



Daring you to ask

# What if?







Centennial Challenges

Monsi Roman and Denise Morris



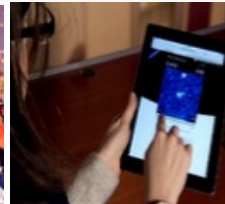


## NASA Crowdsourcing Initiatives

						
<b>Duration</b>	Years	Months	Days/Weeks	Months	Months	Weeks
<b>Awards</b>	\$100K+ to \$Ms	\$1K to \$250K	Recognition	Recognition	Varies	Recognition
<b>Products</b>	Technology demos	Ideas, design, software	Software apps/tech concepts	Scientific observations and analysis	Design	Ideas, info
<b>Who</b>	US-led (to win prize)	Worldwide; US-led (COMPETES)	Worldwide	Worldwide	Students (US)	NASA
<b>Authority</b>	NASA prize authority	Procurement; COMPETES Act	Space Act	Amer. Innov. and Competitive ness Act	Space Act; grants & cooperative agreements	N/A



These opportunities can be accessed at [www.nasa.gov/solve](http://www.nasa.gov/solve)







**STMD's Prizes and Challenges Program supports the use of public competitions and crowdsourcing as tools to advance NASA R&D and other NASA needs.**

- Consists of three elements:

- Prizes and Challenges (P&C):** Facilitates NASA's successful use of prize competitions, challenges, and crowdsourcing by serving as a program that houses information, budget and guidance for many of NASA's crowdsourcing activities.

- NASA Tournament Lab (NTL):** Enables NASA employees to use crowdsourcing approaches to procure novel ideas or solutions to serve R&D and other efforts in support of the NASA mission.

- Centennial Challenges (CC):** Stimulates research and technology solutions to support NASA missions and inspires new national aerospace capabilities through public prize competitions.



## About Us

- NASA's first prize program
- Established to conduct prize competitions in support of the Vision for Space Exploration and ongoing 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.”



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

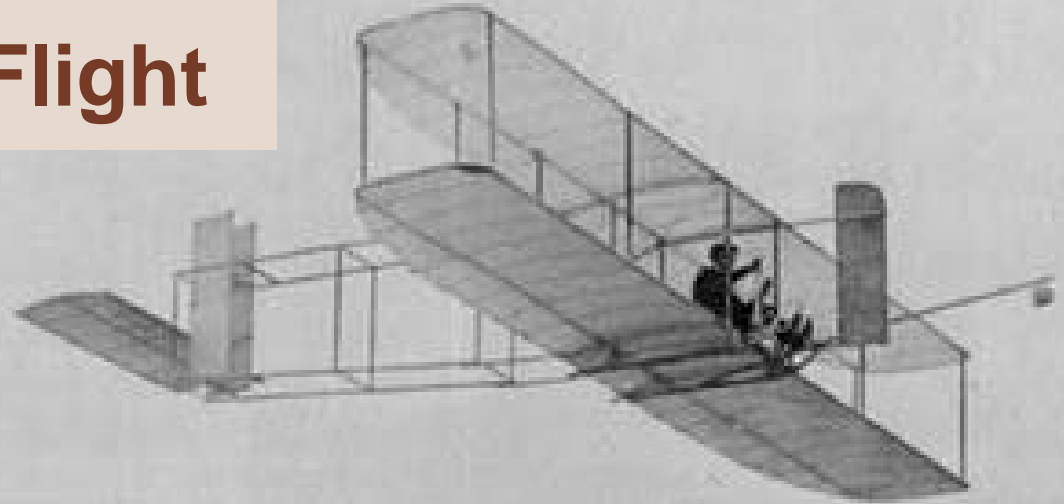


## Centennial Challenges

- Although the first competition was started in 2005, development of the program started in 2003 to commemorate ...



# The Centennial of Flight



## The Wright “Flyer”

An aircraft built of wood, powered by hand made propellers flew at Kitty Hawk, North Carolina, on December 17, 1903, making a 12-second flight.

... when life looked like this.





At the turn of the century, it was probably hard to imagine this ...





# centennial challenges



In the early 1900s, brothers and bicycle builders Wilbur and Orville Wright revolutionized the world with the first successful airplane.



# centennial challenges



## Goal:

Stimulate research and technology solutions to support NASA missions and inspire new national aerospace capabilities through public prize competitions.



## Objectives:

- Expand the pool of potential solutions to meet identified NASA research and technology needs
- Stimulate new capabilities and commercial markets for the Nation
- Cultivate a broader, more diverse community of innovators contributing to NASA and aerospace activities

# centennial challenges



## Summary of Program Competitions by Calendar Year (2005–2019)

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021



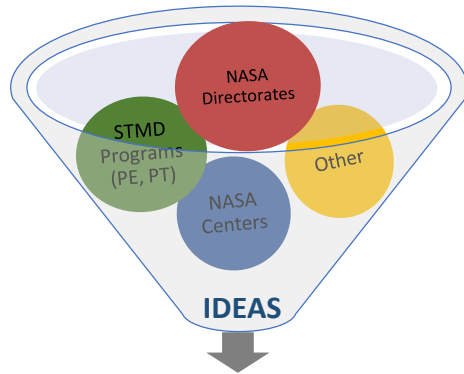


## Centennial Challenge Program\*

(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/  
Non-Profit

- Registrations
- Runs competition
- Judges

## Who designs the Challenge?



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

## What is different?

- Insurance and Indemnification obligation
- Fed Register Notice
- NASA has no rights to the Intellectual Property (IP)

- 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



# centennial challenges



## 3D-Printed Habitat

\$3.1M prize

Additive construction for in-space habitats using regolith and recyclables.

