NASA's Human Research Supporting Space Flight Exploration Missions

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National Aeronautics and Space Administration

www.nasa.gov

David Baumann

NASA Human Research Program

Director

- Experience:
  - 25+ years of managing Spaceflight Human Research projects and payloads
  - Previously Chief Health and Performance Officer for NASA's Human Landing System. Responsible for developing all human system requirements for NASA's Lunar Landers

Why the Moon

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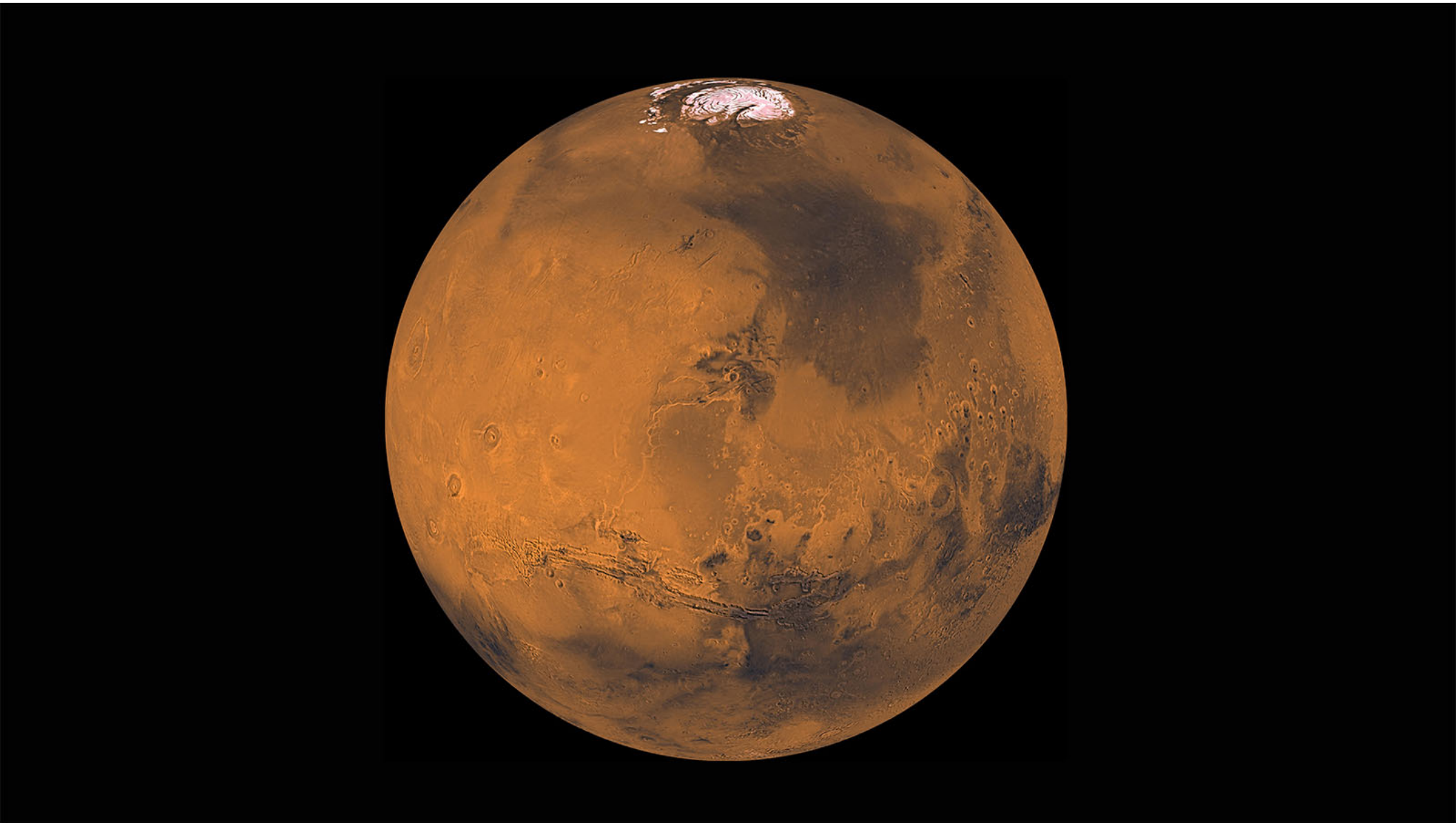
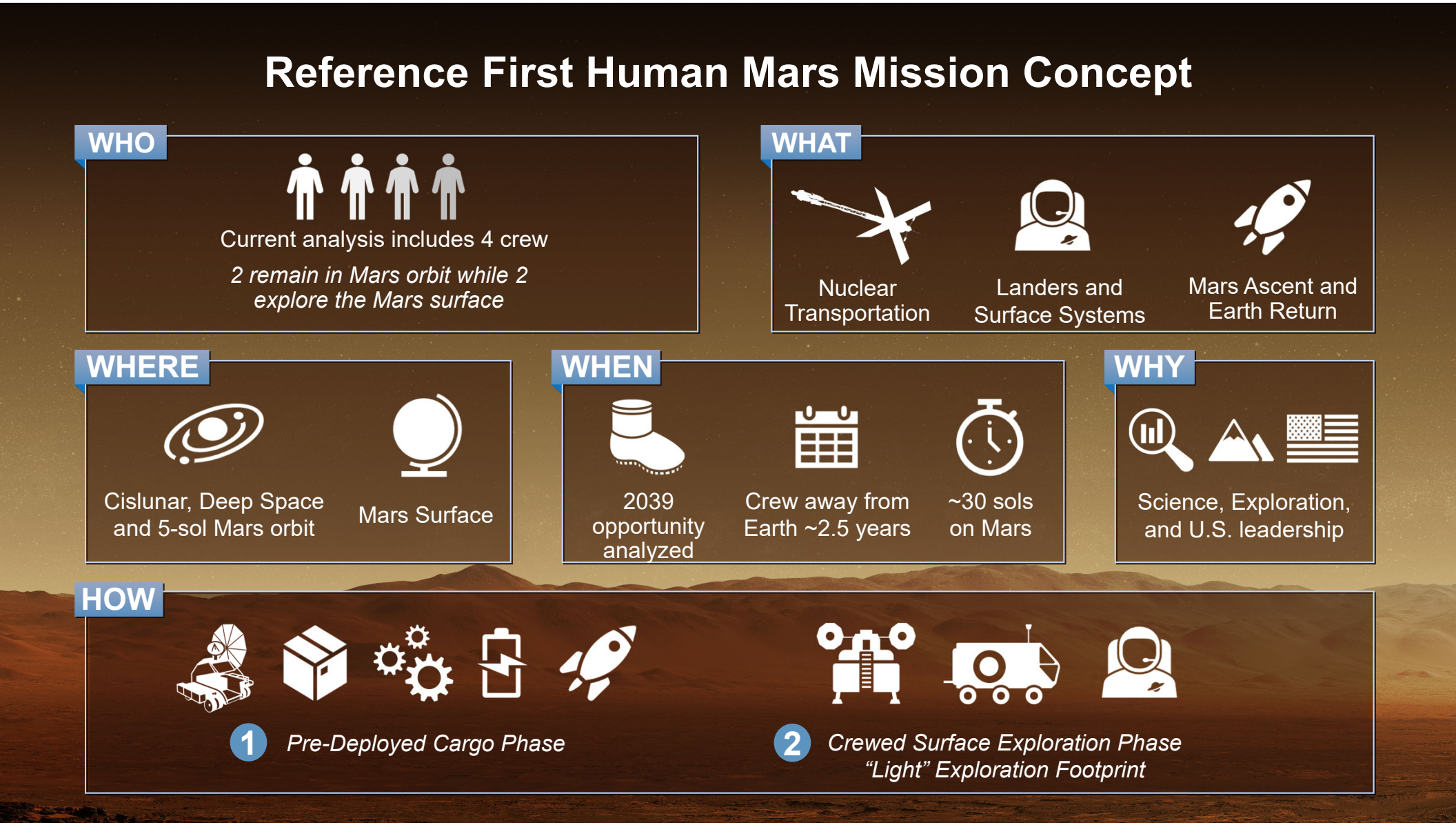
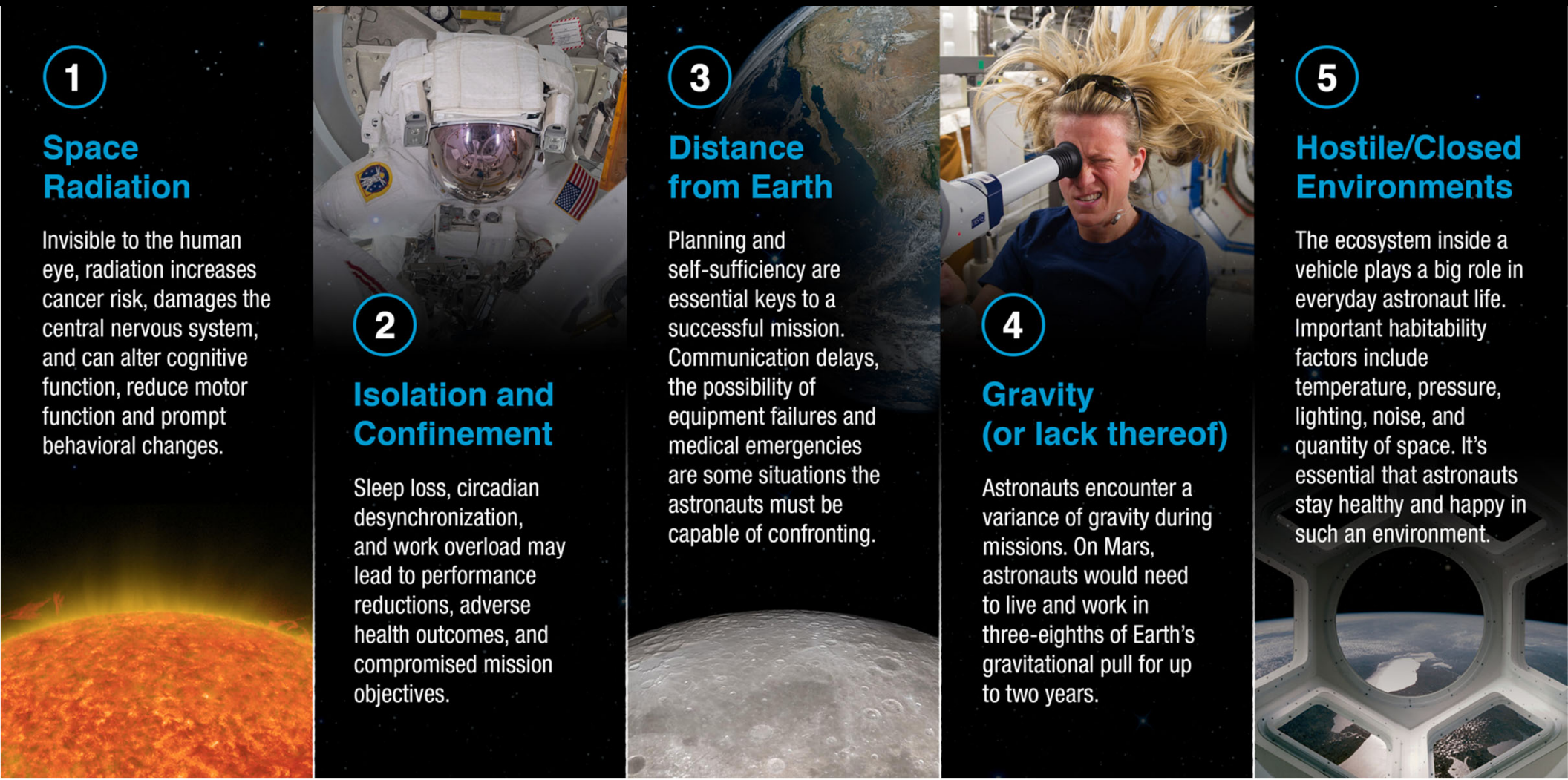


