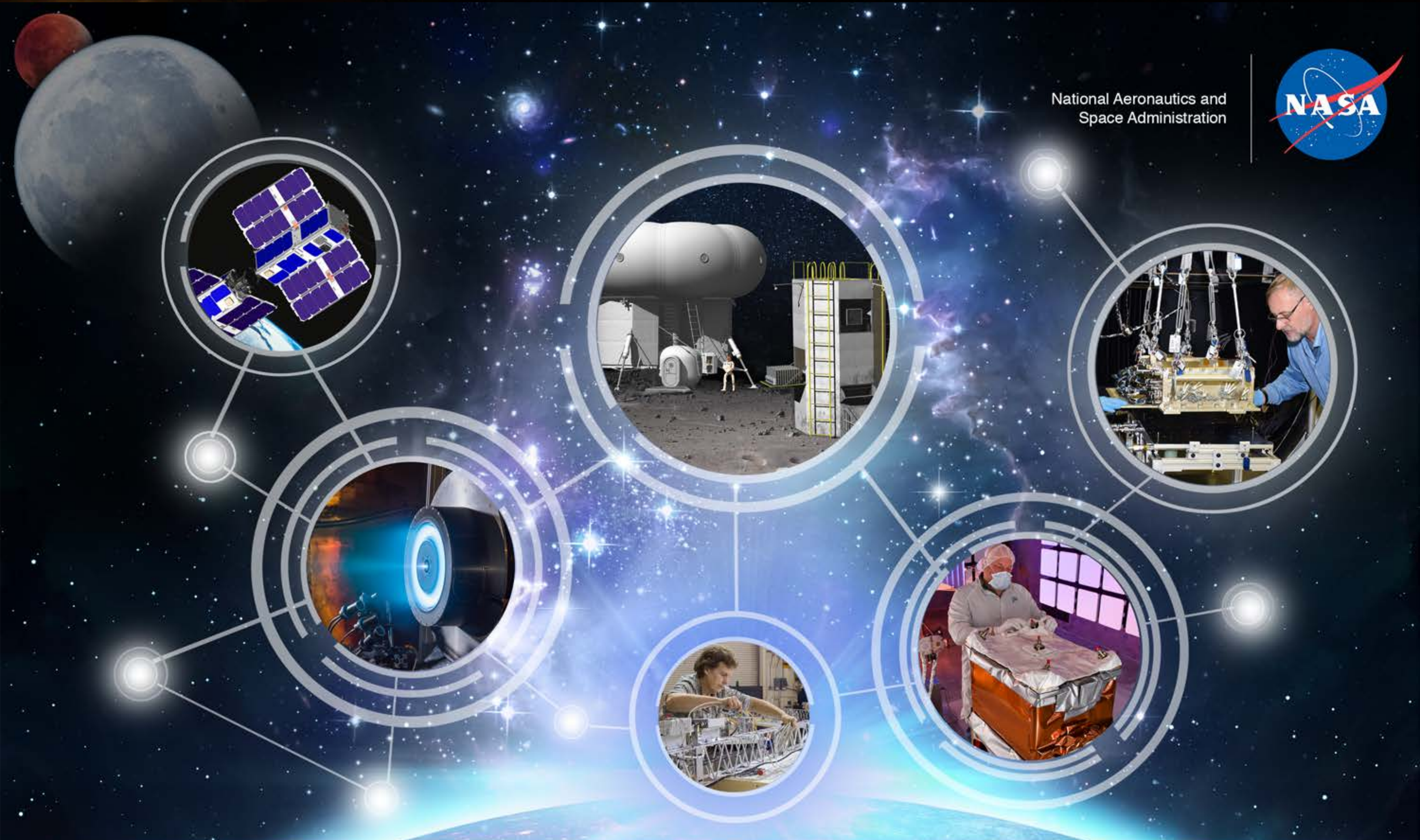


Small Business Innovation Research Small Business Technology Transfer

Gynelle Steele, Carlos Torrez, Robert Jones |

Finding Opportunities within the NASA AR Mission Directorate | 08.15.18

Aeronautics Research Mission Directorate (ARMD)

- NASA's Aeronautics Research Mission Directorate (ARMD) expands the boundaries of aeronautical knowledge for the benefit of the Nation and the broad aeronautics community, which includes the Agency's partners in academia, industry, and other government agencies.
- ARMD is conducting high-quality, cutting-edge research that will lead to revolutionary concepts, technologies, and capabilities that enable radical change to both the airspace system and the aircrafts that fly within it, facilitating a safer, more environmentally friendly, and more efficient air transportation system.
- At the same time, we are ensuring that aeronautics research and critical core competencies continue to play a vital role in support of NASA’s goals for both manned and robotic space exploration.

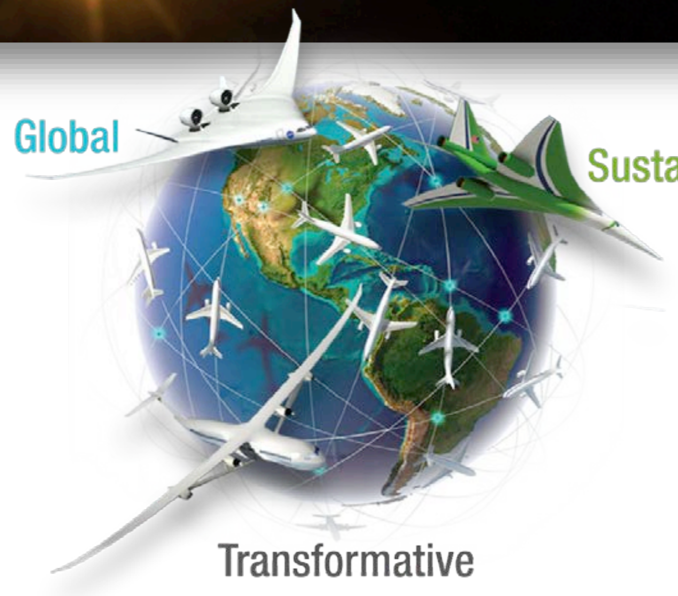
https://www.nasa.gov/aeroresearch

Aeronautics Research Mission Directorate (ARMD)

