

National Aeronautics and
Space Administration



NASA Space Technology Update

NASA Advisory Council Technology, Innovation & Engineering Committee

Dr. Prasun Desai, Acting Associate Administrator

NASA's Space Technology Mission Directorate

November 30, 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

Technology Drives Exploration

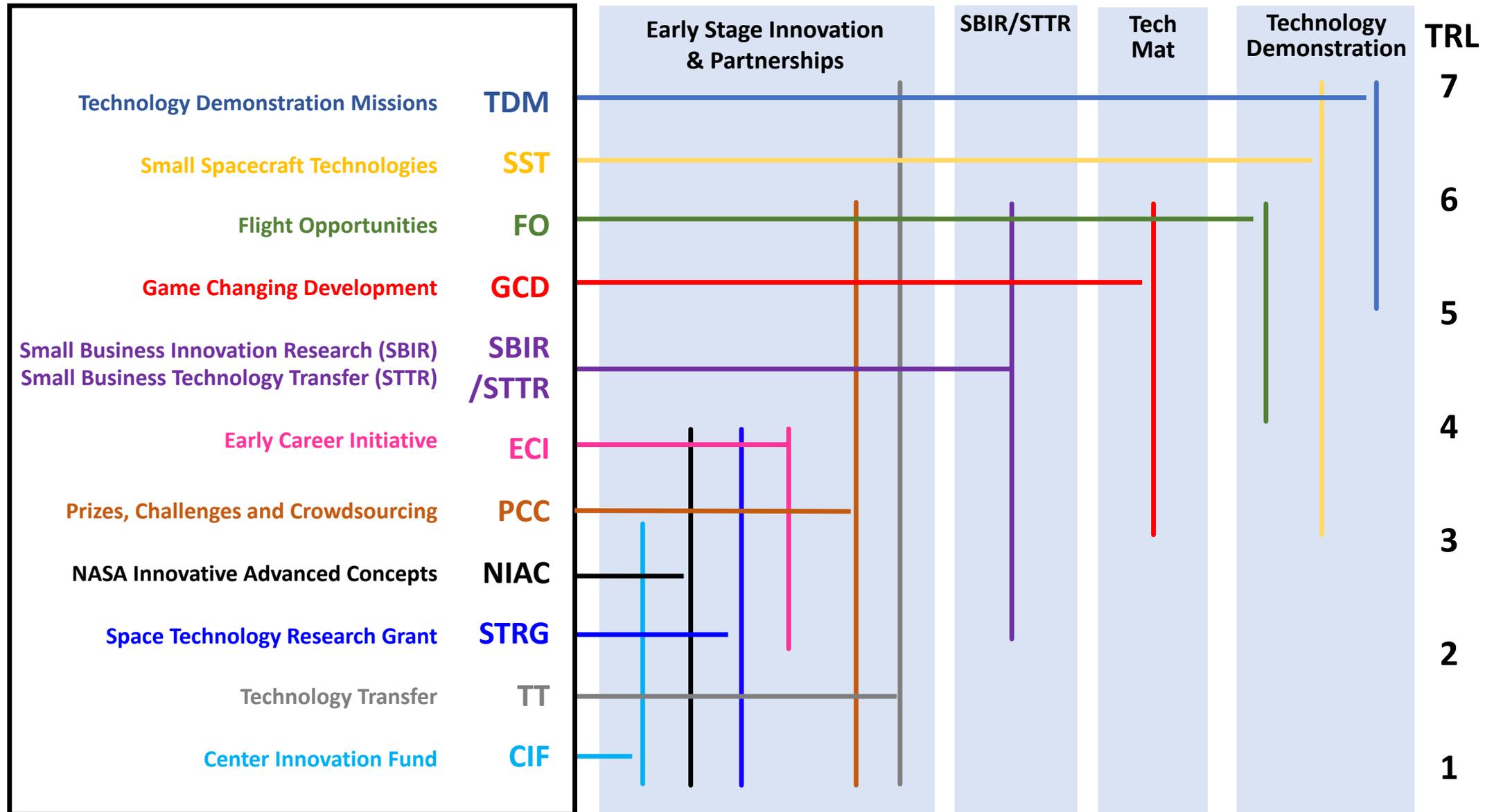
LOW

MID

Technology Readiness Level

HIGH

Space Technology Portfolio



Tech Highlights

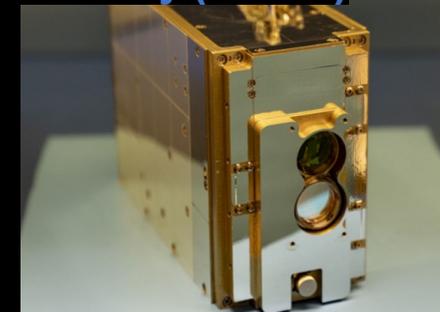
Bernard Kutter LOFTID



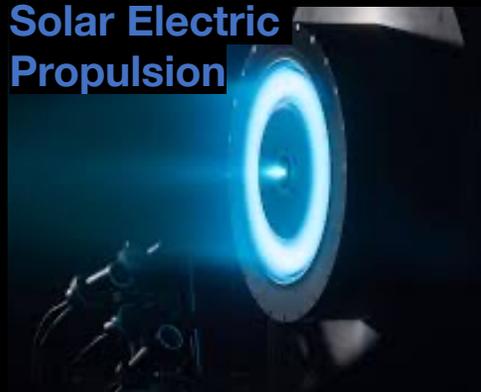
CAPSTONE



TeraByte Infrared Delivery (TBIRD)



