Early Stage Innovations and Partnerships Update

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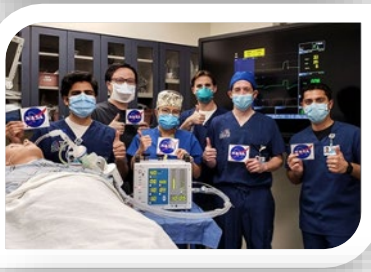
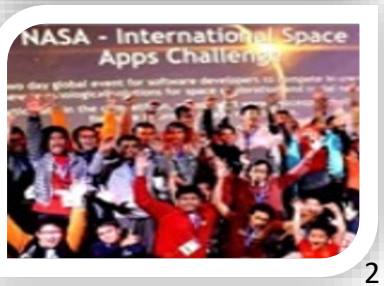
Director, Early Stage Innovations and Partnerships

Early Stage Innovation and Partnerships (ESIP) Portfolio

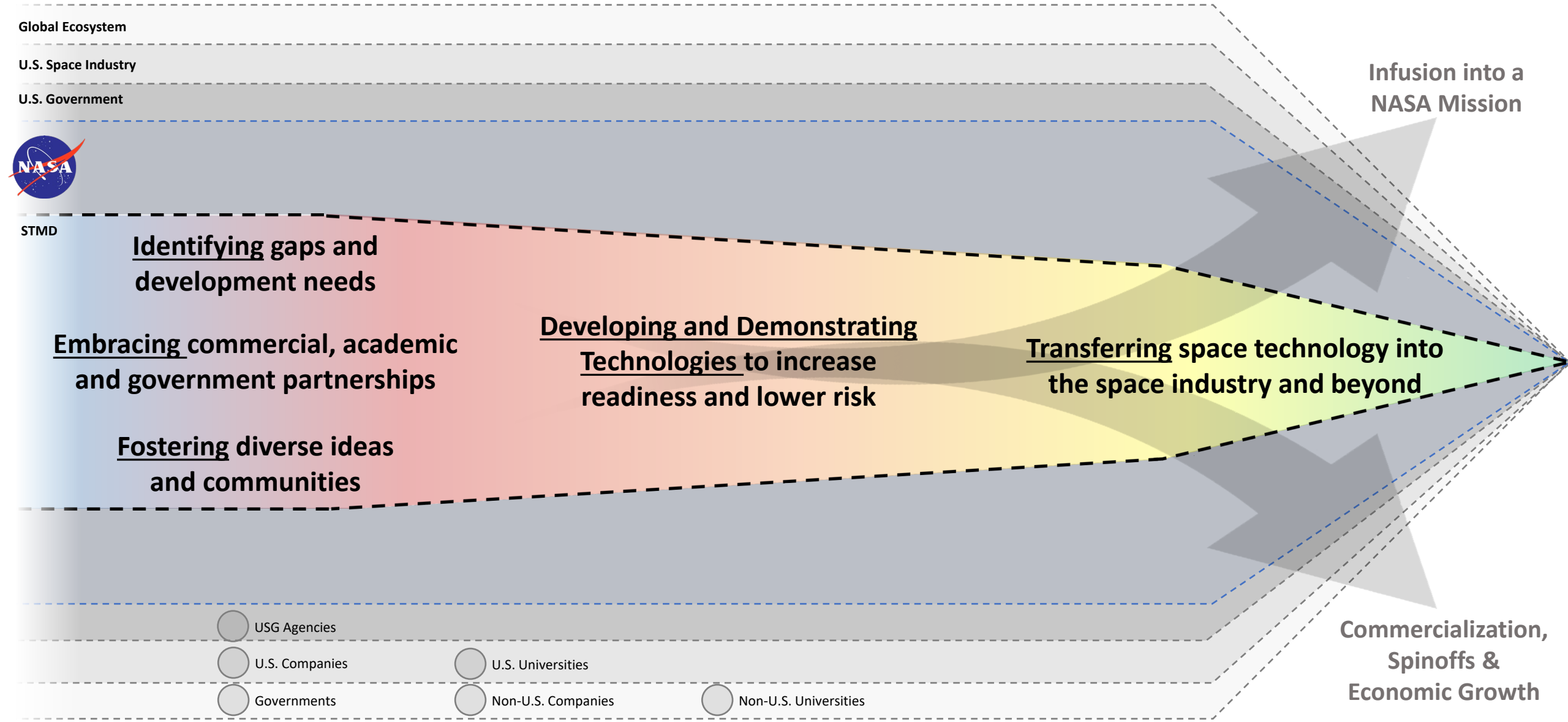
The ESIP Portfolio advances 700+ ambitious projects annually across TRLs and communities to address NASA mission needs and seed future disruptive aerospace capabilities.

NASA Innovative Advanced Concepts (NIAC)	Nurtures **visionary ideas** that could transform future NASA missions with the creation of breakthroughs, while engaging America's innovators and entrepreneurs as partners in the journey.
Space Tech Research Grants (STRG)	Challenges the spectrum of **academic researchers** to examine the theoretical feasibility of ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable.
Center Innovation Fund / Early Career Initiative (CIF/ECI)	Stimulate and encourage creativity and innovation within the **NASA Centers and Early Career leaders** in addressing the technology needs of NASA and the nation.
Prizes, Challenges & Crowdsourcing (PCC)	Makes opportunities available for **public participation** in NASA research and technology solutions to support NASA missions and inspire new national aerospace capabilities.
Small Business Innovation Research (SBIR)/ Small Business Technology Transfer (STTR) Program	Engages **small businesses, research institutions, and entrepreneurs** in R&D of innovative technologies that meet NASA needs and have the potential for commercialization.
Technology Transfer (T2)	Ensures that innovations developed for exploration and discovery are broadly available to the public, maximizing the benefit to the Nation, and enabling **spinoffs**.