- NASA's Aeronautics Research Mission Directorate (ARMD) expands the boundaries of aeronautical knowledge for the benefit of the Nation and the broad aeronautics community, which includes the Agency's partners in academia, industry, and other government agencies.
- ARMD is conducting high-quality, cutting-edge research that will lead to revolutionary concepts, technologies, and capabilities that enable radical change to both the airspace system and the aircrafts that fly within it, facilitating a safer, more environmentally friendly, and more efficient air transportation system.
- At the same time, we are ensuring that aeronautics research and critical core competencies continue to play a vital role in support of NASA’s goals for both manned and robotic space exploration.

https://www.nasa.gov/aeroresearch

NASA Aeronautics – 6 Strategic Thrusts



Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially
reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles
- Pioneer technologies for big leaps in efficiency and environmental performance

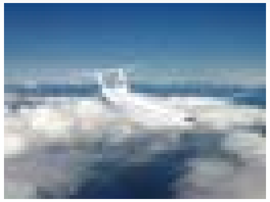
Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

Aeronautics Programs

Advanced Air Vehicle Program



Innovative design concepts developed by AAVP for advanced vehicles integrate multiple, simultaneous vehicle performance considerations that focus on fuel burn, noise, emissions and intrinsic safety. The goal: to enable new aircraft to fly safer, faster, cleaner, quieter, and use fuel far more efficiently.

Airspace Operations and Safety Program

The goal of AOSP-developed NextGen methods and means is to provide advanced levels of automated support to air navigation service providers and aircraft operators for reduced air travel times and air travel-related delays, and to insure greater safety in all weather conditions. By moving key concepts and technologies from the laboratory into the field, AOSP helps to make air travel as safe and efficient as possible – today as well as tomorrow – to directly benefit the flying public.

Integrated Aviation Systems Program

The objective of the IASP is to conduct flight oriented, integrated, system-level research and technology development that supports the flight research needs across the ARMD strategic thrusts, the programs and their projects.

Transformative Aeronautics Concepts Program

Cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation. Focus is on sharply focused research, and also provides flexibility for innovators to explore technology feasibility and provide the knowledge base for radical transformation.

ARMD Programs with Strategic Thrusts

Mission Programs

Airspace Operations and Safety Program (AOSP)

- Safe, Efficient Growth in Global Operations
- Real-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

Advanced Air Vehicles Program (AAVP)

- Ultra-Efficient Commercial Vehicles
- Innovation in Commercial Supersonic Aircraft
- Transition to Low-Carbon Propulsion
- Assured Autonomy for Aviation Transformation (future)

Integrated Aviation Systems Program (IASP)

- Flight Research-Oriented Integrated, System-Level R&T supporting all six thrusts
- X-Planes/Test Environment

Seedling Program

Transformative Aeronautics Concepts Program (TAC)

- High-risk, leap-frog ideas supporting all six thrusts
- Critical cross-cutting tool and technology development
- Assured Autonomy for Aviation Transformation

Human Exploration Mission Directorate (HOEMD)

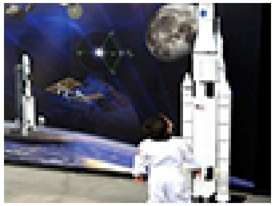
- The Human Exploration and Operations (HEO) Mission Directorate provides the Agency with leadership and management of NASA space operations related to human exploration in and beyond low-Earth orbit.
- HEO also oversees low-level requirements development, policy, and programmatic oversight.
- The International Space Station, currently orbiting the Earth with a crew of six, represents the NASA exploration activities in low-Earth orbit. Exploration activities beyond low-Earth orbit include the management of Commercial Space Transportation, Exploration Systems Development, Human Space Flight Capabilities, Advanced Exploration Systems, and Space Life Sciences Research & Applications.
- The directorate is similarly responsible for Agency leadership and management of NASA space operations related to Launch Services, Space Transportation, and Space Communications in support of both human and robotic exploration programs.

https://www.nasa.gov/directorates/heo

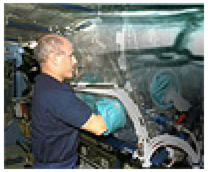
Exploration Education and Outreach

The Human Exploration and Operations (HEO) Mission Directorate is responsible for NASA's human spaceflight activities. In addition to space station operations, space communication and launch services, HEO is responsible for developing new capabilities that will pave the way for the next generation of human explorers.

HEO is dedicated to informing and educating the public about NASA's plans for a new era in space exploration: using the International Space Station for research and exploration activities in low Earth orbit, fostering a commercial industry and focusing our energy and resources on sending astronauts to an asteroid and eventually to Mars. A variety of educational materials are available to educators who want to invite NASA into their classrooms. Many of these resources can be downloaded in minutes — and at no cost



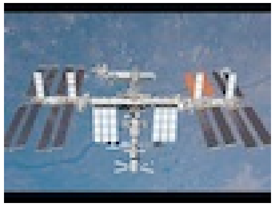
Space Launch Systems Education and Outreach



Space Station for Researchers Discover how NASA partners with industry, academia and federal, state, regional and local entities for research and development.

Space Life Sciences Education

Welcome to the Space Life Sciences education website! Here you will find resources on living organisms in the space environment. Visit the topic sections for more information, and return to the website often for news on space life sciences research. https://www.nasa.gov/audience/foreducators/spacelife/home/index.html

