Early Stage Innovations and Partnerships Update

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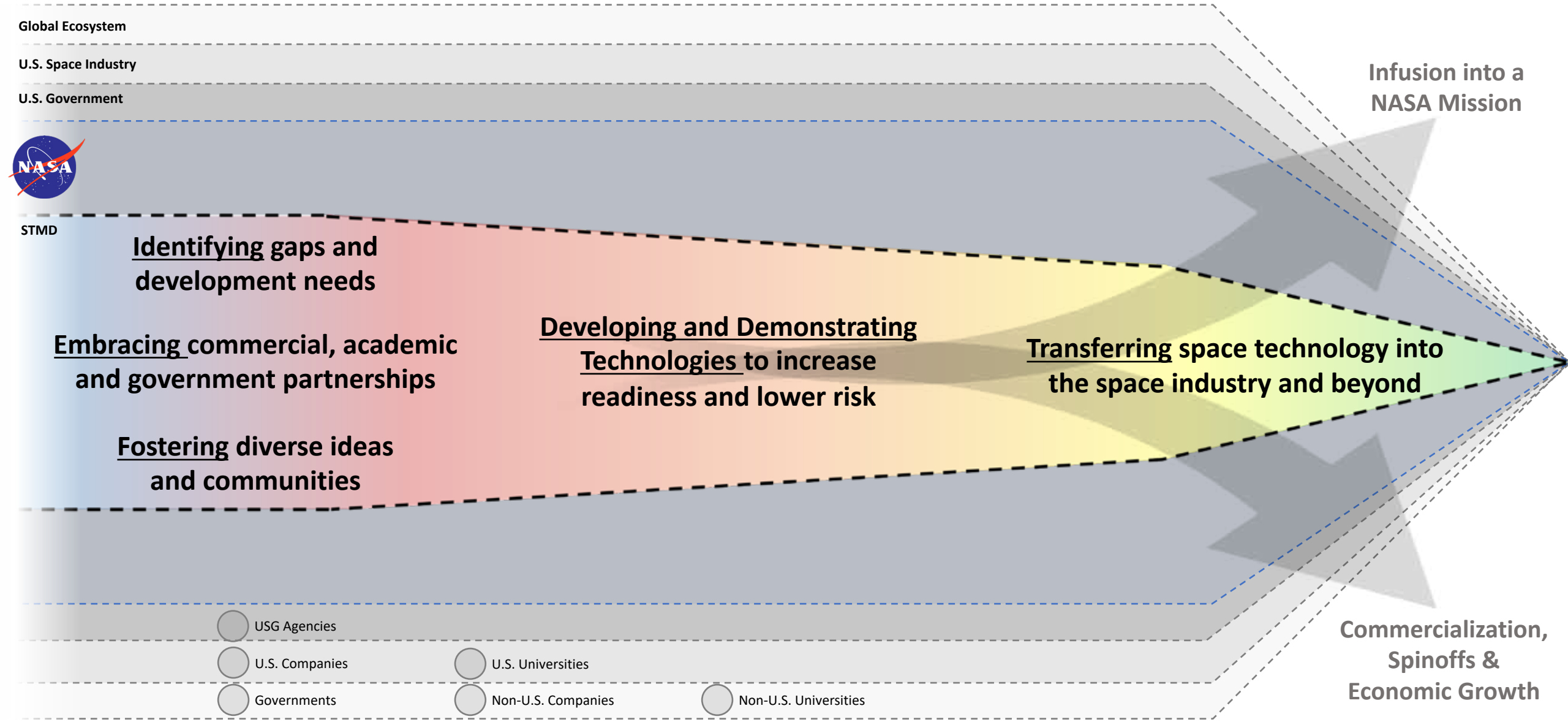
Director, Early Stage Innovations and Partnerships

Early Stage Innovation and Partnerships (ESIP) Portfolio

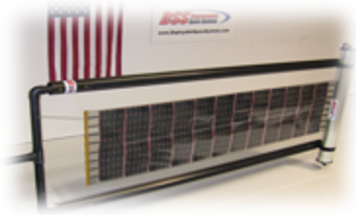
The ESIP Portfolio advances 700+ ambitious projects annually across TRLs and communities to address NASA mission needs and seed future disruptive aerospace capabilities.

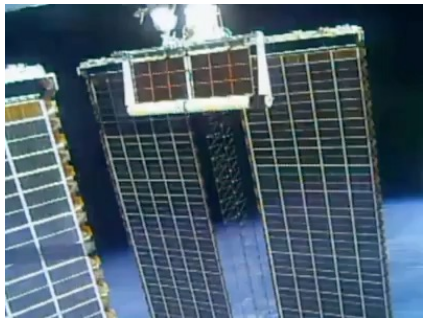
NASA Innovative Advanced Concepts (NIAC)	Nurtures **visionary ideas** that could transform future NASA missions with the creation of breakthroughs, while engaging America's innovators and entrepreneurs as partners in the journey.
Space Tech Research Grants (STRG)	Challenges the spectrum of **academic 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.
Early Stage Innovation and Commerce (ESIC)	Advances **ESIP-portfolio joint priorities and innovative pilots** including enhanced support to underserved communities, evidence-driven programs, academic research to market, and public private partnerships.
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

