National Aeronautics and Space Administration

BIG IDEA CHALLENGE

2019 Call for Proposals: Marsboreal Greenhouse Design

The BIG Idea Challenge is a university-level design competition sponsored by NASA's Space Technology Mission Directorate's Game Changing Development Program and managed by the NIA. **To participate, university teams of up to 8 students will submit proposals on ideas/concepts for the design and operation of a Mars Greenhouse.** Selected teams will be invited to present their concepts to a panel of NASA and industry judges at the 2019 BIG Idea Forum in April at the NASA Langley Research Center in Hampton, VA.

Breakthrough, **I**nnovative & **G**ame-changing Idea Challenge

Context for the 2019 BIG Idea Challenge Theme

Potential human missions to the Martian surface in the 2030s will require systems for effective food production. Access to fresh food will promote crew health and greatly reduce the logistics requirements to support crews on the long surface stays required for a Mars mission.

In 2016/17, the Mars Ice Home feasibility study developed a cost-effective inflatable habitat concept that provides the large flexible workspace needed for an early Martian outpost. A key innovation of the Mars Ice Home design is the utilization of ISRU-derived water ice as shielding from Galactic Cosmic Rays. This type of high energy radiation poses a serious health risk to crews living and working on the surface of Mars. The Mars Ice Home design can be adapted for use as a greenhouse to support an early Mars mission.

NASA has funded many crop cultivation/food production studies to support astronauts in space and now we need to develop an effective greenhouse design that can support an early Martian outpost. This is a multi-disciplinary systems engineering effort that will incorporate information from the many studies done earlier and develop an overall systems approach for a credible greenhouse on Mars.

2019 BIG Idea Design Guidelines and Constraints

This solicitation seeks innovations in the design, installation, and sustainable operation of a Mars greenhouse. The Mars greenhouse should complement the unique design of the Mars Ice Home and adapt some of the innovative features for a "greenhouse" to help support a crew of 4 on a 600-day surface mission. This greenhouse design should respond to and provide a vision for the plausible use of plants for space missions and incorporate as much as possible from In-Situ Resource Utilization (ISRU). The designs should indicate the potential optimization and efficiencies to use plants for food production and also for supporting Environmental Control and Life Support Systems (ECLSS). Designers must consider ease of fabrication, ease of deployment, technology readiness, and operations in Martian environments in their designs. ***Designs should propose a habitat size, form, and systems design concept which provides the surface area and volume needs for efficient plant production balanced with the volume and mass constraints of an inflatable structure-based construction.***

Important Dates

- Notice of Intent Deadline: October 5, 2018
- Proposal Deadline: January 6, 2019
- Selection Notifications: January 25, 2019
- Technical Paper Deadline: March 25, 2019
- 2019 BIG Idea Forum: April 9-10, 2019

Eligibility

Undergraduate and graduate students studying at an accredited U.S.-based university (up to 8 people per team). ***Please carefully review the foreign national restriction policy under "Eligibility" on the BIG Idea website for full details.***

Participation Awards and Prizes

The BIG Idea Challenge offers a $6,000 participation stipend to each of the final 5 teams to present their concepts at LaRC in April 2019 at the Big Idea Forum.

NASA is also setting aside up to 5 summer internships for students on teams that advance to the BIG Idea Forum. Selections will be based on the cumulative merit of each student's individual internship application and availability for summer internships.

Specific Operational Guidelines and Constraints

The primary purpose of this greenhouse will be **food production**. Designs should size the habitat based on (and provide information on) their crop and growth systems choices including:

- Crop selection for nutritional requirements
- Nutrition requirements for crew of 4 and the ability of the on-site greenhouse to supplement food supplied from Earth (food production capability)
- Surface area, volume, and edible biomass density of planted area of the selected crops and growth systems
- Growth time, harvest cycles and efficiencies of the selected crops and growth systems (based on species, genetic or growth system enhancements or adaptations)
- Systems requirements including water, nutrients, lighting, etc.
- Identify automated tasks and manual tasks in an operational context

Plant Systems Design and Systems Integration

The Mars greenhouse should respond to the unique design of the Mars Ice Home's exterior skin, and provide designs which will integrate the necessary systems in a way that complements the Ice Home's design optimizations (see website for full listing of required systems).

Alignment with latest NASA Mars Architectures and habitation concepts

- Teams should align with the latest NASA Mars Architecture documents and must clearly state the assumptions made that support their design.
- Teams should utilize information from the Mars Ice Home ConOps as a starting point for their greenhouse design.

Resources

Please visit the *Resources* section of the *Competition Basics page* on the BIG Ida website for references useful in developing your BIG Idea Challenge concept.

BIG Idea Projects should give special attention to:

- Innovative design
- Creative operational approaches
- Use of technologies that could be ready for use on Mars in the early 2030s
- Effective packaging for launch and Mars landing
- Effective and reliable deployment methods
- Credible fabrication and material selection
- Concept of Operations (ConOps)
  - The design package must include a Mars Greenhouse ConOps that clearly describes the complete life cycle, including all design assumptions and address fabrication, transport, deployment, and operations. The format of the Mars Ice Home ConOps can be used for an abbreviated Greenhouse ConOps.

Systems Engineering Assumptions

The challenge website provides recommended assumptions, however, teams can adjust these assumptions if a good rationale to do so is provided.

Starting point assumptions include:

- **Land mass:** Less than 18,000 kg.
  - This mass limitation was recommended by Entry, Descent, and Landing (EDL) experts as the maximum amount that currently planned technologies could deliver to the Martian surface.
- **Resource margins for future growth:** 30%
  - As with any space flight project, the team should maintain reasonable resource margins (Mass, Volume, Power, etc.) for future growth. A 30% resource margin is a typical number during the early design phase.
- **Placement:**
  - The packaged inflatable greenhouse will be robotically transported from the landing zone to the habitation zone and connected to the Ice Home habitat via the attachment interface. The airlock connection will have interfaces for water, power, command and data, and filtered air. Once connected to the Ice Home habitat, the greenhouse will be inflated via remote commands.
- **Water Production Rates:** 0.1 cubic meter per day
  - Credible ISRU water production rates must be considered during deployment and operation. Consider operations that produce some food early and ramp up as more water becomes available for production and radiation shielding. A water production rate of 0.1 cubic meter per day (~100 kg) is a good starting point for your assumptions.
- **Deployment:** Pre-deployed with simple robotics
  - The deployment aspects should consider integration into an early Martian outpost, outfitting, and also crewed and/or robotic operations. The greenhouse design should simplify the initial deployment so that it can be done with simple robotics. The design should minimize set-up time after crew members arrive so that food production can begin shortly after arrival. Launch opportunities to Mars occur every 25-26 months. This should be considered for pre-deployment.

These are abbreviated guidelines.
Please see the challenge website for additional food production, design, and systems engineering assumptions and considerations.

The Game Changing Development Program is a part of NASA's Space Technology Mission Directorate. *The Program advances space technologies that may lead to entirely new approaches for the Agency's future space missions and provide solutions to significant national needs. The program will focus efforts in the mid Technology Readiness Level (TRL) range of (3-5/6) generally taking technologies from proof of concept through component or breadboard testing in a relevant environment. The program employs a balanced approach of guided technology development efforts and competitively selected efforts from across academia, industry, NASA, and other government agencies. The program strives to develop the best ideas and capabilities irrespective of their source.*

gameon.nasa.gov

For more information, visit

http://BIGidea.nianet.org