National Aeronautics and
Space Administration

HEOMD Utilization and Strategy Overview: From ISS to Moon to Mars

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National Academies BPS Decadal Committee

Presentation Topics Requested

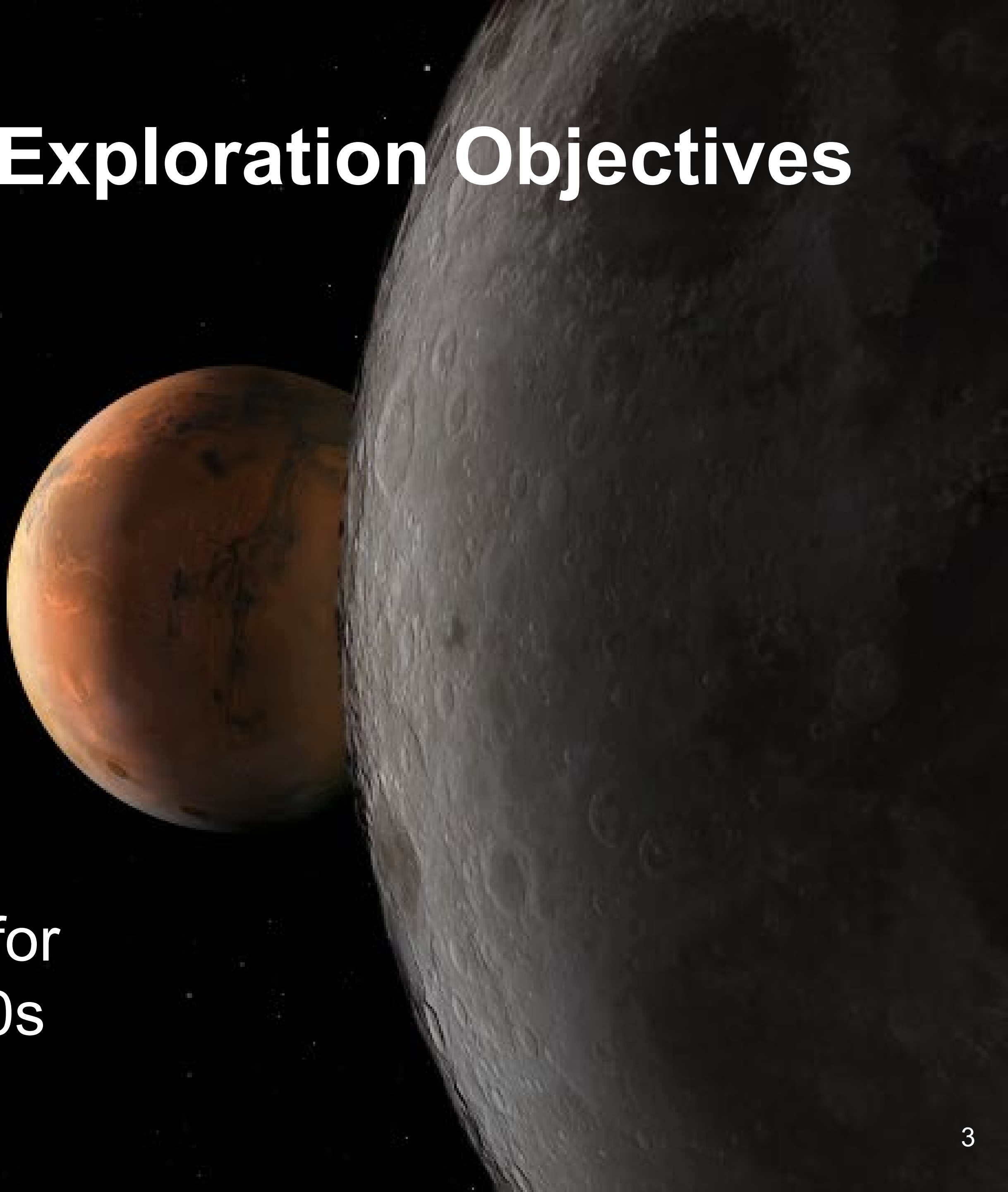
- NASA's exploration plans and the build-up to Mars
- HEO exploration and strategic approach related to the role of BPS research across HEO mission opportunities (e.g. ISS, Commercial LEO, and Deep Space exploration) and what is enabling exploration
- How HEO has organized Science & Technology utilization interfaces to SMD and STMD organizations

NASA Deep Space Human Exploration Objectives

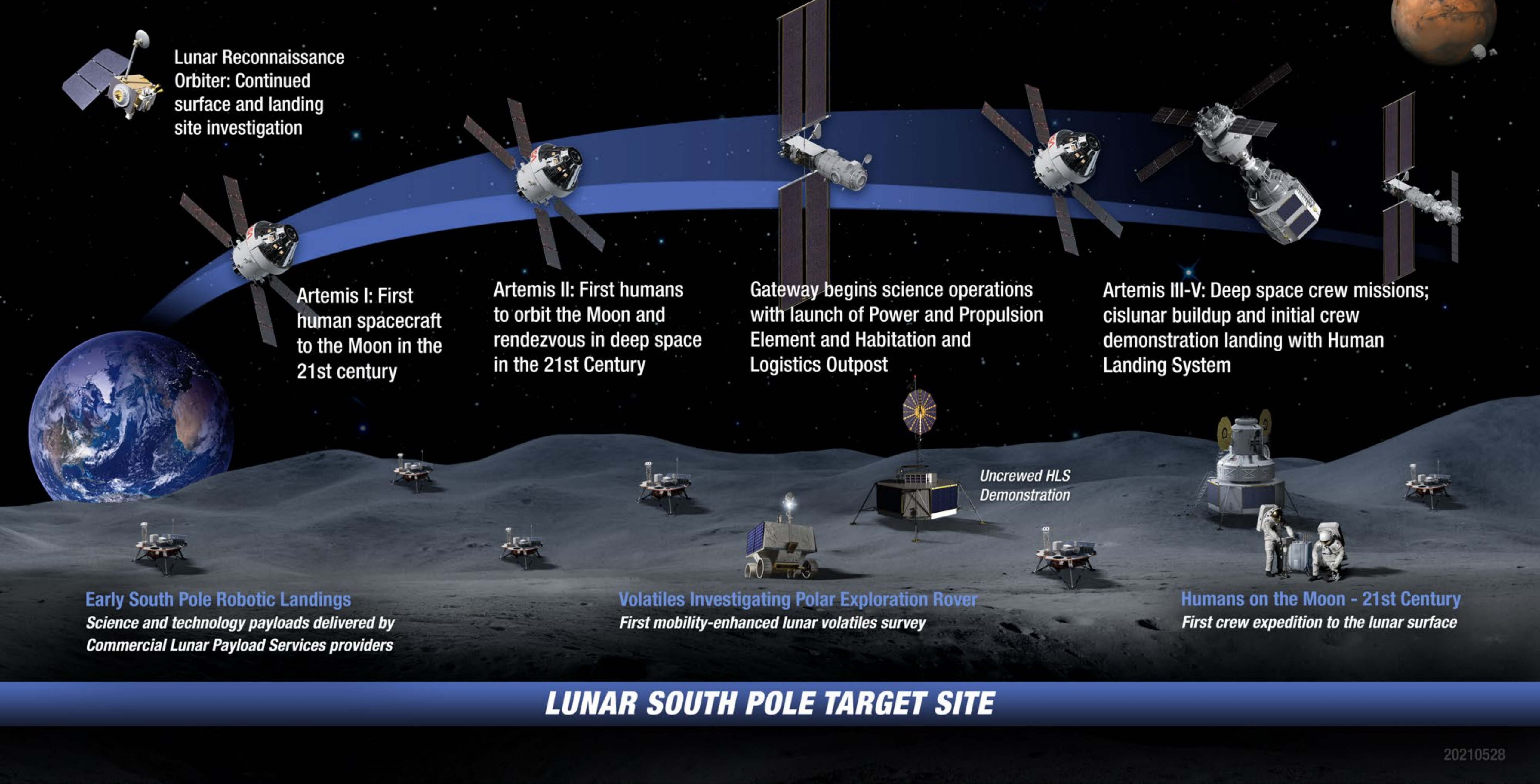
Send first women and first person of color to the lunar surface and safely return them to Earth

