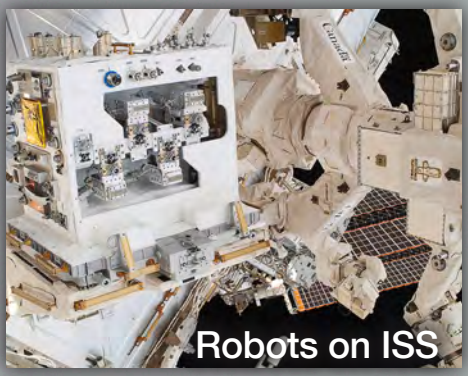
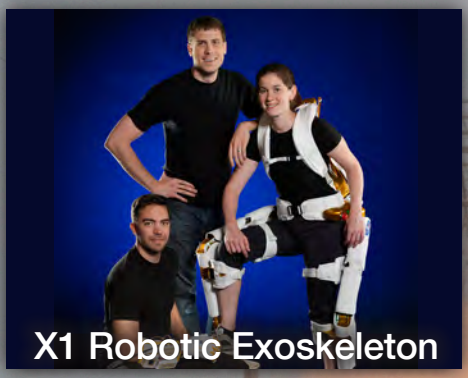
National Aeronautics and Space Administration

Space Technology Game On

Game Changing Development Program


Robots on ISS

Cryotank


X1 Robotic Exoskeleton

The IRVE-3 Experience

Winter 2012

Game On

Team,

I wanted to share my personal thanks with each of you for an outstanding year. We successfully completed our first annual program review and received rave reviews.

Our stakeholders said it was fantastic, and that we did an outstanding job. They were highly impressed with the amount of work that was completed this past year and how well organized we are.

Many others praised our efforts as well. NASA Goddard Space Flight Center's Chief Technologist Peter Hughes said:

"Congrats to you and your team for the excellent annual program review this week. You and your team deserve top marks for a well-planned and well-executed review. The same goes for the program itself. You have established an impressive team, which is delivering significant progress and results. Keep up your strong leadership, excellent communications and persistent focus on innovation and results."

In 2012, we exceeded our annual performance goal for the Agency by an order of seven. We achieved 19 first-time accomplishments with one being the successful launch of IRVE-3. We successfully completed all project continuation reviews to date and met our delivery commitments to AES. We have strong collaborations within Space Technology, which include Center Innovation Funds, Centennial Challenges, Flight Opportunities, Technology Demonstration Missions, Small Business Innovation Research and many more. We also have strong collaborations with Human Exploration Operations Mission Directorate/Advanced Exploration Systems, and Science Mission Directorate/Astrophysics Division. We obligated 98.4% of our new obligation authority.

- Four solicitations with 21 awards
- 20 new starts
- 12 formulation activities
- 31 projects in implementation
- 10 grants
- Five national initiatives

For the upcoming year, we've been challenged to:

- Raise the bar and get more aggressive with our goals and objectives
- Get industry involved sooner and more integrated in our efforts
- Make sure we are making our information available to help with national needs

We are going to build on this success and meet these challenges. Our vision is:

"To be the premier organization within the Agency or country to rapidly advance mid TRL disruptive space technologies from concept to demonstration."

Again, thank you for an amazing year. Congratulations to you all. I feel blessed to be working with such an incredible group of people.

Warmest regards,

Steve Gaddis

Winter 2012

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On the Cover
The Inflatable Reentry Vehicle Experiment (IRVE-3) launches from NASA's Wallops Flight Facility. Insets: the Robotic Refueling Mission module (top) installed on its temporary platform on the International Space Station's Dextre; a composite cryotank (middle), NASA engineers (bottom) demonstrate new X1 Robotic Exoskeleton.

NASA is Game Changing
Rapid Technology Infusion

The Game Changing Development (GCD) Program seeks to develop and advance space technologies that will result in **new** approaches and capabilities used in NASA's future space missions.

