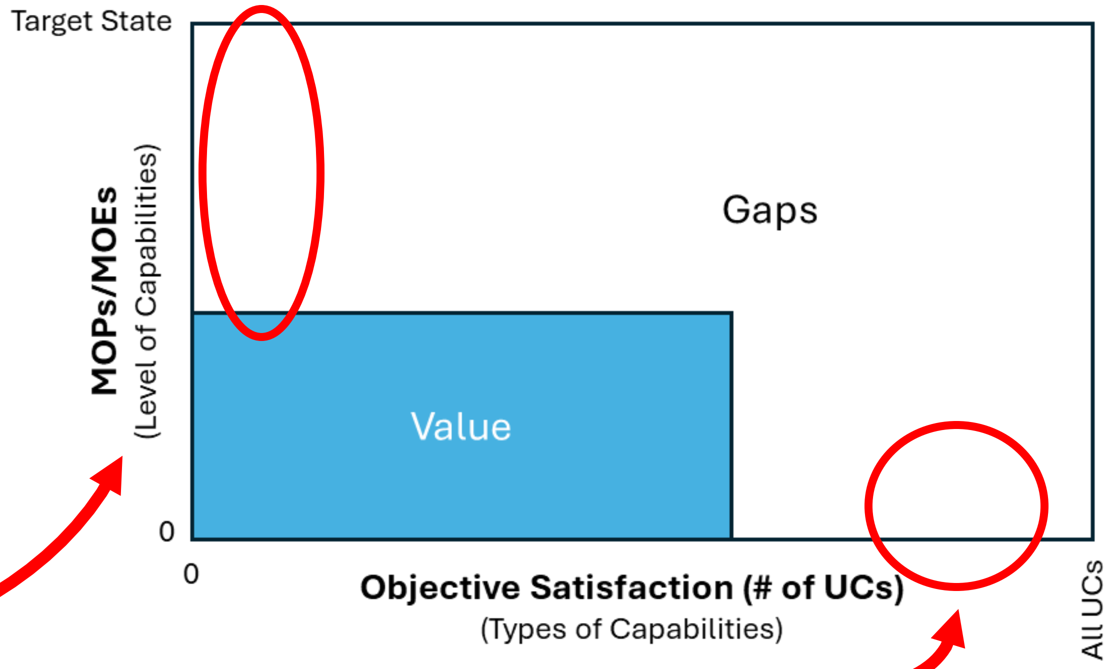
Gaps and Needs
Opportunities for Partnership

Nujoud Merancy
Deputy Associate Administrator
Strategy and Architecture Office
NASA – ESDMD – SAO

Architecture Gap Definition

National Aeronautics and Space Administration

- NASA continues to assess needs to achieve the Moon to Mars Objectives
- Gaps can be identified two ways:
  - Unfilled Use Cases/Functions
  - Performance gap with only partially addressed capability



Example Performance Gap

FN-H-102 L	Enable a pressurized, habitable environment on the lunar surface for moderate duration (month+) use
FN-X-103 L	Provide crew countermeasure system(s) to support the crew for moderate durations (month+) on the lunar surface

Example Capability Gap from ADD

FN-P-101 L	Generate power in the south pole region on the lunar surface
FN-P-202 L	Store energy in the south pole region on the lunar surface

Foundational Exploration Gap Example

National Aeronautics and Space Administration

Power Sharing at Lunar South Pole

Key Functions	
FN-P-101 L	Generate power in the south pole region on the lunar surface
FN-P-202 L	Store energy in the south pole region on the lunar surface
FN-P-301 L	Distribute power in the south pole region on the lunar surface
FN-P-401 L	Provide power for deployed surface utilization payloads(s) and/or equipment
FN-P-402 L	Provide power for deployed external surface utilization payloads(s) and/or equipment for long durations (months to years+)
FN-U-414 L	Provide resources to condition refrigerated sample containers on the lunar surface
FN-U-415 L	Provide resources to condition frozen sample containers on the lunar surface

Key Performance Targets	
Dist. Power on Lunar Surface	>10 kW estimated distributable power in South Pole region

Power generation, storage, and distribution to exploration assets at the lunar South Pole sites, supporting sunlight and eclipse periods.

