



NASA Space Technology Update

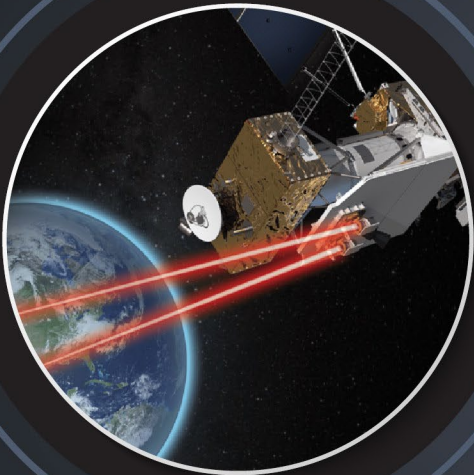
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Deputy Associate Administrator,
NASA Space Technology Mission Directorate

October 2024

NATIONAL TECH BASE FOR CIVIL SPACE

Space Tech leads the development, demonstration, and infusion of transformational space technologies that solve critical stakeholder needs



ADVANCE US space technology innovation and competitiveness in a global context

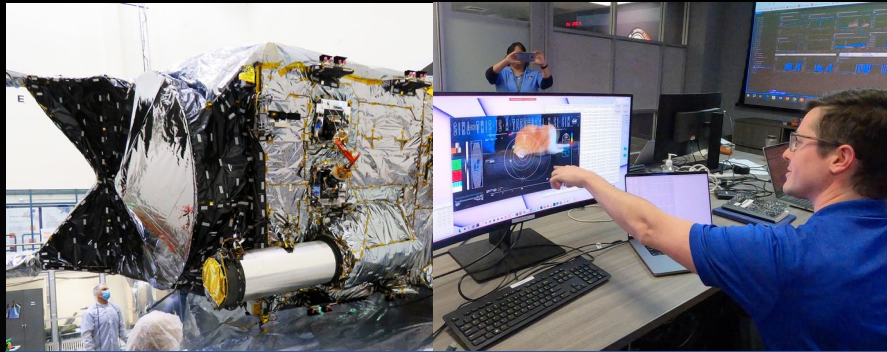


ENCOURAGE technology driven economic growth with an emphasis on the expanding space economy