Completed in May 2019

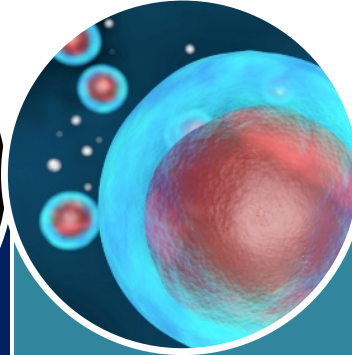


## Cube Quest

\$5M prize

CubeSat propulsion, communication around Moon and into deep space.

Top 3 teams awaiting EM-1 ride.

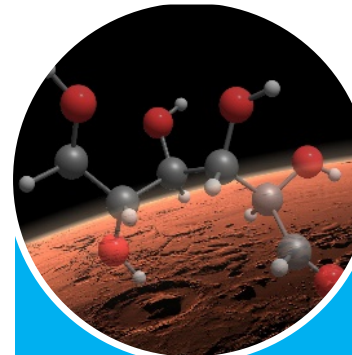


## Vascular Tissue

\$0.5M prize

3D-printed human organ tissue to advance medicine in space and on Earth.

First-to-demonstrate.



## CO<sub>2</sub> Conversion II

\$1.0M prize

Bio-manufacturing from in-situ resources on Mars.

Phase 2 Opened September 2019.



## Space Robotics II

\$1.9M prize

Autonomous robotic navigation and decision systems for ISRU tasks.

Phase 2 Opened August 2019.



## Program Impacts



- People: Inspiring a Workforce for NASA and the Nation
- Engages NASA workforce into implementation of innovative solutions
  - Invite experts outside of NASA to push State of the Art
  - Develop entrepreneurs for space and earth applications



- Technology: Accelerating Development/ Raising the Bar
- Promote technical exchanges
  - Advance the nation's capabilities/solving complex technology needs
  - Demonstrate a variety of technology solutions



- Innovation: Involving the Nation
- Involve non-traditional participants; paying only for success
  - Combine expertise across diverse disciplines
  - Foster commercial applications among participants



- Communication: Reaching the Public
- Engage communities in NASA missions
  - Communicate NASA's message to industry and the public
  - Garner media attention for NASA and participants





What  
motivates  
people to  
compete?



Guts.



Glory.



do Good.



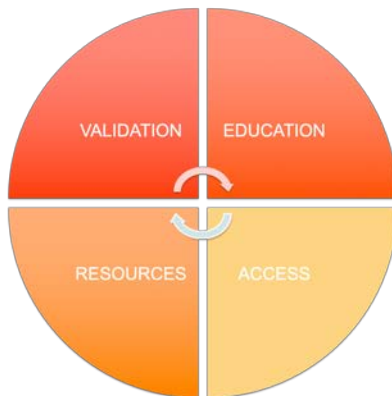
Gold.



## Provide more than a prize purse

### HARD INCENTIVES

- Industry validation
- Third-party verified data



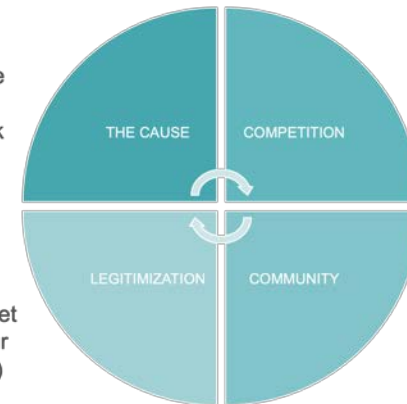
- Business plans
- Pitch sessions
- Crowdfunding
- Market studies

- Capital infusion
- Partnership opportunities
- Regulators

- Testing
- Expertise
- Media exposure
- Brand promotion

### SOFT INCENTIVES

- The cause
- Making a difference in the world
- Interesting work

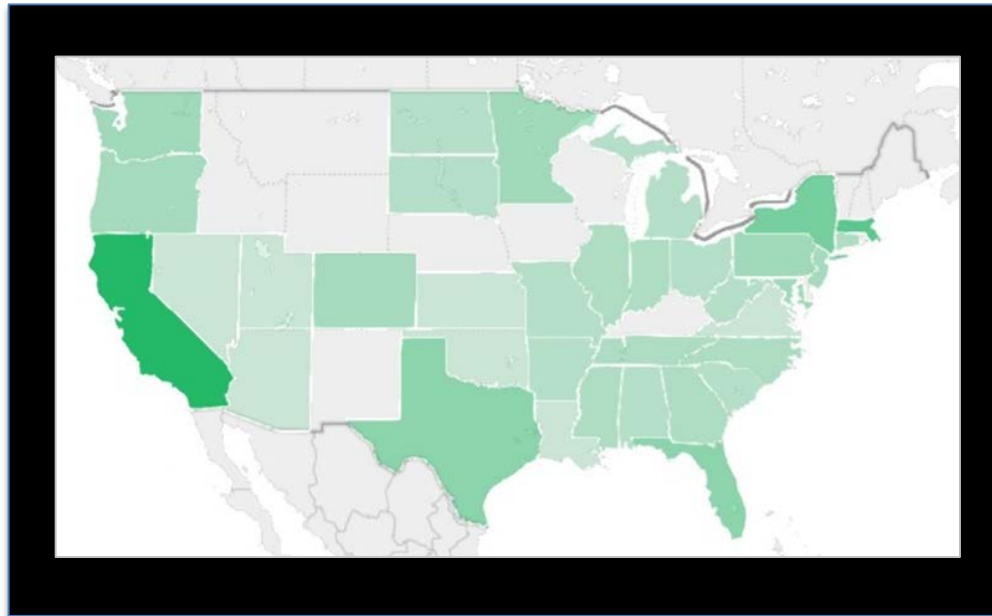


- Glory and prestige
- Pride
- It's fun!
- Attention

- Industry
- Company
- Building a market (during and after the competition)

