

National Aeronautics and
Space Administration



THE NASA SYSTEM ENGAGEMENT LIGHTS



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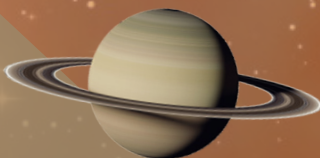


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Spelling Champion Zaila Avant-Garde Visits Johnson Space Center

After Zaila Avant-Garde spelled her way to victory in the 2021 Scripps National Spelling Bee, the 14-year-old from New Orleans mentioned her interest in NASA as a possible career choice. Zaila was invited to spend a day at Johnson Space Center, where she spoke to spaceflight experts, including NASA astronaut Jessica Meir. During her visit, the talented teen – who also holds three world records in basketball – participated in a video for NASA's Office of STEM Engagement in which she showed off her skills by acing a space-themed spelling bee and challenging Meir to dribble three basketballs at once. Released in Sept. 2021, the video garnered over 2 million impressions.





NASA provides an exciting array of STEM experiences and opportunities to immerse students in the agency's missions and projects. By maintaining a steadfast focus on engaging students, and supporting educators and educational institutions, NASA seeks to build the next generation STEM workforce and broaden student participation to increase diversity, equity and inclusion in STEM fields.

NASA makes vital investments in a diverse portfolio of learning opportunities and activities designed to reach as many U.S. students and educators as possible – from kindergarten through graduate school, and through venues from the local library to the university. Through evidence based hands-on activities and products, K-12 students can dig deeper into STEM topics and experience the thrill of exploration and discovery, while student learning opportunities such as challenges and competitions offer middle school, high school, and college students the chance to get involved in the agency's missions and technologies. Internships and fellowships provide unique, authentic work experiences leveraging the agency's experts and facilities. NASA funding for cutting-edge research advances scientific knowledge and innovation while helping communities and populations traditionally underrepresented in STEM to strengthen their STEM infrastructure and capabilities.

NASA's Office of STEM Engagement (OSTEM) provides guidance and strategic direction of the agency's STEM engagement portfolio, and manages the Congressionally

appropriated \$127 million STEM Engagement program, a key element of the portfolio. The STEM Engagement program encompasses four projects: the NASA Minority University Research and Education Project (MUREP), National Space Grant College and Fellowship Project (Space Grant), Established Program to Stimulate Competitive Research (EPSCoR) and the Next Generation STEM Project (Next Gen STEM). OSTEM collaborates with NASA mission directorates, including the Human Exploration and Operations Mission Directorate (HEOMD), Space Technology Mission Directorate (STMD), Science Mission Directorate (SMD), and Aeronautics Research Mission Directorate (ARMD), and NASA field centers, to maximize the agency's reach and impact.

As the COVID-19 pandemic stretched through a second year, NASA continuously adapted its products and activities to accommodate local policies and, ultimately, the needs of students and educators. Never has it been more important to broaden student participation through a diverse set of approaches and mechanisms to meet students where they are – at home, in a brick-and-mortar classroom, or in an informal education setting, such as a museum or library.

Through its many opportunities and programs, NASA aims to help students experience the spark of excitement that discovery creates, and nurture it into a lasting STEM identity. We invite you to read on to learn more about how students and educators nationwide benefited from the enterprise's activities in 2021.

VISION

We immerse students in NASA's work, enhance STEM literacy and inspire the next generation to explore.

MISSION

We engage students in NASA's mission.



STRATEGIC GOAL 1

Create unique opportunities for a diverse set of students to contribute to NASA's work in exploration and discovery.

OBJECTIVES:

- 1.1 Provide student work experiences that enable students to contribute to NASA's missions and programs, embedded with NASA's STEM practitioners.
- 1.2 Create structured and widely accessible experiential learning opportunities for students to engage with NASA's experts and help solve problems critical to NASA's mission.



STRATEGIC GOAL 2

Build a diverse future STEM workforce by engaging students in authentic learning experiences with NASA's people, content, and facilities.

OBJECTIVES:

- 2.1 Develop and deploy a continuum of STEM experiences through authentic learning and research opportunities with NASA's people and work to cultivate student interest, including students from unrepresented and underserved communities, in pursuing STEM careers and foster interest in aerospace fields.
- 2.2 Design the portfolio of NASA STEM engagement opportunities to contribute toward meeting agency workforce requirements serving the nation's aerospace and relevant STEM needs.



STRATEGIC GOAL 3

Attract diverse groups of students to STEM through learning opportunities that spark interest and provide connections to NASA's mission and work.

OBJECTIVES:

- 3.1 Attract a broad and diverse set of students to STEM through targeted opportunities and readily available NASA STEM engagement resources and content.
- 3.2 Foster student exposure to STEM careers through direct and virtual experiences with NASA's people and work.

Space Grant (\$51M)

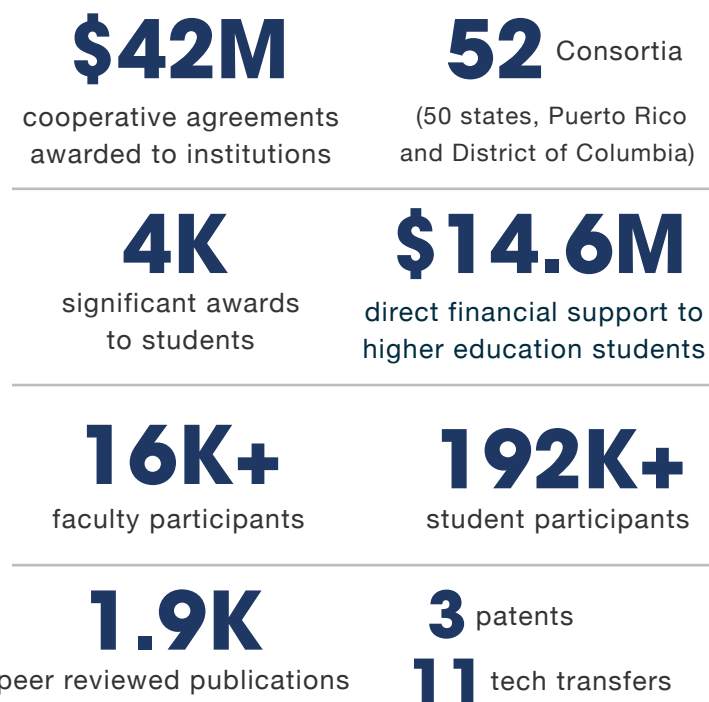
The **National Space Grant College and Fellowship Project, or Space Grant**, is a national network of colleges and universities working with affiliated organizations and institutions to expand opportunities for students to participate in NASA's aeronautics and space projects. The project funds internships, fellowships, and scholarships and offers programs and learning opportunities that enable and support STEM education, research, and student engagement. Space Grant engages students and educators from elementary to secondary levels through hands-on experiences, faculty development, curriculum enhancement, and precollege education.

Space Grant awarded \$42 million in cooperative agreements to institutions across 52 Consortia (50 states, Puerto Rico, and Washington, D.C.). This fiscal year saw the expansion of the Space Grant Consortia to include over 1,100 partner institutions throughout academia, industry, state and local government, and non-profit organizations. In addition to direct awards made to higher education students, the program had more than 193,000 student participants, 16,700 faculty participants, and 400 peer-reviewed manuscripts with another 180 pending.

For more information, visit www.nasa.gov/stem/spacegrant/home/index.html



Mostafa Youssef, a graduate student at Iowa State University and a 2020 Space Grant recipient. Credits: Mostafa Youssef



Space Grant Consortia provide state-wide opportunities that contribute to NASA's mission in:

AERONAUTICS



HUMAN EXPLORATION



SCIENCE



SPACE TECHNOLOGY



Next Gen STEM (\$12M)

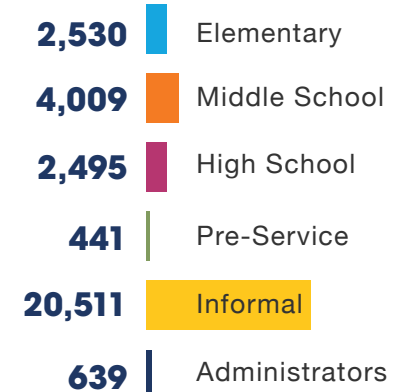
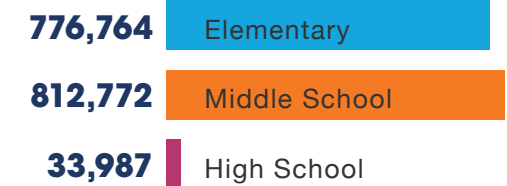


Next Gen STEM is an integrated portfolio of grants, partnerships, activities, educational products, and student engagement opportunities designed to connect NASA's missions, programs, people, and STEM content to a primarily K-12 student audience. Next Gen STEM is designed to provide learning opportunities to students in multiple settings – in school, afterschool programs, informal institutions like museums and science centers, and at home. The goal of these efforts is to make meaningful connections to NASA that spark student interest in STEM, to help students see themselves in STEM careers, and to provide opportunities for students to engage and contribute to NASA's mission in meaningful ways on their paths to higher education.

Through NASA's Teams Engaging Affiliated Museums and Informal Institutions (TEAM II), Next Gen STEM awarded approximately \$4.14 million to ten informal education organizations – supplementing an initial group selected in December 2019 – to promote learning in STEM with the goal of inspiring the next generation of explorers.

Next Gen STEM operates NASA's Museum and Informal Education Alliance, a network of over 1,300 museums, science centers and other informal education institutions around the globe.

For more information, visit <https://www.nasa.gov/stem/nextgenstem/index.html>



Student Work Experiences



Summer intern Isabel Rayas poses in front of the Scarecrow test rover at JPL while holding a spare wheel used to practice Mars rover maneuvers. Image credit: NASA/JPL-Caltech



Seydou Mbaye, is a student at Morgan State University in Baltimore, and a systems engineering intern at NASA's Ames Research Center in California.
Credits: Seydou Mbaye

The **NASA Internships program** provided virtual internships to 2,290 interns in 2021 – a 23% increase from 2020 – simultaneously prioritizing health and safety during the pandemic while reinforcing the agency's STEM workforce pipeline. A commitment to diversity, equity, and inclusion yielded a highly diverse applicant pool and intern population, including a 78% increase from 2020 in the number of interns attending Historically Black Colleges and Universities. Ongoing collaboration with MUREP has resulted in strong relationships with MSIs and other relevant organizations.

In addition to external engagement dedicated to improving outreach and recruitment of highly qualified applicants, the Internships program hosted a variety of virtual events and professional development opportunities to enrich the internship experience for students. In celebration of National Intern Day in July 2021, interns participated in social media question and answer sessions, a

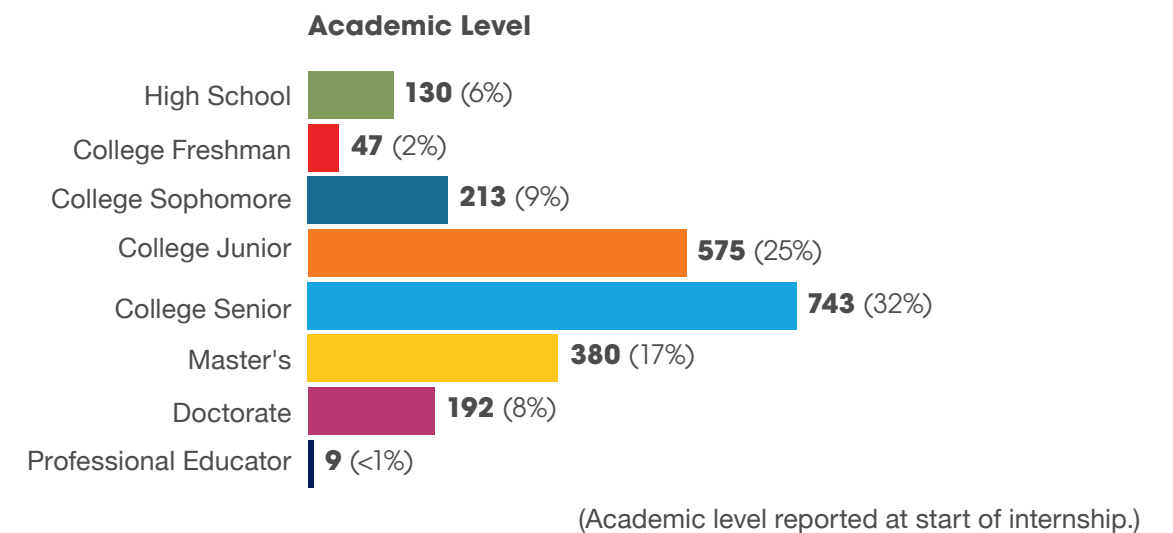
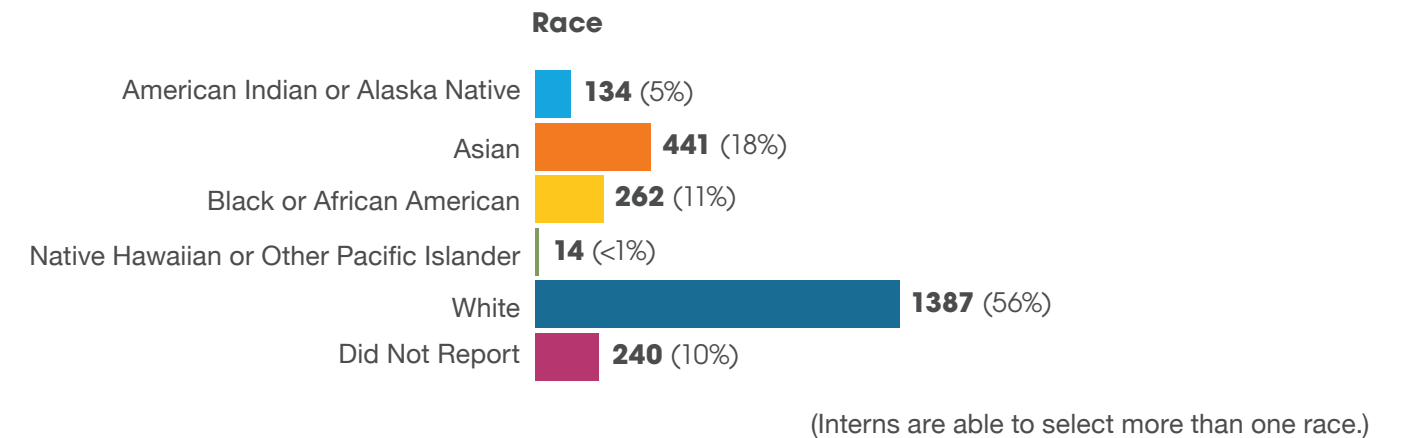
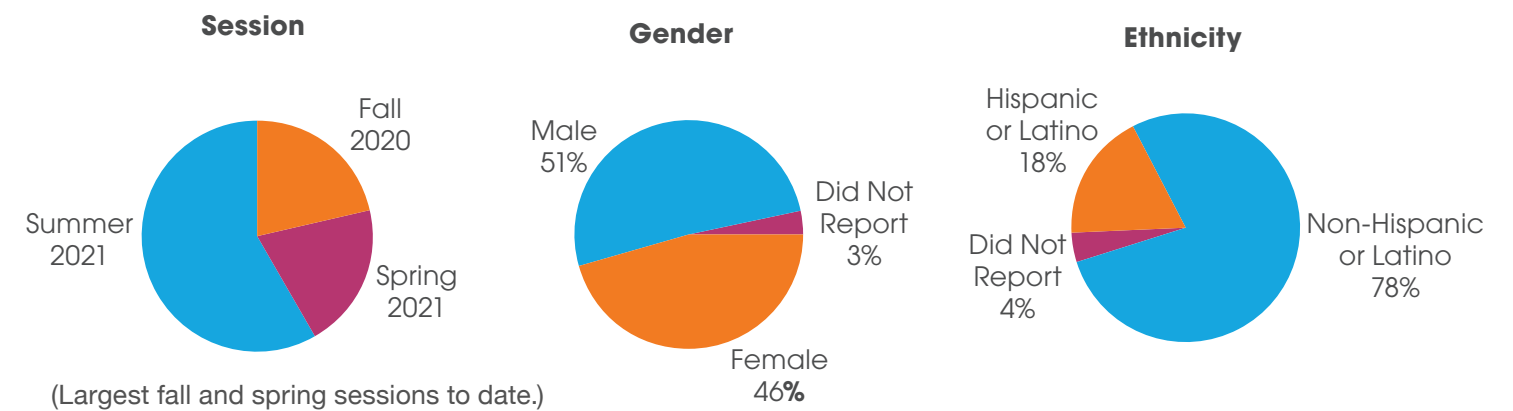
downlink event with astronauts onboard the International Space Station joined by STEM interns at other federal agencies, and an in-person launch event at the Kennedy Space Center. The team also contributed to "**Lessons Learned in Executing Virtual Internships**," a report outlining the value and challenges of virtual internships, developed through a partnership between NASA, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the Departments of Defense, Energy, Interior, and Transportation.

The Internships program also has begun work to reimagine the future of internships, in collaboration with the Office of the Chief Human Capital Officer (OCHCO), with a focus on shared resources and best practices to train students in 21st-century STEM skills critical to the success of the future NASA missions, including those in the Artemis program.

The internship applicant pool nearly doubled over the fiscal year, and both the fall and spring intern cohorts were NASA's largest to date for those sessions.