Economic Growth, Commercialization & Spinoffs

NASA

The U.S. Government

2008 First SBIR from AFRL

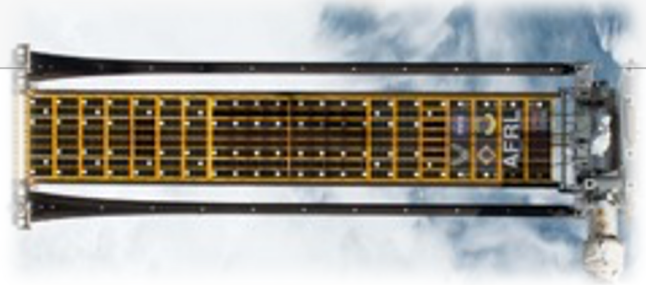
2017 AFRL ISS Demo

The U.S. Space Industry

2008 DSS Founded

Global Ecosystem

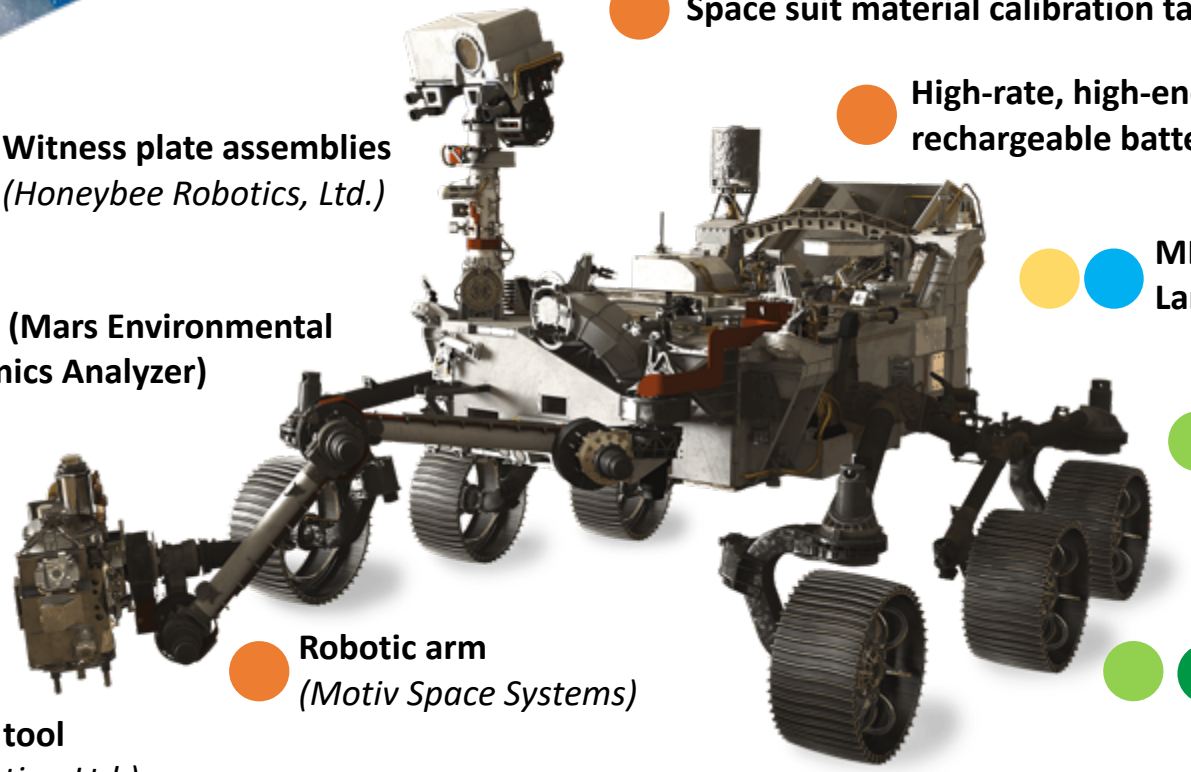
2012 SBIR Phase III for multi-mission space exploration vehicle wings



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 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

Early Stage Innovation and Partnerships Portfolio

Technology Drives Exploration

LOW

MID

HIGH

Technology Readiness Level

Encourage technology driven economic growth with an emphasis on the expanding space economy

Credit: Pixabay

Encourage the transition of STMD funded research to market through **iCorps** entrepreneurial training and **commercialization bootcamps**

Image provided by Colorado School of Mines and ICON, which was a top 10 finalist in the 3D-Printed Habitat Challenge Phase: 3 Level 1 competition.

The 3D printed subscale prototype of the Lunar PAD ready for hot fire testing at Camp Swift. Photo via ICON.

ICON's first 3D printed home in Austin, Texas. Photo via ICON

Harness American ingenuity through **strategic prize competitions** that incentivize new technologies and companies with space and earth applications

NASA T2 FedTech Accelerator

T2 Entrepreneurship workshop with Virginia is for Entrepreneurs (VA4E)

Engage entrepreneurs through **commercialization focused SBIR activities** as well as the **T2X program** to increase venture creation, strategic partnerships, university partnerships, and entrepreneurial opportunities through regional partnerships

Inspiring and developing a diverse and powerful US aerospace technology community

Utilize ALL of America's human potential to achieve technological advances and America's promise

- STMD and ESIP programs have emphasized increasing participation unrepresented and underserved communities:
  - Cooperative agreement between the SBIR/STTR program and the MSI STEM Research and Development Consortium (MSRDC) to increase the participation of HBCUs and MSIs in our programs.
  - Partnership with STEM Engagement's Minority University Research and Education Project (MUREP) through planning grants (M-STTR), capacity building grants (M-STAR), and a higher education spinoff challenge.
  - T2U activities teach business students about NASA's technology portfolio, allowing them to work with agency technology and inventors to discover commercial applications.
  - A DEIA strategy, data management approach, and sustained outreach and engagement through ESIP Innovation and Commerce budget to enable increased participation by underrepresented and underserved groups

NASA Outreach to Tribal Colleges at College of Menominee Nation

T2U connects business students to NASA's technology portfolio.

