National Aeronautics and Space Administration

Space Technology Industry-Government-University Roundtable (STIGUR)

Fall Meeting

Dr. Prasun Desai, Acting Associate Administrator

NASA's Space Technology Mission Directorate

October 2023

Space Technology Portfolio

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

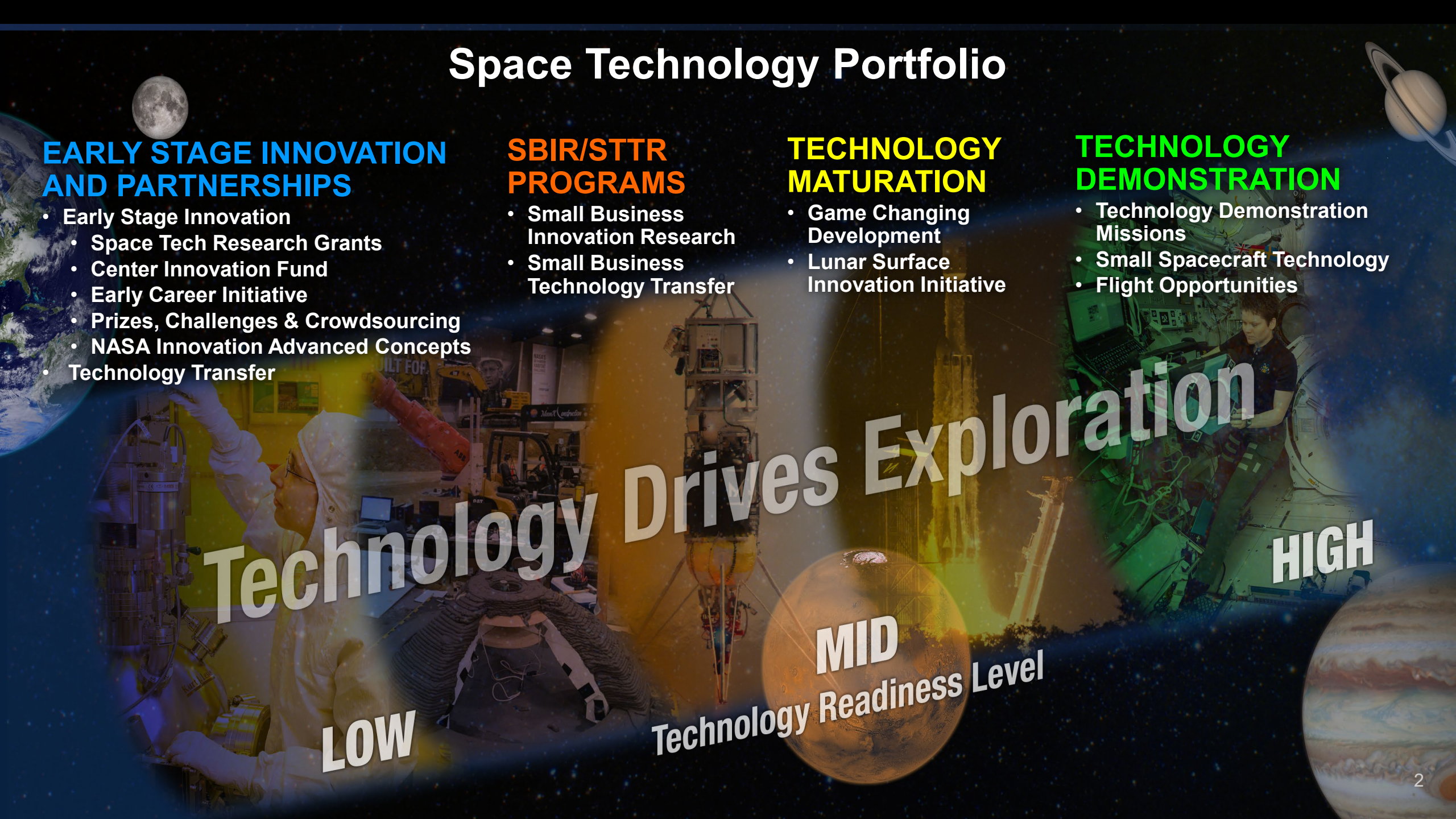
- Small Business Innovation Research
- Small Business Technology Transfer