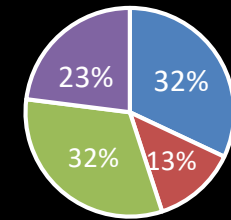
- Experts
- Networking
- Collaboration
- Community
- New team members

# centennial challenges



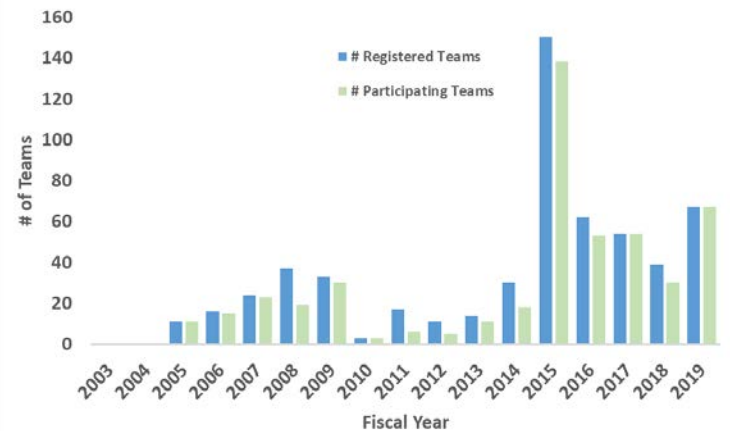
## PARTICIPANTS

### FY19 Team Affiliation



- Academia
- International
- Industry
- Other

### # of Registered and Participating Teams/Year





**SUMMARY OF  
ACTIVE CHALLENGES**



What will home  
look like ...  
on Mars?







## 3D-Printed Habitat Challenge



### 3D-Printed Habitat

**TOTAL PRIZE PURSE:**  
\$3,150,000

#### GOAL:

Advanced additive construction technology to build sustainable shelters on moon and Mars.

#### PHASE 1: Completed

\$50,000 Prize Purse  
Design concepts

#### PHASE 2: Completed

\$1,100,000 Prize Purse  
Focused on material and structural components

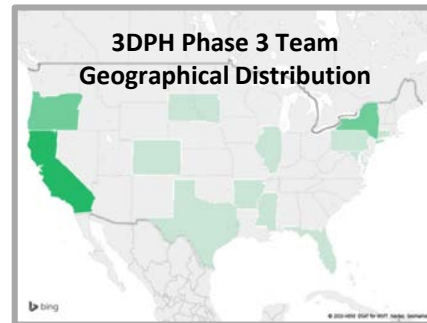
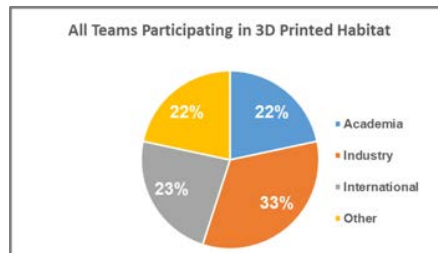
#### PHASE 3: Completed

\$2,000,000 Prize Purse  
Build a subscale (1/3) Mars Habitat

### OVERVIEW

- 3 Phases of competition: Design, Structure, and Subscale Habitat
- Challenge completed 5/4/2019
- \$2.06M awarded (66% of total PP awarded)
- 61 teams participating; hundreds applied
- **Allied Organization:** Bradley University
- **Sponsors:** Caterpillar, Bechtel, Brick & Mortar Ventures, US Corps of Engineers
- Lead Centers MSFC and KSC

### METRICS



### HIGHLIGHTS



Subscale 3D Printed Mars Habitat. Second place winner, Penn State (left); First place winner AI Space Factory (right)

This competition garnered interest from industry, investors and media. Automated vertical 3D-printing disrupts/streamlines traditional construction, increases efficiency and decreases cost.

**The program had an amazing experience working with the Allied Organization who invested ~ 70% of the competition funding.**

*"B&M Venture's involvement in this challenge contributed to our investment in Branch Technology. Branch Technology's growth, recognition and partnerships greatly benefitted as a result of the competition. Additionally, every meeting I attended for The Society for Construction Solutions -- across Australia, USA, and Tel Aviv -- everyone wanted to get an update on space construction technology. Personally, I couldn't think of a better use of my time than to meet people with a selfless driving force to develop science into technology solutions."*

- Curtis Rodgers, Principal, Brick & Mortar Ventures



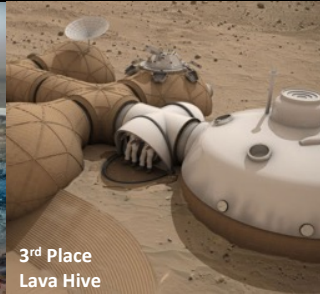
## 3D-Printed Habitat Challenge



1<sup>st</sup> Place  
SEArch/Clouds Architecture  
Office



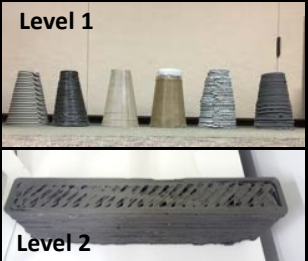
2<sup>nd</sup> Place  
Team Gamma



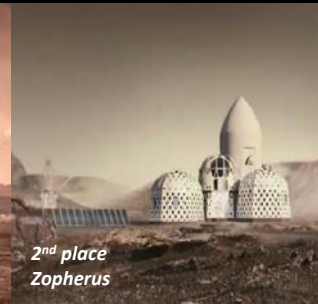
3<sup>rd</sup> Place  
Lava Hive

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



1<sup>st</sup> Place  
SEArch+ / Apis Cor



2<sup>nd</sup> place  
Zopherus



3<sup>rd</sup> place  
Mars Incubator

**3DPH Challenge Phase 3**  
11/2017- 5/2019  
**Prize Purse: \$2,000,000/\$1,320,000 awarded**  
Level 4: Virtual Construction (Building Information Model/BIM)





## 3D-Printed Habitat Challenge

1st Place – Al. Space Factory (New York City, NY)



2nd place: Pennsylvania State University (University Park)



3DPH Challenge Phase 3  
Level 5: Demonstrate an autonomous additive manufacturing system to create a habitat.

