EXCURSIONS AND EVALUATION

ARTEMIS RESEARCH & LONG-DURATION MARS ANALOGS

HUMANS TO MARS

Launch Veh Analyses
Heat Shield Development

SLS BLOCK 1

ORION

ARTEMIS MISSIONS

SLS BLOCK 1B

Global & Regional Site Access

Mobile Assets Meet Crew Where Possible

SLS BLOCK 2

A Campaign, Not Just A Demonstration Mission

Expanded Objectives Similar to Lunar

ISS AND COMMERCIAL LEO PLATFORMS

COMMERCIAL CARGO

Autonomy Software
Diagnostic Systems

GATEWAY

Increased Crew Size & Longer Durations in Micro-gravity

TRANSIT HABITAT AND MARS TRANSIT

COMMUNICATIONS RELAYS

Mars Entry Systems

SURFACE HABITAT

HUMAN LANDING SYSTEM

LOGISTICS LANDER

Nuclear Surface Power

MARS ASCENT VEHICLE

ECLSS
Human Systems Integration

Habitation Systems

Partial Gravity Operations

Mobile Expedition Duration / Mobile Exploration Range

PRESSURIZED ROVER

PRESSURIZED ROVER

LUNAR TERRAIN VEHICLE

In-Situ Resource Utilization

Autonomous Robotics Systems & Contingency Crew Transportation

MARS TERRAIN VEHICLE

VIPER – Exploration Robotics & Flyers
ISRU / Resource Mapping

Segments – Defined more by emerging objective satisfaction emphasis than time

Campaign – Matures based upon reconnaissance, discovery, progress and partners

BioScience & Lunar Sample Return

Evolving Lunar Capabilities Enable Expanded Mars Campaign Objectives

Lunar Surface Evolution

Increased Science Capability

Increased Payload/Cargo Return

Increased Economic Opportunity

Increased Duration & Population

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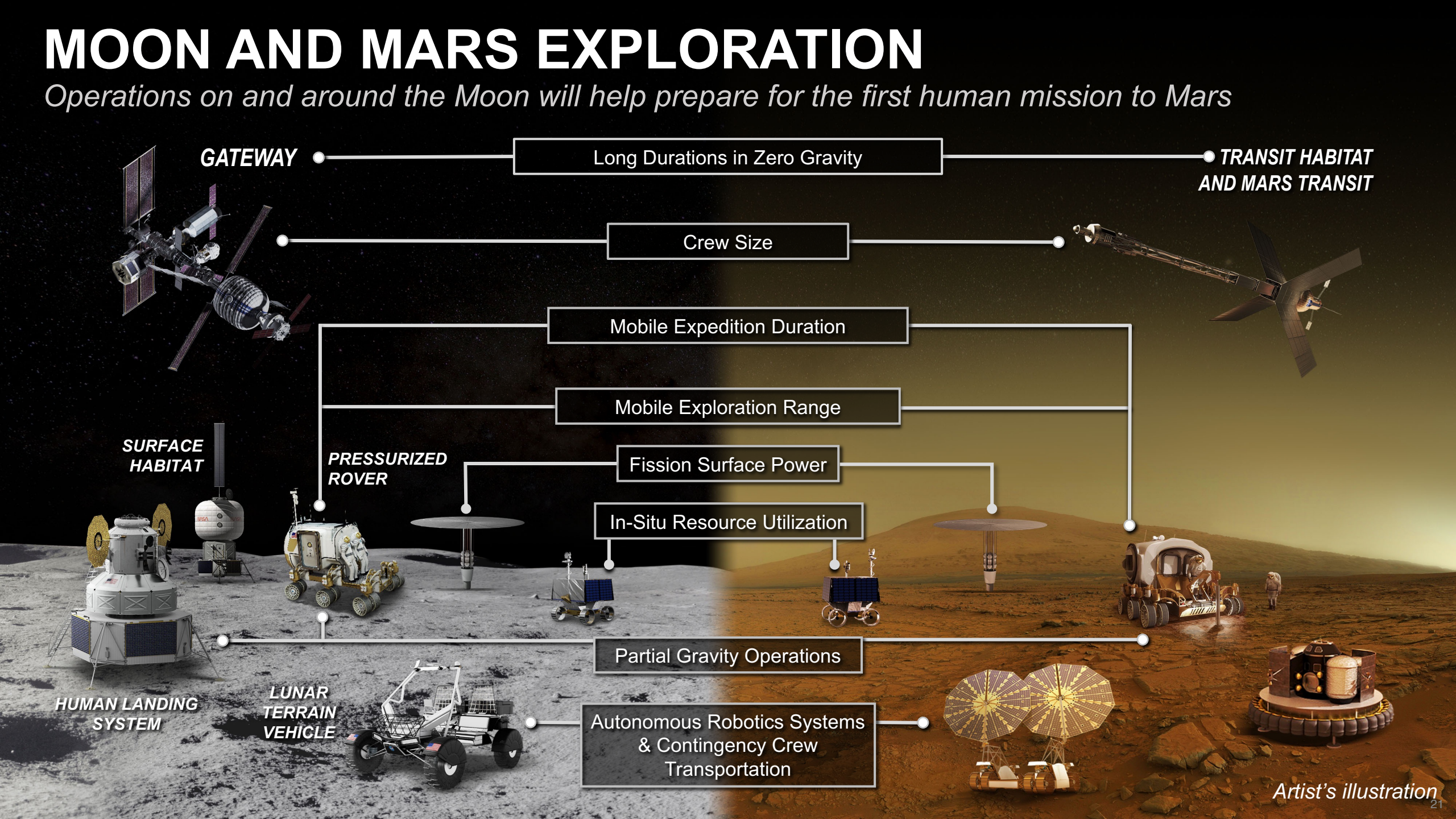
MOON AND MARS EXPLORATION

