

Lunar Surface Science Workshop

NASA Dust Mitigation Strategy

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Gene Cernan, Apollo 17 Commander

Probably the most difficult job of all the closeouts was trying to dust the suits....The real-time transcripts will show just how much time and effort was spent in dusting.” – Gene Cernan, Apollo 17 Commander

EVA 3 Closeout Audio Transcript

Cernan: “...Boy, I tell you, I ain't going to do much more dusting after I leave here. Ever.”

.....3 minutes later.....

“Boy, you got dirty today. I think we're just going to have to live with it.”

Lunar Surface Innovation Initiative (LSII)

STMD develops and performs demonstrations that allow the primary technology hurdles to be retired for a given capability at a relevant scale. While there may be additional engineering development required for scale-up, there should be none required for the foundational technologies.

In Situ Resource Utilization

Collection, processing, storing and use of material found or manufactured on other astronomical objects

Surface Power

Enable continuous power throughout lunar day and night

Extreme Access

Access, navigate, and explore surface/subsurface areas

Surface Excavation & Construction

Enable affordable, autonomous manufacturing or construction

Lunar Dust Mitigation

Mitigate lunar dust hazards

Extreme Environments

Enable systems to operate through out the full range of lunar surface conditions

- Accelerate technology readiness for key lunar infrastructure capabilities enabling technology demonstrations for early un-crewed commercial missions, as well as informing development of crewed flight systems.
- Implement through a combination of in-house activities, competitive programs, and public-private partnerships.
- Coordinate with NASA's Science Mission Directorate and Human Exploration and Operations Mission Directorate to identify priorities.

LSII System Integrator - APL

A key tenet of LSII is to implement a multitude of novel collaborations across industry, academia, and government in order to successfully develop the transformative capabilities for lunar surface exploration.

Origin of the APL Task

- NASA was investigating using a University Affiliated Research Center (UARC) to bring efficiencies to development
- LSII initiated a tasked APL, to assess system integration role for the Lunar Surface Innovation Initiative
- APL established a Lunar Surface Consortium with academia and industry representatives, as well as NASA experts, that span a broad range of capabilities to execute timely studies, tasks, and/or acquisitions

The Consortium will assist NASA in

- Identifying lunar surface technology needs and assessing the readiness of relative systems and components
- Making recommendations for a cohesive, executable strategy for development and deployment of the technologies required for successful lunar surface exploration
- Providing a central resource for gathering information, analytical integration of lunar surface technology demonstration interfaces, and sharing of results



Capability Needs

- *Optical Systems* – Viewports, camera lenses, solar panels, space suit visors, mass spectrometers, other sensitive optical instruments
- *Thermal Surfaces* – Thermal radiators, thermal painted surfaces, thermal connections
- *Fabrics* – Space suit fabrics, soft wall habitats, mechanism covers
- *Mechanisms* – Linear actuators, bearings, rotary joints, hinges, quick disconnects, valves, linkages
- *Seals and Soft Goods* – Space suit interfaces, hatches, connectors, hoses
- *Gaseous Filtration* – Atmosphere revitalization, ISRU processes
- *Lunar Surface Modification* – Lunar landing pads, dust free zones and workspaces

STMD GCD FY20 Dust Mitigation Investments

- One project with six current tasks
 - CLPS Payload Development
 - Electrodynamic Dust Shield
 - Active dust mitigation technology demonstration on CLPS payload
 - Patch Plate Materials Compatibility Assessment
 - Dust adherence on notional materials and passive technologies and dust imaging and characterizing capabilities
 - Technology Development
 - Dust Tolerant Mechanisms
 - Elevate TRL for dust tolerant mechanisms and joints, using existing high TRL mechanisms
 - LO-DuSST Seedling
 - Materials and Active mitigation investigations
 - Dust Mitigation Best Practices Guide
 - A “How To” Guide for dust mitigation to be used by stakeholders
 - Dusty Environments Classifications
 - Addresses requirements, integration, architecture, and technology developer needs.