### Media Engagement:

- Phase 3 generated **408** media features resulting in an estimated **113.5 million** viewers.
- The Facebook Live broadcast of the head to head competition had **1,936 views**.
- Media coverage included **CNN, Business Insider, Fox News, Popular Mechanics, and Popular Science.**

## Technology Highlights

- Demonstration of safe and innovative new **material** compositions for 3D printing pressure vessels on a large scale with application to NASA missions and Earth construction.
- Demonstration of **processes and equipment** for large-scale vertical autonomous construction.
- Diversity/innovation in viable **designs** of realistic planetary Habitats.
- Innovative use of modeling software common to the construction industry as a more **comprehensive design tool** than the software commonly used by the aerospace industry for Additive Manufacturing technologies.
- Demonstration of new **software and control algorithms** for depositing material in a non-two dimensional layer.



## 3D-Printed Habitat Challenge Recap







## 3D-Printed Habitat Challenge Phase 3: Level 5 Winners



**AI Space Factory**  
1<sup>st</sup> Place



**Pennsylvania State University – 2<sup>nd</sup> Place**

*“This has been the perfect challenge, with over 60 teams competing and the final designs are amazing. They are far beyond our current state of knowledge and will greatly impact our lunar and Mars mission architecture for manufacturing and construction. Great job by your team! I can’t wait until the next one.”*

-- John Vickers, Principal Technologist, STMD





## 3D-Printed Habitat Challenge

### How will a challenge competition impact a team?

*"I personally wanted to reach out and thank you for your support of our SEArch+ team again in the recent Phase 3 Centennial Challenge.*

***These competitions have been life changing in so many ways and your leadership role has been a critical key to our success and on-going progress.***

***In addition to the avalanche of press, international museum exhibitions and speaking engagements that the Centennial Challenge competitions continue to generate for us, there is a fantastic 'big collaboration opportunity' for SEArch+ , in partnership with NASA, now on our horizon..."***

- Team SEArch+ e-mail 6/4/2019

*"Participating in the NASA's 3D Printed Habitat Centennial Challenge was one of the more catalytic experiences that ICON has gone through as we continue to develop what we believe will be a paradigm shifting technology.*

*This program has been a model for what it can look like for large government agencies to engage innovative private-sector enterprise in serious work. Our company is better for having participated in the Centennial Challenge."*

- Jason Ballard, CEO, Co-Founder, ICON


AI SpaceFactory Retweeted



Jeffrey Montes  
@jetportal

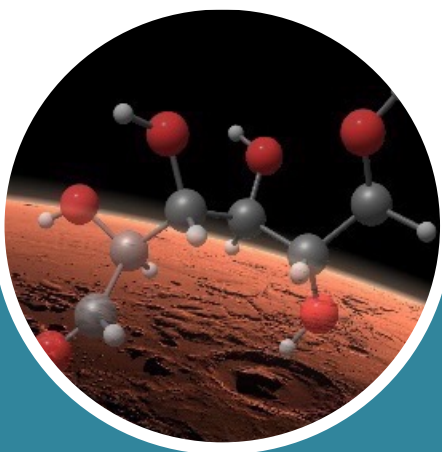
We made it to the print edition of [@PopSci](#) and it starts with "Jeffrey Montes stands high on a ladder in the middle of a dirt-floored arena, squinting at the oculus of what looks like the world's largest vase." wai-wait. what? que? [#dreamysentence](#) by [@meganigannon](#). Gooooo Marsha!



A woman wearing a purple jacket and a grey knit hat with a red trim is shown in profile, looking towards the right. Her hands are clasped together in front of her. The background is a bright, hazy sunset or sunrise over a landscape, with the sun low on the horizon, creating a warm, golden glow. The overall mood is contemplative and hopeful.

What if creating  
a new material  
started with a  
single breath?





## CO<sub>2</sub> CONVERSION

TOTAL PRIZE PURSE:  
\$1,000,000

### GOAL:

Biomanufacturing capability using in-situ resource of carbon dioxide.

### PHASE 1: *Completed*

\$250,000 Prize Purse  
Design concept for conversion of CO<sub>2</sub> to sugars

### PHASE 2: *About to Open*

\$750,000 Prize Purse  
Build and test system for conversion of CO<sub>2</sub> to sugars

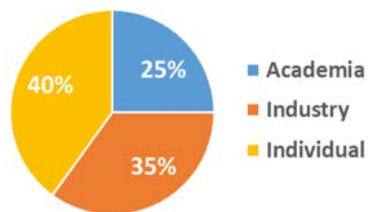
## CO<sub>2</sub> Conversion Challenge

### OVERVIEW

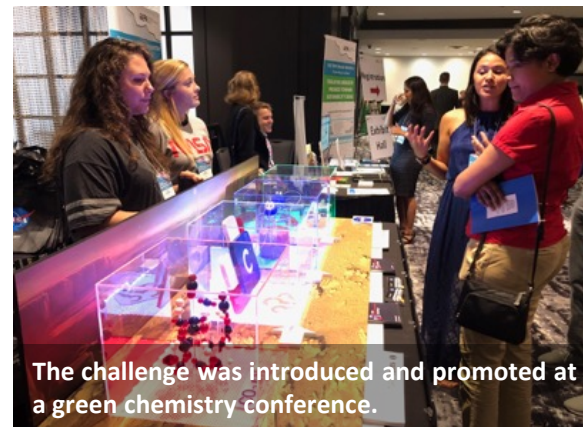
- Phase 1- opened in August 2018/closed March, 2019
- Phase 2 opens September 2019
- 20 teams registered for Phase 1
- HEOMD and STMD collaboration
- NASA-led Challenge
- Lead Center ARC

### METRICS

#### PHASE 1 TEAM BREAKDOWN



### HIGHLIGHTS



The challenge was introduced and promoted at a green chemistry conference.