Operations on and around the Moon will help prepare for the first human mission to Mars



Artist's illustration

Exploration Architecture

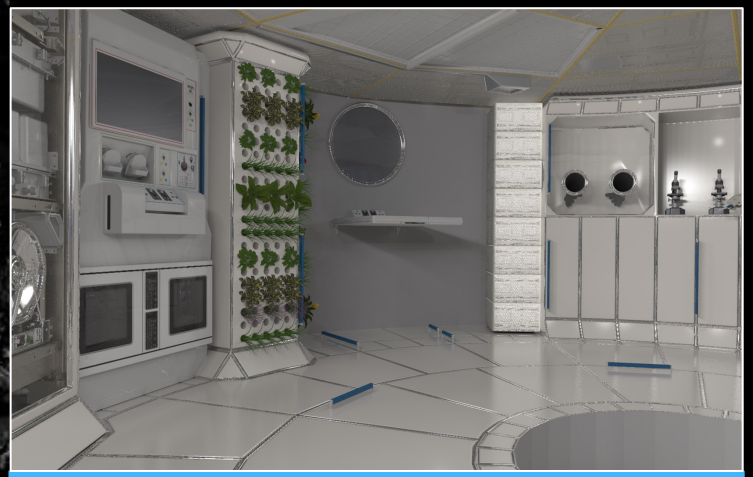
A set of functional capabilities, their translation into elements, their interrelations and operations. The architecture enables the implementation of various mission scenarios that achieve a set of given scientific and exploration systems goals and objectives.



TRANSPORTATION

In Space:
- SLS
- Orion
- Commercial Launch Providers

To/On the Surface:
- Human Landing System
- Lunar Terrain Vehicle
- Pressurized Rover



HABITATION & LIFE SUPPORT

In Space:
- Orion
- Gateway HALO
- Gateway I-Hab

On the Surface:
- Human Landing System
- Spacesuits
- Surface Habitat
- Pressurized Rover



INFRASTRUCTURE

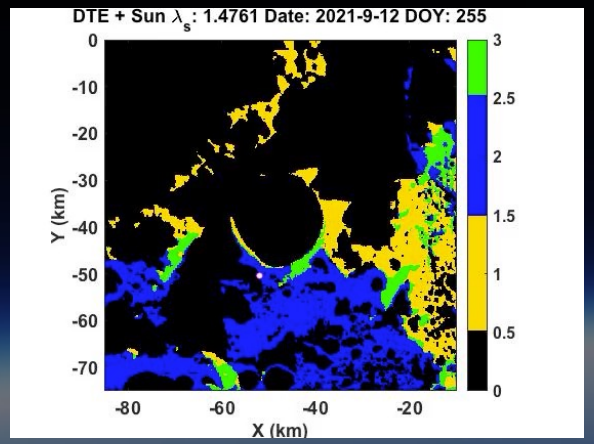
In Space:
- PPE: Comm and Power
- Deep Space Logistics Deliveries
- LunaNet