TECHNOLOGY MATURATION

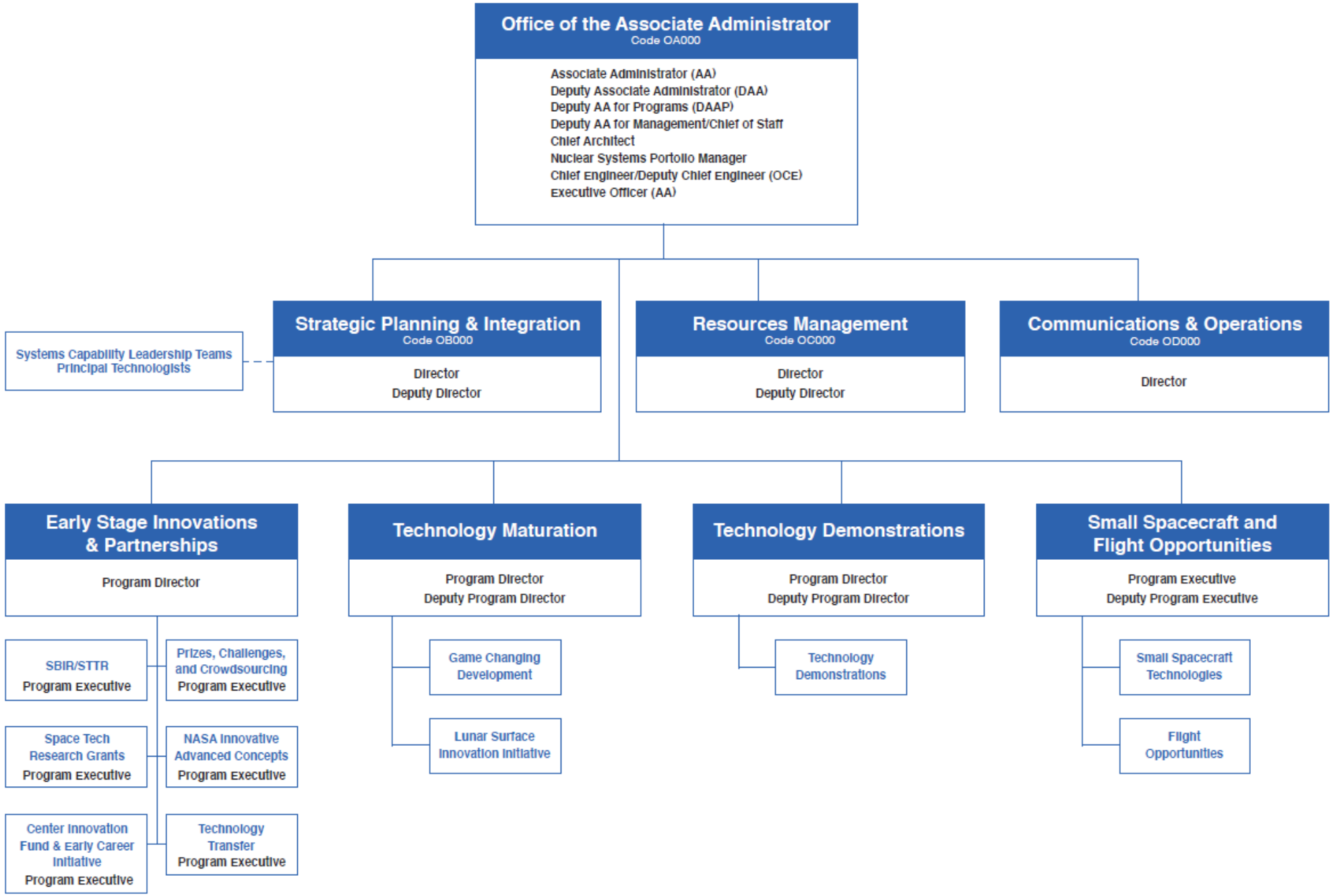
- Game Changing Development
- Lunar Surface Innovation Initiative

TECHNOLOGY DEMONSTRATION

- Technology Demonstration Missions
- Small Spacecraft Technology
- Flight Opportunities



STMD Org Chart

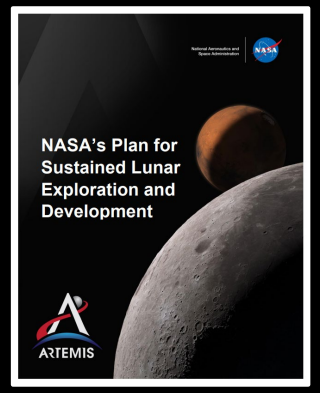


STMD Investment Aligned to Agency Goals

NASA Strategic Plan

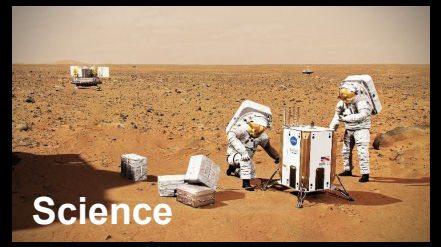
3.1 Innovate and advance transformational space technologies

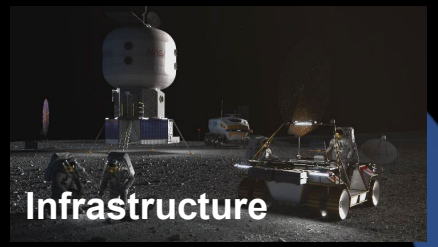
Develop revolutionary, high-payoff space technologies driven by diverse ideas to transform NASA missions and ensure American leadership in the space economy



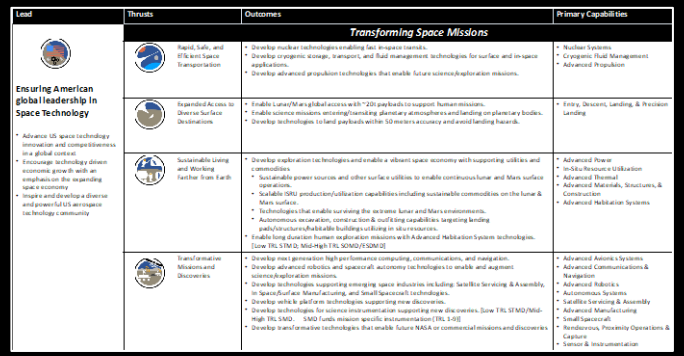
Draws from Artemis architecture, science decadals, and industry identifying technology gaps for investment to develop needed capabilities to support NASA missions and commercial space sector

Moon to Mars Blueprint Objectives





STMD Strategic Framework



Lead	Thrusts	Outcomes	Primary Capabilities
Ensuring American global leadership in Space Technology • 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		*Transforming Space Missions*	
	Rapid, Safe, and Efficient Space Transportation	• Develop nuclear technologies enabling fast in-space transits. • Develop cryogenic storage, transport, and fluid management technologies for surface and in-space applications. • Develop advanced propulsion technologies that enable future science/exploration missions.	• Nuclear Systems • Cryogenic Fluid Management • Advanced Propulsion
	Expanded Access to Diverse Surface Destinations	• Enable Lunar/Mars global access with ~20t payloads to support human missions. • Enable science missions entering/transiting planetary atmospheres and landing on planetary bodies. • Develop technologies to land payloads within 50 meters accuracy and avoid landing hazards.	• Entry, Descent, Landing, & Precision Landing
	Sustainable Living and Working Farther from Earth	• Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities. • Sustainable power sources and other surface utilities to enable continuous lunar and Mars surface operations. • Scalable ISRU production/utilization capabilities including sustainable commodities on the lunar & Mars surface. • Technologies that enable surviving the extreme lunar and Mars environments. • Autonomous excavation, construction & outfitting capabilities targeting landing pads/structures/habitable buildings utilizing in situ resources. • Enable long duration human exploration missions with Advanced Habitation System technologies. [Low TRL STMD; Mid-High TRL SOMD/ESDMD]	• Advanced Power • In-Situ Resource Utilization • Advanced Thermal • Advanced Materials, Structures, & Construction • Advanced Habitation Systems
	Transformative Missions and Discoveries	• Develop next generation high performance computing, communications, and navigation. • Develop advanced robotics and spacecraft autonomy technologies to enable and augment science/exploration missions. • Develop technologies supporting emerging space industries including: Satellite Servicing & Assembly, In Space/Surface Manufacturing, and Small Spacecraft technologies. • Develop vehicle platform technologies supporting new discoveries. • Develop technologies for science instrumentation supporting new discoveries. [Low TRL STMD/Mid-High TRL SMD SMD funds mission specific instrumentation (TRL 5-9)] • Develop transformative technologies that enable future NASA or commercial missions and discoveries	• Advanced Avionics Systems • Advanced Communications & Navigation • Advanced Robotics • Autonomous Systems • Satellite Servicing & Assembly • Advanced Manufacturing • Small Spacecraft • Rendezvous, Proximity Operations & Capture • Sensor & Instrumentation