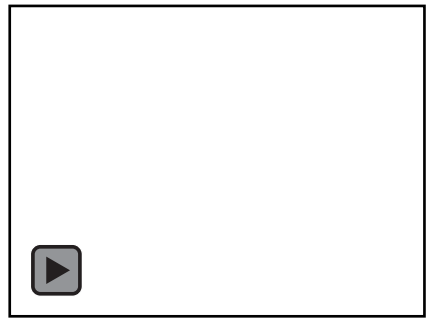




NASA STMD ensures American global leadership in space technology



Impact Story: Roll-Out Solar Array (ROSA)



2009 First NASA SBIR Phase I

2014 20kW Ground Demo, GCD/ TDM

2019 STTR CCRPP

2021 ISS Solar Array Deployment

Global Ecosystem

The U.S. Space Industry

The U.S. Government

NASA

STMD

Infusion into NASA Missions

NASA

The U.S. Government

2008 First SBIR from AFRL

2017 AFRL ISS Demo

The U.S. Space Industry

2008 DSS Founded

Global Ecosystem

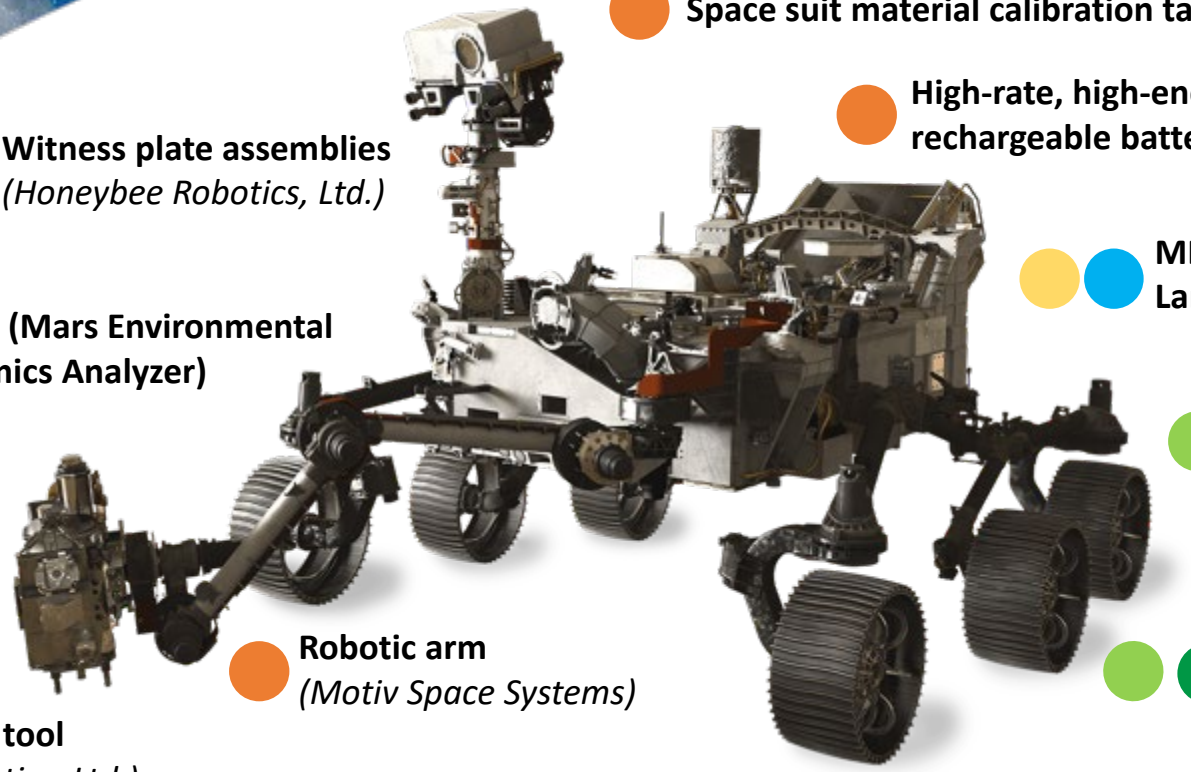
Economic Growth, Commercialization & Spinoffs

2012 SBIR Phase III for multi-mission space exploration vehicle wings

2021 Redwire acquisition of DSS; Planned Redwire Initial Public Offering (IPO)

Innovation Drives Technology….

Technology Drives Exploration



- **Laser for SHERLOC** *(Photon Systems, Inc.)*
- **Space suit material calibration target for SHERLOC** *(ENGI-MAT)*
- **High-rate, high-energy-density, lithium-ion rechargeable batteries** *(Yardney/Eagle Picher)*
- **Witness plate assemblies** *(Honeybee Robotics, Ltd.)*
- **MEDLI2 (Mars Entry, Descent and Landing Instrumentation 2)**
- **MEDA (Mars Environmental Dynamics Analyzer)**
- **TRN (Terrain Relative Navigation)**
- **Six-axis force-torque transducer** *(ATI Industrial Automation, Inc.)*
- **Robotic arm** *(Motiv Space Systems)*
- **Lander Vision System** *(JPL)*
- **Dust mitigation tool** *(Honeybee Robotics, Ltd.)*
- **MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment)**
- ***Scroll compressor*** *(Airsquared)*
- **Synthesizing Flight Software (FSW) Discrete Controllers from Formal Specifications** *(JPL)*

These Mars Rover technologies are also useful here on Earth for everything from safer autonomous vehicles to helper robots in hospitals. To learn more, visit spinoff.nasa.gov.