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

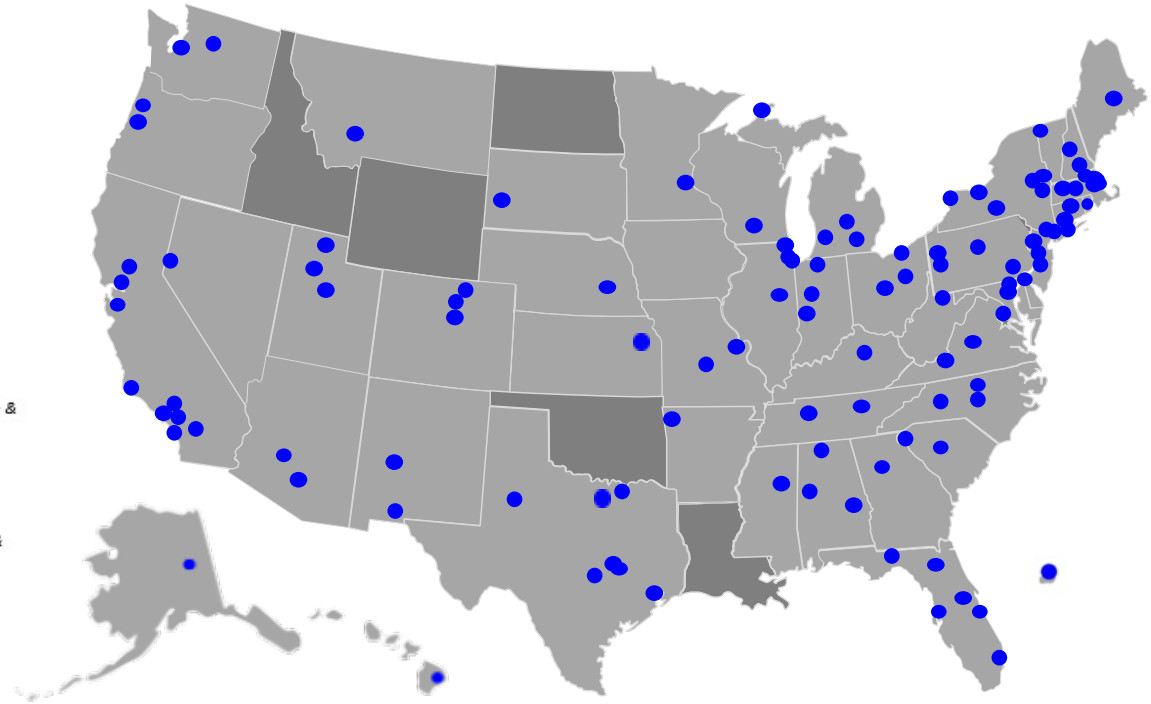
TA05
Communications, Navigation & Orbital Debris Tracking
87 Awards

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
41 Awards

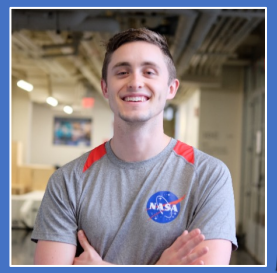
TA12
Materials, Structures, Mechanical Systems & Manufacturing
106 Awards

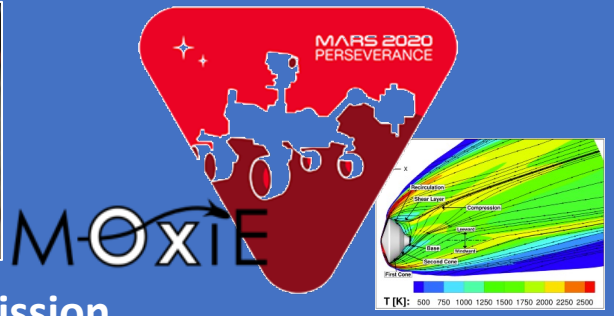
TA13
Ground & Launch Systems
1 Award

TA14
Thermal Management
34 Awards

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

Key FY21 Accomplishments (slide 1 of 2)





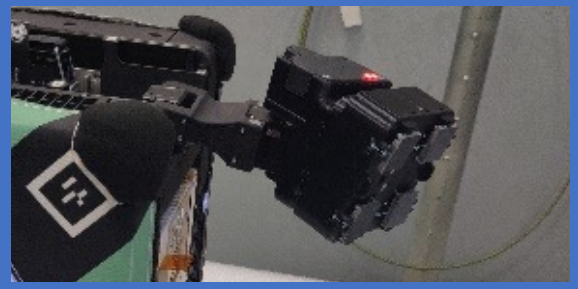
Mars 2020 Mission

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.