Located at NASA's Langley Research Center (LaRC) in Hampton, Va., the Game Changing Development Program is part of the Space Technology Program (STP) within the Office of the Chief Technologist. With an overall budget of $165 million for 2012, GCD has projects spread across nine states and employs approximately 400 highly-skilled experts throughout eight NASA centers.

GCD focuses its efforts on the mid Technological Readiness Level (TRL) range (3-5/6). The general life-cycle of a project at GCD begins with proof of concept (TRL-3) and usually ends with system testing in a relevant environment (TRL-5/6). These projects are typically two to three years long.

The Program's **technology** developments are done primarily in laboratories, which include ground testing in preparation for in-space demonstrations by other stakeholders. However, some of these demonstrations could also be performed under GCD. Successful technologies will transition to other STP programs, such as the Technology Demonstration Missions (TDM) Program or directly to flight missions under NASA's Mission Directorates. The technologies can also transfer to other governmental agencies or support national needs.

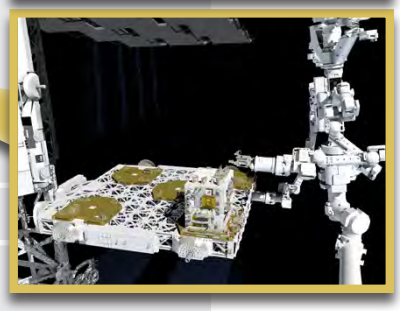
With a focus on game-changing technologies, in a high-payoff, **high-risk** environment, success is not expected with each investment. However, over time we expect dramatic advances in space technologies to enable entirely new NASA missions and provide potential solutions for a wide variety of our society's grand technological challenges.

The GCD Program investments in **innovative** space technologies directly supports NASA's mission to "…drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth..."

For more information about GCD, please visit: http://gameon.nasa.gov

Game Changing Development Alignment to Core Technology Areas

Launch and In-Space Propulsion	• 20 Kelvin 20 Watt Cryocooler • Advanced Space Propulsion Workshop • ***Composite Cryotank Technologies and Demonstration*** • Ground Engine Test Technology Development • In-Space Propulsion • ISS Spheres Fluid Slosh • Microfluidic Electrospray Propulsion • Solar Electric Propulsion • Solar Array Structures • Soldier/Warfighter Operationally Deployer for Space • Space Power Systems
Energy Storage	• Battery Anode (AMPRIUS) • Nuclear Systems
High Data Rate Communication	• Barrier Infrared Detector • Deep Space Optical Communications
Lightweight Space Structures	• Lightweight Materials and Structures
Robotics and Autonomous Systems	• Autonomous Systems • ***Human Robotic Systems*** • Next-Generation Humanoid Disaster Response • ***Robotic Satellite Servicing***
Environment and Life Support Systems	• Next-Generation Life Support • Membrane-Enabled Reverse Lung
Space Radiation	• Advanced Radiation Protection
Scientific Instruments and Sensors	• Adjustable Grazing X-Ray Optics • Advanced Laser Frequency Stabilization • Exoplanet Light Imaging and Spectroscopy • Fastlight Optical Gyroscope for Precision Navigation • Station Explorer X-Ray Navigation and Timing
Entry, Descent, and Landing	• 3-D Mat Compression Pad • Deployable Aeroshell Concepts – Conformal TPS • Heat Shield for Extreme Entry Environment Technology • ***Hypersonic Inflatable Aerodynamic Decelerator*** • Woven Thermal Protection System



NASA's Ironman-Like Exoskeleton Could Give Astronauts, Paraplegics Improved Mobility and Strength

Reprinted from OCT website

Marvel Comic's fictional superhero, Ironman, uses a powered armor suit that allows him superhuman strength. While NASA's X1 robotic exoskeleton can't do what you see in the movies, the latest robotic, space technology, spinoff derived from NASA's Robonaut 2 project may someday help astronauts stay healthier in space with the added benefit of assisting paraplegics in walking here on Earth.