CIF | STRG | SBIR/STTR | GCD | TDM | Flight Opportunities

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

Early Stage Innovation and Partnerships (ESIP)

The ESIP Portfolio **leads innovation by fostering diverse ideas and communities, while transferring space technology into the space economy and beyond** ***advancing 700+ ambitious projects annually across TRLs and communities to address NASA mission needs and seed future disruptive aerospace capabilities.***

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ESIP Portfolio-Level Objectives

Explore innovation pilots to enable breakthrough technology and R&D

Build evidence for what works to advance early -stage innovations and partnerships

Enable technology transition across NASA, OGAs, and Commercial Customers

Increase participation by underserved / underrepresented communities

**Act as a steward for several agency-wide programs and innovation methods for NASA*

Space Technology Research Grants Program

Engage Academia: *tap into spectrum of academic researchers, from graduate students to senior faculty members, to examine the theoretical feasibility of ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable.*

NASA Space Technology Graduate Research Opportunities (NSTGRO)

Early Career Faculty (ECF)

Early Stage Innovations (ESI)

Lunar Surface Technology Research (LuSTR) Opportunities

Space Technology Research Institutes (STRI)

TA01
Launch Propulsion
27 Awards

TA02
In-Space Propulsion
80 Awards

TA03
Space Power & Energy Storage
44 Awards

TA04
Robotics & Autonomous Systems
121 Awards

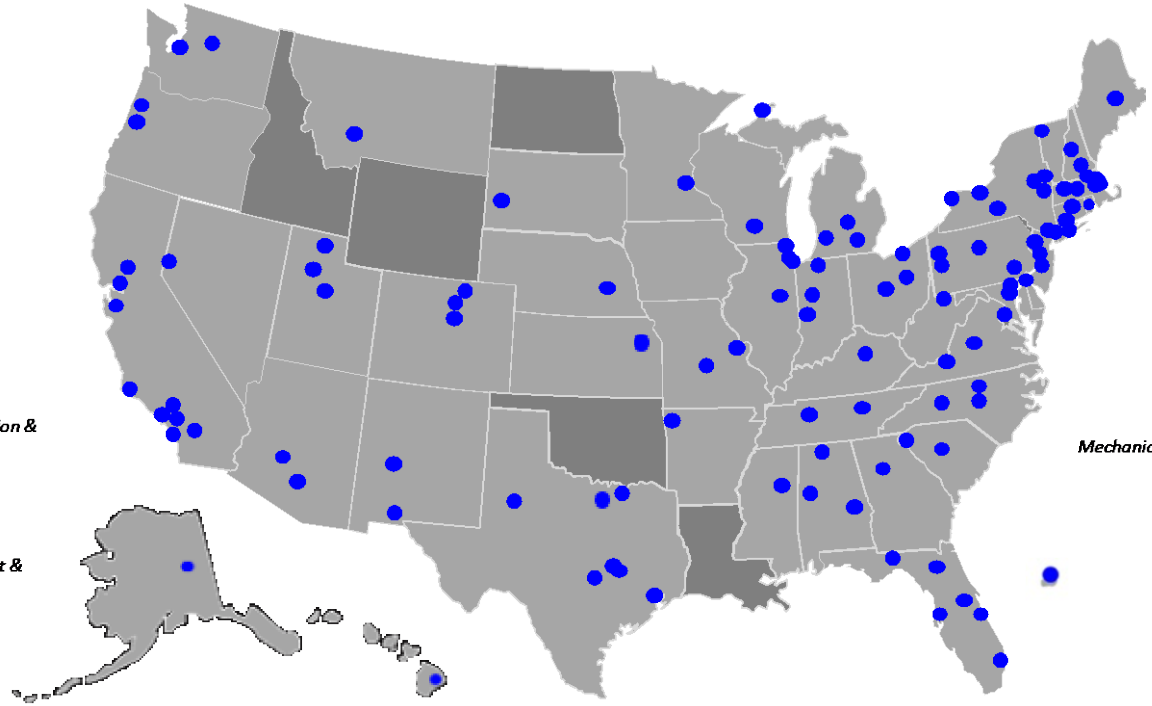
TA05
Communications, Navigation & Orbital Debris Tracking
87 Awards

TA06
Human Health, Life Support & Habitation
61 Awards

TA07
Human Exploration Destination Systems
38 Awards

300+ active awards **116 Universities**

45 States **1 Territory** (PR)



TA08
Science Instruments, Observatories and Sensor Systems
96 Awards

TA09
Entry, Descent & Landing
90 Awards

TA10
Nanotechnology
42 Awards

TA11
Modeling, Simulation, IT & Processing
38 Awards

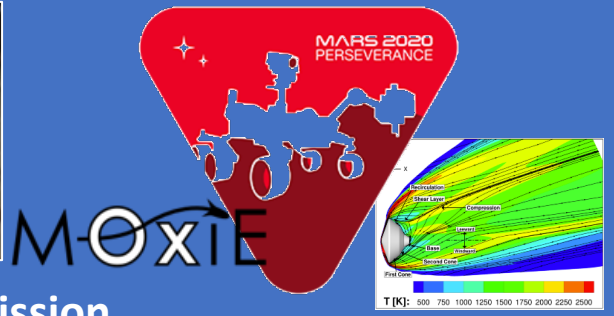
TA12
Materials, Structures, Mechanical Systems & Manufacturing
104 Awards

TA13
Ground & Launch Systems
1 Awards

TA14
Thermal Management
33 Awards

STRG accelerates the development of groundbreaking high-risk/high-payoff low TRL space technologies

Key FY21 Accomplishments (slide 1 of 2)



Mars 2020 Mission

NSTRF17 – Eric Hinterman/ Massachusetts Institute of Technology

Created a high-fidelity model of the oxygen producing MOxiE experiment onboard Perseverance which is used extensively by the MOxiE team. Eric now serves as the MOxiE payload uplink lead during Mars surface operations.