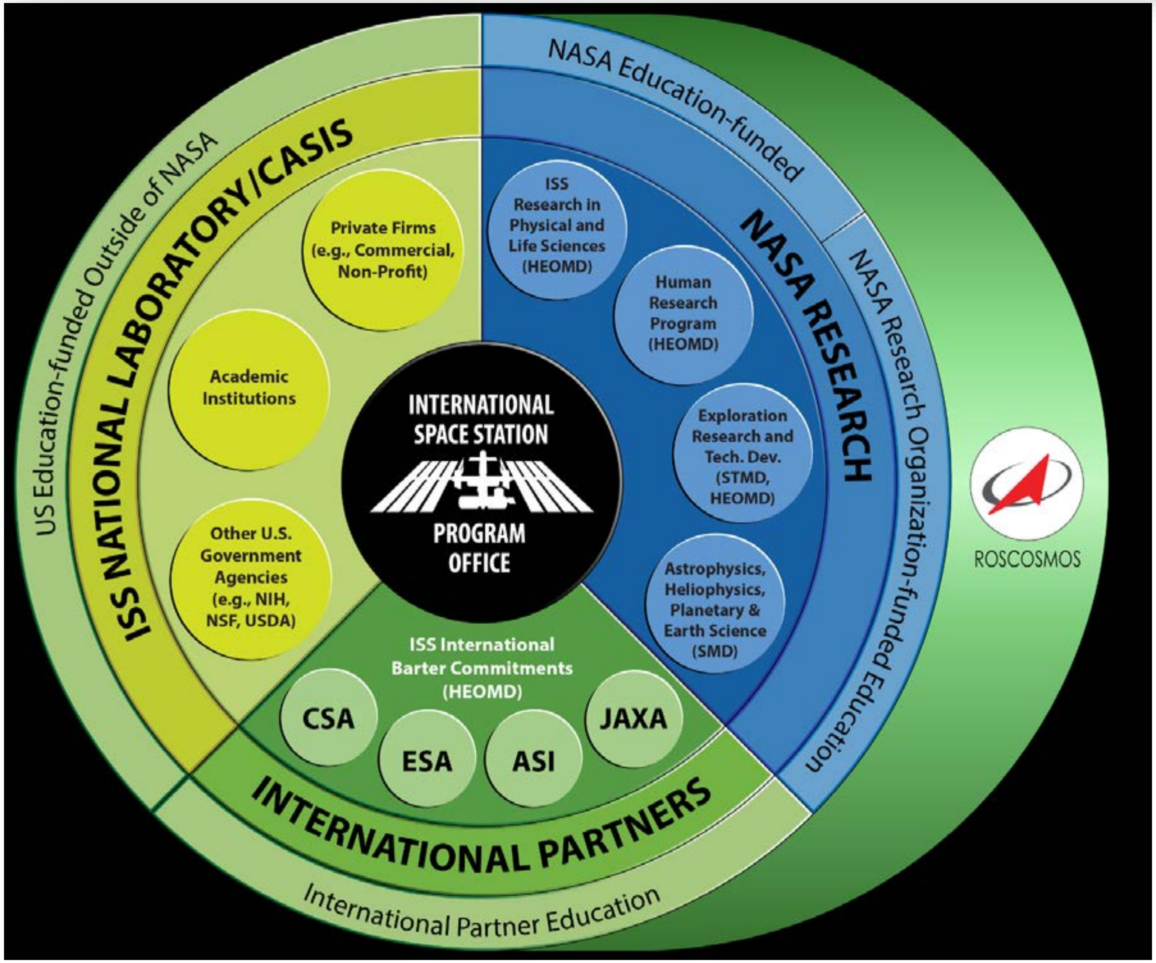


International Space Station for Students

https://www.nasa.gov/mission_pages/station/research/ops/research_student.html and

Teachers https://www.nasa.gov/mission_pages/station/research/ops/research_teacher.html

Funding Sources



(a) NASA Research
Grant opportunities and information in NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) at *http://nspires.nasaprs.com/external/*

(b) National Laboratory Research / The Center for the Advancement of Space in Science (CASIS)
The 2005 NASA Authorization Act designated the U.S segment of the space station as a national laboratory, enabling access by other Federal agencies, non-profits, and the private sector. Opportunities and information in CASIS' website at *www.iss-casis.org/* and *www.spacestationresearch.com/research-on-station/opportunities/*

(c) Educational Activities
Both NASA Education and CASIS offer education opportunities and information at NASA: *www.nasa.gov/audience/foreducators/stem_on_ station/index.html.* and at CASIS: *http://casisacademy.org/*

(d) International Partner Research International investigators should seek sponsorship through their appropriate space agency.

For more information on research sponsorship and funding, see:
http://www.nasa.gov/mission_pages/station/research/ops/funding/

Human Research Program

Space Biology Research

What science does NASA need to conduct? The National Research Council outlined scientific research recommendations in the publication, Strategy for Space Biology and Medicine in the New Century (1998), calling for NASA's space biology research to take, "an integrated multidisciplinary approach that encompasses all levels of biological organization… from molecules to cells to tissues to organs to systems to whole organisms, and employs the full range of modern experimental approaches."

NASA Space Biology Goals are to:

- Effectively use microgravity and other space environment characteristics to enhance our understanding of the adaptation and function of basic biological processes in spaceflight
- Develop a scientific and technological knowledge base that will contribute to a safe, productive human presence in space during exploration
- Apply this knowledge and technology to improve our nation's competitiveness, education, and the quality of life on Earth.

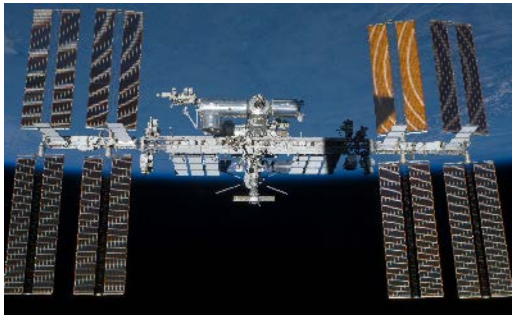
Biophysics

Biological Macromolecules | Biomaterials | Biological Physics | Fluids of Biology

In the International Space Station laboratory, NASA grows more perfect biological macromolecules crystals and analyzes them using a method known as diffraction. Diffraction aims beams of light or particles at the crystals and then studies the scattering pattern to determine the structure of the molecules that form them.
https://www.nasa.gov/content/physical-sciences-research-program

Opportunities to work with HEOMD

- www.nasa.gov/directorates/heo/index.html
- Programs
  - Space Launch System
  - Orion Spacecraft
  - Ground Systems Development
  - Advanced Exploration Systems
  - Space Life and Physical Sciences Research and Applications
  - Human Research Program
  - International Space Station
  - Launch Services
  - Space Communications and Navigation (SCaN)



Space Technology Mission Directorate (STMD)

- The Space Technology Mission Directorate (STMD) enables a new class of missions by drawing on talent from the NASA workforce, academia, small businesses, and the broader space enterprise to deliver innovative solutions that dramatically improve technological capabilities for NASA and the Nation.
- The rapid development and infusion of new technologies and capabilities are critical components to advancing the Nation’s future in space. These activities fuel an emerging aerospace economy and build upon the space technology needs of other government agencies, as well as the overall aerospace enterprise.
- NASA supports these objectives and contributes to the demands of larger national technology goals by investing in Space Technology.