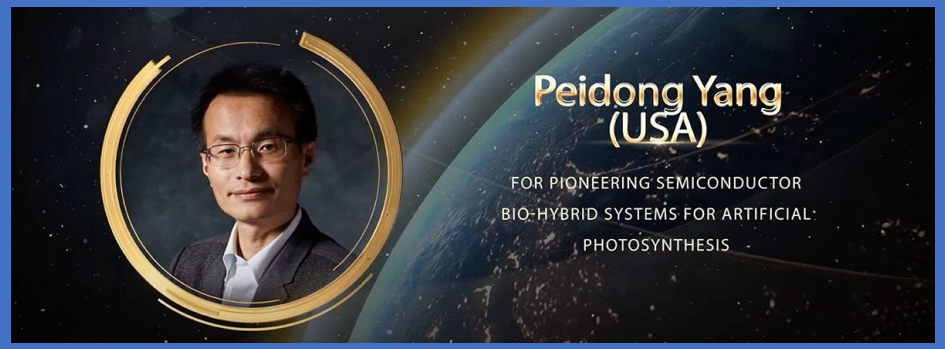


Astrobee Gecko Gripper

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.

Kickoff meeting: January 26th, 2021

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.

Kickoff meeting: October 26th, 2020

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

Over half of both JANUS and ACCESS team members have existing and past ties to STRG including 49 NSTGRO, 7 ECF, and 5 ESI awards

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

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

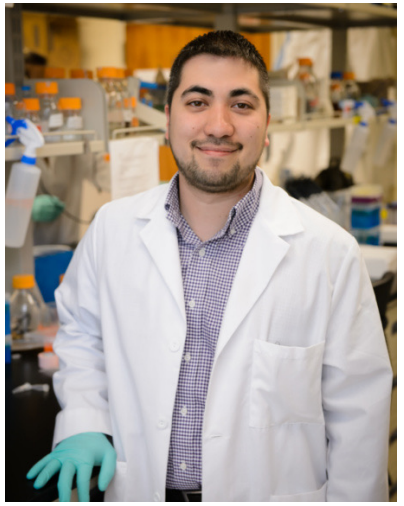
Dr. Pavone created a systematic, algorithmic approach to enable the design of computationally-efficient and provably-correct coordination algorithms for networks of robots. He also designed a provably-correct novel class of sampling-based motion planning algorithms for spacecraft. Dr. Pavone's results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

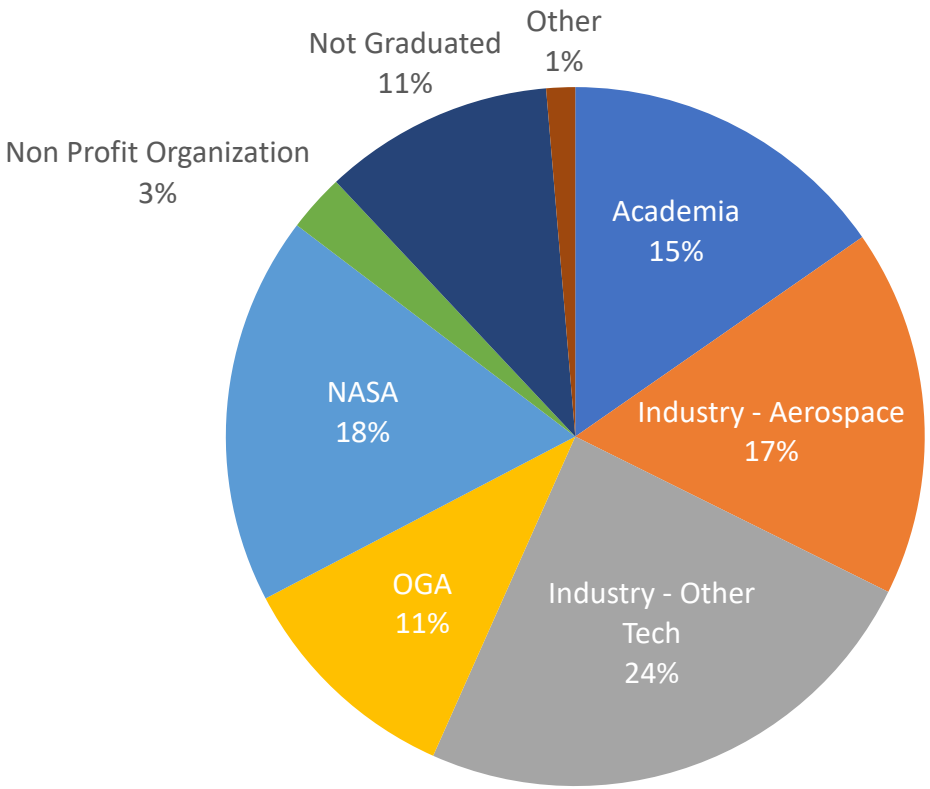
University of Illinois at Urbana-Champaign

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
Google
x∞ 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
T SPACE INSTITUTE
CHARLESTON SOUTHERN UNIVERSITY
UW
WASHINGTON STATE UNIVERSITY
ILLINOIS
Stanford University