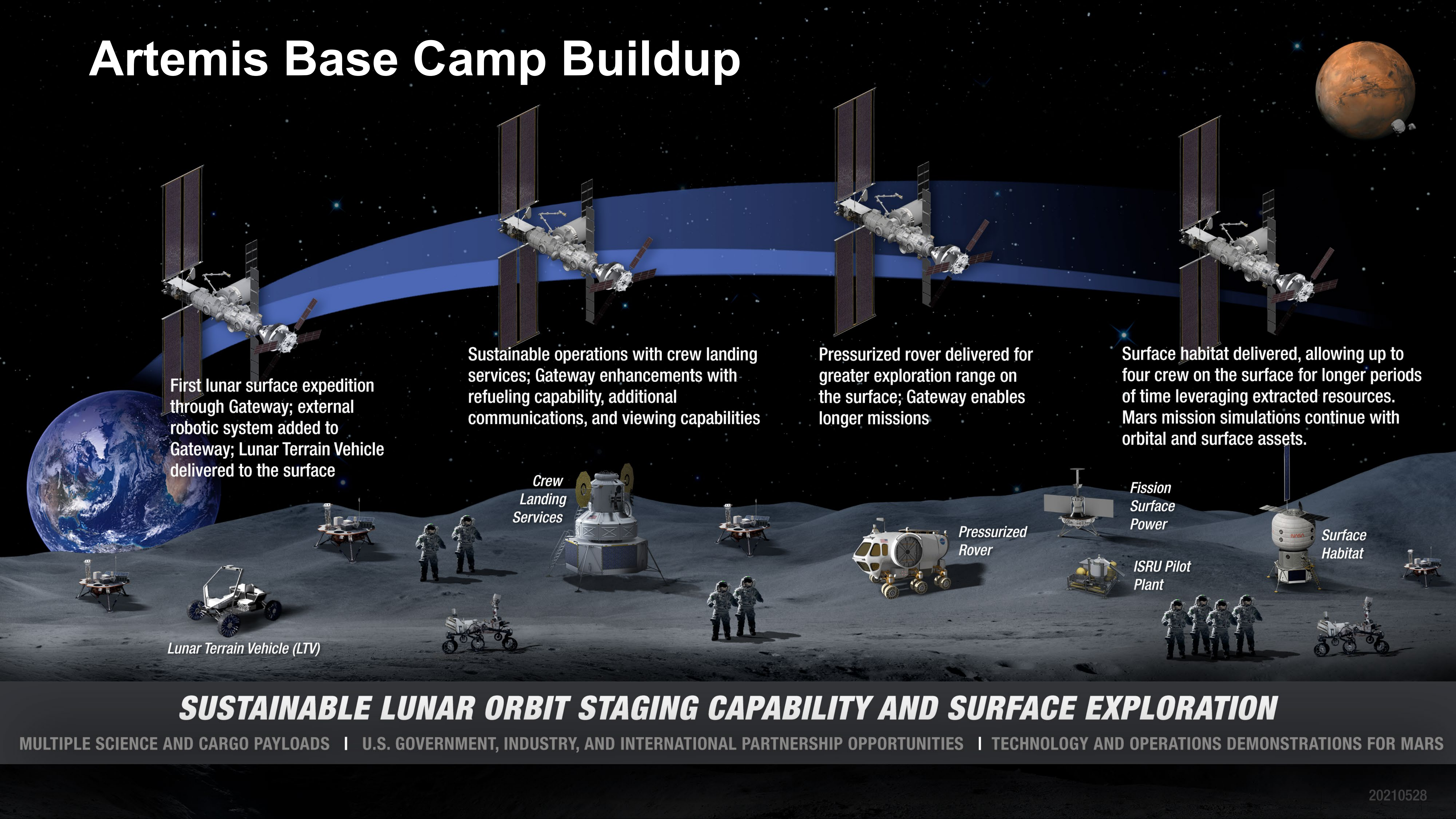
Establish sustained human lunar presence at the Moon by the end of the decade

Leverage lunar missions to prepare for a human mission to Mars in the 2030s



Artemis: Landing Humans On the Moon




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
Fission Surface Power
Pressurized Rover
Surface Habitat
ISRU Pilot Plant
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
20210528

Artemis Base Camp - Sustained Human Lunar Presence

Risk reduction for human Mars exploration

- EVA
- Mobility
- Habitation
- Power
- Communication Navigation
- Closed loop life support
- In situ Resources
- Validate Planetary Protection for Mars

