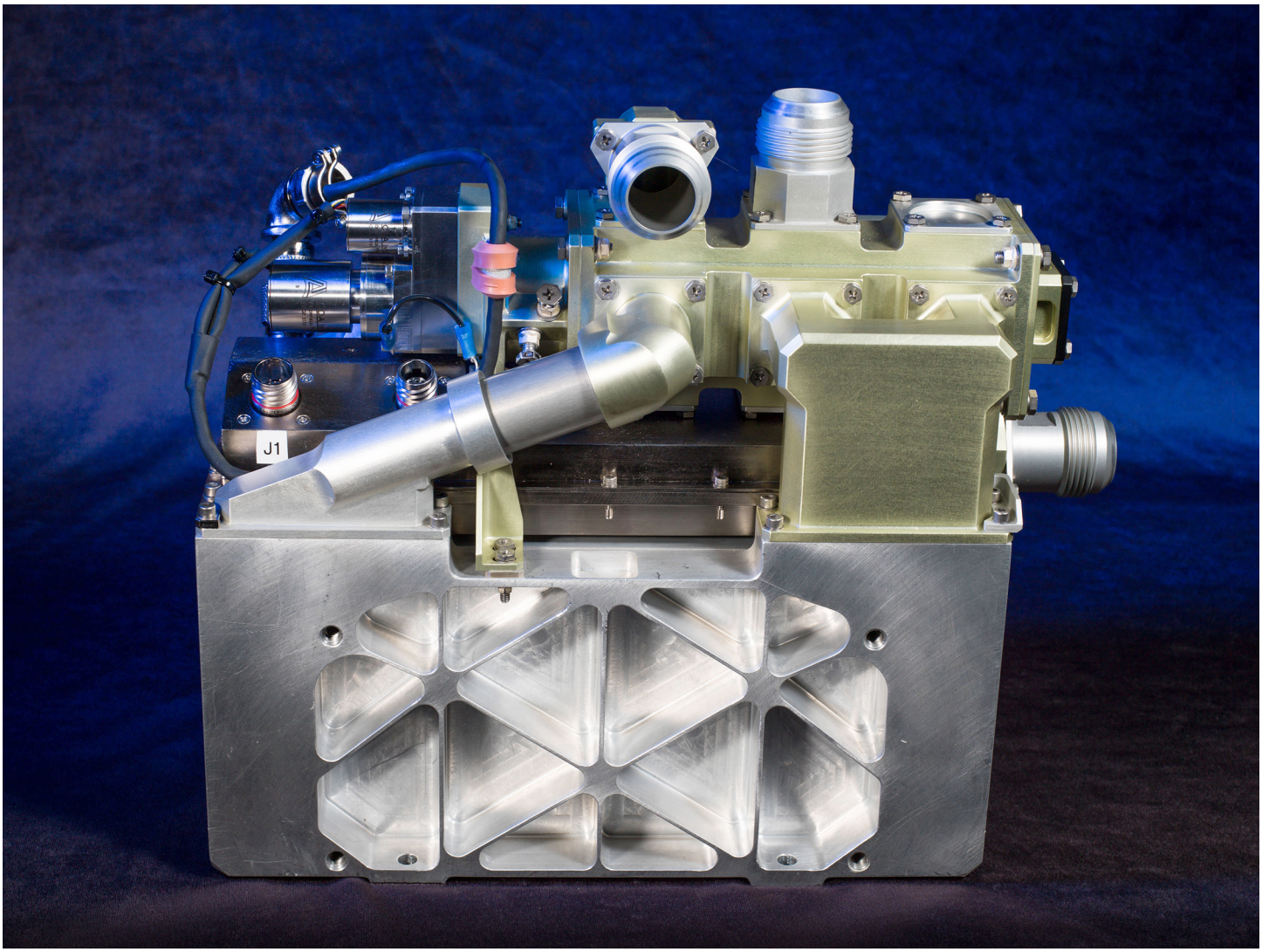
National Aeronautics and Space Administration

Space Technology

Game Changing Development Highlights

May-June 2015

Summer Rocks On With GCD Interns
Next Gen's RCA Technology Swings into Performance Testing
Design Challenges for Space Technologies



Next Gen's Next Breath

—Denise M. Stefula

Game Changing Development's Next Generation Life Support (NGLS) project received a milestone delivery of the Rapid Cycle Amine (RCA) Swingbed 3.0 test article on June 23, 2015, from partner United Technologies Corporation Aerospace Systems.

The RCA technology is a new carbon dioxide and humidity removal system baselined for use in NASA's next-generation space suit. This new unit will undergo performance testing within an advanced Portable Life Support System (PLSS) under development by the NGLS Project's Advanced Exploration Systems (AES) customer, the Advanced Space Suit Project.

During spacewalks, also known as "extravehicular activities," or EVAs, astronauts are limited in the amount of time that can be spent outside the vehicle. The current suit has limited capability for life support and environmental control functions, including carbon dioxide removal and humidity control, which are necessary to maintain air quality within the suit.

The RCA is game changing in several ways. Because it regenerates in place using space vacuum, it eliminates carbon dioxide removal as a duration-limiting subsystem.

"Its humidity removal feature is revolutionary," says NGLS Project Manager Dan Barta. "It greatly reduces complexity of the water and thermal loops by removing the need for a condensing heat exchanger and air water separator. This will increase safety: mishaps such as the International Space Station (ISS) EVA suit water-intrusion incident

in 2013 will not be possible. Designed for more than 100 individual EVAs, it 'breathes new life' into the suit, significantly increasing the duration of operational use over the state-of-the-art.

Technologies that currently perform carbon dioxide removal in the ISS space suits are lithium hydroxide (LiOH) and regenerative metal oxide (MetOx) sorbent technologies. LiOH canisters are installed into a space suit as an individual, one-time-use components, and put a burden on resupply requirements. The MetOx technology requires a 14-hour regenerative cycle that uses extensive energy.