Reference First Human Mars Mission Concept



Hazards of Human Spaceflight



1 Space Radiation

Invisible to the human eye, radiation increases cancer risk, damages the central nervous system, and can alter cognitive function, reduce motor function and prompt behavioral changes.

2 Isolation and Confinement

Sleep loss, circadian desynchronization, and work overload may lead to performance reductions, adverse health outcomes, and compromised mission objectives.

3 Distance from Earth

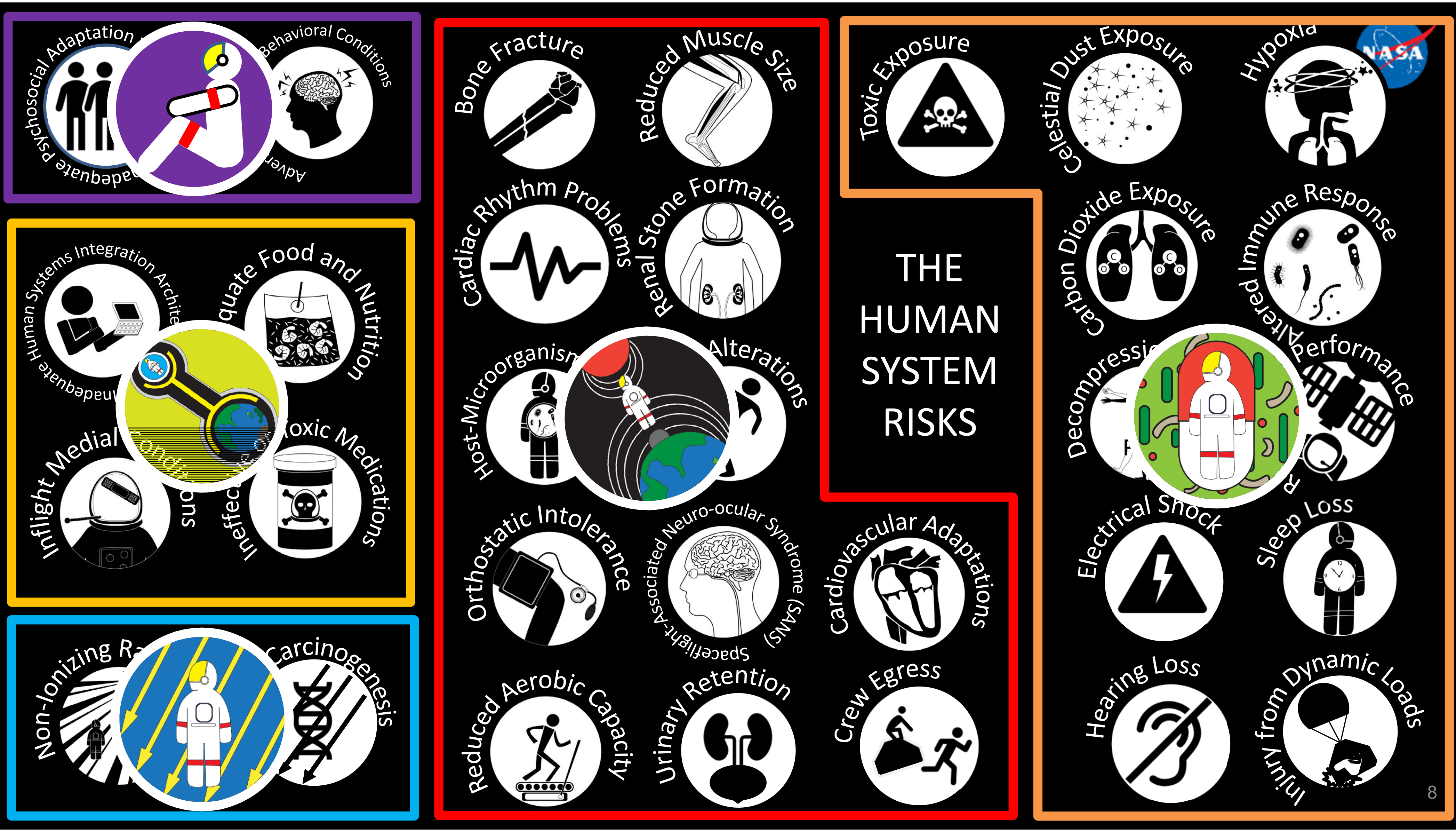
Planning and self-sufficiency are essential keys to a successful mission. Communication delays, the possibility of equipment failures and medical emergencies are some situations the astronauts must be capable of confronting.

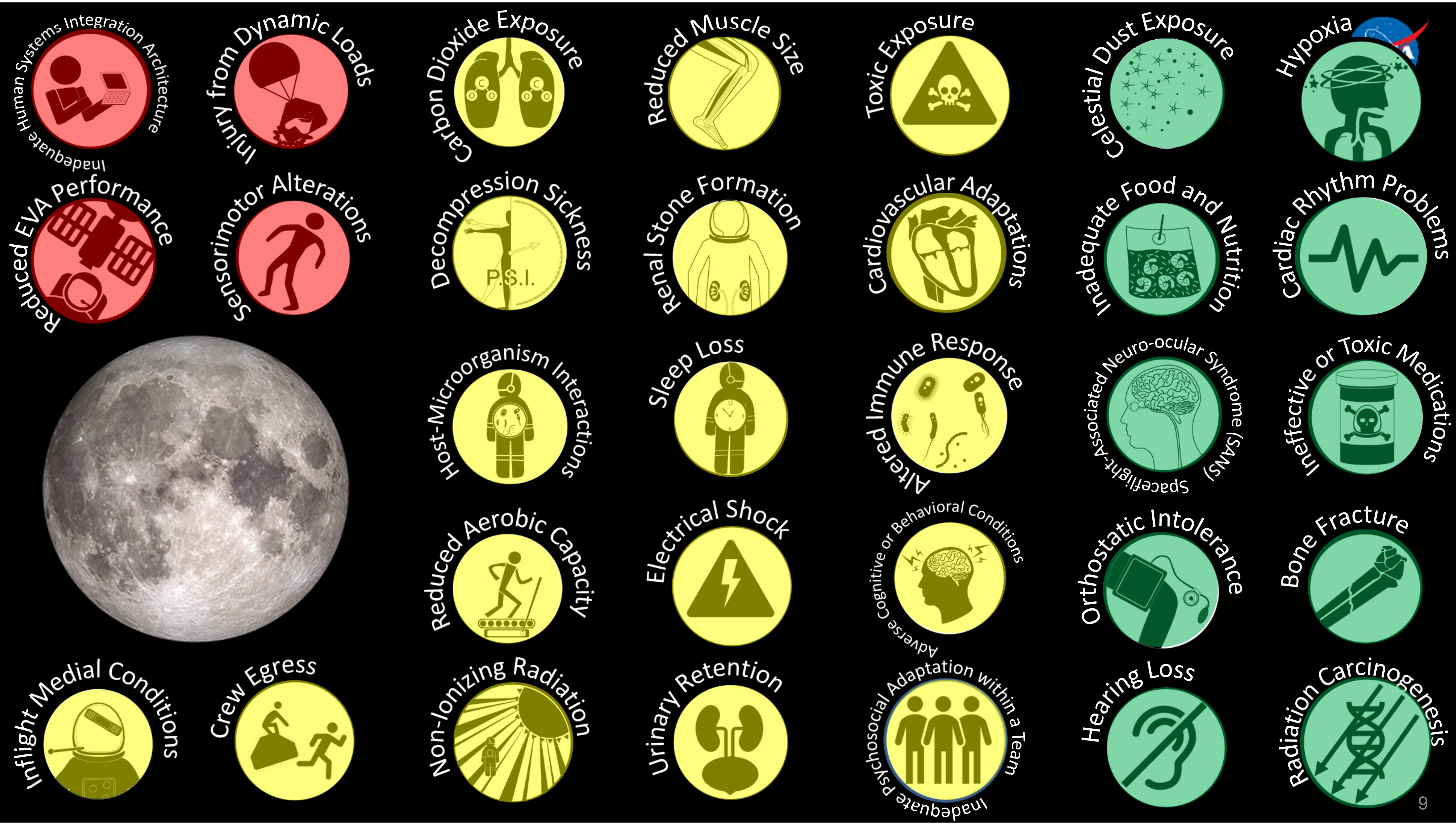
4 Gravity (or lack thereof)

Astronauts encounter a variance of gravity during missions. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years.

5 Hostile/Closed Environments

The ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts stay healthy and happy in such an environment.