NASA SBIR/STTR Program

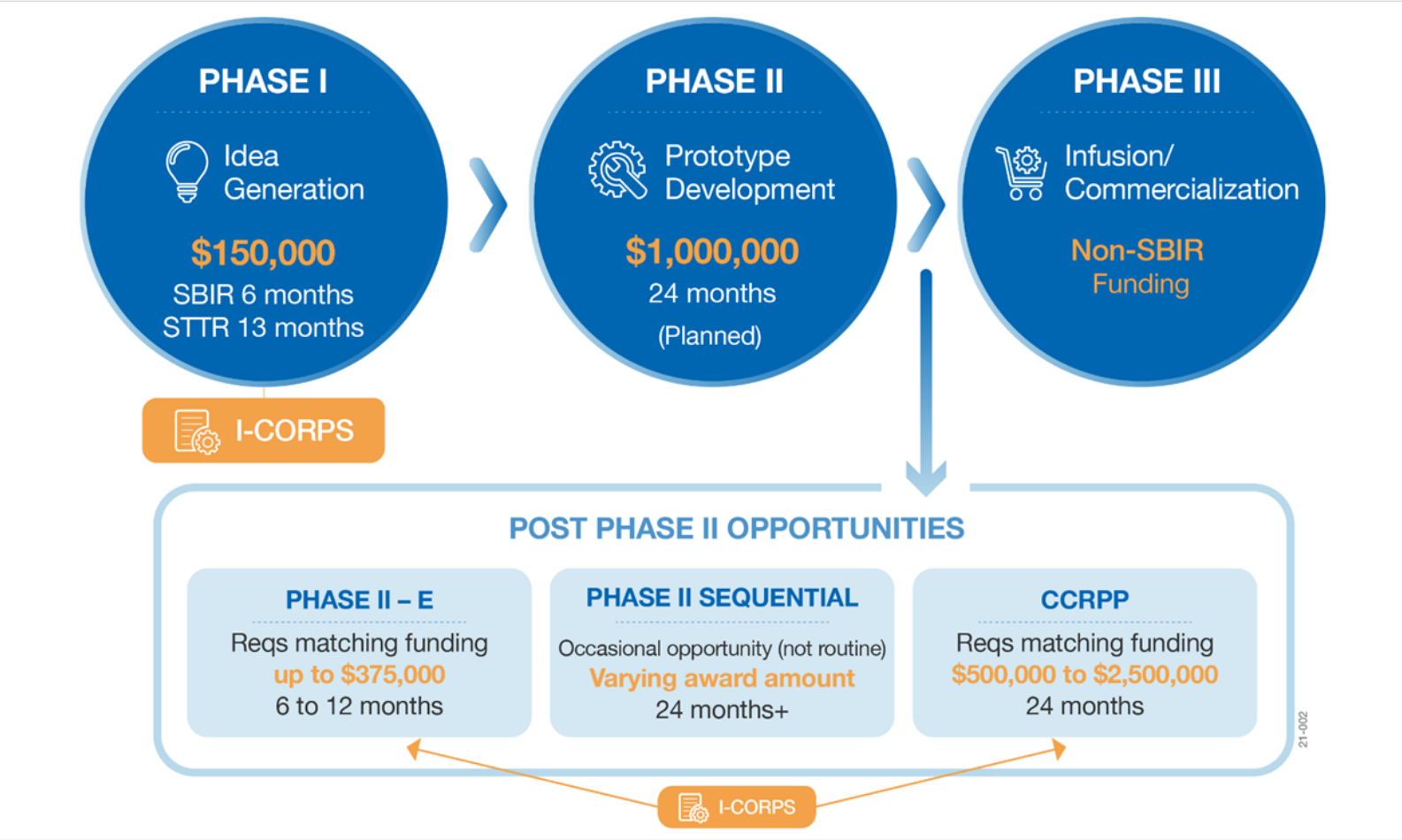
As a program under STMD, the NASA SBIR/STTR program funds the research, development, and demonstration of innovative technologies that fulfill NASA needs.

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

SBIR/STTR Program Phases

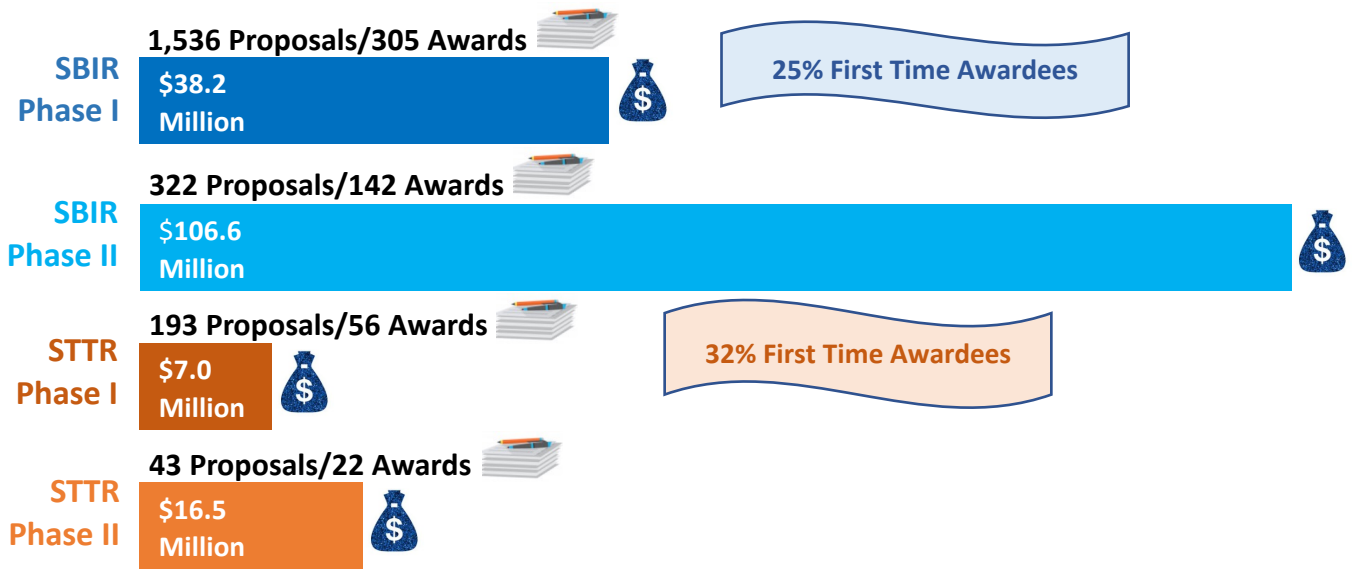
Up to $1.15 million for Phase I and II and nearly $3 million or more for Post Phase II opportunities!



