NASA Centennial Challenges Program:

A crowdsourcing tool to advance life support technologies for future NASA missions

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About Us

- NASA's first and biggest prize program
- Established to conduct prize competitions in support of NASA programs
- Inspired by Orteig Prize and Ansari X Prize, among others
- Established (per NASA Prize Authority, 51 USC 20144): "to stimulate innovation in basic and applied research, technology development, and prototype demonstration that have the potential for application to the performance of the space and aeronautical activities of the Administration."

NASA Prize Authority

- Owner: STMD
- Result: Technology development & demonstration
- Prize: Million+ , US Winners only
- Timeframe: Multi-year
- Partner: non-profit only; can fund additional prize purse

NASA Crowdsourcing Initiatives

	Centennial Challenges	NTL NASA Tournament Lab	International Space Apps Challenge	Citizen Science	NASA Education	NASA@Work
Duration	Years	Months	Days/Weeks	Months	Months	Weeks
Awards	$100K+ to $Ms	$1K to $250K	Recognition	Recognition	Varies	Recognition
Products	Technology demos	Ideas, design, software	Software apps/tech concepts	Scientific observations and analysis	Design	Ideas, info
Who	US-led (to win prize)	Worldwide; US-led (COMPETES)	Worldwide	Worldwide	Students (US)	NASA
Authority	NASA prize authority	Procurement; COMPETES Act	Space Act	Amer. Innov. and Competitive ness Act	Space Act; grants & cooperative agreements	N/A

SOLVE These opportunities can be accessed at www.nasa.gov/solve





centennialchallenges

Summary of Program Competitions

centennialchallenges

Completed

3D-Printed Habitat $3,150,000

Completed 5/2019

Additive construction technology for space

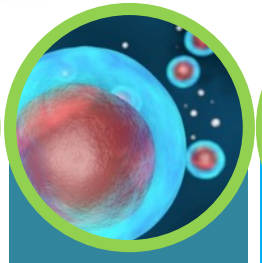
- $2,060,000 awarded
- 120 teams
- Allied Organization: Bradley University. Sponsors: Caterpillar Inc., Bechtel Corp, Brick and Mortar Ventures

Active

Cube Quest $5,000,000

Flight-qualified CubeSats near and beyond the moon

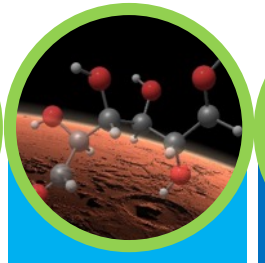
- $460,000 awarded
- 15 U.S. teams
- Innovative propulsion and comm-unication
- 3 payload slots on SLS EM-1
- NASA Led Challenge



Vascular Tissue $500,000

Viable thick tissue for research

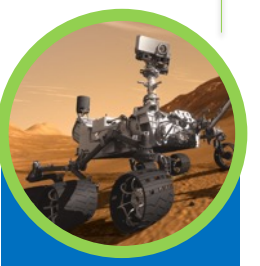
- 13 U.S. teams currently registered
- Innovation in engineered tissue that can stay viable for more than 30 days
- Allied Organization: New Organ Alliance



CO_2 Conversion $1,000,000

Bio-manufacturing from in-situ resources

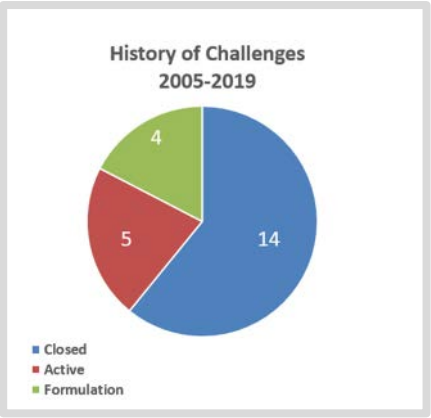
- $250,000 awarded (Phase 1)
- 17 teams
- Phase 2 target open date August 2019
- HEOMD collaboration
- NASA-led Challenge (STMD/ HEOMD)