ECF15 – Marco Panesi / University of Illinois

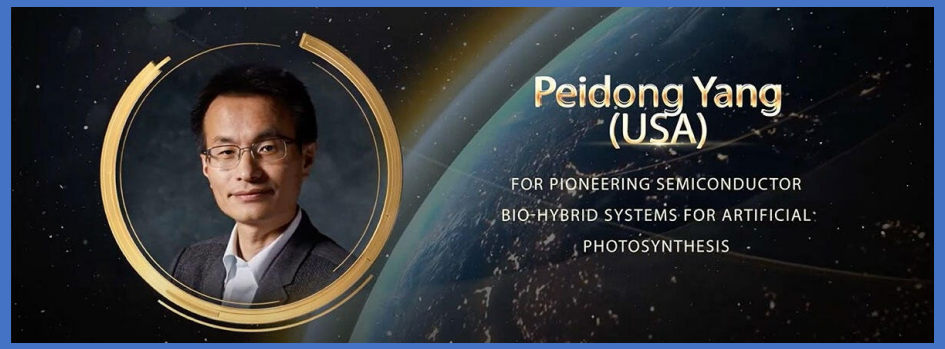
Developed new high-fidelity models of radiation on a planetary entry vehicles backshell. His model was used during aerothermal entry simulations of the Mars 2020 mission.

Astrobee Gecko Gripper

ESI15 – Mark Cutkosky / Stanford University:

Gripper built and tested onboard ISS through an extension to Prof. Cutkosky's ESI15 project which developed the underlying technology. The gripper allows the Astrobee robots to grasp or perch onto nearly any flat surface onboard the space station, greatly increasing the robots' capabilities and allowing them to perch in many locations.
The gripper was installed and initial tests completed successfully onboard the ISS in April.

Several other STRG projects contributed to the effort: **Andrew Bylard (NSTRF15), Arul Suresh (NSTRF16), Abhishek Cauligi (NSTRF16)**



STRI16 (CUBES) – Peidong Yang / University of California, Berkeley

Dr. Yang developed a biohybrid artificial photosynthesis process which can be used to produce various carbon-based resources like methane fuel, polymers, and pharmaceutical precursors. His process doubles the previously reported photon efficiency for plants and generates a specific and easily harvested product. His work has ISRU applications for future Mars missions as well as terrestrial uses. Dr. Yang won the **2020 Global Energy Prize** for his work.

Key FY21 Accomplishments (slide 2 of 2)

Selected six inaugural LuSTR awards

In Situ Resource Utilization

Ahsan Choudhuri
University of Texas in El Paso
Advanced Thermal Mining Approach for Extraction, Transportation, and Condensation of Lunar Ice

Alian Wang
Washington University in Saint Louis
WRANGL3R - Water Regolith ANalysis for Grounded Lunar 3d Reconnaissance

Paul Van Susante
Michigan Technological University
Percussive Hot Cone Penetrometer (PHCP) and Ground Penetrating Radar (GPR) for Geotechnical and Volatiles Mapping

Sustainable Power

Philip Lubin
University of California, Santa Barbara
Moonbeam-Beamed Lunar Power

Arthur Witulski
Vanderbilt University
Silicon Carbide Power Components for NASA Lunar Surface Applications

Jin Wang
Ohio State University
Flexible DC Energy Router Based on Energy Storage Integrated Circuit Breaker

Two New Space Technology Research Institutes:

Joint Advanced Propulsion Institute (JANUS)

Mitchell Walker, Georgia Institute of Technology

The JANUS institute will develop strategies and specific methodologies to overcome limitations in ground testing of high-power EP systems and to improve characterization of the wear and performance of these devices representative of in-space operation.

Partnering universities: University of Michigan; University of California, Los Angeles; University of Illinois at Urbana-Champaign; Colorado State University; Pennsylvania State University; Stanford University; University of Colorado Boulder; Western Michigan University; Clark Atlanta University; Chicago State University; and City Colleges of Chicago. Other partners: The Aerospace Corporation, Aerojet Rocketdyne, and Busek.

Advanced Computational Center for Entry System Simulation (ACCESS)

Iain Boyd, University of Colorado Boulder

The ACCESS institute will advance the analysis and design of NASA entry systems by developing a fully integrated, interdisciplinary simulation capability. ACCESS will focus on thermal protection systems as well as prediction of the extreme environments experienced during entry. It will develop game-changing capabilities using high-fidelity, validated physics models. This advancement will be enabled by innovative numerical algorithms, high-performance computing, and uncertainty quantification methods, with the goal of enabling computational entry system reliability assessments.

Partnering universities: University of Illinois at Urbana-Champaign; University of Minnesota; University of Kentucky, and University of New Mexico.

Five solicitation year: 58 NSTGRO21 TBD ECF21 14 ESI20 6 LuSTR20 2 STRI20

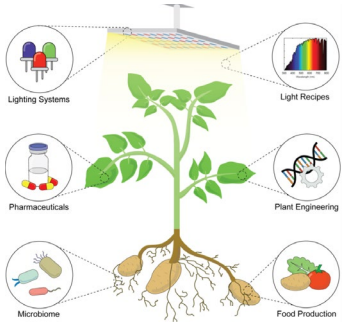
Accomplishments for Space Technology Research Institutes (STRI)

The Center for the Utilization of Biological Engineering in Space (CUBES)

University of California, Berkeley

+5 partner universities and commercial partners

CUBES focuses on biomanufacturing for deep space exploration and advancing the practicality of an integrated, multi-function, multi-organism biomanufacturing system on a Mars mission. The institute is developing continuous and semiautonomous biomanufacturing technologies that primarily use carbon dioxide, water, and sunlight to make a wide range of products including food, polymers, and pharmaceuticals.



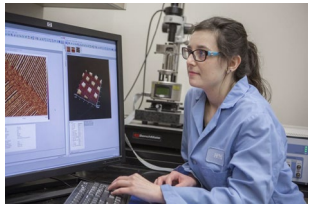
The institute has demonstrated biosynthetic production of pharmaceuticals (e.g., use of transgenic lettuce for production of a parathyroid hormone for bone regeneration), novel LED lighting systems to optimize plant growth, bioengineering for drought resistance and increased photosynthesis, and techniques for ISRU-based manufacturing with novel high-strength biopolymers.