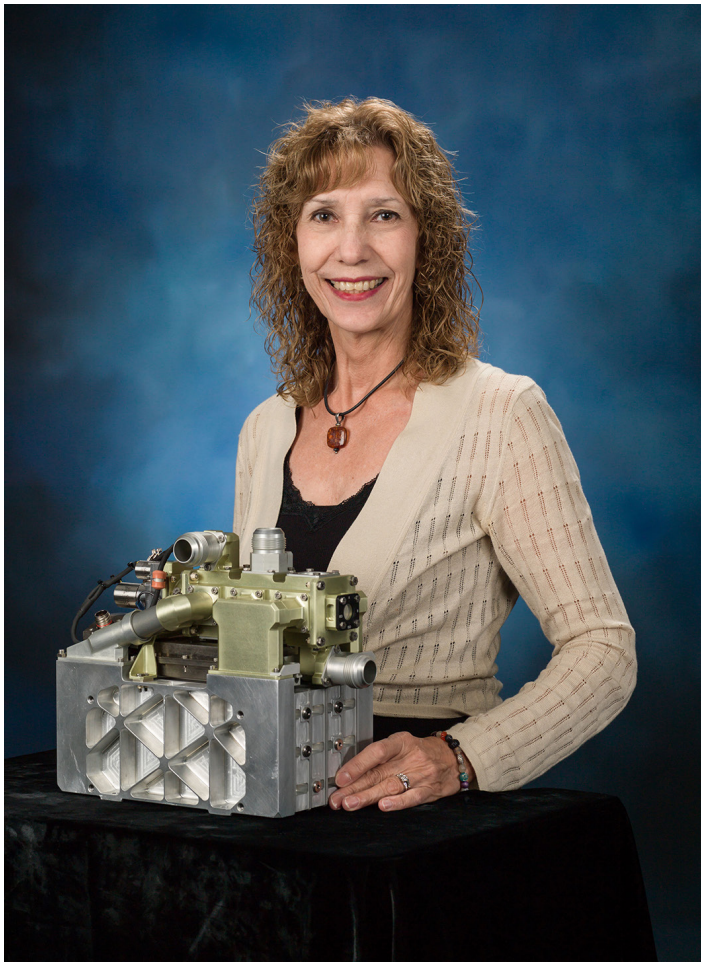
The RCA technology is low power, small, and has performed extremely well in all development testing thus far. The concept is one of alternating adsorbing and desorbing beds: one sorbent bed is exposed to the space suit's ventilation loop, continuously removing carbon dioxide and water, while the other is exposed to space vacuum for regeneration.

There were three design, fabricate, and test iterations for the RCA. The first generation unit, RCA 1.0, was a subscale laboratory-grade, TRL 4 unit with a pneumatic spool valve that demonstrated basic operation and proof of concept. The second-generation unit, RCA 2.0, advanced the technology to a full-sized assembly, with a high-fidelity ball valve and integrated controller. RCA 2.0 integrated into a fully functional PLSS test article to characterize performance of the integrated PLSS system, identify unexpected system interactions, and build confidence in the PLSS design. Relevant environment testing included the integrated PLSS system, testing under vacuum conditions, and human-in-the-loop testing, graduating the technology to TRL 5.

"After an assessment for oxygen compatibility and performance data originating from these iterations of technology readiness levels, a flight-like, oxygen compatible design was selected for the RCA 3.0," explains Dan. "The unit was fabricated and assembled, and functional performance was verified. Now delivered, plans are to test the RCA 3.0 unit independently in an isolated PLSS ventilation test loop and then perform systems level testing in sequentially higher fidelity PLSS test articles (2.5 and 3.0). At delivery, RCA 3.0 is at a high TRL 5 and will graduate to TRL 6 following integrated systems-level testing using 100% oxygen within the ventilation loop."

When discussing project partnerships, Dan adds that the RCA has been a model technology development task with respect to relationships with our HEOMD customer organization. "Considered a technology 'pull' task, NGLS worked closely to involve our Advanced Exploration System (AES) Program customer during design, development and test phases of the technology. NGLS partnered with the AES Advanced Space Suit project for early infusion of its test articles into the AES PLSS 2.0 hardware and supported the RCA during integrated PLSS 2.0 testing performed by AES."

Ultimately this technology will be utilized in the next generation advanced space suit for an extended ISS mission and human exploration beyond low-Earth orbit, including the Earth-Moon neighborhood and transit missions to Mars.



RCA Element Lead (RCA Test Article Engineer) Cinda Chullen with delivered RCA 3.0 assembly.

Mars 3D Habitat Centennial Challenge Offers Big Cash for Top Design

NASA and industry partner America Makes announced May 16th the 3D Printed Habitat Challenge, a $2.25 million NASA Centennial Challenge competition to design a 3D printed habitat for deep space exploration. The multiphase challenge is designed to advance the additive construction technology needed to create sustainable housing solutions for Earth and beyond.

Winning concepts and products will help NASA build technical expertise for a number of applications. On Earth, 3D printing technologies could provide affordable housing to those in need, and for deep-space habitation, with just a printer and a set of plans, a livable structure can be established. Eliminating transportation of bulky, heavy building materials represents a considerable mission savings when factoring in the per-pound cost of launching equipment into space.

"The future possibilities for 3-D printing are inspiring, and the technology is extremely important to deep space exploration," said Sam Ortega, Centennial Challenges program manager. "This challenge definitely raises the bar from what we are currently capable of, and we are excited to see what the maker community does with it."

The competition's first phase, which focuses on architectural concepts, was announced during the Bay Area Maker Faire in San Mateo, Calif., and runs through Sept. 27. First phase submissions will be judged at the 2015 World Maker Faire in New York this fall with the best design concept being awarded $50,000.

