

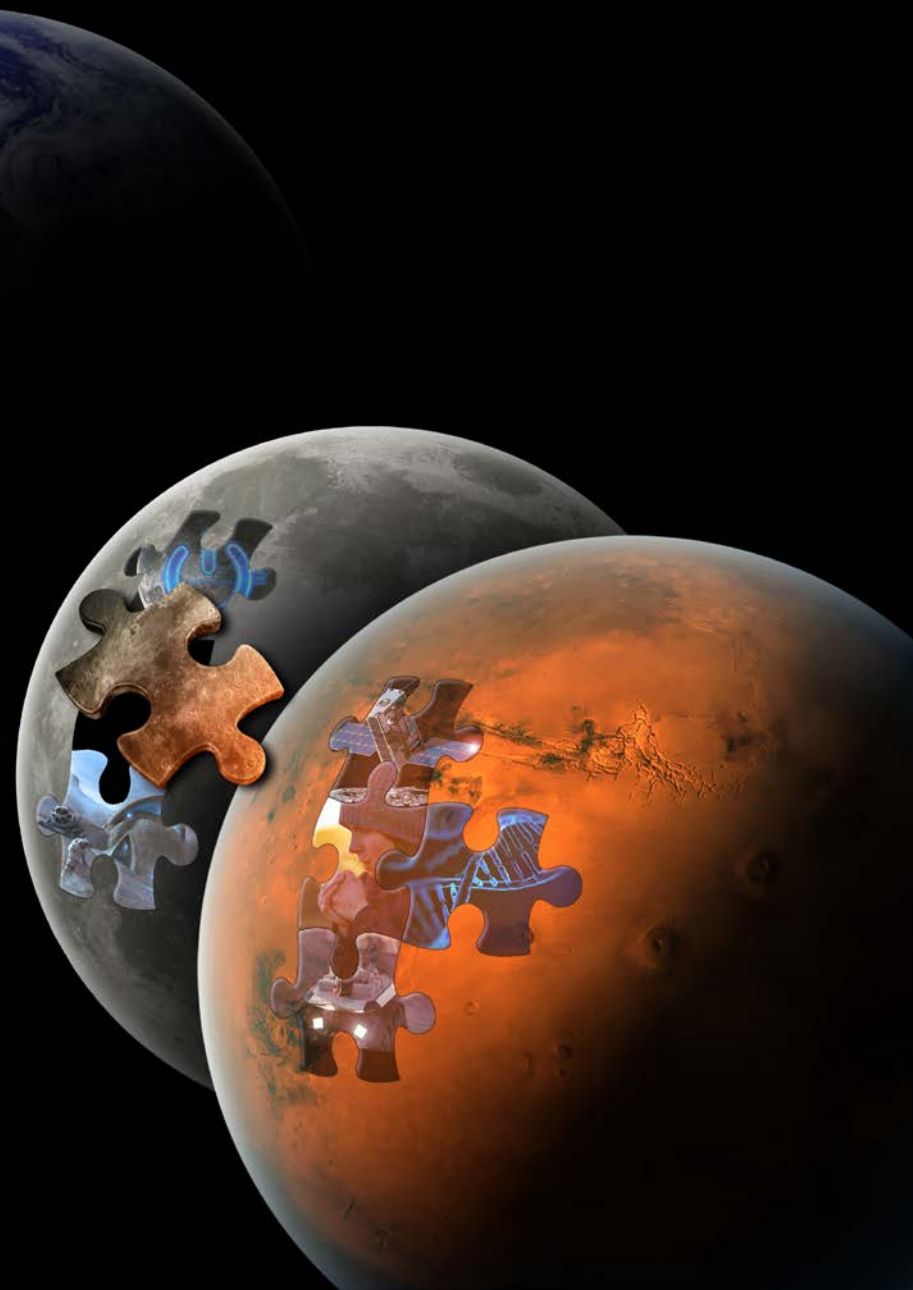


Daring you to ask
What if?

