Panel 1: Opportunities through Universities, Competitions, and Internships

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Space Technology Research Grants Program
NASA and the University of Toledo Virtual Event 2020

Dr. Harry Partridge | Chief Technologist, NASA Ames | 08.13.2020
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)
- Graduate student research in space technology; research conducted on campuses and at NASA Centers and not-for-profit R&D labs

Early Career Faculty (ECF)
- 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 (ESI)
- 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

Lunar Surface Technology Research (LuSTR) Opportunities
- University-led efforts addressing high priority lunar surface challenges
- Short duration, high value grants with emphasis on technology development and potential infusion
- Paid teaming with other universities, industry, and non-profits encouraged

Space Technology Research Institutes (STRI)
- 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
Space Technology Research Grants
Investments Across U.S., Universities, and Technology Areas

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<tr>
<th>TA01</th>
<th>Launch Propulsion</th>
<th>22 Awards</th>
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<tr>
<td>TA02</td>
<td>In-Space Propulsion</td>
<td>67 Awards</td>
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<tr>
<td>TA03</td>
<td>Space Power &amp; Energy Storage</td>
<td>38 Awards</td>
</tr>
<tr>
<td>TA04</td>
<td>Robotics &amp; Autonomous Systems</td>
<td>111 Awards</td>
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<tr>
<td>TA05</td>
<td>Communications, Navigation &amp; Orbital Debris Tracking</td>
<td>79 Awards</td>
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<tr>
<td>TA06</td>
<td>Human Health, Life Support &amp; Habitation</td>
<td>55 Awards</td>
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<tr>
<td>TA07</td>
<td>Human Exploration Destination Systems</td>
<td>27 Awards</td>
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<tr>
<td>TA08</td>
<td>Science Instruments, Observatories and Sensor Systems</td>
<td>88 Awards</td>
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<tr>
<td>TA09</td>
<td>Entry, Descent &amp; Landing</td>
<td>73 Awards</td>
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<tr>
<td>TA10</td>
<td>Nanotechnology</td>
<td>40 Awards</td>
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<td>TA11</td>
<td>Modeling, Simulation, IT &amp; Processing</td>
<td>29 Awards</td>
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<tr>
<td>TA12</td>
<td>Materials, Structures, Mechanical Systems &amp; Manufacturing</td>
<td>92 Awards</td>
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<tr>
<td>TA13</td>
<td>Ground &amp; Launch Systems</td>
<td>1 Award</td>
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<tr>
<td>TA14</td>
<td>Thermal Management</td>
<td>28 Awards</td>
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774 Awards  115 Universities
44 States  1 Territory (PR)
Highlights

• For current and prospective doctoral and master’s students (full requirements in solicitation)
• Up to $80,000 per year
• $36,000 annual stipend plus support for tuition, health insurance, conference attendance, and the faculty advisor
• Support for onsite tenure at NASA Centers across the country
• Up to four years of support are possible for doctoral students

Recipients will collaborate with leading NASA experts in space technology.

Proposal Components

1. Proposal Cover Pages (includes Program Specific Data Questions)
2. Personal Statement
3. Project Narrative
4. Degree Program Schedule
5. Curriculum Vitae (CV)
6. Transcripts
7. Three Letters of Recommendation

Most recent solicitation:
https://tinyurl.com/NSTGRO20
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

PI 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**
- Tenured or tenure-track faculty 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
Introducing
Lunar Surface Technology Research (LuSTR) Opportunities

University-led efforts to develop and mature technologies that address high-priority lunar surface challenges

Technical Characteristics:

• Unique, disruptive or transformational lunar surface technology development: in situ resource utilization, sustainable surface power, extreme access, extreme environments, surface excavation and construction, and lunar dust mitigation

• Low to mid Technology Readiness Level (TRL): TRL 2-5

• Post-award infusion opportunities

Eligibility

• Organization submitting proposal must be an accredited U.S. university

• PI must be a professor at the submitting university; co-Is are permitted

• ≥ 60% of budget must go to accredited U.S. universities

• Up to 40% paid teaming with other universities, industry and non-profits encouraged

Award Information

• Expected duration: 2 years

• Anticipated awards (inaugural solicitation): 10-15 awards valued at up to $1-2M each

• Oversight: Annual reviews and semi-annual briefings at LSIC meetings

• Award instrument: Grants

• Release Date: July 15, 2020
### Space Technology Research Grants
#### Lunar Surface Technology Research Topics