THE HUMAN SYSTEM RISKS
Psychosocial Adaptation
Behavioral Conditions
Human Systems Integration Archite
Food and Nutrition
Inflight Medial
Toxic Medications
Non-Ionizing Ra
Carcinogenesis
Bone Fracture
Reduced Muscle Size
Cardiac Rhythm Problems
Renal Stone Formation
Host-Microorganism
Alterations
Orthostatic Intolerance
Spaceflight-Associated Neuro-ocular Syndrome (SANS)
Cardiovascular Adaptations
Reduced Aerobic Capacity
Urinary Retention
Crew Egress
Toxic Exposure
Celestial Dust Exposure
Hypoxia
Carbon Dioxide Exposure
Altered Immune Response
Decompressio
Performance
Electrical Shock
Sleep Loss
Hearing Loss
Injury from Dynamic Loads
NASA


Inadequate Human Systems Integration Architecture
Injury from Dynamic Loads
Carbon Dioxide Exposure
Reduced Muscle Size
Toxic Exposure
Celestial Dust Exposure
Hypoxia
Reduced EVA Performance
Sensorimotor Alterations
Decompression Sickness
P.S.I.
Renal Stone Formation
Cardiovascular Adaptations
Inadequate Food and Nutrition
Cardiac Rhythm Problems
Host-Microorganism Interactions
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Ineffective or Toxic Medications
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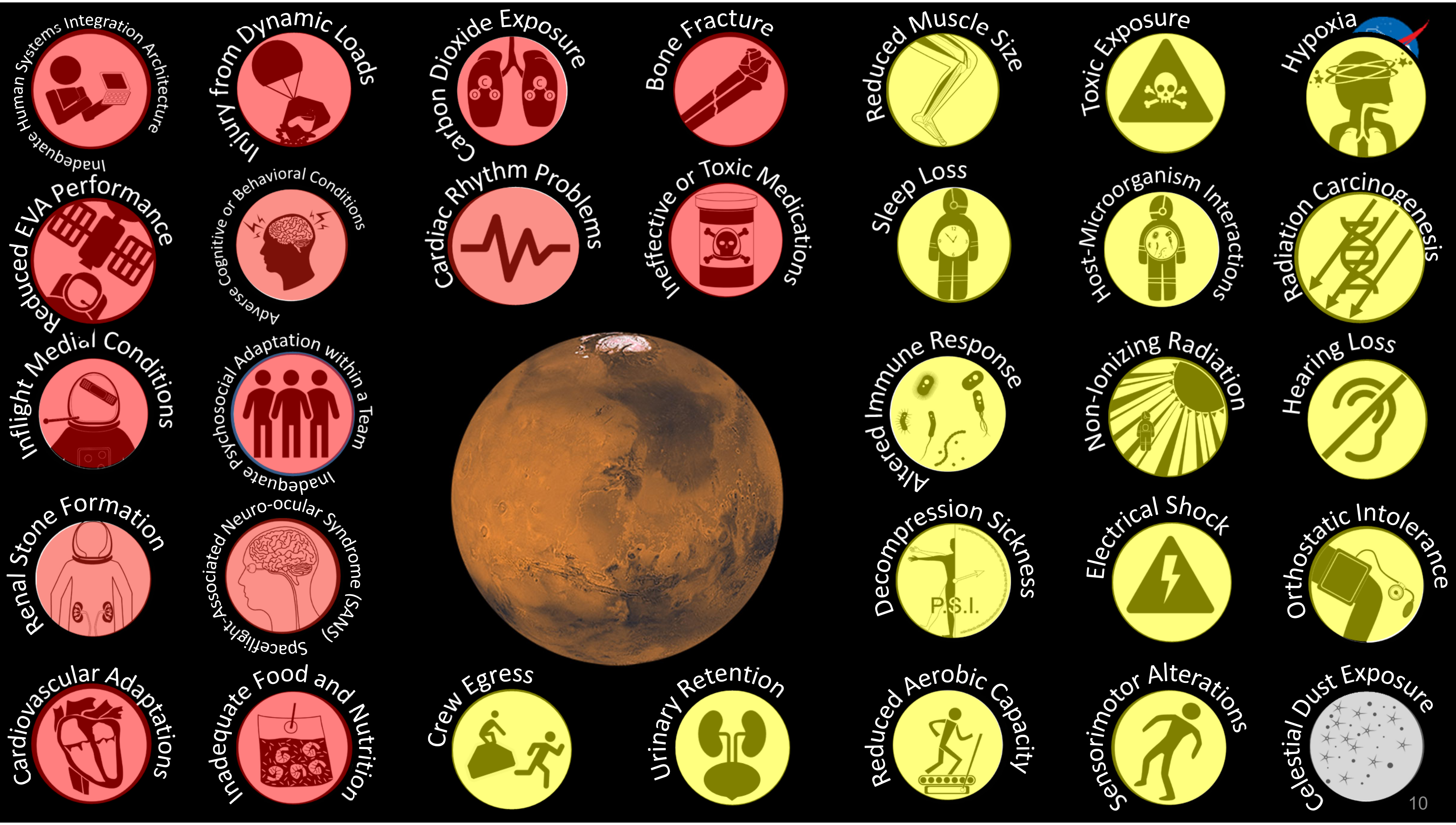
Adverse Cognitive or Behavioral Conditions
Orthostatic Intolerance
Bone Fracture
Inflight Medial Conditions
Crew Egress
Non-Ionizing Radiation
Urinary Retention
Inadequate Psychosocial Adaptation within a Team
Hearing Loss
Radiation Carcinogenesis
9



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Urinary Retention
Reduced Aerobic Capacity
Sensorimotor Alterations
Celestial Dust Exposure
10

Phased Approach to Risk Reduction

National Aeronautics and Space Administration

NASA

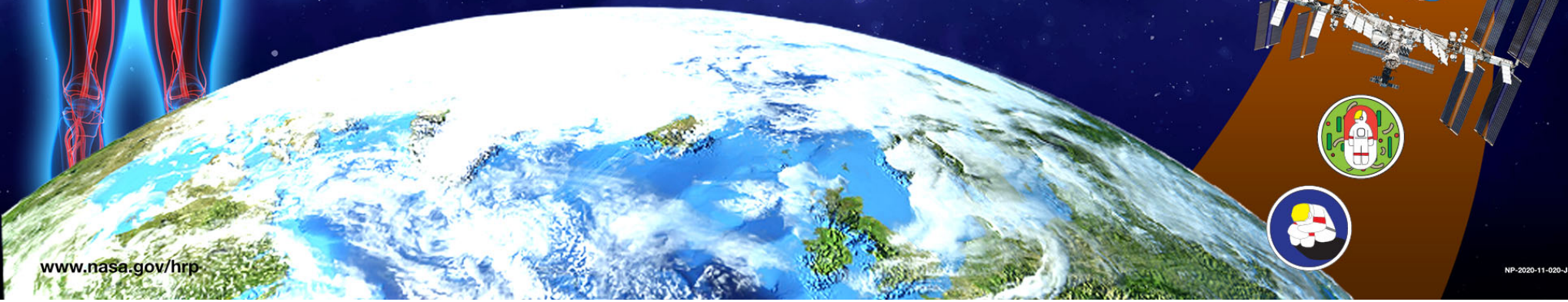
Human Research Program

STEPS TO MARS

EARTH:
Simulated spaceflight hazards in Ground Analogs | :envihab | Antarctic Stations | NEK | HERA | Space Radiation Lab

