Space Technology Mission Directorate Overview and Support of Science Mission Directorate

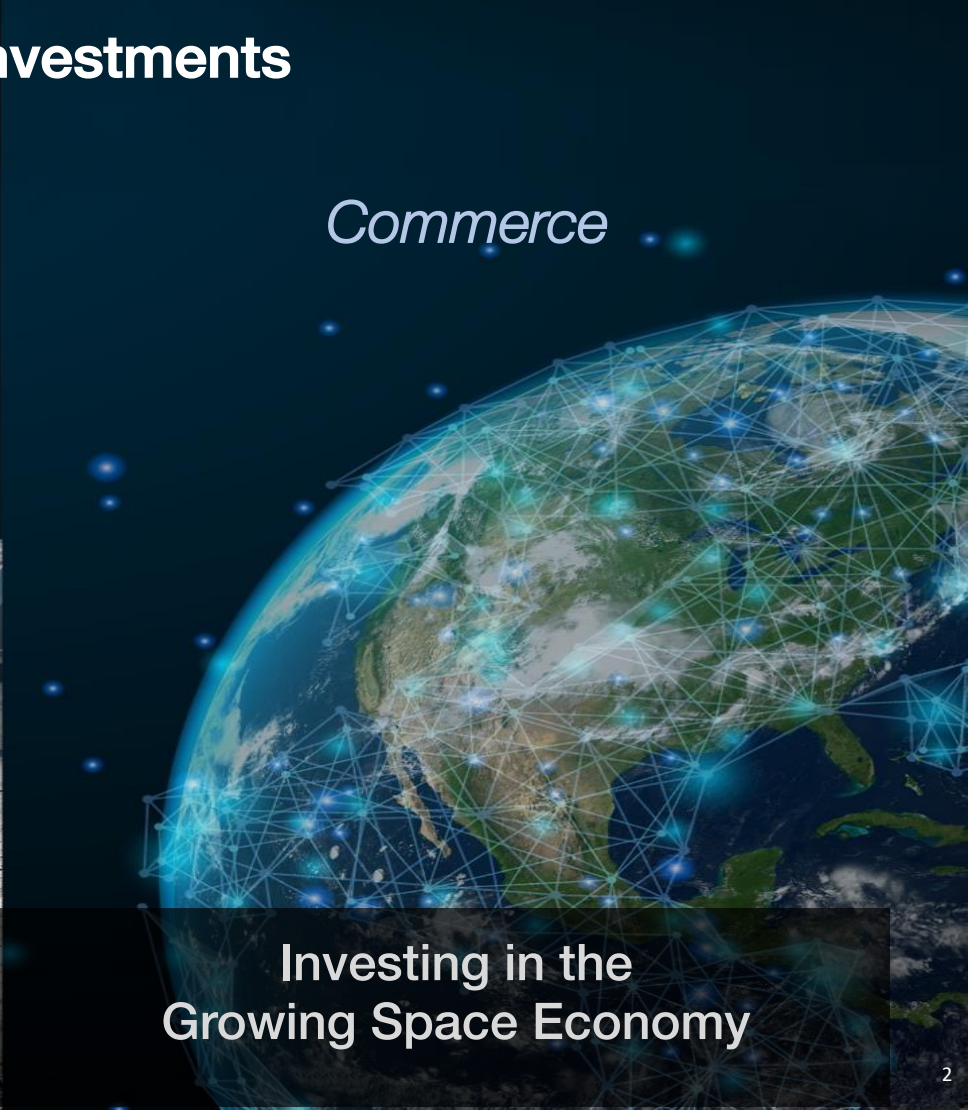
Dr. Prasun Desai | Deputy Associate Administrator, Space Technology Mission Directorate | 06.04.2021

Strategic Investments

Exploration

Human and Science Exploration
Lunar Landings and Sustainability
Mars Forward

Commerce



Investing in the
Growing Space Economy


SPACE TECHNOLOGY PORTFOLIO
EARLY STAGE INNOVATION
• NASA Innovative Advanced Concepts
• Space Tech Research Grants
• Center Innovation Fund/ Early Career Initiative
PARTNERSHIPS AND TECHNOLOGY TRANSFER
• Technology Transfer
• Prizes and Challenges
• iTech
SBIR/STTR PROGRAMS
• Small Business Innovation Research
• Small Business Technology Transfer
TECHNOLOGY MATURATION
• Game Changing Development
• Lunar Surface Innovation Initiative
TECHNOLOGY DEMONSTRATIONS
• Technology Demonstration Missions
• Small Spacecraft Technology
• Flight Opportunities
Technology Drives Exploration
LOW
MID
HIGH
Technology Readiness Level