The second phase has two parts, both of which award a $1.1 million prize and open for registration Sept. 26. In the first part, the Structural Member Competition, inventors are challenged with exploring fabrication technologies to create structural elements from indigenous materials and recyclables, or from indigenous materials alone. The second part is the On-Site Habitat Competition, challenging inventors to implement the structural elements into full-scale habitats.

"We believe that 3D printing/additive manufacturing has the power to fundamentally change the way people approach design and construction for habitats, both on Earth and off," America Makes Director Ralph Resnick said.

America Makes is the National Additive Manufacturing Innovation Institute. As the national accelerator for additive manufacturing (AM) and 3D printing (3DP), America Makes is the nation's leading and collaborative partner in AM and 3DP technology research, discovery, creation, and innovation.

NASA's Centennial Challenges began in 2005 and offers monetary awards for public ideas, unearthing diverse concepts and opening possibilities for accelerating the development of technologies applicable in our everyday lives.

Summer Students

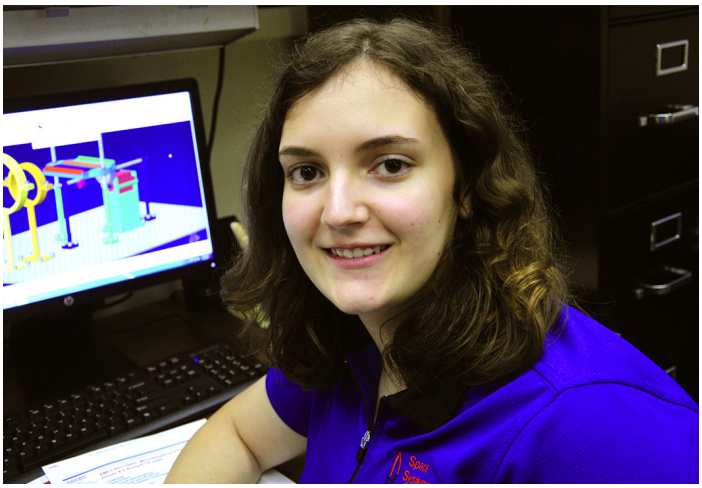
NASA's Game Changing Development Program kicked off the summer by welcoming dozens of college interns to NASA centers across the nation. Students worked on projects in multiple fields including aerospace engineering, material science, chemical engineering, systems integration, communications, journalism and program management. Some even experienced a launch.

Every year, student interns at GCD gain valuable experience working side-by-side with mentors while contributing to ongoing GCD projects.

Johnny Enrique López Calero, a senior studying chemical engineering and industrial biotechnology at the University of Puerto Rico at Mayagüez, supported the Nanotechnology project at NASA's Glenn Research Center. Calero, said the internship allowed him to work with carbon nanotubes for the first time.

"I was in charge of intercalating carbon nanotubes with halogen atoms and performing conductivity testing afterward using a four point probe," explained Calero. "I enjoyed learning how to use many different pieces of equipment like like those found in NASA Glenn's Dual Beam Sputter Deposition Facility, the Raman scatter detector, and a scanning electron microscope."

Johnny Enrique López Calero, a senior from the University of Puerto Rico at Mayagüez, is pictured here working with carbon nanotube electrical conductors.



Kate Malone is a junior studying aerospace engineering at the University of Maryland College Park. She was mentored by Chantel Whatley at Johnson Space Center on the Robo-Glove project.

Kate Malone, a junior studying aerospace engineering at the University of Maryland College Park, was thrilled to be part of the Robo-Glove development team at NASA's Johnson Space Center.

"The Robo-Glove is a glove that can augment human capability, leading to increased hand strength and endurance," explained Malone. "Working on this project allowed me to improve my CAD, mechanical design, and system integration skills. I liked being tasked with an open-ended challenge where I had to design a solution from start to finish."

Within the GCD Program Office, students supported projects such as the Advanced Near Net Shape Technology, Orbital ATK Carbon Nanotube Structures, and Convective Heating Improvement for Emergency Fire Shelters, among other efforts. Interns had many exciting opportunities this summer: preparing a payload for launch during the "Rock-On" camp at NASA's Wallops Flight Facility, traveling to Canada for fire tent testing, to Boston for outreach events and to Stennis Space Center for meetings.

Summer Students

GCD Program Office communications intern Scott Conklin speaks to the public about Robonaut 2 at the "TouchTomorrow" event at Worcester Polytechnic Institute.

Intern Scott Conklin from the University of North Carolina at Chapel Hill supported the program's communications efforts. Conklin wrote several articles, worked with engineers on fact sheets and lithographs, and helped plan and execute exhibits and events.

"Working at GCD doing education and public outreach has really illuminated the power of communication to tap into people's curiosity about space and stoke the flames," said Conklin. "A genuine interaction can make a lifelong learner."

Christian Hodson, an engineering student at Thomas Nelson Community College, spent part of his summer at NASA's Langley Research Center preparing a payload for launch aboard a sounding rocket.

He described the experience as humbling.

"It was incredible to be a part of the payload building and integration process," said Hodson. "I was intrigued by how quickly the process happened for such a large project with a sounding rocket; three days to completely build a payload and one day for integration."

For students supporting GCD projects this summer, the experiences were varied and impactful. The GCD Program Office thanks all project managers, engineers, administrative staff and others who signed up as mentors and helped with the internships.

"Students bring a unique perspective to solving problems, working together and achieving project goals," said Mary Beth Wusk, GCD's Integration Manager. "The students' energy is contagious, and I look forward to getting to know them each summer and watch them gain valuable work experience that is guaranteed to shape their futures."

GCD Program Manager Steve Gaddis added: "We feel strongly about supporting students, and we are committed to teaching them about NASA space technology and encouraging them to pursue their dreams."