https://www.nasa.gov/directorates/spacetech/home

Space Technology Research Grants
Opportunities to Propose

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 Research Fellowships

- Graduate student research in space technology; research conducted on campuses and at NASA Centers and not-for-profit R&D labs

Early Career Faculty

- Focused on supporting outstanding faculty researchers early in their careers as they conduct space technology research of high priority to NASA's Mission Directorates

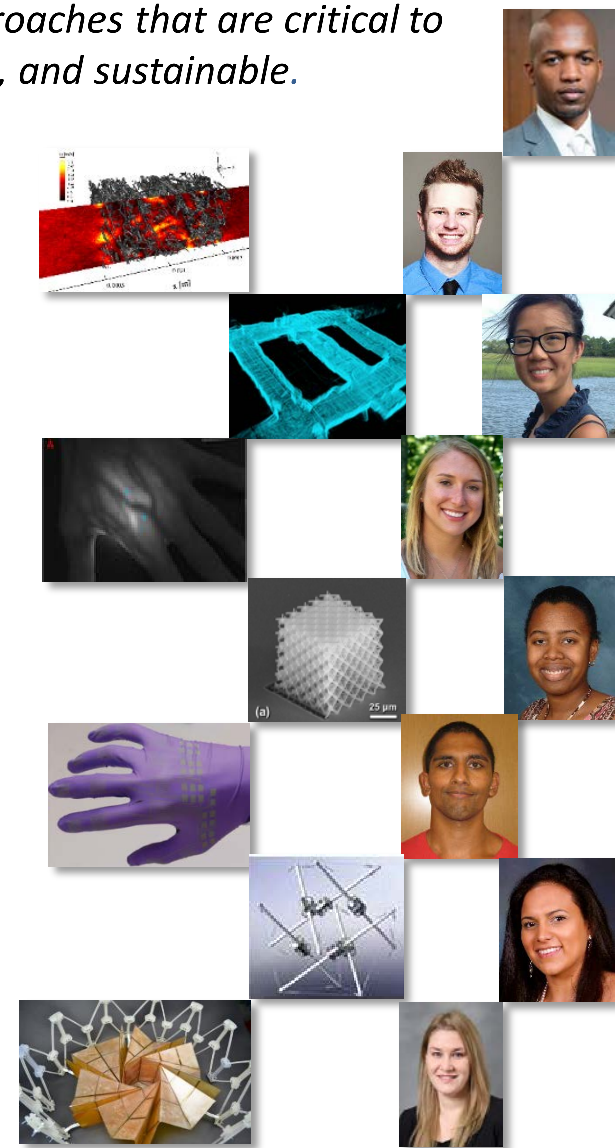
Early Stage Innovations

- University-led, possibly multiple investigator, efforts on early-stage space technology research of high priority to NASA's Mission Directorates
- Paid teaming with other universities, industry and non-profits permitted

Space Technology Research Institutes

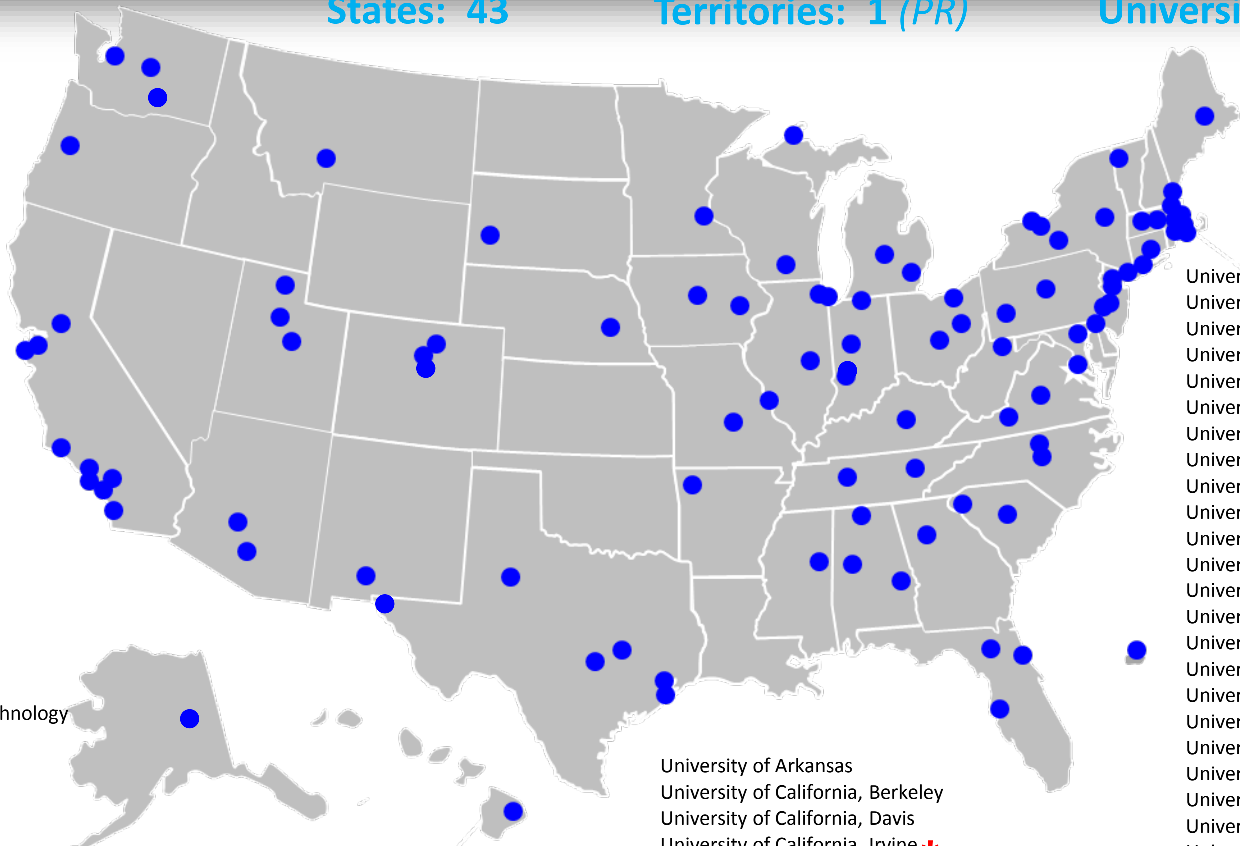
- University-led, integrated, multidisciplinary teams focused on high-priority early-stage space technology research for several years