Note: The 2022 Phase II funding amount is planned to increase to $1 million from $750,000. This is dependent on the final budget appropriated by Congress.

FY21 SBIR/STTR Awards

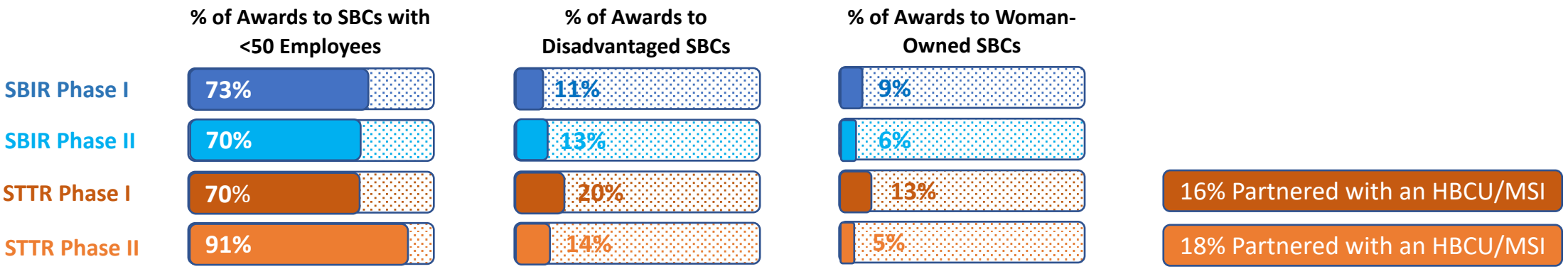
Phase I & II Awards



Post Phase II Awards

Program	# of Awards	SBIR/STTR Funding	Non SBIR/STTR Investor Funding
Phase II-Extended	35	$9.1 Million	$17.4 Million
CCRPP	6	$6.6 Million	$8.1 Million
Lunar-Focused Sequentials	5	$17.4 Million	N/A
Phase III	64	N/A	$24.6 Million

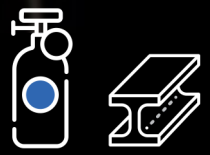
Phase I & II Demographics



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

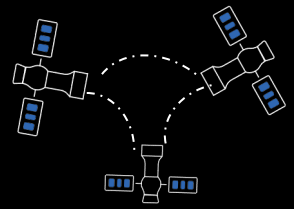
COSM Advanced Manufacturing Systems, LLC - Ipswich, MA

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

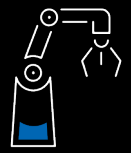
Antara Teknik LLC – Granite Bay, CA

~$29M in selected projects for SBIR/STTR Sequential Phase II Awards in 2020

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

Enable long distance travel propulsion systems on small satellites, allows for alternative less costly ways for lunar communication networks and science missions

Alameda Applied Sciences Corporation – Oakland, CA

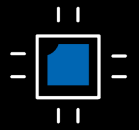


Support a wide range of drive/actuation systems for vehicles, robotics, resource acquisition, and construction in the dusty, cold, extreme lunar environment

Motiv Space Systems, Inc. – Pasadena, CA

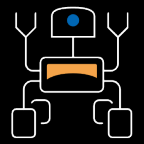
Allow rovers to thermally survive, explore, operate in, and pursue water in and out of permanently shadowed craters

Ashwin-Ushas Corp, Inc. – Marlboro, NJ



Allow off the shelf near-earth avionics for use in lunar radiation and beyond for better onboard processing and long-life reusable displays for astronauts and vehicles

Troxel Aerospace Industries, Inc. – Gainesville, Fl



Enable rovers to thermally survive, explore operate in, and potentially conduct missions during the extremely cold long lunar night

Advanced Cooling Technologies, Inc. – Lancaster, PA

~$20M in selected projects for SBIR/STTR Sequential Phase II Awards in 2021

The University of Colorado Boulder graduate students take measurements and notes of the soil and plant characteristics during flight operations.

Soil Moisture Mapping Small Unmanned Aircraft System (sUAS)

SBIR SUCCESS:

More than $1.3M in total SBIR investments, including Phase II-E and CCRPP. Black Swift's sUAS for soil moisture mapping is available on their website to commercial customers.

SNAPSHOT:

Black Swift Technologies designed a low cost sUAS that provides measurements of volumetric soil moisture content over agricultural-plot sized areas to support water management, agriculture, and fire, flood, and drought hazard monitoring.

> NASA's SBIR program has allowed us to continue our work in using sUAS to better understand the environment with the goal of making a positive change in the world.
>
> – Macief Stachura, PhD, Black Swift Technologies, Soil Moisture Project PI & CTO

PRIZES, CHALLENGES AND CROWDSOURCING

Our prizes, challenges, and crowdsourcing program advances NASA's mission and enhances connections with the public through open innovation tools and approaches.