2,290

Total Interns





Ahsan Khan
Langley Research Center

Ahsan Khan is studying mechanical engineering at the University at Buffalo. During internships in summer and fall 2021, he tested the feasibility of various planetary rover concepts for use on the Moon, Mars, Mercury, and Europa. He performed a detailed systems analysis for each planetary application and expanded the use of tensegrity applications for future NASA missions.

AMAZING INTERNS!



Shilpa Kancharla
Glenn Research Center

Shilpa Kancharla is a master's student in computer science at North Carolina State University. As a Space Communications and Navigation (SCaN) intern, Shilpa spent her summer working on the Cognitive Communications project to create tutorials for the utilization of communications data in artificial intelligence systems.

"Thank you to Dr. Charles Doxley and Dr. Rachel Dudukovich for the opportunity to explore new realms of artificial intelligence research, as well as each of the interns I got to collaborate with and talk to over both my summer and fall internships: Katherine Wagner, Jason Fantl, Shruti Janardhana, and Alexander Fung."



Andrea Lasta
Armstrong Flight Research Center

NASA intern Andrea Lasta studies mechanical engineering at the University of Houston. Andrea immigrated to the U.S. with her family as a child. She worked with Armstrong's Center Operations to analyze logistics operating procedures along with contractor required deliverables and processes vital to the financial success of various NASA projects.

"After years of constant hard work, setbacks, and dreaming about the future, I finally made it to NASA!"



Jamarius Reid
Goddard Space Flight Center

Jamarius Reid is a Ph.D. student in aviation at Embry-Riddle Aeronautical University. Selected for two internships in summer and fall 2021, he researched, developed, and populated a Nationwide Public Safety Unmanned Aircraft Systems Program Directory under mentors at Ames. He then worked on the Moon Trek database during his internship at Headquarters, identifying lunar locations appropriate for landing missions and science and applied research investigations.

"Strive to make an impact wherever you go, because everywhere you've been has made an impact on you."



Jada Ragin Hoyle-Gardner
Ames Research Center

Jada Ragin Hoyle-Gardner was a space systems biology intern and is pursuing a Ph.D. at Florida A&M University, where she studies environmental science. Jada's internship project entailed understanding how certain microorganisms adapt to carbon-limited environments using organized datasets.

"Go for it! NASA makes you feel like family!"



Steven Ngo
Stennis Space Center

Steven Ngo is an intern and recent University of Texas at Arlington mechanical engineering graduate. Following an internship at Marshall Space Flight Center in fall 2020, he supported the NASA pressure system manager at Stennis, where he contributed to the "Green Run" series of Space Launch System engine tests, including participation in pressure system certification and examination efforts during spring 2021.

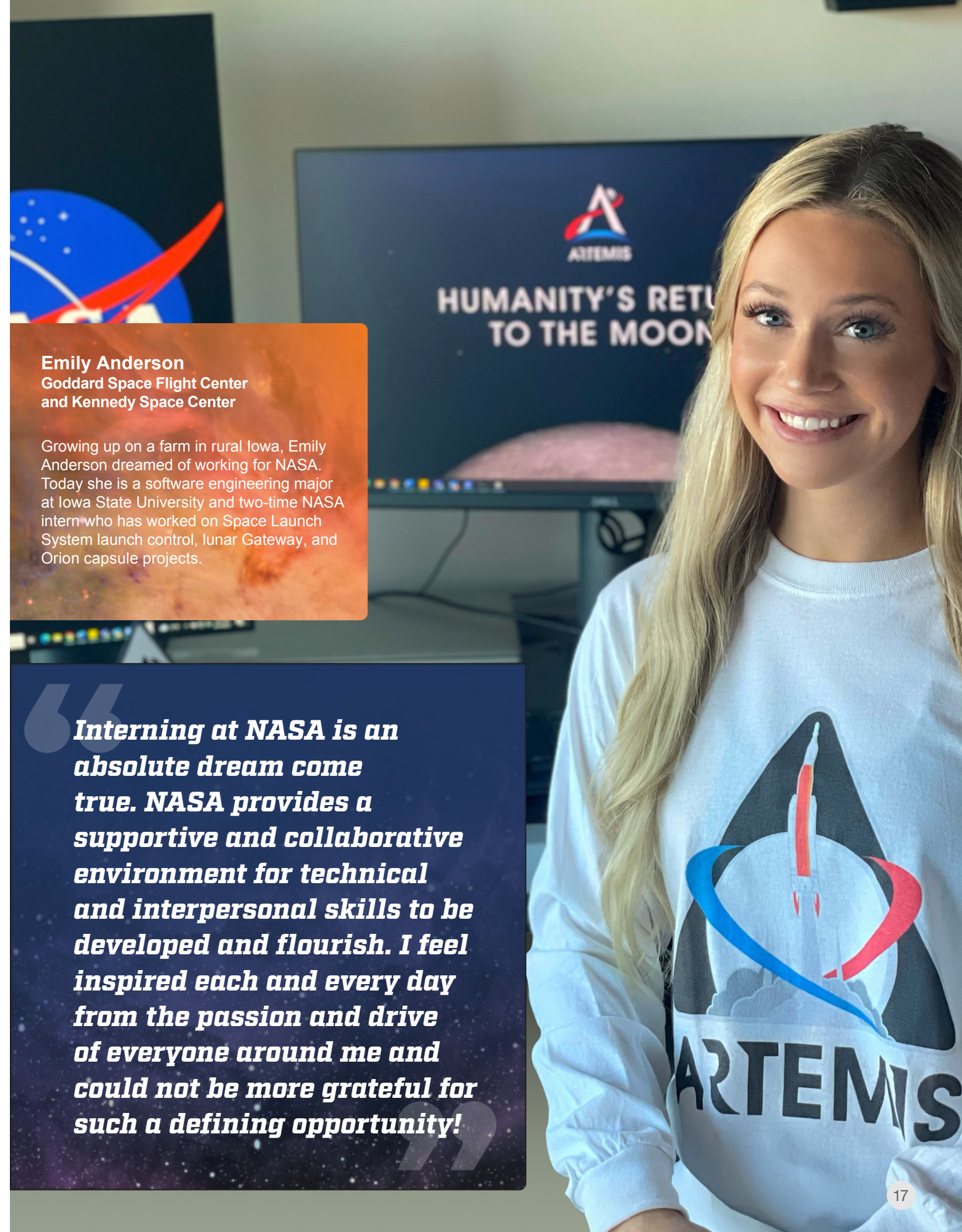
"Being a part of something so much bigger is an experience unlike anything in school, and I've learned so many things beyond the classroom through my NASA internship."



Adam Freidman
Goddard Space Flight Center

Adam Freidman is a computer science student at the University of Michigan. As an intern, he worked on a summer project identifying stars including eclipsing binaries utilizing the Transiting Exoplanet Survey Satellite (TESS) under mentor Brian Powell.

"He was definitely the best supervisor I've ever met. He met with me every single day, just to teach me how to do the project. He really was a great teacher."



Emily Anderson
Goddard Space Flight Center
and Kennedy Space Center

Growing up on a farm in rural Iowa, Emily Anderson dreamed of working for NASA. Today she is a software engineering major at Iowa State University and two-time NASA intern who has worked on Space Launch System launch control, lunar Gateway, and Orion capsule projects.

"Interning at NASA is an absolute dream come true. NASA provides a supportive and collaborative environment for technical and interpersonal skills to be developed and flourish. I feel inspired each and every day from the passion and drive of everyone around me and could not be more grateful for such a defining opportunity!"

Fellowships Overview



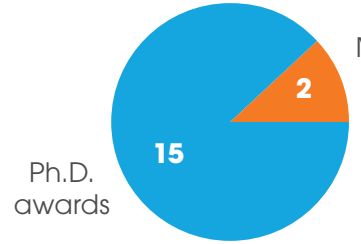
Fellows represent: California, Nevada, Arizona, Oklahoma, Texas, Florida, Georgia, Maryland, Washington D.C., Hawaii, Puerto Rico



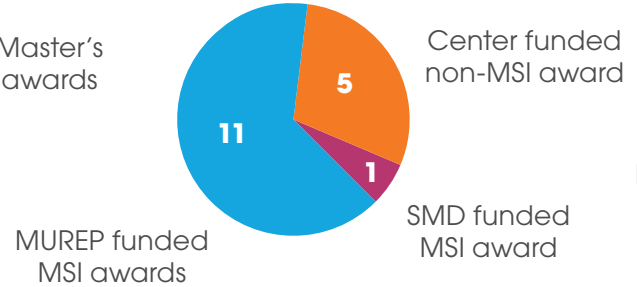
\$165K awarded to Ph.D. students over a 3 year period.

\$100K awarded to Master's students over a 2 year period.

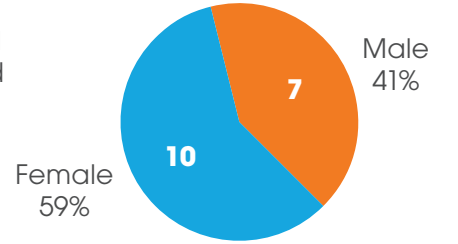
Award Breakdown



Funding Breakdown



Gender Breakdown



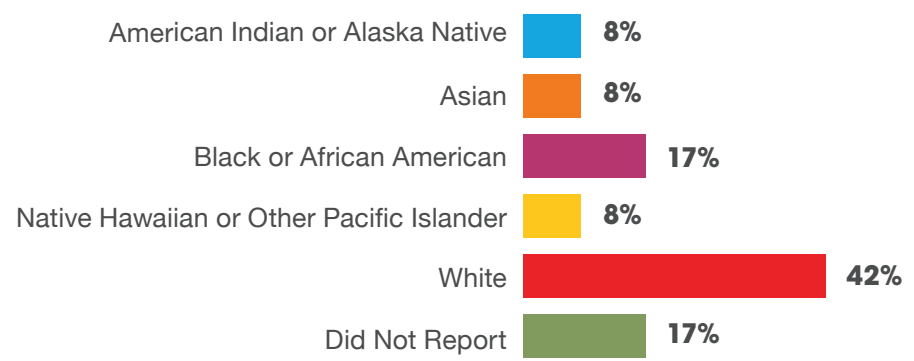
NASA fellowships provide highly qualified graduate students opportunities to gain authentic STEM experience while directly contributing to the agency's mission. Fellowships are competitive awards that support research independently conceived or designed by students with their faculty advisors, with the goal of advancing NASA's science and technology priorities while strengthening the STEM workforce.

A total of 72 active fellows worked at NASA under this program during FY 2021. These included 17 new fellows, renewals of the 55 fellows comprising the 2019 and 2020 cohorts, and no-cost extensions for the 12 fellows within the 2018 cohort. Fifty-four students reported for

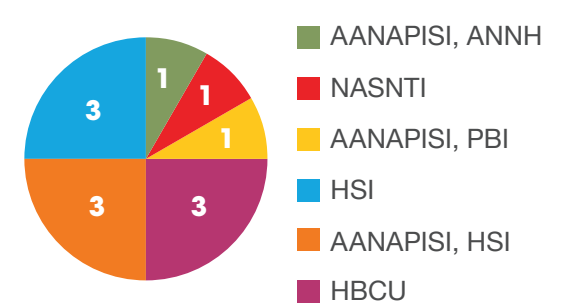
the summer virtual Center-Based Research Experience (CBRE), and one participated in the fall. MUREP provides the majority of funding for these fellowships to enable fellowship opportunities for students from MSIs, with other funding supplied by mentor sponsors from missions and discipline organizations.

In addition to their research experiences, NASA fellows participated in professional development seminars offering training in career development including "Leaders for the Future," which focused on leadership and communications skills. Fellows in the summer CBRE presented about their accomplishments, lessons learned, and best practices.

Race and Ethnicity Breakdown



MSI Representation





Alondra S. Rodriguez-Rolon
University of Puerto Rico Rio
Piedras Campus

Alondra S. Rodriguez-Rolon is a chemistry graduate student. Her research work at Ames Research Center aims to develop a multifunctional material based on a zwitterionic-inorganic double hydrophilic layer membrane with anti-fouling and photochemical properties for water remediation for future long-term duration space missions. Finding ways to reclaim water is important for the success of the Artemis program and other missions to the Moon and beyond.

FABULOUS FELLOWS!



Tre'Shunda James
University of Texas at Arlington

Tre'Shunda James is a graduate student majoring in physics. Her research at Goddard Space Flight Center consists of studying interhemispheric asymmetry in ionospheric currents, focusing specifically on the differences in ionospheric currents during the summer and winter. She hopes to expand the scope of this work by comparing observational results to those derived from models. This work has the potential to improve the current state of models to better predict space weather.

"My career goal is to become a principal investigator on a NASA mission in which I will be able to not only make academic advances, but also to further NASA's objective to make scientific research inclusive and diverse."



Jonas Lee
University of the District of Columbia

Jonas is a first-year graduate student majoring in civil engineering, with a concentration in water resources and environmental engineering. His research project, titled "Aquaponics with Ethylene Scavengers to Support Human Life Off Earth," is designed to test the efficacy of ethylene scavengers in aquaponic systems in airtight conditions in order to reduce ethylene buildup, which can be toxic to plants in high concentrations. This research will help NASA keep scientists in space for long duration space exploration.

"Looking forward to graduate school and beyond, I want to focus my studies and career goals on water resources engineering, with the goal of creating sustainable food systems for both NASA space travel and anywhere soilless systems are needed."



Jie Zhou
University of Hawaii at Manoa

Jie Zhou is a graduate student majoring in electrical engineering. His research at Ames Research Center focuses on the development of a long-range bioscope using time-resolved fluorescence spectroscopy to detect biomarkers up to a distance of 10 kilometers. A long-distance bio-detector can reduce mission time required for lengthy land traversals, accelerating NASA's search for life during future exploration of other planets and moons in our solar system.

"I wish to become an electrical engineering researcher developing biosensors and instruments for a variety of applications that can benefit society. Being a part of the NASA research for life mission is a dream come true."



Ray-Shimry Garatsa
University of Maryland

Ray-Shimry Garatsa is a graduate student majoring in aerospace engineering with research interests in multibody dynamics and space robotics. His project at Langley Research Center aims to develop software that can predict the behavior of large flexible structures in space during spacecraft maneuvers and in-space assembly.

“Our work will be instrumental to the future of spaceflight to the Moon and deep space exploration under the ARTEMIS Program, which will require the use of large space structures. This research is an essential step towards my career goal of designing spacecraft that aid human space exploration.”



Kristen Tagaytayan
University of Nevada, Las Vegas

Kristen Tagaytayan is a graduate student majoring in mechanical engineering. Her research project focuses on development of novel materials for high-temperature space applications, which could accelerate growth in the area of solar power generation technologies.

“It is my general career goal to produce findings that contribute to the overall knowledge of solar cell materials, but it is my passion to one day share my experiences and encourage others to pursue research in a STEM field.”



Matthew Bonanni
Stanford University

A Ph.D. student studying mechanical engineering, Matthew Bonanni is focusing on improving computational fluid dynamics simulations of scramjet engines through advanced combustion models which balance cost and accuracy. His research at Langley Research Center has centered on spray combustion in the context of rocket engines and gas turbines.

“In the future, I hope my research will continue to assist with the development of improved scramjet and rocket engines and serve NASA’s mission of unlocking hypersonic human flight and improving humanity’s access to space.”



Amber Young
Northern Arizona University

A NASA Fellow at Goddard Space Flight Center, Amber Young is a graduate student pursuing a Ph.D. in astronomy and planetary science. Her research project involves utilizing computer modeling techniques to simulate Earth-like exoplanet atmospheres and developing strategies for remote detecting biosignatures. This will be critical for future NASA missions looking to characterize exoplanet atmospheres and evaluating a planet’s ability to host life.

“My career goal is to continue pursuing research in the field of exoplanet science and astrobiology in dedication to the search for life beyond our home planet.”

Student Learning Opportunities



Divers testing student designs inside the Neutral Buoyancy Lab at Johnson Space Center during the 2021 Micro-g Next Artemis Student Challenge. Credits: NASA

Artemis Moon Pod Essay Contest/Future Engineers

In May 2021, NASA's **Artemis Moon Pod Essay Contest** announced its winners, with three U.S. students learning that their creative stories of a pioneering journey to the Moon had earned them front-row seats at the first launch of the Artemis program. NASA and online platform Future Engineers launched the Artemis Moon Pod Essay Contest in September 2020, inviting K-12 students nationwide to create their visions of a weeklong mission to the Moon's South Pole. Nearly 14,000 students from all around the country responded.

Through Future Engineers, the grand prize winners will have the opportunity to travel with their families to Kennedy Space Center in Florida to expand their learning and experience the first launch of NASA's Space Launch System rocket and Orion spacecraft during the uncrewed Artemis I mission.

Over 1,000 educators, professionals, and space enthusiasts served as volunteer judges, narrowing the field to 155 semifinalists and then to nine finalists. A panel of four NASA judges interviewed the finalists and selected the three winners.

Semifinalists were invited to a series of virtual Artemis Explorer Sessions with NASA experts and received an Artemis educational award pack filled with fun learning materials. The contest's finalists were invited to travel with a parent to NASA's Johnson Space Center in Houston to learn more about lunar exploration.

All 13,898 essays submitted to the Moon Pod Essay Contest will fly around the Moon on a USB flash drive aboard Artemis I. On this first flight of the Artemis program, the Orion spacecraft will travel beyond the Moon, nearly 280,000 miles away from Earth – farther than any spacecraft built for humans has ever traveled.

The contest was a collaborative effort between Next Gen STEM and HEOMD in partnership with Future Engineers.