STMD Strategy Framework

Lead	Thrusts	Outcomes	Primary Capabilities
Ensuring American global leadership in Space Technology • Lunar Exploration building to Mars and new discoveries at extreme locations • Robust national space technology engine to meet national needs • U.S. economic growth for space industry • Expanded commercial enterprise in space	 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

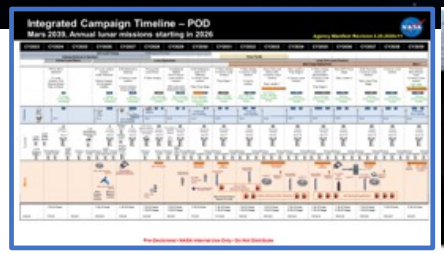
	 Sustainable Living and Working Farther from Earth	• Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities
		  • Sustainable power sources and other surface utilities to enable continuous lunar and Mars surface operations.
		  • Scalable ISRU production/utilization 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 Life Support & Human Performance technologies.
			• Advanced Power
			• In-Situ Resource Utilization
			• Advanced Thermal
			• Advanced Materials, Structures, & Construction
			• Advanced Life Support & Human Performance

	 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 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

Primarily Aligned to SMD

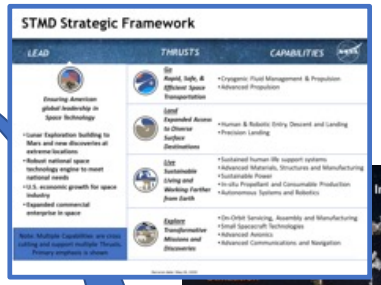
Secondarily Aligned to SMD

Strategic Technology Architecture Roundtable (STAR)



- Draws directly on Agency Artemis/ISS/ Technology **and Science Manifests as well as SMD Science Decadals and Mission Needs to identify technology gaps.**
- Direct participation from Industry, academia and other government agencies for identification of commercial technology needs and forward plans

- Strategic Technology Framework aligned to Agency Strategic Capability Leadership Teams (SCLT's) and Principal Technologists (PT's) with LSII providing specific focus on Lunar Surface



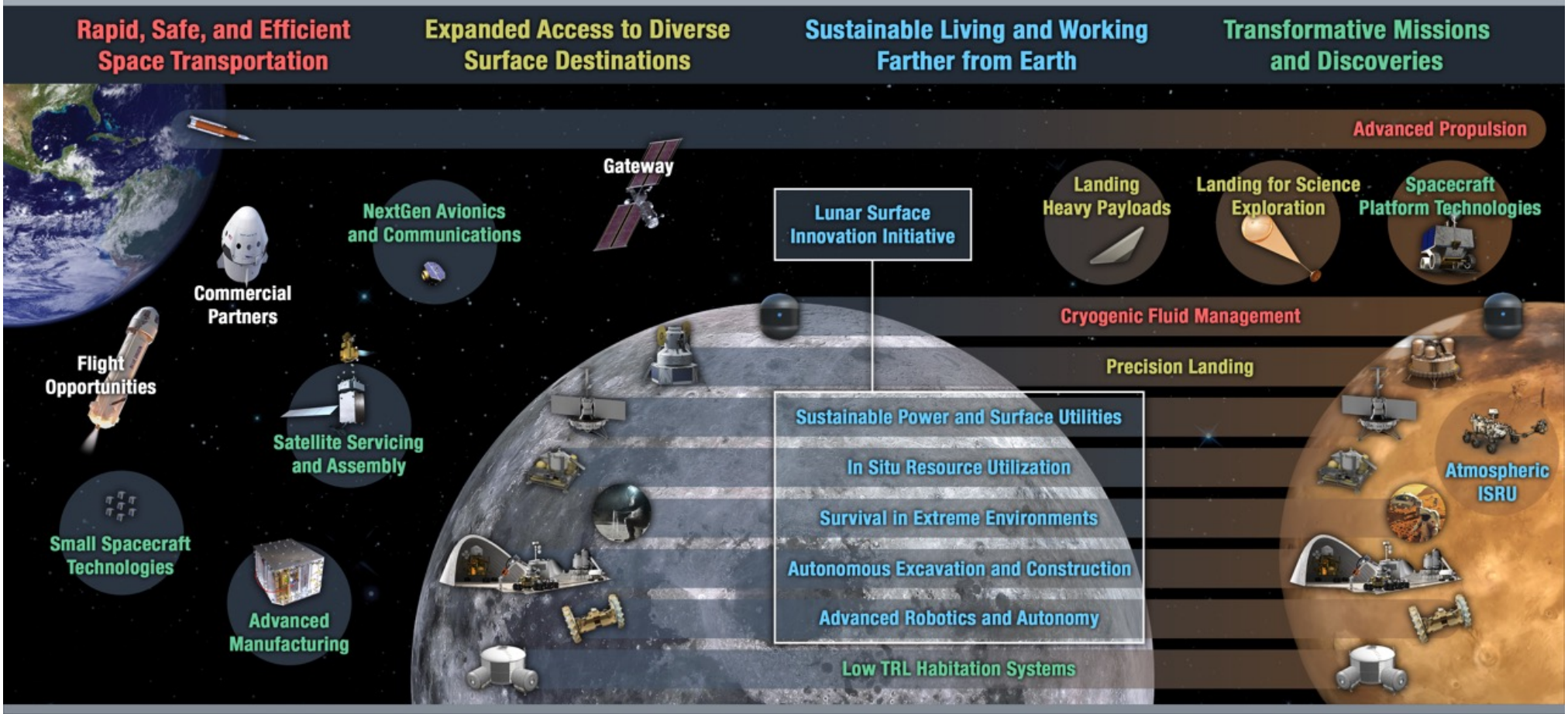
Inclusive, comprehensive engagement strategy to embrace industry, science and exploration needs.