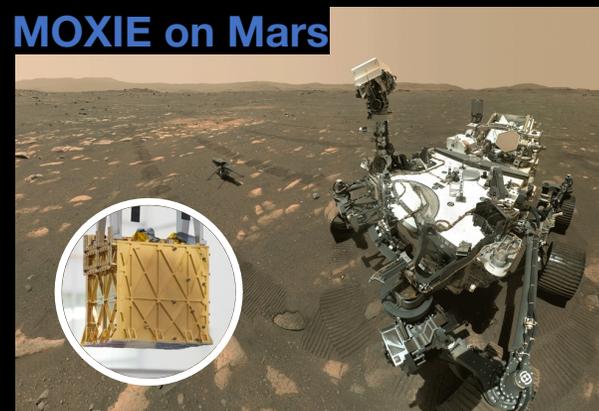
Solar Electric Propulsion



ROSA Infusion



MOXIE on Mars



TALOS Thrusters



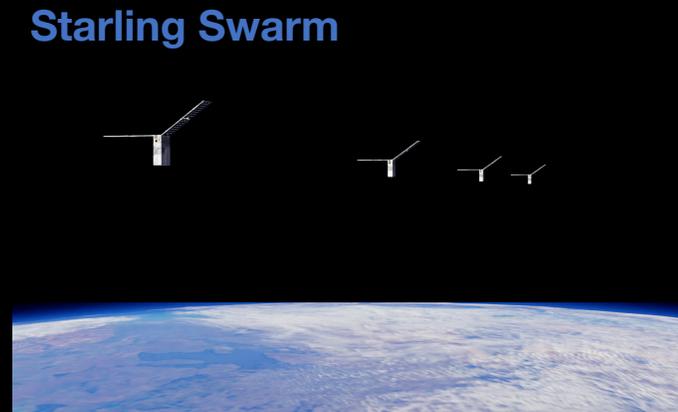
DRACO Agreement



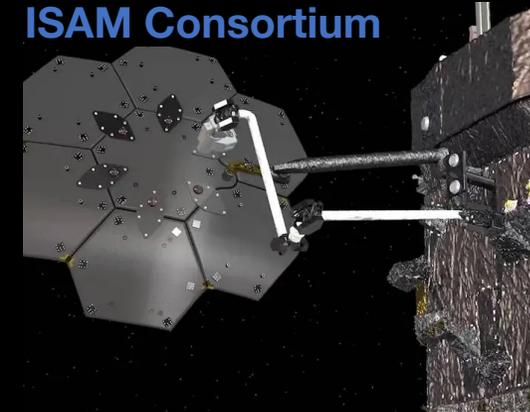
Deep Space Optical Comm



Starling Swarm



ISAM Consortium



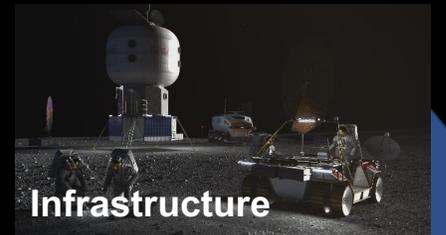
STMD Investment Aligned to Agency Goals

NASA Strategic Plan

3.1 Innovate and advance transformational space technologies

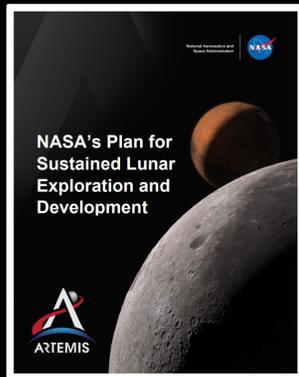
Develop revolutionary, high-payoff space technologies driven by diverse ideas to transform NASA missions and ensure American leadership in the space economy