Grand prize winners



Grades K-4:
Austin Pritts
Wolcott, Indiana



Grades 5-8:
Taia Saurer
Laguna Beach, California



Grades 9-12 :
Amanda Gutierrez
Lincoln, Nebraska

13,898
essays submitted

155
semifinalists

1K+
volunteer judges

Next Gen STEM - App Development Challenge

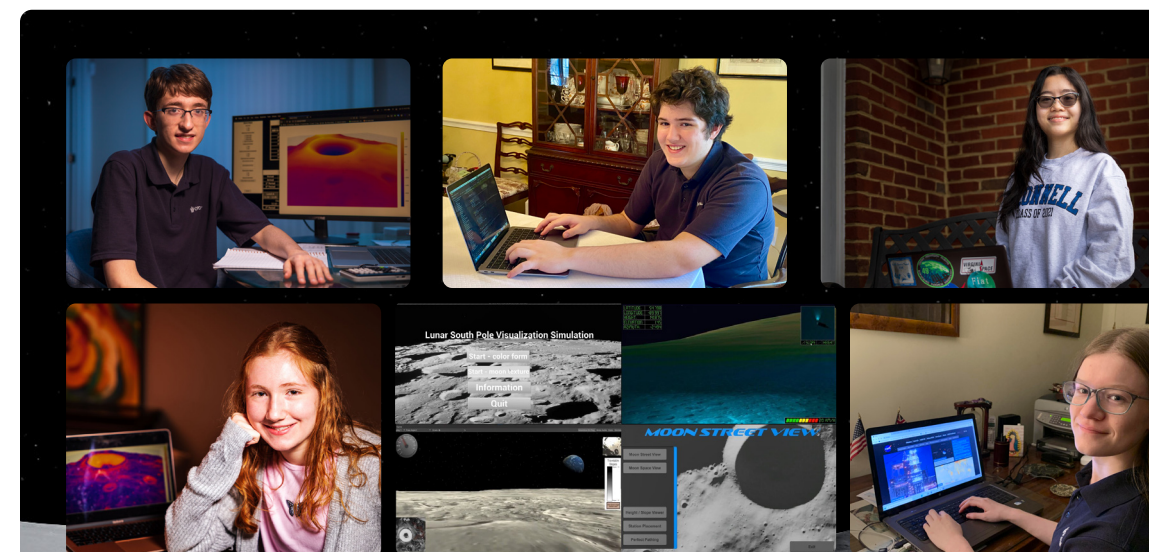
Through the **App Development Challenge (ADC)**, NASA's Next Gen STEM presents technical problems to middle and high school students and invites them to contribute to future exploration missions by developing apps that address these technical concerns. Designed in collaboration with NASA's **Space Communications and Navigation (SCaN)** Program, the challenge launched in late 2020, giving student teams seven weeks to develop an app that visualized the South Pole region of the Moon, displaying essential information for navigation and communication. The challenge was highlighted by a series of live virtual connections in which students learned about NASA's Artemis Program, app development, creating visualizations, space communication and navigation, and NASA internships. These live events brought together subject matter experts from the SCaN, Artemis Communication, Virtual Reality Training Lab, and Internship teams. In total, over 650 students and educators participated in these virtual events.

Teams of middle and high school students across the country participated in the challenge. Based on evaluation

of their efforts, the following 10 schools were selected to attend a virtual experience in February 2021 to showcase their work and participate in additional activities:

- Academies of Loudoun: Leesburg, Virginia
- Bell Creek Academy High School: Riverview, Florida
- Bishop O'Connell High School: Arlington, Virginia
- Falcon Cove Middle School: Weston, Florida
- Gilman School: Baltimore, Maryland
- McNeil High School: Austin, Texas
- Middlesex County Academy for Science, Mathematics and Engineering Technologies: Edison, New Jersey
- Millburn High School: Millburn, New Jersey
- Moore Norman Technology Center: Norman, Oklahoma
- Gretchen Whitney High School: Cerritos, California

At the conclusion of the challenge, the NASA SCaN team reviewed the student-created applications and deemed some to be viable options for future use in mission planning and training activities.



Micro-g NExT – Artemis Student Challenges

Micro-g Neutral Buoyancy Experiment Design

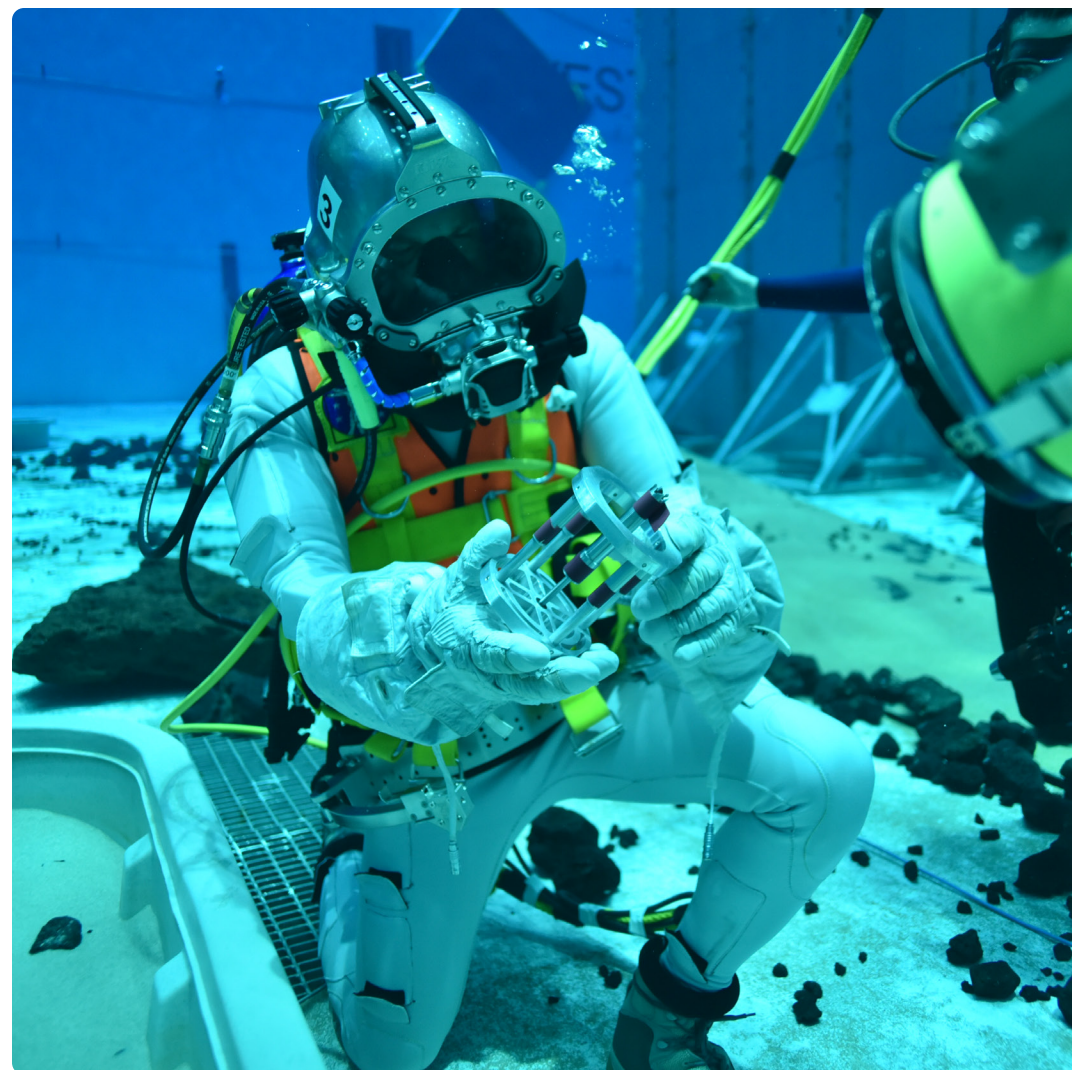
Teams (Micro-g NExT) is an annual mission-driven, authentic NASA STEM experience through which undergraduate students to design, build, and test a tool or device that addresses a current space exploration challenge. Micro-g NExT, a HEOMD-funded activity, brings undergraduate students into technology and hardware development paths of NASA missions in support of human space exploration.

Students were asked to design a surface vehicle capable of assisting astronauts in distress in a maritime environment, through the location and delivery of crew

survival aids. Additionally, students were tasked with developing extravehicular activity (EVA) tools and devices intended for the collection of lunar rocks, regolith, and potentially ice cores for the planned Artemis III mission.

In the culminating event of the Micro-g NExT experience, students test their lunar sample collection or search and rescue prototypes in NASA's Neutral Buoyancy Laboratory.

For more information, visit microgravityuniversity.jsc.nasa.gov/about-micro-g-next.cfm



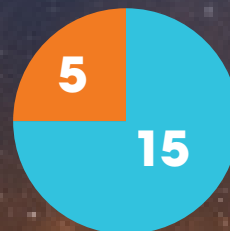
314
total student
participants
(phases 1&2)

227
student
participants
in phase 2

175
student
participants
during test week

26
teams advanced
to phase II

2021 Prototype
Testing



■ Lunar EVA
■ Search and rescue

BIG Idea Challenge – Artemis Student Challenges

Managed by NASA's Space Technology Mission Directorate (STMD), the **Breakthrough, Innovative and Game-changing (BIG) Idea Challenge** is an annual student challenge seeking new concepts and creative solutions from teams at Space Grant-affiliated colleges and universities. These teams support STMD's work maturing high-impact technologies for a broad array of NASA missions. The competition is an open innovation challenge with minimal constraints, meaning that proposing teams can create highly unique, out-of-the box solutions.

The 2021 BIG Idea Challenge provided undergraduate and graduate students the opportunity to design, build, and test unique concepts for near-term dust mitigation technologies for lunar applications. Teams of students and their faculty advisors proposed innovative solutions with supporting original engineering and analysis. The Game Changing Development Program within STMD partnered with NASA's Space Grant project to award nearly \$1 million to seven university teams to build and test a wide range of lunar dust mitigation solutions, including reducing dust clouds upon landing, dust removal from spacesuits and other surfaces, dust obstruction of optical systems, and reducing in-cabin particulate levels, among others. Many participating universities also partnered with industry and/or received funding from industry to leverage NASA's investment in their technologies. BIG Idea Challenge solutions increase the Technology Readiness Level (TRL) of critical technologies needed for lunar exploration and the Artemis mission.

For more information, visit bigidea.nianet.org/



7 teams
selected

135 student
and faculty
participants

Brown University with Rhode Island School of Design
TEST-RAD: Tufted Electrostatic Solution To Regolith Adhesion Dilemma

California Institute of Technology
Habitat Orientable and Modular Electrodynamic Shield (HOMES)

Colorado School of Mines with ICON, Masten Space Systems, Adherent Technologies Inc., TexTech, and the Composite Applications Group
Lunar In-Situ Landing/Launch Environment (LILL-E) Pad

Georgia Institute of Technology
Hybrid Dust Mitigation Brush Utilizing EDS and UV Technologies

Missouri University of Science & Technology
Contaminant Ultrasonic Removal via Vibration Ejection from Solar Cells (CURVES)

University of Central Florida with Morphotonics
LETO - Lunar Dust Mitigating Electrostatic micro-Textured Overlay

Washington State University *2021 Artemis Awardee*** - top honor**
Leidenfrost Dusting as a Novel Tool for Lunar Dust Mitigation

Lunabotics – Artemis Student Challenges

Lunabotics is an annual competition designed to immerse college students in NASA’s systems engineering process through designing and building a prototype lunar robot. Student teams work on developing lunar surface technologies to support a sustainable presence on the Moon and on to Mars. Teams are required to submit the following: a project management plan, a public outreach report, a presentation and prototype demonstration, and a systems engineering paper. In FY 2021, 63 teams composed of 1,393 students from across the U.S. registered to participate, including 10 teams from MSIs. Due to the COVID-19 pandemic, the on-site robotic mining portion of the competition was not held; however, 32 teams completed the remainder of the virtual competition with 15 awards made to eight institutions.

For more information, visit www.nasa.gov/offices/education/centers/kennedy/technology/nasarmc.html



Lunabotics indoor mining arena at NASA's Kennedy Space Center. Credits: NASA

Student Launch – Artemis Student Challenges

Student Launch is a research-based, competitive experiential exploration challenge open to colleges and universities, high schools, and middle schools. Funded by Next Gen STEM and HEOMD, it strives to provide relevant, cost-effective research and development of rocket propulsion systems.

Many of the participating teams in FY 2021 were impacted by restrictions on travel or in-person events and learning opportunities. Student Launch adapted to these considerations by creating additional options to give every team a path to success: a new Design Division and a Launch Division. The all-virtual Design Division allowed teams to conduct all test launches via simulation. In lieu of a final competition launch, a new Payload Modification Vehicle Redesign milestone challenged teams to redesign their vehicles to accommodate a change in payload, similar to how NASA might modify a vehicle for a new mission. The Launch Division provided a launch-at-home opportunity. Initially planned as an alternative for teams unable to travel for a launch event. Ultimately, all Launch Division teams completed the challenge this way when in-person events were cancelled due to continuing COVID-19 concerns. Student Launch utilized a network of local club officers with the National Association of Rocketry and Tripoli Rocketry Association to certify each team’s flights, data, and results.

In lieu of the traditional in-person launch month activities, Student Launch conducted a virtual career fair in partnership with sponsor American Institute of Aeronautics and Astronautics; weekly sessions with subject matter experts and opportunities for student teams to present their projects; and a livestreamed awards ceremony.

For more information, visit www.nasa.gov/stem/studentlaunch/home/index.html



Northrup Grumman, National Space Club - Huntsville, the American Institute of Aeronautics and Astronautics (AIAA), Bastion Technologies Inc, and the National Association of Rocketry provided cash prize support (\$19,000 in total) for 11 of the awards given.

First Nations Launch – Artemis Student Challenges



University of California, Davis students preparing to test launch their rocket.

First Nations Launch (FNL) aims to contribute to NASA’s and the nation’s diverse future technical workforce by engaging the next generation of Native Americans in STEM and inspiring them to pursue STEM careers. This annual competition is a collaboration between NASA and the Wisconsin Space Grant Consortium at Carthage College that provides students an opportunity to demonstrate engineering and design skills through direct application in high-powered rocketry. FNL engages Tribal Colleges and Universities (TCUs), Native American-Serving Nontribal Institutions (NASNTIs), and other Minority Serving Institutions (MSIs) with American Indian Science and Engineering Society (AISES) collegiate chapters, as well as tribal communities. Teams of students and a mentor receive resources and needed component materials, work together to meet multiple competition requirements, and conduct vital outreach for local audiences.

For the 2021 FNL Moon Challenge, teams were asked to design and build a high-powered rocket able to fly to an apogee of 3,500 to 4,000 feet. Rockets were required to carry an onboard warning sensor system (flight recorder) and record two events during the flight, with video for one.

Eight teams participated in the 2021 FNL Moon Challenge, with six successfully completing the competition. The team from University of California, Davis (UCD) won first prize; the University of Washington, Seattle, team was runner-up; and Northern Arizona University’s team placed third.

The first entrant in the new international division was a Canadian team from Queen’s University in Kingston, Ontario. The team won first place overall for Written Reports as well as the Aesthetic Award. Queen’s University was unable to launch its rocket due to pandemic restrictions, so the UCD FNL team conducted the launch on its behalf.

While challenges related to the COVID-19 pandemic remained for the Native American community and MSIs, NASA’s 2021 FNL teams continued to demonstrate the traits that tomorrow’s innovators and explorers will need: ingenuity, perseverance, teamwork, courage, and partnership.

