



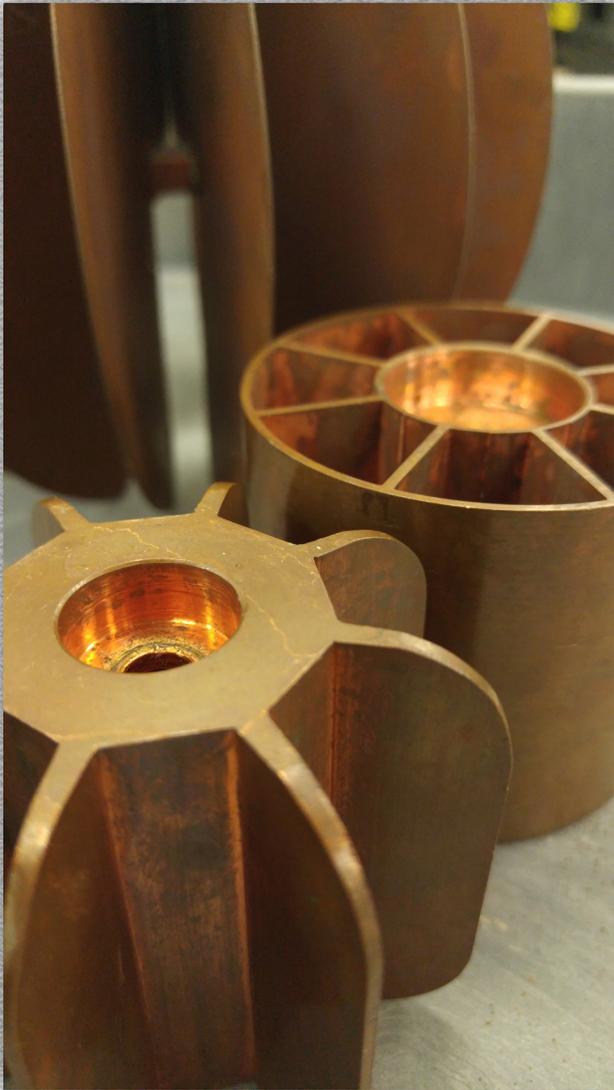
Space Technology

Game Changing Development Highlights

*2016 First-Quarter
Image Contest Winner:
Cryocooler Caps*

January-March 2016

Ocean Worlds project follows the water
Reinventing the gear
STMD announces new GCD PE
GCD's Space Tech Academy returns for another summer



2016 First-Quarter Image Contest Winners Announced

We had another great round of submissions for our first quarter image contest. Thanks to everyone who submitted a photo.

An intern with an eye for creativity is the winning submitter, and her photos of cryocooler caps for the KSC Mars ISRU task took both first (left and cover) and second place (below and back cover).

Elspeth Petersen (below left), a chemical engineering student at Iowa State University, is supporting the KSC Mars ISRU task at NASA's Kennedy Space Center. Petersen operates the Mars Atmospheric Processing Module (APM) equipment. She is also designing and conducting experiments to test the catalyst being used in the Mars APM.

"I could not have asked for a better group to work with or a more interesting project to be a part of," she said.

This is the first time an intern's photo was selected as the top image, so congrats to Elspeth!





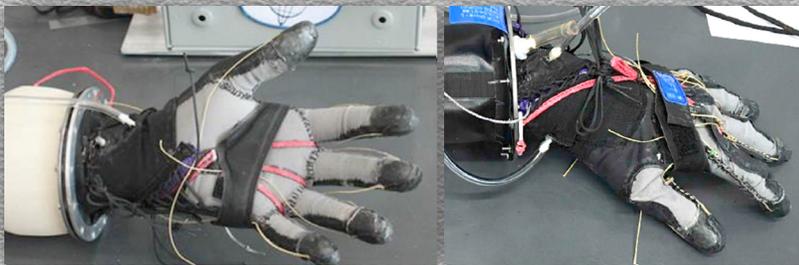
Coming in 3rd place is the 24-inch lightweight torus photo submitted by HIAD2 project manager Joe Del Corso. Find more information about the 24-inch torus on page 18.



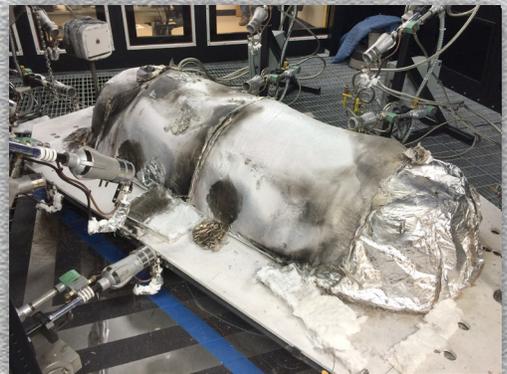
Additive Construction with Mobile Employment



Super Ball Bot



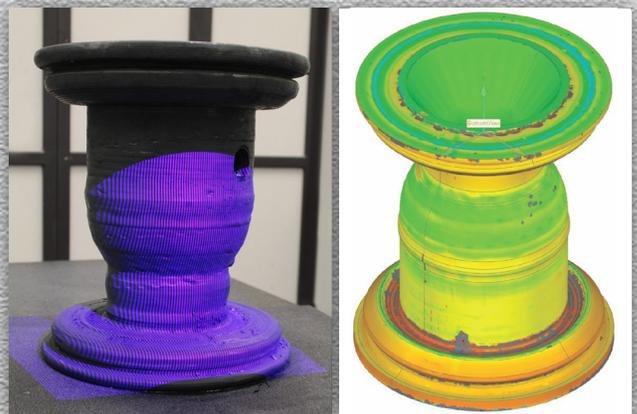
Next Generation Launch Support



CHIEFS



Integrated Display and Environmental Awareness System



Low Cost Upper Stage-Class Propulsion



Ocean Worlds Hold Fluid Promise

—Denise M. Stefula

Of the key ingredients to life—water, chemistry and energy—we now know that vast quantities of liquid water reside beneath the icy shells of outer solar system moons such as Jupiter’s Europa, Calisto and Ganymede and Saturn’s Enceladus and Titan. Could these oceans also hold the chemistry and energy for life? Could they be habitable or even inhabited? This is what motivates NASA’s interest in exploring these so called ocean worlds.

“We know of three key requirements for habitability—liquid water, a suite of biologically essential elements, and a source of energy. Evidence clearly suggests Europa has these ingredients,” says Kevin Hand of NASA’s Jet Propulsion Laboratory.