LOW EARTH ORBIT:
International Space Station – A unique testbed to study micro-gravity and environment hazards, with varying mission durations

LUNAR MISSIONS:
Decreasing Earth-dependence around and on the lunar surface. Provides insight into deep space radiation, behavioral health, and gravity transitions



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Earth Phase: Spaceflight Ground Analogs

HERA

Antarctica

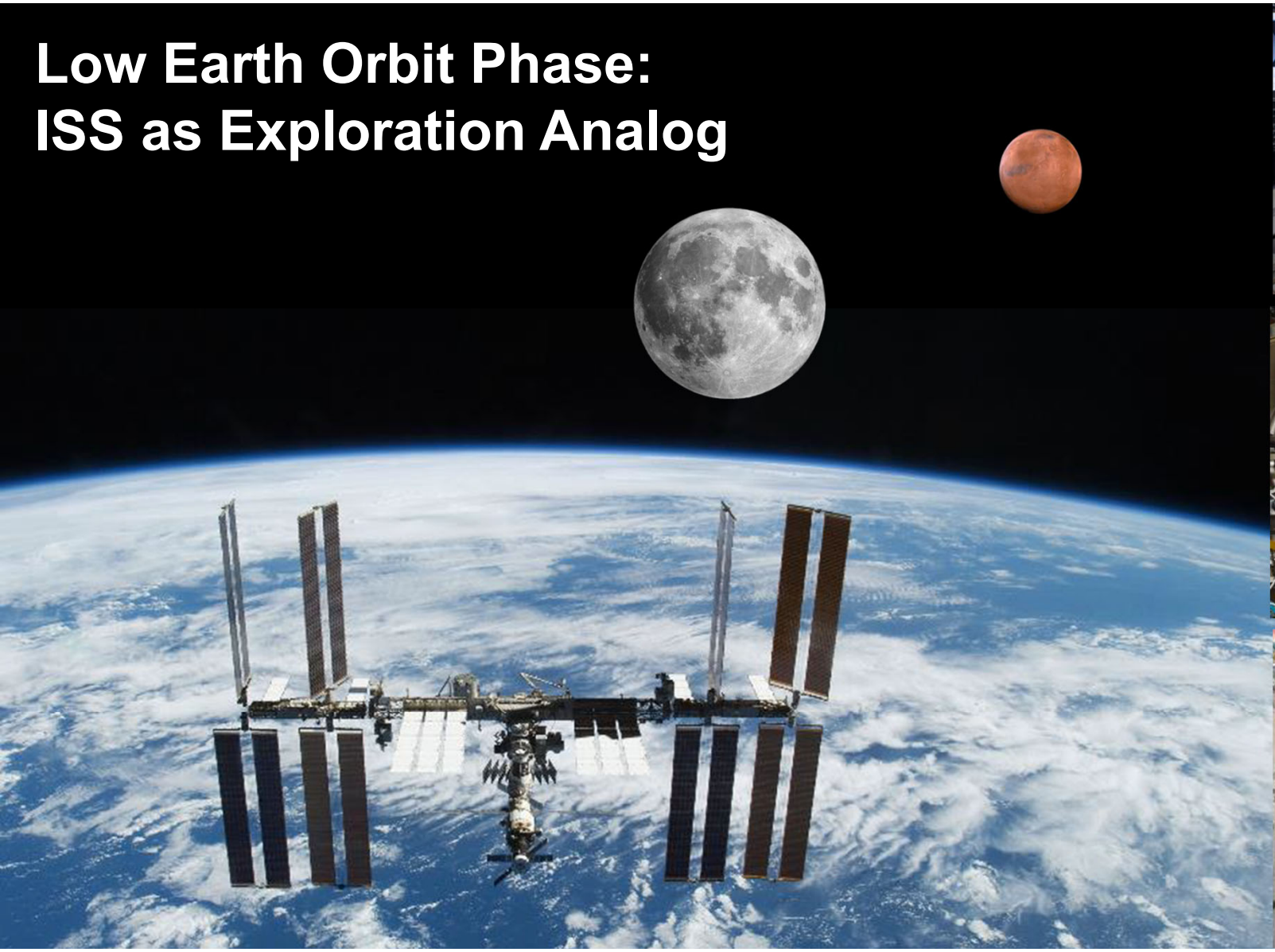
NEK

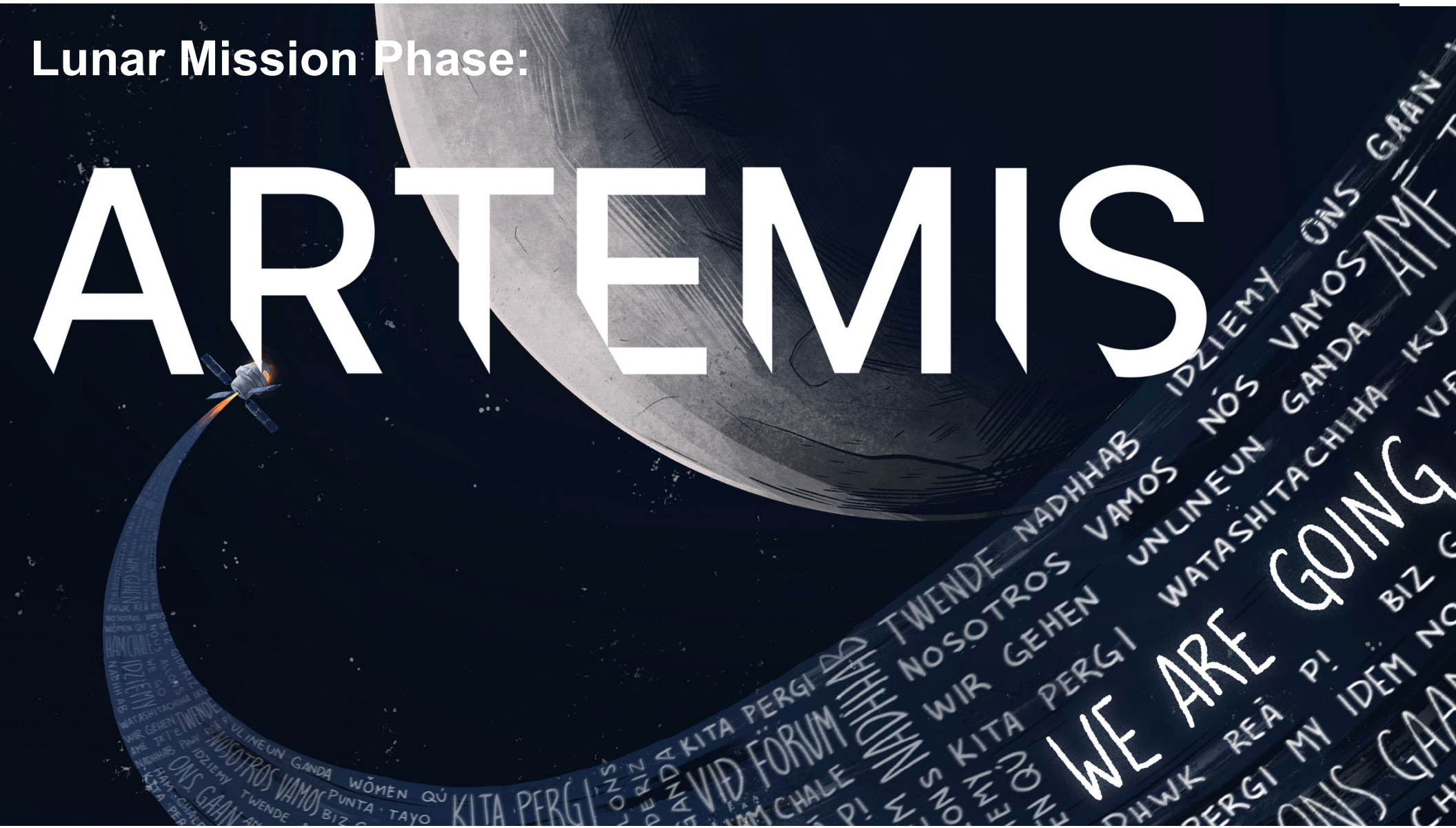