STMD Strategic Framework

STMD rapidly develops, demonstrates, and transfers revolutionary, high pay-off space technologies, driven by diverse ideas

Lead	Thrusts	Outcomes	Primary Capabilities
Ensuring American global leadership in Space Technology • 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	***Transforming Space Missions***		
	 Rapid, Safe, and Efficient Space Transportation	• Develop nuclear technologies enabling fast in-space transits. • Develop cryogenic storage, transport, and fluid management technologies for surface and in-space applications. • Develop advanced propulsion technologies that enable future science/exploration missions.	• Nuclear Systems • Cryogenic Fluid Management • Advanced Propulsion
	 Expanded Access to Diverse Surface Destinations	• Enable Lunar/Mars global access with ~20t payloads to support human missions. • Enable science missions entering/transiting planetary atmospheres and landing on planetary bodies. • Develop technologies to land payloads within 50 meters accuracy and avoid landing hazards.	• Entry, Descent, Landing, & Precision Landing

	 Sustainable Living and Working Farther from Earth	• Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities
		  • Sustainable power sources and other surface utilities to enable continuous lunar and Mars surface operations.
		  • Scalable ISRU production/utilization capabilities including sustainable commodities on the lunar & Mars surface.
		  • Technologies that enable surviving the extreme lunar and Mars environments.
		  • Autonomous excavation, construction & outfitting capabilities targeting landing pads/structures/habitable buildings utilizing in situ resources.
		• Enable long duration human exploration missions with Advanced Habitation System technologies. [Low TRL STMD; Mid-High TRL SOMD/ESDMD]
			• Advanced Power
			• In-Situ Resource Utilization
			• Advanced Thermal
			• Advanced Materials, Structures, & Construction
			• Advanced Habitation Systems

	 Transformative Missions and Discoveries	• Develop next generation high performance computing, communications, and navigation. • Develop advanced robotics and spacecraft autonomy technologies to enable and augment science/exploration missions. • Develop technologies supporting emerging space industries including: Satellite Servicing & Assembly, In Space/Surface Manufacturing, and Small Spacecraft technologies. • Develop vehicle platform technologies supporting new discoveries. • Develop technologies for science instrumentation supporting new discoveries. [Low TRL STMD/Mid-High TRL SMD. SMD funds mission specific instrumentation (TRL 1-9)] • Develop transformative technologies that enable future NASA or commercial missions and discoveries	• Advanced Avionics Systems • Advanced Communications & Navigation • Advanced Robotics • Autonomous Systems • Satellite Servicing & Assembly • Advanced Manufacturing • Small Spacecraft • Rendezvous, Proximity Operations & Capture • Sensor & Instrumentation

STMD Investment Strategy

Advancing U.S. space technology innovation and competitiveness

- **Bring innovative technologies** to flight and infuse them to industry and NASA missions
- Invest in paradigm-shifting technologies that **build a strong U.S. industry,** create good paying jobs, and support a strong national posture

Encouraging technology-driven economic growth emphasizing expanding the space economy

- **Develop a global lunar utilization infrastructure** for sustained operations on the lunar surface
- Create partnerships with industry to **establish commercial space capabilities**
- Transfer the widest possible use of all NASA technologies **to spur economic growth**

Inspiring and developing a diverse and powerful U.S. aerospace technology community

- **Support high growth businesses** of the future through small business research
- **Empower a broad community of innovators** through emphasis on early-stage investments

STMD FY 2024 PBR Summary ($M)	FY 2023 Op Plan	FY 2024 PBR				
		FY 2024 PBR	FY 2025	FY 2026	FY 2027	FY 2028
	1,193.0	1,391.6	1,419.4	1,447.8	1,476.8	1,506.3
SBIR and STTR	**231.7**	**299.9**	**305.9**	**312.0**	**318.2**	**324.6**
Early Stage Innovation and Partnerships	**122.0**	**138.1**	**140.9**	**143.7**	**146.6**	**149.5**
Agency Technology and Innovation	**1.4**	**-**	**-**	**-**	**-**	**-**
Technology Transfer	**21.5**	**22.5**	**23.0**	**23.4**	**23.9**	**24.4**
Early Stage Innovation	**99.1**	**115.6**	**118.0**	**120.3**	**122.7**	**125.1**
Early Stage Innovation and Commerce	2.9	7.0	7.2	7.4	7.6	7.7
Early Career Initiative (ECI) and Center Innovations Fund (CIF)	24.4	28.3	28.9	29.4	30.0	30.6
Prizes, Challenges and Crowdsourcing	11.1	12.0	12.2	12.5	12.7	13.0
NASA Innovative Advanced Concepts (NIAC)	7.2	9.5	9.7	9.9	10.1	10.3
Space Technology Research Grants (STRG)	53.5	58.8	59.9	61.1	62.2	63.5
Technology Maturation / Game Changing Development (GCD)	**323.9**	**402.3**	**410.3**	**418.5**	**426.9**	**435.4**
Space Transportation	17.6	36.7	32.0	30.0	30.0	30.0
Entry, Descent and Landing	37.8	37.1	21.7	17.9	14.2	14.0
Sustainable Exploration	131.7	154.8	188.2	197.8	197.7	197.7
Transformative Missions and Discoveries	62.4	67.7	56.7	55.0	62.0	64.0
Industry & Commerce Innovative Opportunity, Space Tech Management & Integration	74.4	106.1	111.7	117.8	123.1	129.7
Technology Demonstration	**515.4**	**551.3**	**562.3**	**573.6**	**585.1**	**596.8**
Flight Opportunities and Small Spacecraft Technology	**67.1**	**84.0**	**85.7**	**87.4**	**89.2**	**91.0**
Technology Demonstration Missions (TDM)	**448.3**	**467.3**	**476.6**	**486.2**	**495.9**	**505.8**
On-Orbit Servicing and Manufacturing Demonstration-1 (OSAM-1)	227.0	227.0	174.5	123.0	28.7	-
Solar Electric Propulsion (SEP)	18.5	10.8	13.7	7.7	6.4	5.5
Cryogenic Fluid Management (CFM)	75.0*	90.9	99.0	99.0	99.0	99.0
Fission Surface Power	16.0	84.5	135.8	205.1	309.0	315.4
Space Nuclear Propulsion*	91.3*	35.0	35.0	35.0	35.0	35.0
MOXIE, LOFTID, DSOC, LCRD, OSAM-2, TDM Selected ACO/TP, TDM Management & Integration	20.5	19.2	18.6	16.5	16.9	50.9