For more information, visit: <https://www.nasa.gov/stem-ed-resources/first-nations-launch.html>



HERC – Artemis Student Challenges

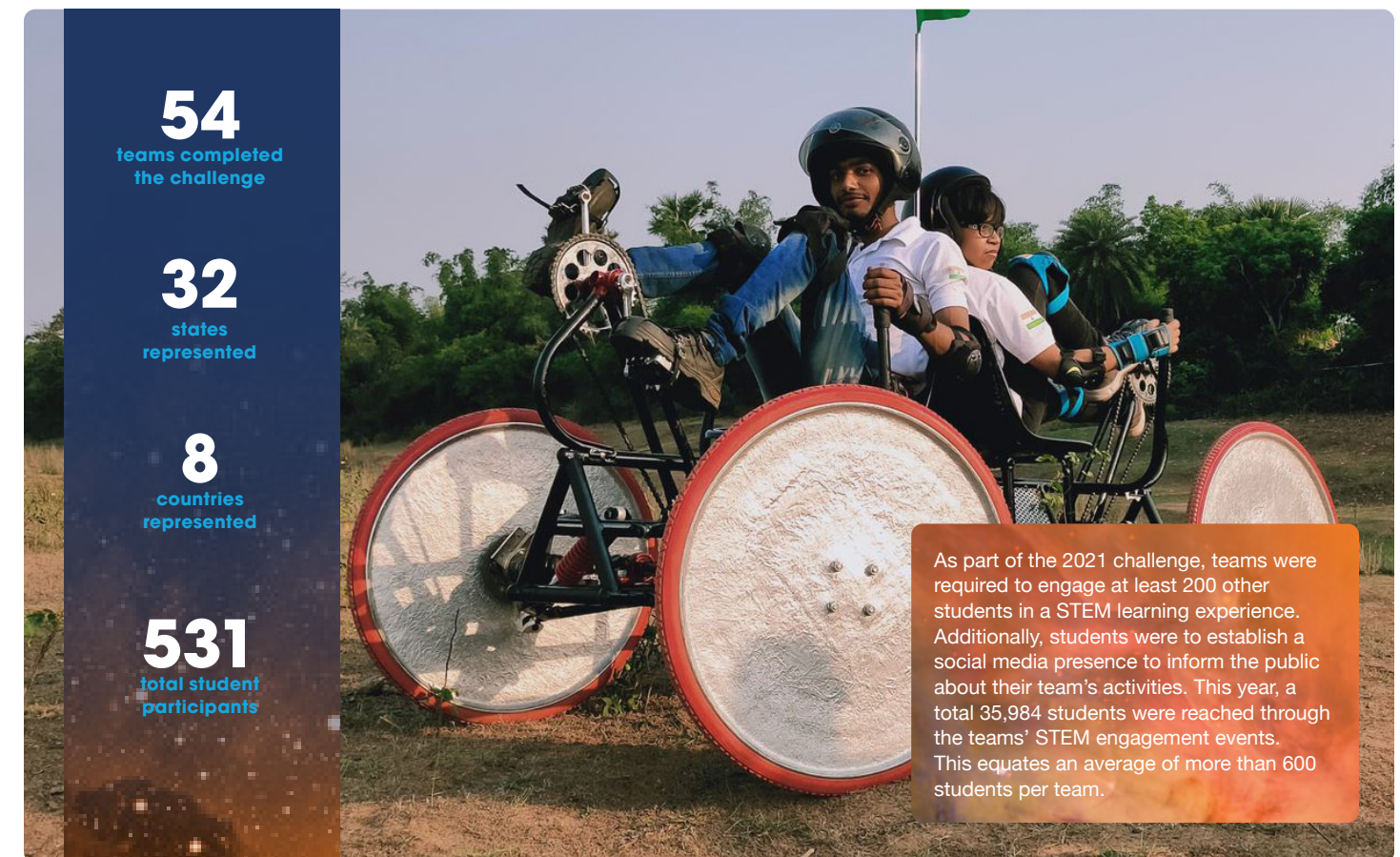
The annual **Human Exploration Rover Challenge (HERC)** is a research-based, competitive, experiential engineering challenge that mimics NASA’s fundamental project life cycle. This challenge is funded by Next Gen STEM and HEOMD and provides students with realistic, cost-effective research, and project development opportunities akin to NASA’s missions. Students work in teams to design, build, and test technologies that enable a two-person vehicle to traverse a variety of challenging terrains. This engineering challenge is a seven-month commitment in which participating students research, design, and build a working vehicle, complete mission tasks with tools they’ve created, submit a series of reports and reviews, provide a project timeline and budget, and engage other students in STEM education through digital platforms and other opportunities.

The idea behind the challenge was motivated by the

Apollo 14 surface mission – teams must make real-time decisions about which mission objectives to attempt and which to leave behind—all driven by a limited, virtual eight-minute supply of oxygen. The approximately .50-mile competition course made up of a simulated field of asteroid debris, boulders, an ancient streambed, and erosion ruts and crevasses must be traversed using the student-designed, student-powered vehicle. Points can be earned as teams progress through all stages of the challenge.

The in-person competition is normally held in Huntsville, Alabama, but did not take place in 2021 due to the COVID-19 pandemic. In lieu of in-person excursions, teams were invited to send rover demonstration videos.

For more information, visit www.nasa.gov/stem/roverchallenge/home/index.html



As part of the 2021 challenge, teams were required to engage at least 200 other students in a STEM learning experience. Additionally, students were to establish a social media presence to inform the public about their team’s activities. This year, a total 35,984 students were reached through the teams’ STEM engagement events. This equates an average of more than 600 students per team.

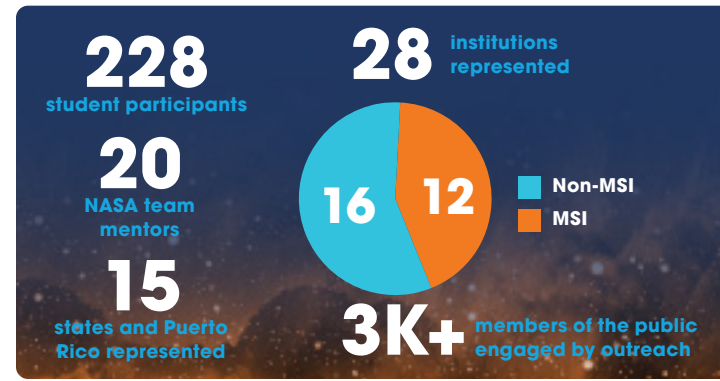
Students from the University of Puerto Rico testing their rover. Credits: University of Puerto Rico

SUITS – Artemis Student Challenges

Through the **NASA Spacesuit User Interface Technologies for Students (SUITS)** Design Challenge, teams of undergraduate and graduate students design and create spacesuit information displays within an augmented reality environment. These efforts contribute to the research and development of human autonomy for future spacewalks on the Moon and Mars in support of the Artemis program. Sponsored by the NASA Extravehicular Activity (EVA) Office and OSTEM, the annual SUITS Design Challenge offers real-world engineering experience that can be applied to meet future needs for astronauts exploring the lunar surface.

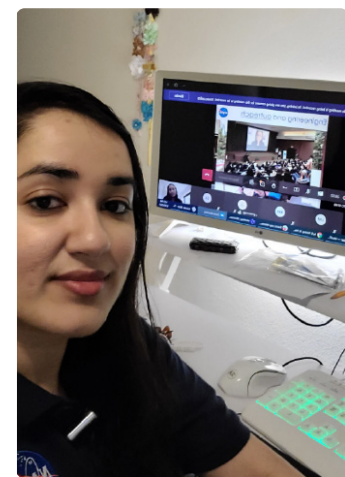
The FY 2021 challenge was completely virtual due to the COVID-19 pandemic. Teams created and designed their displays using a commercially available head-mounted display device. A Space Act Agreement with Microsoft connected participating students with developer support, technical exchange, and skills opportunities and certifications. Students participated in webinars with featured speakers including NASA astronaut Tom Marshburn as well as officials from NASA’s EVA and Search and Rescue Offices, Microsoft, and Electronic Arts. NASA selected the top 10 teams to participate in a virtual test week, in which design evaluators put each team’s prototype to the test in a lunar environment at Johnson Space Center.

For more information, visit microgravityuniversity.jsc.nasa.gov/nasasuits.cfm



NCAS

NASA Community College Aerospace Scholars (NCAS) builds a diverse future STEM workforce by engaging two-year degree seeking students in authentic learning experiences. Scholars get a closer look at NASA’s unique missions and research and learn how to develop their talents, interests, and passion to become future STEM professionals. Selected students may have the opportunity to participate in up to three unique experiences.



“We’ve learned so many things in these few days, including career skills, resume skills, applying for internships, life skills, getting out of your comfort zone, networking, and most importantly,

teamwork. NCAS has inspired me to follow my dream to get a NASA internship and one day work at NASA.”

-Sana Sabri

Mission 1: Discover

NCAS Online – Scholars discover NASA’s research and missions through a guided experience during a five-week self-paced online course, where scholars learn about NASA missions and research.

Mission 2: Engage

Scholars who successfully complete Mission 1 may receive an invitation to participate in the engineering design experience. All the experiences develop students’ talents, interest, and passion to become future STEM professionals. The experience may be structured as one of the following:

- NCAS Virtual – Scholars participate in a gamified mission to the Moon or Mars led by NASA.
- NCAS on Campus – Scholars at NASA Partner campuses participate in a face-to-face robotics engineering challenge led by NASA-trained faculty.
- NASA Career Simulation – Scholars at NASA Partner campuses participate in a simulated job experience led by NASA-trained faculty. Scholars work in teams with STEM industry mentors to create a lunar mission preparing for human exploration.

Mission 3: Explore

Scholars who successfully complete Mission 2 may be selected to participate in Mission 3.

NCAS at NASA – Scholars contribute to NASA’s missions by developing possible solutions to current NASA challenges onsite at a NASA Center. Scholars engage in authentic job shadowing and gain exposure to university campuses.



MINDS

NASA's MUREP Innovative New Designs for Space (MINDS) is a multi-semester undergraduate level activity that supports NASA's Artemis mission and HEOMD. NASA MINDS, which completed its inaugural year in FY 2021, is not a competition but rather a hands-on design and build collegiate learning experience.

Students' skills, creativity, and innovation are challenged as they are asked to design and build technologies needed for Artemis with the support of a faculty advisor. The most unique feature of NASA MINDS is found in its broad-based approach. While competitions focus on a specific technology all teams must work on, teams in NASA MINDS independently select a technology that is relevant to Artemis, allowing students to focus on

technologies that interest and inspire them the most.

All MSIs are eligible to have a faculty-led student team. Student teams submit a proposal with a design concept that meets a series of requirements. Teams selected by NASA receive \$1,500 to build their design. Teams must have a faculty mentor, who receives a \$1,000 stipend upon successful completion of all requirements. Selected team projects are reviewed by NASA judges and teams can receive recognition awards for up to \$5,000.

Thirty-one teams representing 26 minority-serving institutions completed the NASA MINDS challenge in its first year. NASA astronaut Winston Scott, a veteran of two space shuttle missions, took part in a virtual awards ceremony to congratulate the student teams.



MITTIC

MUREP Innovation & Tech Transfer Idea Competition (MITTIC) MUREP Innovation & Tech Transfer Idea Competition is a higher education spinoff challenge established to develop new ideas for commercialization by seeking concept papers from multi-disciplinary student teams enrolled at minority-serving institutions.

The competition is primarily based on each team's spinoff concept developed from one of seven chosen NASA intellectual properties. An additional component was added in 2021 in partnership with the **Lucy Student Pipeline Accelerator and Competency Enabler (L'SPACE) Academy**, requiring at least one student from each team attend one of two L'SPACE programs. NASA L'SPACE is designed to increase entrepreneurial skills and the quality of concept paper development. Eight teams were selected to participate in MITTIC this year based on their concept paper submissions.

The teams attended a virtual immersion experience with NASA leading up to a pitch competition. Participants heard from STEM subject matter experts and were given an authentic entrepreneurial experience with the help of NASA, contributing organizations and industry partners: Microsoft Corporation, JES Tech, Barrios Technology, MORI Associates Inc., and NASA's STMD, Ames Research Center Partnerships Office, Technology Transfer Program, Small Business Innovation Research/Small Business Technology Transfer Program, Office of Small Business Programs, and SMD L'SPACE Academy.

The winner of the 2021 competition was a team from Fayetteville State University. Their "BioLidar" innovation uses selected laser frequencies to identify pathogens, cancerous cells, and dead cells by two techniques of optical-spectroscopy and mass-spectrometry, then remove the cell by laser assisted break-down the chemical substance of the cell. Their concept used the

NASA Intellectual Property of Laser Surface Treatment and Spectroscopic Analysis System. As NASA's MITTIC 2021 champions, the team received \$15,000 for winning the competition and submitting all required deliverables. The MITTIC team from Fayetteville State University is scheduled to engage in a virtual immersion experience with Ames Research Center featuring virtual tours, conversations with subject matter experts, and an opportunity to present their concept to local business leaders in spring 2022.



MITTIC also collaborated with the **White House Initiative on Advancing Educational Equity, Excellence, and Economic Opportunity through Historically Black Colleges and Universities (HBCU)** in FY 2021 to host a miniature version of MITTIC, or "Mini MITTIC," for 86 HBCU scholars representing 54 institutions.

For Mini MITTIC, the HBCU scholars were broken into ten teams, with each team representing multiple institutions. Teams selected from a list of six NASA Intellectual Properties, created a concept, and developed a short elevator pitch to deliver to "investors" – competition judges representing NASA and the White House Initiative. The investors selected the top three teams to record presentations for the closing day of the White House Initiative for HBCU Scholars event.

Next Gen STEM - Team II Awards

In FY 2021, three new **TEAM II awards** were made from proposals to the previous 2019 solicitation, totaling \$2.99 million. These new proposals focused on the Artemis missions and the overall Moon to Mars theme.

Awardees were the ScienCenter in Ithaca, New York, for its proposed “Explore Science: Destination Moon” project; Space Science Institute in Boulder, Colorado, for its proposed “From Our Town to the Moon, Mars, and Beyond” project; and The Franklin Institute in Philadelphia for its proposed “Mission to Mars: Boosting Community Engagement with NASA Resources” project.

A 2021 TEAM II funding opportunity notice was released offering a variety of distinct program elements – including a new funding level for one-to-two-year Community Anchor Awards – to which eligible informal education institutions may propose. TEAM II Community Anchor Award institutions will have demonstrated existing expertise in working with underserved communities. These awards provide funding to help recipient institutions establish or further themselves as local NASA STEM informal education community resources, offering authentic NASA STEM experiences that benefit their diverse local audiences.

This augments and expands the TEAM II awardee pool beyond the larger customary TEAM II awards for projects spanning two to four years.

In a new NASA Informal Education Learning Cohort to be implemented in 2022, they can develop skills in implementing NASA-themed activities, develop collaborations and build a relationship with NASA that lasts beyond their initial project.



Team II Awardees

ScienCenter
Ithaca, New York
“Explore Science: Destination Moon”

Space Science Institute
Boulder, Colorado
“From Our Town to the Moon, Mars, and Beyond”

The Franklin Institute
Philadelphia, Pennsylvania
“Mission to Mars: Boosting Community Engagement with NASA Resources”

78

participating organizations

37

states represented plus District of Columbia and Puerto Rico

Next Gen STEM - Remote Opportunity Rapid Response

The **TEAM II Remote Opportunity Rapid Response (RORR)** was a new competitive solicitation issued in response to the unique learning challenges presented by the COVID-19 pandemic. RORR provided financial support in the range of \$100,000 to \$175,000 for up to one year for competitively selected informal education institutions. The funding enabled institutions to amplify or create innovative remote or distance-learning programs, opportunities, or projects to reach K-12 students using relevant NASA content to be implemented in the 2020-2021 school year and summer.

One successful RORR project, Nevada State Library and Archive’s “NASA HOLA: STEM Hands-On Learning Activities to Inspire a Diverse Population,” partnered with the Desert Research Institute in Las Vegas to bridge the digital divide through the development of 5,000 physical kits based on three CCP activities. The kits were distributed to nearly 90 Nevada libraries, which built family-day programs around them or distributed them directly to families to enjoy at home.

Selected Projects

World Building on Mars: Educational Program for Middle School Students

Michigan State University, Abrams Planetarium

Indoor Farming Innovation Zone Remote Learning Program

Boys & Girls Club of Pueblo, Colorado

EVOLVE (Expanding Versatile Offerings for Learning in Virtual Environments)

Museum of Science, Boston, Massachusetts

Understanding the Invisible: Studying Ozone through Bioindicator Gardens under NASA's TEMPO Mission

Virginia Living Museum

Growing Beyond Earth: Distance Learning for Underserved Communities

Fairchild Tropical Botanic Garden, Coral Gables, Florida

Project Ianos: Inspirational Space Education, Past, Present and Future

Sharespace Foundation, Los Angeles, California

NASA HOLA: STEM Hands-On Learning Activities to Inspire a Diverse Population

Nevada Department of Administration, Doing Business As: Nevada State Library and Archives



Left: 6th grade student Kailani Labady watering newly planted seeds in a GBE growth Chamber, Jos Mart MAST 6-12 Academy, Hialeah, Florida. Right: Dr. Shannon Walker watering newly planted seeds, including a plant variety selected through GBE student research, in a Veggie growth chamber on the International Space Station.

Student Experiments Launch Aboard Suborbital Vehicles

After being developed via a virtual learning experience, experiments built by university students across the U.S. took to the skies aboard NASA suborbital flight vehicles in FY 2021. On June 25, 2021, a NASA Terrier-Improved Orion suborbital sounding rocket carrying student experiments launched from the agency's Wallops Flight Facility in Virginia, and on Sept. 14, 2021, a NASA heavy-lift balloon carried the 15th **High-Altitude Student Platform (HASP)** mission aloft from Fort Sumner, New Mexico.

The 36-foot long, two-stage Terrier-Improved Orion rocket carried 32 **RockOn! experiments**, eight experiments in the **RockSat-C program**, and more than 60 small cubes with experiments developed by middle school and high school students as part of the Cubes in Space program, a partnership between idoodlelearning inc., NASA Wallops, and the Colorado Space Grant Consortium.

Conducted with the Colorado and Virginia Space Grant Consortia, RockOn! is in its thirteenth year and RockSat-C its twelfth year. RockOn! participants receive instruction on the basics required to develop a scientific payload for flight on a suborbital rocket. After RockOn!, students may then participate in RockSat-C, in which they design and build a more complicated experiment for flight.

This year, due to COVID-19, the prelaunch RockOn! workshop traditionally held at Wallops was conducted virtually, enabling the development of more experiments than in previous years. As a result, more flight-ready projects were developed than the rocket could accommodate, so 34 of the experiments flew as part of the High-Altitude Student Platform through the Louisiana Space Consortium on a NASA scientific balloon launched from Fort Sumner, New Mexico.

HASP is a joint project between NASA's Wallops Flight Facility Balloon Program Office in Virginia, SMD, the

Louisiana Space Grant Consortium (LaSPACE) in Baton Rouge, and the Columbia Scientific Balloon Facility in Palestine, Texas.