Moon to Mars Blueprint Objectives



STMD Strategic Framework

Lead	Thrusts	Outcomes	Primary Capabilities
		Transforming Space Missions	
		<ul style="list-style-type: none"> Develop nuclear technologies enabling fast in-space transit. Develop cryogenic storage, transport, and fluid management technologies for surface and in-space applications. Develop advanced propulsion technologies that enable future science/exploration missions. 	<ul style="list-style-type: none"> Nuclear Systems Cryogenic Fluid Management Advanced Propulsion
		<ul style="list-style-type: none"> Enable Lunar/Mars global access with "TOO" payloads to support human missions. Enable science missions entering/traversing planetary atmospheres and landing on planetary bodies. Develop technologies to land payloads within 50 meters accuracy and avoid landing hazards. 	<ul style="list-style-type: none"> Entry, Descent, Landing, & Precision Landing
		<ul style="list-style-type: none"> 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 building volumes in situ resources. Enable long duration human exploration missions with Advanced Habitation System technologies. [Low TRL STMD, Mid-High TRL STMD/ISRM] 	<ul style="list-style-type: none"> Advanced Power In-Situ Resource Utilization Advanced Thermal Advanced Materials, Structures, & Construction Advanced Habitation Systems
		<ul style="list-style-type: none"> 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/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 STMD, SMD funds mission specific instrumentation (TRL 1-9)] Develop transformative technologies that enable future NASA or commercial missions and discoveries. 	<ul style="list-style-type: none"> Advanced Avionics Systems Advanced Communications & Navigation Advanced Robotics Autonomous Systems Satellite Servicing & Assembly Advanced Manufacturing Small Spacecraft Advanced, Proximity Operations & Capture Sensor & Instrumentation



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

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.



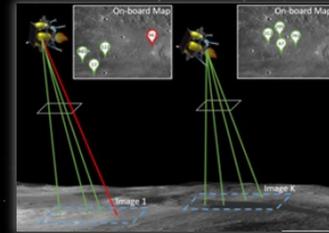
LI-2^L: Develop a lunar surface, orbital, and Moon-**MI-2^M** to-Earth **communications** architecture capable of scaling to support long term science, exploration, and industrial needs.



LI-3^L: Develop a lunar **position, navigation and** **MI-3^M** **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.



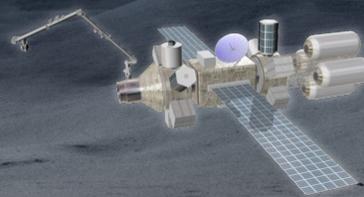
LI-5^L: Demonstrate **precision landing** capabilities in support of continuous human lunar presence and a robust lunar economy.



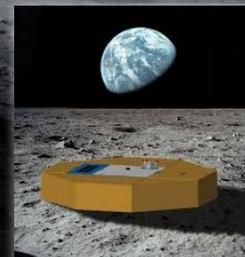
LI-6^L: Demonstrate local, regional, and global **surface** transportation and **mobility** capabilities in support of continuous human lunar presence and a robust lunar economy.



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.

2023 Architecture Concept Review



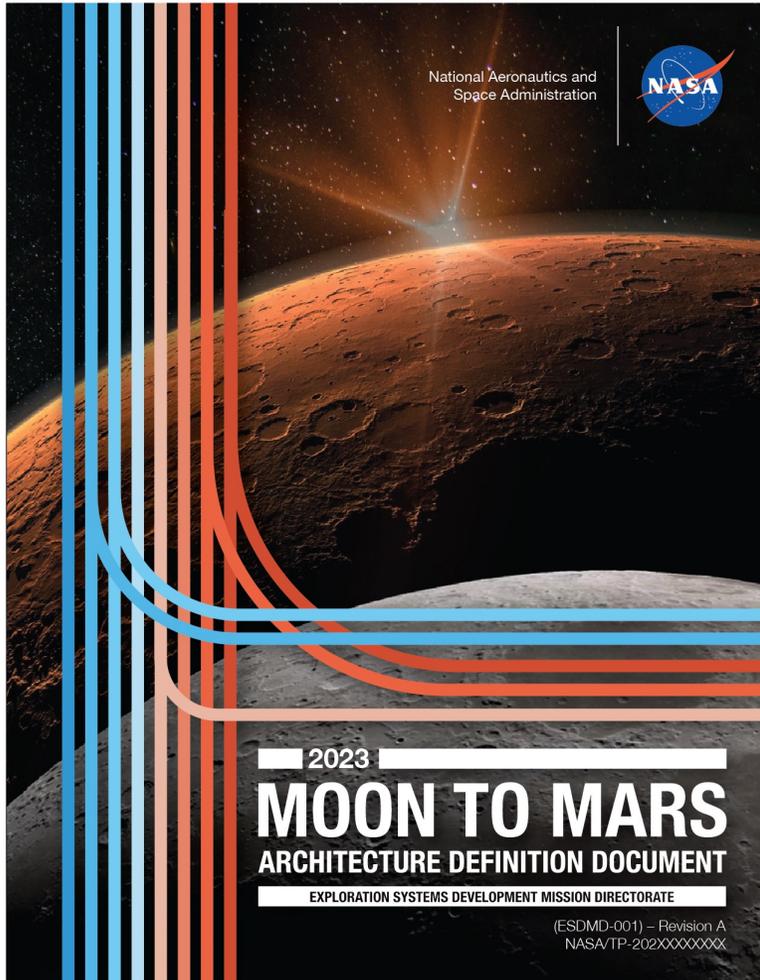
NASA's Kennedy Space Center

November 14-16, 2023



- The agency's annual Architecture Concept Review process enabled stakeholders across NASA and among its partners to provide feedback on our Moon to Mars exploration plans.
- Products that come out of the Architecture Concept Review include updates to the agency's Architecture Definition Document and White Papers highlighting key results from that year's Strategic Analysis Cycle.
- ACR23 focused on refining and adding subarchitectures, adding mature elements, and architectural strategies for the first crewed missions to Mars.