While orbiting Jupiter in the 1990s, NASA’s Galileo spacecraft revealed exciting imagery and data of this potential ocean world: the probable existence of deep water beneath Europa’s outer layer. The moon’s icy crust is covered in cracks suspected to result from tidal forces on the water below as it orbits Jupiter. Also observed are iceberg-like protrusions from what appears to be where water erupts through the surface like a volcano and then freezes.

To verify extant life or habitability, NASA will need to do more than just study photographs and imagery. Scientists suspect that Europa harbors more water than all of Earth’s oceans combined, but all of that water is contained underneath Europa’s icy shell, shielded from the surface. Answering questions about signs of life on Europa requires the in situ investigations only capable during a landed mission, collecting key samples to study the water and studying material that may have once been in Europa’s ocean.

The Europa Lander Mission’s broad science goals are to confirm the presence of an interior ocean, characterize the satellite’s ice shell, and understand its geological history. The Game Changing Development (GCD) Program’s Ocean Worlds Europa Technologies (OWET) project, a new startup for 2016, is investigating concepts to support the goals of searching for signs of life on Europa and the other ice-covered ocean worlds.

“The OWET technologies we are developing are absolutely essential to meet science goals of a landed mission,” says OWET Project Manager Tom Cwik. “The tech development we are undertaking breaks fundamentally new ground in

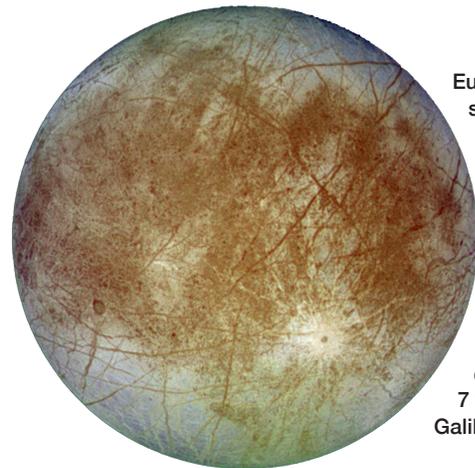
some areas like batteries and electronics, and quite simply, will require breakthrough inventions in other areas such as probing and sensing deep below the icy surface.”

OWET research includes concepts for an intelligent landing system, ultra-low temperature batteries, ultra-low temperature electronics, and mobility and sensing.

Creating an intelligent landing system means developing terrain relative navigation that includes hazard detection. This will allow the lander to “sense” a safe touch down site—diverting the final landing site if necessary—with good proximity to identified science sites. Intelligent landing systems such as this will enable any mission whose destination has an extreme surface environment with hazardous terrain.

Ultra-low temperature battery advancements seek to enable extended mission architectures by enhancing power margins and reducing mass and power consumption. Commercially available primary batteries do not offer an operational window long enough to sustain lengthier mission goals nor are they designed to last in the extreme low-temperature environment of a moon like Europa. Improvements to mass and power consumption give way for additional science instrumentation and their operations.

Ultra-low temperature electronics development is focused on a next-generation, compact avionics package for command and data handling, and power and motor control. These electronics will be lightweight with increased power efficiency and allow the Europa lander to last longer on the surface. An avionics design with reduced volume, mass and power has potential to be used in numerous other architectures.



Europa's trailing hemisphere in approximate natural color. The prominent crater in the lower right is Pwyll and the darker regions are areas where Europa's primarily water-ice surface has a higher mineral content. Imaged on 7 September 1996 by Galileo spacecraft.

Mobility and sensing concepts include autonomous systems for exploring and gathering samples on and beneath the surface as well as long range mobility. This project technology development entails analysis, modeling and simulation; prototyping; and experimental evaluation in laboratory test beds to evaluate performance of the concepts generated. Successful concepts are expected to transfer to meet other technology needs, such as autonomous systems for robotic exploration of other bodies.

Europa is considered by many the most likely place in our solar system to find life because it is believed to have all three of life's key ingredients.

“Such a discovery would have an enormous impact on science and society, and it would provide us with another world through which to advance our understanding of how biology ‘works’,” says Hand.

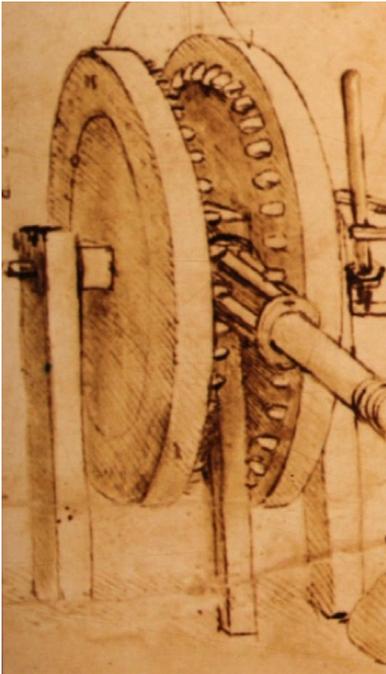
Getting there sometime in the next decade and spending time there to gather science absolutely require advancing technologies beyond current capabilities. GCD's OWET project will help develop the necessary technologies and advanced concepts.

“In order to survive the environment on Europa for a short 10 days, our current technology is not good enough,” says Program Element Manager Wade May of the GCD Program Office. “We must extend our technology for batteries and electronics to survive the extreme radiation environment and the very cold temperatures. And that is just to land on the surface. If we want to move around after landing, then further developments in mechanical systems must be made.”

Life on Earth as we know it? It just may be replicated in some form or another elsewhere after all, and possibly only an ocean world away.



Artist's concept of a hypothetical ocean cryobot, or robot that can penetrate water-ice, and its deployed autonomous underwater vehicle collecting sample information on Europa to send back to Earth.



New Game Changing Project Could Reinvent the Gear

—Denise M. Stefula

The earliest known gears were constructed of wood and designed with cogs that were cylindrical pegs; when operating, animal fat was used as the lubricant. Today, the most commonly used materials—steel, brass, aluminum, plastic—are an obvious improvement in reliability and longevity over wood. But, along with the normal wear and tear of regular use, they are also subject to changes or degradation in adverse environments.

NASA is investigating modern metallurgy for alloys with improved performance, and some of these materials are strong enough to increase the useful lifespan of gearbox components for in-space applications. To meet objectives of icy-body missions such as Europa, researchers are additionally challenged with the need for heaterless gearboxes capable of functioning in extreme cold without the benefit of solar panels or nuclear sources for power generation.

“In order to maintain an operational environment for gearboxes today, it requires lubricated gearboxes that must be heated to operate,” says Mary Beth Wusk, GCD’s acting program manager. “When you are paying by the pound to send hardware to space, you want to reduce your weight and power needs. This technology has the potential to do both by eliminating the need for power hungry heaters. We also anticipate this system will extend our surface mission life by three times that of current heated systems performances.”