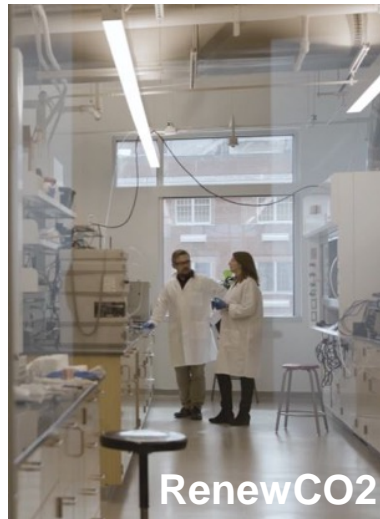
The ultimate goal is to produce the sugar D-glucose as it is a readily metabolized carbon and energy substrate that will optimize bioreactor efficiency. Glucose can also be directly used as a food ingredient for human consumption.

**Strong collaboration with HEOMD.**





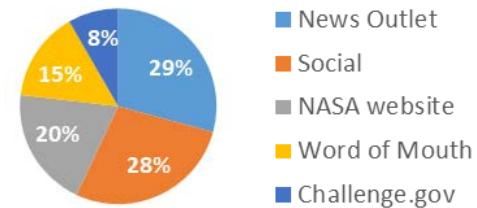
## CO<sub>2</sub> Conversion Challenge



### STRUCTURE & STATUS

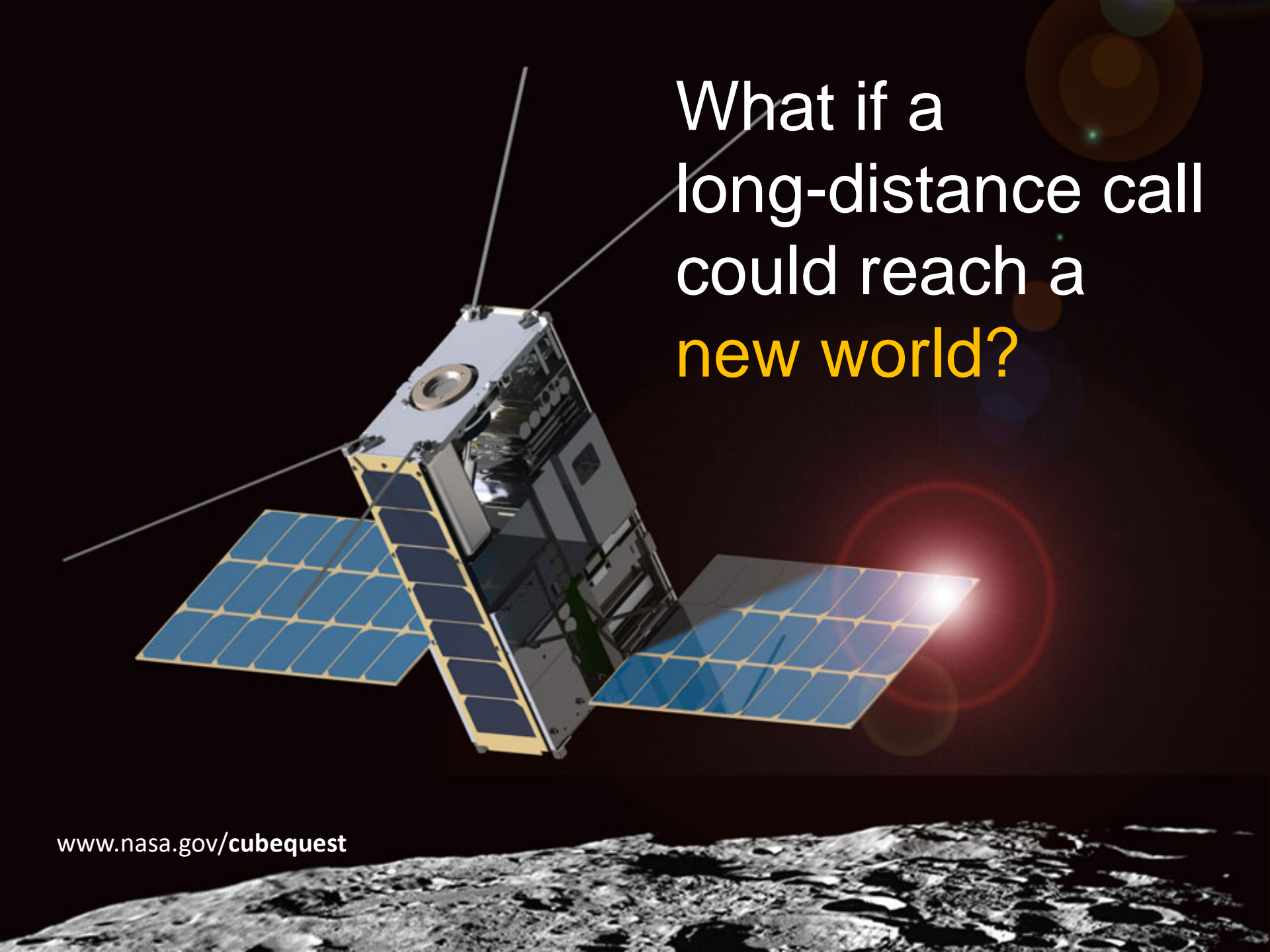
**Phase 1:** (system concept): \$250,000 awarded to 5 winners/\$50K each.