FY21 was an incredibly productive year for PCC. The PCC Program managed 65 projects and awarded $3.65M. Phase IIs for several high priority challenges are planned for FY22.

Public Competitions in FY21 and FY22 – some highlights:

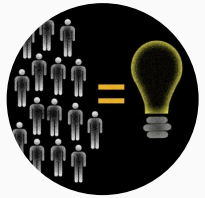
Watts on the Moon
Phase 1 Awarded: May 20, 2021
Awarded Prize: $500,000
Phase 2 Opens: FY22

Deep Space Food
Phase 1 Awarded: Oct 20, 2021
Awarded Prize: $450,000
Phase 2 Opens: FY22

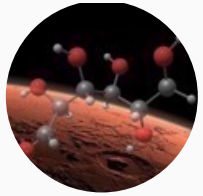
NASA TechRise Student Challenge
Submissions Closed: Nov 3, 2021
Target Flight: NET Q2 FY23
TechRise Prize: $85,000 & Flight Opportunities

Break the Ice Lunar
Phase 1 Awarded: Aug 18, 2021
Awarded Prize: $500,000
Phase 2 Opens: FY22

Space Robotics
Phase 2 Awarded: Sept 27, 2021
Phase 2 Prize Awarded: $780,000



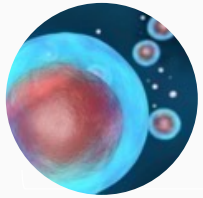
Crowdsourcing Contenders
Awarded: June 2021
$600,000 to support ~13 NASA crowdsourcing projects
Challenges opened beginning Q4 FY21



CO_2 Conversion
Phase 2 Awarded: Aug 23, 2021
Phase 2 Awarded Prize: $750,000

CubeQuest
Closes: 1 year after 1st SLS launch
Prize: $5M ($450K awarded to date)

Future-Scaping Our Skies
Awarded: July 28, 2021
Awarded: $21,000

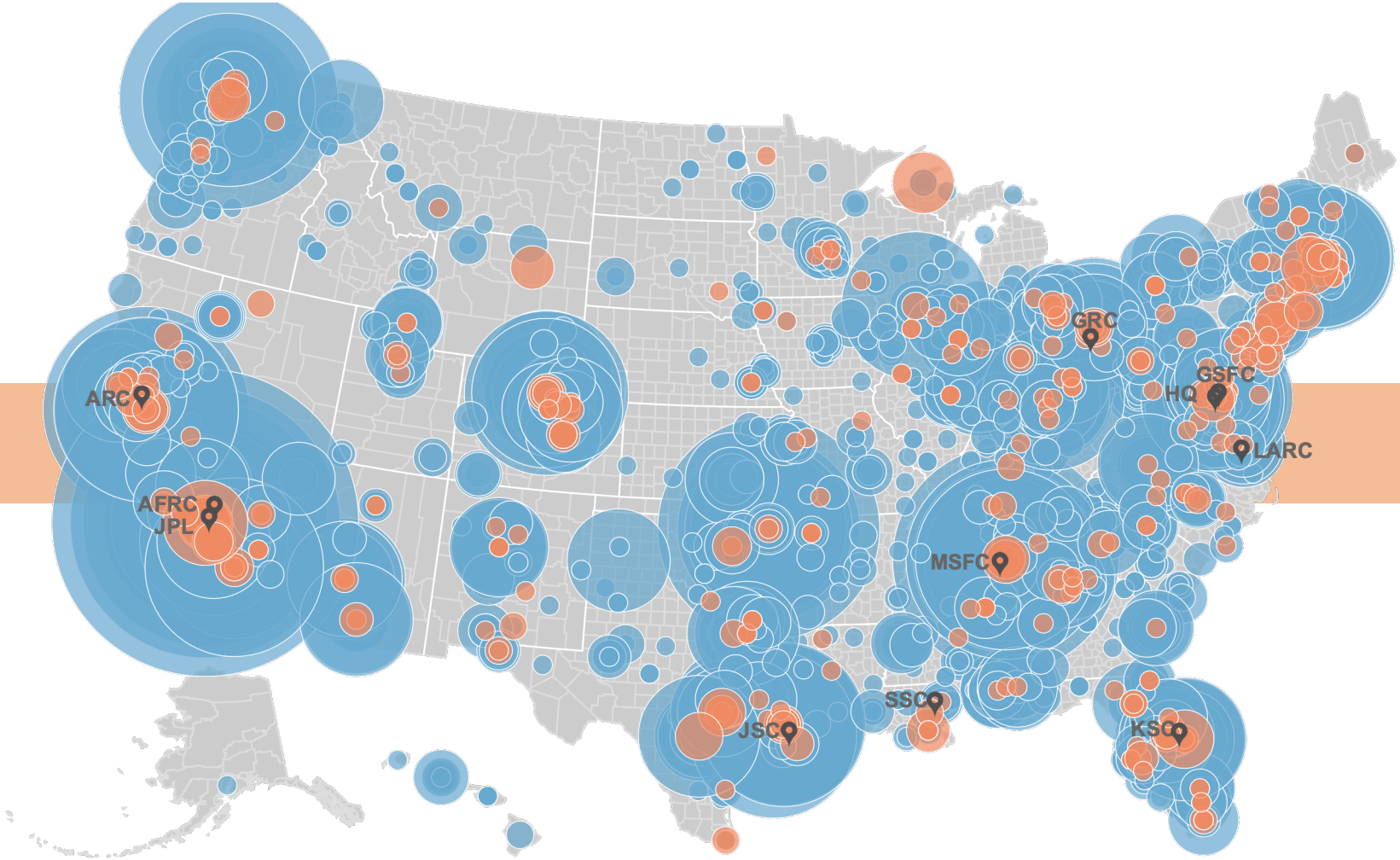


Vascular Tissue
Awarded: June 9, 2021
Awarded Prize: $400,000

NASA TechLeap Prize
Winner Selection: Oct 7, 2021
Target Flight: NET Q3 FY22
Awarded: $600,000 ($900,000 remaining for teams to win)