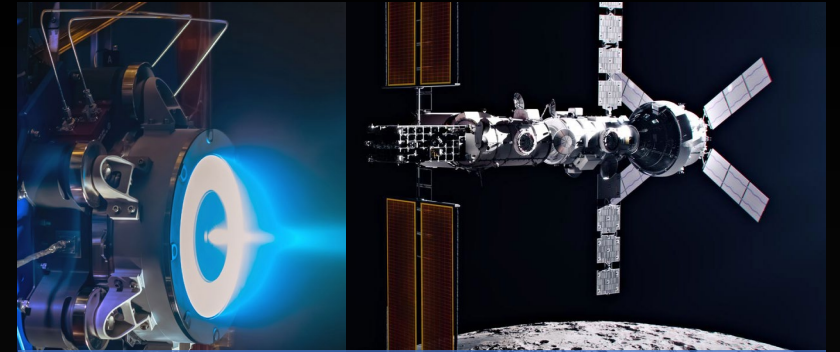


INSPIRE and develop a diverse and powerful US aerospace technology community

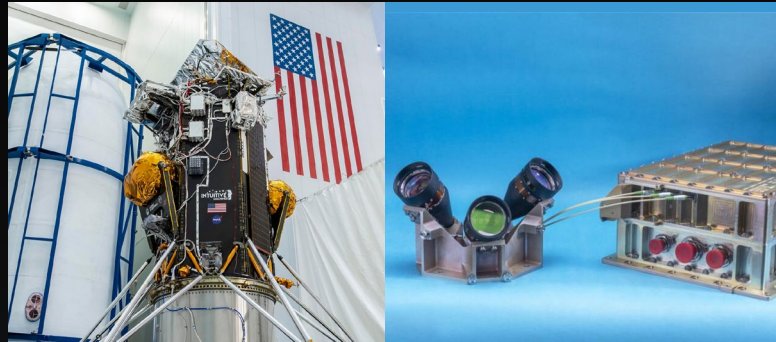
Recent Tech Highlights



Deep Space Optical Communications



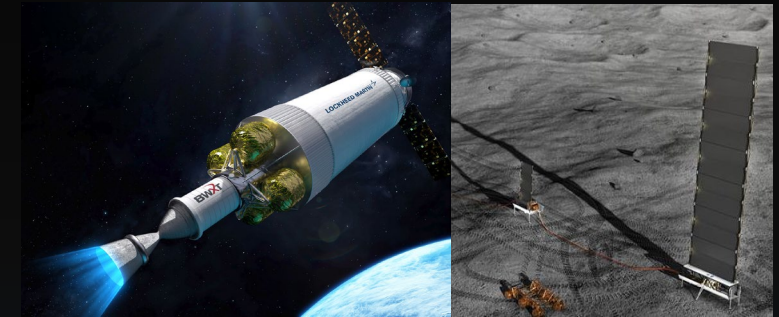
Solar Electric Propulsion



Intuitive Machines 1 CLPS Payloads



Cryogenic Fluid Management Demo



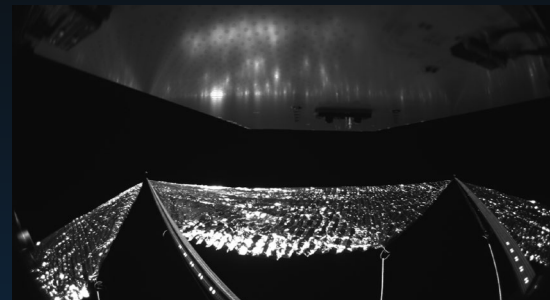
Space Nuclear Technologies



Starling Swarm Demo



Cooperative Robotic Scouts



Solar Sail Boom Deploys

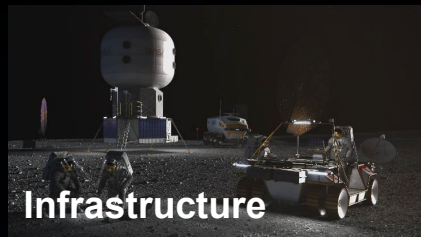


Flight Opportunities

Moon-to-Mars Blueprint Objectives



Moon to Mars Blueprint Objectives



Enabling Key Moon-to-Mars Lunar Infrastructure Objectives



LI-1^L: Develop an incremental **lunar power**
MI-1^M generation and distribution system that is evolvable to support continuous robotic/human operation and is capable of scaling to global power utilization and industrial power levels.



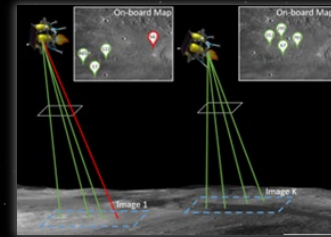
LI-2^L: Develop a lunar surface, orbital, and Moon-to-Earth **communications** architecture capable of scaling to support long term science, exploration, and industrial needs.



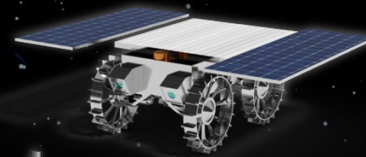
LI-3^L: Develop a lunar **position, navigation and timing** architecture capable of scaling to support long term science, exploration, and industrial needs.



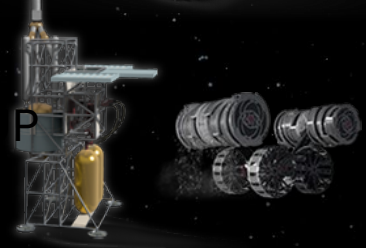
LI-4^L: Demonstrate **advanced manufacturing and autonomous construction** capabilities in support of continuous human lunar presence and a robust lunar economy.