- Minimum closure 2 major elements:
  - Power generation and/or storage of 10kW
  - Power distribution/interface/cabling system
- Stretch and/ or alternate capabilities:
  - Redundant power systems at multiple locations
  - Power system ranges from 3 to 10 kW or greater
- Estimate 2-4 ton relocatable systems

Multiple ways to address this gap are possible, characterizing the need and constraints enable collaboration

High Priority Gaps

Foundational Exploration Segment

Sub-Architecture	Integrated Gap	Summary Element Need
Power	Power Sharing at Lunar South Pole	2 Major (power + interface/cabling), stretch 2-3 more elements
Mobility	High-Capacity Mobility at Lunar South Pole	2-3 Major Elements
Logistics	Logistics Delivery and Mgmt Systems	1 major/1 minor both with repeat production
Logistics	Water and Gas Transfer on Lunar Surface	multiple sub-elements with repeat production
Transportation	Large Cargo Delivery to the Lunar Surface	2-3 major elements
Transportation	Large Cargo Return from NRHO to Earth or from Lunar Surface to Earth	2 major elements, return vehicle & Gateway docking mitigation
Habitation	Extended Crew Habitation at Lunar South Pole	1 -2 major elements, multiple sub-elements/systems
Habitation	Extended Crew Habitation in NRHO	1 major element
Utilization	Resource Identification on Lunar Surface	Pending Utilization Analysis
Utilization	Deep Subsurface Sampling on Lunar Surface	Pending Utilization Analysis
Utilization	Storage of Cryogenic Samples	Pending Utilization Analysis

Priority defined by the significance of closure to objective satisfaction and overall mission capability achieved

Secondary Gaps

Foundational Exploration Segment

National Aeronautics and Space Administration

Sub-Arch	Integrated Gap
Mobility	Crew Mobility at Distributed Locations on the Lunar Surface
Power	Power Sharing at Distributed Locations on the Lunar Surface
Mobility	Extra Vehicular Activity Capability on Lunar Far Side
Utilization	Lunar Surface Observation
C&PNT	PNT Capabilities at non-South Pole Sites on the Lunar Surface
Data	In-Space Processing of Data
Transportation	Delivery of Payloads and Equipment to Deep Space
Utilization	Hosting of Utilization Payloads in Deep Space

Sub-Arch	Integrated Gap
Auto/Robotics	Robotic Assistance of Crew on Lunar Surface
Habitation	Management of Waste Streams on Lunar Surface
ISRU	Demonstration of Oxygen and Water ISRU on Lunar Surface
ISRU	Demonstration of Regolith-Based ISRU on Lunar Surface
Auto/Robotics	Demonstration of Autonomous Construction on Lunar Surface
Transportation	Long-Term Storage of Propellants
Transportation	Access Tank Residuals from Transportation Elements
Habitation	Demonstration of Advanced ECLSS Capabilities

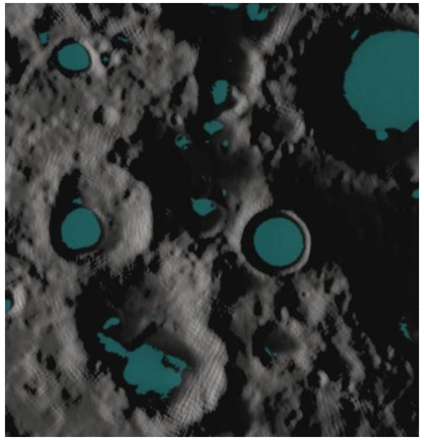
Targeted needs and gaps to enhance FE and/or enable technology and capabilities for Humans to Mars Segment