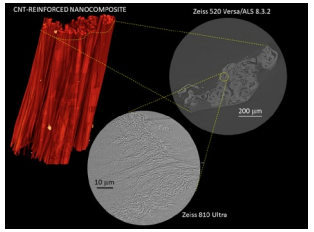
The Institute for Ultra-Strong Composites by Computational Design (US-COMP)

Michigan Technological University

+11 partner universities and commercial partners

US-COMP is enabling computationally-driven development of carbon nanotube based ultra-high strength lightweight structural materials within the Materials Genome Initiative (MGI). The teams efforts have significantly increased mechanical properties compared to SoA carbon fiber reinforced polymer composites. Dr. Jim Warren, Director of the NIST Materials Genome Program, has commented*: US-COMP…has a fantastic story. I think it's a story of a true interdisciplinarity that combines the best ideas in the integration of modeling and experiment to building the knowledge infrastructures to accelerate the design of new composites*.





Habitats Optimized for Missions of Exploration (HOME)

University of California, Davis

+8 partner universities and commercial partners

The HOME institute seeks to enable resilient, autonomous, and self-maintained habitats for human explorers through the advancement of early-stage technologies related to autonomous systems, human and automation teaming, data science, machine learning, robotic maintenance, and explainable artificial intelligence.

The team has developed a simulation testbed for CO_2 removal that will allow for the collection of data under nominal and anomalous conditions to inform and validate habitat self-awareness models. Additionally, HOME is developing the Digital Twin framework, a database of static and dynamic information provided by sensor measurements, simulations, and records about the form and function of the SmartHab. The information from the Digital Twin will aid in the understanding of the cause-and-effect of habitat conditions and when they need to be remediated.

Resilient ExtraTerrestrial Habitats Research Institute (RETHi)

Purdue University

+5 partner universities and commercial partners

RETHi will design and operate resilient deep space habitats that can operate in both crewed and uncrewed configurations. The institute plans to leverage expertise in civil infrastructure with advanced technology fields, such as modular and autonomous robotics and hybrid simulation to develop, deploy, and validate different capabilities.

The development of the Virtual Cyber Physical Testbed and the Cyber Physical Testbed is nearly complete. The testbeds focus on their ability to quickly test “plug and play” system models from anywhere in a complex space habitat environment.

The team has also made substantial progress in robot factors including a redesign of the NASA AES Modular Power System component that allows its robotic replacement for first time. The technology is extensible to avionics (processors, etc.), enabling a wide opportunity for robotic maintenance.

5 ECF PIs Have Received PECASE Awards

PRESIDENTIAL EARLY CAREER AWARDS FOR SCIENTISTS AND ENGINEERS

The highest honor bestowed by the United States government on outstanding scientists and engineers early in their research careers

Michelle Manuel (ECF12)

University of Florida

Self-Repair and Damage Mitigation of Metallic Structures

Dr. Manuel developed a novel self-healing aluminum alloy and shape memory alloy (SMA) wire composite material that can close large scale (mm to cm) cracks and repair itself. When heated, the SMA wires will apply a clamping force to cracked material and liquefy a fraction of the matrix welding the crack back together with the resulting joint demonstrating >90% of original strength.

Marco Pavone (ECF12)

Stanford University

Algorithmic Foundations for Real-Time and Dependable Spacecraft Motion Planning

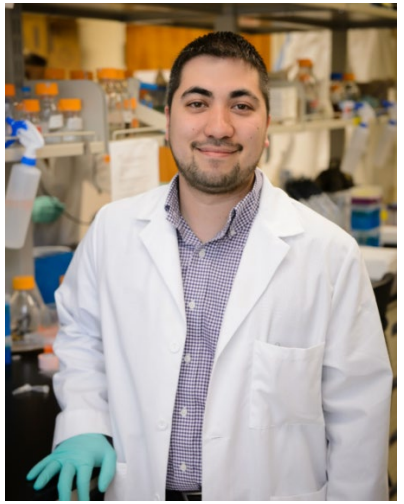
Dr. Pavone created a systematic, algorithmic approach to enable the design of computationally-efficient and provably-correct coordination algorithms for networks of robots. He also designed a provably-correct novel class of sampling-based motion planning algorithms for spacecraft. Dr. Pavone's results represent a major breakthrough in this field.

Rebecca Kramer (ECF14)

Yale University

Active Elastic Skins for Soft Robotics

Dr. Kramer's soft robot design approach uses active "robotic skins." These robotic skins are modular, conformable sheets with embedded sensing and actuation, and can be applied-to the surface of soft bodies (e.g., inflatables, foams, and limbs) to impart motion and turn them into active soft robots which can perform a number of tasks.



Mark Blenner (ECF15)

Clemson University

Synthetic Biology for Recycling Human Waste into Nutraceuticals, and Materials: Closing the Loop for Long-Term Space Travel

Dr. Blenner's work developing a space-based biomanufacturing system that uses wastes to generate a microbial media that is then converted to the final target products (bioplastic and omega-3 fatty acids).

Kelly Stephani (ECF15)