The performance of current gearboxes in extreme cold limit NASA mission operations and science return. The Game Changing Development (GCD) Program’s Bulk Metallic

Glass (BMG) Gears project is developing and testing newly invented BMG alloys to mold into components for assembling heaterless planetary and strain wave gearboxes that can operate in the extreme cold environments of space and other worlds.

“When you are paying by the pound to send hardware to space, you want to reduce your weight and power needs.”

—Mary Beth Wusk, GCD acting program manager

“The innovative BMG Gears technology takes advantage of strong, highly elastic and wear resistant materials that can operate in harsh environments without heaters,” says Wusk. “Our goal is to demonstrate how this technology will deliver the next-generation transmission (gearbox) for future exploration vehicles such as the Europa lander.

By reducing mass and power needed to operate the vehicle, there will be more real estate available for future science payloads.”

BMG Gears project’s unique material solution is a metallic glass with mechanical properties very similar to ceramics but with greater toughness; it is high in strength, wear resistant, and holds up to extreme temperatures. Ceramics or metal alloys alone will not succeed as materials for the project’s proposed gearboxes.

In February, BMG Gears completed its first in a series of tests planned for the next three years: spur gear life testing in ambient conditions of a copper and zirconium-based BMG alloy. The test results will be used to evaluate feasibility for the material’s use in fabricating gearbox test article components.

BMG Gears Project Manager R. Peter Dillon of NASA's Jet Propulsion Laboratory explains that much of our ability to travel to and explore space is due to the development of new materials.

"By continuing to develop new materials we further enable our ability to explore," he says. "The copper and zirconium-based BMG alloy was selected for the planetary gearbox for its combination of strength, toughness, and wear resistance."

The GCD communications team asked Dillon a few specifics about the testing completed in February.

GCD Q: What are your findings and how are they important to the project's ongoing R&D process?

RPD: While not unexpected, we are finding out how important light element content (e.g., carbon, nitrogen, oxygen) is to the properties and manufacturability of the BMG alloy we are using. One of the benefits of using a BMG alloy is that we can mold components with the material. To do this, however, the material needs to cool before it can crystallize. The light element content can greatly affect the cooling rate needed to prevent crystallization. By setting limits on these light element "contaminants" early on we can avoid convoluting our results.

GCD Q: What did you want to see in your test results and why?

RPD: Maybe it's counterintuitive, but we actually like to see some level of failure in our testing. It's helpful to find the limits of what can and can't be done with the technology. When BMGs fail they tend to fail catastrophically. If we can quantify things like critical flaw size and wear rates as a function of time, load and environment, we can determine the acceptable composition, material property and part quality ranges we need for designing and fabricating flight-quality mechanisms with BMGs that can survive the mission requirements.

BMG GEARS FACTBOX

The Game Changing Development Program is responsible for developing technologies needed to explore promising places in the solar system ranging from Mars to the icy moon of Jupiter, Europa. These locations have extreme environments that require hardware to withstand temperatures below -50 °C. To put that in perspective, the lowest recorded temperature on any location on Earth's surface was -93.2 °C (-135.8 °F) on an Antarctic plateau. The BMG technology will need to operate at surface temperatures of -183 °C (-297 °F).

GCD Q: Tell us a little about potential or proposed prototype development and use.

RPD: The team is attempting to develop prototypes as flight-like as possible with the resources we have. The intent is to integrate test units into the Europa lander's robotic arm so they can be part of the testing the arm undergoes. In parallel, the team will also be testing other test units to generate the data necessary to be considered by the Europa lander mission for acceptance into the flight project.

GCD Q: How is this technology being used on the Europa lander's arm anticipated to benefit the mission, specifically?

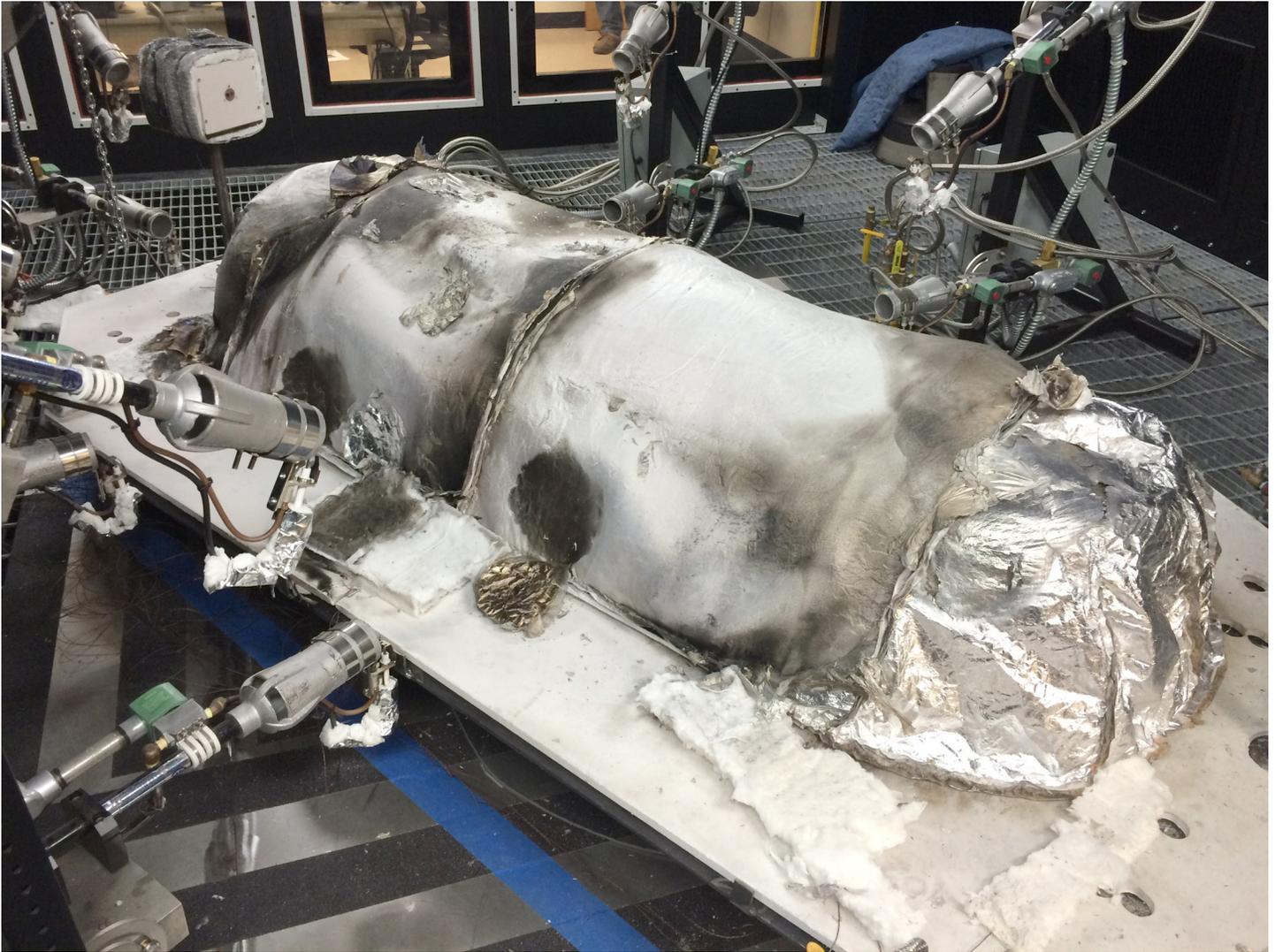
RPD: This technology would eliminate the need for heaters on the arm's gearboxes. This would allow the power that would be required to heat gearboxes to be used for other systems and increase science return. Eliminating the need for gearbox heaters should also help decrease system mass and complexity.