FY 2024 Appropriations Status

STMD Appropriations	FY 2023 IOP	PBR	FY 2024 House Proposal	FY 2024 Senate Proposal
OSAM-1 (Restore and SPIDER)	227.0	227.0	227.0	227.0
Nuclear Thermal Propulsion	110.0	17.5	110.0	110.0
Reactor Development	*45.0*		*45.0*	
Fuel Materials Development	*45.0*		*45.0*	
*Non-Nuclear Systems Development/Acquisition Planning***	*20.0*		*20.0*	
SBIR/STTR*	231.7	299.9	299.9	299.9
All other directions	129.1	288.4	TBD	56.0-61.0
Nuclear Electric Propulsion	1.3	17.5		
Lunar Surface Power (FSP & VSAT)	23.8	100.2		
Regional Economic Development**	7.0	7.0		
Flight Opportunities	27.0	27.0		
Innovative Nanomaterials	5.0	6.5		
In-Space Additive Manufacturing	15.0	28.9		
Moon-to-Mars Landing Demonstrations**	45.0	75.3		
Orbital Debris Remediation**	5.0	26.0		
Remaining STMD Programmatic Content	495.2	558.8	TBD	420.0-425.0
Total	**1,193.0**	**1,391.6**	**1,205.0**	**1,118.0**

*To be refined upon completion of OCFO extramural R&D calculation
***Activities across STMD portfolio

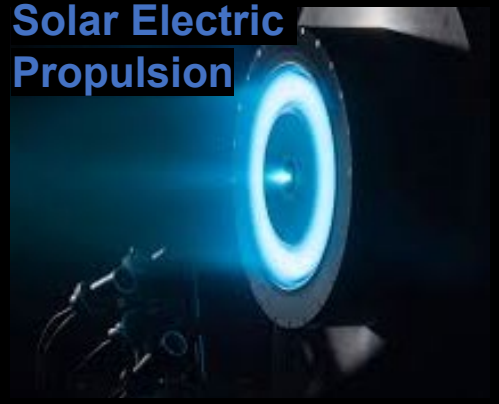
Tech Highlights

Bernard Kutter LOFTID

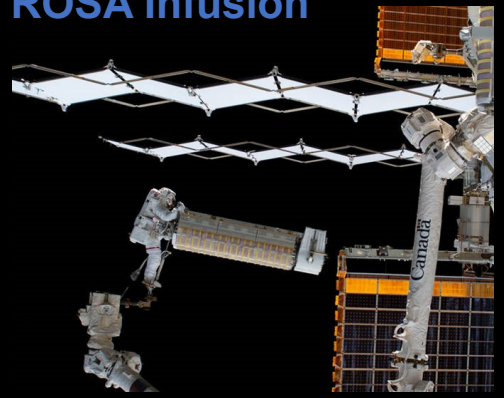
CAPSTONE

TeraByte Infrared Delivery (TBIRD)