STAR

Technology Gaps identify specific needs and closure plans → Strategic Technology Gaps → Strategic Outcome Implementation Plans → PPBE Process

- STAR process inclusive of Center Chief Technologists, HEO & **SMD Representation,** and OCT. Maps to OCT Taxonomy.
- Strategic Technology Gaps (STG's) organized by Capability Areas and led by SCLT/PT's capture all technology gaps. Strategic Outcome Implementation Plans allow for prioritization and forward planning to inform PPBE Process.

Ensuring American Global Leadership in Space Technology



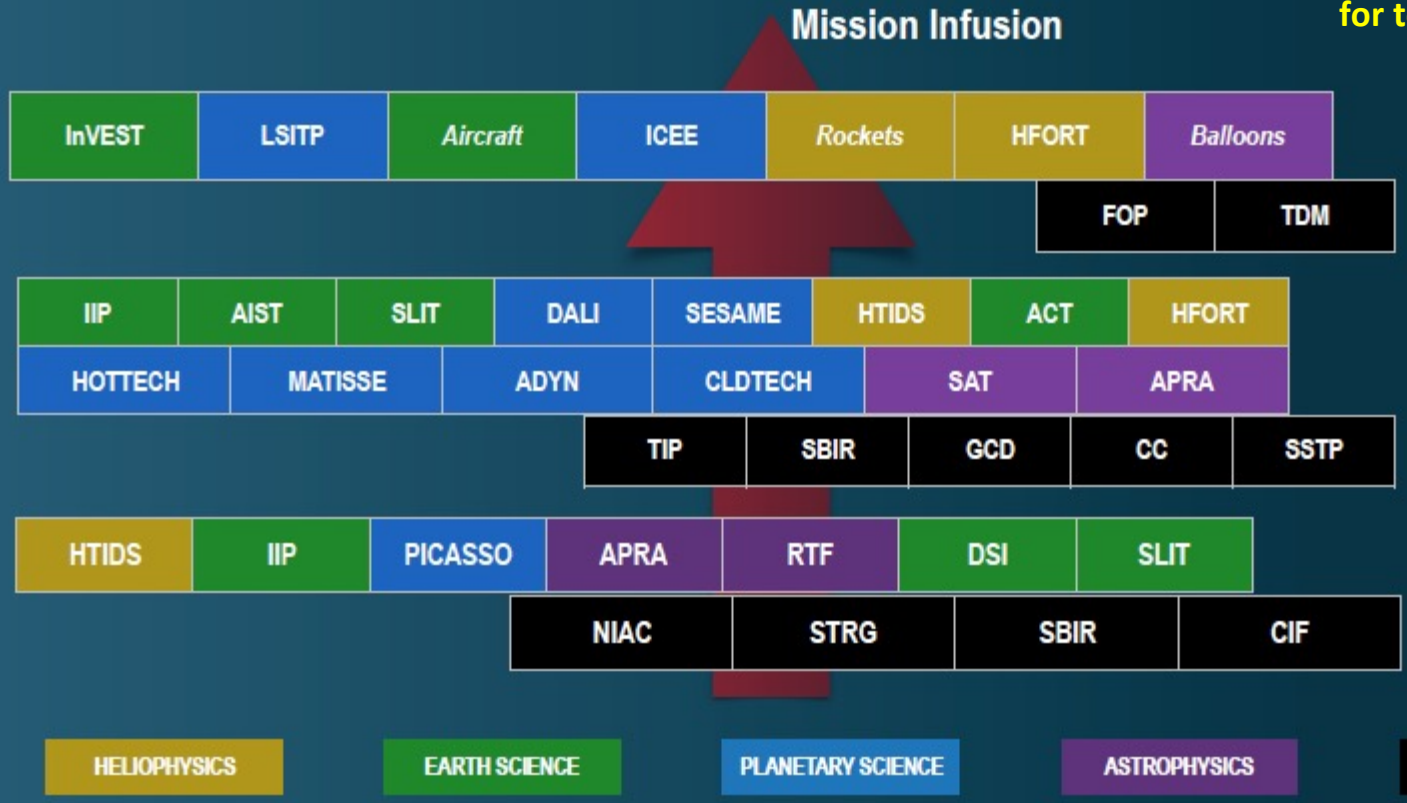
Technology Drives the Space Economy

STMD/SMD Interactions

- STMD/SMD have had strong involvement across STMD programs
- STMD's focus is generally on Technology Readiness Level (TRL) 1-7 space technologies
- SMD's focus is generally on instrument technology development with some platform technology development which is coordinated with STMD
- SMD involved in developing STMD strategy and provides priority areas of interest
- SMD is integral to STMD's solicitation topic selection, proposal review, and proposal selection
- STMD New technology demonstrations are offered to be flown on SMD missions of opportunity (e.g., New Frontiers, Discovery)
- STMD utilizing CLPS landers through SMD for technology demonstration on lunar surface