- Strong interest from community; 83 submissions started in the website
- Surpassed the goal of completed valid submissions: >20
- Strong support from the Dept of Energy and Space Tango
- **60% of competitors that signed up were reached by news outlets and social media posts.**



**Phase 2** (system construction): up to 3 winners; \$750,000 purse

- Opened September 19, 2019

A satellite with two large blue solar panels is shown in space. The satellite is white and grey with various instruments and antennas. It is positioned above the dark, cratered surface of the moon. A bright sun is visible in the background, creating a lens flare effect. The text "What if a long-distance call could reach a new world?" is overlaid on the right side of the image.

What if a  
long-distance call  
could reach a  
new world?

[www.nasa.gov/cubequest](http://www.nasa.gov/cubequest)

# centennial challenges



## CUBE QUEST

TOTAL PRIZE PURSE:  
\$5,000,000

### GOAL:

Flight-qualified CubeSats with advanced propulsion and communication capabilities for missions to the moon and beyond.

### PHASE 1: Completed

\$500,000 Prize Purse

Four ground tournaments focused on design and build-up of new CubeSat technologies

### PHASE 2: On Hold until Artemis 1

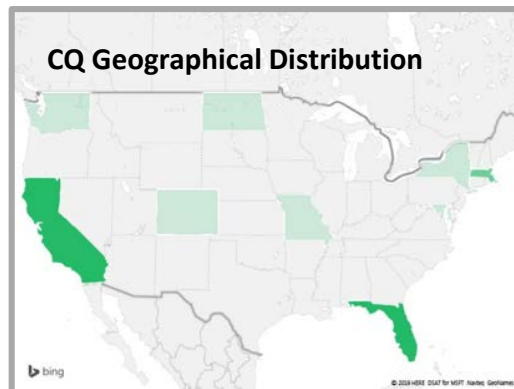
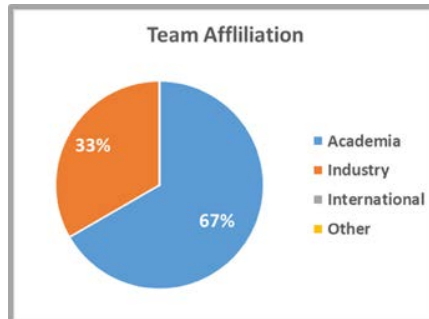
\$4,500,000 Prize Purse  
Demonstration of new technologies; in-space competition

## Cube Quest Challenge

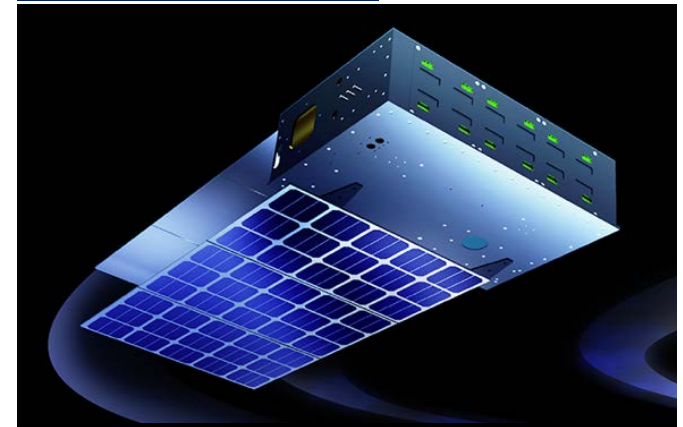
### OVERVIEW

- NASA-led Challenge
- 4 Ground Tournaments completed
- 15 U.S. teams competed
- \$460,000 awarded to date
- 3 secondary payloads on Artemis 1
- Lead Center ARC