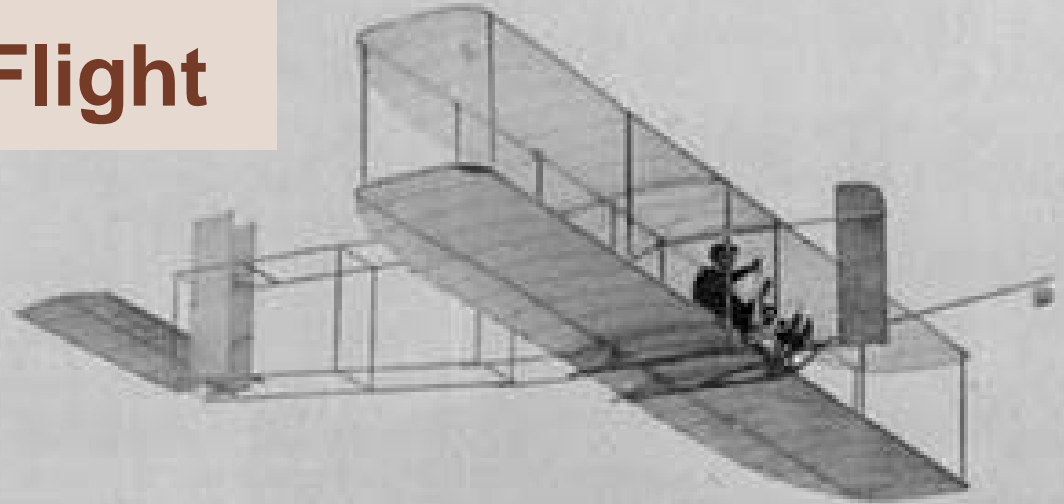
Centennial Challenges

Monsi Roman, Program Manager

Denise Morris, Deputy Program Manager



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 ...