Architecture Definition Document (ADD)



Draft Cover Art for the 2023 Revision of the ADD



Rev A Publication

January 22, 2024

- The Architecture Definition Document is a NASA-published reference document that presents the current state of the human spaceflight architecture and exploration strategy.
 - The document decomposes Moon to Mars objectives into functions and use cases for allocation to implementable programs and projects.
 - It includes current partnerships presence in the architecture, identifies architectural gaps, and presents opportunities for further collaboration.
 - It is **NOT** a requirements document, a mission definition document, a planning manifest, or a procurement strategy.
 - The [current version](#) was published April 1, 2023.
- NASA plans to publish yearly updates to the Architecture Definition Document, incorporating the results of the prior year's Architecture Concept Review.

New Partnerships



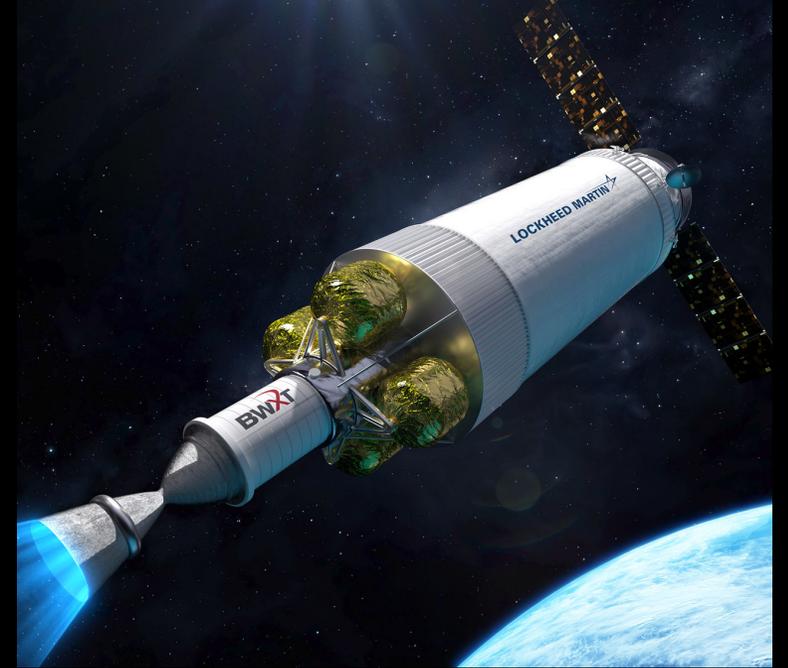
Announcement of Collaboration Opportunity