Accelerate development of groundbreaking high-risk/high-payoff low-TRL space technologies



STRG Portfolio – Awards To-Date Universities

Awards: 539 **States: 43** **Territories: 1 *(PR)*** **Universities: 106**



* Minority serving institution

Arizona State University
Auburn University
Boston University
Brigham Young University
Brown University
California Institute of Technology
Carnegie Mellon University
Case Western Reserve University
Clemson University
Colorado State University
Colorado School of Mines
Columbia University
Cornell University
Duke University
Florida Institute of Technology
Georgia Institute of Technology
Harvard University
Illinois Institute of Technology
Iowa State University
Johns Hopkins University
Massachusetts Institute of Technology
Michigan State University
Michigan Technological University
Mississippi State University
Missouri University of Science and Technology
Montana State University
New Jersey Institute of Technology
New Mexico State University *
New York University
North Carolina State University
Northeastern University
Northwestern University
Ohio State University
Oregon State University
Pennsylvania State University
Portland State University
Princeton University
Purdue University
Rensselaer Polytechnic University
Rochester Institute of Technology
Rose-Hulman Institute of Technology
Rutgers University
South Dakota School of Mines and Technology

Stanford University
State University of New York, College of Nanoscale Science & Engineering
State University of New York, Stony Brook
Texas A&M University
Texas Tech University
Tufts University
University of Akron
University of Alabama, Huntsville
University of Alabama, Tuscaloosa
University of Alaska, Fairbanks
University of Arizona

University of Arkansas
University of California, Berkeley
University of California, Davis
University of California, Irvine *
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara *
University of Central Florida *
University of Colorado, Boulder
University of Connecticut
University of Delaware
University of Florida
University of Hawaii
University of Houston *
University of Illinois, Chicago
University of Illinois, Urbana-Champaign
University of Iowa

University of Kentucky
University of Maine
University of Maryland
University of Massachusetts, Amherst
University of Massachusetts, Lowell
University of Michigan
University of Minnesota
University of Nebraska, Lincoln
University of New Hampshire
University of Notre Dame
University of Pennsylvania
University of Pittsburgh
University of Puerto Rico, Rio Pedras *
University of Rochester
University of South Carolina
University of South Florida
University of Southern California
University of Tennessee
University of Texas, Austin
University of Texas, El Paso *
University of Utah
University of Vermont
University of Virginia
University of Washington
University of Wisconsin, Madison
Utah State University *
Vanderbilt University
Virginia Polytechnic Institute & State University
Washington State University
Washington University, St. Louis
Western Michigan University
West Virginia University
William Marsh Rice University
Worcester Polytechnic Institute
Yale University

STRG Opportunities to Propose
NSTRF

Eligibility Requirements for NSTRF18

1. **Pursuing or seeking to pursue advanced degrees directly related to space technology.**
2. **Are U.S. citizens or permanent residents of the U.S.**
3. **Are or will be enrolled in a full-time master's or doctoral degree program at an accredited U.S. university in fall 2019.**
4. **Are early in their graduate careers.**

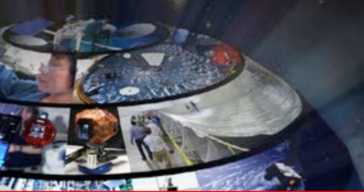
NSTRF**18**: http://tinyurl.com/NSTRF2018
NSTRF**17**: http://tinyurl.com/NSTRF2017
NSTRF**16**: http://tinyurl.com/NSTRF2016
NSTRF**15**: http://tinyurl.com/NSTRF2015
NSTRF**14**: http://tinyurl.com/NSTRF14
NSTRF**13**: http://tinyurl.com/NSTRF13
NSTRF**12**: http://tinyurl.com/NSTRF12-OCT
NSTRF**11**: http://tinyurl.com/NSTRF11-OCT

Application Components

1 **Application Cover Page** (Program Specific Data Questions)
2 **Personal Statement**
3 **Project Narrative**
4 **Degree Program Schedule**
5 **Curriculum Vitae**
6 **Transcripts**
7 **GRE General Test Scores**
8 **Three Letters of Recommendation**

Award Value

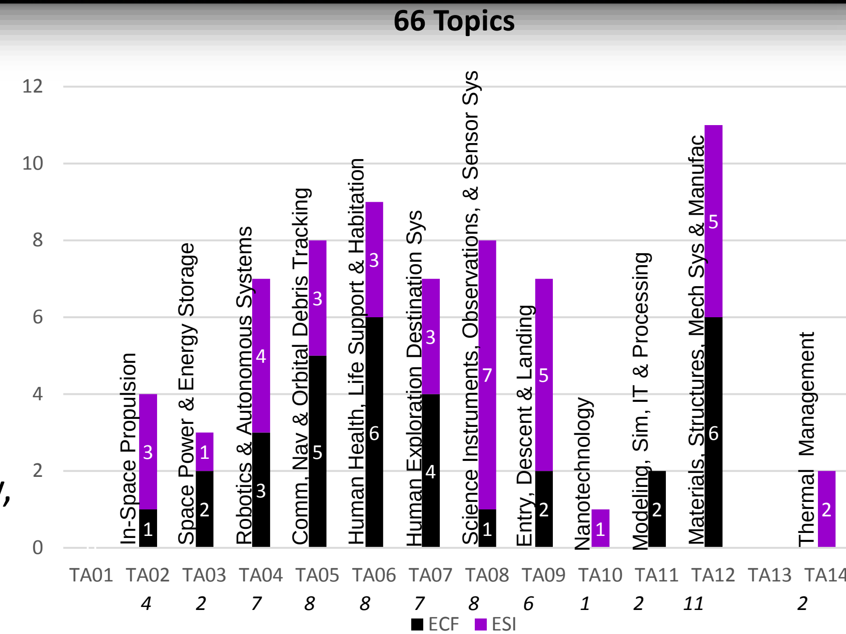
Fellowship Budget Category	Max value
Student Stipend	$36,000
Faculty Advisor Allowance	$11,000
Visiting Technologist Experience Allowance	$10,000
Health Insurance Allowance	$1,000
Tuition and Fees Allowance	$17,000
TOTAL	**$75,000**