On the cover

"When I left Huntsville, Alabama, looking for an adventure, Game Changing Development was there to provide," said intern Tara Sprinkle. "A brief overview of the technical experiences NASA LARC has opened the way for me include: launching sounding rockets, calibrating thousand-dollar 3D printers, modeling rocket assemblies, and assisting CMM scans. But even collectively, these activities would not have formed the venturesome summer I've had without my intern team standing beside me, on base and off. Team RaPID, or Rocket and Payload Integration Development, consists of myself and seven other undergraduate interns predominantly in STEM majors from across the states. Together, we are assisting GCD in final integration of the HESH 36.310 sounding rocket launch that is scheduled at Wallops Flight Facility in late September. Coincidentally, the launch occurs after the conclusion of my NASA internship. I don't know about you but that sounds a lot like another cross country road trip to me! Thanks a lot for giving me this opportunity of a lifetime GCD; you and the other interns been more than amazing to work alongside!"

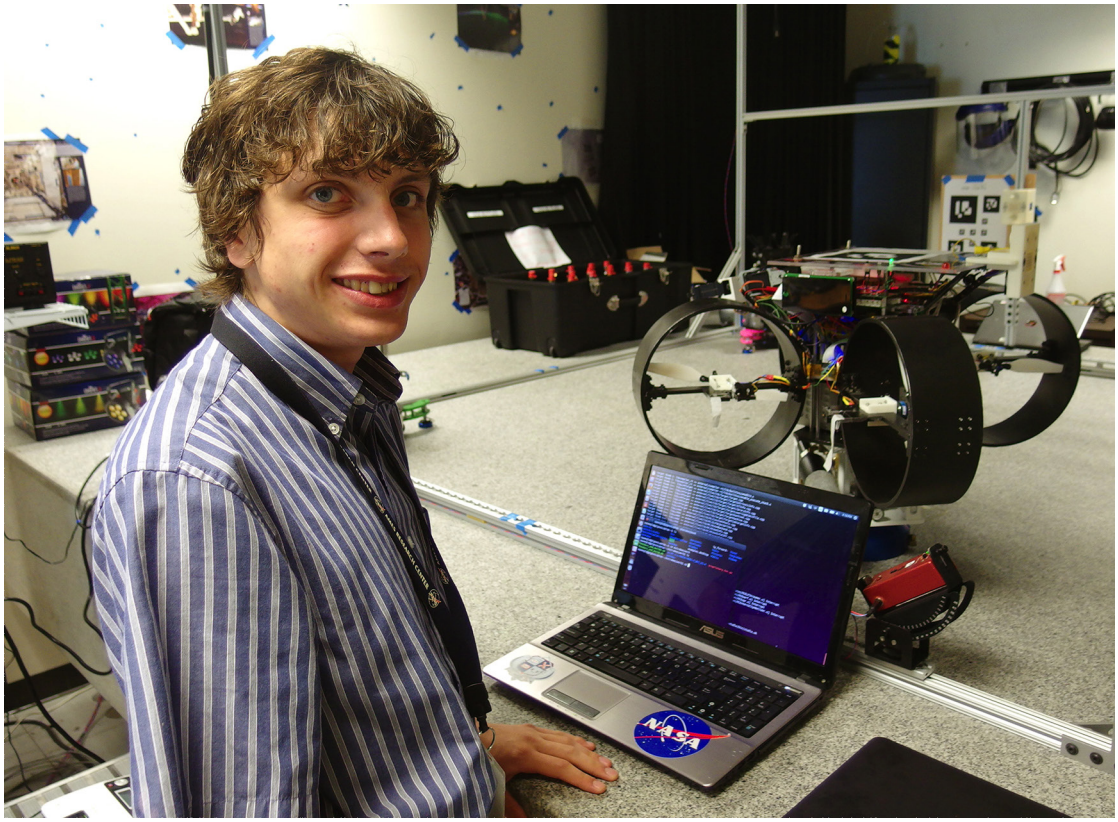
On the cover beginning at left: Austin Hehir, Brian Katona, Peyton Young, Cecilia Stoner, GCD Program Intergration Manager Mary-Beth Wusk, Tara Sprinkle, Christian Hodson, John Mulvaney and Wyatt Witzen pose for a photo at NASA Wallops Flight Facility before a Terrier Improved Orion sounding rocket launches the team's sensor payload into space as part of the NASA Wallops "RockOn" camp.

Pathways intern Curtis Stump (center) from Cal State University-Long Beach is supporting the TGALS scaled twin-glider flight test. Curtis stands in front of the twin fuselage glider on Rogers Dry Lake, June 12, 2015, supporting Flight 005. Curtis is assigned to AFRC Operation Engineering branch.

Kyle Otsuka, Hannah Misenar, and Rogelio Ramirez work to integrate real time Bluetooth® technology onto the Integrated Display and Environmental Awareness System smart glasses.

Interns at the GCD Program Office at NASA Langley participate in an ice-breaking team building exercise.

Summer Students



Brandon Gigous testing Astrobee free-flying robot subsystem prototypes.

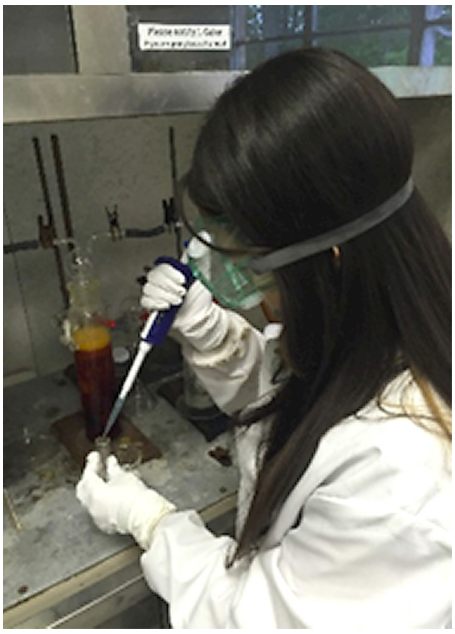
Interns with NASA's Game Changing Development Program, Taylor Ray and Dalton Roe, worked alongside researchers in a remote section of Canada's Northwest Territories to conduct real fire tests of the prototype fire shelters. The fire shelters are instrumented to collect thermal and heat flux data inside and out during the experiments.