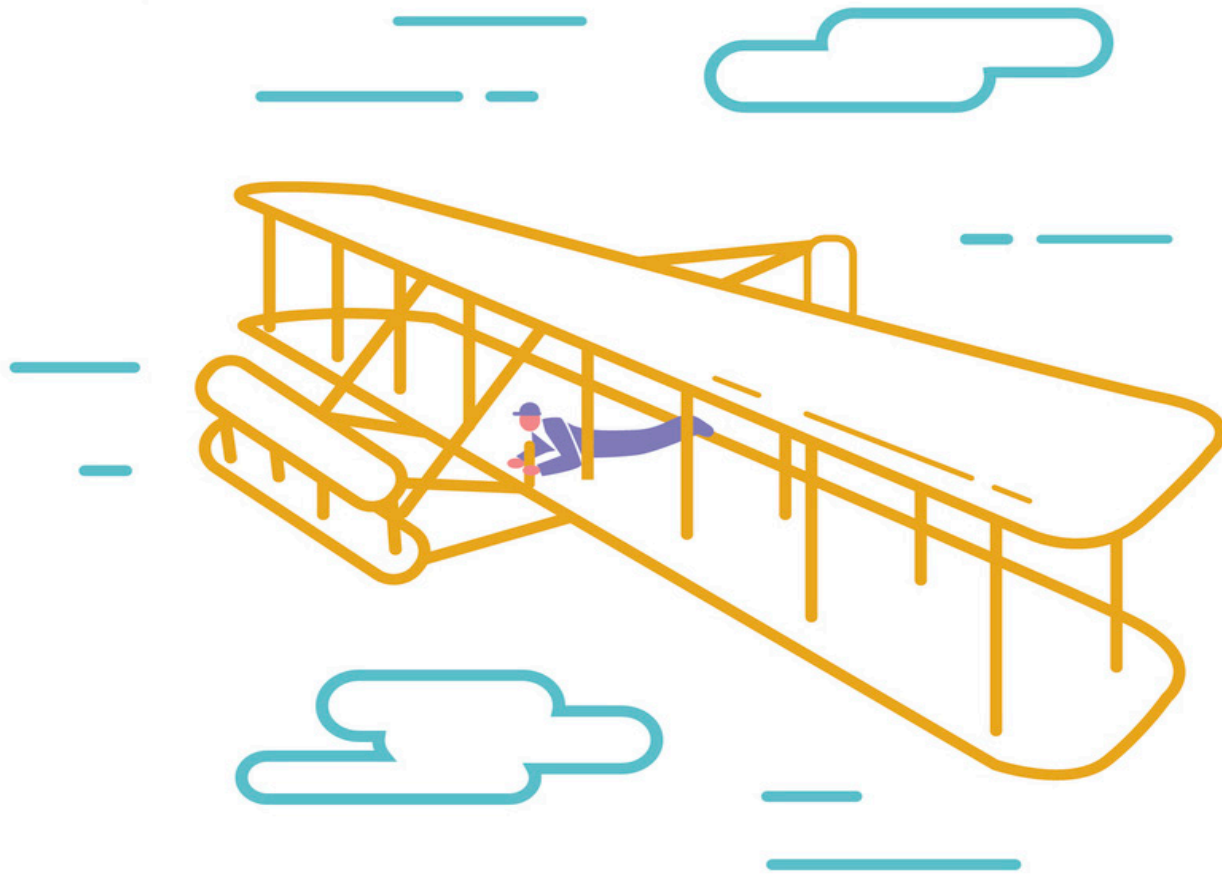


centennial challenges



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





All successful airplanes since have incorporated the basic design elements of the 1903 Wright Flyer.

centennial challenges



“ If we worked on the assumption that what is accepted as true really is true, then there would be little hope for advance. ”

- Orville Wright



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 challenges



Completed



3D-Printed Habitat
\$3,150,000

Completed 5/2019

Additive construction technology for space

- \$2,060,000 awarded

- 60 teams participated

- Allied Organization: Bradley University. Sponsors: CAT Inc., Bechtel Corp, Brick and Mortar Ventures

Active



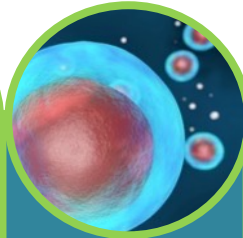
Cube Quest
\$5,000,000

Flight-qualified CubeSats near and beyond the moon

- \$460,000 awarded

- 15 U.S. teams registered

- NASA Led Challenge



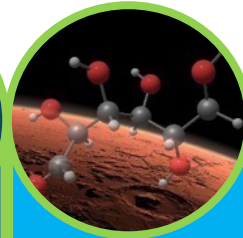
Vascular Tissue
\$500,000

Viable thick tissue for research

- \$0 awarded

- 13 teams registered

- Allied Organization: New Organ Alliance



CO₂ Conversion
\$1,000,000

Bio-manufacturing from in-situ resources

- \$250,000 awarded/Ph1

- 20 teams registered/Ph1

- Phase 2 target open date Sept 10, 2019
- NASA-led Challenge (STMD/HEOMD)



Space Robotics
\$1,900,000

Advance robotics software for full autonomous operations

- \$570,000 awarded/Ph1

- 92 teams registered/Ph1

- Phase 2 opened Aug 12, 2019
- Allied Organization: Space Center Houston Sponsor: BHP

Development



Lunar Nutrition
(Up to \$5 M)

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

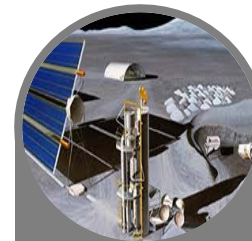
Targeted to open no earlier than Sept. 2020

Formulation



Lunar Power
(Up to \$5 M)

Portable energy storage.



Lunar Excavation, Manufacturing & Construction
(Up to \$5 M)

Autonomous manufacturing/construction.



What
motivates
people to
compete?



Guts.



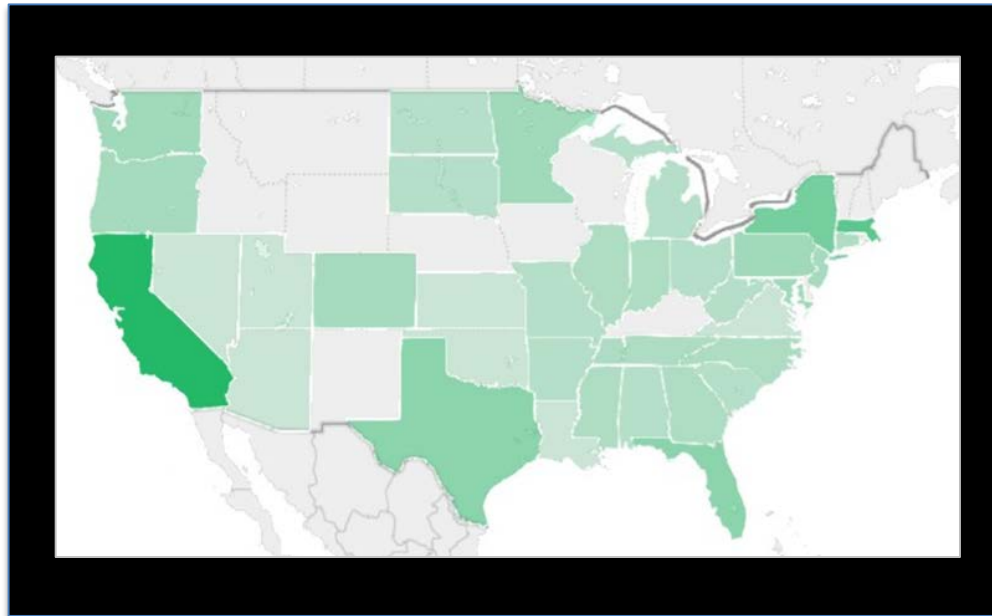
Glory.