The HASP platform houses and provides power, mechanical support, interfacing, data downlink, and command uplink communications for up to 12 payloads. In addition to 11 student experiments already slated to fly on this mission, Colorado Space Grant Consortium hitched a ride on the final available flight spot, carrying RockOn! student payloads.



A Terrier Improved Orion sounding rocket launched at 8:32 a.m. EDT on June 25, 2021, from NASA's Wallops Flight Facility carrying 40 student experiments for the RockOn/RockSat-C mission.

“One of the great attributes of the NASA suborbital flight vehicles is the ability to support educational flight activities. Despite the challenges that dealing with COVID-19 presented, everyone came together to make this launch happen this year after having to postpone the project in 2020.”

—Giovanni Rosanova
Chief of the NASA Sounding
Rockets Program Office
NASA Wallops Flight Facility

Space Grant - Innovative Solar Discoveries in Chile

In December 2020, university students from the Idaho, Oklahoma, and Montana Space Grant Consortia traveled to Santiago, Chile, under strict COVID-19 protocols to assist NASA and NSF with first-of-its-kind solar eclipse research.

Space Grant assembled teams of students and interns to go to Chile after scientists detected eclipse-driven gravity waves for the first time in 2017. Gravity waves are fundamental to the movement of energy and momentum through the atmosphere. These waves affect the weather and climate, and understanding their influence allows for improvements in forecasting. Measuring wave characteristics produced by an eclipse also provides crucial data in the development of accurate physical descriptions of gravity waves. Space Grant sought to add to this research by measuring the atmospheric effects of a pair of solar eclipses that were visible in South America in June 2019 and December 2020.

In 2019, the first student teams traveled to the Andes Mountains in Chile, where they were able to detect the first eclipse-driven stratospheric gravity waves by deploying sensor-carrying balloons. Excited by the students' discovery, Space Grant began planning the second trip to build on the research.

The next opportunity to capture a solar eclipse traveling from West to East over the same geographic region was December 2020. It was essential to return to Chile in 2020 because the next opportunity to study two solar eclipses traveling in the same direction in the southern hemisphere will not occur until 2037 and 2038 in Australia.

Despite the challenges posed by the COVID-19 pandemic, with extensive planning, 17 student researchers were able to travel to Chile in early December 2020.



“This [field research] has been an excellent opportunity to synthesize the tools I've learned in the classroom with the messy problems we're trying to understand in the field. My experience in Chile—and all of the preparation and analysis related to it—has cemented my interest in a research career.”

— Malachi Mooney-Rivkin
Space Grant student researcher from Idaho

The students were assigned to one of two teams at two different launch sites, and the 48-hour launch campaign began on Dec. 13. Every hour, balloons were launched carrying sensors to measure changes in atmospheric temperature, pressure, relative humidity, and wind speed and direction. The group also implemented a surface station to measure these factors and solar irradiance changes during the eclipse, and were able to successfully detect stratospheric gravity waves, like the 2019 teams before them. The teams were able to record over 150 gravity waves throughout the field campaign and they hope to gain a clearer understanding of their origins.

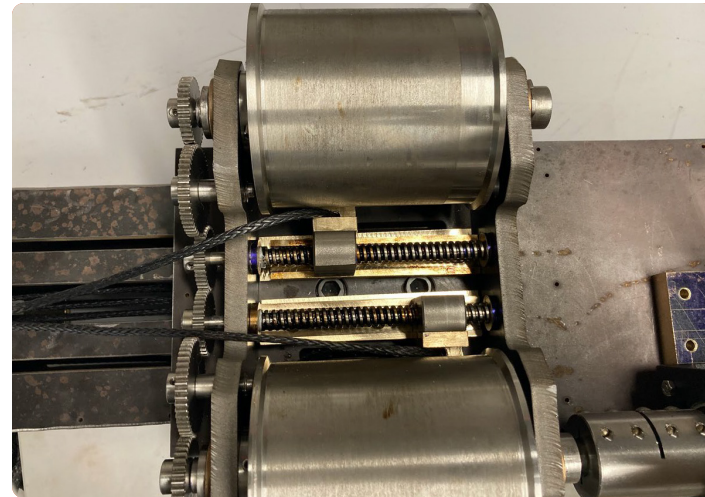
Moon to Mars eXploration Systems and Habitation

The **Moon to Mars eXploration Systems and Habitation (M2M X-Hab)** Academic Innovation Challenge provides university students with the opportunity to be on the forefront of innovation. NASA identifies necessary technologies and studies for deep space missions and invites universities from around the country to develop concepts, prototypes, and lessons learned that will help shape future space missions. Universities propose on a variety of proposed projects and are judged on technical merit, academic integration, leveraged funding, and outreach. Winning teams are given monetary awards ranging from \$15,000- \$50,000 to assist them in designing and producing studies, research findings or functional products that bridge strategic knowledge gaps, increase capabilities and lower technology risks related to NASA's Moon to Mars space exploration missions.

Each university assembles a multidisciplinary team of students that invest months working together, developing concepts, and, frequently, producing working prototypes. Through M2M X-HAB, students gain quality experience by developing potential solutions to real-world problems and work closely with NASA subject matter experts who guide them through an official engineering development process.

For the 2021 challenge, M2M X-Hab teams were asked to design, manufacture, assemble, test, and demonstrate functional prototypical subsystems and innovations that enable increased functionality for human space exploration missions in the areas of habitation systems; vehicle systems; foundational systems such as avionics, communications, and navigation systems; robotic precursor activities; and human spaceflight architecture systems with emphasis on the Gateway.

X-Hab projects have resulted in follow-on collaborative research projects with NASA Environmental Control Life Support System (ECLSS) and at least two university



Compact electric bi-directional pulley actuator spooling assembly. Credits: Lamar University patents.

M2M X-Hab is managed under Advanced Exploration Systems as a service to HEOMD projects.

One example is an excavator arm for lunar mining and construction developed by Lamar University in Beaumont, Texas. While significant work has been dedicated to the study of potential uses of in-situ resources once mined, the methods to mine the raw materials have not been fully explored. This project presents the first attempt at producing a drop-in replacement for hydraulic cylinders on heavy construction equipment with an electromechanical actuator utilizing pulleys to convert a single motor's rotational motion to bidirectional linear motion. The produced actuator can be applied or scaled for near direct replacement of hydraulic cylinders on terrestrial mining and construction equipment for faster development of off-Earth use. Significant work remains to refine the concept into flight hardware, but the concept shows promise.

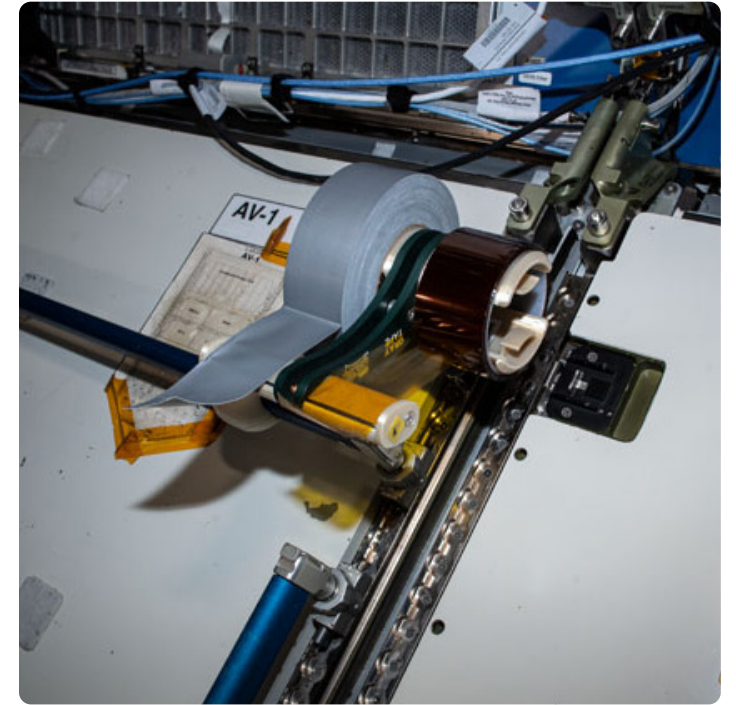
The project was executed by the Department of Mechanical Engineering, Lamar University, Beaumont, Texas, and sponsored by MUREP.

HUNCH

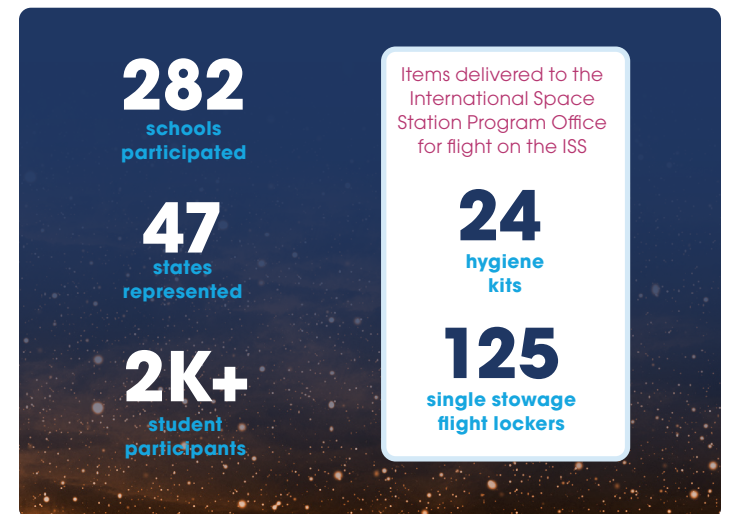
High school students United with NASA to Create Hardware (HUNCH) began 19 years ago with three schools producing hardware training items for the International Space Station. HUNCH has grown to more than 282 schools from 47 states. In addition to producing space flight hardware for the space station and crew training, HUNCH reaches a diverse population of students through design projects, sewing flight and training articles, a video challenge and a culinary challenge. More than 40,000 students have participated in HUNCH, with 94 percent moving on to pursue undergraduate degrees.

More than 2,700 students participated in HUNCH during the 2020-2021 school year. As a result, 24 hygiene kits and 125 single stowage flight lockers were delivered to the International Space Station Program Office for flight to the orbiting laboratory. The stowage lockers play a key role in resupplying the space station, providing storage for payloads such as space mechanical parts, food, and other items. The lockers also can house experiments and projects onboard the station inside racks. Hygiene kits contain pouches and pockets to hold personal-care items such as lip balm, a hairbrush, and toothbrush and toothpaste.

In March 2021, NASA astronaut Mike Hopkins demonstrated the HUNCH Tape Dispenser aboard the International Space Station. The HUNCH Tape Dispenser was developed to help crew members control the adhesive tapes most often used in space. By providing a tape dispenser that can be operated with one hand, astronauts can hold other equipment while cutting the needed tape or pull off longer strips without the tape sticking to itself.



The tape dispenser onboard the International Space Station designed by students participating in HUNCH. See the dispenser in use [here](#). Credits: NASA



EarthKam

Despite the COVID-19 pandemic that disrupted classrooms around the world, in FY 2021, **EarthKam** conducted five missions allowing students access to real-time science onboard the International Space Station. In all, 76,671 global students participated from 786 schools, requesting 101,470 images. Students from 48 states and U.S. territories and 40 countries were represented. In support of Missions 71 through 75, the U.S. Space & Rocket Center promoted the program in professional development sessions with educators and developed new lesson plans to bring EarthKam into classrooms. Additionally, geospatial imaging students at the University of Alabama in Huntsville provided annotated images from the mission gallery. Visit the EarthKam gallery [here](#).



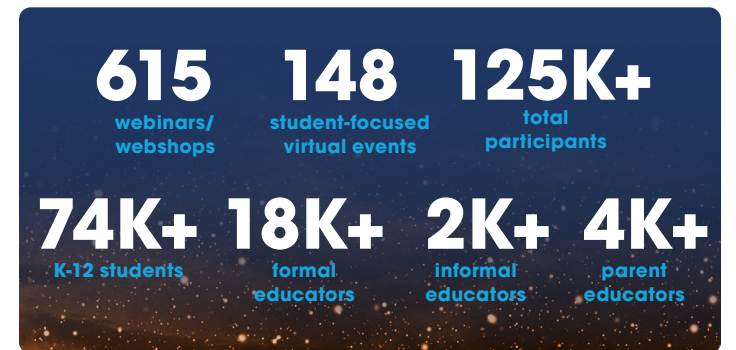
EarthKam photo of Oceania, Australia, March 2021.

Engagement and Educator Professional Development

NASA STEM Engagement & Educator Professional Development Collaborative (EPDC) serves STEM educators and their students across the country. In response to the ongoing COVID-19 pandemic, NASA EPDC dramatically increased its virtual offerings in FY 2021, holding 615 webinars/virtual workshops – 77% more than the previous year.

NASA EPDC partnered with the Edwards Air Force Base 412th Test Wing STEM Outreach Program and the Air Force Research Lab in support of Edwards' Virtual Airshow in October 2020. EPDC Educator Specialists Monica Uribe and Sara Torres presented multiple sessions, included a Spanish language session, throughout the three-day event, sharing engaging NASA STEM hands-on activities and information with educators, students, and their families. More than 2,200 educators and nearly 45,000 K-12 students accessed the virtual presentations through Zoom, YouTube, Twitter, Twitch, and the Edwards Air Force website.

The collaborative combined professional development and community engagement during a three-day event in September 2021. Texas State faculty members Dr. Omar Lopez and Dale Blasingame provided two days of professional development for EPDC specialists and staff members on the operation and uses of Unmanned Aerial Vehicles, or drones. On the third day, the EPDC specialists hosted a community engagement event in conjunction with the Round Rock Express Kids Day at the Dell Diamond in Round Rock, where approximately 350 students and their parents participated in six hands-on NASA activities.



Mission to Mars Student Challenge

NASA's Jet Propulsion Laboratory (JPL) Education created and led the **Mission to Mars Student Challenge**, involving nearly 1.2 million students worldwide in the landing of the Perseverance rover on Mars, followed by the flights of the Ingenuity helicopter above the surface of the Red Planet. Educators and parents received seven weeks of mission-phase themed lessons. Students engaged in livestream events with experts in education, Perseverance, and Ingenuity, while students were encouraged to ask questions of rover experts during special, student-centered landing week livestreams. Additionally, educators, parents, and students submitted approximately 600 entries to the **Mission to Mars Student Showcase**.

Connecting students to **#CountdownToMars Toolkit** served as a one-stop-shop for NASA educational resources and continues to serve as a valuable archive of materials. Designed to deliver the excitement of the Mars 2020 mission to students in classrooms or at home, the toolkit includes lessons and lesson plans, activities, graphics, animations, podcasts, and social media.

Activities were extended into summer 2021 with the "Mission to Mars Student Challenge: Summer Camp Edition" Zoom sessions, with subject matter experts answering students' questions about each of the weekly themes. JPL hosted seven training sessions for out-of-school-time staff and collaborated with the U.S. Department of Education to provide six live webinars for students to interact with Mars 2020 subject matter experts. On behalf of Next Gen STEM, JPL created a summer camp-specific web page through the Museum and Informal Education Alliance with links to challenge resources, and direct emailed registrants with information about upcoming sessions.

These summer activities placed an emphasis on diversity, through subject matter experts and by connecting with professional organizations that exist to reach underserved

students in STEM. The team also provided Spanish-language captions for all videos.

Mission to Mars Student Challenge activities were conducted in support of SMD, OSTEM, and the Mars 2020 mission.

NASA's Mission to Mars Student Challenge!

nearly 1.2M students worldwide

600 entries received for Mission to Mars Student Showcase

6.4K+ students were involved in the Mission to Mars Student Challenge: Summer Camp Edition

MARS 2020 STEM TOOLKIT

International Space Station Education Downlinks

Education downlinks provide educational organizations the opportunity to experience a 20-minute question-and-answer session with astronauts currently serving aboard the International Space Station. Here are a few highlights from FY 2021's downlinks.



Downlink with Shine On Project - May 6, 2021

Run by college women at State University of New York College at Plattsburgh, the Shine On program is designed to build resilient, confident elementary-age girls. As part of this downlink, Shine On hosted a day-long virtual STEM conference for students in pre-k through 8th grade from across the state of New York. This event reached 6,261 students and 355 educators.

Downlink with SciAccess & Ohio State University - May 19, 2021

SciAccess is an initiative of Ohio State University dedicated to promoting disability inclusion in STEM. Questions were submitted by students and teachers from schools serving deaf and blind students across America, as well as members of the SciAccess Working Group, an international collective of professional working to advance disability access in STEM. This event reached 125 educators and 150 students through a live Zoom watch party.

Downlink with Federal Agency Interns - July 28, 2021

Through this downlink, interns from several U.S. federal agencies – NASA, the National Oceanic and Atmospheric Administration, National Science Foundation, U.S. Forest Service, Department of Transportation, Department of Defense, and U.S. Space Force -- asked questions about the astronauts' careers and experiences in space. This event reached 98,432 people.