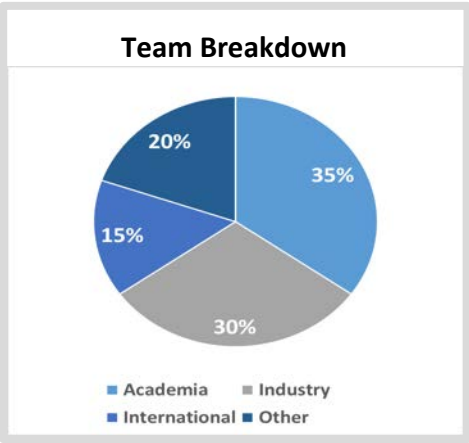


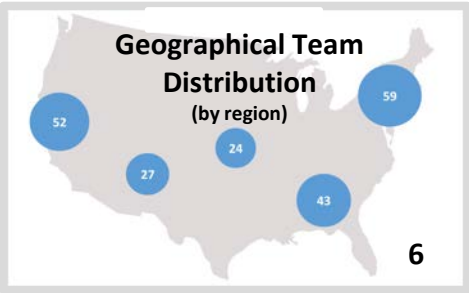
Space Robotics $1,900,000

Advance robotics software for full autonomous operations

- Multi-robotic systems working together in short-term and long-term ISRU missions.
- Phase 2 target open date in August 2019
- Allied Organization: Space Center Houston



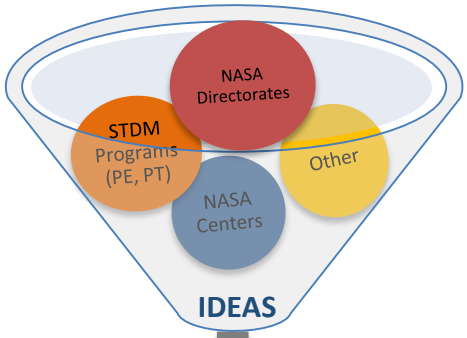




centennialchallenges

Centennial Challenge Program*
(Dedicated NASA Team)
Stimulate innovation in basic and applied research, technology development, and prototype demonstration that have potential NASA applications.

*NASA Prize Authority



NASA Senior Management approves development of the competition

Who is in charge?

NASA
- **Leads**
- **Prize Purse**

+

Allied Organization/ No-Profit
- **Registrations**
- **Runs competition**
- **Judges**

What is different?
- Insurance and Indemnification obligation
- Fed Register Notice
- NASA has no rights in solutions

Who designs the Challenge?

- **NASA**
- **Allied Organization**
- **SME's (NASA, Other Gov Agencies, industry)**

- **Hard to solve technology gaps**
- **Create community of solvers and interaction with SMEs**
- **Media Interest in competition**

Evaluation Criteria

Clearly defined before competition opens

NASA Interacts with competitors throughout the competition

Competitions & Prizes: Overview

Innovation challenges can help us leverage the crowd to overcome our biggest hurdles

- **Proven tool** for innovation for >300 years
- **Inspire** and **incentivize** positive action
- **Focus communities** and **foster collaboration**
- Leverage funding and **investment**
- Democratize innovation and **encourage new ideas**
- **Reduce risk**
- Influence **public perception** and activate the public

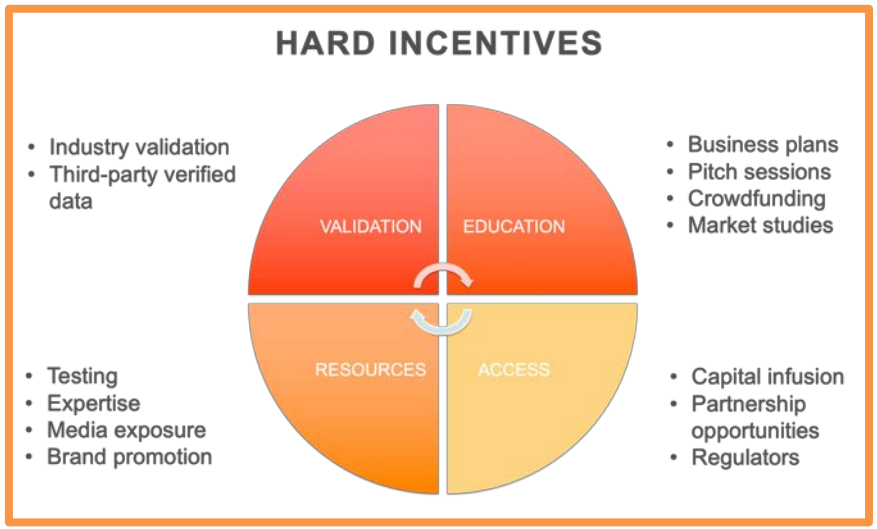
Competitions & Prizes: Best Target Areas