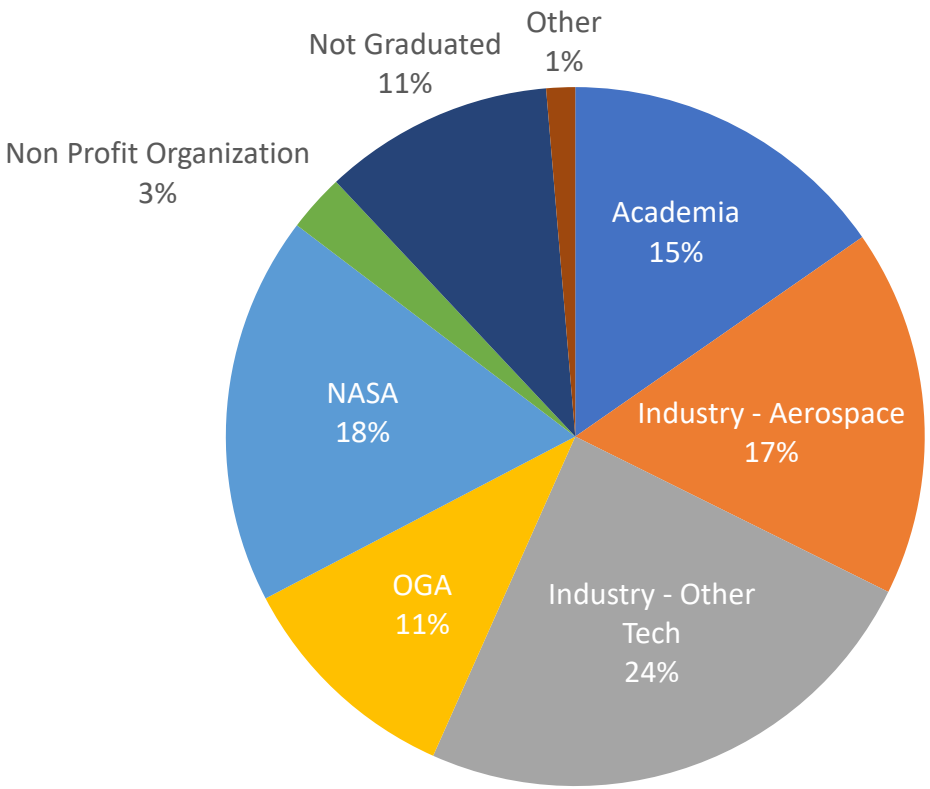
University of Illinois at Urbana-Champaign

A phase-space coupled hybrid framework for combined continuum/rarefied high speed flows

Dr. Stephani used a novel approach based on phonon theory to model regions of breakdown that occur near the surface of a material that is chemically reacting with the surrounding environment. Her work has strong implications for development of accurate, physics-based engineering tools used in the design of spacecraft.

Post-NSTGRO Employment

Post graduation, NSTRF & NSTGRO researchers contribute their expertise across a wide variety of organizations in industry, government, and academia.



Over 300 graduate students have completed their NSTRF/NSTGRO research and begun their careers

INDUSTRY

BOEING
ASRC FEDERAL
analytical space
SCALED COMPOSITES
Ford
SPACEX
NORTHROP GRUMMAN
Ball
Raytheon
KINETX AEROSPACE
LOCKHEED MARTIN
BLUE ORIGIN

GOVERNMENT LABS

APL
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Sandia National Laboratories
NATIONAL INSTITUTE OF AEROSPACE
AEROSPACE
NASA
DRAPER
NIST
cnrs

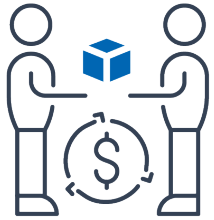
ACADEMIA

University of Dayton
FORT LEWIS COLLEGE
SPACE INSTITUTE
CHARLESTON SOUTHERN UNIVERSITY
UW
WASHINGTON STATE UNIVERSITY
ILLINOIS
Stanford University

NASA SBIR/STTR Program

As a program under STMD, the NASA SBIR/STTR program funds the research, development, and demonstration of innovative technologies that fulfill NASA needs.

NASA's SBIR/STTR Program has **awarded more than $3.75 billion** to research-intensive American small businesses



Engineers and scientists from **more than 12,000** small businesses in all 50 States, DC and Puerto Rico have participated

COVID –SBIR Activities to Provide Economic Stimulation and Small Business Support

Phase I Contract Negotiations

- Reduced the time from notification of selection, to first payment for Phase I awards

New Phase II Awardees

- Reduced time between selection and first payment from five months to two months by introducing a new report deliverable which is due within 10-15 days of the contract award instead of waiting until the end of the first quarter of work.

Existing Contracts

- Received approval to grant provisional acceptance of deliverables to pay for work performed on existing contracts while centers were closed or with reduced staff present.

Solicitations

- Extended 2020 Solicitation deadline by four weeks to allow firms time to adjust to the new work environment.
    - Streamlined the review & selection processes so that the selection announcement only slid ~ 2 weeks and funding for firms was not delayed a full month.
- Accelerated 2021 solicitation release date to November 2020 (instead of January 2021) to provide an additional earlier funding opportunity.

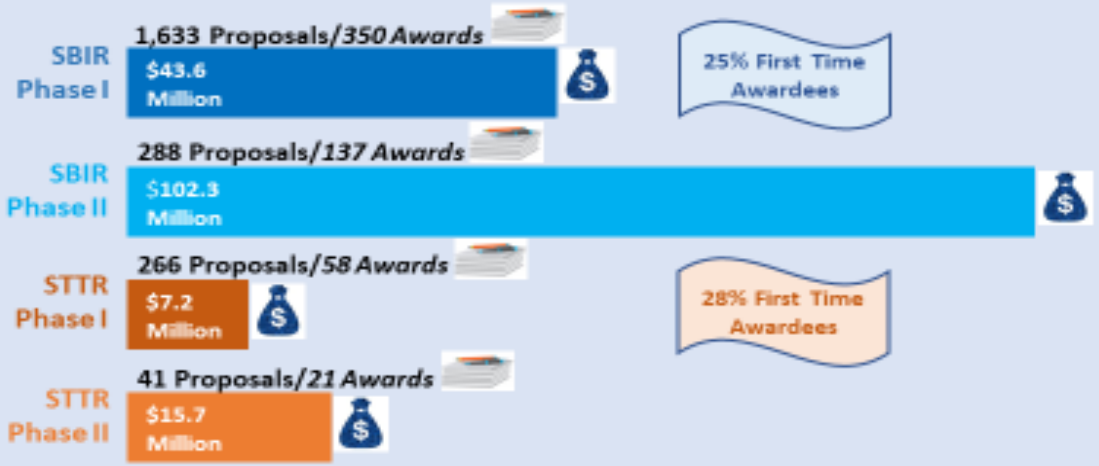
Virtual Innovation and Opportunity Conference

- Annual conference held to connect small business & research institutions with the NASA SBIR/STTR program & provide them with resources, engagement opportunities, & actionable next steps towards transitioning their technologies. 1,800+ registrants in virtual 2020 event.