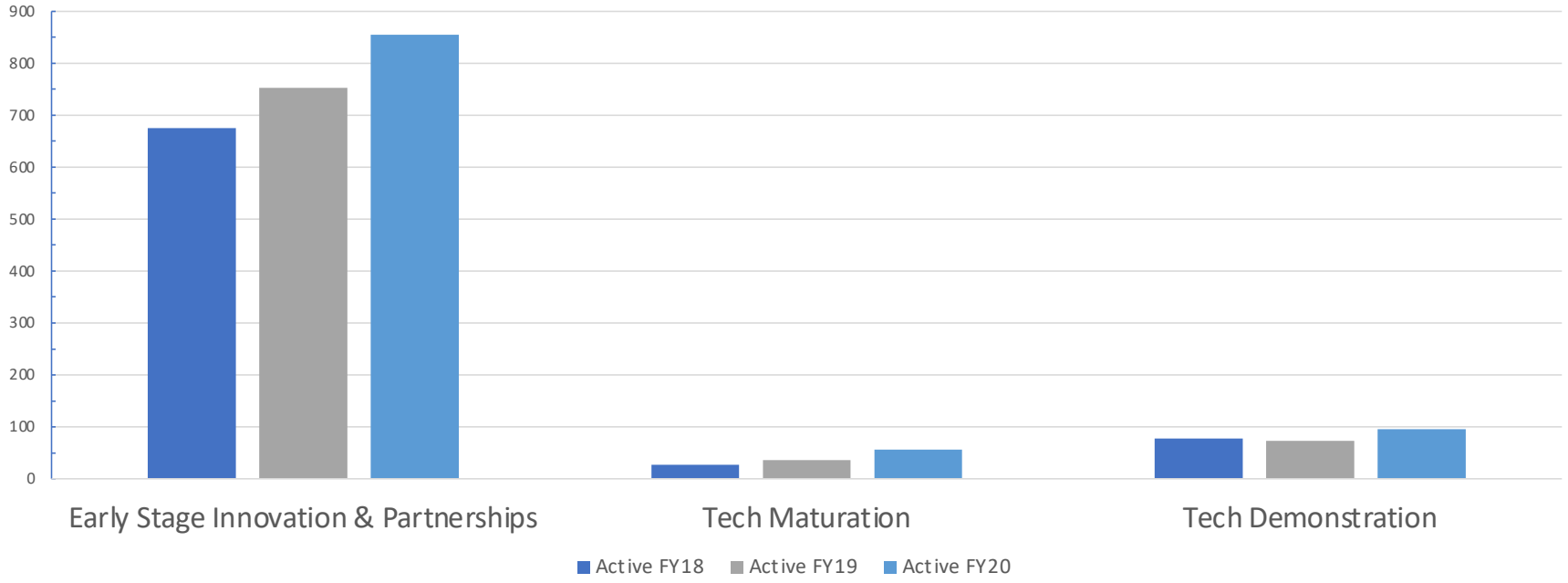
SMD Technology Programs

SMD Chart illustrating reliance on STMD Program for technology development

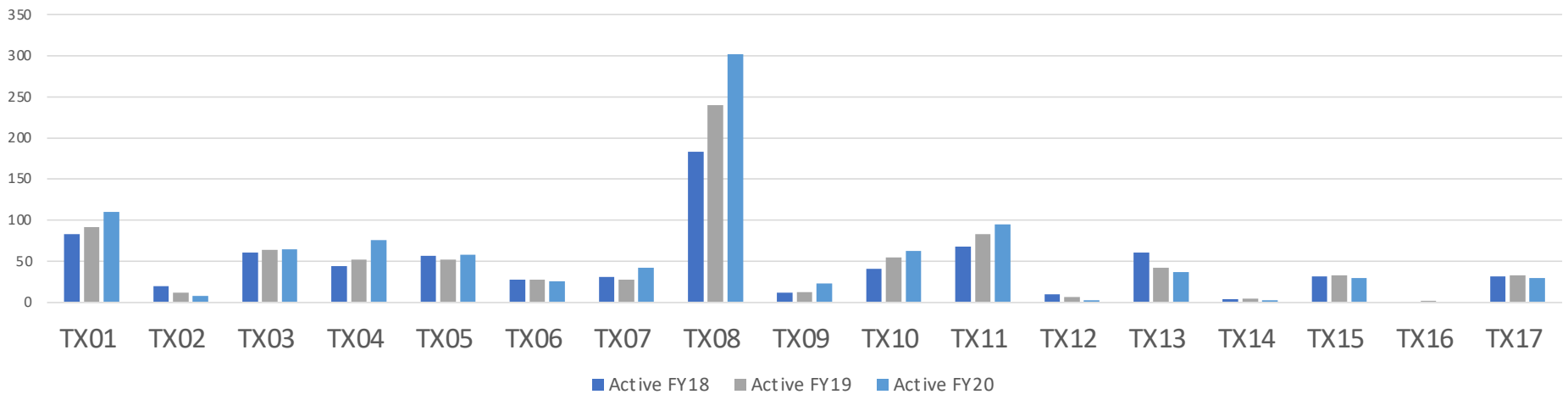


FOP: Flight Opportunities Program
TDM: Technology Demonstration Mission
TIP: Tipping Point Solicitation
SBIR: Small Business Innovation Research
GCD: Game Changing Development
CC: Centennial Challenges
SSTP: Small Spacecraft Technology Program
NIAC: NASA Innovative Advanced Concepts
CIF: Center Innovation Fund

SMD Relevant Projects by TRL FY18-FY20 (preliminary analysis)



SMD Relevant Projects by Taxonomy Area FY18-FY20 (preliminary analysis)



TX01: Propulsion
TX02: Flight Computing & Avionics
TX03: Power & Energy Storage
TX04: Robotic Systems
TX05: Comms, Nav, & Orbital Debris
TX06: Human Health, Life Support, & Habitation

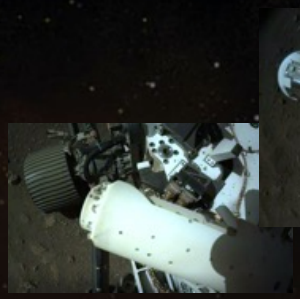
TX07: Exploration Destination Systems
TX08: Sensors & Instruments
TX09: EDL
TX10: Autonomous Systems
TX11: Software, Modeling, Simulation, & Info Processing