16 projects from 12 companies selected
April 2023



Tipping Point

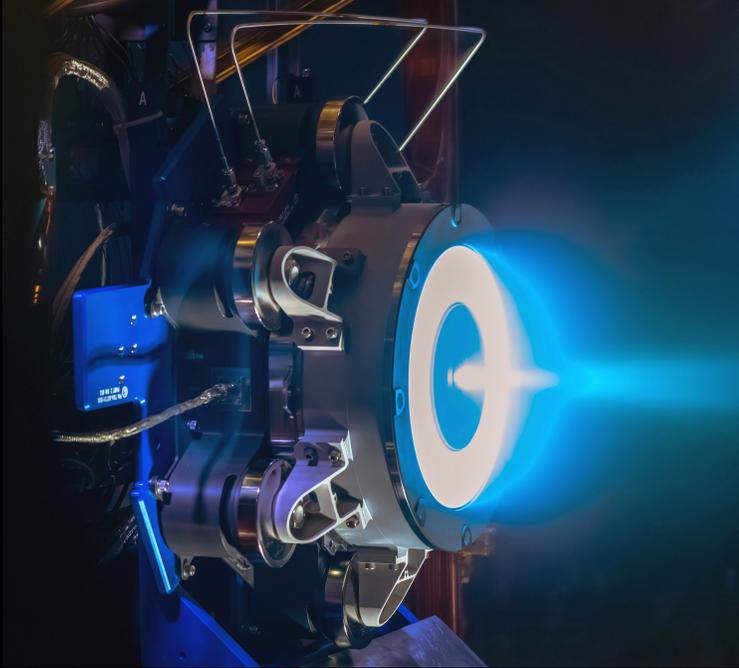
11 projects/companies awarded July 2023



DRACO Program

Interagency agreement signed January 2023
Industry contract awarded July 2023

Technology Demonstrations



Solar Electric Propulsion
Qualification testing began July 2023

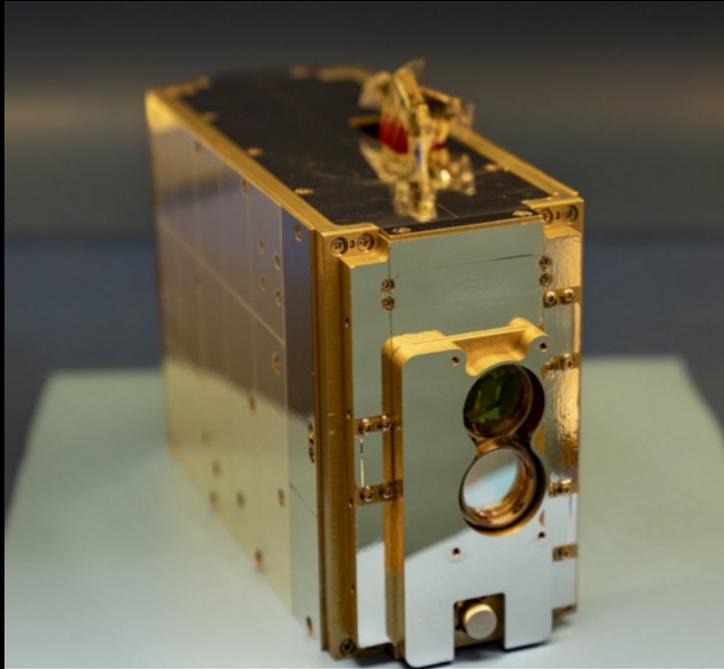


**Mars Oxygen In-Situ Resource
Utilization Experiment (MOXIE)**
Completed Mars mission September 2023



Deep Space Optical Communications
Launched October 2023
First light November 2023

Small Spacecraft Technology & Flight Opportunities



TeraByte InfraRed Delivery (TBIRD)
Achieved highest optical communications
data rate April 2023

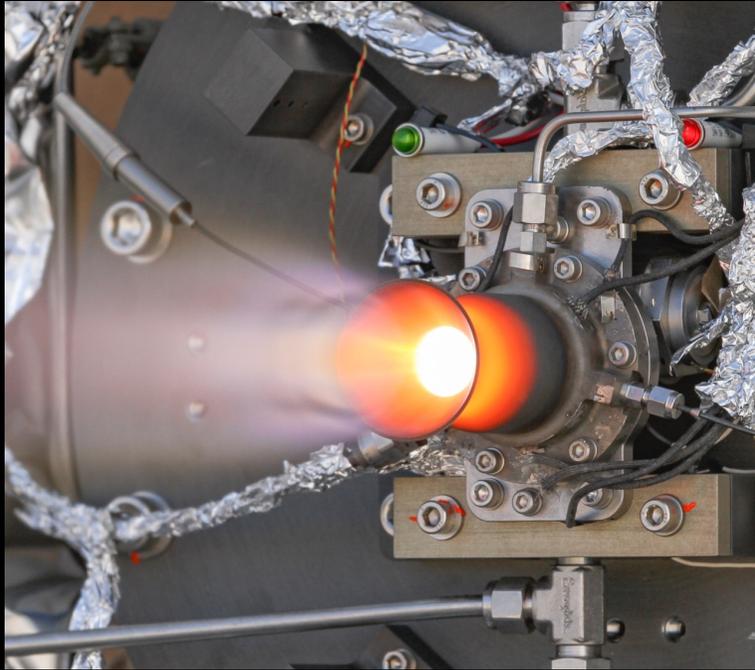


Starling Swarm
Launched and started mission operations
July 2023



Technology Payload Tests
31 tests via 20 commercial suborbital flights
FY 2023

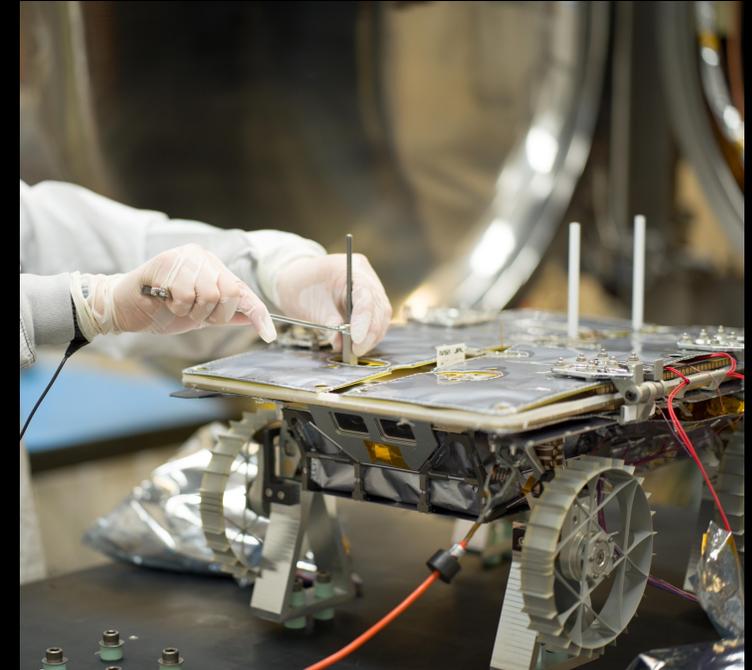
Technology Maturation



Thruster for the Advancement of Low-Temperature Operations in Space (TALOS) Tipping Point
Frontier Aerospace delivery to Astrobotic
February 2023