FY20 SBIR/STTR Awards

AWARDS MADE IN FY 2020

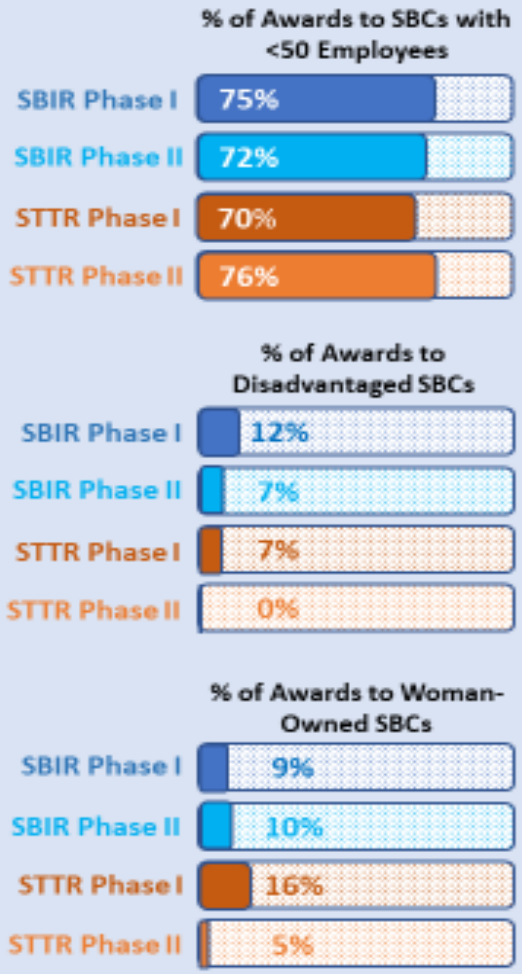
Phase I & II Awards



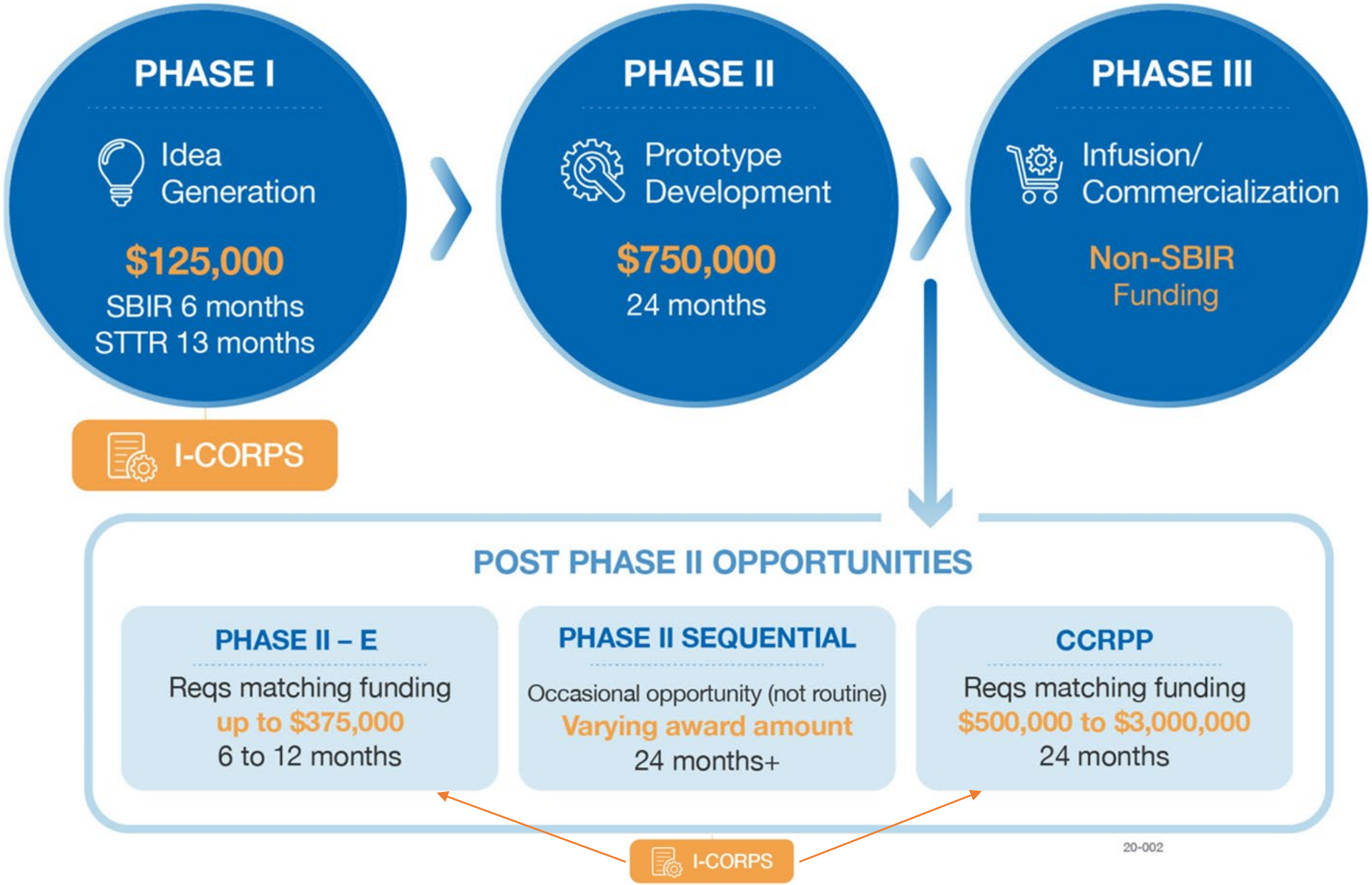
Post Phase II Awards

Program	# of Awards	SBIR/STTR Funding	Non SBIR/STTR Investor Funding
Phase II-Extended	32	$8.9 Million	$9.4 Million
CCRPP	8	$6.8 Million	$5.3 Million
Lunar-Focused Sequentials	4	$17.1 Million	N/A
Phase III	81	N/A	$44.0 Million