Concept illustration

FIRST HUMAN MARS MISSION CONCEPT OVERVIEW

WHO

Current analysis includes 4 crew

Some could potentially remain in Mars orbit while others explore surface

WHAT

- Mars Transit
- Landing and Surface Exploration
- Mars Ascent and Earth Return

WHERE

- Cislunar, Deep Space and Mars orbit
- Mars Surface

WHEN

- As early as 2030s
- Crew away from Earth ~2 years
- ~30 sols on Mars

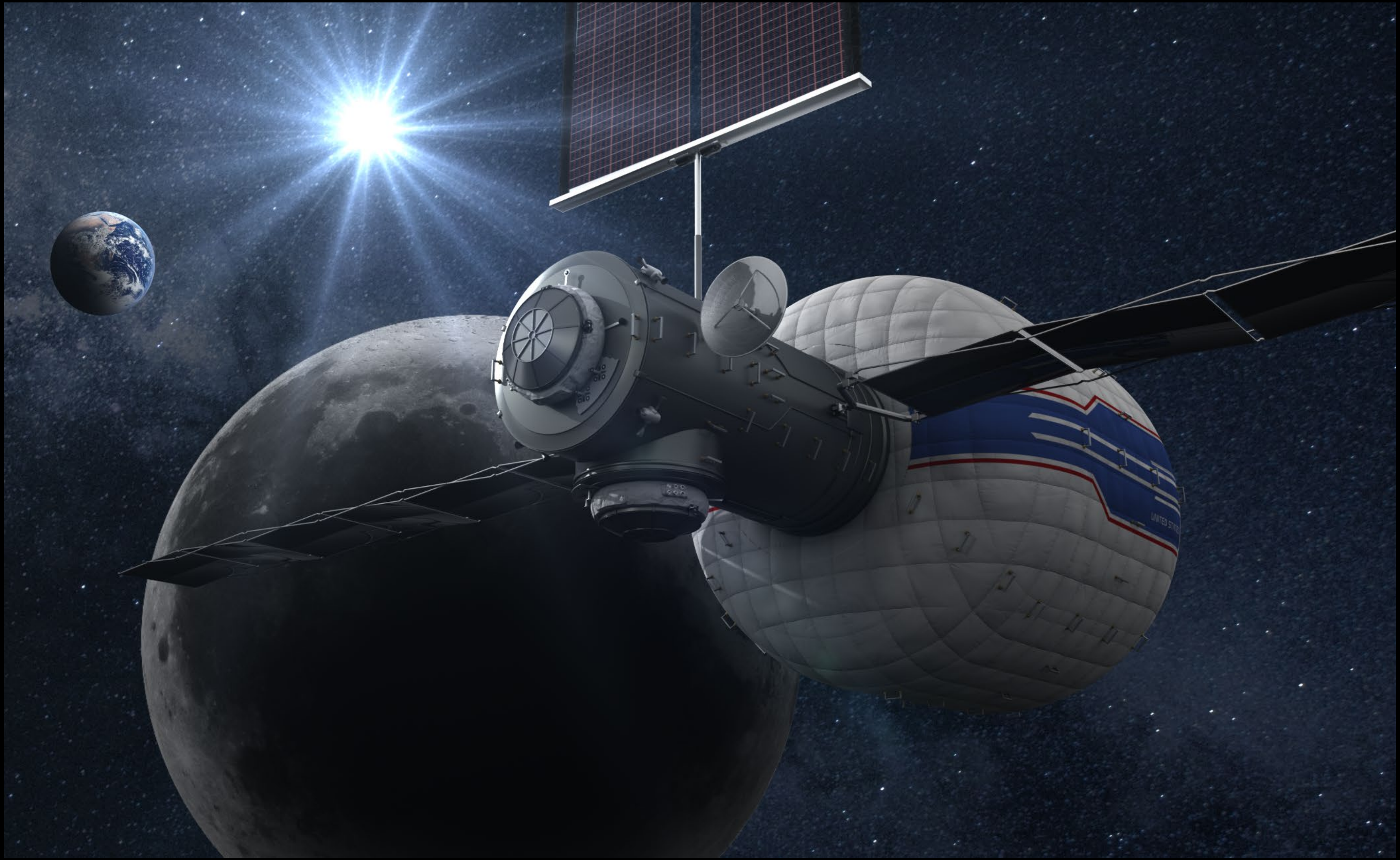
WHY

Science, Exploration, and U.S. leadership

HOW

1. *Pre-Deployed Cargo Phase*
2. *Crewed Surface Exploration Phase*

Getting There: Mars Transit Habitat

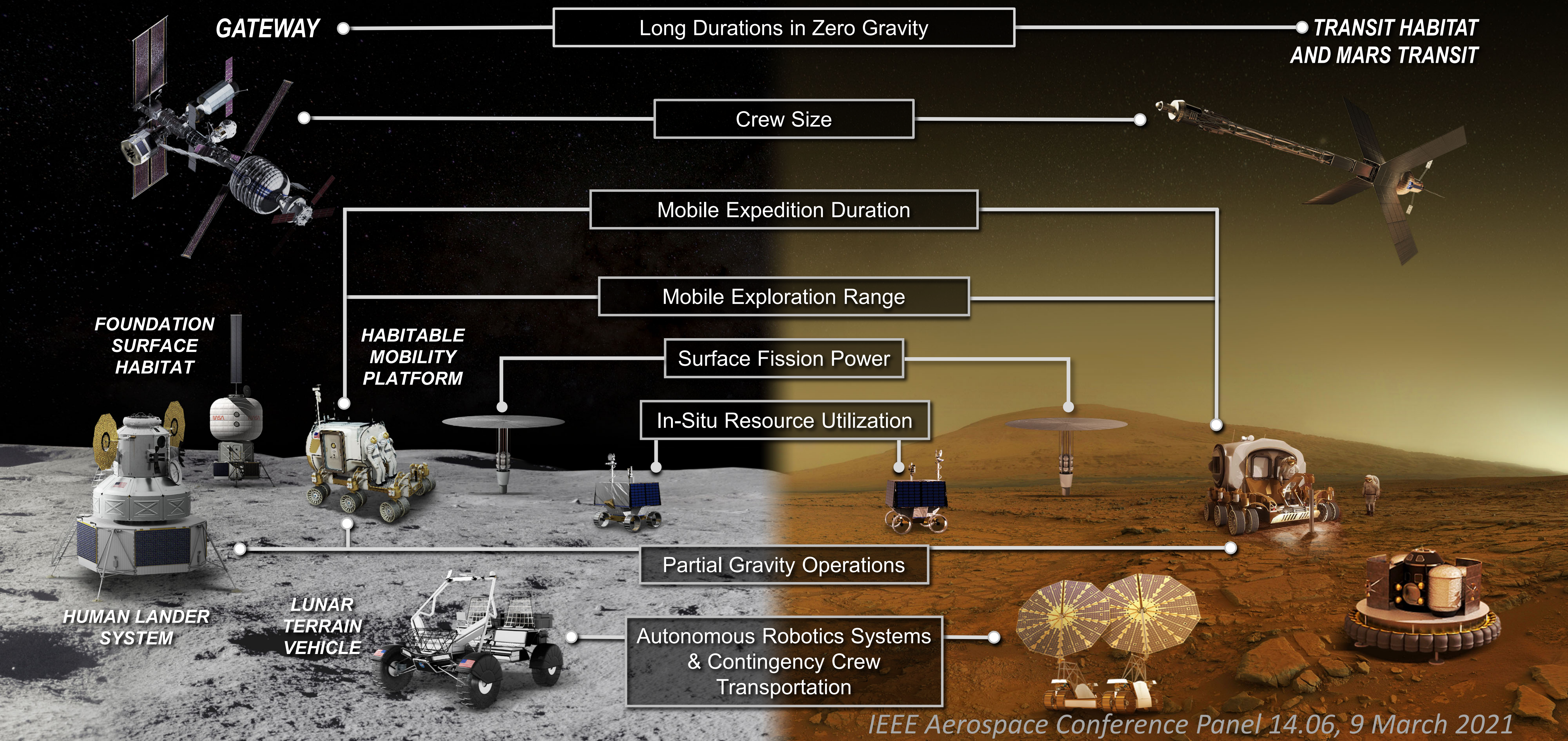


Some Key Technologies Under Consideration

- Inflatable to minimize launched volume
- Lightweight materials and structures
- High availability subsystems such as Life Support with reduced spares mass and increase reliability
- Low mass, low-power, long term food storage
- Long duration, semi-autonomous medical monitoring and care systems
- Lightweight, low power exercise equipment

MOON AND MARS EXPLORATION

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



HEOMD Human Exploration Perspectives

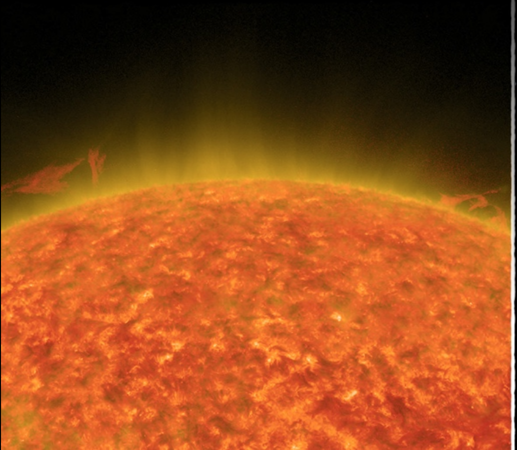
Research enabling human exploration

The 5 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.

*** May not be relevant to BPS portfolio**

4

Gravity (or lack thereof)

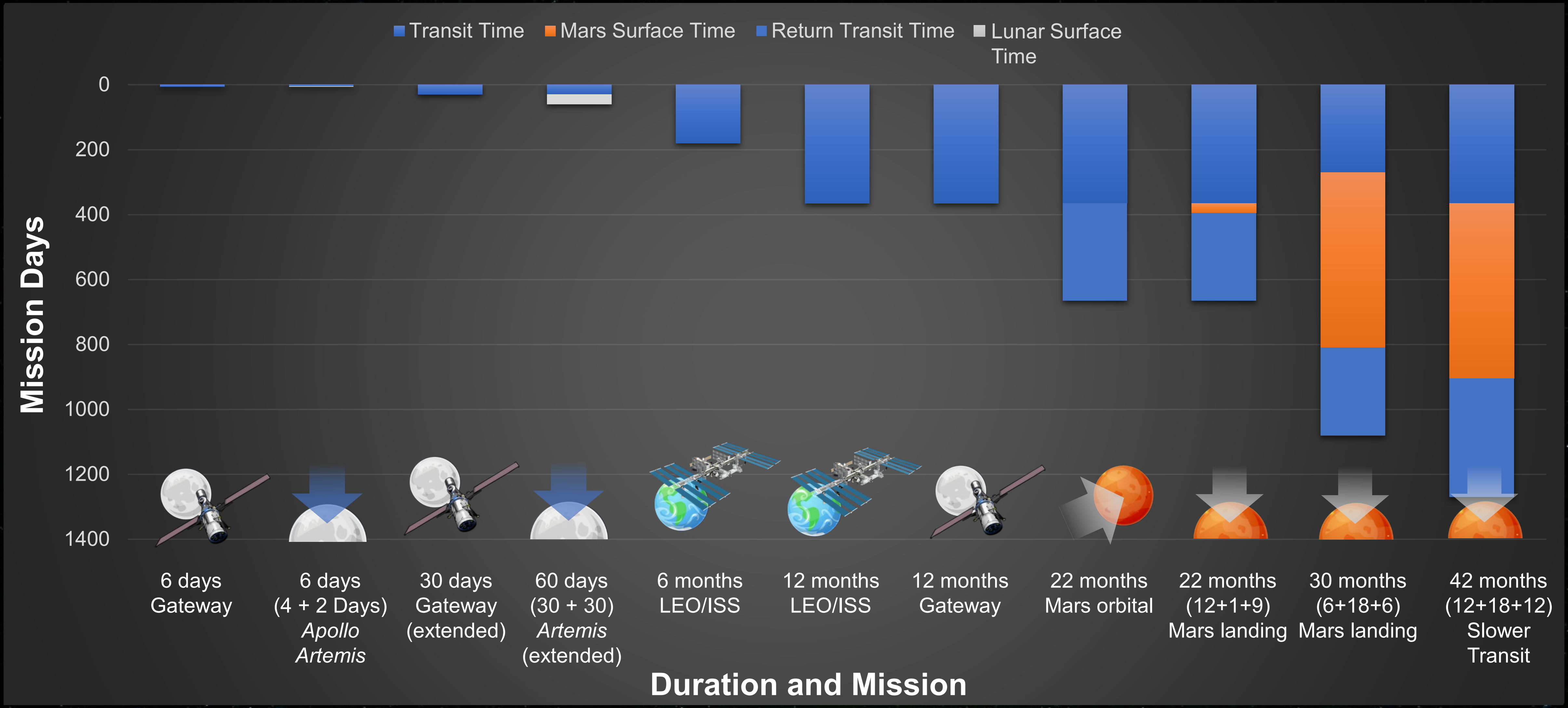
Astronauts encounter a variance of gravity during missions. On Mars, astronauts would need to live and work in three-eighths of Earth's gravitational pull for up to two years.