:envihab

Parabolic Flight

NSRL

Low Earth Orbit Phase:
ISS as Exploration Analog

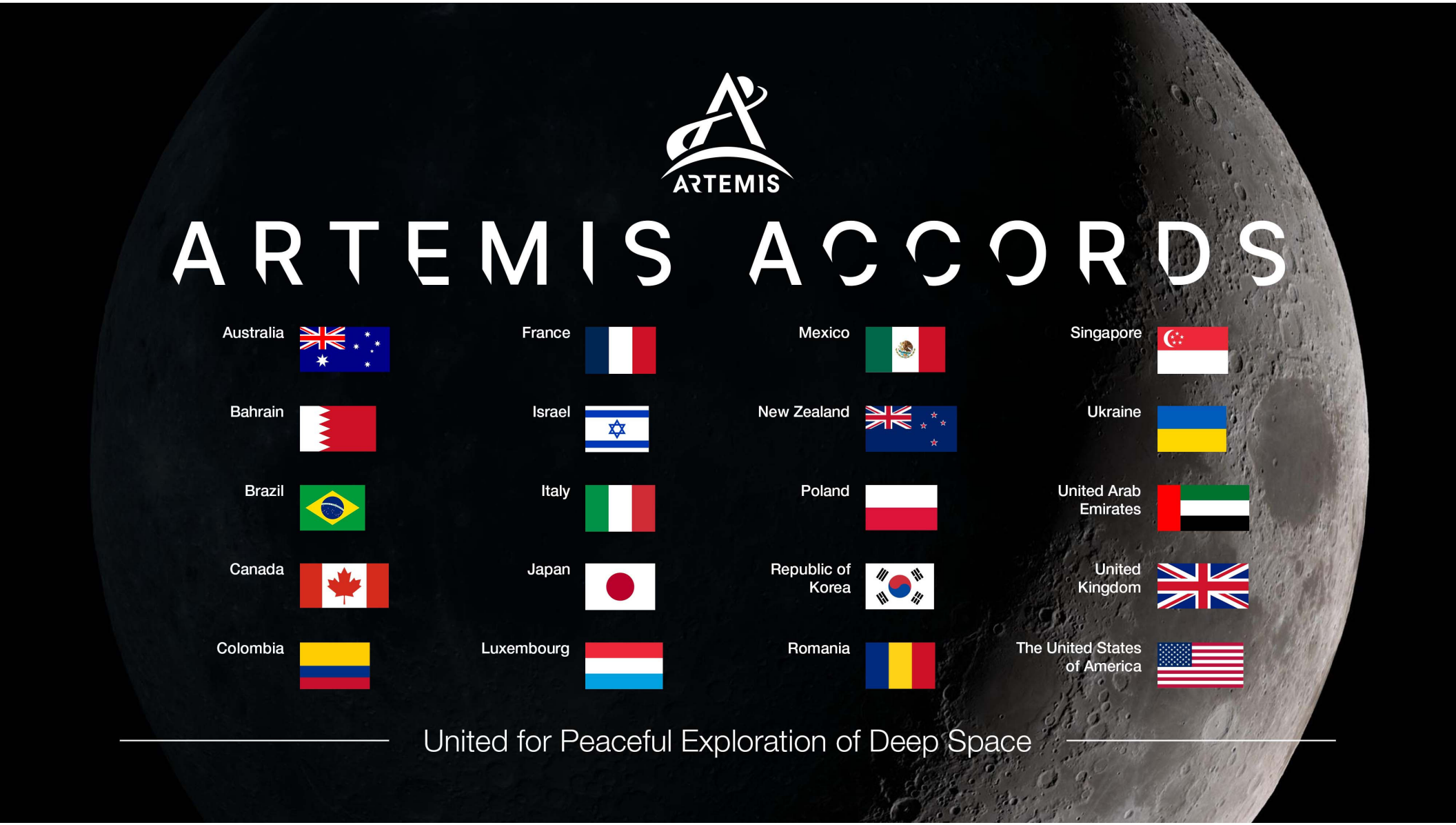



Lunar Mission Phase:
ARTEMIS
WE ARE GOING
NOSOTROS VAMOS
KITA PERGI
VID FORUM
TWENDE
NADHHAB
IDZIEMY
VAMOS
NÓS
GANDA
UNLINEUN
WATASHITACHIHA
WIR GEHEN
ONS GAAN
WÕMEN QÚ
PUNTA TAYO
HAM CHALE
BIZ GIDIYORUZ
IDEM NO

ARTEMIS

Twin sister of Apollo and goddess of the Moon in Greek mythology.

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.