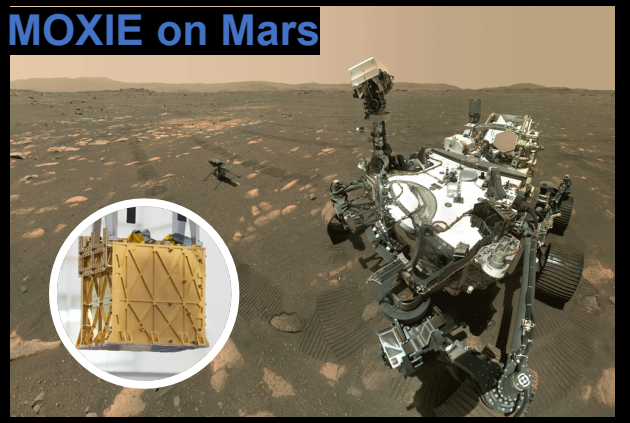
Solar Electric Propulsion



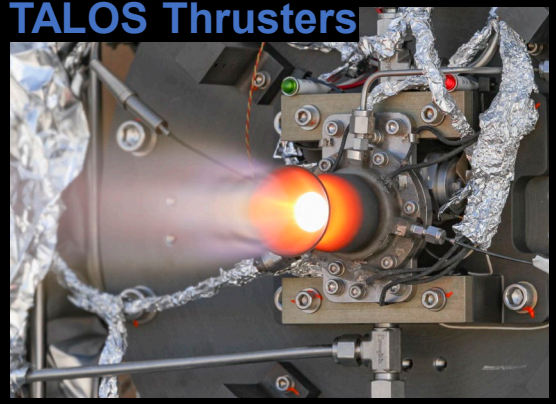
ROSA Infusion



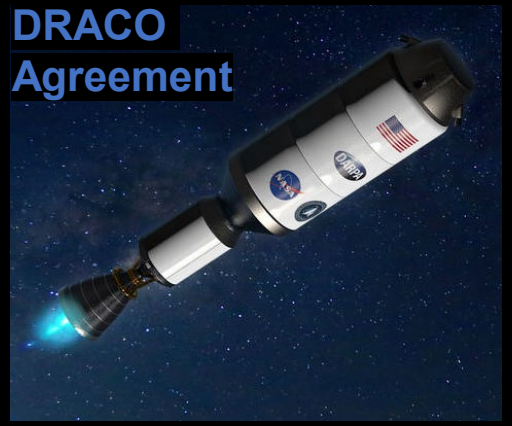
MOXIE on Mars



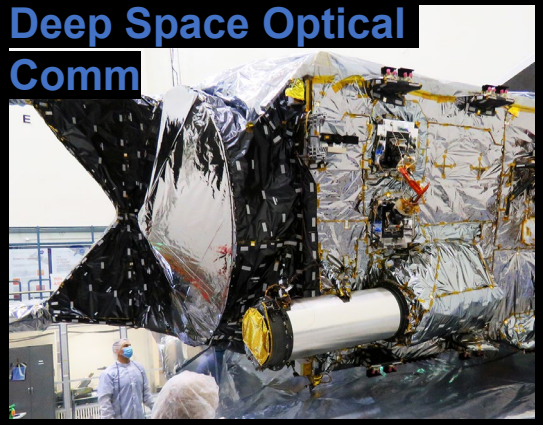
TALOS Thrusters



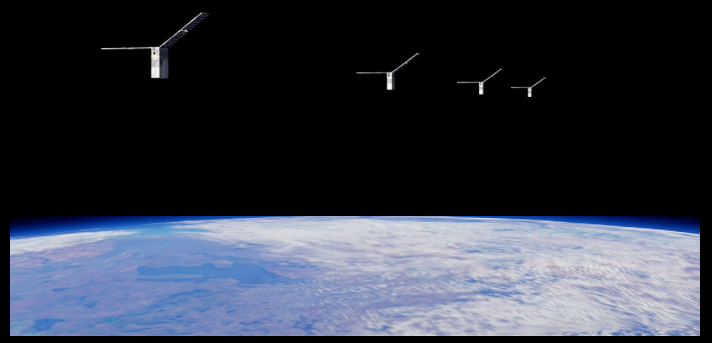
DRACO Agreement



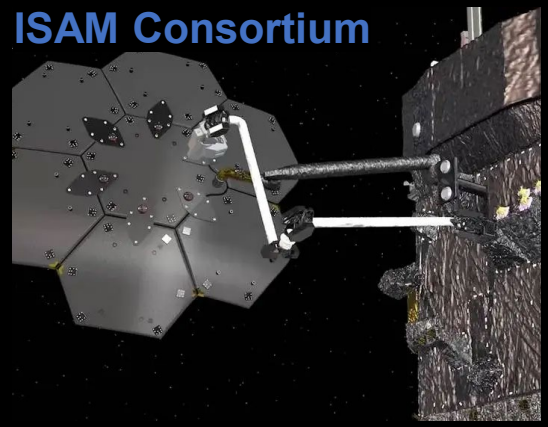
Deep Space Optical Comm



Starling Swarm



ISAM Consortium

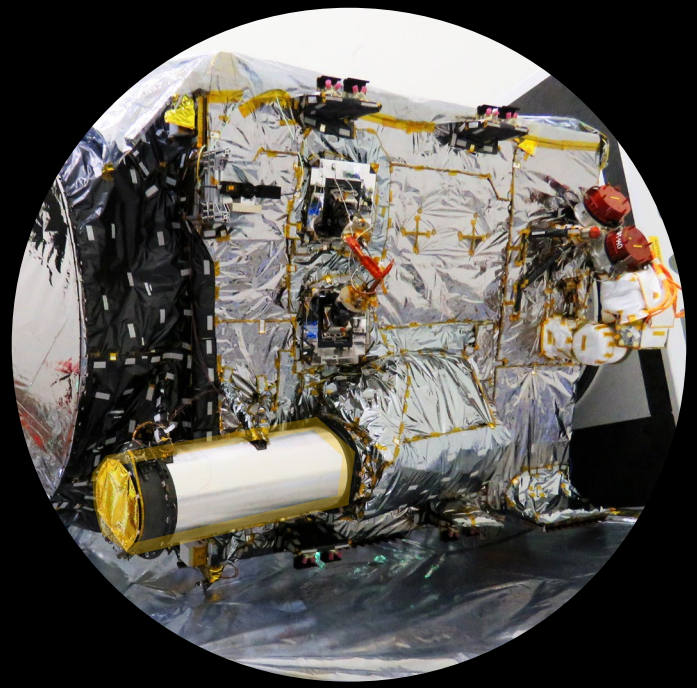


Deep Space Optical Communications (DSOC) Technology Demonstration

Ground transmitter (uplink)