5

Hostile/Closed Environments

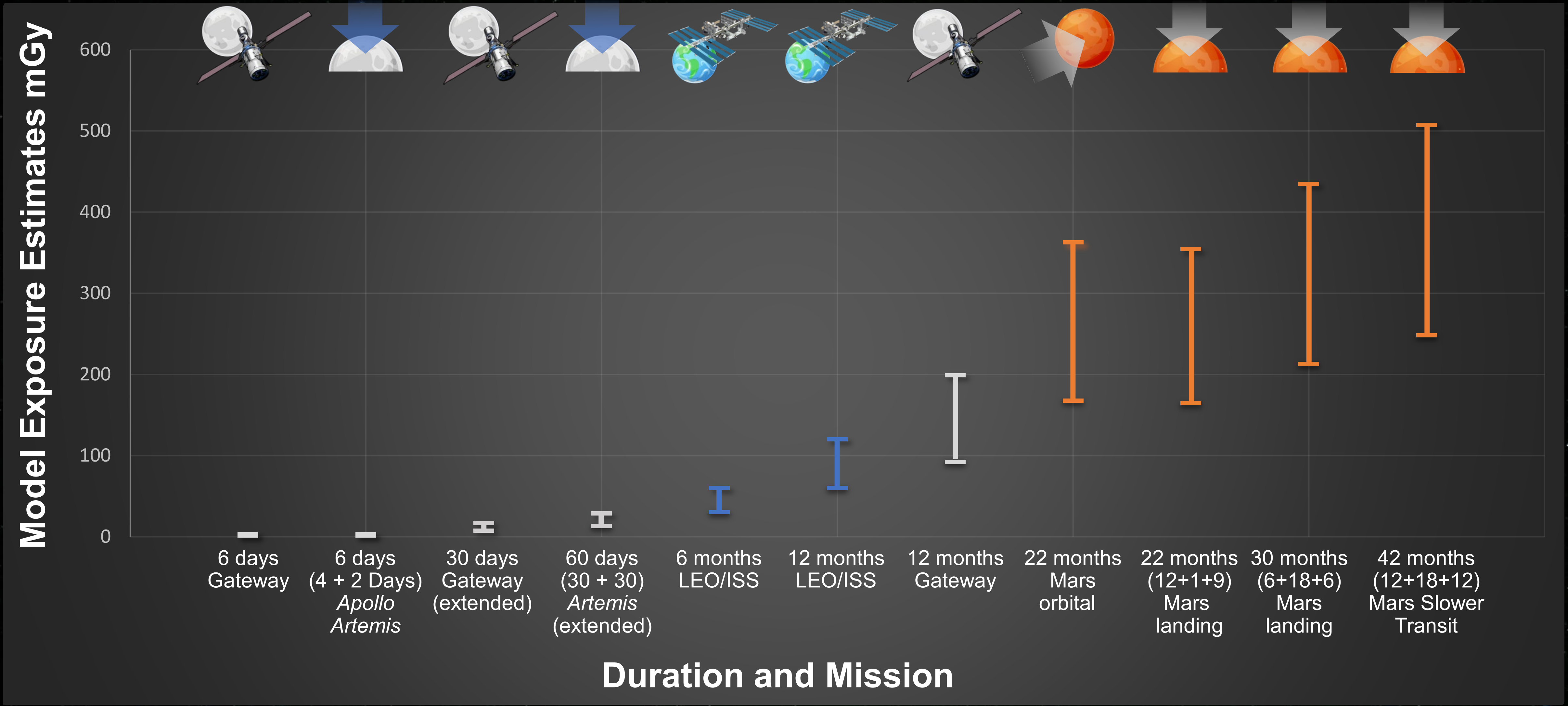
The ecosystem inside a vehicle plays a big role in everyday astronaut life. Important habitability factors include temperature, pressure, lighting, noise, and quantity of space. It's essential that astronauts stay healthy and happy in such an environment.

Gravity Levels:
Microgravity, Partial Gravity and Mission durations:



Radiation: Astronaut Mission Exposures

including vehicle shielding (mGy)



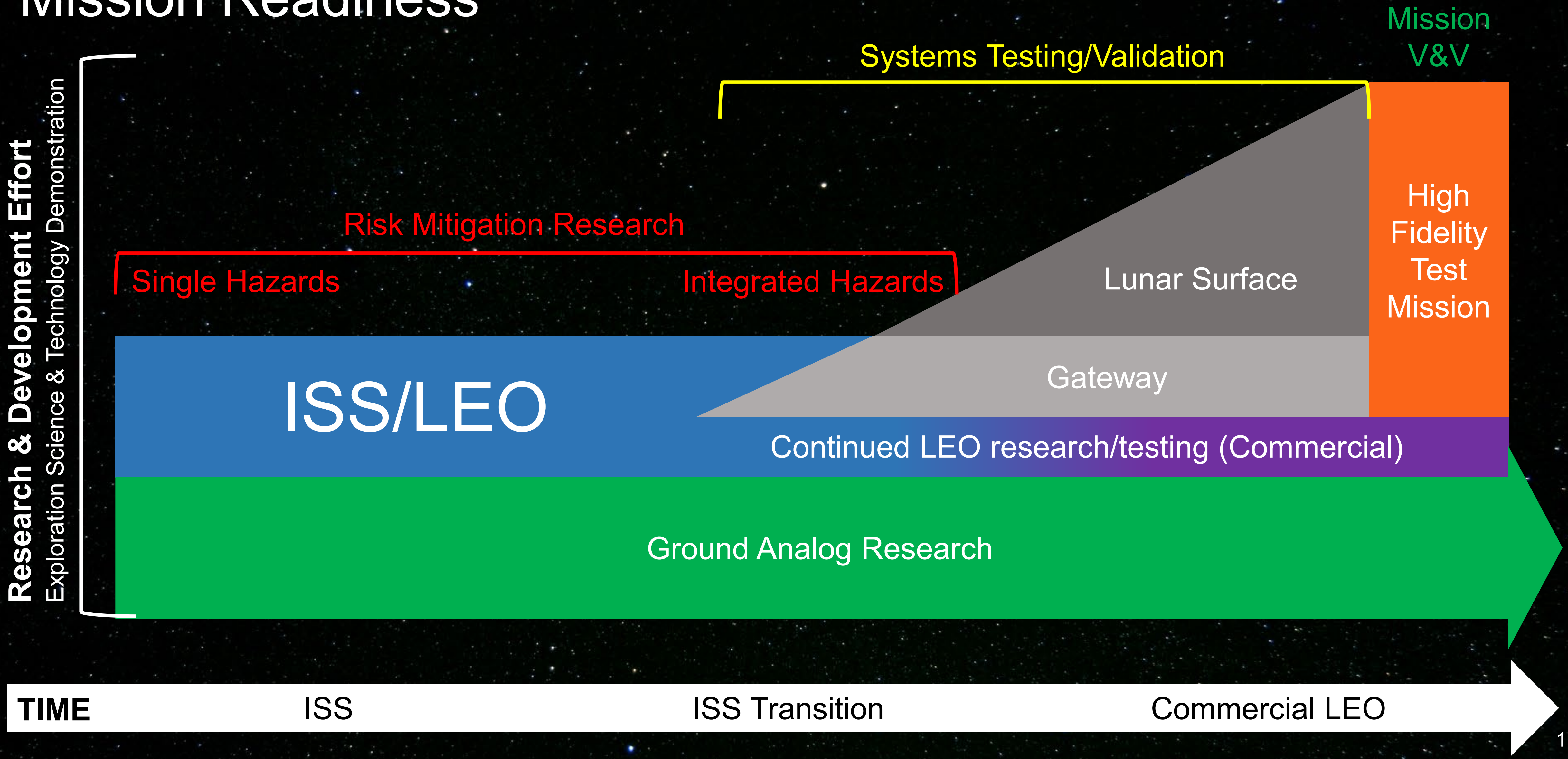
Notes: (1) Assumes Shielding for Solar Particle Events (2) ISS Exposures are roughly from 50% protons/SAA and 50% GCR, so total exposure may not reflect impact on a given system.