NASA and The Florida Institute for Human and Machine Cognition (IHMC) of Pensacola, Fla., with the help of engineers from Oceaneering Space Systems of Houston, have jointly developed a robotic exoskeleton called X1. The 57-pound device is a robot that a human could wear over his or her body either to assist or inhibit movement in leg joints.

In the inhibit mode, the robotic device would be used as an in-space exercise machine to supply resistance against leg movement. The same technology could be used in reverse on the ground, potentially helping some individuals walk for the first time.

NASA's new exoskeleton holds enormous potential for paraplegics.

"Robotics is playing a key role aboard the International Space Station and will continue to be critical as we move toward human exploration of deep space," said Michael Gazarik, director of NASA's Space Technology Program. "What's extraordinary about space technology and our work with projects like Robonaut are the unexpected possibilities space tech spinoffs may have right here on Earth. It's exciting to see a NASA-developed technology that might one day help people with serious ambulatory needs begin to walk again, or even walk for the first time. That's the sort of return on investment NASA is proud to give back to America and the world."

NASA's Game Changing Development Program, part of NASA's Space Technology Program, funds the X1 work. NASA's Space Technology Program focuses on maturing advanced space technologies that may lead to entirely new approaches for space missions and solutions to significant national needs.

IMAGE COURTESY OF ROBERT MARKOWITZ

Rochelle "Shelley" Rea, an engineer with the X1 project, demonstrates the suit.

The IRVE-3 Experience

By Mary Beth Wusk

Photo Credit: Kathy Barnstorff

The drive to Wallops is a very familiar one. Over the past six years I have made this journey so many times I think my car makes the trip on its own. I am in the area for the Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project's IRVE-3 launch, but most people, who are in Chincoteague at this time of year, are there for the annual pony penning. The friendly ladies at the hotel greet me warmly as I join several vacationing families in the lobby for breakfast. The families ask me about our project and I proudly tell them what we plan to achieve. With this explanation comes a mix of excitement and anxiety.

This will be my third launch from Wallops. Each launch I experienced a unique set of challenges. In 2009, we had proved that the concept of inflatable heatshields is a viable option for exploring other worlds. But this time, we are launching twice the amount of payload and trying to achieve heat rates ten times what we experienced during the previous mission.

Project Manager Mary Beth Wusk (above) inside the TDT at NASA Langley.

The day before launch, I arrive at the Mission Control Center and find my way to my console for the dress rehearsal. I see the familiar faces of both Langley and Wallops' team members. We step through the countdown procedure and everyone is confident in his or her calls over the intercom. The video feed from the island launch pad displays the three-staged launch vehicle mounted on the rail as the shed is pulled back and the vehicle is repositioned to the launch inclination. Four other screens give the team views into the payload. These screens will play an important role during the revealing story of the actual IRVE-3 experiment. That is something none of us can really appreciate during the mission rehearsal.

With the rehearsal successfully completed, I meet with the Wallops management to ensure we are all green for launch. I think about all the tests we have done to get to this point starting with the arc jet tests on smaller thermal protection system layups and how the material performed during those tests. I think about the multiple inflatable structures we built and the load tests completed. I think about the system-level ground tests the team completed and the results of those tests. I think back to our last risk meeting where we reviewed every outstanding risk and the mitigations completed to reduce the risk. I think about the last team meeting where the project manager polled the team for readiness of each sub-system. I think about the live feed that is going to distribute the launch to thousands of people as well as the VIPs attending the launch in person. I think about the importance of this launch to the Space Technology Program, since it is the first major milestone being completed since the organization was established. I think about the performance of the team during the rehearsal. I report that the payload is green for launch.