do Good.

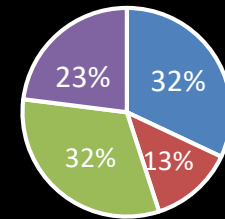


Gold.



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

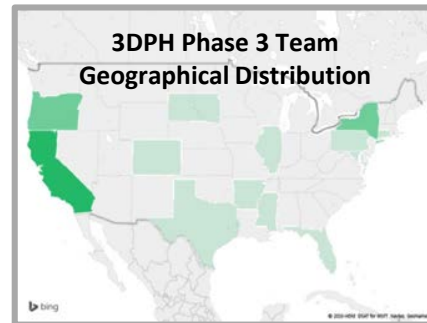
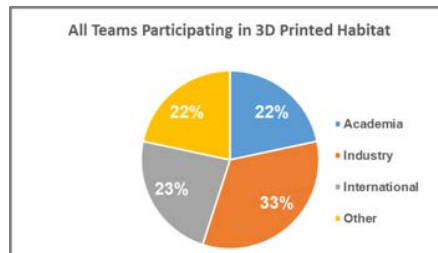
PHASE 3: Completed

\$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



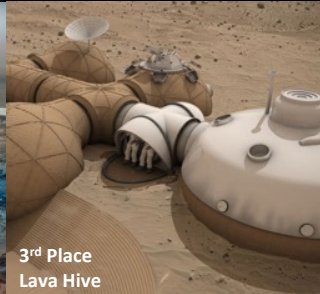
3D-Printed Habitat Challenge



1st Place
SEArch/Clouds Architecture
Office



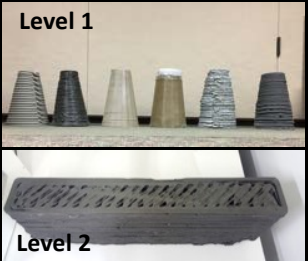
2nd Place
Team Gamma



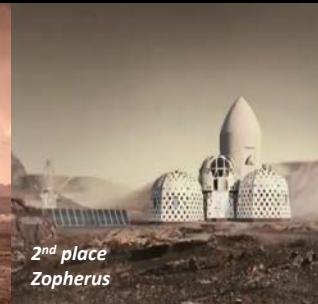
3rd Place
Lava Hive

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



1st Place
SEArch+ / Apis Cor



2nd place
Zopherus



3rd 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
1st Place



Pennsylvania State University – 2nd 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



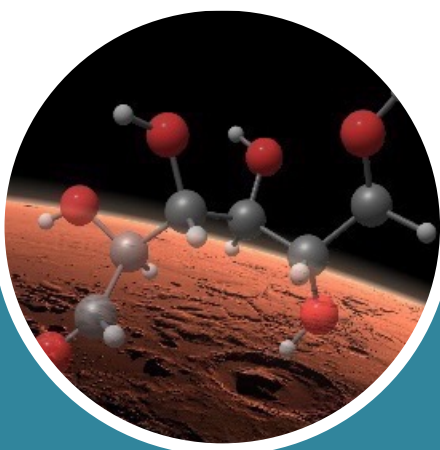
Jeffrey Montes
@jetportal

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 out over a sunset. Her hands are clasped together in front of her. The background is a bright, hazy sunset over a landscape.