NASA's Langley Research Center in Hampton, Va., is working with the U.S. Department of Agriculture's Forest Service to see if flexible thermal protection system technology being developed for space entry vehicles could also work to protect firefighters caught in a raging forest fire.

Following testing in the labs, NASA engineers along with the help of skilled interns are now testing full-sized fire tent prototypes in a real world environment.

They expect that what they learn from the full-scale burn tests will lead to another generation of shelter designs with better protection that will improve the safety of wildland firefighters.

Taylor Ray and Dalton Roe sport mosquito protection while in the Northwest Territories in Canada while testing fire shelters as part of the Convective Heating Improvement for Emergency Fire Shelters (CHIEFS) project.

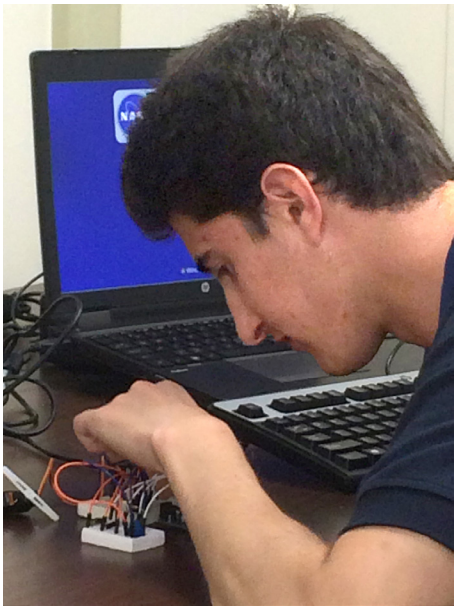


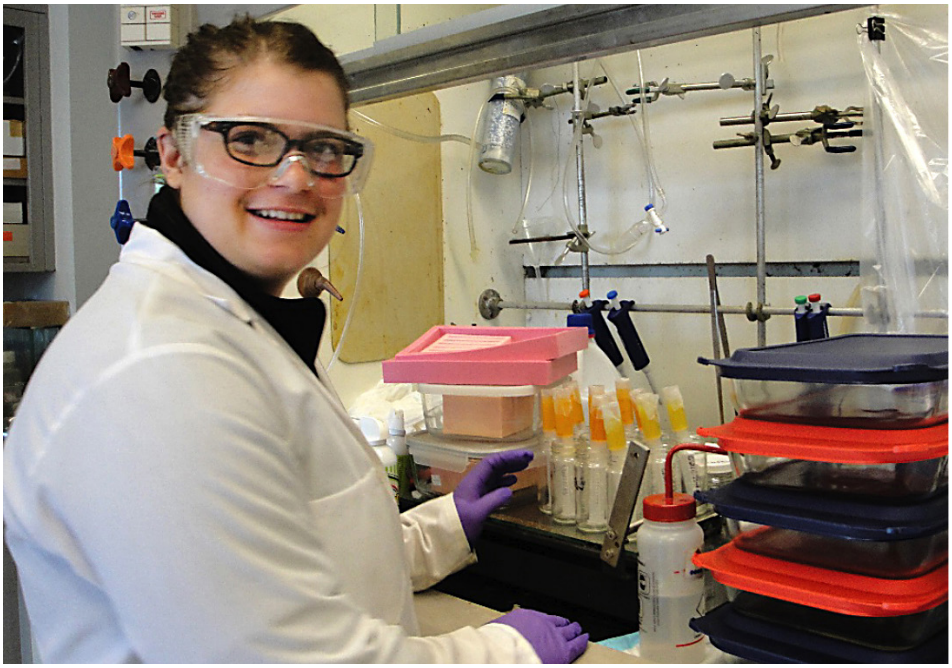
Kiara Rivera Rodriguez is a junior majoring in chemical engineering, minoring in materials science and engineering at the University of Puerto Rico at Mayagüez.

Rodriguez worked on the Stability Testing and Electrical Conductivity of Intercalated Carbon Nanotube Fibers with Halogens Materials project at NASA's Glenn Research Center under mentor Deborah L. Waters. This nanomaterials project conducts research to develop materials and structures for extreme environments to be used in the new generation of aircraft and spacecraft.

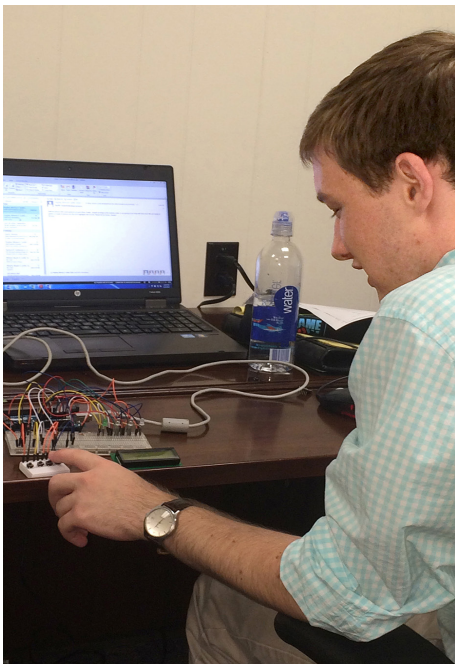
Carbon nanotubes can make multifunctional materials of high interest to industry due to the excellent mechanical, thermo-mechanical, optical and electrical properties.