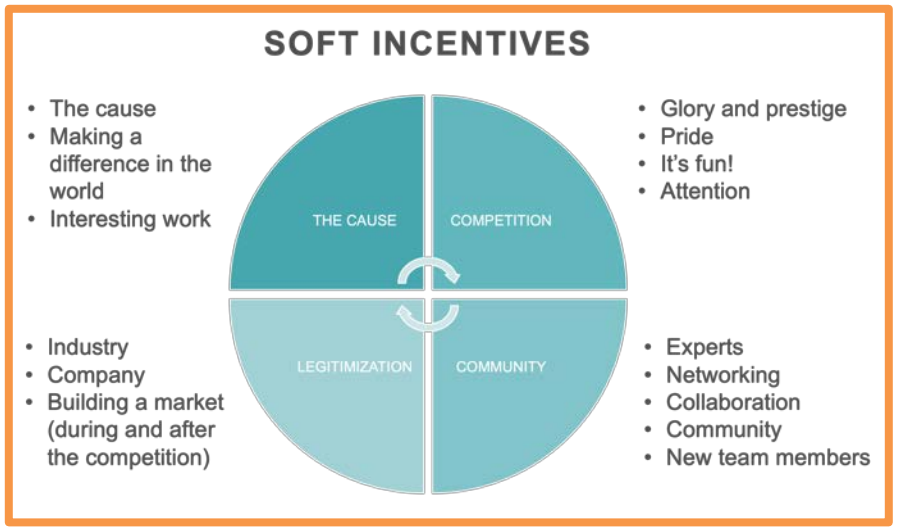
- Complex opportunity that may require multiple attempts
- Opportunity that is not being solved in the marketplace or by governments quickly enough; lack of relevant incentives?
- The means by which the problem or opportunity will be solved are unknown or too speculative for traditional research, contracts, or grants
- Opportunity where it is not known who will develop the best solutions or where the best solutions will come from
- Opportunity that is not purely regulatory or political

Competitions & Prizes: Best Design Practices

- Define the problem, not the solution
- Define an audacious but achievable target
- Offer a clear measure of success
- Design to have a media-friendly winning moment, and tell great stories along the way
- Design for after the prize is won
- Make it easy for you to operate
- … And rewarding and simple for teams to compete

Provide more than a prize purse





What motivates people to compete?

Guts

Glory

do Good

Gold

Challenges in Formulation

StarHab

$4,000,000

GOAL:
Addressing technology gaps in nutrition and life support systems for future planetary missions.

Lunar ISRU

$5,000,000

GOAL:
In Situ Resource Utilization (ISRU) competition targeting a large scale, end-to-end demonstration.

Planetary Protection

$250,000

GOAL:
Detection of microorganisms to confirm compliance with planetary protection requirements.

Lunar Power

$5,000,000

GOAL:
Portable energy storage competition to enable powering a rover through several cycles of lunar daylight and darkness.

How do we provide astronauts with:

- A viable food system for long duration missions?
- An approach that meets their daily nutritional needs in a confined space?
- A palatable diet with limited or no dependency on Earth resupplies?
- A ‘harvest’ that provides a variety of fresh food choices?

Why A Prize-based Challenge?

This challenge competition seeks to leverage open-source innovations in areas like genetic modification of crops to address nutrition optimization and food production.