<table>
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<tr>
<th>Topic</th>
<th>Focus Area</th>
<th>Description</th>
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<tr>
<td>Advanced Technologies for the Extraction and Processing of Water from Regolith</td>
<td>ISRU</td>
<td>The objective of this topic is to develop/advance novel water extraction and processing technologies for use in lunar ISRU consumable production systems.</td>
</tr>
<tr>
<td>Determining the Spatial Distribution and Geotechnical Properties of Water-Bearing Regolith</td>
<td>ISRU</td>
<td>The goal of this topic is to develop instruments and measurement techniques focused on acquiring the lunar surface knowledge needed to design effective ISRU systems.</td>
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<tr>
<td>Flexible Power Distribution for Difficult-to-Reach and Mobile Applications</td>
<td>Sustainable Power</td>
<td>The goal of this topic is to promote the development of wireless energy transmission technologies to enable exploration in environments where conventional means of power generation, storage, and distribution are impractical.</td>
</tr>
<tr>
<td>Advanced, Radiation-Tolerant Power Electronics</td>
<td>Sustainable Power</td>
<td>The objective of this topic is to enable the reliable insertion of silicon carbide power components into lunar surface applications while withstanding the hazardous space radiation environment.</td>
</tr>
<tr>
<td>Low-Temperature Batteries</td>
<td>Sustainable Power</td>
<td>The objective of this topic is to provide reliable, high-performing primary and secondary battery technologies for sustained operation in low-temperature lunar conditions.</td>
</tr>
<tr>
<td>Advanced Power System Control for Interoperability</td>
<td>Sustainable Power</td>
<td>The objective of this topic is to develop the advanced power control technologies needed to enable the operation of interconnected systems with distributed and diverse energy sources.</td>
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**https://www.nasa.gov/strg/new_nasa_lunar_tech_funding_opportunity_for_us_universities**

### Schedule

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<td>Solicitation Release</td>
<td>Jul 15th</td>
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<tr>
<td>NOIs Due</td>
<td>Aug 12th</td>
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<td>Proposals Due</td>
<td>Sep 09th</td>
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<td>Selection Notification</td>
<td>Feb 2021</td>
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<tr>
<td>Award Date</td>
<td>May 2021</td>
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The Appendix: [https://tinyurl.com/NASA-2020LuSTR](https://tinyurl.com/NASA-2020LuSTR)

Email questions to: hq-LuSTR@mail.nasa.gov
Key Features

- **Empowered** university-led team
- Guiding Vision with **resilient** research strategy
- Specific research objectives with **credible expected outcomes** in next 5 years
- **Multidisciplinary** research program – synthesis of science, engineering and other disciples
- Innovative approaches for accelerated progress
- **Leveraging** SOA capabilities (likely created by OGA investments)
- Talented, **diverse**, cross-disciplinary, fully-integrated team; HBCU and MSI participation encouraged
- 70% of the budget must go to U.S. universities

Award Information

- Expected duration: **5 years**
- Award amount up to **$3M per year** ($15M over 5 years)
- Award instrument: grants
- Institutes expected (and **empowered**) to implement their own review processes
- NASA oversight – annual reviews and brief quarterly status reports

Only U.S. universities may submit proposals

Creative teaming arrangements are sought
- Other universities (required) – 2+
- Non-profits
- Industry

Co-Investigators are required

Institute leadership or participation from Historically Black Colleges and Universities (HBCUs) or other Minority Serving Institutions (MSIs) is strongly encouraged

70% of the budget must go to U.S. universities

Inventive approaches for accelerated progress

Leveraging SOA capabilities (likely created by OGA investments)

Talented, diverse, cross-disciplinary, fully-integrated team; HBCU and MSI participation encouraged

Student involvement in research

Low to mid TRL

Publications (many) and open source access to results

Research products tied to the research institute’s Vision and research objectives.
The goal of the Space Technology Research Institutes (STRI) is to strengthen NASA's ties to the academic community through long-term, sustained investment in research and technology development critical to NASA's future.

### Computationally Accelerated Materials Development for Ultra High Strength Lightweight Structures

- **Institute Title:** The Institute for Ultra-Strong Composites by Computational Design (US-COMP)
- **Lead Organization:** Michigan Technological University
- **Partner Organizations:** University of Utah, Florida A&M University; University of Minnesota, John Hopkins University, MIT, Georgia Tech, University of Florida, Nanocomp Technologies Inc., AFRL, Virginia Commonwealth University, Solvay
- **US-COMP** will serve as a focal point for partnerships to:
  - Enable computationally-driven development of carbon nanotube based ultra high strength lightweight structural materials within the Materials Genome Initiative (MGI)
  - Expand the resource of highly skilled engineers, scientists and technologists in this emerging field.

### Bio-Manufacturing for Deep Space Exploration

- **Institute Title:** The Center for the Utilization of Biological Engineering in Space (CUBES)
- **Lead Organization:** University of California, Berkeley
- **Partner Organizations:** University of Florida, Utah State University, University of California, Davis, Stanford University, Autodesk
- **CUBES** will leverage partnerships to:
  - Support biomanufacturing for deep space exploration
  - Advance the practicality of an integrated, multifunction, multi-organism biomanufacturing system on a Mars mission
  - Showcase a continuous and semiautonomous biomanufacturing of fuel, materials, pharmaceuticals, and food in Mars-like conditions
Poly(ionic liquid)-ionic liquid membranes reinforced by graphene sheets for CO₂ capture and conversion in microgravity

The research program develops new advanced materials to reduce cabin CO₂ concentration for life support systems. Technology is based on ionic liquids (IL) formulated and synthesized by Dr. Gurkan and her team. **Accomplishments include:**

- Synthesized gram amounts of CO₂-reactive ILs and IL capsules, and assessed their CO₂ capacity, absorption-desorption rate and cyclability to identify the most promising candidates
- Measured CO₂ capacity for the reactive IL (74 mg CO₂ per gram IL) **exceeds** state-of-the-art absorber Zeolite 13X (55 mg CO₂ per gram) at 3.8 Torr and 25°C
- Demonstrated rapid absorption of CO₂ at room temperature and regeneration at 40 – 50°C or mild vacuum and could **reduce** energy requirements for regeneration

**Additional Benefit of Gurkan’s Design:**

- Membrane system has been designed to support future development of oxygen recovery technology, by electrolysis of CO₂. The graphene oxide structure in the membrane can serve as an electrode and the ILs as the electrolytes.