Hostile Closed Environment:

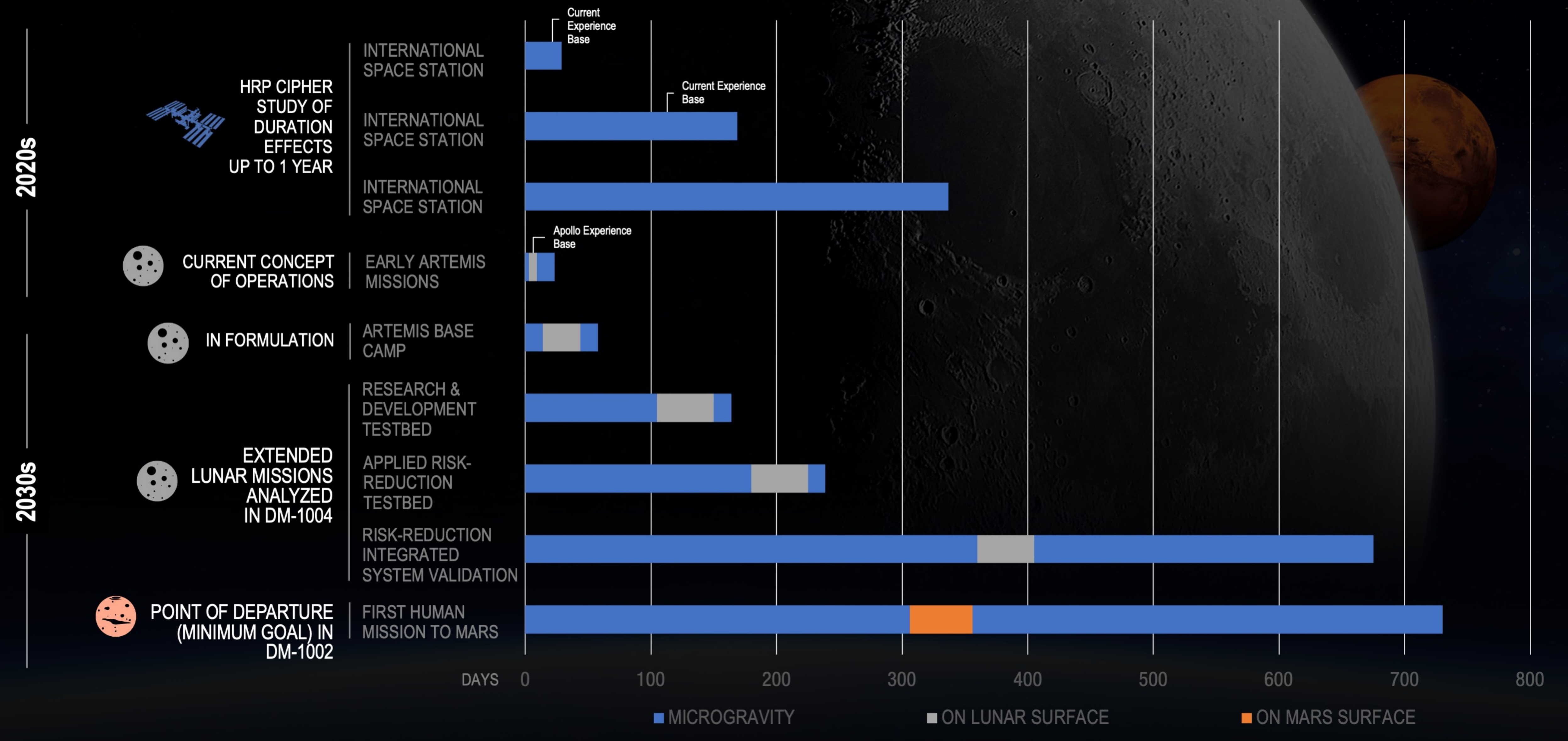
Analog Comparisons by Different Hazards of the Closed Environment

	6 days *Artemis* 3	30 days Gateway (extended)	60 days (30 surface) *Artemis* (extended)	4-12 months ISS LEO	22 months Mars orbital	22-30 months (1-18 surface) Mars landing
Exploration Atmosphere *TBR/TBD	Low Pressure (8.2 psi / 34% O_2, other options possible)*			Earth-like (14.7psi / 21% O_2)	Low Pressure (8.2 psi / 34% O_2, other options possible)*	
CO_2	Current ECLSS (2-4 mm Hg)		New ECLSS	Current ECLSS	New ECLSS (2 mm Hg)	
Microbes of Built Environment & Wetted Systems	Intermittent Occupancy, Limited Inputs			20 y Continuous Evolution/ multiple inputs	2-3 y Evolution, Single input	
Microbes Outside	Colonization		Colonization			Planetary Protection / Colonization
Food System						
Dust	Lunar Dust		Lunar Dust			Mars Dust, Storms

Strategy for Integrated Research and Testing for Mars Mission Readiness



Mitigating Human Systems Risks for Mars
Leveraging Increasing Mission Durations on ISS and at the Moon



Cross-platform Strategy for Exploration-related Biological Sciences

	EARTH	ISS	GATEWAY	LUNAR SURFACE	MARS DRM*
Crop Production	Research and develop crop system	Research and develop technology for microgravity crop production and reliability for Mars transit	Deep space seed viability; Validate Mars transit crop system	> 1 Year, Dormancy robotic surface crop system	Transit and Surface food systems ready
Microbiome		Microbiome of the Built Environment (MoBE) under continuous occupancy/turnover; In-situ monitoring technology	MoBE deep space radiation and intermittent occupancy	Lunar surface MoBE; Planetary spread of Earth-origin microbes and metabolites	MoBE under long duration occupancy without turnover; Planetary Protection applications and surveillance

*For likely parameters in future Mars missions

Cross-platform Strategy for Exploration-related Physical Sciences

	EARTH	ISS	GATEWAY	LUNAR SURFACE	MARS DRM*
Dust Mitigation	Earth simulant tests	Microgravity deposition studies for intra-vehicle, habitat, & ECLSS mitigation		Lunar dust mitigation technology demonstrations	Mars dust mitigation plans and technologies
Cryogenic Storage, Chill- down & Tank Transfer	Cryogenic fluid physics one-G, drop tower, aircraft, suborbital, testing	Fluid Physics uG data and model development ↓ μG Chill-down & Tank Transfer (for Gateway propellant depot technology)		1/6 G Storage, Chill-down and Tank Transfer	3/8 G Tank Transfers
Flam-ability, fire safety	One G testing, Drop towers for micro & partial G, modeling	μG combustion testing for analysis, modeling, and one-g fire safety test comparison		1/6 G Combustion Tests of planetary habitat materials	3/8 G Combustion Models

Cross-platform Strategy for Exploration-related Physical Sciences

	EARTH	ISS	GATEWAY	LUNAR SURFACE	MARS DRM*
Regolith Extraction and Solidification	One-G testing and analysis, simulation of materials processes and modeling	Cement formation, metal, & water ice extraction testing in μG and partial G via centrifuge (lunar & mars regolith simulant materials)		1/6 G Extraction & solidification demonstration	3/8 G Construction Techniques
Materials Performance	Materials simulation studies	Exposure facilities for radiation, thermal, atomic oxygen and vacuum exposure	Exposure facilities for deep space radiation and thermal, residual dust	Exposure facilities for deep space radiation, thermal, and primary dust	Validation of materials performance on Mars

Enabling measurements and samples:

- Dust samples
- Regolith samples

Analog Strategy for Human Systems Across Platforms

ISS	Artemis Initial	Artemis Extended	MARS DRM

- Biomarkers Individual/Team Performance Actiwatch → Unobtrusive Measures: Individual/Team Performance Wearable Devices → CHP System
- Autonomy Simulations and Medical Ops → Ultrasound → CHP System
- Pharmacy LEO Evironmental Testing → Pharmacy Deep Space Environmental Testing → CHP System
- Opthalmic Measures (OCT2) → Opthalmic Measures (e.g. MOD) → CHP System
- Onboard Monitoring (e.g. dry saliva) → Dry Saliva → CHP System
- Exploration Counter-measures (Exercise, Food) → CHP System

CHP System

- Behavioral Health & Performance
- Medical Capability
- Physiological Health & Countermeasures

→ Operational, Validated Mars Crew Health and Performance System

BPS Linkages

- Microgravity & Gravity Transition Hazards → Short Duration/Small Volume Integrated Hazards → Microgravity/Small Volume/Radiation Integrated Hazards; Integrated Partial Gravity/Surface Hazards → Studies of Integrated Hazards
- Gene/Environment → Gene/Environment → Gene/Environment; Gene/Environment → Gene/Environment

ECLSS-CHP SCLT Capability Areas

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS (ECLSS)