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



CO₂ 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 CO₂ to sugars

PHASE 2: *About to Open*

\$750,000 Prize Purse
Build and test system for conversion of CO₂ to sugars

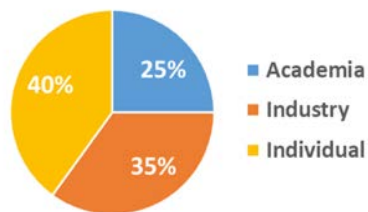
CO₂ Conversion Challenge

OVERVIEW

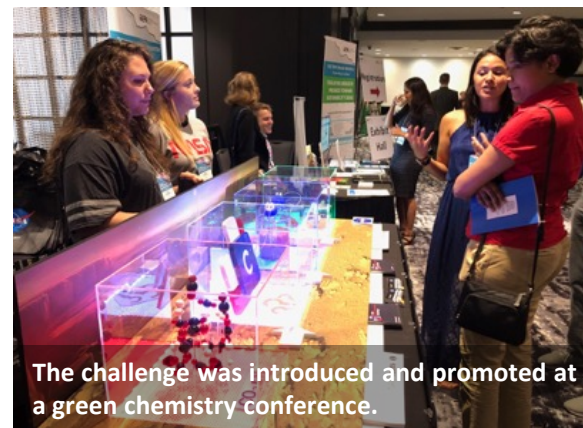
- Phase 1- opened in August 2018/closed March, 2019
- Phase 2 opens September 2019
- 20 teams registered for Phase 1
- HEOMD and STMD collaboration
- NASA-led Challenge
- Lead Center ARC

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.



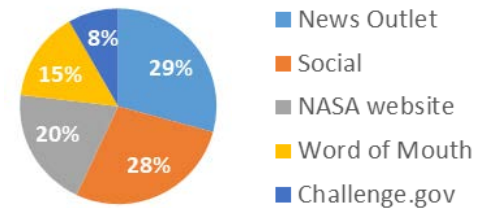
CO₂ Conversion Challenge



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.**

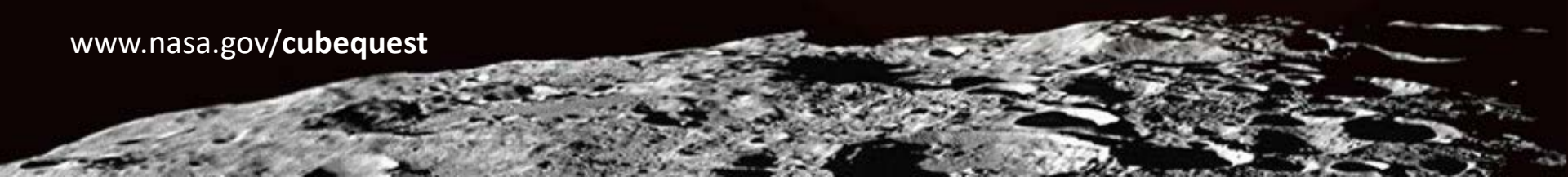


Phase 2 (system construction): up to 3 winners; \$750,000 purse

- Opened September 19, 2019

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

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

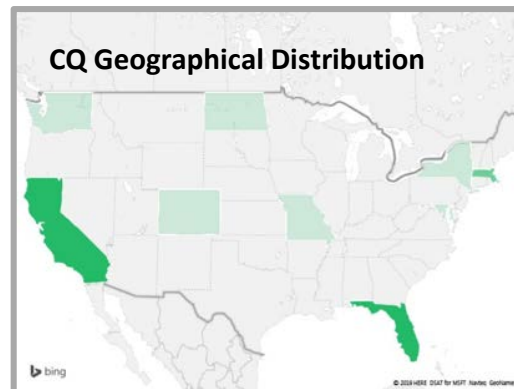
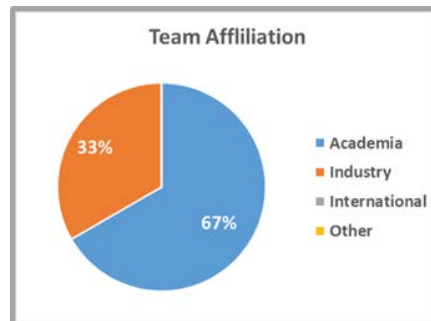
Demonstration of new technologies; in-space competition