With chemical modification their electrical conductivity can be improved to the point that they can be used as lightweight and high strength electrical power conductors in place of copper wiring in airplanes and spacecraft.





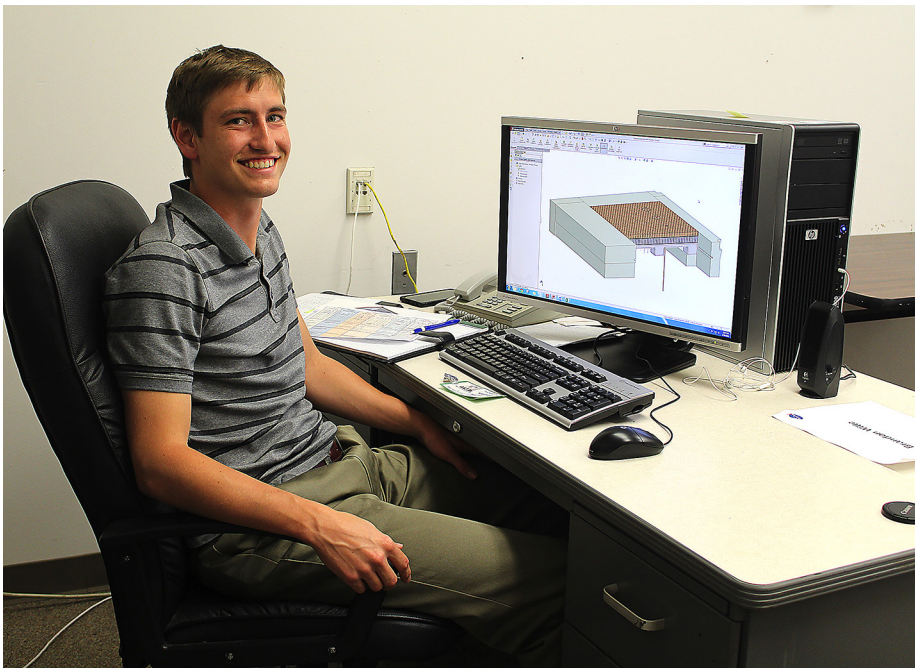
Carena Daniels is heading into her senior year at Concordia College in Moorhead, MN. She is currently undertaking an internship at NASA's Glenn Research Center working on polyimide aerogels for aerospace applications. This work draws on and puts to task her interest and skills in chemistry and chemical engineering.



Brian Katona, top, and John Mulvaney, above, work on Arduino kits in preparation for the upcoming RockOn! 2015 workshop at WFF.

Summer Students

Peyton Young, a senior aerospace engineering student at the University of Virginia, examines samples from the Advanced Near Net Shape Technology project using a scanning electron microscope.



Brandon Witte is working on the MEDLI 2 project under Jose A. Santos at NASA's Ames Research Center. Specifically, he is designing "development and do no harm" tests for the back shell instrumentation, which will be flying on the Mars 2020 mission. These test programs include arc jet testing, vibration, shock, and thermal vacuum testing. Brandon attends the University of Kentucky as a graduate student and is currently working on his master's degree in mechanical engineering.

May and June 2015 GCD Employees of the Month: Eric Vitug and Denise Stefula

"Within our Game Changing team, members contribute to the STMD mission of 'building, flying, testing' in everything they do. Each month we are recognizing a GCD Employee of the Month, one who embodies the strong STMD 'can do' attitude." —Steve Gaddis, GCD program manager

Some of you may have heard the names but ask: Who are Eric and Denise? Operating primarily under the radar, Eric Vitug and Denise Stefula, LITES contracting support for GCD's Game On! website and presence on Space Tech's NASA Portal page, and information management for project communications and publications, are our employees of the month for May and June 2015.

Image credit: Eric Vitug

Eric is a senior application developer and Denise a technical editor with Craig Technologies, a contract company headquartered in Cape Canaveral, Fla. Both joined the team early in 2013 to support our burgeoning communications activities as we endeavor to reach the public, our partners, and our stakeholders with information and updates on GCD projects.

Program Manager Steve Gaddis shared examples of recent support the LITES team provided and for which the recognition is given.

"Eric launched changes to GCD's Portal pages along with the new nasa.gov upgrade. If you visit the STMD programs listing page, Game Changing and NASA Innovative Advanced Concepts are the only two with their landing pages created in the new format.

"Denise completed our 2015 Annual Program Report, our only deliverable to STMD. This was the first time we took a different approach and put the technical data in a magazine-style format. She did an outstanding job in a short amount of time.

"We have a great team behind the scenes that is making a difference," said Steve.

Eric and his wife Winny live in Virginia Beach with their three daughters, Alyssa, Isabella, and Angelina. Eric says coming home to his family is the perfect stress reliever after a busy day and the long commute from Hampton to the beach. "As any husband or father could relate, coming home from work with these three lovely daughters running to you ready with hugs and kisses, that is the sweetest gift that I could ever ask for in my life."

Camaraderie is one thing Eric values about working for GCD. "I like that I get to support this task coinciding with my other LITES position. But I truly enjoy working with this GCD Web support team; it's 'par excellence'. Talk about peas and carrots—we all blend together as a team…and it's fun!"

Eric enjoys building model airplanes and plays both piano and guitar by ear. When outside, he likes hitting the nature trails for soothing walks and, for an occasional inside activity, Eric and family love to watch a 3D movie.

Image credit: Denise Stefula

Denise and her husband Billy live in Poquoson and have been married close to 30 years. "Our daughter Casiphonie lives with her family just up the street and around the corner," Denise said. "It is really nice that they are so close and to have had a front row seat watching our grand-daughter grow up. Haylie graduated this spring with an advanced studies diploma."