### METRICS



### HIGHLIGHTS

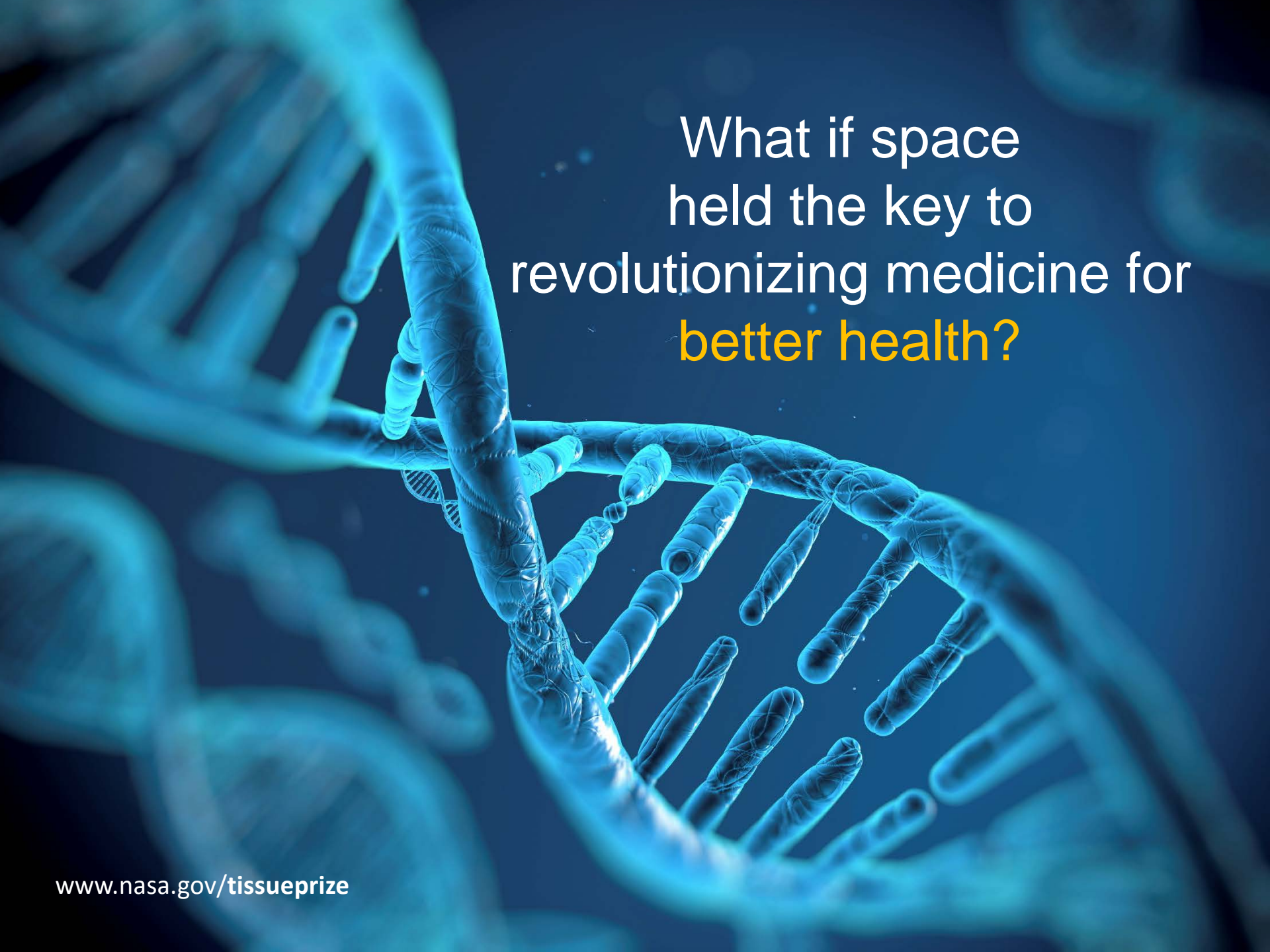


*"The SLS team is very happy with the progress of the Centennial Challenges payloads. Their schedule is on track and all three teams have passed Phase 3 Safety Reviews."*

- Jim Cockrell, Chief Technologist SSTP

- Team Ragnarok, the 4<sup>th</sup> place winner teamed with Radio Amateurs from Maryland in a proposal submitted to the 2017 NASA CubeSat Launch Initiative that was selected for award.
- Ragnarok was awarded an SBIR Phase 1 proposal.
- Anticipating registrations of new teams with own launches.

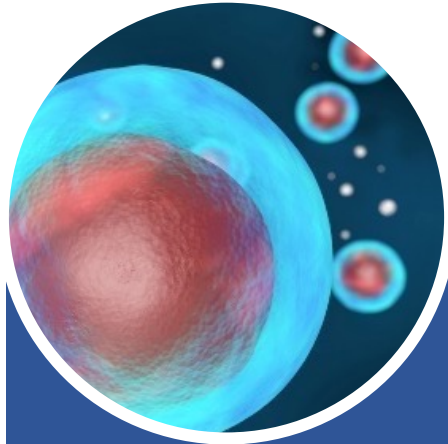




What if space  
held the key to  
revolutionizing medicine for  
**better health?**



## Vascular Tissue Challenge



### VASCULAR TISSUE

In Progress

**PRIZE PURSE:**  
\$500,000

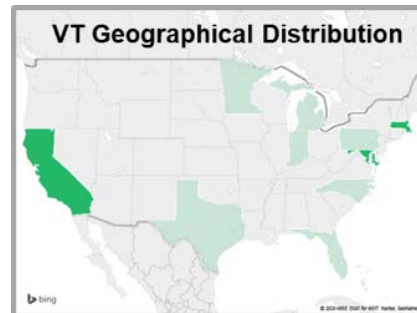
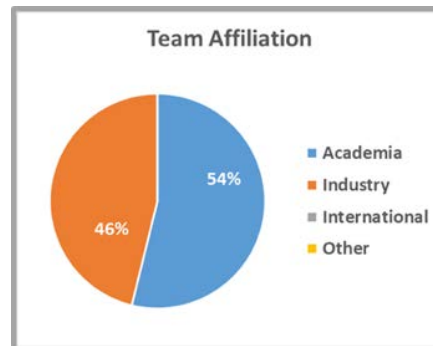
#### GOAL:

Viable thick organ tissue that can be used to advance research and medicine in space and on Earth.