SBIR Dust Mitigation Investments

- Active and Passive Surfaces (Z13.01)
 - Hedgefog Research, Inc. – Bendable Electrodynamic dust Shields
 - PolyK Technologies, Inc. – Integrated Approach for Space Active and Passive Dust Mitigation Enabled by Electroactive Polymer Technology
 - WattGlass – Solar Array Coatings for Mitigating Lunar and Martian Dust
- Dust Tolerant Mechanisms (Z13.02)
 - Triton Systems, Inc. – Dust Tolerant Joints
 - Off Planet Research, LLC – Self Cleaning Dust Proof Fluid and Gas Connector
 - Astrobotic Technology, Inc. – High Power Near-Field Wireless Transfer for Dust Intensive Applications
- Lunar Dust Management Technology for Spacecraft Atmospheres and Spacesuits (H3.03)
 - BlazeTech Corporation - Lunar Dust Filter for Spacecraft Atmospheres
 - Applied Particle Technology, Inc. - In-situ optical speciation and size distribution monitoring instrument for lunar dust management
 - Mainstream Engineering Corporation - Cyclone Precipitator Sub-Micron Particulate Separator

Early Stage Innovations 2020

- Topic 2 - Modeling of Lunar Dust Behavior and Mitigation Techniques
 - Particle adhesion/cohesion
 - Particle transport
 - Lunar dust particle characteristics
 - Evaluation of mitigation techniques
- Important dates
 - Selection Notification – October 2020
 - Award Date – mid-January 2021



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
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SPACE TECHNOLOGY MISSION DIRECTORATE
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**SPACE TECHNOLOGY RESEARCH GRANTS PROGRAM,
EARLY STAGE INNOVATIONS APPENDIX**

to

NASA Research Announcement (NRA): Space Technology –
Research, Development, Demonstration, and Infusion 2020
(SpaceTech–REDDI–2020), 80HQTR20NOA01

APPENDIX NUMBER: 80HQTR20NOA01-20ESI-B2

Appendix Issued: April 29, 2020
Notices of Intent Due: May 20, 2020 (5 PM Eastern)
Proposals Due: June 17, 2020 (5 PM Eastern, 2 PM Pacific)

NASA BIG Idea Challenge 2021

- Breakthrough, Innovative, Game-changing Idea Challenge
- *Open to U.S. universities officially affiliated with their state's Space Grant Consortium*
- Awards ranging from \$50,000 - \$180,000
- Looking for active and passive technologies in one or more of the following areas
 - Landing dust mitigation
 - Spacesuit dust tolerance
 - Exterior dust clean up
 - Cabin clean up
- Solicitation Released – July 22, 2020
- [BIG Idea Challenge 2021](https://bigidea.nianet.org)



Breakthrough, Innovative & Game-changing (BIG) Idea Challenge

The BIG Idea Challenge is a university-level design competition sponsored by NASA and managed by the NIA. To participate, university teams of 5-25 students will submit proposals on concepts for a wide range of solutions for issues including reducing dust clouds upon landing, difficult dust removal from spacesuits and other surfaces, dust obstruction of optical systems, and in-cabin particulate levels, among others. Selected teams will receive up to \$180,000 to build and test their proposed dust mitigation solutions, then will present their test results to a panel of NASA and industry subject matter experts (SMEs) at the BIG Idea Forum in November 2021.

Background

Through the agency's Artemis lunar exploration program, NASA has its sights set on a place no humans have ever gone before: the lunar South Pole. The Moon's environment presents unique challenges, and lunar dust is one of the principal limiting factors in returning to the lunar surface for extended duration missions. Lunar dust is difficult to remove or mitigate as it is extremely abrasive, highly cohesive, electrically charged, and small in size.

For future lunar exploration missions, dust will inevitably be introduced into habitable spaces, where, under lunar gravity, fine lunar dust particles will be a health hazard to humans. In addition to threatening astronaut health, lunar dust issues have also resulted in incorrect instrument readings, vision/optical system obscuration, performance reduction, altered thermal properties, and equipment failure. High-velocity dust ejected by descent engine exhaust can cause damage to the lander, as well as nearby surface assets.

To enable sustainable human operation of the Moon in the coming decade, NASA is looking for near-term, innovative and viable solutions for dealing with the Moon's abrasive dust. Dust mitigation technologies can be categorized into active and passive technologies. Active technologies are those that are used to clean or protect a surface from dust deposition through external forces. Passive technologies do not require activation, such as chemically pretreated surfaces and dust tolerant coverings.