STRG Opportunities to Propose
ECF and ESI

Technical Characteristics:

- Unique, disruptive or transformational space technologies
- Low TRL
- Specific topics tied to Technology Area Roadmaps and the NRC's review of the roadmaps
- Big impact at the system level: performance, weight, cost, reliability, operational simplicity or other figures of merit associated with space flight hardware or missions



http://tinyurl.com/NASA-14ECF http://tinyurl.com/NASA-15ECF http://tinyurl.com/NASA-16ECF http://tinyurl.com/NASA-17ECF http://tinyurl.com/NASA-18ECF
http://tinyurl.com/NASA-14ESI http://tinyurl.com/NASA-15ESI www.tinyurl.com/NASA-16ESI http://tinyurl.com/NASA-17ESI

Eligibility Summary:

Both ECF and ESI proposals must be submitted by accredited U.S. universities

Early Career Faculty

- Untenured assistant professor and on tenure track
- U.S. citizen or permanent resident
- No current or former Presidential Early Career Awards for Scientists and Engineers (PECASE)
- No co-investigators

Early Stage Innovations

- PI must be from proposing university
- Co-investigators are permitted
- ≥ 50% of the proposed budget must go to the proposing university
- ≥ 70% of the proposed budget must go to universities

STRG Highlights and Plans

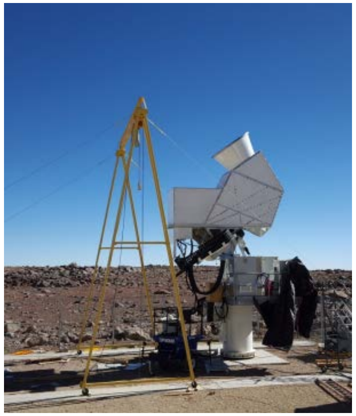
TA14- Corey Kruse, U Nebraska Lincoln: Using Femtosecond Laser Processing to improve heat transfer on bare stainless steel and copper surfaces by nearly 7x over traditional materials.
.

TA06- Heather Hava, CU Boulder: Developed in situ food (plant) production systems for space exploration, relevant for long duration missions; Completed the design of an intelligent pot (SmartPOT) that can be remotely monitored and controlled.

TA12- Scott Zavada, U Michigan: established the viability of using an in situ polymerizable liquid as an autonomic healing layer within a rigid structure, which was validated by ballistics testing.

STRG is impacting all Technology Areas. Here are some examples.

TA04- Jennifer King, Carnegie Mellon: Successfully expanded the types of tasks that can be performed by robots while reducing the need to hard-code task-specific action sequences. The algorithms use simple physics models (including estimates of friction, mass, etc.) to enable a robot to autonomously plan its interactions with the environment and perform manipulation tasks beyond just pick and place.

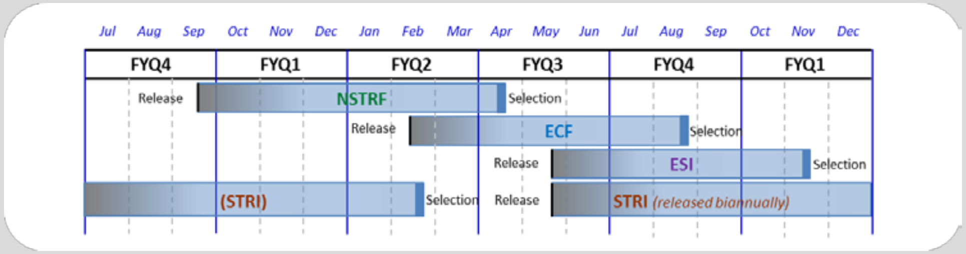


TA08- Kathleen Harrington, Johns Hopkins: successfully installed and operated Variable-delay Polarization Modulators (VPMs) on the Cosmology Large Angular Scale Surveyor (CLASS) telescope in Atacama, Chile.

Recent Milestones

Solicitation	Date
NSTRF	4/5/18: NSTRF18 announcement
ECF	2/7/18: ECF18 announcement
ESI	Early May 2018: ESI18 release

Annual Solicitation Schedule



NASA Innovative Advanced Concepts (NIAC) Program Overview

Space Technology
Mission Directorate

March, 2018

Jason Derleth
Program Executive, NIAC
hq-niac@mail.nasa.gov

What is NIAC?