Steel (left) and amorphous metal (right) harmonic drives. Harmonic drives have been used on many spacecraft because they provide the highest torque per unit mass of any commercially available gear sets, but they are very difficult and expensive to manufacture. Amorphous metal can be cast into the final shape with no post-casting finishing steps required. Precise teeth shapes can be incorporated into the mold and replicated nearly perfectly into the castings. Certain alloys of amorphous metal (metallic glass) also have extremely good elastic, contact stress, and galling properties for this application.

Opposite page:

Image credit: Istituto e Museo di Storia della Scienza



CHIEFS Conducts Full-Scale Fire Shelter Testing at NC State

The CHIEFS team traveled to North Carolina State University, in Raleigh, to conduct full scale fire shelter laboratory testing. NC State and CHIEFS have been developing a collaborative relationship as both entities endeavor to improve the resistance of wild land fire fighter emergency shelters.

CHIEFS fire shelter technology is under advancement with the Game Changing Development (GCD) Program's Entry Systems Modeling project. GCD's partnership with the US Forest Service was initiated after an observation that advanced entry, descent and landing technologies, particularly heat shield materials, could potentially be of benefit to fire shelter protection research and development.

"CHIEFS benefits from expertise, test methodology, and technology gained during NASA's development of flexible thermal protection systems for inflatable reentry vehicles," explains Josh Fody, CHIEFS project manager at NASA's Langley Research Center. "These tools, developed for space applications, are applied here on earth to enhance the ability of the US Forest Service's emergency fire shelter to protect fire fighters from direct flame heating, where CHIEFS hopes to save lives on the ground. In return, there is a synergy where new materials and passive thermal concepts realized by CHIEFS are being investigated for use in the next generation of flexible heat shields via the Entry Systems Modeling project."

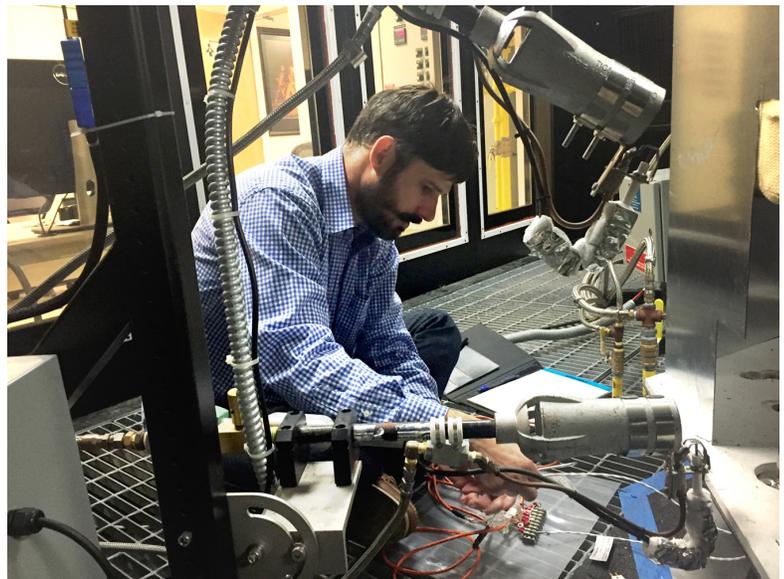
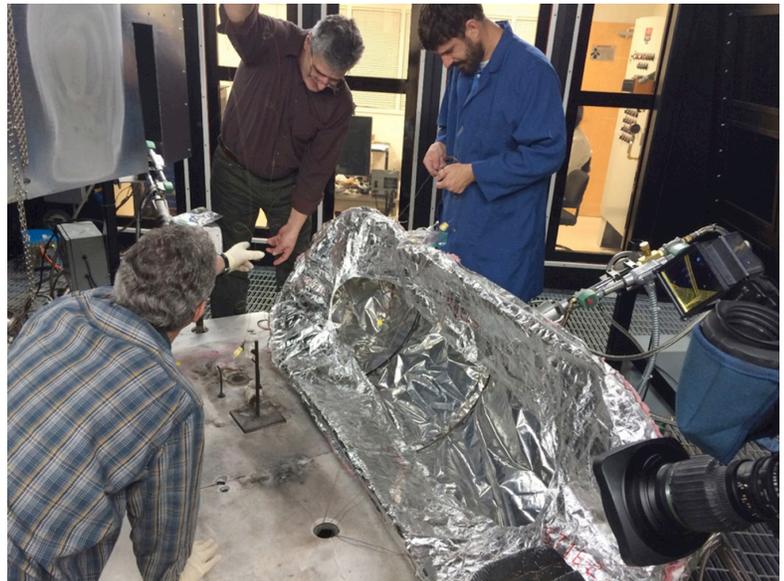
NC State researchers have established a full-scale shelter test apparatus, and invited CHIEFS to conduct screening tests on 10 fire shelter concepts known as “Generation 2” shelters. Of these candidates, different wall and floor seam concepts were tested in five novel material layup configurations. All of the material layups were fabricated into full scale M2002 geometry designs that were comparable in weight and volume to the existing fire shelter.