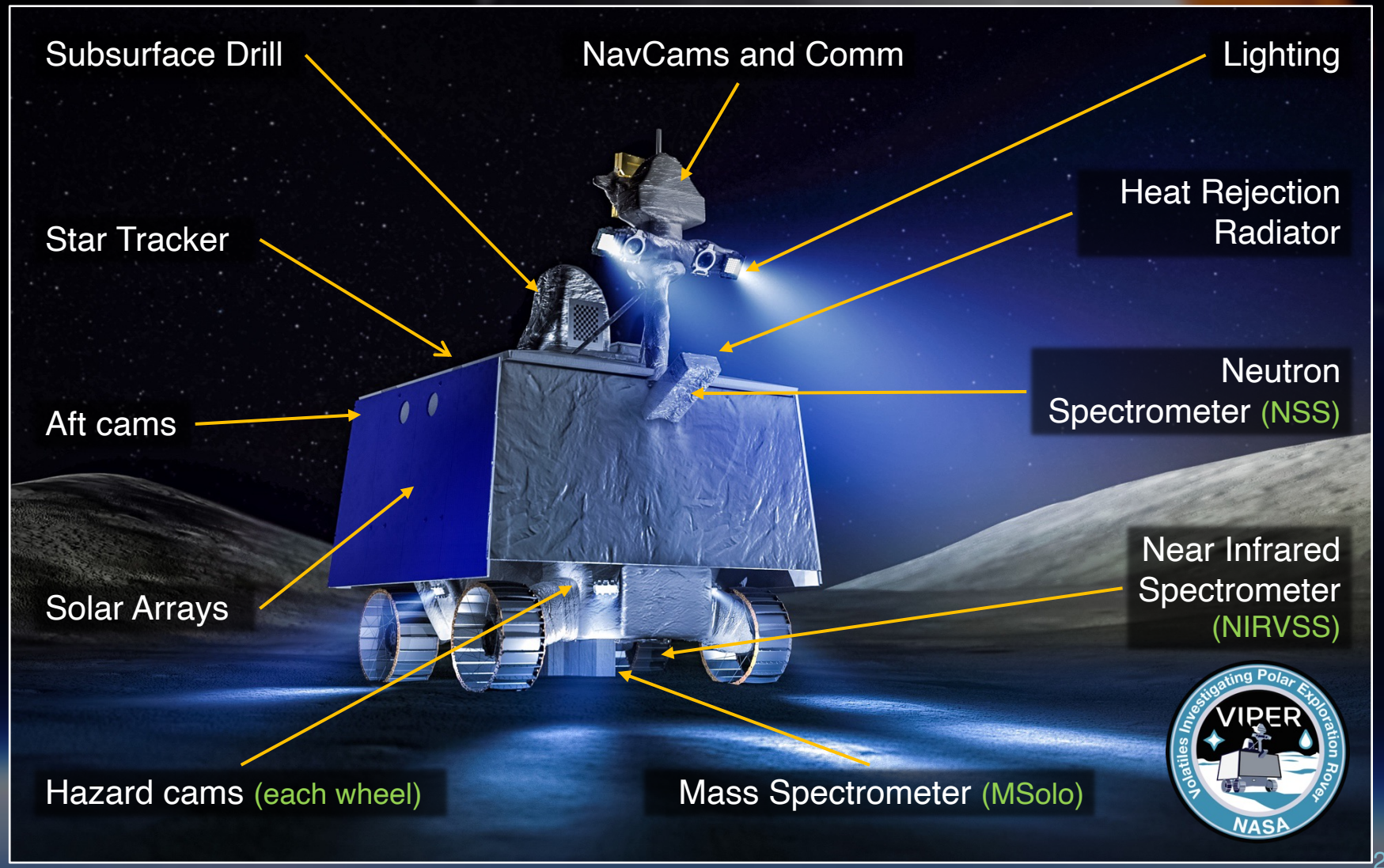
On the Surface:
- Fission Surface Power
- Logistics and Science Deliveries