LIFE SUPPORT
- Atmosphere Management
- Water Management
- Waste Management

ENVIRONMENTAL MONITORING
- Pressure O_2 & N_2
- Moisture
- Particles
- Microbes
- Chemicals
- Sound

FIRE SAFETY
- Detection
- Protection
- Suppression
- Cleanup

LOGISTICS
- Tracking
- Relocating
- Clothing
- Packaging
- Trash

CREW HEALTH AND PERFORMANCE (CHP) SYSTEMS

EVA PHYSIOLOGY
- Physiological Inputs and Outputs
- ConOps/Crew Capabilities
- Informatics
- Injury & Risk Mitigation
- Exploration Atmosphere/Prebreathe

COUNTERMEASURES
- Exercise Systems
- Sensorimotor Systems
- Physiology Monitoring
- Countermeasure & Performance Informatics

RADIATION
- Models & Forecasting
- Monitoring
- Shielding

EXPLORATION MEDICAL
- Diagnostic
- Treatment
- Imaging
- Pharmacy

FOOD & NUTRITION
- Pre-packaged Food
- Food Storage
- Food Resources
- Dietary Tracking
- Health & Performance

ECLSS Capability Gaps

FUTURE: Deep Space

TODAY: International Space Station

CAPABILITY AREAS

CAPAB-ILITIES

Goal KPPs · Gaps · SOA KPPs

LIFE SUPPORT

Goal KPPs (Future: Deep Space)
- 98% H_2O recovery
- >75% O_2 Recovery from CO_2
- Reduced spares through reliability and maintainability
- Tolerate >9 months dormancy and planetary dust

SOA KPPs (Today: International Space Station)
- 90% H_2O Recovery
- 47% O_2 Recovery from CO_2
- Heavy reliance on spares and maintenance
- No periods of dormancy or planetary dust

Capabilities
- Atmosphere Management
- Water Management
- Waste Management

ENVIRONMENTAL MONITORING

Future
- Support planetary protection detection
- Identify and quantify chemical and microbial species and organisms in air & water with no sample return

Today
- Limited, crew-intensive on-board capability
- Reliance on sample returns to Earth for analysis

Capabilities
- Pressure O_2 & N_2
- Moisture
- Particles
- Microbes
- Chemicals
- Sound

FIRE SAFETY

Future
- ECLSS-compatible fire suppression
- Fire cleanup capability
- Common fire safety strategy & equipment across architectures
- Tested partial gravity flammability

Today
- ISS-specific fire detection and supporession incompatible with future architectures
- Only depress/repress clean-Up
- Limited understanding of partial gravity flammability

Capabilities
- Detection
- Protection
- Suppression
- Cleanup

LOGISTICS

Future
- RFID-enabled autonomous logistics
- Repurposed materials with additive manufactoring
- Reduced clothing mass
- Trash resource recovery and safe jettison

Today
- Manual scans, Displaced items
- Packaging disposed
- Disposable cotton clothing
- Bag and discard through cargo vehicles

Capabilities
- Tracking
- Clothing
- Relocating
- Packaging
- Trash

CHP Capability Gaps

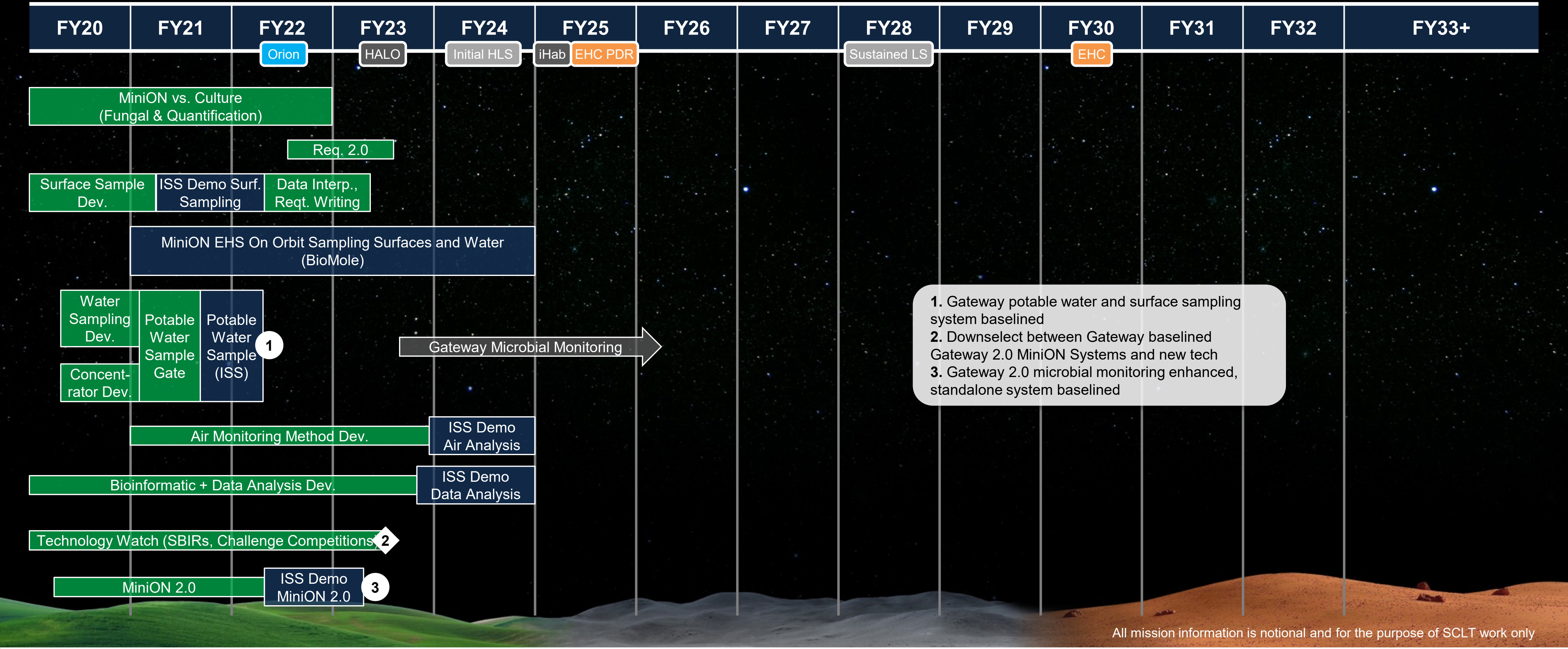
	EVA PHYSIOLOGY	COUNTERMEASURES	RADIATION	EXPLORATION MEDICAL	FOOD & NUTRITION
FUTURE: Deep Space	Mitigate Decompression Sickness with Exploration Atmosphere Mitigation of Injury Risk in Exploration EVAs Improved Crew Performance during EVA Operations Physiological informatics parameters provided in-suit	Unassisted partial gravity landing egress In-Flight Biometric Monitoring with Feedback Sensorimotor, Strength, and Aerobic Fitness Standards for Exploration Smaller Exploration Exercise Equipment & low-mass VIS	Storm Shelter Materials (Integration with Vehicles) Active Shielding, GCR Thick Shielding Accurate prediction of radiation event duration and intensity	In-flight diagnostics & treatment Autonomous medical skill & decision support systems	Cold Stowage for Food Innovation to Reduce Food Fatigue and Supplement Nutrition Reduce launched water mass in Food Nutritional Shelf Life > 5 Years
TODAY: International Space Station	ISS Prebreathe from Normal Atmosphere Injury Risk due to Sub-Optimal Suit Fit ISS EVA Lessons Learned on Crew Performance	Assisted Earth landing egress Pre- and Post-Flight Biometric Monitoring Exercise Performance Standards in Development Large ISS Exercise Equipment & High-mass Vibration Isolation System (VIS)	Limited Radiation Shielding Needed at ISS GCR Models, Vehicle Models Active and passive monitors	Real-time Ground Support, Resupply and Evacuation Capability ISS Medical Kit	No Cold Stowage for Food Food Fatigue is Resolved with Variety via Resupply Nutritional Shelf Life < 3 Years
CAPABILITY AREAS	**EVA PHYSIOLOGY**	**COUNTERMEASURES**	**RADIATION**	**EXPLORATION MEDICAL**	**FOOD & NUTRITION**
CAPAB-ILITIES	• Physiological Inputs/Outputs • ConOps/Crew Capabilities • Informatics • Injury & Risk Mitigation • Exploration Atmosphere/ Prebreathe	• Exercise Systems • Sensorimotor Systems • Physiology Monitoring • Countermeasure & Performance Informatics	• Models & Forecasting • Monitoring • Shielding	• Diagnostic • Treatment • Imaging • Pharmacy	• Pre-packaged Food • Food Storage • Dietary Tracking • Food Production