Table Mountain, California

In-space transceiver



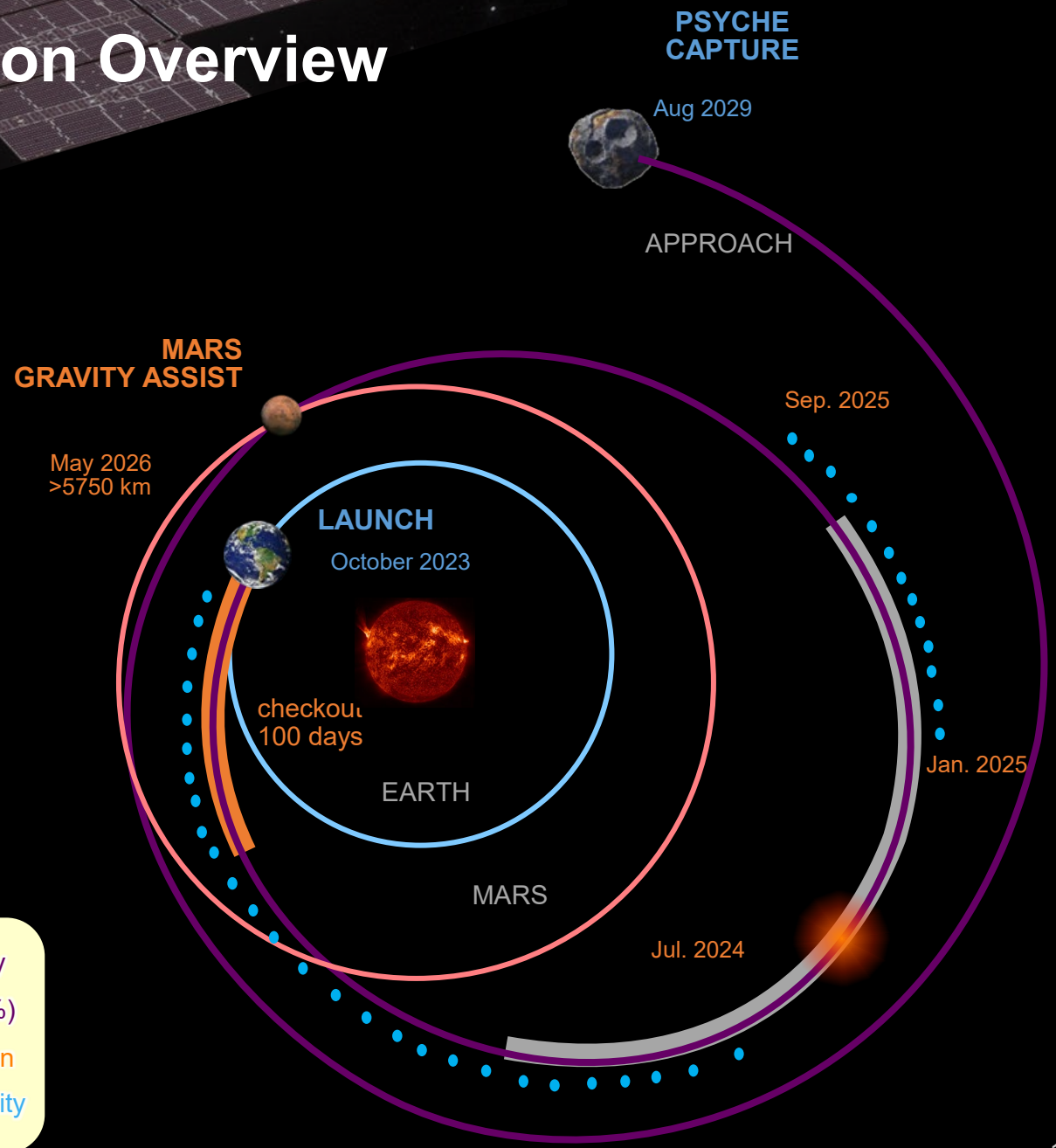
onboard Psyche

Ground transceiver (downlink)

Palomar Mountain, California

DSOC Mission Overview

- Operations for two years after launch
- Weekly communications opportunities
- Farthest transmission ~200 million miles
- The challenge: Pointing and locking the laser over millions of miles while accounting for the relative motion of Earth and Psyche

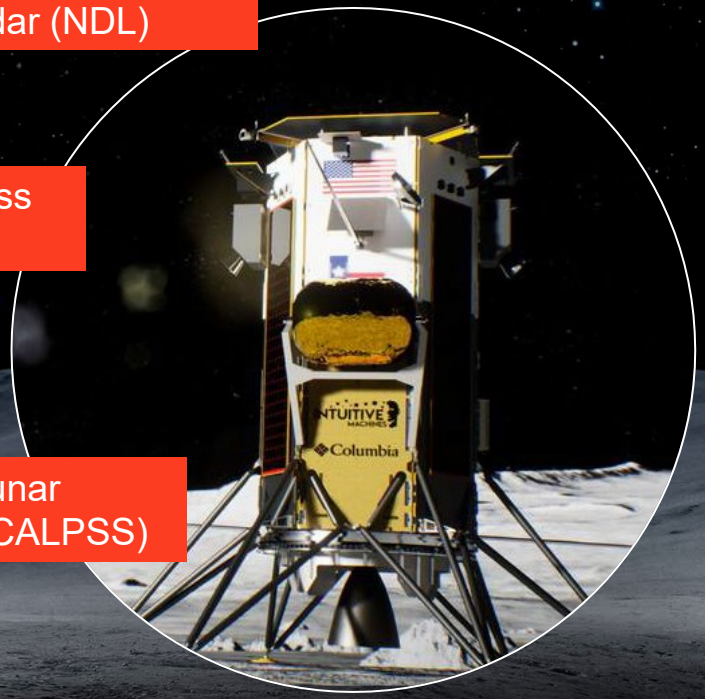


First Commercial Lunar Payload Services (CLPS) Deliveries Technology Demonstrations & Investments

Navigation Doppler Lidar (NDL)

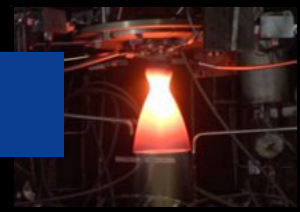
Radio Frequency Mass Gauge (RFMG)