NASA
*Concept image

VIPER Rover @ Lunar South Pole







24

ARTEMIS I

Uncrewed Flight Test

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

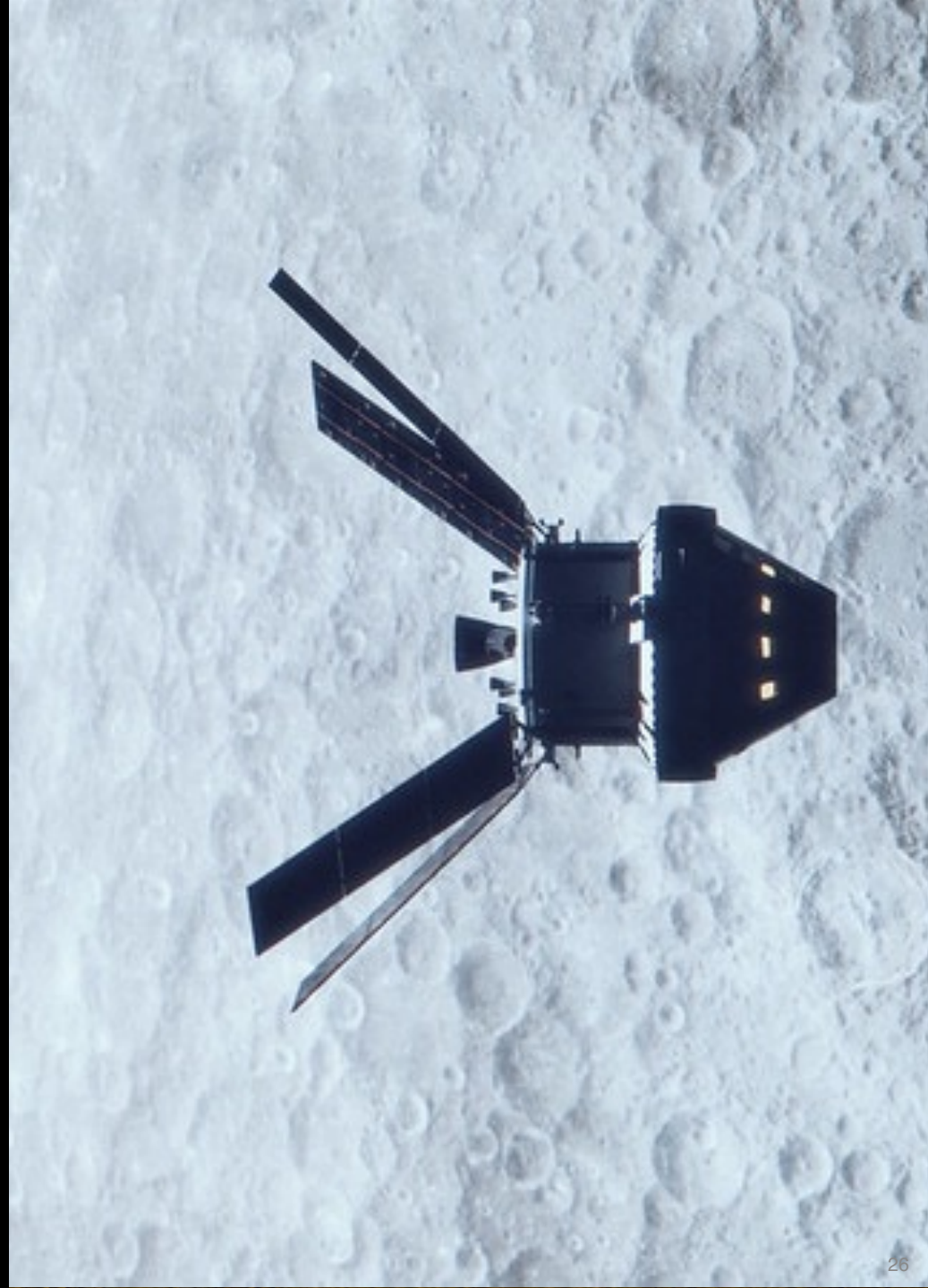
Status Update: Started rolling back to VAB last night. No new launch date yet, but expect late October/November



ARTEMIS II

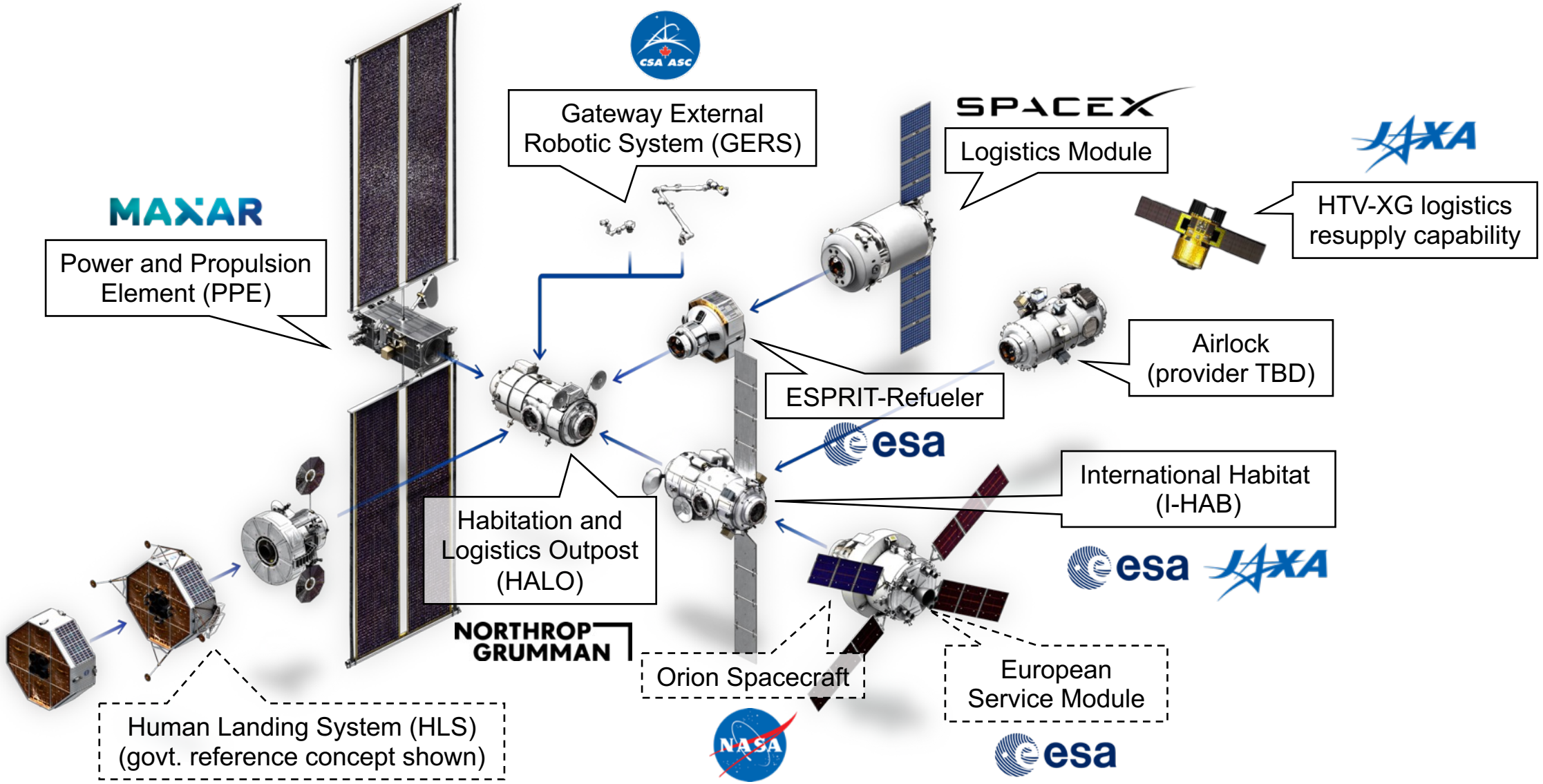
First Crewed Flight Test to the Moon Since Apollo