NASA Innovative Advanced Concepts

NASA Innovative Advanced Concepts

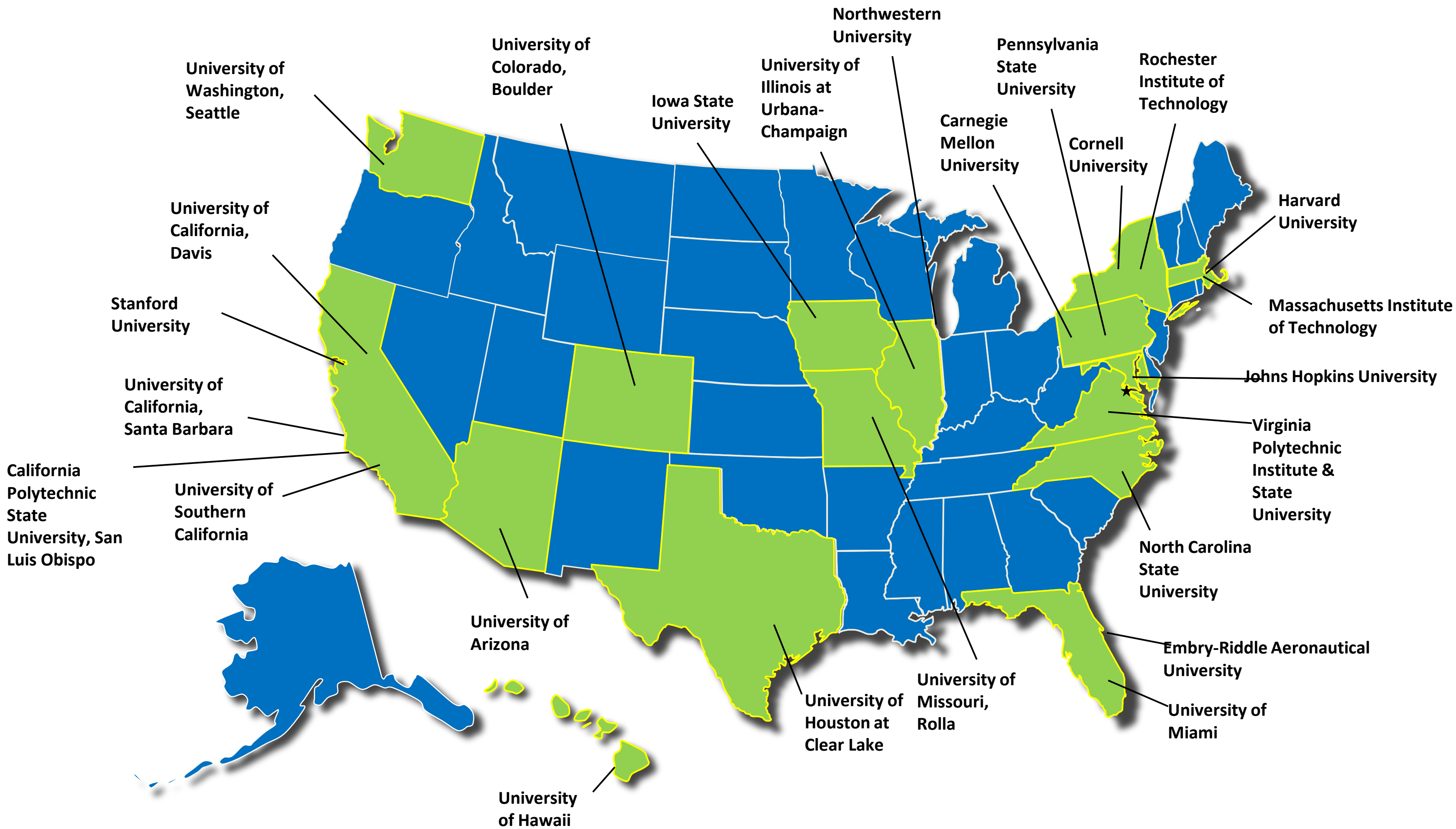
A program to support early studies of innovative, yet credible, visionary concepts that could one day "change the possible" in aerospace.

NIAC Awards, Scope, Criteria

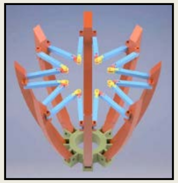
- NIAC grant awards support 2 phases of study:
  - **Phase I**: up to $125K, ~9 months, for concept definition and initial analysis in a mission context
    - **Proposal Submission & Selection Process**: Two-step Process; Step A is fully- open; Step B by Invitation only; Independent Peer Review. (https://www.nasa.gov/directorates/spacetech/niac/niac-phase-I-solicitation)
  - **Phase II**: up to $500K, 2 years, for further development of most promising Phase I concepts, comparative mission analysis, pathways forward
  - **Eligibility:** All categories of U.S organizations may apply. Non-U.S. organizations may partner in, or lead, NIAC studies on a no-exchange of funds basis, and subject to NASA's policy on foreign participation. **How to Apply**: (https://www.nasa.gov/feature/how-to-apply-to-niac)
  - **Goal:** Early studies of visionary aerospace architecture or mission concept
  - **Technology Readiness Level (TRL):** TRL 2 or lower at start of award
  - **NIAC Key Dates:** 2018 Phase I Proposals Due: **19 Sep '17**; Selections: **28 Mar '18**; 2018 Phase II Call for new proposals—Early Dec. 2018 (Planned); (https://www.nasa.gov/content/key-dates-and-solicitations)
- Scope of NIAC Phase I Studies:
  - **Aerospace architecture or mission concepts** (not focused tech.)
  - **Exciting**: offering a potential breakthrough or revolutionary improvement
  - **Unexplored**: novel, with basic feasibility and properties unclear
  - **Credible**: sound scientific/engineering basis and plausible implementation
- NIAC proposal evaluation criteria:
  - **Potential of the Concept** (all scope elements above, especially exciting)
  - **Strength of the Approach** (research objectives, technical issues, suitability of team and cost)
  - **Benefits of the Study** (concept definition, mission analysis, wider benefits, scientific/engineering contributions, notably new/different/inspiring)

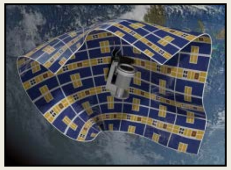
NIAC Educational Institutions

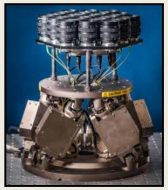
UNIVERSITY PARTNERS: Inspiring Our Nation's Innovators

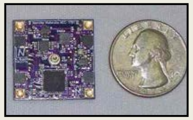


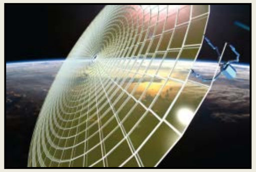
NIAC Awards & Successes











Total reported post-NIAC funding =
$133,062,264.00

Robert Youngquist , NASA KSC- A notable technical paper based on his Phase II study, Cryogenic Selective Surface (Solar White) entitled, "A Cryogenic Deep Space Thermal Control Coating" in the AIAA Journal of Spacecraft and Rockets.

Prof. Mel Ulmer, Northwestern University- His magnetic smart materials to build a large in-space telescope received add-on funding of $450,000 from another government agency. It has the potential to decrease size/cost of space telescopes and correct mirror shape/optics. He produced two notable technical papers related to APERTURE– a precise extremely large reflective telescope using re-configurable elements.

Stephanie Thomas, Princeton Satellite Systems- developed an invention, HQN-11484-1 Magnetic Dipole Cancellation for Space Devices Requiring Extremely High Magnetic Fields.