Denise's son Braxton is a young adult with autism and remains at home with the support of family. "This work has been a true blessing first because I enjoy the creative element. Most important for us though is the flexibility, which affords us the opportunities to plan as a family to meet our son's medical and emotional needs appropriately. I feel very fortunate and greet each new day with a lot of gratitude."

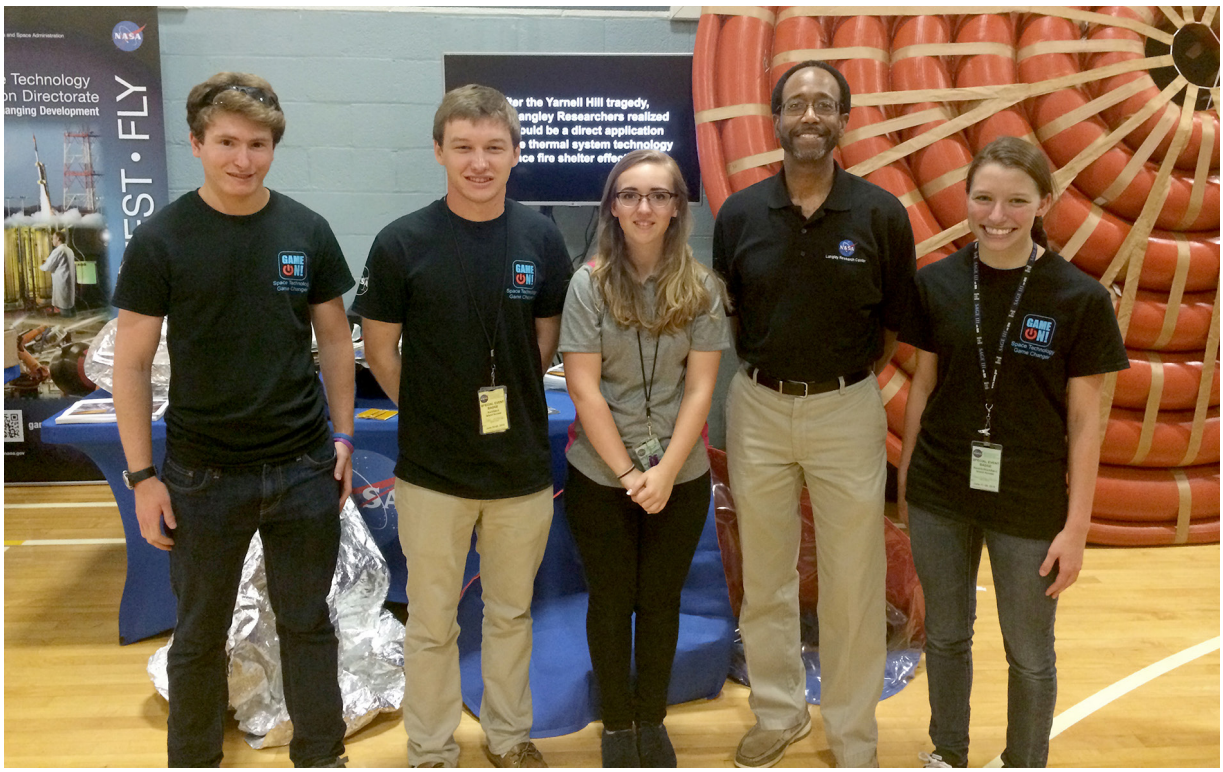
When it's time to relax, Denise likes to write poetry, dabble in computer design, and spend time in her flower or vegetable garden.

Education & Public Outreach

Intern Christian Hodson talks with an attendee about carbon nanotubes.

Wallops Open House

More than 7,000 people attended the NASA Wallops Open House event June 27. GCD had a large presence with exhibits promoting the Hypersonic Inflatable Aerodynamic Decelerator (HIAD), Convective Heating Improvement for Emergency Fire Shelters (CHIEFS), Advanced Near Net Shape Technology (ANNST) and Carbon Nanotube Technology (CNT) projects. Student interns working on the projects created posters, exhibits and educational activities in support of their projects. Highlights of the exhibits included the 3.7-meter inflatable HIAD display as well as the CHIEFS fire shelter prototypes, which people were able to get inside.



GCD interns (from left) Christian Hodson, John Mulvaney, Tara Sprinkle, and Cecilia Stoner pose with LaRC's Deputy Director Clayton Turner (second from right) at the Wallops Open House.

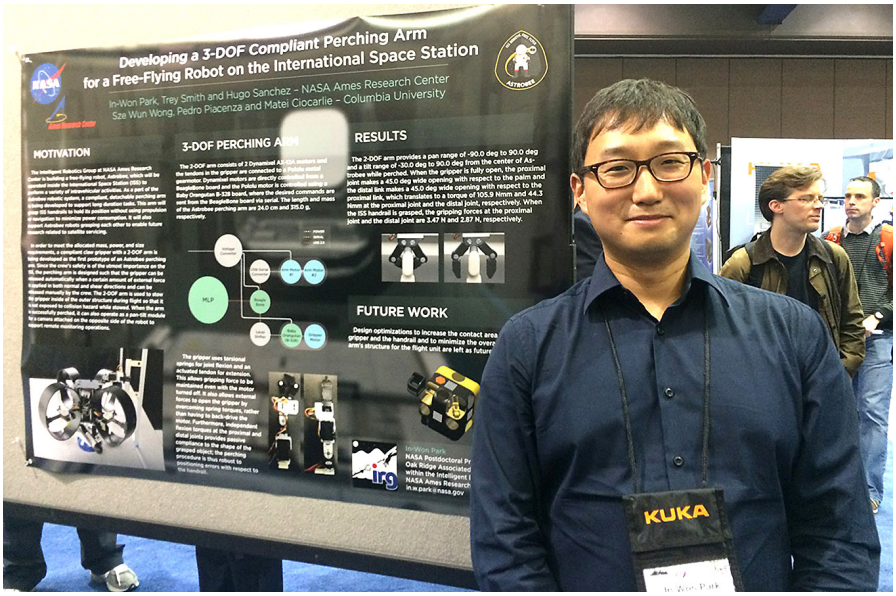
HIAD2 at World Science Festival

The Agency supports the World Science Festival in NewYork each year with educational exhibits. Here, student groups as well as the public learn what NASA is doing in entry, descent and landing and how new technologies will get humans to Mars in the 2030s.