- Proximity Operations Demonstration in high-Earth orbit
- Four days outbound transit, free return trajectory
- Lunar flyby 4,000 nmi lunar farside altitude



GATEWAY

Gateway Integrated Spacecraft



ARTEMIS III

First Crew Return to the Lunar Surface

- Demonstrate Crewed SpaceX Starship Human Landing System
- Conduct field science in new spacesuits
- Deploy instruments
- Collect a variety of samples to return to Earth for later research
- Capture real-time human response measures and environmental characterizations



Artemis III Candidate Landing Regions

KEY LANDING REGION CONSIDERATIONS

Proximity to the South Pole

Gentle slope for landing and moonwalks

Constant view to Earth for communications

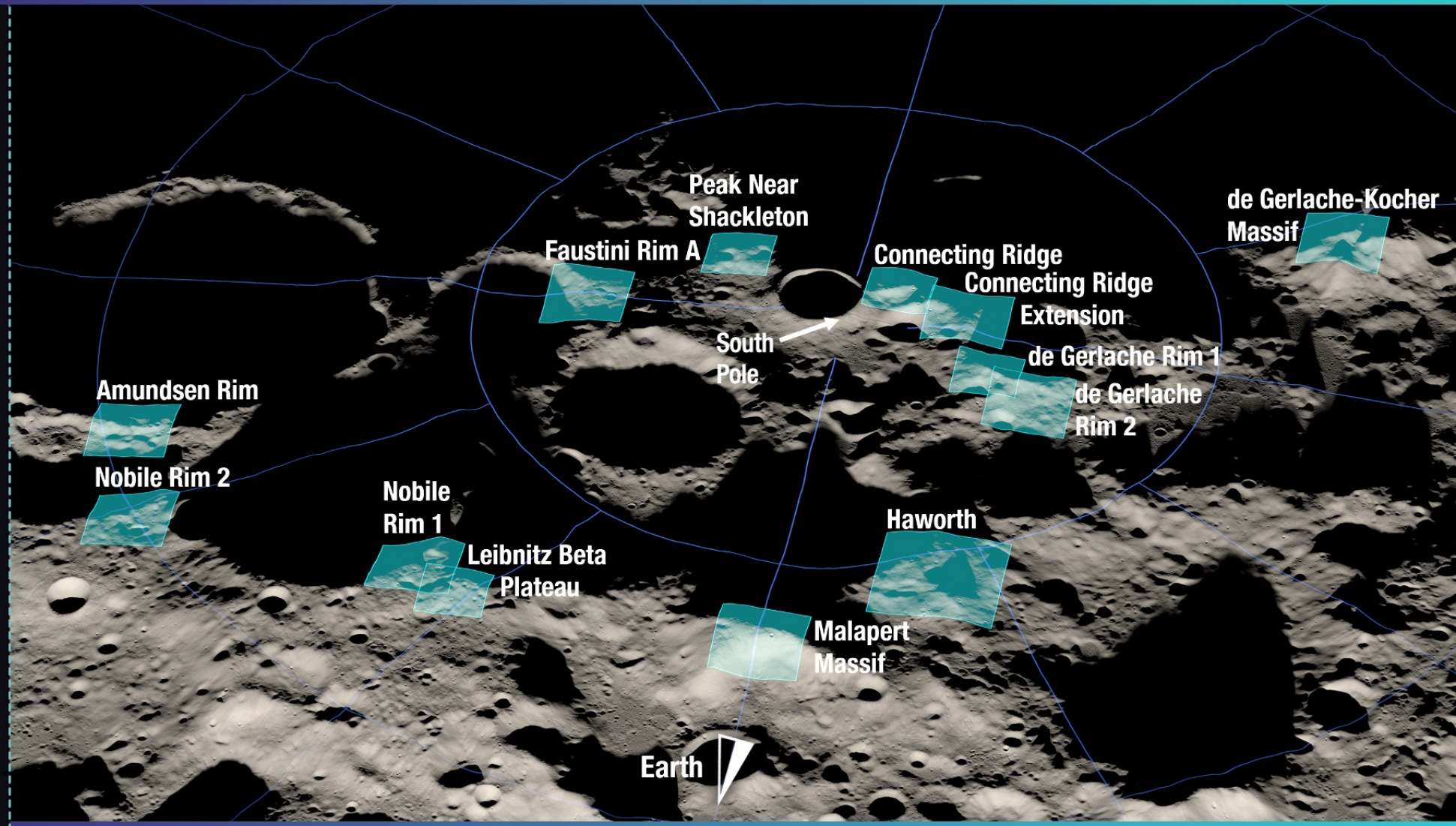
Continuous sunlight throughout the surface expedition of about 6.5 days