All CHIEFS shelters performed well, with the top contender providing an internal shelter environment 300 °F lower in temperature than measured for the existing shelter subjected to the same exposure time. This leading contender weighs only 7 percent more than the existing shelter and utilizes a commercial fiberglass batting imbedded with intumescent graphite particles. The material layup is a unique concept developed by CHIEFS and implemented in a successful trial run by the manufacturer of the fiberglass batting.

In general, the Generation 2 shelters demonstrated efficient designs with significant thermal improvement over the existing shelter, but with a much closer match to the current design’s weight and volume than the Generation 1 shelters tested last September. Results are being evaluated now, and will be used to drive a decision about the composition and construction of the next round of full-scale test shelters.

Current plans are to down-select to two candidate layups and fabricate shelters by mid-April that the US Forest Service will use in tests planned over the next couple of months in Canada.

“CHIEFS is currently in an exciting phase,” says Fody. “The culmination of development and lessons learned over the past two years have demonstrated a consistent improvement in test results. The next round of testing, later this Spring, will implement these shelter improvements to be demonstrated to the Forest Service in full-scale tests at the University of Alberta in Edmonton, Canada. The results of this test will help decide which CHIEFS shelter will move toward field tests where units would be carried by deployed wildland firefighters during the 2017 fire season.



Top: Fire shelters in packed configuration are shown side by side: an existing M2002 shelter on the left and a Generation 2 prototype on the right.
Middle: Walt Bruce, Anthony Calomino, and Josh Fody configure thermocouples that will measure temperatures at various locations within the shelter to determine its performance.
Bottom: Josh Fody wires a heat-flux gauge to measure flame intensity.
Opposite page: A fire shelter, post-test.



PISCES, Partners Test Rocket Engine on Lunar Landing Pad

The Pacific International Space Center for Exploration Systems tested its robotically-built lunar landing pad on Sunday.

A four-second test burn of a rocket engine, with power matching that of 26 and a half pounds of dynamite, took place at the PISCES landing site, located within Puna Rock in Kea'au.

Sunday's test placed emphasis on the durability of the landing pad.

The test was the accumulation of months of cooperative efforts between PISCES scientists, NASA engineers, and Honeybee Robotics, creating the first robotically built Vertical Take-Off/Vertical Landing Pad in the state.

Using basalt materials mined from a quarry on the island, much like materials found on the Moon and Mars, the landing site was created, ultimately providing a method of construction that could be used for future space missions.

The landing pad, like the one built by PISCES' robotic rover Helelani, offers a flat, stable surface to prevent damages that occur as spacecrafts take off or land on planetary objects.

Big Island Now got the inside look at the unveiling of the basalt landing pad in October.

When rocket engine "Astro the Rocket" deployed onto the pad on Sunday, the mission was deemed successful despite some of the pavers being impacted by the blast.

PISCES Executive Director Rob Kelso said the impact wasn't totally unexpected.

"We're still looking at the data. It was an extremely valuable test that will help us evaluate the interlocking pavers and the interaction of a high thrust rocket engine on a lunar pad," Kelso said.

PISCES will now look at the interlocking pavers and the pad construction to evaluate the data for the next design phase.

The project is part of PISCES' Additive Construction for Mobile Emplacement (ACME) project and is a partnership with NASA, Honeybee Robotics, ARGO, Hawai'i County Department of Research and Development, and the state of Hawai'i. PISCES also partnered with Ena Media Hawai'i for the rocket engine firing test.

Read more about the ACME project at http://sites-e.larc.nasa.gov/gcd/files/2016/02/GCD_HL_Oct-Dec_160127.pdf

Source: bigislandnow.com, March 21, 2016.



Top: Telescope imaging team from command platform 200 meters from pad. Bottom: PISCES' VTVL pad performance test under 1000 lbf rocket engine static firing, March 20, 2016.



Top: Beginning of paver displacement during firing. Middle: Sustained displacement during burn. Aero lifting. Bottom and opposite page: Post firing data. Image source: Ena Media Haw

Space Technology Announces New Program Executive for GCD Program

In January 2016, LaNetra C. Tate officially began her new role in the Game Changing Development (GCD) Program as program executive. Most recently, Tate served as STMD Principal Technologist for Nanotechnology and Advanced Manufacturing and the NASA Representative to the National Manufacturing Initiative. Prior to her work at Headquarters, she was repair lead with the GCD Composite Cryotank Technologies project and then Kennedy Space Center's lead for that project.

In February, Tate and other program officials from Headquarters paid a visit to Langley Research Center and the GCD Program Office team. We followed up with Tate to get her thoughts as she gets underway with this important and very busy leadership role.

GCD Q: Please describe the role of GCD PE.

LCT: As Program Executive (PE) I am the overall strategic manager, NASA official, and advocate of the Program. I am responsible for program formulation, solicitation development and implementation, external and internal advocacy, establishing policy, defining objectives and requirements, ensuring allocation of resources to the Level II Program Office, assessing performance of the programs or projects/activities, performing the HQ reporting/review functions, representing and keeping NASA HQ informed, and managing the overall annual budget process. I also integrate and collaborate with other programs and elements within STMD, the other NASA Mission Directorates, federal agencies, industry, and other offices at Headquarters and the Centers.

GCD Q: Describe how you feel your first year as PE will be characterized.

LCT: My hope is that my first year will be collaborative and efficient.



GCD Q: What interests you most about being PE?

LCT: Being able to engage a broad spectrum of technologies and represent a great program that has produced relevant and innovative technology is an exciting opportunity.

GCD Q: What do you think will challenge you most about being PE?

LCT: Working within budget constraints is always difficult when trying to mature technology. I have been a researcher so I understand that perspective of needing funding. So I think one challenge is maintaining momentum and a steadiness within the entire GCD team across the agency in a highly dynamic environment.

GCD Q: Please tell us about something specific you have in mind to bring to the role of PE and/or GCD as PE.

LCT: I would like to ensure that the GCD portfolio has a good balance of push and pull efforts and that risk posture is aligned with the vision of GCD and STMD. I would also like to strengthen and leverage partnerships between GCD and STMD's Early Stage Innovation Portfolio.

GCD Q: What are some of the latest early stage innovations showing promise for future advancement through GCD?

LCT: STMD's Early Stage Innovation Portfolio has several efforts within the overall portfolio (NASA Innovative Advanced Concepts, Center Innovation Fund, Space Tech Research Grants) that could potentially make a great impact in future NASA missions once matured. One area that GCD is currently funding, the Additive Construction for Mobile Emplacement project, has components that began in the NIAC and CIF programs. This project aims to use 3D additive construction to build large structures made from in situ resources on planetary bodies. This effort initially started as an early stage investment and has a successful partnership with the Army Corp of Engineers as well. Another area is in our Human Exploration Telerobotics area and the SUPERballbot project. This effort has components that were initially invested within STMD's NIAC program and focuses on developing structurally compliant tensegrity robots.