Additively Manufactured Rocket Engine Nozzles
RAMPFIRE ground testing summer 2023
Relativity Space's Terran-1 launch March 2023

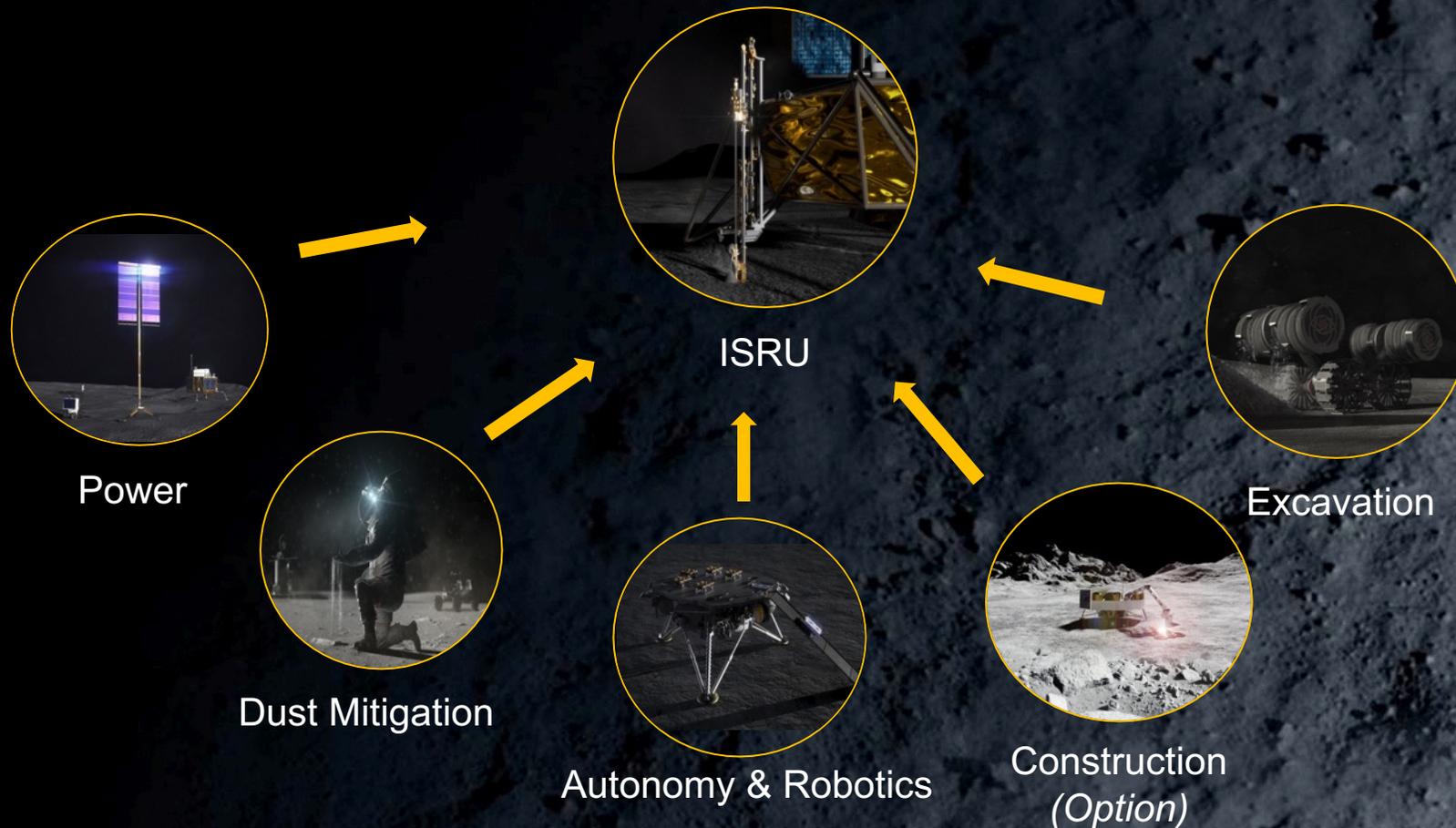


Cooperative Autonomous Distributed Robotic Exploration (CADRE)
Thermal vacuum testing October 2023

Lunar Resource Utilization Demo: LIFT-1

Request for Information (RFI) open through Dec. 18 to obtain feedback and gauge interest from industry for in-situ resource utilization demonstration on the Moon

Lunar Infrastructure Foundational Technology-1 (LIFT-1) Demonstration



Early Stage Innovations & Partnerships



**Small Business Innovation
Research/Small Business
Technology Transfer (SBIR/STTR)**
Invested more than \$190 million in FY 2023