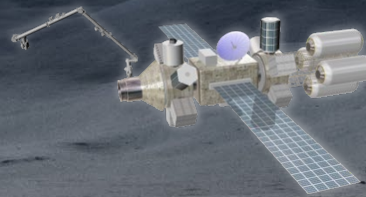
LI-5^L: Demonstrate **precision landing** capabilities in support of continuous human lunar presence and a robust lunar economy.



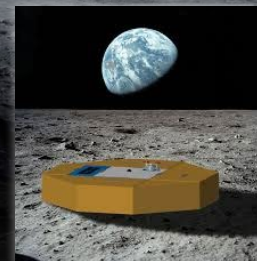
LI-6^L: Demonstrate local, regional, and global **surface** transportation and **mobility** capabilities in support of continuous human lunar presence and a robust lunar economy.



LI-7^L: Demonstrate industrial scale **ISRU** capabilities **MI-4^M** in support of continuous human lunar presence and a robust lunar economy.



LI-8^L: Demonstrate technologies supporting cislunar orbital/surface depots, **construction and manufacturing** maximizing the use of in-situ resources, and support systems needed for continuous human/robotic presence.




LI-9^L: Develop **environmental monitoring**, situational awareness, and early warning capabilities to support a resilient, continuous human/robotic lunar presence.


STMD Contributions to Artemis & Beyond

COMPLETE


DEVELOPMENT



Thermal protection material
3DMAT Orion
compression pads




Pathfinder for Gateway orbit
CAPSTONE
CubeSat



Landing systems
Navigation
Doppler Lidar



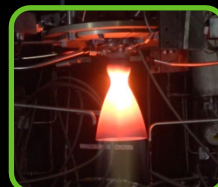
Terrain
Relative
Navigation




Deployable solar arrays
ROSA for Gateway power
and propulsion element



Solar electric propulsion
AEPS Gateway thrusters



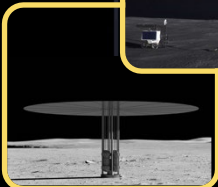
Low-temperature thrusters
TALOS for robotic
lunar landers




Ice mining experiment
PRIME-1 in-situ
resource utilization
demonstration



Power
VSAT vertical
solar arrays



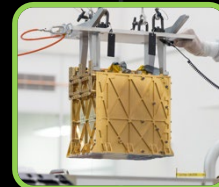
FSP fission
surface power



Propulsion systems
Nuclear thermal (DRACO) &
nuclear electric



Landing technology
LOFTID inflatable
decelerator



Oxygen generating experiment
MOXIE in-situ resource
utilization demonstration

**HUMAN LUNAR
RETURN**

**FOUNDATIONAL
EXPLORATION**

**SUSTAINED
LUNAR EVOLUTION**

**HUMANS
TO MARS**

SPACE TECHNOLOGY PORTFOLIO

As currently organized:

EARLY STAGE INNOVATION AND PARTNERSHIPS

- Early Stage Innovation
 - Space Tech Research Grants
 - Center Innovation Fund
 - Early Career Initiative
 - Prizes, Challenges & Crowdsourcing
 - NASA Innovation Advanced Concepts
- Technology Transfer