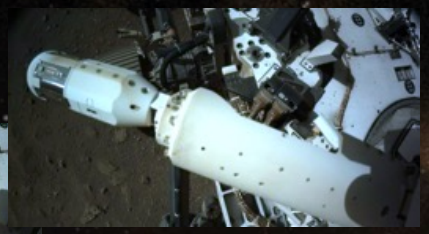
TX12: Materials, Structures, Mechanical Systems, & Manufacturing
TX13: Ground, Test, & Surface Systems
TX14: Thermal Management
TX15: Flight Vehicle Systems
TX16: Air Traffic Management & Range Tracking
TX17: Guidance, Navigation, & Control

Space Technology for Mars 2020 Perseverance

MEDA *(Mars Environmental Dynamics Analyzer)*

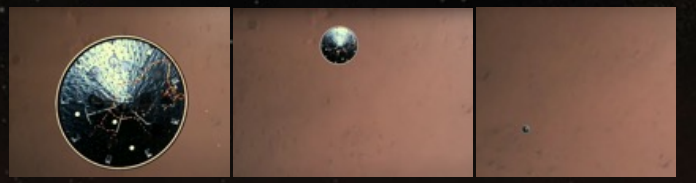
A set of sensors that will provide measurements of temperature, wind speed and direction, pressure, relative humidity and dust size and shape in the Martian atmosphere

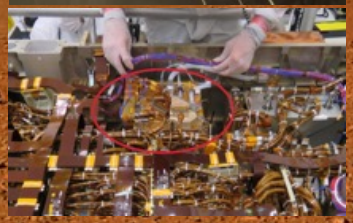




MEDLI2 *(Mars Entry, Descent and Landing Instrumentation 2)*

MEDLI2 is a next-generation sensor suite for entry, descent and landing (EDL). It collects temperature and pressure measurements on the heat shield and afterbody during EDL





MOXIE *(Mars Oxygen In-Situ Resource Utilization Experiment)*

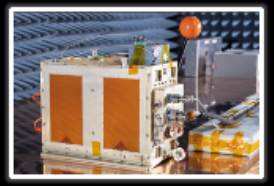
MOXIE will demonstrate a way that future explorers might produce oxygen from the Martian atmosphere for propellant and for breathing.

TRN *(Terrain Relative Navigation)*

TRN gives a spacecraft the ability to autonomously avoid hazards we already know about and can land in more (and more interesting) landing sites with far less risk

Mars 2020 EDL Targeted Location

STMD FY 2021-2022 Highlights

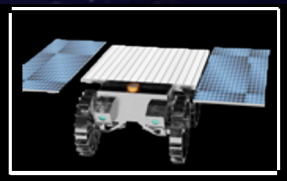


Blue Origin Deorbit Descent & Landing (BODDL-TP)/SPLICE
October 2020
Flight demo 1 aboard suborbital rocket

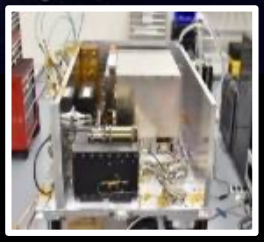
Robotic Refueling Mission 3 On Orbit Robotics Ops
October 2020
Operations Complete

Laser Comm Relay Demo
June 2021
Launch

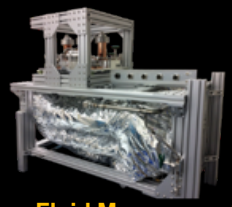
Flight Ops and Small Spacecrafts
40+ suborbital and small spacecraft flights planned 2021



CADRE
Q2 2022
Autonomy Testbed Demonstration

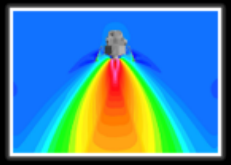


Deep Space Atomic Clock (DSAC)
August 2020
1-Year Operations Complete

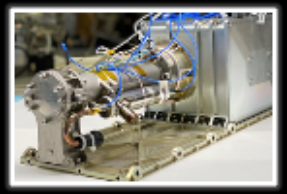


Cryo Fluid Management
April/May 2021
Initiate 4 Flight Demos

CAPSTONE/NRHO
Fall 2021
Launch

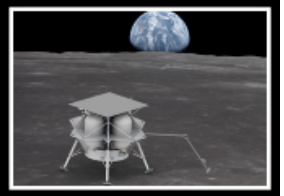


Plume Surface Interaction (PSI)
April 2021
Physics focused ground test

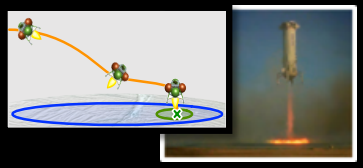


Polar Resources Ice Mining Experiment 1 (PRIME-1)
April 2021
MSolo and TRIDENT assembled for environmental testing w/ delivery to CLPS provider Intuitive Machine in **Spring 2022**