Prof. Christopher Walker, Univ. Arizona- a new Arizona company, *FreeFall Aerospace*, has been formed based on his NIAC study, Large Balloon Reflector. FreeFall develops next generation in-space telecom and remote sensing systems. www.freefallaerospace.com/

Siegfried Janson, Aerospace Corporation- is expanding space counter-collision studies with Brane Craft and developing carbon nanotube technology, radiation hardened photosensors and polymer matrix thin film "muscles" used to flex the spacecraft. Also had a notable article in Aviation Week & Space Technology.

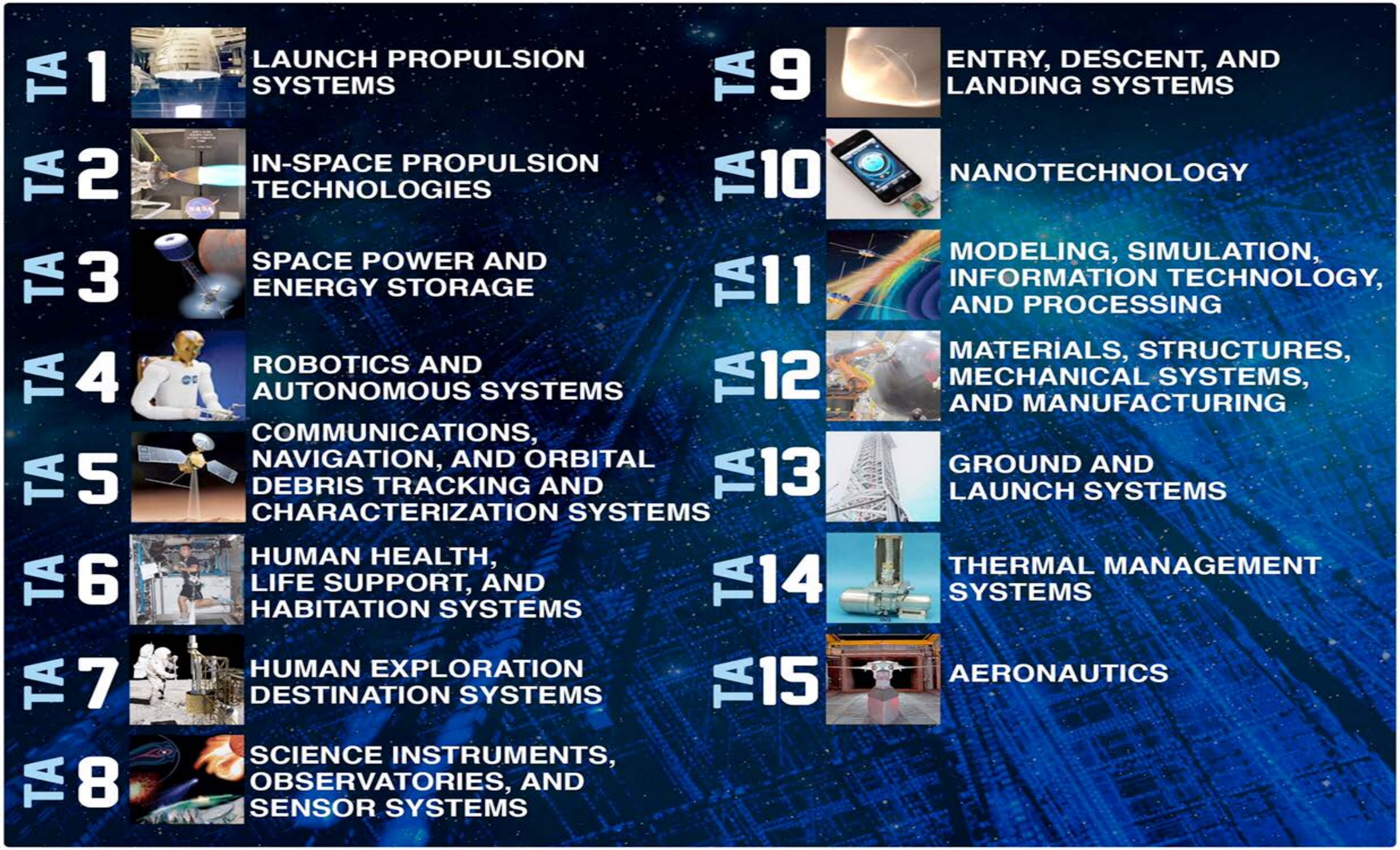
Prof. Philip Lubin, **University of California, Santa Barbara-** was invited to Capitol Hill to meet with members of Congress/staffers. The $100M private funding created for his NIAC directed energy interstellar concept continues to advance and has notable media coverage in Science, Space.com, Scientific American, and the Discovery Channel. He has lectures about his photonics work nationwide and most recently at The Institute for Energy Efficiency.

Robert Hoyt, Tethers Unlimited- won 4 NASA contracts to develop orbital manufacturing and construction technology, a DARPA contract for in-space manufacture of high-throughput SATCOM satellite, selected to build FabLab for ISS and won an Army contract to develop gigabit-class data link for smallsats.

OUT OF THIS WORLD

SPIN OFF

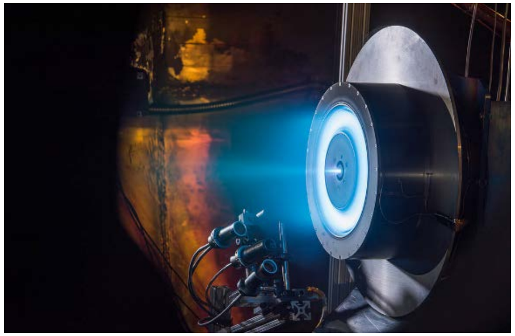
NASA's Technology Roadmaps



https://www.nasa.gov/offices/oct/home/roadmaps/index.html

Opportunities to work with STMD

- https://www.nasa.gov/directorates/spacetech/home/index.html
- Programs
  - Centennial Challenges
  - Center Innovation Fund
  - Flight Opportunities
  - Game Changing Development (GCD)
  - NASA Innovative Advanced Concepts (NIAC)
  - Prizes and Challenges
  - Regional Economic Development
  - SBIR/STTR
  - Small Spacecraft Technology Program
  - Space Technology Research Grants
  - Technology Demonstration Program
  - Technology Transfer



Contact us and let’s innovate together

Website: **www.sbir.nasa.gov**

NASA Help Desk: **301.937.0888**