GCD Q: What are some of the latest innovations advancing into technology demonstrations or being infused/transitioned that show promise for future missions or the state of the art?

LCT: Deep Space Optical Communications (DSOC) will transition from GCD to TDM in FY2017. The DSOC project technologies matured within GCD and then within TDM will provide a deep space optical receiver and a ground receiver that will enable more than 10 times the data rate of current state-of-the-art radio frequency systems used

for deep space communications. This will be critical to human exploration beyond cis-lunar space.

GCD Q: What role does the PE play in identifying opportunities for mission infusion?

LCT: As strategist for the program, the PE is instrumental in making sure that GCD is meeting the needs of our partners and stakeholders (specifically HEOMD and SMD) as well as fostering partnerships with industry and academia. As PE, I am 100 percent engaged in conversations with STMD leadership and counterparts in other mission directorates to make sure our investments align with the needs of NASA.

GCD Q: How does the PE role interact with or facilitate work within GCD projects?

LCT: The PE role is supported by the GCD Program Office, which interfaces with the GCD projects. My interactions with the projects are through the Program Office. However, I am always available to the projects and centers to discuss current accomplishments, issues and potential future work.

GCD Q: How does the PE support efforts to create new markets for these technologies? Why is this important?

LCT: As the PE and the primary advocate for GCD, I am in constant communication with stakeholders both internal and external to NASA in order to transition technology where applicable and advocate for potential infusion of current work. GCD matures technology from TRL 3/4 to TRL 5/6 and it is essential to the mission of GCD and STMD that I engage with the community at large to ensure that our investments are relevant and meaningful to NASA.

GCD Q: How is it important or advantageous to have industry, other government agency and academic involvement?

LCT: Partnerships with industry, other government agencies and academia are extremely important in maturing technology. Many of the specific requirements that NASA needs are unique to NASA, yet beneficial to other markets, so it is a goal of GCD to lead, motivate, and inspire technology development and innovation through collaborative relationships between government, academia, and commercial entities.

GCD's Space Tech Academy Prepares for its Second Summer

—Denise M. Stefula

NASA has a long history for reaching out to academia with educational materials to use in classrooms and offering internship opportunities for both high school and college students.

Last summer, the Game Changing Development (GCD) Program launched its first internship opportunities through the NASA Internships, Fellowships, and Scholarships (NIFS) program, calling it “Space Tech Academy.” Following that success, another Space Tech Academy is planned for 2016 and student selections are well underway.

“Students bring energy, enthusiasm, innovative ideas and new perspectives to the technology challenges we are working in GCD,” says Mary Beth Wusk, acting program manager for GCD. “They provide insight to the latest tools being used by academia and unique approaches to solving complex problems.”

The NIFS program is a paid educational experience that creates opportunities for students to come to NASA's Centers to conduct robust research and work on exciting projects side-by-side with NASA's finest scientists, researchers, engineers, and mission support teams.

“GCD's Space Tech Academy gives students a chance to learn about its projects through hands-on experiences with senior engineers,” says Carrie Rhoades, with Langley's Engineering Directorate (ED). “The interns are given real engineering tasks to accomplish that support GCD projects directly.”

Rhoades is assistant branch head for the Systems Integration and Test Branch in ED who has been working with GCD's Space Tech Academy since its inception. She and Adelle Helble, an engineer with Booz Allen Hamilton supporting GCD's Program Office, organize the students' technical work and “anything else it takes” to make the student program successful.

“Interns with GCD's Space Tech Academy, Rocket and Payload Integration and Design (RaPID) team, will work in a collaborative environment developing ground test procedures to verify hardware is ready for system level integration,” says Helble. “Component level development will be completed at Langley Research Center and system level integration will be completed at Wallops Flight Facility.”

Summer projects vary from year to year depending on the work GCD has going on at that time. The six interns selected for 2016's “Team RaPID” are being tasked with real flight project work that will fly later in the year.

“The RaPID team's work can vary depending on what payloads GCD is supporting and where the rocket is in the integration phase of the schedule when the students are here,” says Rhoades. “This year the rocket has a couple of GCD-sponsored payloads. One is the COPV, or Carbon nanotube Over-wrapped Pressure Vessel, which will be used as a research attitude control system.

“We will also be working with Orbital-ATK on a materials development payload called LEO-II. Last year we did some



Mary Beth Wusk, front row left, in the lab with 2015 Team RaPID interns.

fit checks of their structures for LEO-I and worked instrumentation testing with them. This year we will be more involved with their actual flight build and testing. In addition, we plan for students to work with global positioning satellite systems and with Arduino, an open-source electronic prototyping platform for creating interactive electronic objects.”

Wusk believes students gain real-life experience working technical issues in a team environment. “They learn about the strategic goals of NASA and how they can be part of the solution. The more involved students are, the more invested they will be, which ultimately fosters pride in working for NASA.”

Rhoades, who says she grew through her internship at NASA’s Armstrong Flight Research Center, hopes each student participant is provided many moments to experience independence and gain self confidence in knowledge, ability to learn, and capability.

“This is a chance to help develop students into independent and confident engineers that can take on the challenges of tomorrow,” she says.

Wusk agrees. “The Space Tech Academy internship experience should inspire students to be part of NASA’s future through arranging hands-on projects that help develop GCD technologies and grow the students professionally.”

Aside from providing a set of circumstances for this dual benefit, Wusk has a strong personal conviction about offering internships.

“I want to be that person reaching out to academia,” she says. “I want to make students excited about working for NASA, not just by talking about the great work we’ve done but by having them actively participate in the technology development for what we still need to do.”

GCD’s Program Manager [acting] Mary Beth Wusk worked directly with the 2015 summer interns. When asked to share what she thought was the most memorable moment, Wusk was quick to say there were many. Here are a few of those memories.

The first had to do with watching the students experience the RockOn Camp at Wallops Flight Facility. In less than a week, they learned how to build, integrate, test and ultimately launch a student payload on a sounding rocket. It was impressive to see them go from eight individual students to a high performing team. They worked to solve complex problems together by pulling on the diverse perspectives of each team member.

Another was when Astronaut Kent Rominger talked to the students about his experiences on the five missions he

Along with the rocket and payload work, GCD is awarding five internships this summer for students who participated in the Breakthrough, Innovative and Game-changing (BIG) Idea Challenge competition. Over the last year, challenge participants have been working projects at their schools on new concepts for the Hypersonic Inflatable Aerodynamic Demonstrator (HIAD). The challenge is to conceive technology options and innovative approaches for generating lift using the HIAD technology. Intern selections from the BIG Idea Challenge are being announced after an April forum at Langley during which a panel of judges will select a winning concept.