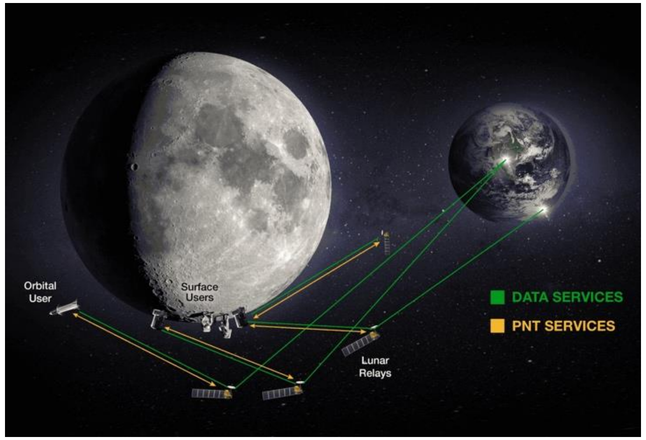
Foundational Exploration Capability Gaps for Science

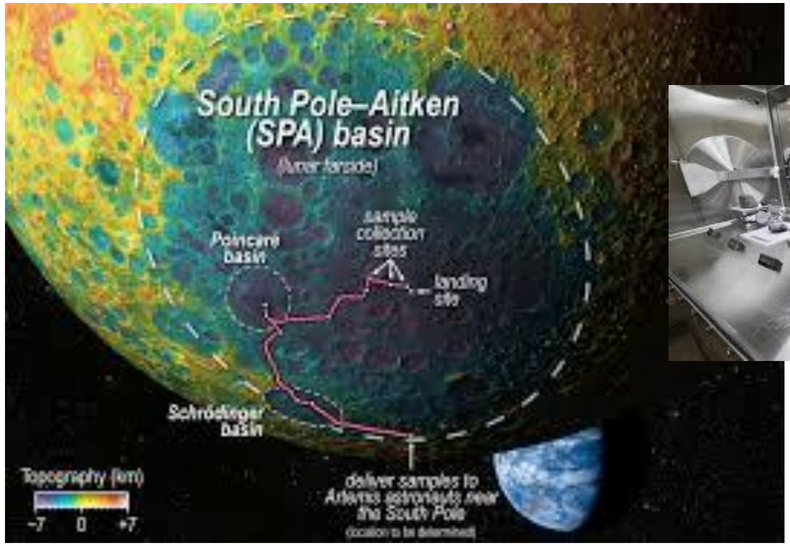
Joel Kearns
Deputy Associate Administrator
for Exploration
Science Mission Directorate
NASA - SMD

Key Gaps Existing for Science

Foundational Exploration Segment







Current High Priority Gaps for Science

- Payload delivery, transport, and survive/operate the night
- Far Side Sample Return
- Large Cargo Return
- Communications (EVA, deployed instruments, far side/global)
- Power (long lived instruments, recharge, storage, StN/operate through night)
- Cold conditioned sampling and curation (sampling/PSR conops, technologies, curation, analytical facilities)

Upcoming Academy / SDT Studies That Will Inform Architecture

- High Priority Science Campaigns for Human Explorers on the Surface of Mars
- SPA Return & Exploration (SPARX) Science Definition Team
- Key Destinations Across the Moon to Address Decadal-level Science Objectives with Human Explorers
- *Science Accomplished during Human Mars Transit (planned)*
- *Science Addressed from a Sustained Lunar Basecamp (planned)*

Foundational Exploration Capability Gaps, Partnership Opportunities

Walt Engelund
Deputy Associate Administrator for Programs
Science Mission Directorate
NASA - STMD

National Aeronautics and Space Administration

2024 STMD Technology Shortfall Rankings

National Aeronautics and Space Administration

Shortfall: *Identified, problem-focused technology area requiring further development to meet future exploration, science, and other mission needs*

- Documented 187 shortfalls within 20 capability areas
- Collected stakeholder feedback (1,231 responses) on the importance of each shortfall
- Processed the data to assemble an integrated, ranked civil space problem list
    - Survive and operate through the lunar night ranked #1 on the integrated list and in the top 10 across all stakeholder groups
    - Agreement across stakeholder groups that the top 5 shortfalls are very important
    - Relatively broad consensus and support for the top 30 shortfalls
    - Diverse representation of capability areas in the top 20 (advanced habitation systems, autonomous systems and robotics, communication and navigation, power, avionics, nuclear propulsion)
- Integrated list is one of several factors guiding STMD projects and investments
- Results informing the development of technology roadmaps
- Using lessons learned to refine the approach