The problems can be approached from numerous angles and with a broader pool of potential solutions

- Attract new “eyes” and new perspectives from new and sometimes unexpected places
- Solvers dedicate their own resources and NASA only awards the prize funds for successful outcomes
- Develop techniques to optimize indoor agriculture that will be useful on Earth as well as in space

NASA Technology Gaps

- Stored food degrades over time; vitamins and micronutrients are space labile. Enjoyable, desirable food is critical for crew physical and mental health, but processing (dehydration, retort) change texture and palatability
- Current crews frequently get fresh food delivered with stored food, but the cost of this type of resupply is not sustainable.
- ISS payloads are small scale, science focused, and only sometimes are used to produce food crops.
- Growing food crops in space has had mixed success, and is not yet reliable or predictable enough to be a critical system in the spacecraft
- Limited number of crops have been demonstrated, and models and predictions are limited.
- Spacecraft do not currently accommodate mass, volume and water needs of food production
- Stored food dominates logistics needs for space missions, but using existing NASA technologies is not a positive mass trade.

StarHab Formulation Process

STEP ONE: Assessment of the Current State-of-the-Art Technology

- We interviewed experts internal and external to NASA
  - *Centennial Challenge Program Team*
  - *Plant Research Team at KSC*
  - *17 Experts from NASA, industry and academia*
  - *Relevant literature and internal NASA documents*
- Purpose: to identify potential areas of opportunity to help frame the discussions at the Ideation Workshop

STEP TWO: Ideation Workshop

- 36 Experts from NASA, industry and academia were invited to KSC on December 4, 2018
- Purpose: to discuss, validate and prioritize the potential areas of opportunity from the assessment

STEP THREE: Outcomes

- Based on outcomes from the Workshop, we developed three (3) options for the topic and potential structure of the StarHab Challenge
- Purpose: to identify a potential Challenge based on researched, vetted, and validated topic areas

Overview Of Workshop Results

Technology areas selected through the formulation process included:

1. FOOD PRODUCTION EFFICIENCY

- *Cost effective*
- *Energy efficient*
- *Optimization of height/volume/density, water, nutrients, light*
- *Automation and control*
- *Efficient use and recycling of water*

2. PLANT MODIFICATION

- *Optimized for nutrition*
- *Effectiveness, efficiency*
- *Engineer plants to fit a given environment*
- *Plant sensing*
- *Molecular farming*

3. VERIFIED MODELS FOR MARS PLANNING

- *Modeling ECLSS and air/water/plant integration*
- *Big data analysis*
- *Develop models and applications for remote operations*

From these, the team was able to identify potential StarHab challenges that are based on researched, vetted and validated topic areas.

StarHab: Proposed Challenge Options

- Concept #1: Comprehensive
  - Two phases
  - First phase lays the groundwork for the full development of the teams' solutions in the second phase
  - The same teams would continue throughout the entire competition and NASA would commit to launching the entire competition.
- Concept #2: Staged
  - Large-scale, staged competition with phases
  - Each of the phases builds upon the previous phase
  - Could be launched through just the first phase, through the first and second phases, or through all three phases
  - Phases are designed to build upon each other to eventually reach an audacious outcome
  - Teams can choose to participate in all phases that are launched or exit or enter at any phase
- Concept #3: Building Blocks
  - Multiple separate challenges that can run simultaneously or one at a time
  - Although designed to be independent of each other (and therefore can be launched in parallel or sequentially and any can be launched with or without the others), they are also designed to complement each other
  - If more than one is launched, the aggregate value will exceed the value of the individual challenges

Proposed Competition Structure

PHASE ONE: IDEATION CHALLENGE

Large segments of the public will compete in one or a series of ideation competitions. Submissions will be scored and prizes awarded.

PRIZE PURSE: $100,000
DURATION: 6 months

Food must be considered as a system-level issue

Key formulation question: What parts of the diet are set as fixed by NASA?