SBIR/STTR PROGRAMS

- Small Business Innovation Research
- Small Business Technology Transfer

TECHNOLOGY MATURATION

- Game Changing Development
- Lunar Surface Innovation Initiative

TECHNOLOGY DEMONSTRATION

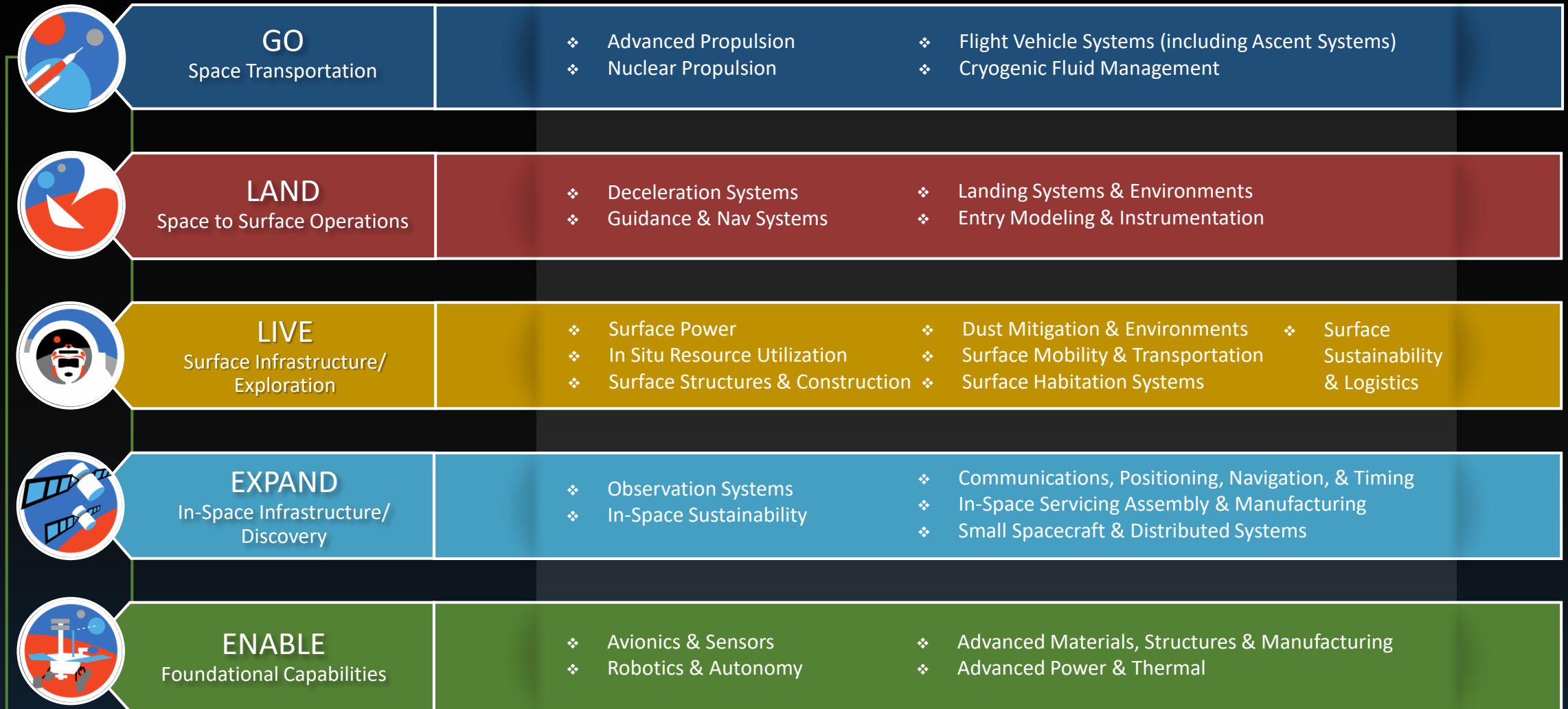
- Technology Demonstration Missions
- Small Spacecraft Technology
- Flight Opportunities

LOW

MID
Technology Readiness Level

HIGH

Tech Base Functional Domains



❖ Capability Portfolio

CATALYSTS Innovative Mechanisms	<ul style="list-style-type: none"> • NIAC/CIF/ECI • STRG • PCC • Tech Transfer • SBIR/STTR • Flight Opportunities • TP/ACO • Inclusive Innovation 			

STMD Restructuring Update

- Restructuring from a TRL-based structure to a capability-focused management approach
- Domains will be responsible for maturing space capabilities across the full technology readiness spectrum
- New structure will:
 - ✓ Better prioritize development efforts to address common stakeholder needs
 - ✓ Avoid programmatic scope expansion beyond assigned TRL range
 - ✓ More efficiently transition technologies along the maturation scale
 - ✓ Increase accountability for performance within a capability roadmap
- STMD will continue to manage cross-cutting programs for the agency and invest in disruptive, early-stage ideas
- FY2025 will be a transition year