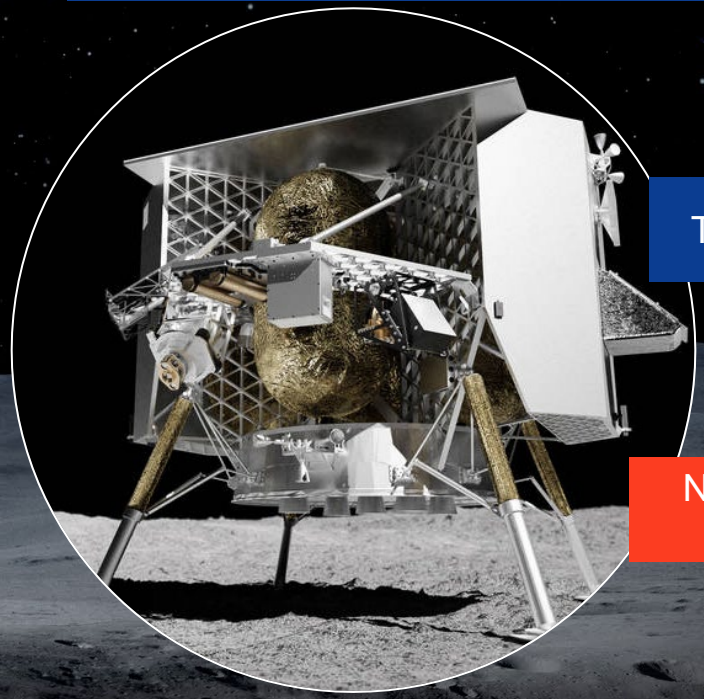
Stereo Camera for Lunar Plume Surface Studies (SCALPSS)



Intuitive Machines 1

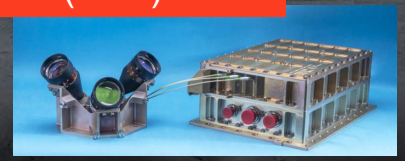
Thruster for Advancement of Low Temperature Operations in Space (TALOS)*