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



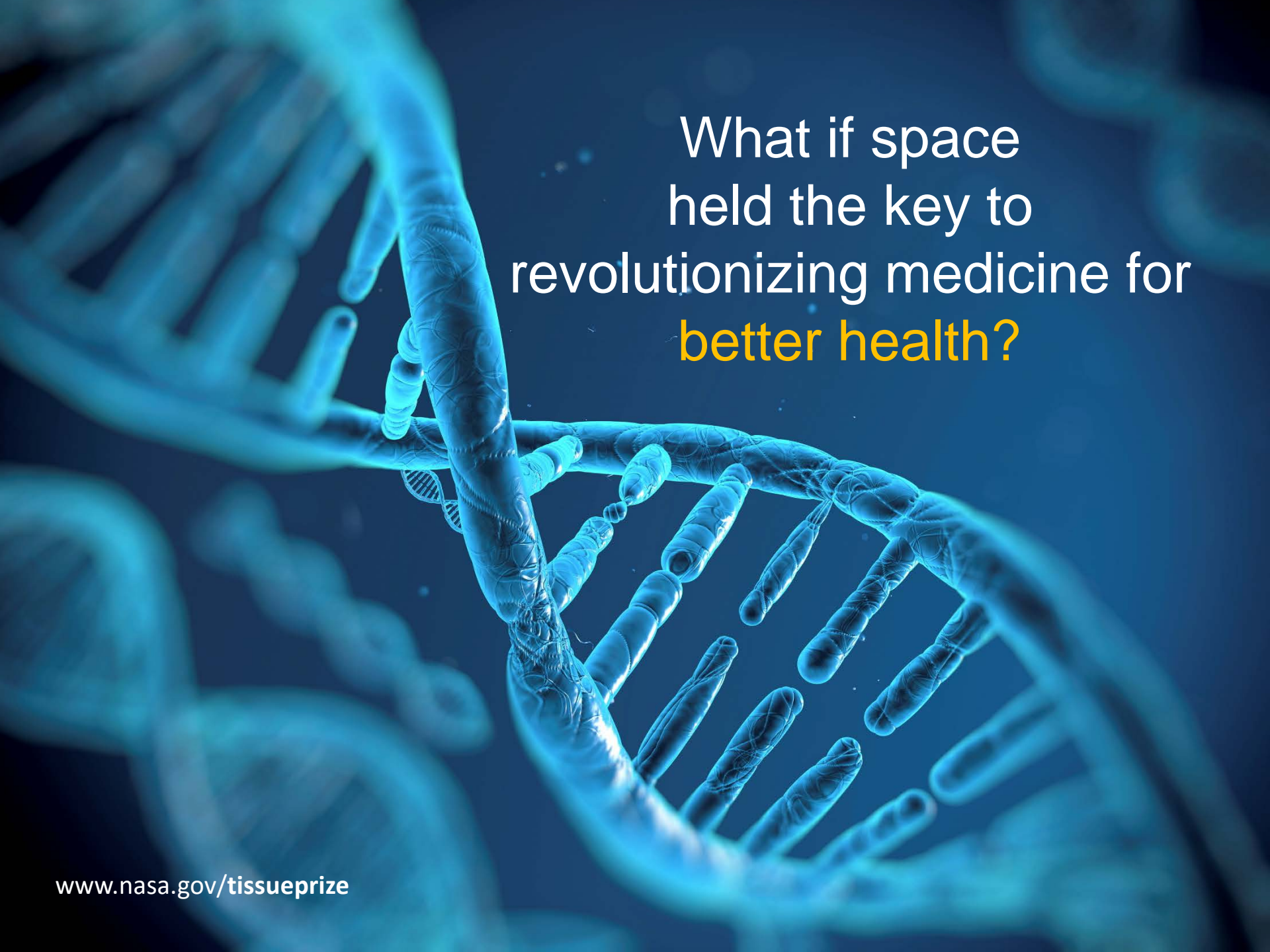
HIGHLIGHTS



"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

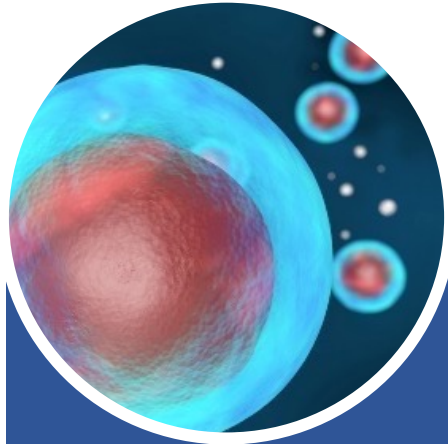
- Team Ragnarok, the 4th place winner teamed with Radio Amateurs from Maryland in a proposal submitted to the 2017 NASA CubeSat Launch Initiative that was selected for award.
- Ragnarok was awarded an SBIR Phase 1 proposal.
- Anticipating registrations of new teams with own launches.



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



Vascular Tissue Challenge



VASCULAR TISSUE

In Progress

PRIZE PURSE:
\$500,000

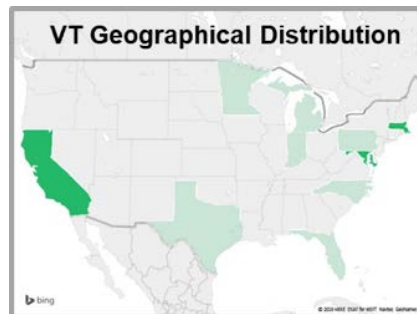
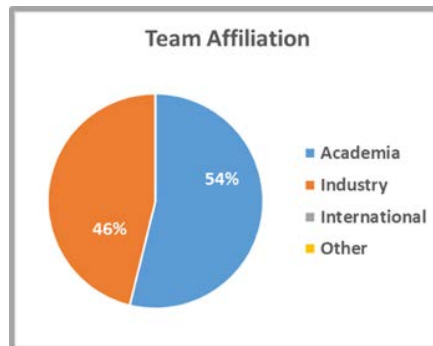
GOAL:

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

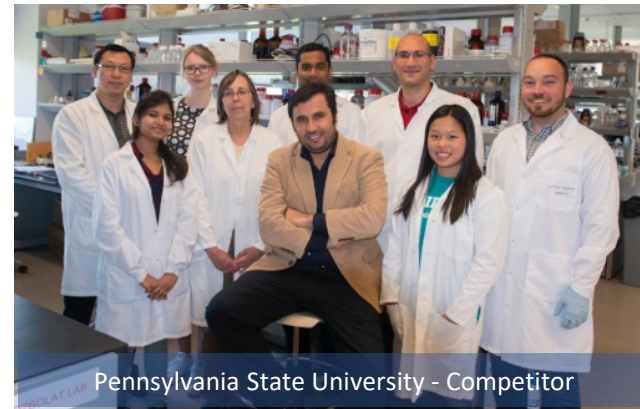