Phase I & II Demographics



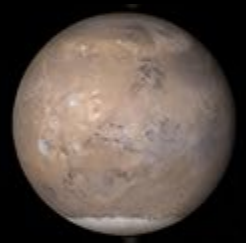
SBIR/STTR Program Phases

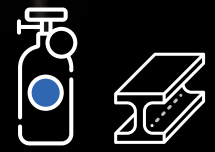


NASA Increases Investment in US Small Businesses to Mature Lunar Capabilities for Artemis

High data rate communications networks on small spacecraft platforms at the Moon and beyond

Fibertek, Inc. – Herndon, VA



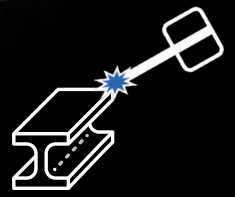


On-demand production of oxygen and steel on the Moon and Mars for life support, propulsion, power, and hardware assets

Pioneer Astronautics – Lakewood, CO

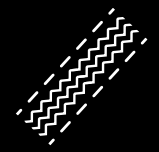
Autonomy for long duration, long distance, crewed and un-crewed space vehicles and systems

Qualtech Systems, Inc. – Rocky Hill, CT



In-transit and at-destination capability for manufacturing, assembling, modification, and repair of components

COSM Advanced Manufacturing Systems, LLC - Ipswich, MA

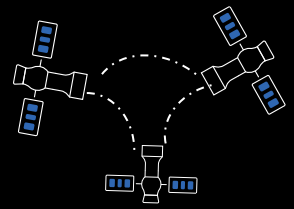


Traction control and improved roving and driving of a range of vehicles in unknown and highly variable terrain

Protoinnovations, LLC – Pittsburgh, PA

Advanced consolidation and joining capability to address a key challenge in manufacturing high-power Moon and Mars Fission Power Systems

The Peregrine Falcon Corporation – Pleasanton, CA



Secure, efficient, scalable, and disruption-tolerant communication network capabilities for multiple distributed platforms and assets

Antara Teknik LLC – Granite Bay, CA

~$29M in selected projects for SBIR/STTR Sequential Phase II Awards to date

Astronaut Jessica Meir is using the BFF at the International Space Station.
Photo courtesy of Techshot

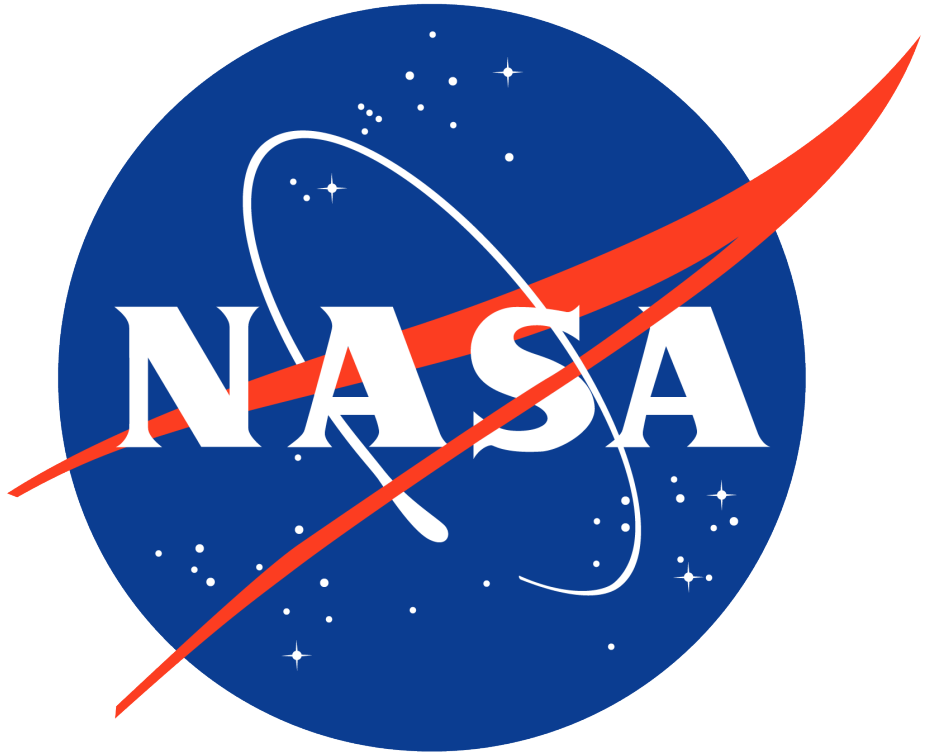
3-D Bioprinter Overcomes Gravity by Printing Living Tissues in Space

POST-AWARD SUCCESS:
More than $5 million external investment attributed to BFF, including $2.5 million from ISS Program

SNAPSHOT:
Techshot, Inc., based in Greensville, IN, is the first U.S. company to 3-D print organic products on the International Space Station (ISS). The company's BioFabrication Facility (BFF), developed in collaboration with nScrypt, Inc., prints in space to overcome the effects of gravity on Earth, which cause 3-D printed tissues to disform under their own weight. Techshot's BFF was launched to the ISS supported by the NASA SBIR/STTR program in 2019. The company has since worked with NASA and other customers, valuing BFF's external investments at more than $5 million, including $2.5 million from the ISS Program.

"Our company has been able to provide jobs in a rural area in a non-space state, and we really tie that back to the SBIR program.

– Richard Boling VP of Corporate Advancement, Techshot


NASA

FY 2020 SBIR and STTR investments through Phase I, Phase II, Phase II E, Sequential, and CCRPP awards