View the results:
nasa.gov/civilspaceshortfalls

Top Lessons Learned

National Aeronautics and Space Administration

Level set shortfall construct and provide context

- Limit shortfall definition to problem space only; Lower levels can capture the possible solution space which should be detailed in the roadmaps
- Restructure/combine shortfalls to portray more holistic definition of the problem space
- Assign a single person the responsibility of coordinating the definitions of shortfalls from a holistic perspective, with significant input from relevant PTs/SCLs
- Work with ESDMD and SMD counterparts to ensure 1-to-1 mapping for consistency and clarity

Use a shortfall Identifier to allow for easy capability area reference

- Use category names in the gap numbers, e.g. ISAM-708 not just “708”

Standardize survey construct

- Have one survey for internal and external stakeholders
- Research and evaluate best practice methodologies for large surveys

Revise data analysis methodology to be applied consistently across stakeholders

- Reconsider collecting consolidated responses
- Communicate stakeholder weightings with survey release

Integrated Top 30 Shortfalls Compared to Stakeholder Rank

Higher Ranking Shortfalls	>	Lower Ranking Shortfalls				
1	30	60	90	120	150	180

Not Ranked (NR)

National Aeronautics and Space Administration

Integrated Rank	Average Score	Shortfall ID	Category	Stakeholder Group Rank								
				Academia	Small Industry	Large Industry	OGA	Other	NASA Centers	NASA ESDMD	NASA SMD	NASA Other MDs
1	8.103	1618: Survive and operate through the lunar night	Thermal Management Systems	4	2	2	2	9	6	4	9	1
2	7.612	1596: High Power Energy Generation on Moon and Mars Surfaces	Power	13	1	1	40	20	4	21	NR	16
3	7.435	1554: High Performance Onboard Computing to Enable Increasingly Complex Operations	Avionics	80	28	21	27	13	3	34	1	56
4	7.383	1557: Position, Navigation, and Timing (PNT) for In-Orbit and Surface Applications	Communication and Navigation	9	11	15	29	67	10	28	NR	3
5	7.247	1545: Robotic Actuation, Subsystem Components, and System Architectures for Long-Duration and Extreme Environment Operation	Autonomous Systems and Robotics	34	27	28	63	10	40	13	9	49
6	7.208	1552: Extreme Environment Avionics	Avionics	176	49	6	38	23	54	6	9	62
7	7.196	1519: Environmental Monitoring for Habitation	Advanced Habitation Systems	20	101	72	75	61	49	17	19	13
8	7.168	709: Nuclear Electric Propulsion for Human Exploration	Propulsion: Nuclear	43	131	23	4	52	32	7	NR	7
9	7.114	1304: Robust, High-Progress-Rate, and Long-Distance Autonomous Surface Mobility	Autonomous Systems & Robotics	27	42	30	121	91	34	25	25	66
10	7.095	1520: Fire Safety for Habitation	Advanced Habitation Systems	23	24	78	12	12	12	29	55	14
11	7.052	1531: Autonomous Guidance and Navigation for Deep Space Missions	Autonomous Systems & Robotics	47	67	24	3	89	42	64	23	15
12	7.045	1591: Power Management Systems for Long Duration Lunar and Martian Missions	Power	40	12	10	52	24	68	35	NR	27
13	7.034	702: Nuclear Thermal Propulsion for Human Exploration	Propulsion: Nuclear	36	114	36	14	78	62	7	NR	11
14	7.031	1559: Deep Space Autonomous Navigation	Communication and Navigation	62	129	27	5	120	38	64	23	10
15	6.968	1527: Radiation Countermeasures (Crew and Habitat)	Advanced Habitation Systems	5	23	22	6	2	5	63	NR	6
16	6.948	1526: Radiation Monitoring and Modeling (Crew and Habitat)	Advanced Habitation Systems	6	53	41	81	1	13	27	38	35
17	6.946	879: In-space and On-surface, Long-duration Storage of Cryogenic Propellant	Cryogenic Fluid Management	21	37	3	95	22	1	59	NR	2
18	6.843	1548: Sensing for Autonomous Robotic Operations in Challenging Environmental Conditions	Autonomous Systems & Robotics	42	17	26	90	16	44	14	26	57
19	6.804	1558: High-Rate Communications Across The Lunar Surface	Communication and Navigation	25	73	29	77	162	20	5	NR	51
20	6.792	1626: Advanced Sensor Components: Imaging	Sensors and Instruments	18	75	12	45	160	22	NR	18	68
21	6.784	792: In-space and On-surface Transfer of Cryogenic Fluids	Cryogenic Fluid Management	17	29	4	51	26	2	62	NR	29
22	6.720	1569: High-Mass Mars Entry and Descent Systems	Entry Descent and Landing	152	156	48	117	5	33	16	NR	12
23	6.711	1525: Food and Nutrition for Mars and Sustained Lunar	Advanced Habitation Systems	8	32	116	41	45	30	11	NR	58
24	6.695	1571: Navigation Sensors for Precision Landing	Entry Descent and Landing	14	62	37	23	4	31	45	28	9
25	6.689	1573: Terrain Mapping Capabilities for Precision Landing and Hazard Avoidance	Entry Descent and Landing	30	31	9	12	8	11	45	28	53
26	6.662	1562: Advanced Algorithms and Computing for Precision Landing	Entry Descent and Landing	54	65	45	23	3	25	45	28	8
27	6.593	1597: Power for Non-Solar-Illuminated Small Systems	Power	85	26	5	39	125	47	93	12	20
28	6.592	1568: Entry Modeling and Simulation for EDL Missions	Entry Descent and Landing	101	115	76	60	15	50	45	5	45
29	6.584	1516: Water and Dormancy Management for Habitation	Advanced Habitation Systems	49	98	127	158	53	69	26	51	22
30	6.569	1524: Crew Medical Care for Mars and Sustained Lunar	Advanced Habitation Systems	12	64	94	1	11	21	58	NR	17