Advanced Air Mobility Career Series

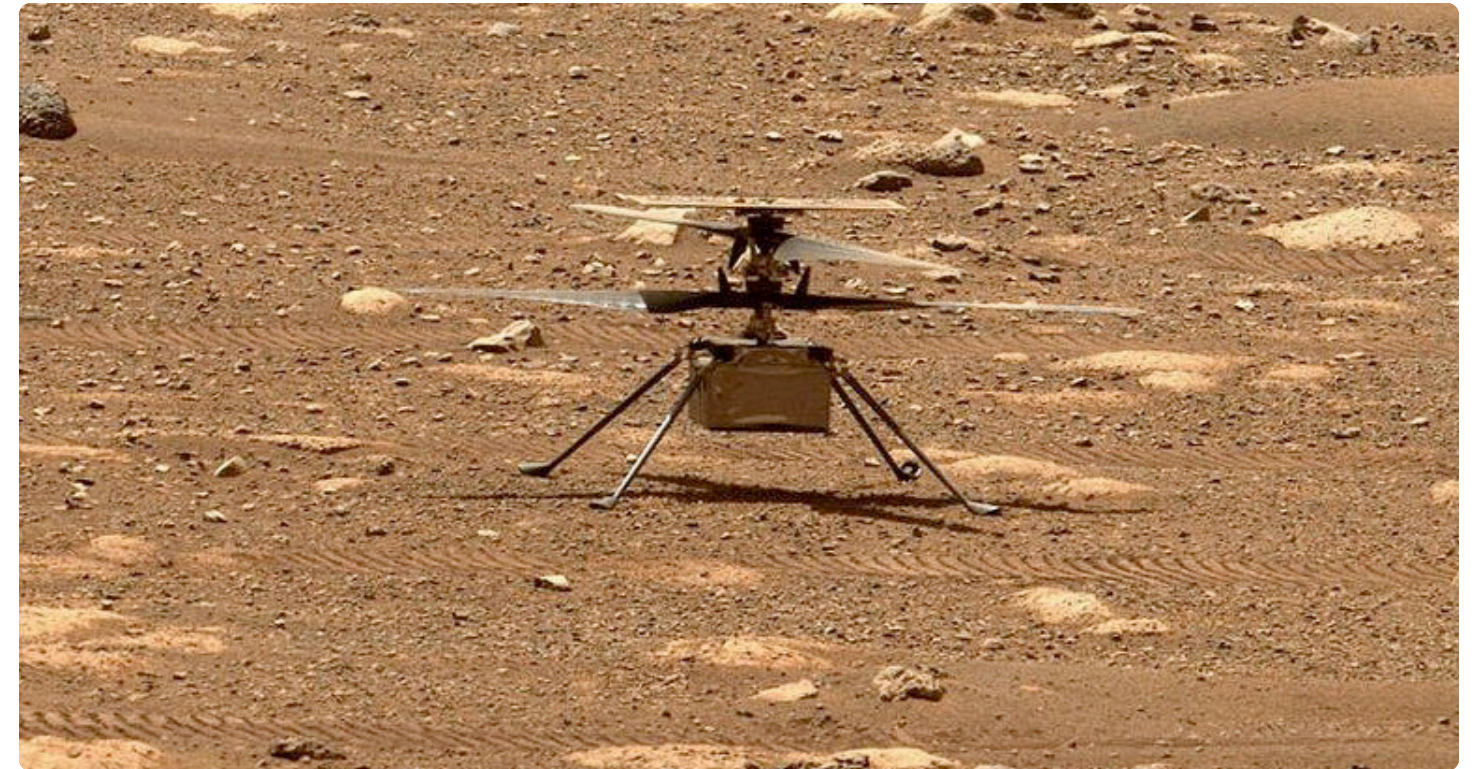
NASA Aeronautics' Advanced Air Mobility (AAM) program kicked off a new focus on K-12 STEM opportunities with a series of virtual engagements to highlight the people and career opportunities associated with drones in society. Multiple STEM Stars episodes, educator professional development workshops, and a culminating virtual Career Day in May 2021 rounded out the second half of the 2020-2021 academic year. August 2021 launched the AAM Academy for 2021-2022, which includes an AAM Safety Poster Contest, virtual subject matter expert sessions throughout the year, an opportunity for classrooms to become a "Classroom of the Quarter" for more in-depth time with a subject matter expert, and once more, a virtual Career Day to complete the academic year.



Renderings of virtual AAM opportunities. Credits: NASA



EAA/Shades of Blue Ingenuity Event



NASA's Ingenuity Mars Helicopter preparing to fly through the Red Planet's skies. Credits: NASA/JPL-Caltech

NASA's Aeronautics Research Mission Directorate and Glenn Research Center's Office of STEM Engagement worked with **Shades of Blue and the Experimental Aircraft Association (EAA)** and their Young Eagle Flight Scholars to present a "Wright Brothers and Ingenuity: Great Minds Think Alike" virtual STEM opportunity in April 2021. Both organizations work to inspire and support students who have a passion for aviation, and participating students had the opportunity to hear from Glen Center Director Dr. Marla Perez-Davis, subject matter experts for the Mars Ingenuity helicopter, and Orville Wright reenactor Roger Storm, and ask questions about the Mars Ingenuity helicopter and its connection to the Wright Brothers.



Top row: Panelists Dominguez and Young. Bottom row: Catherine Graves, Office of STEM Engagement; and panelist Benson (Orville Wright).

RASC-AL Competition

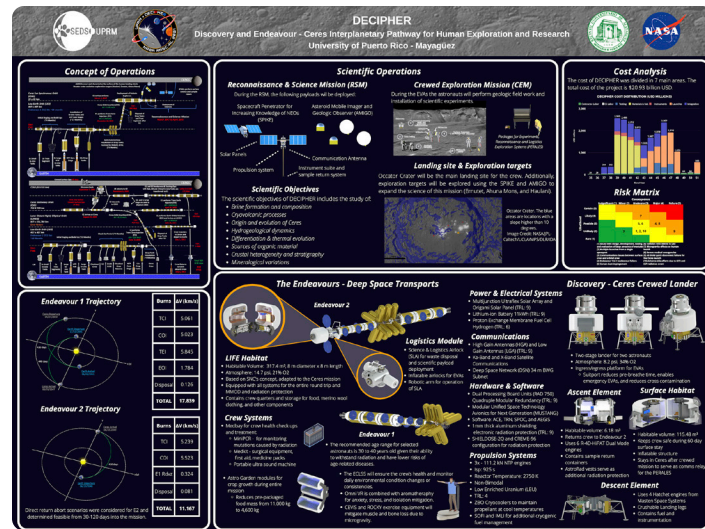
The Revolutionary Aerospace Systems Concepts - Academic Linkage (RASC-AL) Competition provides the opportunity for university-level engineering students to design projects based on real NASA engineering challenges while offering NASA access to new research and design ideas by top collegiate talent. The 2021 RASC-AL teams designed and proposed innovative solutions with original supporting engineering and analysis in response to one of the following five themes:

- Durable Low-Mass Lunar Surface Habitat
- Minimum Mars Ascent Vehicle
- Venus Flyby Mission
- Human Mission to Ceres
- Distributed Lunar Sample Aggregation, Analysis, and Return to ISS

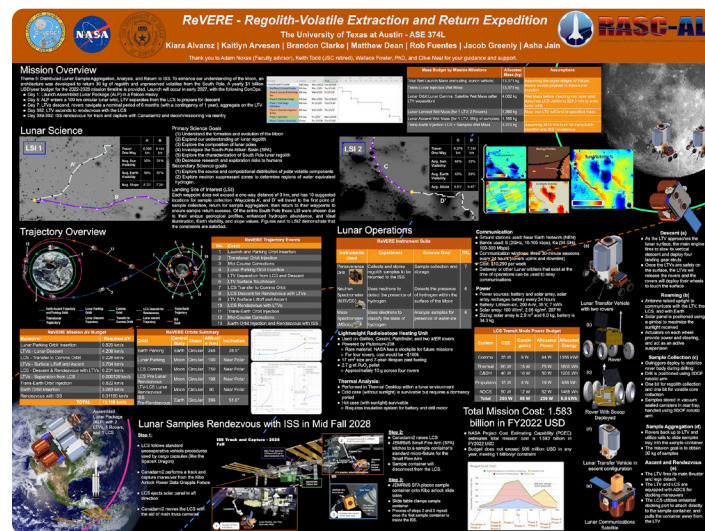
Nearly 270 students and faculty actively participated in the competition on finalist teams throughout the academic year. The competition's culminating event was the 2021 RASC-AL Forum, held June 15-17, 2021, in which 16 finalist teams from 14 universities presented their concepts to a panel of NASA and industry judges in a competitive design review. First Place Overall winner was awarded to the University of Puerto Rico - Mayagüez for its project, "Discovery and Endeavour - Ceres Interplanetary Pathway for Human Exploration and Research (DECIPHER)," and Second Place Overall was awarded to The University of Texas at Austin for its project, "Regolith-Volatile Extraction and Return Expedition (ReVERE)." These top-placing universities were guaranteed technical presentation slots to present condensed versions of their concepts during the 2021 ASCEND Conference in November 2021..

NASA staff from the RASC-AL program and the National Institute of Aerospace (NIA) supported and planned the challenge and livestream activities.

To view all of the 2021 RASC-AL presentations, posters, and technical papers, visit <http://rascal.nianet.org/2021-teams>.

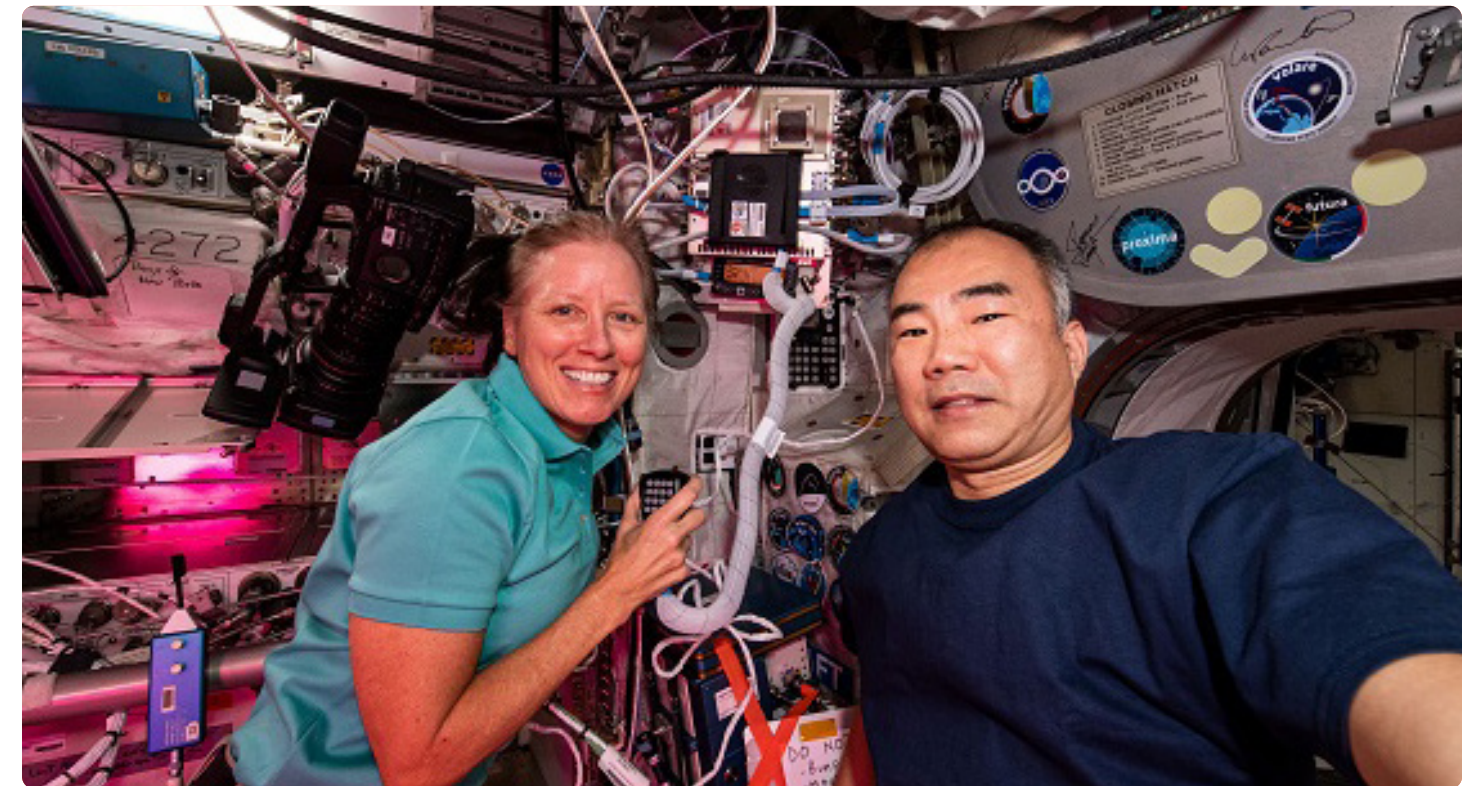


1st place winner - University of Puerto Rico, Mayagüez.



2nd place winner - University of Texas at Austin

Amateur Radio on the International Space Station



NASA astronaut Shannon Walker and JAXA (Japan Aerospace Exploration Agency) astronaut Soichi Noguchi pose for a photo during an Amateur Radio on International Space Station (ARISS) ham radio session with students at Hisagi Junior High School, Zushi, Japan.

Amateur Radio on the International Space Station (ARISS) is an educational outreach program through HEOMD in which students engaged in a science and technology curriculum are given the opportunity to speak with the International Space Station (ISS) on-orbit crew via amateur radio. Sponsored by NASA, the ISS National Laboratory, and national amateur radio organizations, ARISS asks formal and informal education organizations to submit education proposals that will engage students in exciting STEM topics. These proposals are competitively selected by educational peer judges and the educational organization is slotted with an ARISS contact time. Internationally, ARISS supports 60-80 of these astronaut connections each year. During their 10-minute overhead pass window, students ask the orbiting astronauts

questions about life in space, space research, and a myriad of other space topics. In the four to six months leading up to the amateur radio space connection, education groups perform hands-on activities that have included model rocket launches, star parties, STEM-payload balloon launches, satellite building, satellite tracking, physics experiments, virtual reality investigation, codes, and wireless technologies. ARISS education groups' curricula exposes students, educators, and the public to human spaceflight through direct communication with crew members on the space station. Beginning with the first ARISS contact in December 2000, this program continues to inspire, engage, and educate our next generation of space explorers.

Educator and Student Resources Snapshot



James Webb STEM Toolkit

To help bring the thrill of astronomy into the classroom, the James Webb Space Telescope STEM Toolkit for teachers and students offers lesson plans, printable materials, videos, activities, and ways to stay connected to the mission. The toolkit was a collaborative effort between OSTEM's Next Gen STEM project, SMD, James Webb Space Telescope mission team, and Space Telescope Science Institute. It can be found at www.nasa.gov/stem/nextgenstem/webb-toolkit.html



STEMonstrations

Three new STEMonstrations were released in FY 2021, covering Newton's first law of motion, Earth observations, and the five senses, bringing the total number of videos in the STEMonstrations series to 16. Each video is accompanied by a Classroom Connection lesson plan to help educators and students explore the topic further. Visit the STEMonstrations website at www.nasa.gov/stemonstrations



Launch America STEM Mission Toolkit

In FY 2021, Next Gen STEM and the Commercial Crew Program collaborated to build this toolkit, a broad set of resources and authentic STEM experiences spanning grades K-12. These resources and opportunities were designed to engage educators and students in the accomplishments of the agency and its commercial partners. https://www.nasa.gov/stem/nextgenstem/commercial_crew/launchamerica-stem-mission-toolkit



The Astro-Not-Yets

Part of the Astro-Not Yets series offered by Next Gen STEM, this short story helps young students learn how NASA's Commercial Crew Program spacecraft will return astronauts safely from space at high speeds. This time, the class is preparing to watch a Commercial Crew mission landing. Students are taken through the engineering design process as they design their own systems to return their egg astronauts, or "Eggstronauts," safely to the ground. The storybook can be found at www.nasa.gov/stem-ed-resources/the-astro-not-yets-explore-energy-storybook.html



Aeronaut-X Educator Guides

Next Gen STEM released two new Aeronaut-X educator resources in FY 2021. Both guides deploy evidence-based student activities to engage 6-8 grade middle school students in unique NASA learning experiences beyond the traditional classroom – focusing on aeronautics content that inspires learners to bolster their STEM studies and gain further interest in a future STEM career. Both guides can be found at www.nasa.gov/stem/nextgenstem/aeronaut-x/index.html

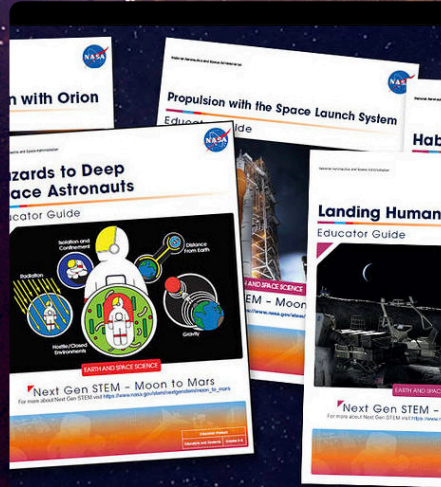


NASA STEM Stars

NASA STEM Stars is a webcast series that connects ages 13+ with experts at NASA. In FY 2021 episodes highlighted a range of careers relating to upcoming missions, including an episode in Spanish focused on the Mars 2020 rover, an Artemis III episode with Astro Camp Community Partner participants, and an episode with CCP Deputy Program Manager Dana Hutcherson ahead of the SpaceX Crew-3 launch. The collection of STEM Stars episodes can be found at <https://www.nasa.gov/stem/nextgenstem/nasa-stem-stars/index.html>