An additional GCD intern is accepted to support education and public outreach communication initiatives. This role includes writing ancillary materials and helping the engineering interns create exhibits and outreach tools about their projects.

The following students have accepted for “Team RaPID”:

Austin Fuller, Virginia Polytechnic Institute, freshman in electrical engineering

Margaret Story, University of Virginia, sophomore in mechanical engineering

Marquis Burgess, Tuskegee University, sophomore in aerospace engineering

Maria Hovanessian, University of California-Santa Cruz, senior in electrical engineering

Monty Noblezada, Virginia Polytechnic Institute, junior in electrical engineering

Tim Burks, Bluefield State College, junior in electrical engineering The education and public outreach intern for 2016 is:

Scott Conklin, University of North Carolina at Chapel Hill, junior in public relations, entrepreneurship

completed through his career. It was great to watch the students’ expressions as he told personal stories of life on the space station and working with international partners. You could hear a pin drop, as all the students appeared to be bit by the NASA bug! After four hours of stories and lots of questions and answers, the students left the discussion completely motivated and ready to be NASA ambassadors.

A significant moment had to do with some of the students returning for the NASA/ATK research payload launch on board the Black Brant IX in October. This was after the internship was complete, and some students drove over 14 hours to support the launch. The students were able to understand the importance of their summer work as we monitored data on the console in the Range Control Center during the launch.

GCD Technologies Take Flight

May

Jun

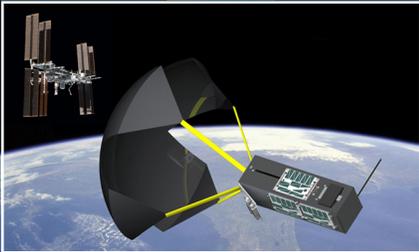
Jul

Aug

Sep

Oct

Nov



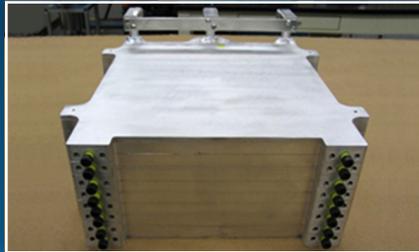
Entry Systems Modeling

Launch Date: May 31, 2016

Launch Partner:
Orbital 5

Technology/Payload:
Exobrake/TechEdSat-5

Scheduled for launch with TechEdSat-5, the Exobrake technology is a large drag-modulated (like a parachute), passive means of deorbiting from low-Earth orbit that can reconfigure itself if necessary so it can make a controlled reentry flight. Other reentry capsule concepts are based on designs using propulsive technologies, which not only require complex systems to operate but also carry inherent safety concerns both inside and outside the ISS environment. Currently, no easily achieved means of deorbiting small payloads/samples from the ISS exist, other than waiting for an opportunity on SpaceX Dragon capsule return flights. The Exobrake demonstration planned is to perform a large-scale modulated test flight and hot reentry test with follow studies of the test results. NASA says that in addition to returning samples to Earth, the technology could be used to land small payloads on Mars or other planets with atmospheres.



Phase Change Materials

Launch Date: June 24, 2016

Launch Partner:
SpaceX-9

Technology/Payload:
Wax PCM Heat Exchanger

The objective of the Phase Change Material Heat Exchanger (PCM HX) development project is to create viable solutions for future exploration vehicles in the area of long-term supplemental heat rejection. A typical PCM HX is used to store excess thermal energy during periods of high heat loads (or hot thermal environments) by melting a material and rejecting the stored energy at a later time. During the rejection period, the material is frozen again preparing it for the next heat load period. The project has identified two PCM HX concepts that have paths for possible infusion to future vehicles such as Orion: one is wax based and the other water. An upcoming launch on SpaceX-9 or -10, or Orbital 5, is planned for the wax based concept to perform a technology demonstration in a relevant environment, on the ISS. The water based PCM HX will undergo technology demonstration at a later date.



Affordable Vehicle Avionics

Launch Date: November 2016

Launch Partner:
FOP – UP Aerospace SL-11

Technology/Payload: AVA
Controlled Roll Axis Flight Test

Public and private “nanolaunch” developers are reducing the cost of propulsion, but conventional high-performance, high-reliability avionics remain the disproportionately high cost driver for launch. AVA technology performs as well or better than conventional GNCs, but with a fraction of the recurring costs. AVA enables nanolaunch providers to offer affordable rides to LEO as primary payloads – meaning, nano-sat payloads can afford to specify their own launch and orbit parameters. AVA’s flight opportunity hopes to demonstrate technology advancements that can provide order-of-magnitude reductions in recurring costs of avionics suitable for guiding small launch vehicles to low-Earth orbit.

Launch dates subject to change.

Oct

Nov

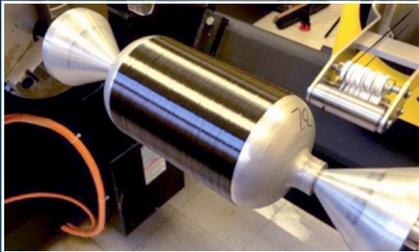
Dec

Jan

Feb

Mar

Apr



Nanotechnology

Launch Date: December 2016

Launch Partner:
Black Brant Sounding Rocket

Technology/Payload:
Composite Overwrapped
Pressure Vessel

Carbon nanotube reinforced Composite Overwrap Pressure Vehicles (COPV) enable 30 to 50 percent mass savings for aerospace structures as compared with using bare metallic lined pressure vessels. CNT materials for COPV fabrication were prepared from optimized CNT reinforcements and the most appropriate matrix resin(s) identified from stand and cylinder test results, then ground tested for durability. The flight test follows and will launch from Wallops Flight Facility, and the recovered COPV will undergo post flight testing and evaluation. The objective is to demonstrate the flight readiness of CNT reinforced COPVs by using them as the propellant system in a sounding rocket attitude control system.