Terrain Relative Navigation*

Navigation Doppler Lidar (NDL)*



Astrobotic Peregrine 1

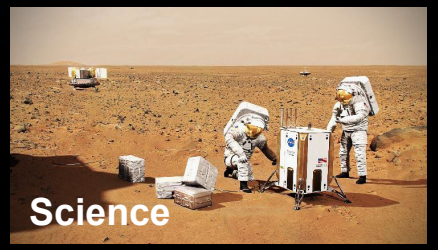
* Mission critical

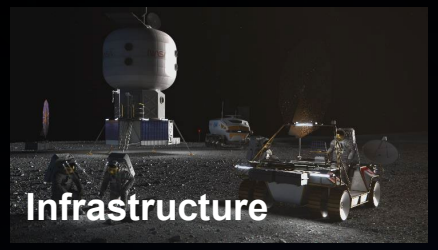
NASA payload

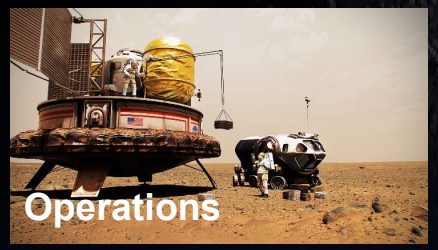
Tipping Point

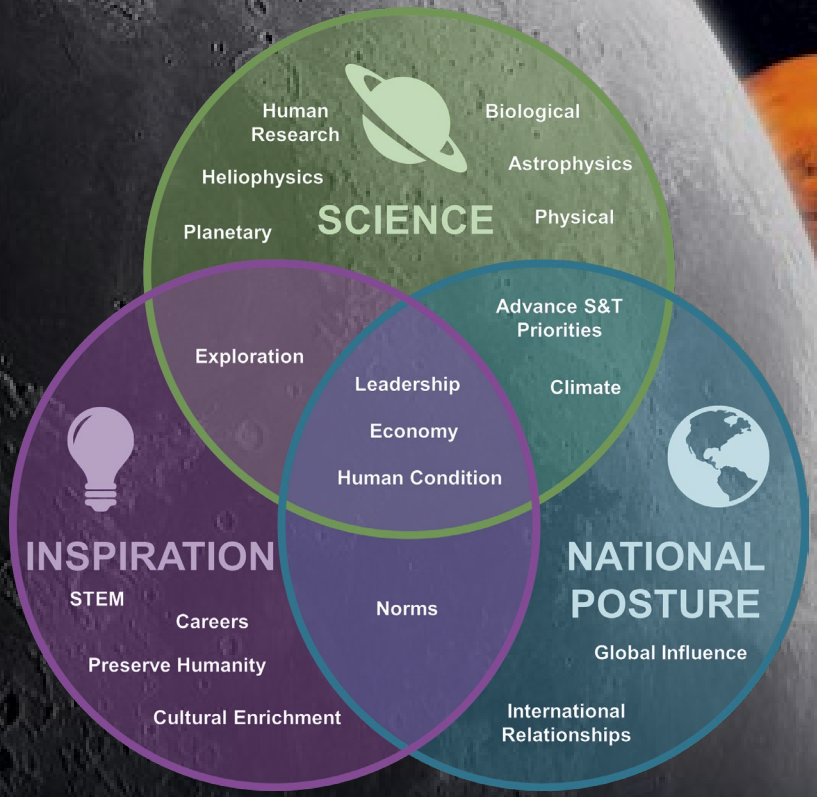
Moon-to-Mars Blueprint Objectives

Moon to Mars Blueprint Objectives

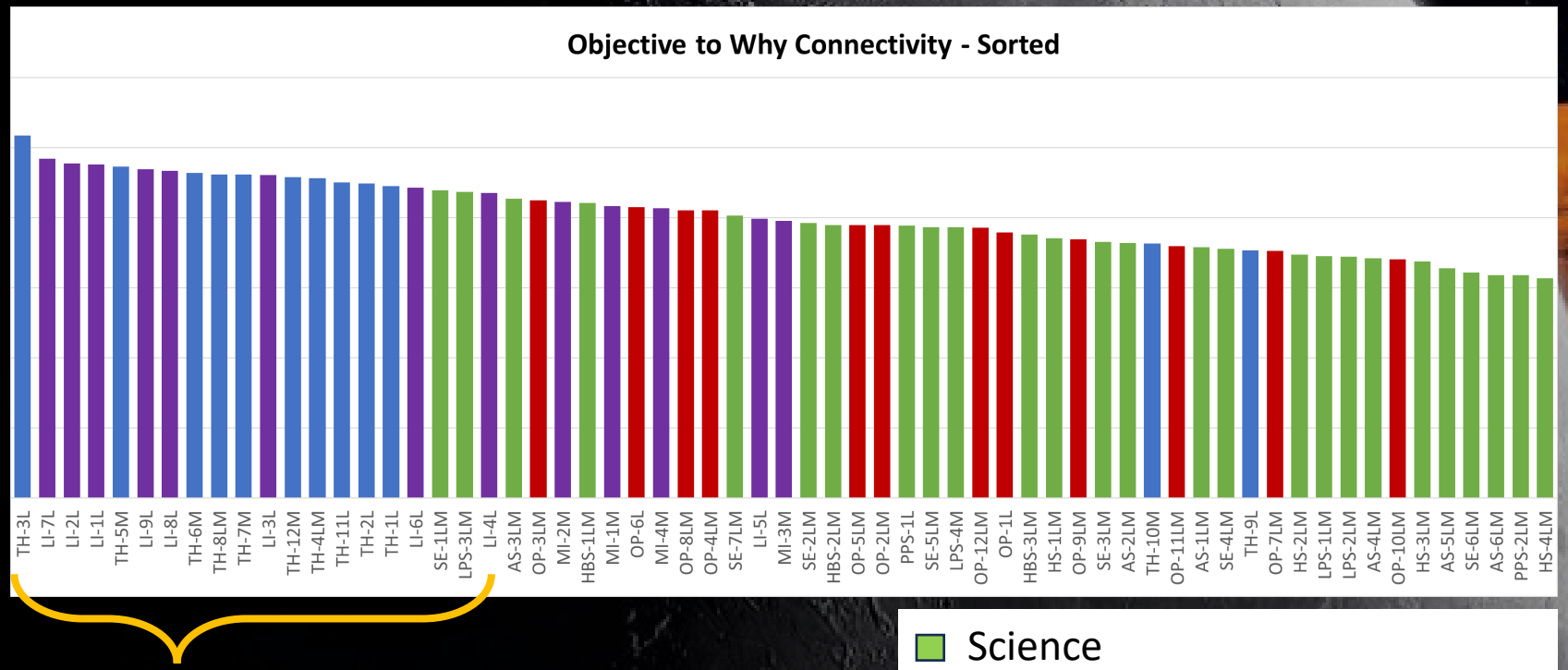








Mapping of M2M Objectives to Blueprint "Whys"



- Objectives mapping to Whys dominated by Transportation and Infrastructure
- Highlights criticality of investing in Infrastructure Objectives early

Lunar infrastructure is essential to support sustainable lunar exploration

STMD Lunar Surface Technology Demonstration Strategy

Early lunar surface demonstrations are required to increase technology readiness for 7 of the 9 Moon-to-Mars Infrastructure Objectives and leverage collaboration with OGAs, industry, academia, and international partners

Peregrine 1
- Astrobotic Terrain Relative Navigation (TP)

CP-11
- Cooperative Autonomous Distributed Robotic Explorers (CADRE)

CS-3
- LUSEE Night

19-D
- Electrodynamic Dust Shield (EDS)
- Stereo Camera for Lunar Plume Surface Studies (SCALPSS)

IM-2
- Polar Resources Ice Mining Experiment (PRIME-1)
- Nokia 4G LTE Communications (TP)
- Intuitive Machines Deployable Hopper (TP)

VIPER (SMD)
- Volatiles Investigating Polar Exploration Rover

CT-1 (O2 Extraction)

CT-2 (Pilot Pre-cursor)

CT-1 & 2 Candidate Technologies
- ISRU
- Power
- Excavation
- Dust Mitigation
- Autonomy & Robotics
- Construction

LI-5[L]: Demonstrate precision landing capabilities…

LI-1[L]: Develop an incremental lunar power generation and distribution system…

Fission Surface Power Demo

ISRU Pilot Plant

LI-2[L]: Develop a lunar surface communications architecture….

LI-4[L]: Demonstrate advanced manufacturing and autonomous construction capabilities…

LI-6[L]: Demonstrate local, regional, and global surface transportation and mobility capabilities…

LI-7[L]: Demonstrate industrial scale ISRU capabilities…

LI-8[L]: Demonstrate technologies supporting cislunar orbital/surface depots, construction and manufacturing maximizing the use of in-situ resources, and support systems…

Demo Missions

TP = Tipping Point

2023 **2033**

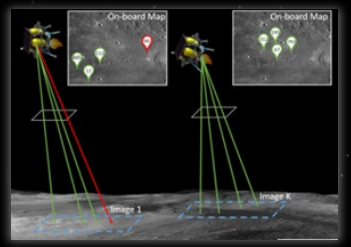
Enabling Key Moon-to-Mars Lunar Infrastructure Objectives

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 MI-2[M] capable of scaling to support long term science, exploration, and industrial needs.

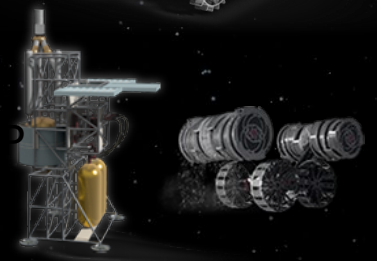
LI-3[L]: Develop a lunar position, navigation and timing architecture MI-3[M] capable of scaling to support long term science, exploration, and industrial needs.

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

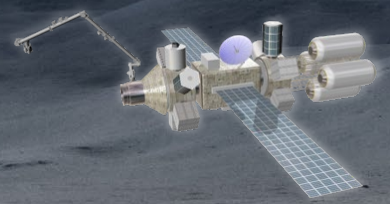


LI-5[L]: Demonstrate precision landing capabilities in support of continuous human lunar presence and a robust lunar economy.

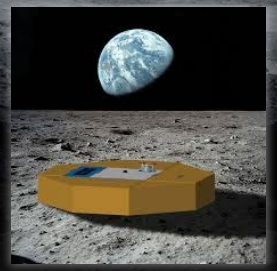
LI-6[L]: Demonstrate local, regional, and global surface transportation and mobility capabilities in support of continuous human lunar presence and a robust lunar economy.



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.

Current STMD Investment Areas

www.nasa.gov/specials/calliefirst

First Woman Issue No. 2
will be released soon

Read and download the
award-winning story and app