Landing Accuracy

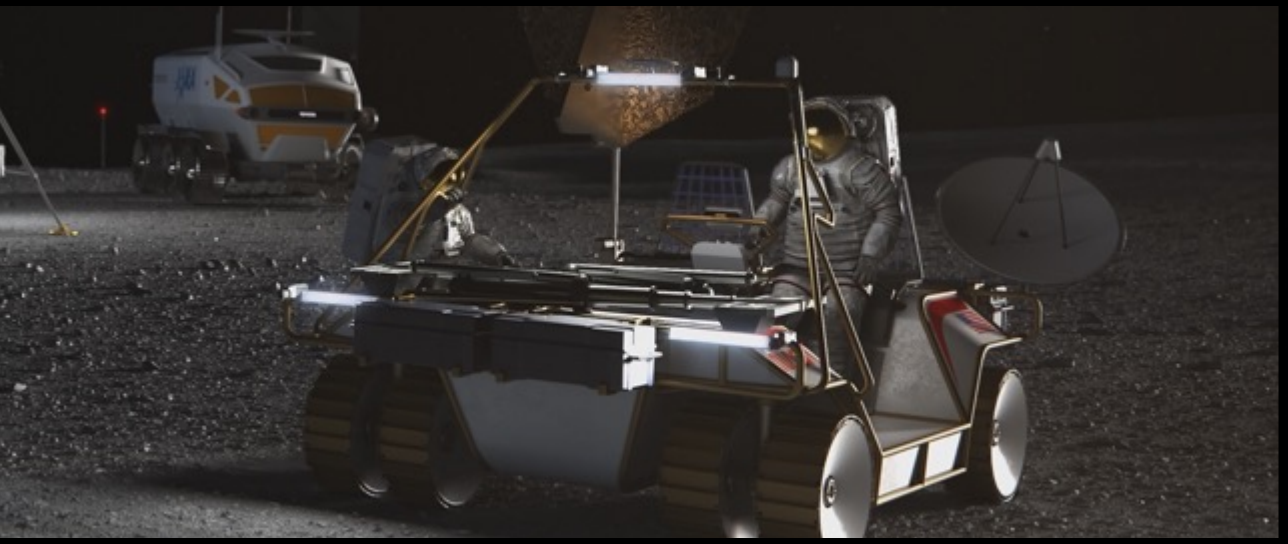
Surface data resolution

Combined mission vehicle capabilities: Space Launch System, Orion spacecraft, Starship Human Landing System

A landing *region* is approximately 15 km^2. Each landing region includes multiple potential landing sites.