ARTEMIS
ARTEMIS ACCORDS
Australia
Bahrain
Brazil
Canada
Colombia
France
Israel
Italy
Japan
Luxembourg
Mexico
New Zealand
Poland
Republic of Korea
Romania
Singapore
Ukraine
United Arab Emirates
United Kingdom
The United States of America
United for Peaceful Exploration of Deep Space

Artemis: a Foundation for Deep Space Exploration


Space Launch System


Orion spacecraft


Human Landing System


Surface Operations

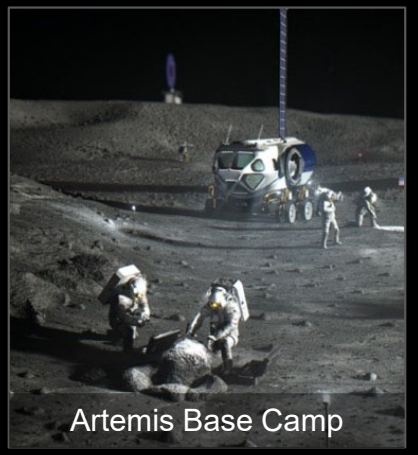

Gateway

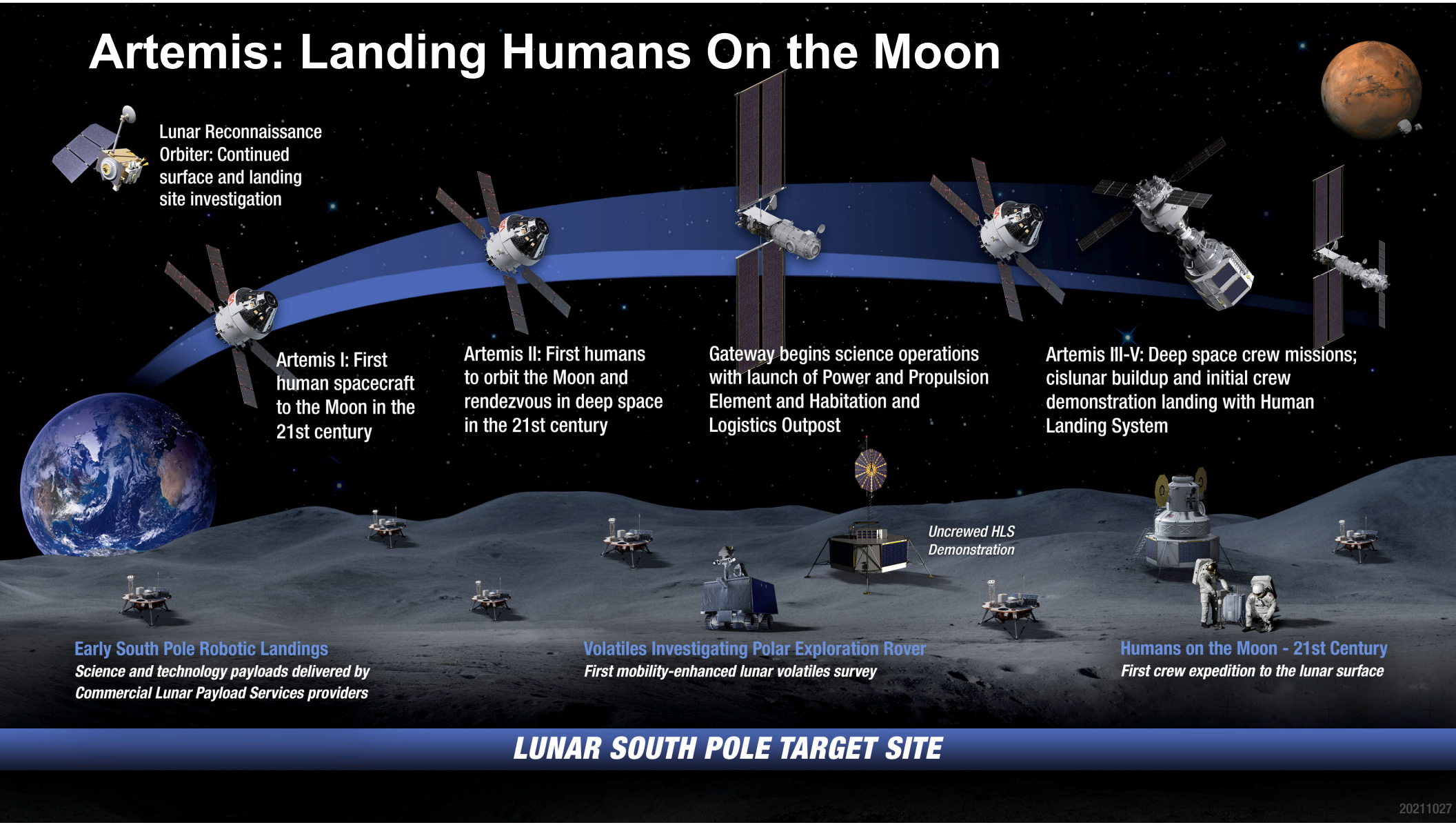
Exploration Ground Systems

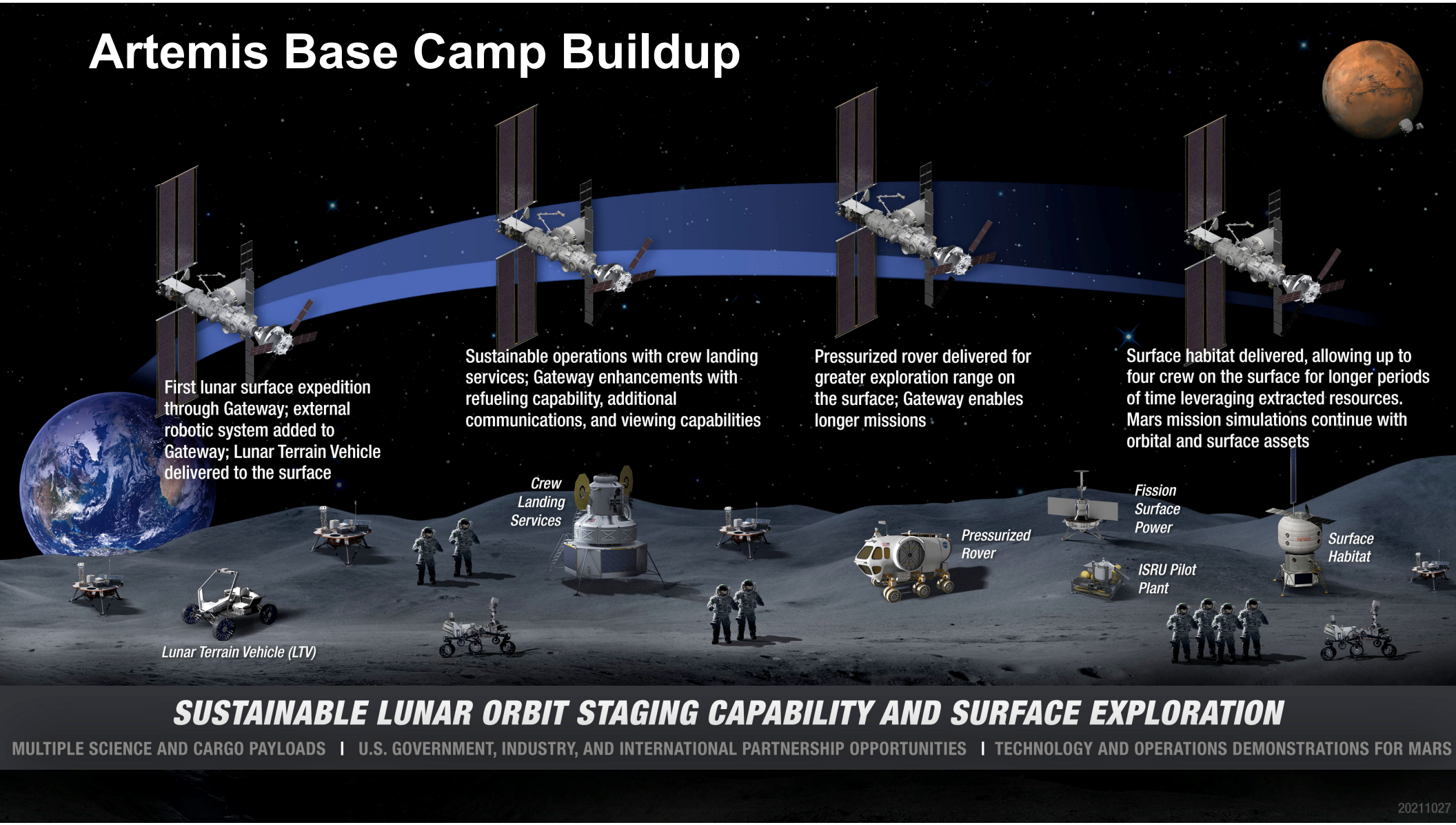

Space Communications & Navigation


Surface Mobility


Space Suits


Artemis Base Camp


Artemis: Landing Humans On the Moon
Lunar Reconnaissance Orbiter: Continued surface and landing site investigation
Artemis I: First human spacecraft to the Moon in the 21st century
Artemis II: First humans to orbit the Moon and rendezvous in deep space in the 21st century
Gateway begins science operations with launch of Power and Propulsion Element and Habitation and Logistics Outpost
Artemis III-V: Deep space crew missions; cislunar buildup and initial crew demonstration landing with Human Landing System
Uncrewed HLS Demonstration
Early South Pole Robotic Landings
Science and technology payloads delivered by Commercial Lunar Payload Services providers