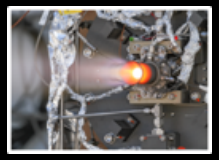
OSAM-1 and OSAM-2
Fall 2021
Critical Design Reviews



Cold Operable Deployable Arm (COLDArm)
April 2021
Mission Concept Review

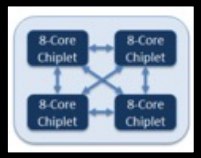


Blue Origin Deorbit Descent & Landing Sensor (BODDL-TP)/SPLICE
Summer 2021
Flight demo 2 aboard suborbital rocket



TALOS and A-TRN
December/TBD 2021
TALOS and A-TRN flight on Astrobotic Peregrine 1 lander

CLPS Mission
Spring 2022
Intuitive Machine's "hopper" mission in partnership with Nokia to est. 4G/LTE tech for lunar exploration



High Performance Spaceflight Computing
February 2022
Contract Award

Deep Space Optical Comm
August 2022
Psyche Launch

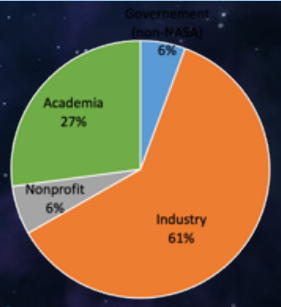
Lunar Surface Innovation Initiative (LSII)

Since inception, LSII has engaged ~400 organizations across 48 states and Puerto Rico to advance the technologies needed to explore the lunar surface and stimulate economic development.

Focus Areas

- In-situ resource utilization
- Surface power
- Dust mitigation
- Extreme environment
- Extreme access
- Excavation and construction

LSII Representation



Lunar Surface Technology Demonstration Planning

LSII leverages early lunar missions to accelerate development of core surface technologies

2020 — 2030

ISRU

- Polar Resources Ice Mining Experiment (PRIME)
- Volatiles Investigating Polar Exploration Rover (VIPER/SMD)
- ISRU Ice-Mining Demo
- ISRU Oxygen Extraction Demo
- ISRU Processing Demo
- ISRU Pilot Plant

Surface Power

- Regenerative Fuel Cell Power
- Wireless Charging for Lunar Surface Demo
- Vertical Solar Array Technology (VSAT)
- Chemical Heat Integrated Power Source (CHIPS)
- Fission Surface Power Demo

Dust Mitigation

- Electrodynamic Dust Shield
- Lunar Dust Level Sensor & Affects on Radiators
- Lunar Dust Smart Sensor for Crewed Environments
- Lunar Dust Removal Tool
- Lunar Dust Separation

Extreme Environments

- Lunar Arm w/ Bulk Metallic Glass Gears
- Lunar Materials Demo
- Lunar Camera
- Lunar Thermal Toolbox
- Lunar Night Material Survivability