**Space Technology Research
Grants (STRG)**
Surpassed 1000 grants to academia
July 2023



Space Tech Catalyst Prize
Inclusive innovation prize launched
September 2023

STMD-Supported Consortia



Lunar Surface Innovation Consortium (LSIC)
More than 3000 participants from 900+ organizations across 50 states, Puerto Rico, and 57 countries in FY 2023



Consortium for Space Mobility and ISAM Capabilities (COSMIC)
Kick off meeting November 2023

STEM Engagement



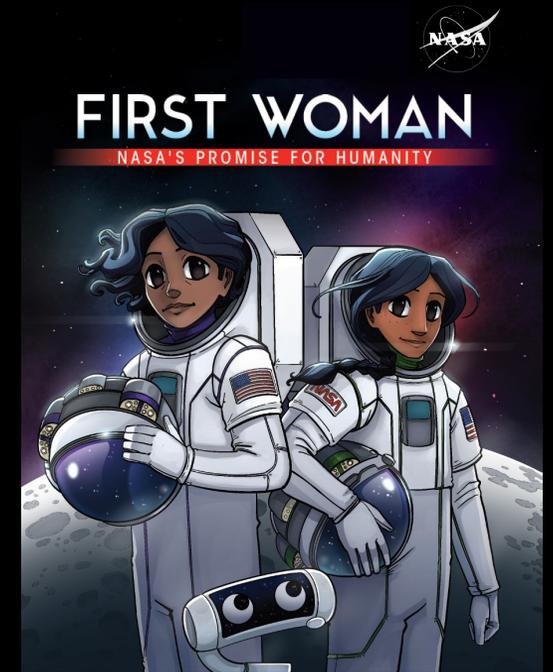
TechRise Student Challenge

Tested student payloads on suborbital rocket-powered vehicles and high-altitude balloons
May-August 2023



MUREP Space Technology Artemis Research (M-STAR)

Awarded grants to minority serving institutions and historically black colleges and universities July 2023



First Woman Graphic Novel

Issue 2 released October 2023

Upcoming 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)