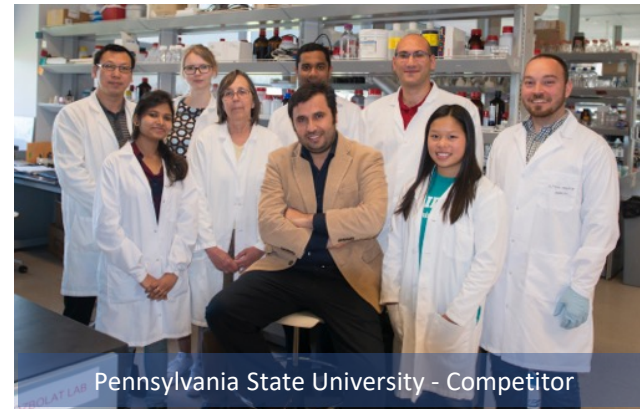
### OVERVIEW

- 13 U.S. teams currently registered
- Innovation in engineered tissue, 10x larger than existing state of the art & can stay viable for >30 days
- **Allied Organization:** New Organ Alliance
- Lead Center ARC; supporting JSC

### METRICS



### HIGHLIGHTS



- **Rice University approved to start trial of liver tissue in September 2019**
- Results of this challenge competition have the potential to help foster **Low Earth Orbit commercialization** as well as have revolutionary benefits for humans on Earth.
- Government agencies outside of NASA supporting this challenge include: National Science Foundation (**NSF**), National Institute of Health (**NIH**), Department of Defense (**DoD**) and Department of Veteran Affairs (**VA**).
- One of the participants is a commercial space company that is using competition with hopes that “space can help push technology needed to break through the tissue vascularization barrier on Earth”.

What if your rover  
could fetch **on its  
own?**







## Space Robotics Challenge



### SPACE ROBOTICS

#### TOTAL PRIZE PURSE:

\$1,900,000

#### GOAL:

Advance robotics software and autonomous capabilities.

#### PHASE 1: Completed

\$900,000 Prize Purse

Focus on Humanoid capabilities in a Mars environment

#### PHASE 2: Open

\$1,000,000 Prize Purse

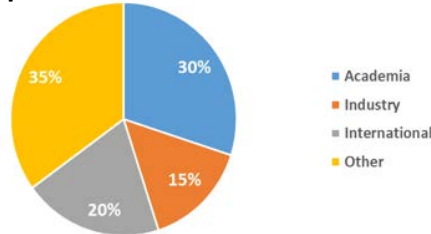
Focus on Rover capabilities in a Lunar environment.

### PHASE 1 OVERVIEW

- \$570,000 awarded in Phase 1
- 92 Teams (79 U.S., 13 international)
- **Allied Organization:**  
Space Center Houston
- Lead Center JSC

### PHASE 1 METRICS

#### Space Robotics Teams: Ph1



#### SR Geographical Distribution: Ph1



### HIGHLIGHTS



Centennial Challenges Team shares Phase 2 launch at Sphero Robotic Mission Competition, Space Center Houston.

- **PHASE 1:**
  - Results can be used in the future by NASA and industry to push robotic autonomy and manipulation technologies.
  - **Strong student STEM component designed and executed by the Allied Organization.**
- **PHASE 2:**
  - Opened August 12, 2019

### COLLABORATORS

- Army Corps of Engineers
- Sphero
- BHP



# centennial challenges

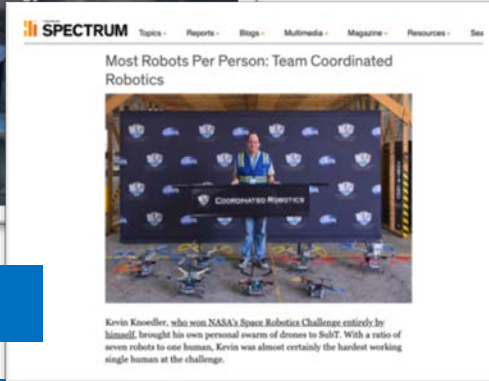




## Space Robotics Challenge



Winner in the DARPA Subterranean Challenge Tunnel Circuit



## PHASE 2 MEDIA

### Social Media:

- 5 Posts on @NASAPrize Twitter
- 1,236,562 Views
- 184 Engagements (Likes and Shares)
- The tweet announcing the competition (pictured at right) garnered \$1.1M views alone. This is well above average.

### Web Feature on nasa.gov:

- 1,689 views (as of 8/19)



## PHASE 2 STATUS

Registration opened August 12<sup>th</sup>

## PHASE 2 STRUCTURE

Demonstrate fully autonomous operations, navigation, and decision making capabilities within a simulation environment.

### • Qualification Round

- This initial round will test competitors abilities to complete specific tasks that will be required during the competition round.
- The top scoring competitors will be awarded a prize, and will compete in the Virtual Competition.

### • Virtual Competition Round

- Competitors will autonomously deploy a robotic team, and then prepare and gather lunar regolith during a long-term lunar mission.
- Competitors will take into account failures, performance, degradation and maintenance.



*“We will go the Moon in the next decade in a way we have never gone before. We will go with innovative new technologies and systems to explore more locations across the surface than was ever thought possible. This time, when we go to the Moon, we will stay. And then we will use what we learn on the Moon to take the next giant leap - sending astronauts to Mars.”*

—NASA Administrator Jim Bridenstine



# centennial challenges



## GO

## LAND

## LIVE

## EXPLORE

Rapid, Safe, and Efficient  
Space Transportation

Expanded Access to Diverse  
Surface Destinations

Sustainable Living and Working  
Farther from Earth

Transformative Missions  
and Discoveries



Advanced Propulsion

Advanced  
Communication

Landing  
Heavy Payloads

In-Space Assembly/Manufacturing  
In-Space Refueling

Autonomous Operations

Sustainable Power

Dust Mitigation

Precision Landing

Commercial Lunar Payload Services

In Situ Resource Utilization

Atmospheric  
ISRU

Cryogenic Fluid Management

Surface Excavation and Construction

Extreme Access/Extreme Environments

Advanced  
Navigation

2020

203X

# centennial challenges



## Challenges in Formulation



### Lunar Nutrition

**\$4,000,000**

**GOAL:**

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



### Lunar Excavation, Manufacturing & Construction

**\$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.

# centennial challenges



@NASAPrize



/NASACC



NASAPrize



[www.nasa.gov/winit](http://www.nasa.gov/winit)





Daring you to ask

**What if?**