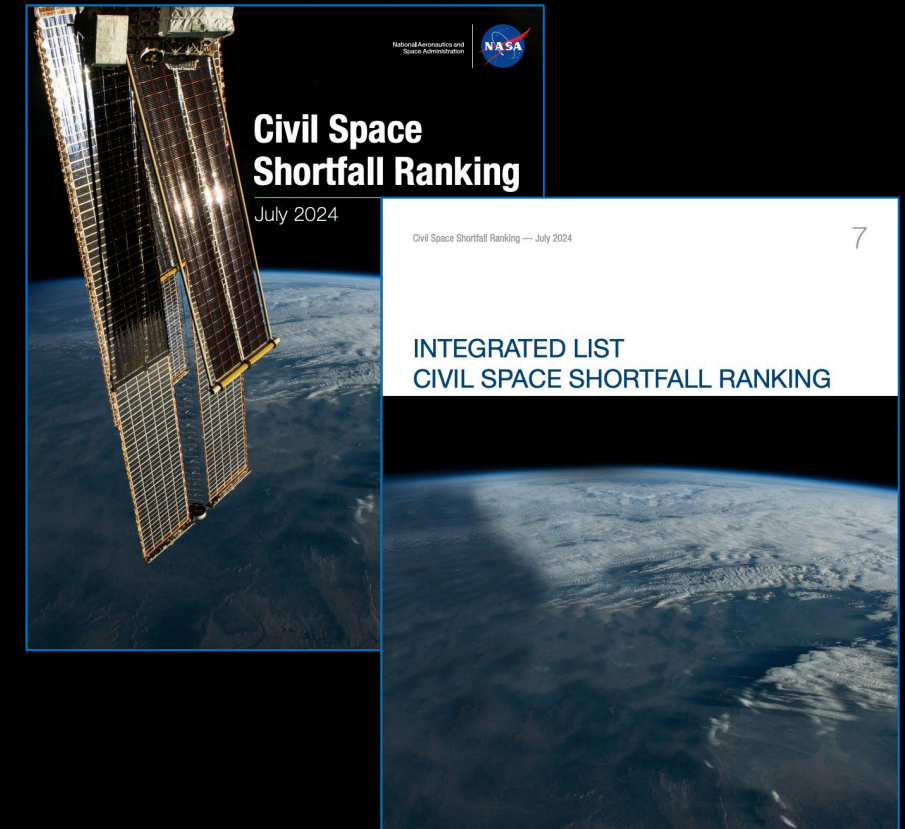


STMD FY 2025 PBR Summary (\$M)	FY 2024 Op Plan	FY 2025 PBR
	1,100.0	1,181.8
SBIR and STTR	217.8	241.8
Early Stage Innovation and Partnerships	116.9	140.1
Agency Technology and Innovation	-	-
Technology Transfer	21.0	23.1
Early Stage Innovation	95.9	117.0
Early Stage Innovation and Commerce	2.7	5.3
Early Career Initiative (ECI) and Center Innovations Fund (CIF)	23.6	28.4
Prizes, Challenges and Crowdsourcing	9.8	12.0
NASA Innovative Advanced Concepts (NIAC)	7.2	9.6
Space Technology Research Grants (STRG)	52.8	61.6
Technology Maturation / Game Changing Development (GCD)	252.7	340.8
Space Transportation	16.4	30.3
Entry, Descent and Landing	35.4	19.7
Sustainable Exploration	117.4	189.9
Transformative Missions and Discoveries	36.3	37.7
Industry & Commerce Innovative Opportunity, Space Tech Management and Integration	47.3	63.2
Technology Demonstration	512.6	459.1
Flight Opportunities and Small Spacecraft Technology	68.1	72.7
Technology Demonstration Missions (TDM)	327.5	386.4
On-Orbit Servicing and Manufacturing Demonstration-1 (OSAM-1)	206.9	11.0
Solar Electric Propulsion (SEP)	8.5	13.0
Cryogenic Fluid Management (CFM)	75.9	82.7
Fission Surface Power	16.0	113.8
Space Nuclear Propulsion (NTP and NEP)	117.0	110.0
MOXIE, LOFTID, DSOC, OSAM-2, LCRD, TDM Selected ACO/TP, TDM Mgt & Integration	20.2	55.9