Volatiles Investigating Polar Exploration Rover
First mobility-enhanced lunar volatiles survey
Humans on the Moon - 21st Century
First crew expedition to the lunar surface
LUNAR SOUTH POLE TARGET SITE
20211027


Artemis Base Camp Buildup
First lunar surface expedition through Gateway; external robotic system added to Gateway; Lunar Terrain Vehicle delivered to the surface
Sustainable operations with crew landing services; Gateway enhancements with refueling capability, additional communications, and viewing capabilities
Pressurized rover delivered for greater exploration range on the surface; Gateway enables longer missions
Surface habitat delivered, allowing up to four crew on the surface for longer periods of time leveraging extracted resources. Mars mission simulations continue with orbital and surface assets
Crew Landing Services
Pressurized Rover
Fission Surface Power
ISRU Pilot Plant
Surface Habitat
Lunar Terrain Vehicle (LTV)
SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION
MULTIPLE SCIENCE AND CARGO PAYLOADS | U.S. GOVERNMENT, INDUSTRY, AND INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS
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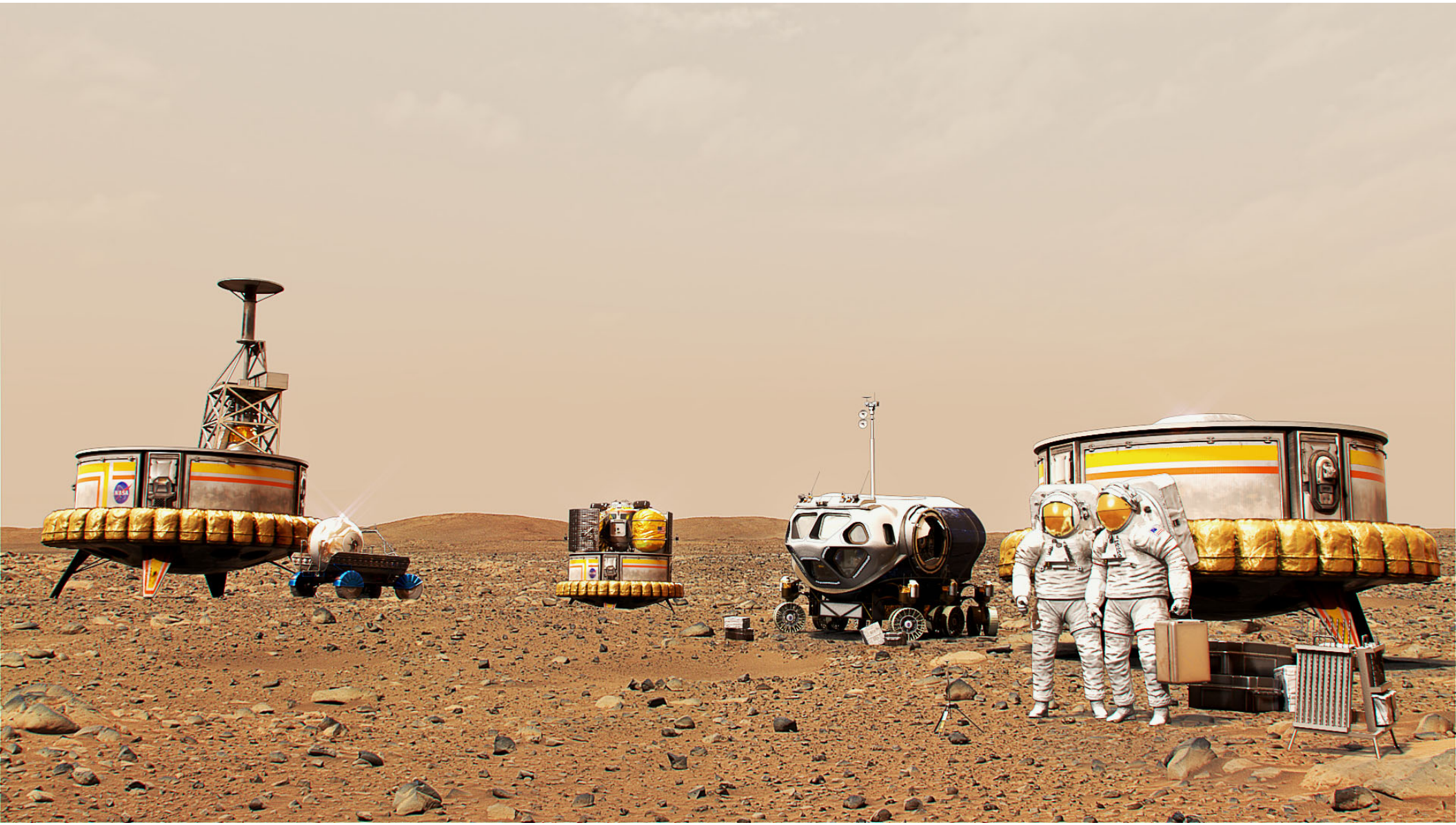
HUMAN RESEARCH PROGRAM




HUMAN RESEARCH PROGRAM
ARTEMIS
QUESTIONS?

Taking the Next Giant Leap

Humans on Mars