Basic Challenge

Develop active and passive dust mitigation (or dust tolerant) capabilities and technologies to be used in components of future lunar missions, in one or more of the following categories:

- Landing dust mitigation
- Spacesuit dust tolerance
- Exterior dust clean up
- Cabin clean up

Design Constraints

- Able to manage and mitigate abrasive dust
- Able to mitigate small particles (1-50 μm)
- Minimal barriers to NASA adoption (e.g. low mass, small size, low power, etc.)
- Cost-effective solution
- Non-flammable
- Able to work in harsh environments
- Tech should reach a minimum technology readiness level (TRL) of 4

<http://bigidea.nianet.org>

2021

Theme Preview

Full competition details will be available on the BIG Idea Challenge website by August 3, 2020.

Some details may be subject to change.

Important Dates

Notice of Intent Deadline – September 25, 2020
Proposal Deadline – December 13, 2020
Selection Notifications – January 29, 2021
Mid-Point Report Deadline – May 20, 2021
Technical Paper Deadline – October 27, 2021
2021 BIG Idea Forum – November 17–19, 2021

Eligibility

Participation is limited to teams of undergraduate and graduate students at accredited U.S.-based colleges and universities officially affiliated with their state's Space Grant Consortium. However, non-Space Grant affiliated colleges/universities may partner with a Space Grant-affiliated institution. (5-25 people/team)

Awards

A wide range of award sizes is expected (in the range of \$50,000 - \$180,000 per team). Proposers are encouraged to request what is actually needed to conduct the proposed work.

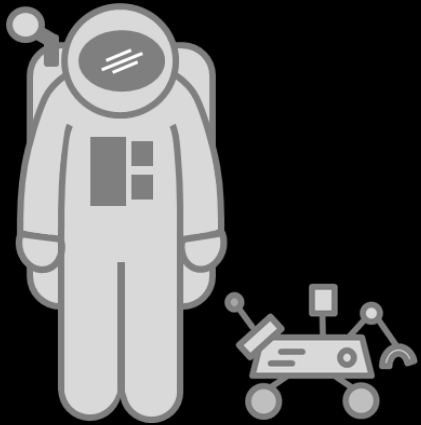
Dust Mitigation Technologies

Teams submit proposals for novel active and passive dust mitigation technologies that could be used for lunar applications, including but not limited to:

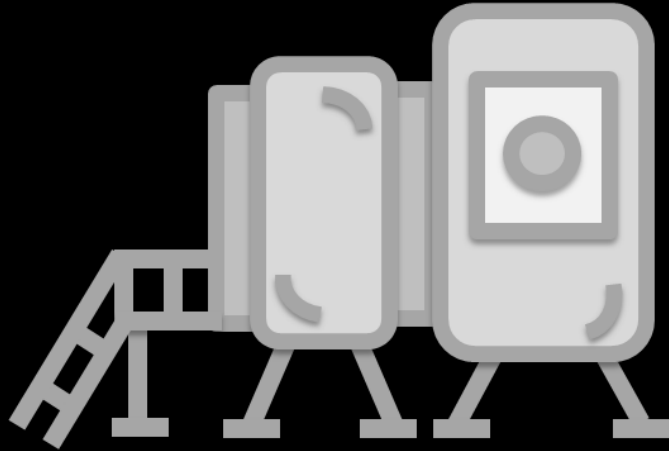
- Dust-free zones (i.e., landing pads, lunar surface modification, dust-free workspaces)
- Optical systems (i.e., viewports, camera lenses, solar panels, space suite visors, mass spectrometers, other sensitive optical instruments)
- Thermal systems (i.e., thermal radiators, painted surfaces, or connections)
- Dust-tolerant textiles and fabrics (i.e., space suit fabrics, soft wall habitats, mechanism covers)
- Dust-tolerant mechanisms (i.e., linear actuators, bearings, rotary joints, hinges, quick disconnects, valves, linkages)
- Seals and soft goods (i.e., space suit interfaces, hatches, connectors, hoses)
- Gaseous filtration (i.e., atmosphere revitalization, In-Space Resource Utilization (ISRU) processes)

Integrated Dust Mitigation Strategy

SURFACE OPERATIONS



HABITATS



DESCENT/ASCENT



ORBITAL