Civil Space Shortfall Ranking

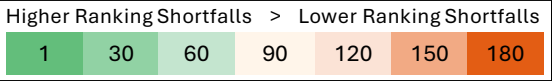
Shortfall: *Identified, problem-focused technology area requiring further developments to meet future exploration, science, and other mission needs*

- 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
- Integrated list is one of several factors guiding STMD projects and investments
- The results will also inform the development of technology roadmaps
- Using lessons learned to refine the approach and schedule for future years



View the results:
nasa.gov/civilspaceshortfalls

Integrated Top 30 Shortfalls Compared to Stakeholder Group Rank



Not Ranked (NR)

Integrated Rank	Average Score	Shortfall ID	Category
1	8.103	1618: Survive and operate through the lunar night	Thermal Management Systems
2	7.612	1596: High Power Energy Generation on Moon and Mars Surfaces	Power
3	7.435	1554: High Performance Onboard Computing to Enable Increasingly Complex Operations	Avionics
4	7.383	1557: Position, Navigation, and Timing (PNT) for In-Orbit and Surface Applications	Communication and Navigation
5	7.247	1545: Robotic Actuation, Subsystem Components, and System Architectures for Long-Duration and Extreme Environment Operation	Autonomous Systems and Robotics
6	7.208	1552: Extreme Environment Avionics	Avionics
7	7.196	1519: Environmental Monitoring for Habitation	Advanced Habitation Systems
8	7.168	709: Nuclear Electric Propulsion for Human Exploration	Propulsion: Nuclear
9	7.114	1304: Robust, High-Progress-Rate, and Long-Distance Autonomous Surface Mobility	Autonomous Systems & Robotics
10	7.095	1520: Fire Safety for Habitation	Advanced Habitation Systems
11	7.052	1531: Autonomous Guidance and Navigation for Deep Space Missions	Autonomous Systems & Robotics
12	7.045	1591: Power Management Systems for Long Duration Lunar and Martian Missions	Power
13	7.034	702: Nuclear Thermal Propulsion for Human Exploration	Propulsion: Nuclear
14	7.031	1559: Deep Space Autonomous Navigation	Communication and Navigation
15	6.968	1527: Radiation Countermeasures (Crew and Habitat)	Advanced Habitation Systems
16	6.948	1526: Radiation Monitoring and Modeling (Crew and Habitat)	Advanced Habitation Systems
17	6.946	879: In-space and On-surface, Long-duration Storage of Cryogenic Propellant	Cryogenic Fluid Management
18	6.843	1548: Sensing for Autonomous Robotic Operations in Challenging Environmental Conditions	Autonomous Systems & Robotics
19	6.804	1558: High-Rate Communications Across The Lunar Surface	Communication and Navigation
20	6.792	1626: Advanced Sensor Components: Imaging	Sensors and Instruments
21	6.784	792: In-space and On-surface Transfer of Cryogenic Fluids	Cryogenic Fluid Management
22	6.720	1569: High-Mass Mars Entry and Descent Systems	Entry Descent and Landing
23	6.711	1525: Food and Nutrition for Mars and Sustained Lunar	Advanced Habitation Systems
24	6.695	1571: Navigation Sensors for Precision Landing	Entry Descent and Landing
25	6.689	1573: Terrain Mapping Capabilities for Precision Landing and Hazard Avoidance	Entry Descent and Landing
26	6.662	1562: Advanced Algorithms and Computing for Precision Landing	Entry Descent and Landing
27	6.593	1597: Power for Non-Solar-Illuminated Small Systems	Power
28	6.592	1568: Entry Modeling and Simulation for EDL Missions	Entry Descent and Landing
29	6.584	1516: Water and Dormancy Management for Habitation	Advanced Habitation Systems
30	6.569	1524: Crew Medical Care for Mars and Sustained Lunar	Advanced Habitation Systems