OVERVIEW

- 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



Pennsylvania State University - Competitor

- **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

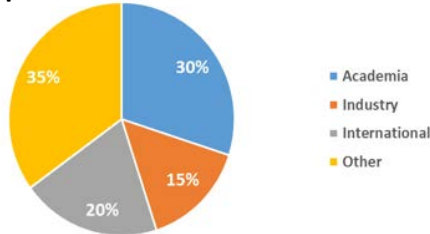
Focus on Rover capabilities in a Lunar environment.

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

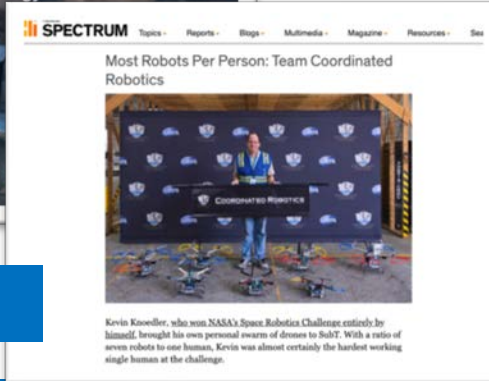
- Army Corps of Engineers
- Sphero
- BHP



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 12th

PHASE 2 STRUCTURE

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

• Qualification Round

- This initial round will to 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.

centennial challenges



centennial challenges



@NASAPrize



/NASACC



NASAPrize



www.nasa.gov/winit



Daring you to ask

What if?