Connections to LEO Microgravity Strategy

Steve Bowen
Director, Cross-Directorate
Technical Integration Office
Science Mission Directorate
NASA - SOMD

LEO Microgravity Strategy

National Aeronautics and Space Administration

NASA's Low Earth Orbit Microgravity Strategy document outlines what NASA intends to achieve by continuing human activities in low Earth orbit after the retirement of the International Space Station.

By maintaining a robust presence in low Earth orbit, NASA will continue to drive scientific discovery, technological innovation, commercial growth, and international cooperation, all while positioning the United States to remain at the forefront of space in the coming decades.

Read the Strategy
https://bit.ly/3EycgVg

LEO Exploration Goals

National Aeronautics and Space Administration

Exploration Technology

Leverage the unique environment of low Earth orbit to advance technologies that enable future human exploration on and around the Moon and Mars.

Human Health and Performance Research in Exploration Analog Environments

Advance understanding of how to sustain human health and performance using relevant exploration analog environments in low Earth orbit to reduce risks and inform Moon, Mars, and deep space missions.

Using Low Earth Orbit Operations to Prepare for Deep Space Exploration

Validate crewed mission operations in low Earth orbit as part of a timely and effective methodology to test the agency's evolutionary approach to living and working in environments relevant to Moon and Mars exploration.

PANEL

National Aeronautics and Space Administration

Foundational Exploration: Capability Gaps, Partnership Opportunities

Moon to Mars Architecture Workshop

Room Name

MODERATOR

Clark Esty
Executive Officer to the Associate Administrator
ESDMD

Nujoud Merancy
Deputy Associate Administrator
ESDMD, SAO

Joel Kearns
Deputy Associate Administrator for Exploration
SMD

Walt Engelund
Deputy Associate Administrator for Programs
STMD

Steve Bowen
Director, Cross-Directorate Integration Office
SOMD