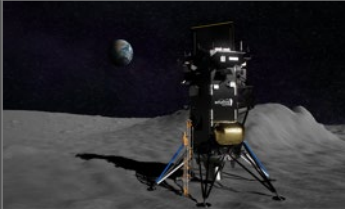
Stakeholder Group Rank								
Academia	Small Industry	Large Industry	OGA	Other	NASA Centers	ESDMD	SMD	Other MDs
4	2	2	2	9	6	4	9	1
13	1	1	40	20	4	21	NR	16
80	28	21	27	13	3	34	1	56
9	11	15	29	67	10	28	NR	3
34	27	28	63	10	40	13	9	49
176	49	6	38	23	54	6	9	62
20	101	72	75	61	49	17	19	13
43	131	23	4	52	32	7	NR	7
27	42	30	121	91	34	25	25	66
23	24	78	12	12	12	29	55	14
47	67	24	3	89	42	64	23	15
40	12	10	52	24	68	35	NR	27
36	114	36	14	78	62	7	NR	11
62	129	27	5	120	38	64	23	10
5	23	22	6	2	5	63	NR	6
6	53	41	81	1	13	27	38	35
21	37	3	95	22	1	59	NR	2
42	17	26	90	16	44	14	26	57
25	73	29	77	162	20	5	NR	51
18	75	12	45	160	22	NR	18	68
17	29	4	51	26	2	62	NR	29
152	156	48	117	5	33	16	NR	12
8	32	116	41	45	30	11	NR	58
14	62	37	23	4	31	45	28	9
30	31	9	12	8	11	45	28	53
54	65	45	23	3	25	45	28	8
85	26	5	39	125	47	93	12	20
101	115	76	60	15	50	45	5	45
49	98	127	158	53	69	26	51	22
12	64	94	1	11	21	58	NR	17

ESDMD and SMD provided ranked lists (numbers shown above) in addition to shortfall scores (used for integrated list).
ESDMD and SMD did not score all shortfalls. Unscored shortfalls were also not ranked.

Near-term Lunar Technology Demos

NASA's Commercial Lunar Payload Services (CLPS) provides opportunities to mature key capabilities required for NASA and industry

Intuitive Machines (IM)-2



Polar Resources Ice-Mining Experiment (PRIME-1)



4GLTE Proximity Comms (Tipping Point with Nokia)

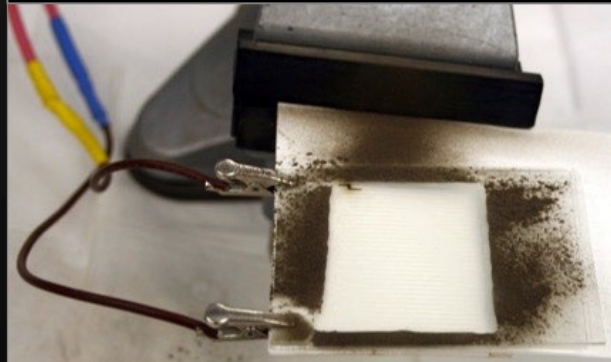


Deployable Lunar Hopper (Tipping Point with IM)

Blue Ghost Mission 1 (Firefly)



Stereo Camera for Lunar Plume Surface Studies (SCALPSS)



Electrodynamic Dust Shield (EDS)

Intuitive Machines (IM)-3

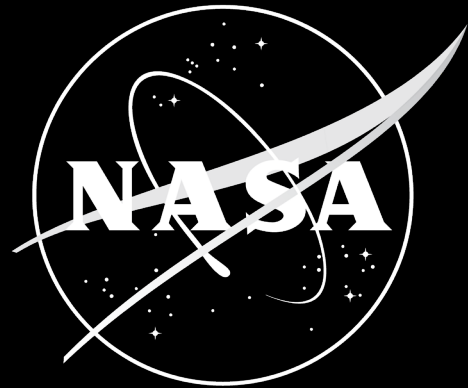


Cooperative Autonomous Distributed Robotic Explorers (CADRE)

Learn more about NASA lunar tech and science flying on CLPS missions:



<https://science.nasa.gov/lunar-science/clps-deliveries/>



www.nasa.gov/spacetech