Dr. Gurkan is one of 32 researchers from across the globe selected by the editors of **Industrial & Engineering Chemistry Research** as a member of their **2019 Class of Influential Researchers**
**Smart Deep Space Habitats (SmartHabs)**

- Two institutes funded under this topic in September 2019

- **Institute Title:** Resilient ExtraTerrestrial Habitats research institute (RETHi)
- **Lead Organization:** Purdue University
- **Partner Organizations:** University of Connecticut, Harvard College, University of Texas at San Antonio, ILC Dover, Collins Aerospace
- RETHi seeks to 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 and
  - Plans to create a cyber-physical prototype testbed of physical and virtual models to develop, deploy and validate different capabilities.

- **Institute Title:** Habitats Optimized for Missions of Exploration (HOME)
- **Lead Organization:** University of California, Davis
- **Partner Organizations:** University of Colorado, Boulder; Georgia Tech Applied Research Corporation; Carnegie Mellon University; Howard University; Texas A&M Engineering Experiment Station; University of Southern California; Blue Origin, LLC; Hamilton Sundstrand Space Systems International Inc
- 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 onboard manufacturing.

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**STRI 2020 released this summer, two topics were included in the solicitation:**

- High-Power Electric Propulsion Ground Testing and Modeling Extensible to In-Space Operation
- Revolutionary Advancements in Multidisciplinary Modeling and Simulation of Entry Systems
The goal of this work is to develop an Electron Cyclotron Resonance (ECR) thruster, an alternate type of low-power electric thruster that uses microwave energy to create and heat a plasma.

- Designed and built a 30-watt ECR thruster to assess device performance
- Tested his ECR source on the GRC micro-Newton torsional thrust stand and the University of Michigan Plasmadynamics and Electric Propulsion Laboratory (PEPL) thrust test stand
- Used microwave power meters to determine changes in the discharge impedance and laser-induced fluorescence to measure ion velocities in the plume
- Performed tests with chamber background pressures ranging from $8 \times 10^{-7}$ Torr to $2 \times 10^{-5}$ Torr and observed that microwave coupling and plasma potential are dependent on background pressure
- Developed a wireless power coupling to improve efficiency that will be evaluated at NASA GRC this fall
- Developing a theoretical model to support his ECR source design and reduce development time

Characterization of Plasmadynamics within a Small Magnetic Nozzle

Wireless power coupler

ECR Thruster mounted to NASA Glenn thrust stand (left) and the PEPL thrust stand (right).
Nonprehensile Terrain Manipulation for Planetary Rover Mobility Enhancement

This project is developing new methods to use the wheels of planetary exploration rovers to manipulate and shape the surrounding terrain

- Built a model that simulates the interaction of rover wheels in various driving modes with loose/noncohesive soil to accurately predict the geometry of the soil after its interaction with the rover
- Model accounts for soil characteristics, wheel geometry and wheel slip and angle and slip ratio
- Model predictions have been validated against testing in a custom built rover wheel test platform in a soft soil test bed
- Recent effort to further validate the research in a more realistic test environment
  - Experiments performed with NASA AMES KREX2 rover in the Atacama Desert

These techniques could allow lunar and Mars rovers to fill in crevasses, build ramps, traverse previously inaccessible terrain, or even remove surface soil to expose underlying regolith to enable science experiments

KREX2 Rover in the Atacama Desert after digging a shallow trench

Plots of measured trenches (blue) and model-predicted trenches (red) for slip angles (θ) and slip ratios (s) shown [top]. Single wheel testbed [bottom].
A Drag Device and Control Algorithm for Spacecraft Attitude Stabilization and De-Orbit

This project is developing a novel method of de-orbiting small satellites using aerodynamic drag forces

- Cubesats and other small satellites often do not have onboard propulsion, but do experience small amounts of aerodynamic drag in low earth orbit, this project is exploiting this fact by using aero surfaces to guide smallsats to a specific deorbit point
- A deployable boom mechanism has been designed and manufactured to increase drag and provide basic trajectory control and concurrently building a trajectory model to enable guidance based on the system. This system will be test flown on a dedicated 2U size cubesat in 2020
- The algorithm has been validated against the STK High-Precision Orbit Propagator and shows that the system is able to steer the satellite to within 25km of its destination more than 99.7% of the time. These methods are already in use to better predict deorbit points for NASA Ames TechEdSat series of cubesats.
- Will allow satellite operators to reliably deorbit their cubesats at a time and location of their choosing minimizing space junk and safety concerns with reentry over populated areas.