Honey, I Shrunk the Payload
Closes: January 28, 2022
Award: $800,000

Nationwide Tech Transfer – 2011-2021



NASA technology transfer activity is not limited to places that have Field Centers.

We transfer our technologies to companies, universities, and other federal labs all around the country.

Each unique circle represents work done in a county. The larger the circle, the more activity.

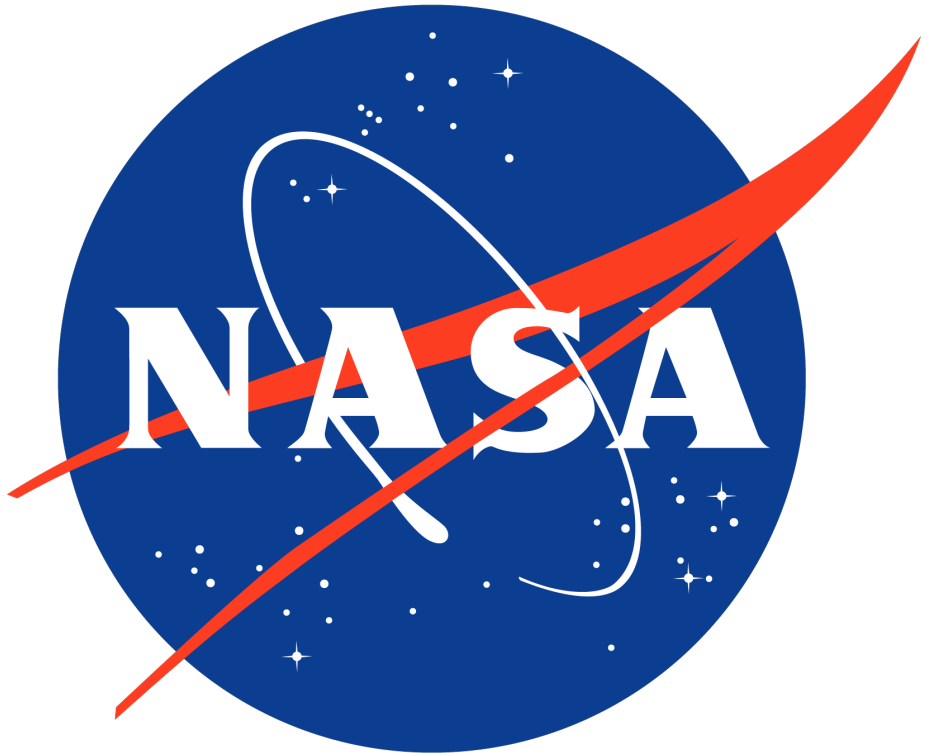
Patent Licenses: 840

Software Usage Agreements: 29,217

FY21 T2X Significant Program Impact

- Co-developed and launched minority-focused accelerator program
- Canvassed 28 regions across the U.S. for entrepreneurial engagement, leading to numerous formal and informal collaborations
- Trained 80 employees through NASA Entrepreneurial Workforce (NEW) Commercialization Boot Camps
- Created and launched Startup NASA Feature Series
- Generated 17 licensing leads; 11 licenses executed through entrepreneurship and commercialization activities
- Supported Inter-agency initiatives with EDA and SBA
- Reached thousands through events and ecosystem engagement activities

(Above) Entrepreneurs completed training at Virginia Tech Corporate Research Center's Accelerator Network Program (ANP) event on August 12, 2021.


NASA

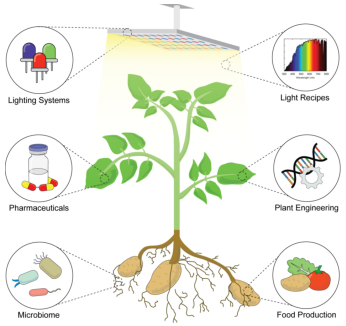
Accomplishments for Space Technology Research Institutes (STRI)

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.



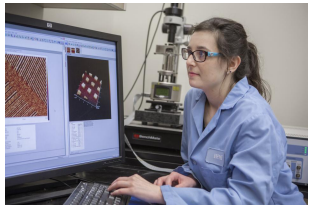
The institute has demonstrated biosynthetic production of pharmaceuticals (e.g., use of transgenic lettuce for production of a parathyroid hormone for bone regeneration), novel LED lighting systems to optimize plant growth, bioengineering for drought resistance and increased photosynthesis, and techniques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

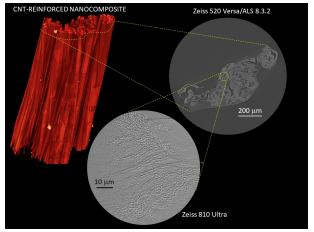
The Institute for Ultra-Strong Composites by Computational Design (US-COMP)

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.