ARTEMIS FUTURE ELEMENTS



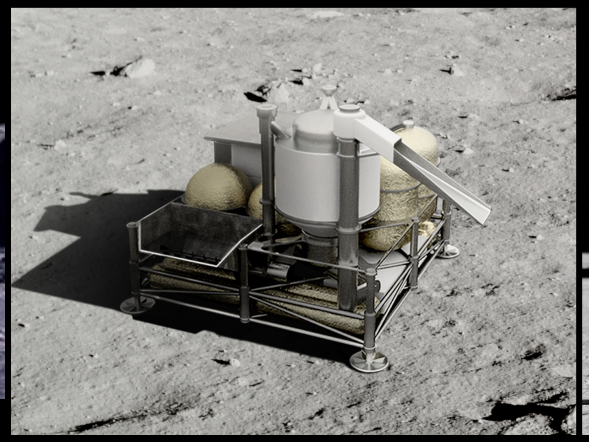
LUNAR TERRAIN VEHICLE (LTV)



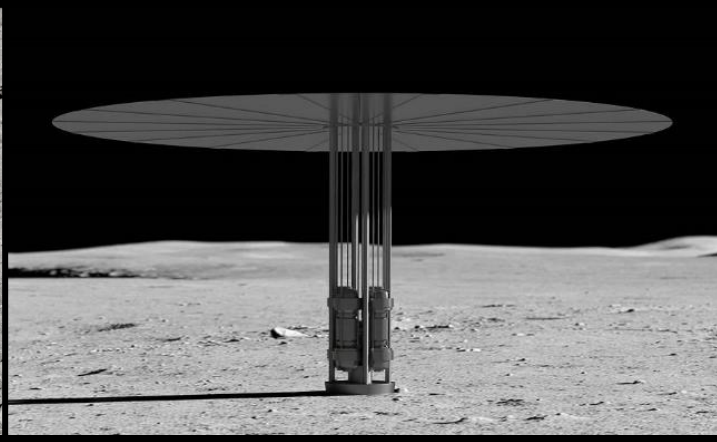
PRESSURIZED ROVER



SURFACE HABITAT



IN-SITU RESOURCE UTILIZATION



FISSION SURFACE POWER



Artemis III & IV
SpaceX Starship HLS

Artemis V
Blue Origin Blue Moon MK2 Lander

Artemis I

Uncrewed flight test

COMPLETE



SLS, Orion, EGS

Artemis II

Crewed flight test



SLS, Orion, EGS

Artemis III

Crewed surface expedition

SpaceX Starship



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

Blue Origin Blue Moon



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

STARSHIP

Human Landing System (HLS)

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

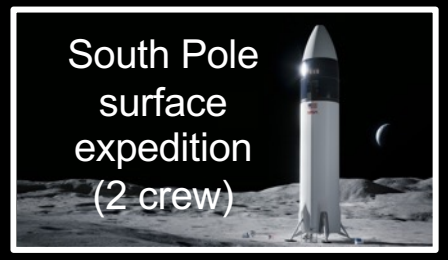
- Artemis III - the mission that will put the next two Americans on the surface of the Moon
- Artemis IV - which meets an extended set of requirements such as docking with Gateway for crew transfer, more mass to the surface, and longer mission durations

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

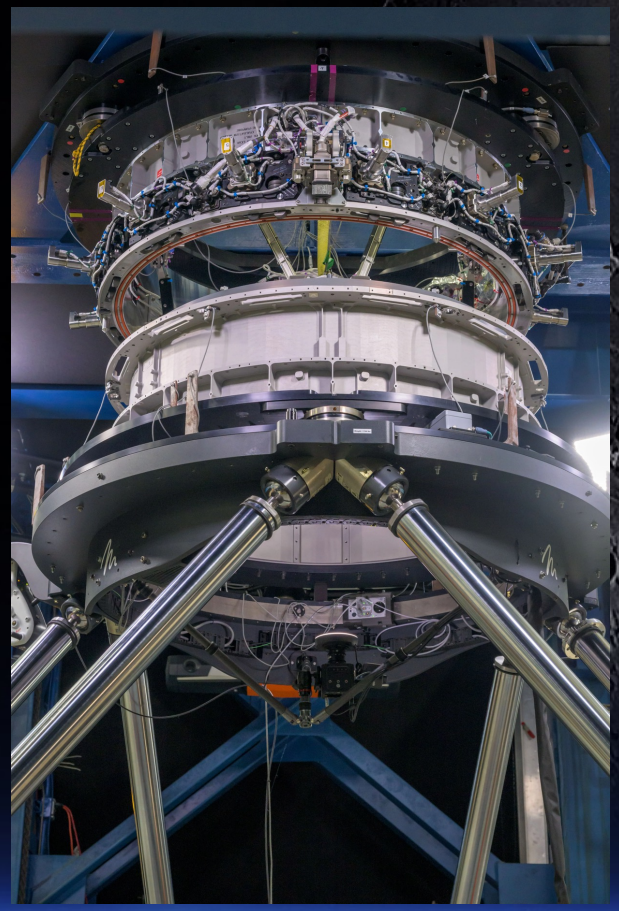
Surface expedition

Crew returns in Orion

Starship Human Landing System (HLS)
Artemis III & IV Progress



Suited Crew-in-the-Loop Elevator Testing



Docking System
Qualification Testing





Third Integrated Flight Test

BLUE MOON

Human Landing System (HLS)

NASA is working with Blue Origin to develop a human landing system for use on:

- Artemis V – meets NASA's extended set of requirements such as docking with Gateway for crew transfer, more mass to the surface, and longer mission durations

Blue Origin will perform an uncrewed demonstration mission prior to the crewed Artemis V mission.