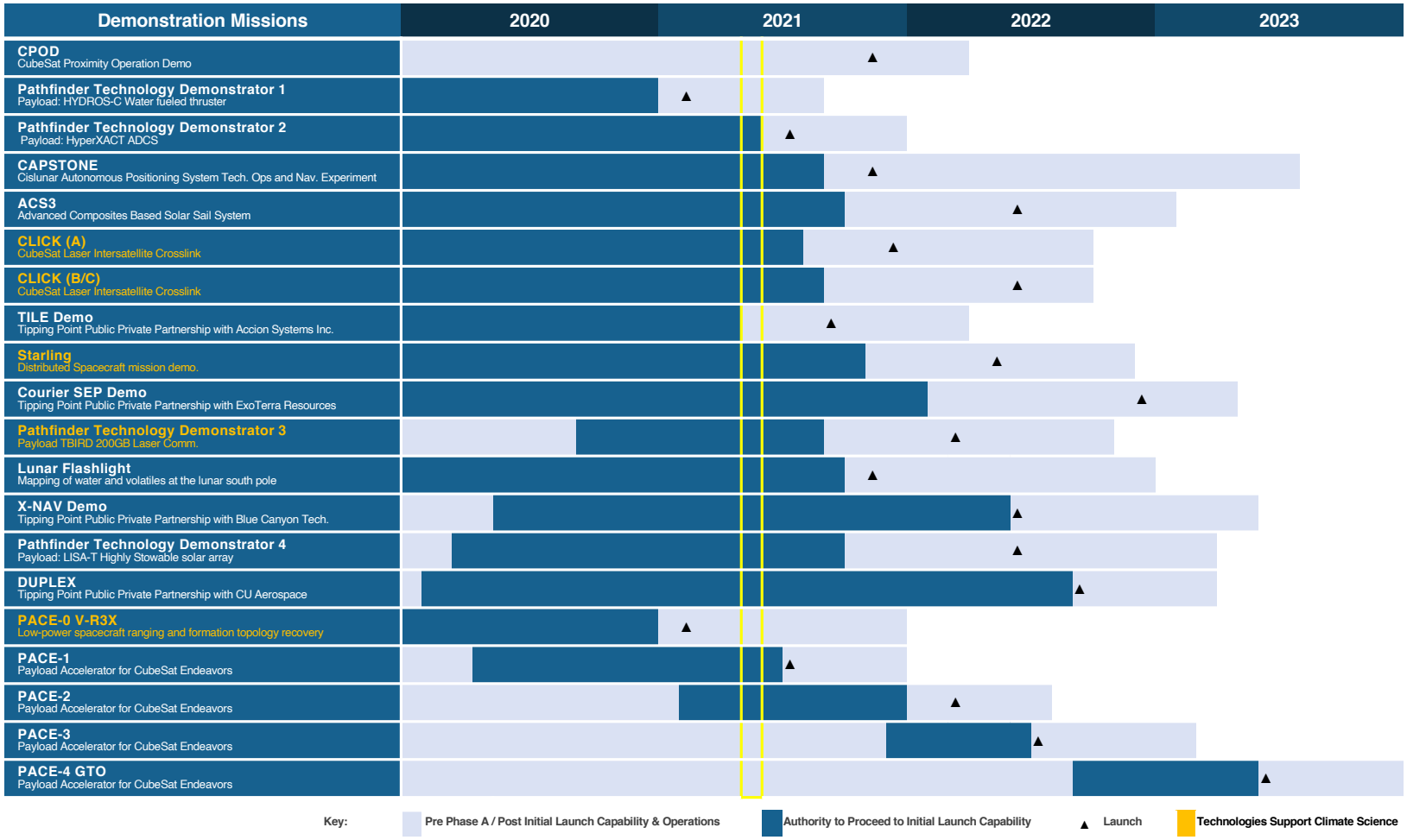
Extreme Access

- Surface Robotic Scouts
- ***Tipping Point Early Hopper CLPS Opportunity***
- Lunar Navigation Demo
- Video Guidance System
- Day/Night Lunar Rover Obstacle Avoidance
- Autonomous Robotics
- Deployable Hopper
- Autonomous Exploration of Lunar Pits

Excavation & Construction

- ISRU Pilot Excavator
- Lunar Surface Construction Demo 1
- Lunar Surface Construction Demo (Landing Pad)

Small Spacecraft Technology Demonstration Missions



FUTURE MISSIONS FOR 2022+

The direction for the programs is to support activities that enhance capabilities and reduce costs across the full range of NASA missions, with specific emphasis on:

- National efforts at the Moon and in cislunar space, inclusive of human and robotic exploration and scientific discovery.
- Earth-observing capabilities to support breakthrough science and National efforts to address climate change.
- Technologies that ensure National leadership in space and help the commercial space industry grow.

Testing Through Use Of Flight Opportunities Program

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

SINCE 2011* FLIGHT OPPORTUNITIES HAS…

* As March 30, 2021

- Supported **212** successful fights
- Enabled **736** tests of payloads
- **307** technologies in the portfolio
- **12** active commercial providers
- In FY21 FO has had **22** suborbital flights and is projected to have a total of **31** flights

COMMERCIAL FLIGHT PARTNERS:

Virgin Galactic · Blue Origin · Masten · UP Aerospace · exos Aerospace · zero G · World View · Raven · NSC · Ångstrom Designs · Stratodynamics · AMOCAL

Summary

- STMD/SMD have been working well together over the past years
- Moving forward, the STMD Strategy Framework will provide a more structured approach to discuss technology priorities and collaborations
- Continue to build on success of incorporating STMD technology demonstrations on SMD missions
  - Two Discovery-19 Venus missions just announced (DSAC2 and entry instrumentation)
- Understanding/familiarity of utilizing CLPS landers will further help build successful demonstrations on lunar surface


NASA
EXPLORESPACE TECH
TECHNOLOGY DRIVES EXPLORATION