EXAMPLE

Microbial Monitoring - Slide 1 (slide 2 not shown)

POC(s): Sarah Wallace

Revised: 01/19/2020



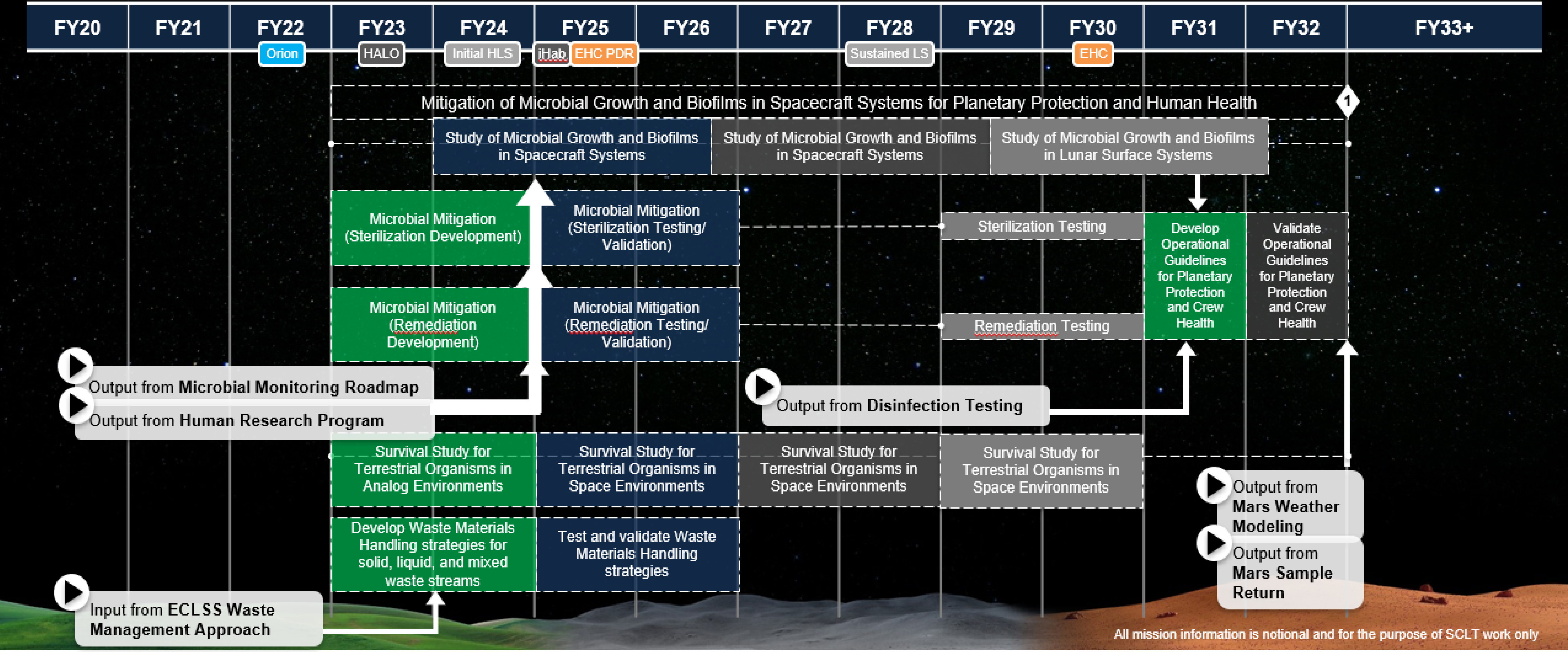
- Ground Activity
- ISS / LEO
- Orion
- Gateway
- Lunar Surface
- Mars Transit
- Mars Surface
- Events/Milestones
- ◆ Decision Point
- HLS = Human Landing System
- EHC = Expanded Habitation Capability
- HALO = Habitation and Logistics Outpost

Objectives: Roadmap beyond 2025 under formulation. Quantify and identify microbial species in-flight without sample return. Common core technologies with evolving planetary protection needs. Reduced crew time through integration and automation. >3 year shelf life consumables and calibration.

Planetary Protection Strategic Roadmap Coordination Activity for HEOMD (Artemis, Moon to Mars)

Develop Planetary Protection Capability for Crewed Missions to Mars (Slide 2 of 2)

POC(s): Andy Spry/Bette Siegel
Revised: 03/26/2021



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(1) Determine Acceptable Levels of Microbial/Organic Releases from Humans and Support Systems

Working Document under ongoing review


SCIENCE THAT ENABLES EXPLORATION
MISSIONS ENABLING SCIENCE AND TECHNOLOGY

HEOMD Organization to support Science & Technology Utilization across human spaceflight platforms

HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE

ASSOCIATE ADMINISTRATOR FOR HUMAN EXPLORATION AND OPERATIONS
—Kathryn Lueders—
DEPUTY ASSOCIATE ADMINISTRATOR
—Ken Bowersox—
DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT
—Toni Mumford—

SENIOR ADVISOR TO HEO ASSOCIATE ADMINISTRATOR
—Dr. Paul McConnaughey—
SENIOR ADVISOR TO HEO ASSOCIATE ADMINISTRATOR
—Jim Norman—
SPECIAL ASSISTANT TO HEO ASSOCIATE ADMINISTRAATOR
—Patrick "Pat" Forrester—

DEPUTY ASSOCIATE ADMINISTRATOR, HEO SYSTEMS ENGINEERING AND INTEGRATION
—Marshall Smith—
ASSISTANT DEPUTY ASSOCIATE ADMINISTRATOR
—Dr. Greg Chavers—

SPECIAL ASSISTANT
—Sam Scimemi—
CHIEF SCIENTIST FOR SCIENCE RESEARCH & UTILIZATION
—Dr. Julie Robinson—

SENIOR CAPABILITIES LEADER, ECLSS
—Vacant—
STRATEGIC & ARCHITECTURE MGR
—Vacant—

DIRECTOR, STRATEGIC INTEGRATION & MANAGEMENT DIVISION
—Dr. Alotta Taylor—
DEPUTY DIRECTOR, STRATEGIC INTEGRATION & MANAGEMENT DIVISION
—Tonya McNair—

DIRECTOR, RESOURCES MANAGEMENT OFFICE
—Brian Dewhurst—
DEPUTY DIRECTOR, RESOURCES MANAGEMENT OFFICE
—Elaine Slaugh—

DEPUTY ASSOCIATE ADMINISTRATOR, SPACE COMMUNICATIONS & NAVIGATION
—Badri Younes—
ASSISTANT DEPUTY ASSOCIATE ADMINISTRATOR, SENIOR SPECTRUM ADVISOR
—Victor Sparrow—

DIRECTOR, NETWORK SERVICES
—Sue Chang—

SENIOR TECH LEAD COMM & NAV
—Jason Mitchell—

DIRECTOR, LAUNCH SERVICES OFFICE
—Bradley Smith (Acting)—

DEPUTY ASSOCIATE ADMINISTRATOR EXPLORATION SYSTEMS DEVELOPMENT DIVISION
—Tom Whitmeyer—
ASSISTANT DEPUTY ASSOCIATE ADMINISTRATOR
—Amit Kshatriya (Acting)—
PRINCIPAL ADVISOR FOR SPACE TRANSPORTATION
—Janet Karika—

DIRECTOR CSI:
—Wayne Jermstad (Acting)—
ARTEMIS MISSION MANAGER:
—Mike Sarafin—

ESD SAFETY MISSION & ASSURANCE MGR:
—Thomas Hartline—

DEPUTY ASSOCIATE ADMINISTRATOR ADVANCED EXPLORATION SYSTEMS DIVISION
—Mark Kirasich—
ASSISTANT DEPUTY ASSOCIATE ADMINISTRATOR
—Steve Creech—

MANAGER, AES SE&I
—Erika Alvarez (Acting)—

DIRECTOR, COMMERCIAL SPACEFLIGHT DEVELOPMENT DIVISION
—Phil McAlister—

DIRECTOR, INTERNATIONAL SPACE STATION DIVISION
—Robyn Gatens—

DIRECTOR, HUMAN SPACEFLIGHT CAPABILITIES DIVISION
—Benjamin Neumann—

SPACE LAUNCH SYSTEM PROGRAM	J. Honeycutt	MSFC
EXPLORATION GROUND SYSTEMS PROGRAM	M Bolger	KSC
ORION PROGRAM	C. Koerner	JSC
GATEWAY PROGRAM	D. Hartman	JSC
HUMAN LANDING SYSTEM PROGRAM	L. Watson-Morgan	MSFC
ISS NAT'L LAB	Interface managed by ISSNL Prog Exec at HQ and CATO at JSC	
COMMERCIAL CREW PROGRAM	S. Stich	KSC
COMMERCIAL LEO DEV PROGRAM	A. Hart	JSC
ISS PROGRAM	J. Montalbano	JSC
ROCKET PROPULSION TEST PROGRAM	C. Powell (Acting)	SSC
HUMAN RESEARCH PROGRAM	D. Baumann (Acting)	JSC
LAUNCH SERVICES PROGRAM	A. Mitskevich	KSC