GCD Integration Manager Mary Beth Wusk and engineer Anthony Calomino discuss HIAD2.

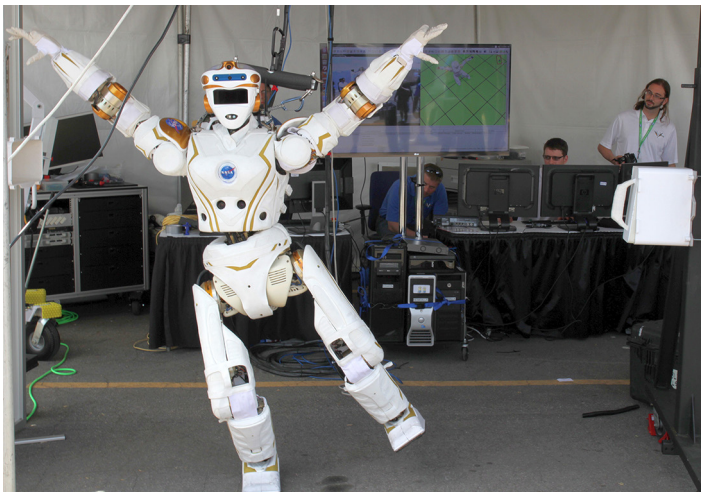
ICRA 2015

NASA Ames engineer Inwon Park participated in a poster session at the IEEE International Conference on Robotics and Automation (ICRA) 2015. The poster detailed the Astrobee robotic arm.



DARPA Robotics Challenge Exposition

The R5 team participated in the DARPA Robotics Challenge (DRC) Exposition from June 5 to 6, 2015. Two R5 units were displayed to an estimated crowd of over 20,000 citizens during this time. R5 unit A performed balancing maneuvers to show off the control software developed by the Florida Institute of Human and Machine Cognition (the second place finisher at the DRC Finals) and also demonstrated mobile manipulation skills involving changing out "planetary replacement units" in a mock-up habitat. Unit B posed as a stationary "photo-op" backdrop for individuals to inspect further and photograph. The team disseminated information about the upcoming Space Robotics Challenge to garner interest in the competition and provided interaction with the public about R5's current status and place in the future of NASA Robotics.



NASA Looks to University Robotics Groups to Advance Latest Humanoid Robot

June 11, 2015

Are you ready for that upgrade? NASA's R5 robot is and the agency is looking for help.

R5 is a new humanoid robot initially designed to complete disaster-relief maneuvers; however, its main goal is to prove itself worthy of even trickier terrain—deep space exploration.

For that, NASA is looking to members of the robotics community.

Through a competitive selection process, NASA will award two R5 robots to university groups competing in the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge (DRC) this month. Recipients will have possession of the robots for two years; receive up to $250,000; and have access to onsite and virtual technical support from NASA.

The selected university groups will have two years to perform research and software development that will improve the robot's autonomy.

"NASA often looks to the commercial and academic sector to help advance the technologies we will need to explore beyond low-Earth orbit," said Steve Jurczyk, associate administrator for the Space Technology Mission Directorate (STMD) at NASA Headquarters in Washington. "By providing the R5 platform to multiple robotics research groups, we are progressing the robot's technological readiness so it will have the skills it needs for future space missions."

The two additional robots also have another purpose — in 2016, they will compete in a Space Robotics Challenge through NASA's Centennial Challenge Program. The robotics challenge is a virtual competition using robotic simulations and a physical competition using the two upgraded R5 robots.

"NASA continues to lead in humanoid robotic development for space applications. Upgrades to the R2 unit on ISS have included the addition of legs, and improved mobility software is soon to arrive. Right now we are reaching out to universities for novel ideas," said Steve Gaddis, program manager for STMD's Game Changing Development Program. "The R5 robot is the latest humanoid robotic development from NASA and it will be exciting to see where university researchers take the next step in advancement."

Over the next year, STMD will continue to seek industry and university partnerships to assure the agency has the capabilities it needs on our journey to Mars, while helping America maintain its leadership in the technology-driven global economy.

These investments will focus on in-space propulsion and advanced high-power solar arrays; robotics and avionics for outer planetary exploration, especially high-reliability and low-mass, deep ice penetration systems; advanced materials, including large composite structures; and space observatory systems, with a focus on advanced optical coating materials.

Eligibility for this competition will be limited to U.S. university participants in the DRC finals in June 2015. Universities that receive an R5 will not be eligible to participate in the 2016 Space Robotics Challenge.

The solicitation, entitled "SpaceTech-REDDI-2015 NNH15ZOA001N-15GCD-C2 Hosting of Humanoid Robots and Validation of Task Performance for the NASA Space Robotics Challenge Appendix," is available through the NASA Solicitation and Proposal Integrated Review and Evaluation System website by going to "Solicitations" and then "Open Solicitations" at: http://nspires.nasaprs.com/

NASA's R5 robot is NASA's newest humanoid robot and was built to compete in the DARPA Robotics Challenge and advance the state of the art of robotics within the agency. Image released Dec. 12, 2013.

Game On!

http://gameon.nasa.gov

All images credited to NASA
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