Artemis-Focused Curriculum Support Guides

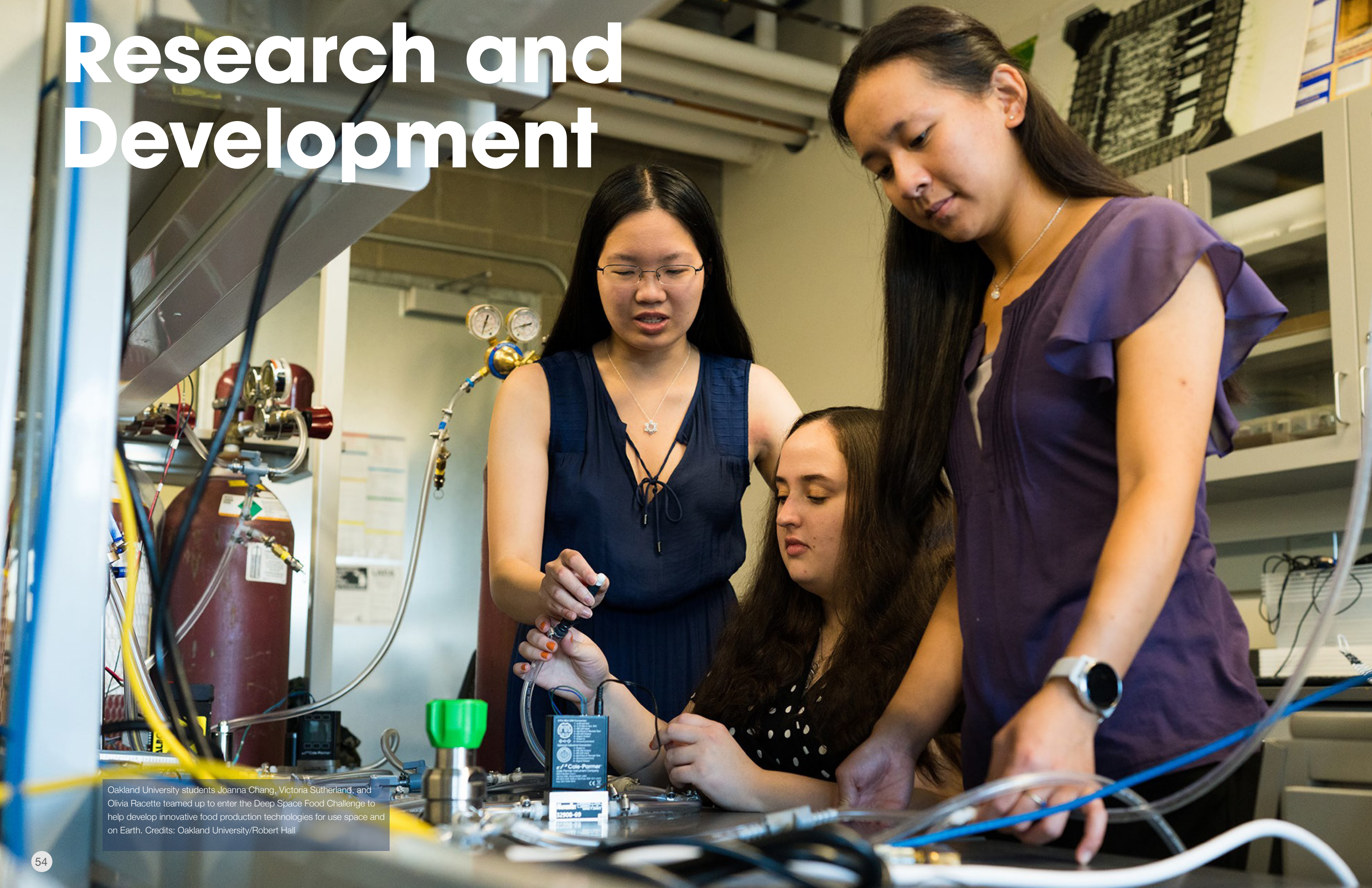
NASA's Next Gen STEM project published several Artemis-focused educator guides in FY 2021, including new and revised hands-on lessons, some with accompanying demonstration videos. The total of six guides offer lessons on NASA's Orion capsule and Space Launch System rocket, the planned orbiting Moon outpost called Gateway, landing humans on the Moon, hazards to astronauts, and deep space communications. The guides can be accessed by educators on the nasa.gov NASA @Home and Join Artemis websites. Three additional guides, focused on exploration ground systems, Artemis generation spacesuits, and lunar surface exploration, will be published next year. The guides are available at <https://www.nasa.gov/feature/new-stem-educator-guide-available-to-inspire-artemis-generation>



NASA's Join Artemis Website

To support the use of Artemis content in STEM education and outreach experiences, NASA's Office of STEM Engagement launched a new Join the Artemis Mission to the Moon website that consolidates the best Artemis-themed STEM activities, curriculum guides, challenges, and opportunities in a single location. The website, launched in April 2021, allows students, educators, families, and the public to explore a variety of content aimed to inspire a new generation and encourage careers in STEM. Visit the new site at <https://stem.nasa.gov/artemis/>

Research and Development

A photograph of three young women in a laboratory setting. They are gathered around a piece of scientific equipment, possibly a microfluidic system or a small-scale reactor. The woman on the left is wearing glasses and a dark blue sleeveless top. The woman in the center is wearing a black top with white polka dots. The woman on the right is wearing a purple top. They are all looking intently at the equipment. In the background, there are various pieces of laboratory equipment, including a large red gas cylinder and a stainless steel cabinet. The overall atmosphere is one of focused research and collaboration.

Oakland University students Joanna Chang, Victoria Sutherland, and Olivia Racette teamed up to enter the Deep Space Food Challenge to help develop innovative food production technologies for use space and on Earth. Credits: Oakland University/Robert Hall



A large patch of sargassum approaches a reef in Cayo San Cristobal, Puerto Rico. Through NASA MUREP's OCEAN award, the University of Puerto Rico Mayaguez will study sargassum blooms to improve modeling and better understand its impact on marine ecosystems. Credit: University of Puerto Rico Mayaguez/Omar López

A collaboration between MUREP and SMD, the Ocean Biology and Biogeochemistry (OCEAN) award helps MSIs prepare to compete in future funding opportunities in line with NASA's efforts to gain a deeper scientific understanding of our home planet. In FY 2021, NASA awarded 10 MSIs more than \$1.4 million in cooperative agreements, enabling these institutions to take an active role in studying climate change and its effects.

MUREP established the OCEAN funding opportunity in support of NASA's research into ocean health, focusing primarily on the impacts of climate change on aquatic biology and ecosystems. NASA sought proposals that would develop remote sensing capabilities to analyze the impacts and/or vulnerability of aquatic ecosystems due to changing climate or improve understanding of carbon cycle processes and feedbacks in critical aquatic zones that are particularly vulnerable to environmental changes.

The recipient institutions and their proposed projects are:

Florida Atlantic University, Boca Raton

Improving the Coastal Carbon Budget: Is Sediment-Derived CDOM (Colored Dissolved Organic Matter) a Significant Portion of CDOM in Coastal Areas?

Northwest Indian College Foundation, Bellingham

Extending the California Harmful Algae Risk Mapping (C-HARM) domoic acid model to the Pacific Northwest

Texas State University, San Marcos

Integrating Systems Models and Remote Sensing to Explore Aquatic Ecosystem Vulnerability to Global Change in Lake Huron

University of Puerto Rico, Mayagüez

Remote Sensing of Sargassum Accumulation and Impacts on Tropical Marine Ecosystems: A Multi-Scale Approach

University of Alaska, Fairbanks

Enhancing Ocean Color Remote Sensing Tools to Better Constrain Fisheries Forecasting Models in a Critical Subarctic System

University of California, Irvine

Linking Genomic and Remote Sensing Observations to Quantify the Physiological Nutrient Stress Dynamics in Ocean Ecosystems

University of California, Merced

Wildfire Impacts on Watershed Transport of Carbon to Coasts

University of Hawaii Systems, Hilo

Quantifying Vulnerability to Sea Level Rise Across Multiple Coastal Typologies

University of Massachusetts, Boston

Using Hyperspectral Imagery to Assess the Effects of Warming on New England Kelp Forests

University of the Virgin Islands, Charlotte Amalie

Climate Change and the Effects of Golden Tides on Caribbean Coastal Sustainability – Multiscale Predictions for an Emerging Biocomplex Problem



The MUREP Space Technology Artemis Research (MSTAR)

awards support NASA's Artemis program, which will send the first woman and first person of color to the Moon. M-STAR was created in partnership with the agency's Space Technology Mission Directorate (STMD) to promote STEM literacy and boost MSIs' capabilities to compete in agency research required for missions to the Moon, Mars, and beyond.

M-STAR implementation funding builds on M-STAR planning grants awarded in August 2020. In FY 2021 the agency awarded nearly \$1.7 million in cooperative agreements to seven institutions, five of which previously received M-STAR planning grants.

The recipient institutions and their proposed projects are:

Fayetteville State University, Fayetteville*

Active and On-demand Multi Robot Perception (AOMRP)

Florida International University, Miami*

Sustainable Power Generation and Secure Distribution Systems for NASA Artemis Mission

Howard University, Washington, D.C.

Raman Cube Rover (R3R) for Enabling Lunar Science and Exploration: Integrating Technology Development with STEM Engagement

New Mexico State University, Las Cruces*

MUREP Advancing Regolith-related Technologies & Education (MARTE)

San Diego State University, San Diego

Propellant-Optimal Integrated Entry and Powered Descent Guidance for Human-Scale Mars Missions

University of Arizona, Tucson*

Advancing Site Preparation, Excavation and Mining Technologies in Support of Future Lunar Missions

University of Central Florida, Orlando*

Forging a Trajectory for STEM Readiness in Space Technology

Institutions with an asterisk (*) received M-STAR planning grants in 2020.

MUREP INCLUDES



NASA and the National Science Foundation's Directorate of Engineering signed a memorandum of understanding in 2021 to work together on a new initiative to bring a broader scope of perspectives to NASA's missions. **MUREP INCLUDES** built upon the NSF INCLUDES (Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) model to help MSIs form and lead coalitions dedicated to broadening participation in engineering. Its goal is to increase participation of underrepresented minorities in STEM fields by 2026. This partnership aims to further scale activities as a result of increased lessons learned.

In FY 2021 NASA awarded six institutions nearly \$2.4 million in MUREP INCLUDES cooperative agreements. This funding will be used to determine which methods are most effective at bringing diverse students into engineering research, expand existing programs that are already successful, and explore innovative approaches to fill in identified gaps.

The recipient institutions and their proposed projects are:

Alabama State University, Montgomery

Developing NASA Pathways to Engineering and Experiential Research for Student Success: NASA PEERSS

Florida A&M University, Tallahassee

Broadening Participation of Next Generation Aerospace Engineers

J.F. Drake State Technical College, Huntsville

Drake State Engineering Frontiers Coalition

Navajo Technical University, Crown Point

Broadening Participation in Engineering, Robotics and Computer Science using Zero Robotics on Astrobee

Texas A&M University, Kingsville

Proactive Pathways of Excellence to Engage Minority Students in Aerospace Engineering

University of Massachusetts, Boston

Partners Aligned To Heighten Broad Participation in STEM

MSTTR



The MUREP-Small Business Technology Transfer

Research (MSTTR) planning grants are designed to reduce barriers and pave the way for MSIs and small businesses to compete in STMD's annual Small Business Innovation Research/Small Business Technology Transfer Research (SBIR/STTR) solicitation.

NASA's SBIR/STTR program enables small businesses to take part in federal research and development. Through STTR, small businesses partner with research institutions to explore their technological capabilities, with the potential to profit on their innovations through commercialization. The new M-STTR funding enables MSIs to team up with small businesses to explore ideas, build teams, engage stakeholders, and, ultimately, have an action plan to respond to the solicitation.

In FY 2021 the agency awarded nearly \$540,000 in planning grants to 10 institutions for 11 projects. The selected institutions have four months to develop their STTR action plans.

The recipient institutions and their proposed projects are:

Delaware State University, Dover

Au-Plasmonic absorber-based microbolometers for uncooled infrared imaging

Fisk University, Nashville

Development of Advanced APbX3 (APX) Perovskites as Room Temperature Semiconductor Detectors for Neutron and Gamma Radiation Detectors

Florida A&M University, Tallahassee

Graphene-based Aircraft Batteries

Oakwood University, Huntsville

UV Protective Coating for Photovoltaic Solar Cells in Space

Tennessee State University, Nashville

Imaging-non-Imaging Satellite-Airborne-Terrestrial Data for Dynamic Modeling: Impact Analyses of Climate Change on Natural Resources

University of Arizona, Tucson

Advanced Materials for Thermal Control Devices via Additive Manufacturing

University of Central Florida, Orlando

Scalable and Tailorable Thermoforming and Reforming of Large Composite Spacecraft Structures

University of Central Florida, Orlando

Planning Collaboration and Commercialization in the Area of Advanced Laser and Optical Sensors for Aerospace Applications

University of District of Columbia, Washington

Improving Design of Hybrid Two-Phase Capillary Cold Plates through Additive Manufacturing

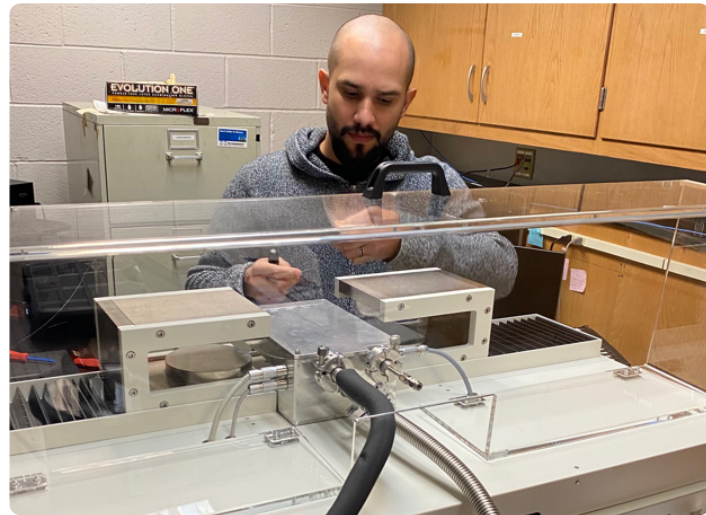
University of North Texas, Denton

Developing a Cylindrical-type Wireless High Temperature Pressure Sensor for Rocket Propulsion System Test

University of Texas, San Antonio

Towards Enabling Advanced Non-Intrusive Measurements of Hypersonic Air-Breathing Propulsion Systems

Twenty active awardee institutions of MIRO continue to demonstrate progress in building research capacity at their respective campuses. NASA STEM-related academics and research promoted through the MIRO-funded projects have allowed the awardees to establish viable partnerships, conduct research to support NASA missions, and offer experiential opportunities for diverse student groups.



Delaware State University's Optics for Space Technology & Applied Research Center (O*STAR)

Delaware State University's Optics for Space Technology & Applied Research Center (O*STAR), funded by MIRO, contributes to future NASA missions by developing and maturing cutting-edge technologies and instruments. The center has supported NASA's goal in broadening student participation by providing education and research training in optics and photonics to underrepresented students. Much of O*STAR's success is due to successful collaborations with Goddard Space Flight Center, Los Alamos National Laboratory, Delaware Aerospace Education Foundation, and partner higher education institutions.

Research continued on laser-induced breakdown spectroscopy (LIBS) investigations with final results published in the peer-reviewed journal *Spectrochimica Acta Part B Atomic Spectroscopy*. The Photonic Sensors Systems Laboratory research team received additional funding from the National Science Foundation and the U.S. Department of Defense to expand research on sensors and imaging systems.



The Puerto Rico Space Partnership for Research Innovation and Training (PR-SPRInT)

Puerto Rico Space Partnership for Research Innovation and Training (PR-SPRInT) is guided by several technology areas within the NASA Space Technology Roadmap. In response, PR-SPRInT created two interdisciplinary research and education groups. One group focuses on human-centered research, environmental control, and life support to enable long-term missions. The other focuses on the design and development of high-performance batteries for space exploration missions.

Enhancements to research infrastructure included the addition of four 3D printers, one laser cutter, and a computer numerical controlled (CNC) machine in the School of Architecture's Fabrication Laboratory. The new algae cultivation facility enables research on the development of life support systems and bioremediation of water and air.

As a result of current progress in research, 15 manuscripts were published in peer-reviewed journals and 12 presentations were made at local and national scientific symposiums. In addition, PR-SPRInT received \$20,000,000 in research funding awards, of which 50% are NASA-related grants or agreements. The institution's Dean of Graduate Studies has also committed additional funding.



Center for Advanced Manufacturing in Space Technology & Applied Research at University of the District of Columbia

The University of the District of Columbia's Center for Advanced Manufacturing in Space Technology & Applied Research (CAM-STAR) focuses on investigating advanced manufacturing techniques and their application in space exploration technology and research. CAM-STAR hosted eight technical exchange events in collaboration with Goddard Space Flight Center and Johnson Space Center. More than 20 NASA subject-matter experts explored technical topics and experiential opportunities with CAM-STAR researchers, faculty, and students.

The center had two teams compete in the 2021 NASA MINDS competition, an undergraduate-level activity supporting the Artemis mission and HEOMD. One team created a solar probe design for lunar south pole expeditions, and the other focused on lunar dust management technology for spacecraft atmospheres and spacesuits. The center also had a team compete in the 2021 NASA Human Rover Challenge. The American Society of Mechanical Engineers accepted their design for a peer-reviewed conference proceeding.