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HEO SE&I Functional Descriptions

Systems Engineering & Integration Deputy Associate Administrator

Responsible for ensuring the overall HEO strategy is reflected in program requirements; leads architecture, formulation mission planning and provides technical direction for HEO activities (Moon, Mars and other human missions)

Strategy and Architecture

Translates Agency vision into an integrated HEO portfolio that supports national exploration goals through development of campaigns and architectures and performing formulation activities

Capability Integration

Articulates capability needs for lunar and Mars missions, identifies integration and overlap between mission needs, and develops strategies for advancing key capabilities that support those needs

Science and Technology Utilization

Integrates science and technology goals from mission directorates and international partners to develop HEO utilization goals, objectives and requirements for Artemis missions, and the cross-platform research strategy to prepare for human missions to Mars

Technical Integration

Focused on ensuring agency strategies are achieved through HEO systems and programs, establishes and maintains HEO top-level requirements, and allocates to the various campaign elements and initiatives

Portfolio Integration

Provides cross-cutting support to HEO systems and programs coordinating activities, boards, schedules and driving issue resolution

HEO Science & Technology Utilization

HEOMD Deputy Associate Administrator for SE&I
Marshall Smith (HQ FTE)

HEOMD SE&I Assistant Deputy Associate Administrator
Greg Chavers (HQ FTE)

Science and Technology Utilization

Manager (Acting): Julie Robinson
Chief Exploration Scientist: Jacob Bleacher
Technology Integration Lead: Dionne Hernández-Lugo (GRC)
Program Executive: Bette Siegel
Integrator: Michael Waid (JSC)

Multicenter Support Team

Lead Integrator: Cindy Evans (JSC)

John Gruener (JSC)
Joseph Hamilton (JSC)
Sam Lawrence (JSC)
Tim Lewis (LaRC)
Torin McCoy (JSC)
Paul Niles (JSC)
Noah Petro (GSFC)
Sharmi Watkins (JSC)
Kelsey Young (GSFC)

Solar System Exploration / Research Virtual Institute (SSERVI)

Greg Schmidt (ARC)
Christina Gibbs (ARC)
Coordination with SMD

Planetary Protection Office HEO Integration

Coordination with OPP, SMD, STMD

Last revision: 21 July 2021

Utilization Coordination and Integration Group (UCIG)*

Mission Directorate "Level 0"

- Three Mission Directorate co-chairs
- SMD, STMD and HEOMD evaluate, define and own their own utilization objectives and selections
- HEO integrates and determine what utilization objectives can be accommodated in mission capabilities
- Documentation in HEO-006 Utilization Plan

Mission Directorate Representatives that fund utilization

- SMD/ESSIO
- SMD/BPSD
- SMD/DAA Programs
- STMD
- HEOMD/HRP
- HEOMD/AES Enabling Capabilities
- Office of Planetary Protection

HEO Representatives

- **Science & Technology Utilization (SE&I)**
- Other SE&I Orgs

Implementing Divisions

- ESD
- AES
- HSFCD
- ISS
- CSDD
- SCaN

Observers

- Office of the Chief Scientist
- Office of the Chief Technologist
- Office of International and Interagency Relations
- Technical Authorities

Implementing Programs

- Gateway
- HLS
- LTV
- ISS

Requirements Flow

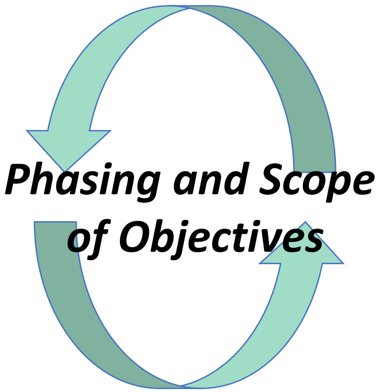
Science and Technology Utilization – Processes
Transition from Strategy to Execution

HEO Level

HEO Science & Technology Utilization Office

Jointly With SMD and STMD

- Works with users and AES to integrate high-level Goals, Objectives, Cornerstone Utilization Capabilities and strategic plans
- "Utilization Coordination and Integration Group (UCIG)" co-chaired with SMD (ESSIO) and STMD
- Integrates HEO-006 Utilization Plan
- Mission Phased Objectives as a realistic subset (**Level 0 Utilization Requirements**)



Artemis Division Level

Advanced Exploration Systems,

with Exploration Systems Development

- Works with users, programs and HEO S&TU on detailed mission objectives, approach to implementation, and payload manifest
- "Artemis Utilization Coordination Panel (AUCP)' for AES, "Payload ITT" for ESD
- Tactical research plans with increased level of detail (**Level 1 Utilization Requirements**)

Draft approach, subject to final Mission Directorate Approvals

Science & Technology Utilization Products

HEO-006 Utilization Plan, Baselined Content Planned by Sept 2021

Main Body

1.0 INTRODUCTION

2.0 APPLICABLE AND REFERENCE DOCUMENTS

3.0 Human Exploration Utilization Goals and Objectives (ISS, Commercial LEO, Artemis)

- **3.1 SMD**
- **3.2 STMD**
- **3.3 HEOMD**
- **3.4 NASA Multi-directorate**

4.0 Introduction to Annexes

Appendices – Acronyms, Definitions, Open Work, Forward Work

Annexes

Annex 1 – Cornerstone Utilization Capabilities that Enable Multiple Objectives (Use Cases)

Annex 2 – Ten-year Utilization Phasing Plan

Annex 3 – Integrated LEO Utilization Objectives

Post-Sept 2021

Annex 4 – Integrated Artemis Mission Utilization Objectives

- 4.1 Artemis First Crewed Landing
- 4.2 Artemis Second Crewed Landing

HEO 006 Annex 1 Cornerstone Utilization Capabilities
(Use Cases, First Priority for Baselining. Others to Follow as Needed)

1.1 Model Traverse Approaches: Access to and operations in new terrain including traverse use cases to inform crew and rover mobility, communications.
1.2 End-to-End Sampling Strategy: Sampling, curation, and transport strategy including core tube samples, stratigraphy, identification and collection of rocks, biological samples, cold sample curation, documentation tools both geological and biological sample.
1.3 Integrated Planetary Protection Strategy: Planetary protection strategy and microbial monitoring across PPO, PSD, BPSD, and HRP, and ECLSS SCLT research.
1.4 Extended Missions: Extended duration orbit/surface missions for experiments and technology development (applies to both ISS and Artemis)
1.5 Integrated Crew Research: Integrating/coordinating access to human test subjects pre- and post-flight
1.6 Robotic Utilization for HEO Assets: Uncrewed/robotic operations for utilization of HEO assets (use cases, characterization of local environment, instrument deployment)
1.7 Integrated Instrumentation Strategy: In situ instrumentation and measurements (external instruments, real time EVA and shirtsleeve measurements)
1.8 PSR Operations: Complex operations in permanently shadowed regions/cold regions (sampling, measurements, ISRU)

Impact: Development these documents led to modifications of 10 Top-level Artemis Requirements
Future Work: Expect to begin ~3 more use cases in September 2021

Questions?

Acronyms

- AES- Advanced Exploration Systems (HEOMD)
- AUCP - Artemis Utilization Coordination Panel
- BPSD – Biological and Physical Sciences Division (SMD)
- CSDD – Commercial Spaceflight Development Division (HEOMD)
- DAA Deputy Associate Administrator
- ESD – Exploration Systems Division (HEOMD)
- ESSIO – Exploration Science Strategy and Integration Office (SMD)
- HEO - Human Exploration and Operations (Mission Directorate)
- HRP – Human Research Program (HEOMD)
- HSFCD – Human Spaceflight Capabilities Division (HEOMD)
- HLS – Human Landing System
- ISS – International Space Station (HEOMD)
- ITT – Integration Task Team
- LTV – Lunar Terrain Vehicle
- SCaN – Space Communications and Navigation (HEOMD)
- SE&I - Systems Engineering and Integration (HEOMD)
- SMD – Science Mission Directorate
- STMD – Space Technology Mission Directorate
- UCIG – Utilization Coordination Integration Group