Scope Title
Extraterrestrial Surface Construction

Scope Description
Lunar and martian construction of infrastructure from extraterrestrial materials and materials beneficiated or produced from in situ resources has the potential to radically reduce the cost and increase the scale of ambitious future space exploration. Technologies that support development of infrastructure structural elements are sought. Innovative materials and processes technology advancements are required to enable rapid advancement of a lunar or martian village in a cost-effective manner.

Specific areas of technology development that are of interest include, but are not limited to, the following:

1. Construction technologies shall be based on the use of extraterrestrial materials and limit the need for any terrestrial materials. Development of lunar-construction-relevant materials and processes for infrastructure elements listed in point 2 below are highly encouraged.
   - Materials must have a defined application in a mission context.
   - Proposers are asked to define any consumable materials that must be brought from Earth for construction.

2. Fabrication and assembly of pressurized and unpressurized structural systems, including (for example) landing/launch pads, roads, blast shields, and habitats.
   - Both stationary and mobile fabrication/assembly systems shall be considered.
   - Novel fabrication and assembly methodologies shall be considered.
     - Low-power methods and methods that benefit from the extraterrestrial surface environment are desired.

Technology development shall include design, analysis, fabrication, and testing of components, subsystems, and materials to enable full assessment and accountability of the technology product and fundamental findings with respect to their value toward reaching NASA’s goals. Existing design and nondestructive evaluation (NDE) techniques are expected to be used when applicable. A relevant commercially available extraterrestrial simulant that mimics the silicate and oxide minerals in regolith and/or the volatiles in the lunar permanently shadowed regions or martian surface and atmosphere is expected to be used for structure construction. Lunar materials,
components, and systems that would be necessary for the proposed technology must be able to operate on the lunar surface (with thermal mitigations) in temperatures up to 110 °C (230 °F) during sunlit periods and as low as -170 °C (-274 °F) during periods of darkness. Martian materials, components, and systems must be able to operate on the martian surface in a CO$_2$-rich atmosphere (with thermal mitigations, if necessary) in temperatures up to 20 °C (70 °F) and as low as -153°C (-225 °F). Systems must also be able to operate for at least 1 year with a goal of 5 years without substantial maintenance in the dusty regolith environment. Proposers should assume that operations involving other systems (e.g., robotics) and future astronauts will be ongoing not more than tens of meters away from the local fabrication and construction activities (i.e., minimization of dust generation is expected).

**Expected TRL or TRL Range at completion of the Project**

3 to 5

**Primary Technology Taxonomy**

**Level 1**

TX 12 Materials, Structures, Mechanical Systems, and Manufacturing

**Level 2**

TX 12.X Other Manufacturing, Materials, and Structures

**Desired Deliverables of Phase I and Phase II**

- Research
- Analysis
- Prototype
- Hardware
- Software

**Desired Deliverables Description**

Phase I deliverables may be a conceptual design with analysis to show feasibility at relevant scales and/or a small demonstration of the concept.

Phase II deliverables should be hardware demonstrations at a relevant scale. See Scope Description for additional information on Phase I and Phase II deliverables.

**State of the Art and Critical Gaps**

Planetary surface construction is not a current capability. The state of the art is terrestrial-based construction technology, e.g., cement, wood, and steel forms and terrestrial additive construction.

**Relevance / Science Traceability**

The work desired applies to Technology Taxonomy (TX) Area 7: Exploration Destination Systems. It applies to 2018 NASA Strategic Plan Strategic Goal 2: Extend Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization. It also applies to the Plan's Strategic Objective 3.1: Develop and Transfer Revolutionary Technologies to Enable Exploration Capabilities for NASA and the Nation.

**References**

Construction of Infrastructure. Earth and Space 2021 (pp. 1141-1155).