



EXPLORE SPACE TECH

2022 SmallSat Technology Partnerships Technology Exposition

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EXPLORE SPACE TECH

WITH SMALL SPACECRAFT

The Small Spacecraft Technology program expands the ability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector.



EXPLORE SPACE TECH






THROUGH SUBORBITAL FLIGHT

The Flight Opportunities program rapidly demonstrates promising technologies for space exploration, discovery, and the expansion of space commerce through suborbital testing with industry flight providers.



SPACE TECHNOLOGY MISSION DIRECTORATE STRATEGIC FRAMEWORK

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

THRUSTS	OUTCOMES		CAPABILITIES
 <p>Lead Ensuring American global leadership in Space Technology</p> <ul style="list-style-type: none"> • 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 	 <p>Go Rapid, Safe, & Efficient Space Transportation</p>	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Nuclear Systems • Cryogenic Fluid Management • Advanced Propulsion
	 <p>Land Expanded Access to Diverse Surface Destinations</p>	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Entry, Descent, Landing, & Precision Landing
	 <p>Live Sustainable Living and Working Farther from Earth</p>	<ul style="list-style-type: none"> • Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities <ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Advanced Power • In-Situ Resource Utilization • Advanced Thermal • Advanced Materials, Structures, & Construction • Advanced Habitation Systems
	 <p>Explore Transformative Missions and Discoveries</p>	<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/Surface Manufacturing, and Small Spacecraft technologies. • Develop vehicle platform technologies supporting new discoveries. • Develop technologies for science instrumentation supporting new discoveries. • 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 → • Rendezvous, Proximity Operations & Capture • Sensor & Instrumentation

EXPLORE SPACE TECH

CHANGING THE PACE OF SPACE

Leveraging small spacecraft and responsive launch to rapidly expand space capabilities at dramatically lower costs

Rapid Leap from Lab to Orbit

Commercial suborbital and orbital test capabilities de-risking technology for future missions. Technology moves from lab to orbit in <9 months.

Responsive deep space access

Expanded space commerce
On-orbit manufacturing, assembly, and inspection

Sustained deep space presence
Commercial lunar activity
In-situ resource extraction and utilization

On-Demand Missions Beyond Earth

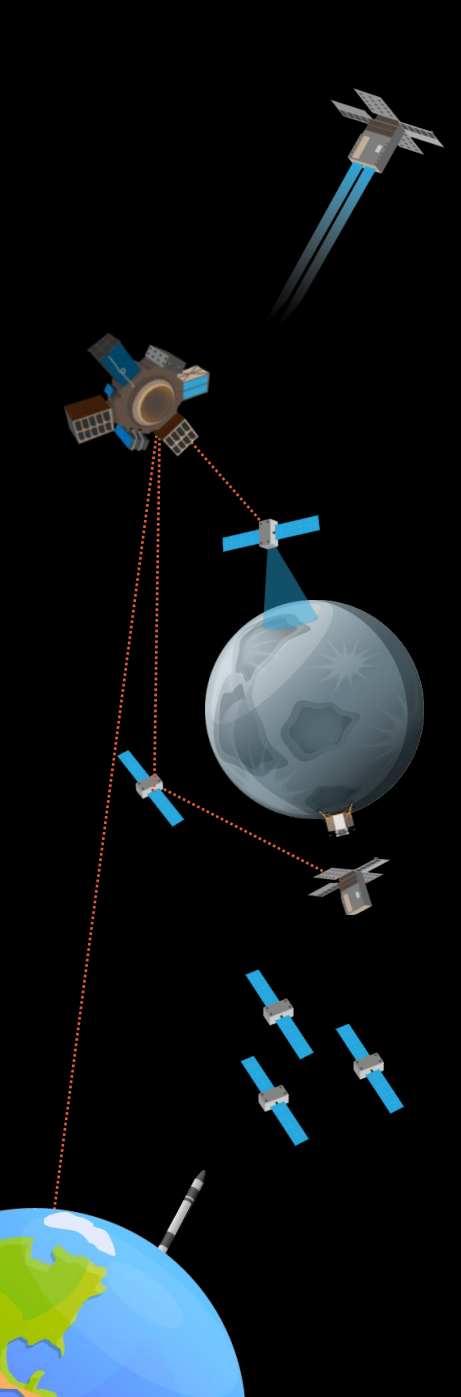
Targeted measurements of Moon, Mars, Venus, and the asteroid belt in response to events and opportunities. Capabilities are competitive with traditional systems but developed for <\$30M in <3 years.

Unprecedented Deep Space Infrastructure

Modular communications, navigation, and mission support that provides full coverage of Moon and Mars. Each node costs <\$20M to build and deliver to space.

Unparalleled Sensing Capabilities

Networked spacecraft providing multi-kilometer synthetic apertures and massive sensor webs of 30 to 100 spacecraft. Each node costs <\$10M to build and deliver to space.

A diagram illustrating various small spacecraft technologies. It shows a rocket launching a satellite, a satellite in Earth orbit, a satellite in deep space orbit, and several small satellites in formation. Dotted lines represent communication links between the satellites and the Earth. The Earth is shown at the bottom left, and the background is a dark blue gradient.

CHANGING THE PACE OF SPACE: Envisioned Future For Small Spacecraft Technology

High dV Small Spacecraft Propulsion Systems

Low size, weight, power, and cost (SWaP-C) systems capable of imparting 2-5+ km/s change in velocity (dV) to microsatellites. Highly manufacturable and compatible with the deep space environment. ▶ Small missions to the Moon, Lagrange Points, NEOs and beyond as well as plane changes and more responsive missions in Earth orbit.

Deep Space Orbital Maneuvering Vehicles (OMVs)

OMVs capable of 10+ km/s dV and providing position, navigation, and timing (PNT) services and communications relay to deployed spacecraft or hosted payloads. Affordable and demonstrated in the deep space environment. ▶ Expansion of small risk-tolerant missions further beyond Earth and the ability to reach multiple destinations from a single launch.

In-Space Autonomy for Small Spacecraft and Distributed Systems

Significant (~75%) reduction in ground station aperture time for single small spacecraft missions. Increased in-space autonomy that allows 10's of small spacecraft to operate as a single unit beyond Earth. ▶ Large distributed missions (e.g., heliophysics) and missions in Earth-orbiting or beyond that can react without ground stations in the loop.

Small Spacecraft Communications and PNT Services

Small spacecraft that can be deployed to the Moon and other deep space destinations to provide global PNT and communications relay infrastructure. ▶ Addresses future strain on terrestrially-based capabilities (e.g., tracking) caused by concurrent cislunar missions and global surface missions where direct communications with Earth is not feasible.

Interoperable Networking for Small Missions

Increased interoperability between government and commercial space networks. Operational interoperability protocols that help pair the NASA DTN and LunaNet with the Hybrid Space Architecture. ▶ Ubiquitous communication between in-space assets, airborne systems, in-situ sensors, and ground assets as well as networking in cislunar space.

Small Spacecraft Proximity Operations and Abort Systems

De-risked low size, weight, power and cost (SWaP-C) proximity sensors and reliable proximity abort systems. ▶ Reduced risk in use of small satellites in close proximity to high value assets (e.g., for servicing / inspection) and for small missions to natural targets like NEOs.

Responsive Access to Suborbital and Orbital Space

Additional suborbital vehicle performance and payload accommodations for technology testing (e.g., payloads hosted on recoverable orbital launch vehicle stages and hosted orbital payloads). ▶ Rapid advancement of capabilities requires frequent risk-tolerant opportunities to test and evaluate in an operational environment.