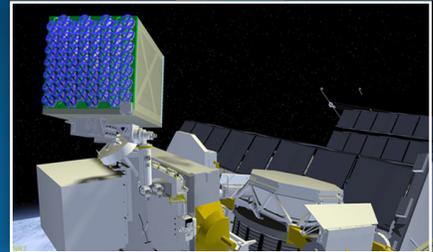
Conformal Ablative TPS

Launch Date: December 2016

Launch Partner: Terminal
Velocity Aerospace (TVA)

Technology/Payload:
Conformal Phenolic Impregnated
Carbon Ablator and an RF-
transparent conformal ablator

A Conformal Ablative Thermal Protection System (CA TPS) over a rigid aeroshell has the potential to solve a number of challenges face by traditional rigid TPS materials. Compared with other tile or honeycomb type materials, CA TPS offers a high strain to failure, or compliant, nature that will make it much easier to integrate with aeroshell structures because larger segments can be used, reducing the overall parts count and the cost of installation. Very high energy planetary entry systems that will be proposed for future missions will have TPS requirements that are most likely met by the conformal ablator. NASA is providing conformal ablative materials and instrumentation to be installed on Terminal Velocity Aeroshell's test articles that will be used as demonstration units. The flight articles for TVA's Orbital Cygnus manifest are heat shield and backshell TPS materials; NASA designed and manufactured the molds required to process the materials for both the arc jet test articles and the flight articles.



SEXTANT

Launch Date: March 2017

Launch Partner:
SpaceX-11

Technology/Payload:
NICER

SEXTANT is the Stations Explorer for X-ray Timing and Navigation Technology. As part of a multipurpose mission, SEXTANT is planned for flight on SpaceX-11 with the Neutron-star Interior Composition Explorer (NICER) instrument for an in-space demonstration of the technologies. This one-of-a-kind investigation seeks to demonstrate advanced navigation capabilities from a relatively low-cost instrument that takes advantage of an already existing platform, the International Space Station (ISS). SEXTANT's goals are to (1) enable GPS-like autonomous navigation anywhere in Solar System, and beyond, using millisecond period X-ray emitting neutron stars (Millisecond pulsars) as beacons, and to (2) explore the utility of pulsar-based time scale, and potential to maintain clock synchronization over long distances. The ISS orbit that ranges between 51.6 degrees north and south latitudes will give the instrument a good view of the cosmos to accomplish both its scientific and technology objectives.



Pictured with the torus from left to right are Brian Giles, Keith Johnson, Anthony Calomino, Greg Swanson, and in the back, Paul Anderson. In this image, the strings are not what is holding the torus up—it is so lightweight that the torus is resting on Paul's index finger.

HIAD-2 Inflatable Structures Achieves Large Scale Torus Manufacture

Members of Langley's Mechanical Systems Branch and Atmospheric Flight & Entry Systems Branch (Engineering Directorate) traveled to Airborne Systems (AS) in California to oversee the manufacture of the first 24-inch section diameter, 160-inch major diameter torus constructed with high-temperature-capable Zylon bias braid and a 3-mil fluoropolymer liner for the Hypersonic Inflatable Aerodynamic Decelerator-2 (HIAD-2) project.

This was the largest torus with this material combination manufactured to date and was a positive step toward the development of the next generation of large-scale, high-temperature-capable HIAD structure. The largest previously demonstrated section diameter using this material combination was 9.9 inches.

Test articles planned for the demonstration included alternate torus braids, liner materials, low-outgassing adhesives, and inflation ports and hoses. The articles were evaluated for material specifications, manufacturing methods and fabrication procedures for future applications. A study will follow to evaluate facilities, equipment, fabrication procedures, test hardware, and assess costs.

This test also allowed the team to evaluate a new design for inflation ports shaped to reduce braid distortion at the penetration while increasing the flow area to help improve fill times on very large tori. The team documented changes to be implemented in the upcoming attempt to manufacture a 24-inch section diameter, 200-inch major diameter torus to eventually be paired with the first unit.

The HIAD-2 task is part of a comprehensive, 4- to 5-year plan to push materials and manufacturing development beyond current capabilities to support the entry, descent and landing architecture study sponsored by NASA's Space Technology Mission Directorate. The task is divided into four primary efforts: flexible thermal protection systems development, inflatable structures development, aeroshell integration, and inflation system scalability. A fifth, ancillary task is to investigate large-scale flight demonstration opportunities with industry partners.

NASA's goal to send humans to the surface of Mars requires sustained and coordinated efforts over time, like HIAD-2, to enable missions by providing robust, reliable, and Earth-testable solutions that are crucial to advancing the technology.

Education & Public Outreach

JSC Hosts Second Lady of the United States



As part of Scott Kelly's return from his year in space, JSC hosted the Second Lady of the United States Dr. Jill Biden (right, third from bottom). HRS Project Manager Bill Bluethmann had the opportunity to brief Dr. Biden, Astronaut Captain Mark Kelly (USN ret) and Dr. John Holdren, Assistant to the President for Science and Tech-

nology, about the US FIRST NASA JSC house team, the Robonauts. Bill introduced the guests to the US FIRST program, this year's game, and some of the Agency's goals through support of the program before handing Dr. Biden to the team's students so they could give her a demonstration of their robot.

Space Tech at SXSW Interactive Festival



NASA continued to reach large and diverse audiences recently with a presence at the South By Southwest (SXSW) Interactive Festival in Austin, Texas. A large NASA booth was featured in the exhibit hall and featured NASA's Space Launch System, Orion Capsule, James Webb Space Telescope, Centennial Challenges Program and Space Technology Mission Directorate. Astronauts Jessica Meier and Victor Glover were also on hand to sign autographs. GCD Communications Manager Amy McCluskey and exhibit technician Brandon Guethe (left with festival visitor) staffed the R2 exhibit and the new Mars Google Cardboard app created by STMD.

In addition to the exhibit, STMD Chief Engineer Jeff Sheehy, JPL engineer Ian Clark and Principal Technologists Michelle Munk and Molly Anderson (below from left) presented the panel discussion "Occupy Mars." The panelists presented to a packed room on the Next Stage in the exhibit hall.



Vic Rottenstein @RottDJ 2d
En 5 minutos la @NASA sobre si vamos a ocupar Marte #sxsw #sxroi2016 #nasa



Jennifer Swift @J_swift619 2d
"We're putting a condo on #Mars."
#OccupyMars #NASA #SXSW
@NASA @sxsw



Bolden Visits ARC Roverscape



On February 18, Administrator Bolden, Associate Administrators Jurczyk (STMD) and Weaver (Communications), and Congressman Honda (D-CA) were briefed on GCD HRS Rover Technology development at Ames Research Center (ARC). This briefing included demonstration of the K-REX planetary rover and the VERVE robot driving software, which are being used by HRS to support technology development and risk reduction for the NASA Resource Prospector (RP) mission. Administrator Bolden personally drove K-REX over steep slopes, rocks, and craters in the ARC Roverscape.





Game On!

<http://gameon.nasa.gov>



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