Additional accomplishments for CAM-STAR in FY 2021 include three approved United States patents, 21 peer-reviewed publications, and 60 presentations at national workshops, professional conferences, and special meetings.



Navajo Tech Additive Manufacturing Education and Research (NAMER)

Navajo Tech Additive Manufacturing Education and Research (NAMER) demonstrated progress with infrastructure enhancements, curriculum development, and student research engagement. NAMER acquired software, materials, and other resources to enable functional grade materials printing, continuous printing to minimize changeover, and simultaneous metals printing to quickly build metal parts.

Eight students enrolled in the Industrial Engineering 495 Special Topics Course, "Introduction to Metal Additive Manufacturing," co-taught by Navajo Technical University, University of Alabama-Huntsville, Optomec Inc., and V & M Global Solutions. The course introduced 3D metal printing, metals and alloys, materials characterization, metrology, tomography, and mechanical properties of metals.

NAMER had a student team selected to participate in the 2022 NASA Lunabotics Competition, in which students will design, build, and operate a lunar excavator prototype.



To learn more about MIRO-funded research and education projects, visit <https://www.nasa.gov/stem/murep/projects/miro.html>

EPSCoR - Rapid Response Research

NASA selected 39 research and development projects for funding through the **EPSCoR Rapid Response Research (R3)** solicitation that could help address some of the science and technology challenges that impact the agency's missions. The agency awarded approximately \$4.3 million in cooperative agreements to states and territories across the nation to get these projects off the ground.

R3 is designed to provide an on-ramp mechanism for researchers to work on NASA projects while speeding up the development of innovative solutions that align with NASA's needs. Proposed R3 research projects cover a wide array of missions and sciences and include topics such as flying robots navigating the atmosphere of Venus, wearable sensors for low-power environments, on-demand health monitoring for humans in space, and more.

For this year's R3 research awards, EPSCoR teamed up with nine organizations within NASA to identify research and development challenges specific to their subject areas: ARMD; SMD's Planetary Science, Earth Science, and Biological and Physical Sciences Divisions; STMD; the Commercial Space Capabilities Office of HEOMD; the Office of the Chief Health and Medical Officer at NASA Headquarters; Marshall Spaceflight Center in Huntsville, Alabama; and Goddard Spaceflight Center in Greenbelt, Maryland.

Read the 2021 EPSCoR Rapid Response Research selectees' abstracts at <https://www.nasa.gov/stem/epscor/rapid/index.html>.



Pablo de León tests sample collection tools at the Lunar Regolith Lab at NASA's Kennedy Space Center in Florida. Photo credits: NASA



EPSCoR - International Space Station/Suborbital Flight Opportunity

Under **EPSCoR's International Space Station/Suborbital Flight Opportunity**, awardees can develop and fly their projects aboard the orbiting laboratory or on suborbital missions aboard high-altitude balloons or sounding rockets. On June 4, 2021, NASA announced EPSCoR funding awards totaling \$1.4 million to nine universities across the country. The awardees' projects are applicable to NASA's work in Earth science, aeronautics, and human and robotic deep space exploration. Six support International Space Station flight opportunities, while three represent suborbital flight opportunities.

Developing these capabilities contributes to the jurisdictions' economic viability and expands the nation's base for aerospace research and development. The universities also transfer research results from the projects to NASA, where they may be used as part of ongoing agency work.



2021 ISS Flight Opportunities Awards

University of Delaware, Newark

Reliability evaluation of the integrated photonic receiver subsystems with all-optical signal processors.

Iowa State University, Ames

Properties and Performance of Solder Joints Produced in Reduced-Gravity Environments: ISS Flight Opportunity.

University of Kentucky, Lexington

KRUPS: ISS Flight for Instrument Testing.

Montana State University, Bozeman

Microgravity Demonstration of a Novel In-Space Food Production System.

Oklahoma State University, Stillwater

Enhanced Active Tissue Equivalent Dosimeter (eATED) for Space Crew Dosimetry.

University of Puerto Rico, San Juan

NASA EPSCoR ISS: Microgravity Experiment to measure the Speed of Sound inside simulated Asteroid Regolith in the ISS environment (MESSAR).

2021 Suborbital Flight Opportunities Awards

University of Alabama, Huntsville

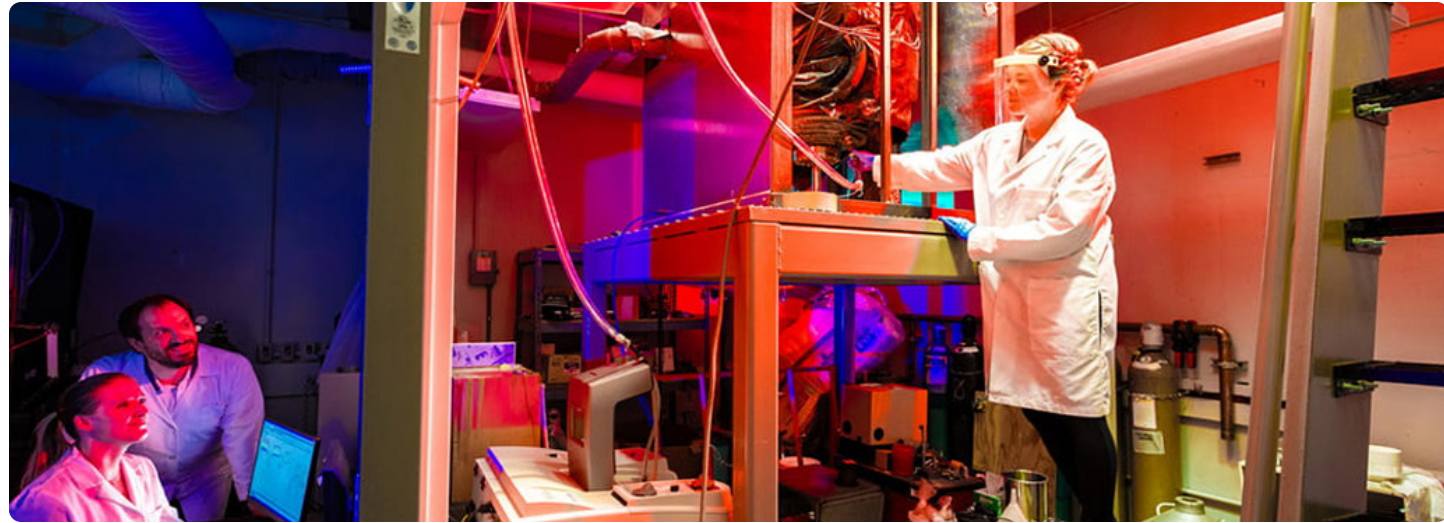
Three-Dimensional Plume-surface Interaction and Crater Formation Dynamic Measurements in Reduced Gravity Environments.

University of Mississippi

Thermal transport characterization of phase-change material (PCM) infused in annular passage filled with additively manufactured metal foam obtained through Octet-shaped unit cell reticulation under micro-gravity conditions.

Oklahoma State University, Stillwater

Suborbital Flight Demonstration of Ionizing Radiation Dosimeters for use in the Upper Atmosphere.



Innovative ideas can come from anywhere – this has been one of the basic tenets behind NASA EPSCoR since its inception in 1992. On July 28, 2021, NASA EPSCoR announced the 2021 awardees under its Research Cooperative Agreement Notice (CAN) opportunity. Each eligible jurisdiction submitted one proposal, for a total of 28. Of these proposals, 16 were awarded research funding totaling nearly \$12 million.

These researchers will work alongside NASA and commercial partners for up to three years, with the intention of further strengthening the bonds among NASA EPSCoR jurisdictions, NASA, commercial partners, and other entities.

Examples include: One grant awardee from Louisiana will address NASA challenges of aerospace power and energy storage by developing new, safe, and high-capacity solid-state electrolyte batteries for future NASA missions. In the process, an interdisciplinary team of researchers from University of Louisiana at Lafayette, Louisiana State University in Baton Rouge, and Louisiana Tech University will collaborate with NASA partners at Glenn Research Center and JPL, as well as industrial partners at General Motors and IBM. The project will aid the economy of Louisiana by developing an advanced battery research infrastructure in the state, as well as generate professional

development pathways by providing testing capability, training opportunities for project students as well as early-career faculty, and advice on project methods and activities.

Another grant award to the University of Vermont, Burlington, will support NASA by developing research to use magnetic nanoparticles for diagnosing and mitigating life support system biofilms. The formation of biofilm, which is a colony of microorganisms adhered to surfaces to form a slimy layer, has been an area of significant concern for long-duration space missions. The proposed approach seeks to remove biofilm formations from critical systems such as water pipes, air ducts, and life support systems in ways that could prove safer and more effective than current mitigation methods.

Another awardee from the University of Hawaii, Honolulu, will support NASA by using machine learning algorithms to create a rover capable of autonomously exploring deep space celestial surfaces, specifically the Moon, for water ice. Implementing the necessary research will allow young faculty to lead research staff, train students, arrange new facilities, and organize partnerships.

For the full list of awardees, [click here](#).



Dr. Maria Katzarova (left), associate scientist in the chemical and biomolecular engineering department at University of Delaware, and Jennifer Mills, a fourth-year PhD chemical engineering student, perform compression testing of cast Martian regolith cubes. Credits: University of Delaware

FAST is a joint pilot effort by NSF EPSCoR and NASA EPSCoR specifically focusing on institutions of higher education that primarily serve underrepresented and underserved students in STEM. Eligible institutions include MSIs, community colleges, women's colleges, those that primarily serve students with disabilities, and primarily undergraduate institutions. NSF and NASA aim to build research capacity and transform the career trajectories of early career and non-tenured faculty investigators at these institutions and to further develop their individual research potential through extended collaborative research at select NASA centers. The benefits of the fellowship experience are also expected to enhance research capacity of the investigator's home institution and jurisdiction.

This EPSCoR Research Infrastructure Improvement Track 4: EPSCoR Research Fellows solicitation provides an opportunity for faculty to engage in extended collaborative visits at the nation's premier research facilities. The fellowship period may be used to initiate new collaborative relationships, to expand existing partnerships in ambitious new directions, or to make use of unique equipment not available at the principal investigator's home institution.

Successful fellowships will positively impact and potentially transform the recipient's research career trajectory. This fellowship support is intended to provide opportunities for researchers to work at facilities of national prominence that would not otherwise be possible.

Two proposals were selected in September 2021. The University of Hawaii at Manoa in Honolulu was awarded nearly \$191,000 by NSF and \$60,000 by NASA for its proposal to investigate tropical cyclone intensity using synthetic aperture radars and complementary satellite ocean observations. Middlebury College in Middlebury, Vermont, was awarded nearly \$232,000 by NSF and \$60,000 by NASA for its proposal, "Numerical Simulations of Bose-Einstein Condensates in Microgravity (NumeriCAL)."

\$542K+ in total FAST awards
\$422K+ in subtotal NSF awards
\$120K in subtotal NASA awards

Strategic Partnerships



NASA's Office of STEM Engagement has more than 25 Space Act Agreements for STEM Engagement activities with external organizations. Through collaboration with external partners, NASA expands its reach, engaging students of all grade levels through opportunities that align with the agency's missions and STEM Engagement programs – and sparking a love of space and STEM topics.

NASA STEM Engagement fostered an array of new partnerships in FY 2021 that connected students from across the nation with NASA's most exciting endeavors. These efforts reached students as young as pre-kindergarten through university undergraduates, including students from groups and communities underrepresented in STEM. Through partnerships between industry and NASA's experts and resources, these agreements forged connections to the Artemis missions, the Mars Perseverance landing, STEM careers, and more.

Read on for a closer look at this year's strategic partnerships.

Strategic Partnerships



NASA and the Million Girls Moonshot Reach for the Stars

The STEM Next Opportunity Fund and NASA collaborated on an International Space Station downlink opportunity and watch party that engaged afterschool programs across the U.S. in STEM content. The event is part of the Million Girls Moonshot, a five-year partnership designed to cultivate an engineering mindset within one million girls by 2025. The downlink and watch party allowed students to interact live with NASA astronauts Kate Rubins and Shannon Walker aboard the space station. Following the live downlink, a panel of female NASA engineers and scientists answered additional career questions from students. Over 24,000 students registered for the event.



Discovery Education connects students around the World with NASA's Mission

NASA and Discovery Education kicked off a multi-year collaboration to improve access to high quality digital STEM resources for K-12 students. The partnership launched in FY 2021 with a major focus on the Mars Perseverance landing. Discovery Education simulcast the landing and built-out collections of Mars videos and lessons plans for use by students around the world. The effort resulted in 4.4 million teacher and student interactions with NASA-themed videos, lesson plans, and other multimedia.



STEM Connector and NASA Introduce Students to Day of Design

STEM Connector and NASA collaborated on a series of Day of Design opportunities that introduced students to STEM content and careers. The Day of Design program helps inform students of future STEM careers by connecting them to STEM professionals, real-world challenges, and project-based learning. "NASA's Day of Design: Shooting Stars" connected students to female scientists making an impact in space. The no-cost webinar series engaged over 50 schools during Women's History Month.



The Girl Scouts of America Launch a First Ever Virtual STEM Festival

NASA supported the Girl Scouts of the USA's National Girl Scouts STEM Festival in April 2021. Girl Scouts across the country explored different STEM topics led by STEM role models and subject matter experts with a shared mission of inspiring and preparing more girls to enter the STEM workforce. NASA provided 17 speakers from across its mission directorates and support offices for both small-group career discussions and large-scale keynote presentations. More than 7,000 girls and their families attended this event, in which they participated in hands-on activities, live events, challenges, and age-appropriate breakout sessions—all from the comfort of their own homes.

Strategic Partnerships continued



TRIO

Council for Opportunities in Education Bring Mars Content to Federal TRIO Programs During the Summer

NASA and the Council for Opportunity in Education (COE) collaborated to develop a Summer STEAM Club Curriculum designed to excite and engage students in Mars Perseverance content. COE is a non-profit dedicated to furthering the expansion of college opportunities for low-income, first-generation students, and students with disabilities. NASA and COE developed this curriculum to address the needs of students participating in summer programs connected with the federal TRIO Program. COE shared content and professional development opportunities with TRIO professionals implementing the Upward Bound, Upward Bound Math-Science, and Talent Search programs



Computer Science Education Week Collaboration with Microsoft

Although Computer Science Education Week is open to all, Microsoft shifted its focus to creating specialized programs for underrepresented and minority students in order to achieve the greatest impact for local schools and communities throughout the U.S., as well as address the lack of access to technology and professional underrepresentation in the tech industry. This year's focus was targeted toward deaf and hard-of-hearing students in grades K-12. The Next Gen STEM Commercial Crew Program team collaborated with Microsoft for this year's event, teaching NASA's "Rocket Science: Ride to Station" app to participating students. 225 students participated in the live event. Five private sessions were hosted to play back the class and presentation, reaching over 600 additional attendees



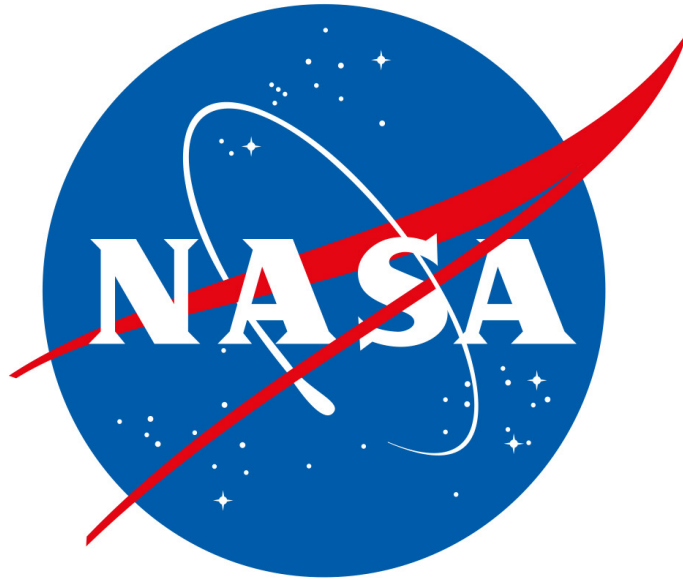
NOGGIN and NASA Collaborate to Bring Space and STEM Topics to Preschool

NASA and NOGGIN are working together to introduce Pre-K students and families to a variety of STEM roles, careers, and concepts. Noggin is a research-based early learning mobile application. The first-year relationship has featured content ranging from a space station downlink; the release of "My Best," an inspirational video that commemorates the accomplishments of Guy Bluford, the first African American astronaut to fly to space, and trailblazing NASA mathematician Katherine Johnson; and the development of new interactives featuring space-related careers scheduled for release in 2022. "My Best" is part of a NOGGIN series called "Rhymes Through Times" and has garnered over 1.4 million views on YouTube since its release.



LEGO and NASA Team up on Build to Launch to Introduce Student to Artemis

NASA and LEGO® Education collaborated on a 10-week series designed to build interest and excitement in the Artemis I launch. The series launched in September 2021 and provided educators with free, hands-on interactive lessons that covered the Artemis missions to engage children in STEAM learning while building their interest and curiosity about careers in science and technology. The digital series included open-ended prompts to allow flexibility for K-12 teachers and a weekly release of a new video clip featuring animated LEGO minifigures, NASA missions and career profiles of scientists, engineers, technicians, and other STEM role models. The series was used by more than 4,000 teachers, schools, and parents in over 100 countries.



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