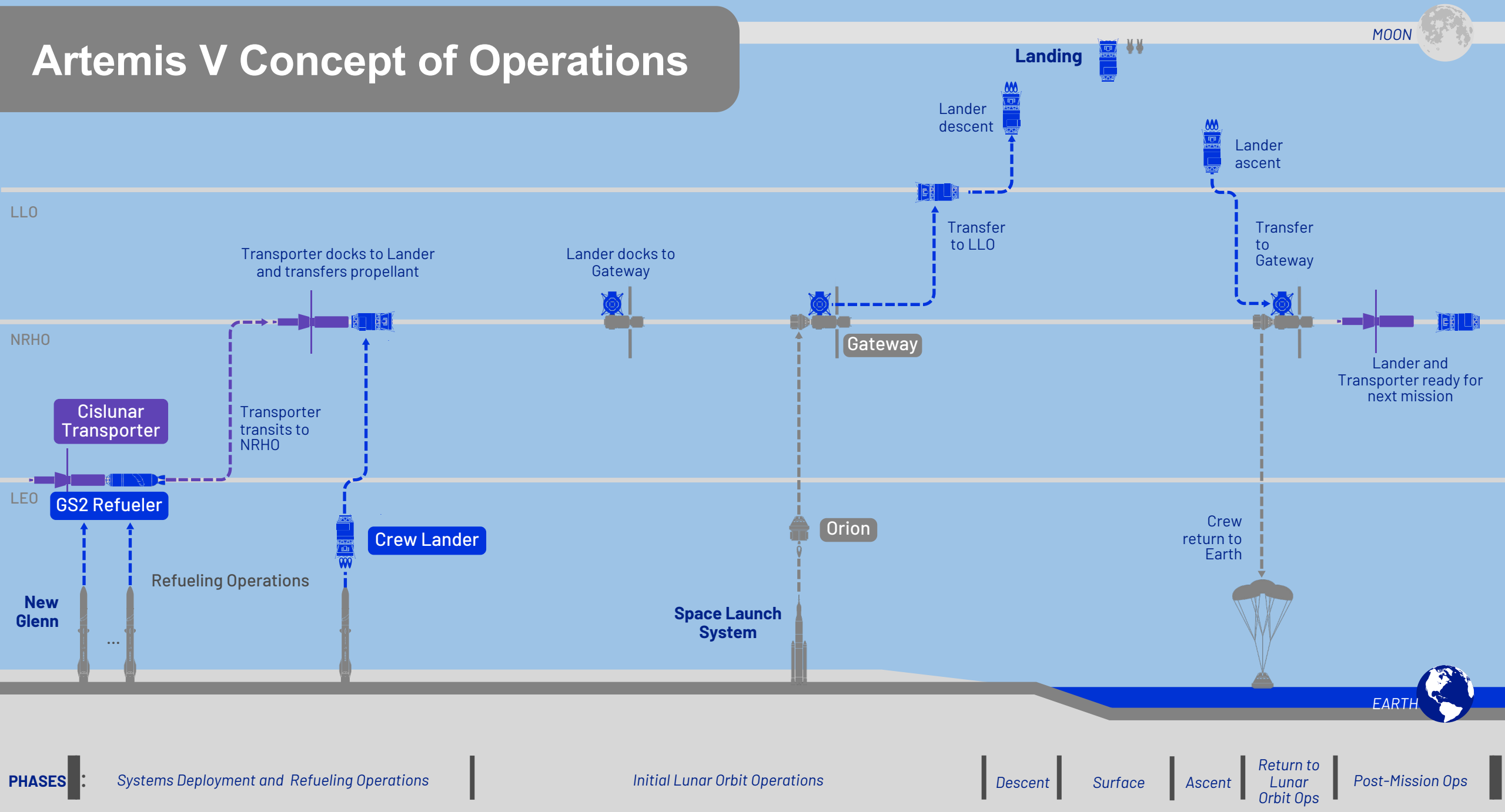
The team's approach consists of: **Blue Origin's** Blue Moon lander and **Lockheed Martin's** Cislunar Transporter along with partners:

- **Draper**
- **Boeing**
- **Astrobotic**
- **Honeybee 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*

Blue Origin Human Landing System (HLS)
Artemis V Progress



BE-4 Testing



BE-7 Testing



New Glenn Testing at LC-36


ARTEMIS
Future Elements
A sustainable environment to live and work on the lunar surface
Artist's Concept