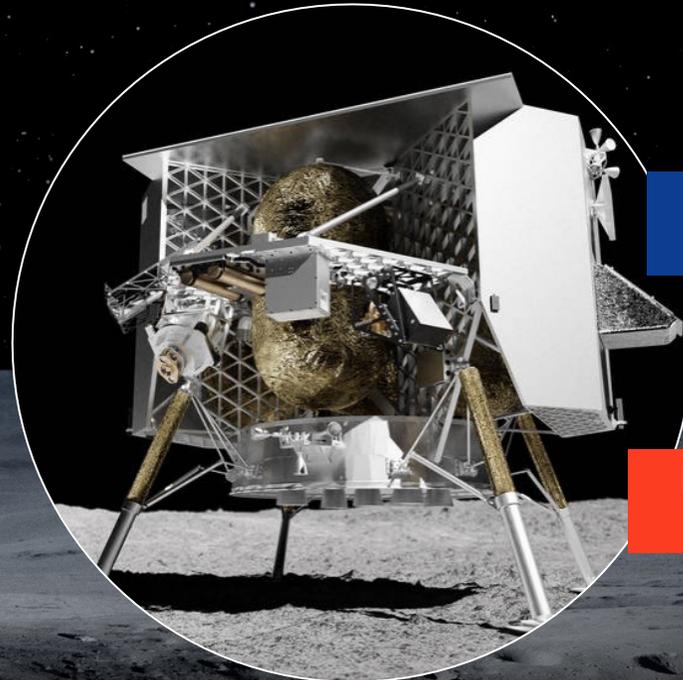


Intuitive Machines 1

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



Terrain Relative Navigation*



Astrobotic Peregrine 1

Navigation Doppler
Lidar (NDL)*



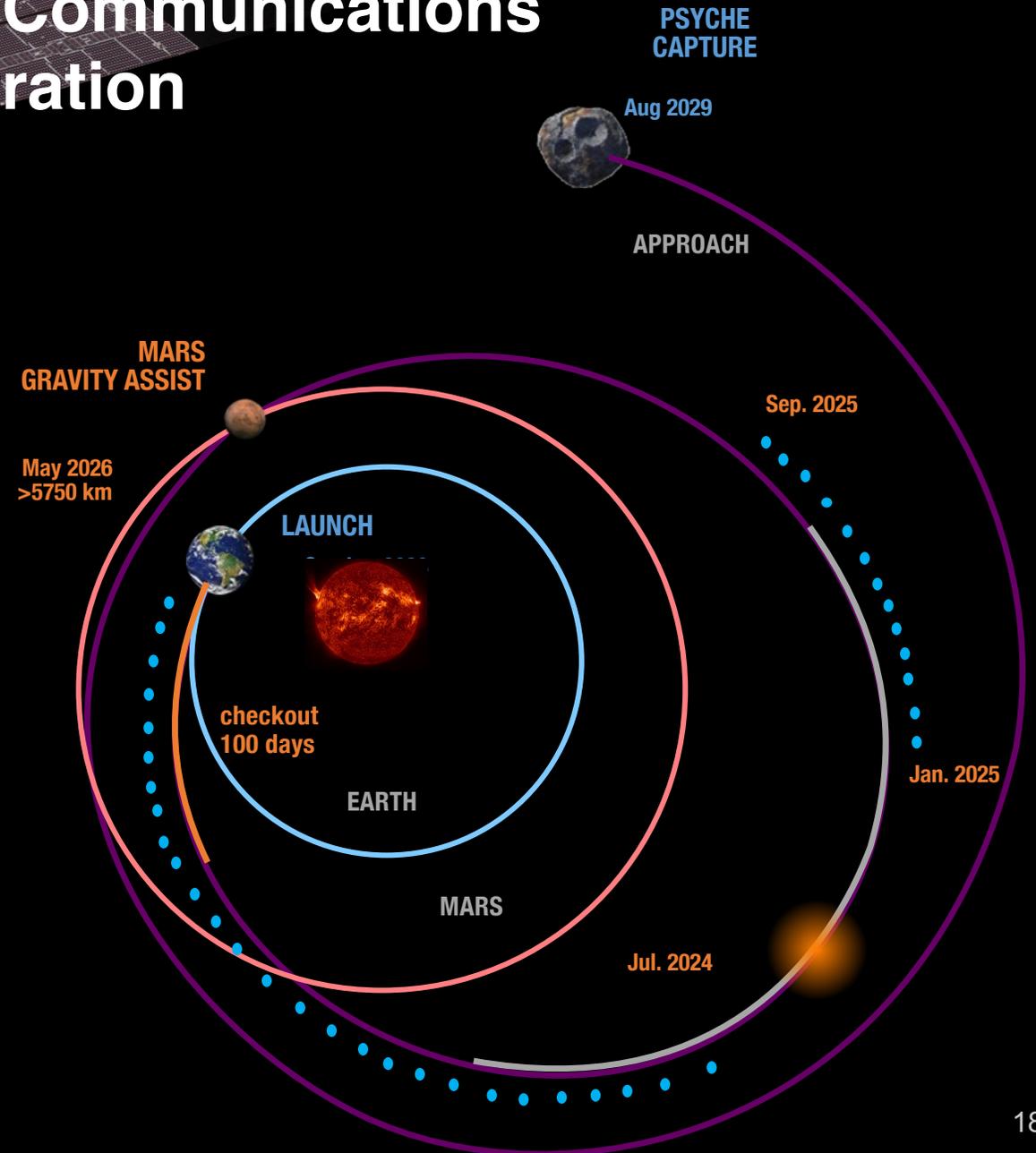
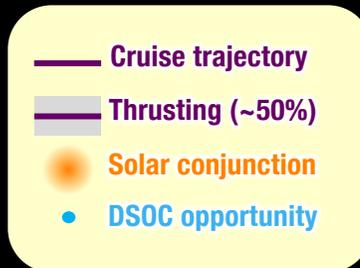
* Mission critical

NASA payload

Tipping Point

Deep Space Optical Communications Demonstration

- Operations for two years after launch (Oct. 23, 2023)
- Achieved first light November 2023
- 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



FY 2024 Appropriations Status

STMD Appropriations	FY 2024 PBR	House Proposal	Senate Proposal	Delta (House)	Delta (Senate)
OSAM-1 (Restore and SPIDER)	227.0	227.0	227.0		
Nuclear Thermal Propulsion (NTP)	17.5	110.0	110.0	92.5	92.5
SBIR/STTR*	299.9	299.9	299.9		
All other directions	288.4	135.0	77.0	-153.4	-211.4
Nuclear Electric Propulsion (NEP)					
Lunar Surface Power (FSP, VSAT, other Surface Power)**					
Regional Economic Development**					
Flight Opportunities					
Innovative Nanomaterials					
In-Space Additive Manufacturing					
Moon-to-Mars Landing Demonstrations**					
Orbital Debris Remediation**					
Remaining STMD Programmatic Content (22-27% reduction)	558.8	433.1	404.1	-125.7	-154.7
Total	1,391.6	1,205.0	1,118.0	-186.6	-273.6

*SBIR/STTR - to be refined upon completion of OCFO extramural R&D calculation

**Activities across STMD portfolio

Visit the new and improved NASA website!
nasa.gov/spacetech

TECHNOLOGY

Impact Stories

NASA's Space Technology Mission Directorate (STMD) develops technologies through a community of entrepreneurs, researchers, and innovators to solve the nation's toughest challenges and enable future NASA and commercial missions to the Moon, Mars, and beyond.

Go to Impact Stories →



FreeFall Tests Spherical Antennas at 159,000 feet on NASA's 60 million cubic foot stratospheric balloon.
Dr. Christopher Walker, NIAC Fellow / FreeFall Aerospace