Top Competitors Proceed

PHASE TWO: SUBSCALE PROTOTYPE

Teams will design system models, validate key items, and be scored. Top teams will be awarded a prize and be invited to compete in Phase 3.

PRIZE PURSE: $1,500,000
DURATION: 12 months

Developers will have to make trade-offs

Key formulation question: How do we weight multiple performance parameters?

PHASE THREE: DEMONSTRATION

Selected Teams from Phase 2 will develop full size prototypes of their systems and operate over a given duration for multiple cycles.

PRIZE PURSE: $2,000,000
DURATION: 18 months

Reliability & human acceptability are critical

Key formulation question: How long is the demo and can people safely eat the products?

Status and Plan Forward

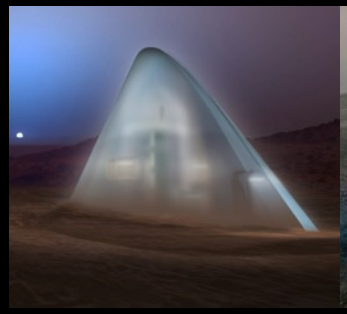
- The challenge competition was approved by STMD Senior Management to start the process of development
- NASA customers will be working with the Centennial Challenge Program team to develop a path forward that will be presented to STMD to start the looking for an Allied Organization
- If approved by management after the challenge is developed, it is expected to open for registration late summer/early fall

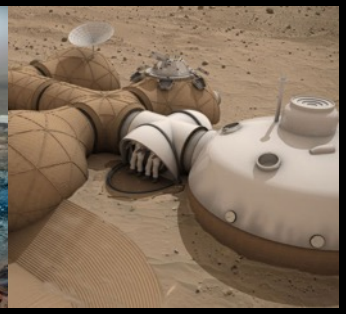
Daring you to ask

What if?


What will home look like ...
on Mars?
www.nasa.gov/3DPHab

2nd Place
Team Gamma





1st Place
SEArch/Clouds Architecture Office

3rd Place
Lava Hive

3DPH Challenge Phase 1: Design
7/2015- 9/2015
Prize Purse: $50,000/$40,000 awarded

Develop state-of-the-art architectural concepts that take advantage of the unique capabilities offered by 3D printing.

3DPH Challenge Phase 2: Material
6/2016- 5/2017
Prize Purse: $1,100,000/$701,000 awarded

Autonmously 3D Print structural components using terrestrial/space based materials and recyclables.

Level 1

Level 2

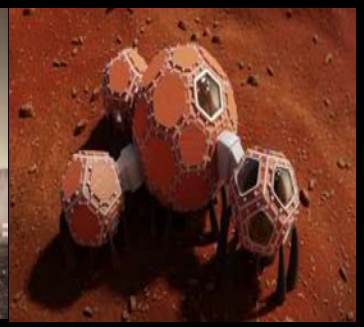
Level 3

2nd Place
Penn State

1st Place
Branch Technologies

Level 4: Virtual Construction (Building Information Model/BIM)

2nd place
Zopherus



1st Place
SEArch+ / Apis Cor

3rd place
Mars Incubator

3DPH Challenge Phase 3: Build it
11/2017- 5/2019
Prize Purse: $2,000,000/$1,320,000 awarded

Level 5: Demonstrate an autonomous additive manufacturing system that can create a complete habitat.

PennState

SpaceFactory
design | construction | advisory

The PSU construction approach utilized two robots, one for placement of components and one for printing the concrete-like structure.

Habitat crush test. Notice excavator treads off of the ground!

Completed Habitats

3D Printed Habitat Recap

Acknowledgements

The authors would like to thank all parties that contributed to the assessment process and all of the experts that participated in the formulation discussions that resulted in the proposed options for the StarHab Challenge.

Questions?

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BACK-UP CHARTS


What if a long-distance call could reach a new world?
www.nasa.gov/**cubequest**


What if your coworkers came with batteries?
www.nasa.gov/**spacebot**


What if space
held the key to
revolutionizing medicine
for better health?
www.nasa.gov/tissueprize


What if creating
a new material
started with a
single breath?
www.nasa.gov/co2challenge