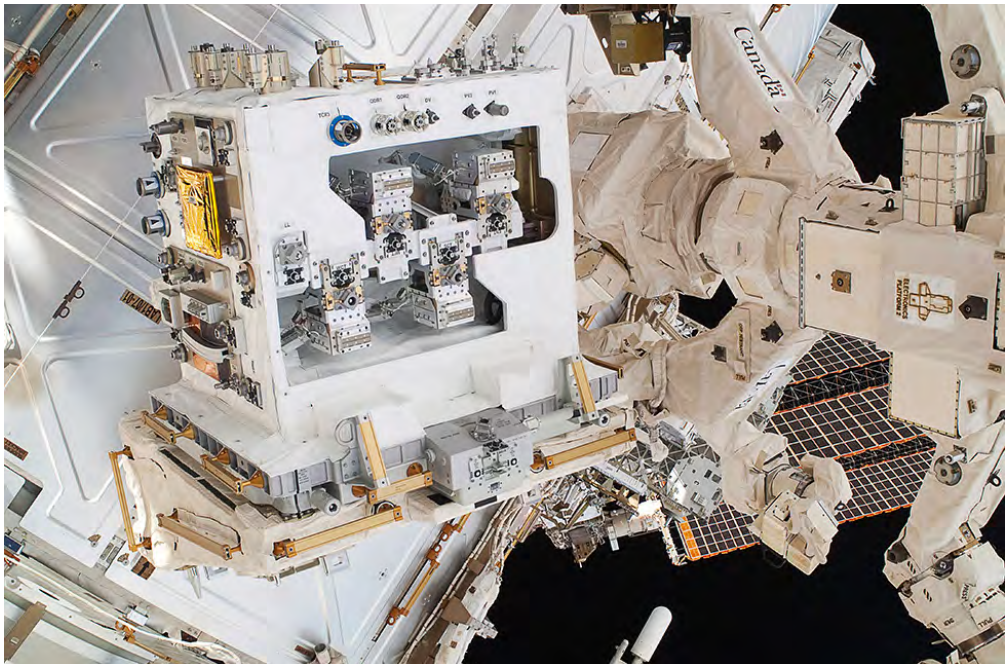
The morning of the launch, the room is buzzing with the anticipation as the count begins just after midnight. The ground stations are active. The recovery boat is in position. The air surveillance team is ready to deploy. The team is relaxed as we step through pages of the count down procedure. We are finally down to the final count. L minus 30 seconds, 20, 10, 5, 4, 3, 2, 1… With Headquarters management sitting next to me at the console, we watch the vehicle ascend 290 miles as planned then begin to descend back to earth.

I monitor the CAD model of the payload that is being driven by flight data telemetered to the control center. Then, the four on-board cameras come alive and the story unfolds. I see the third stage drop away. I see the restraint bag release. I see the inflatable heatshield test article take shape and the payload reorient all as planned. The most spectacular sight is the Earth in the background as the payload completes its journey through the experiment window. The reentry seems effortless for the heatshield as it maintains it shape while experiencing 20 g's during reenty and survives the highest heat pulse every experienced by an inflatable heatshield.

Yes, after three years of the team's hard work and many tests, we were definitely green for launch.

PHOTO CREDIT: NASA/SEAN SMITH

The Inflatable Reentry Vehicle Experiment (IRVE-3) was launched by sounding rocket at 7:01 a.m. Monday, July 23, from NASA's Wallops Flight Facility.



The RRM module installed on its temporary platform on the International Space Station's Dextre robot.

PHOTO CREDIT: NASA

Robots in Space!

The Satellite Servicing Capabilities Office (SSCO) at NASA's Goddard Space Flight Center was established in 2009 to continue NASA's long legacy of satellite servicing and repair. Building upon thirty years' experience servicing assets from Solar Max to the Hubble Space Telescope, SSCO exists to enable the routine servicing of satellites that were not designed with servicing in mind; position the United States to be the global leader in in-space repair, maintenance, and satellite disposal; as well as help to enable a future U.S. industry for the servicing of satellites.

To meet these objectives, SSCO – funded by Space Technology's Game Changing Development Program and the Human Exploration and Operations Mission Directorate – is conducting an aggressive technology campaign." geared towards making robotic servicing missions in geosynchronous Earth orbit (GEO) a reality. America depends on GEO satellites for defense, communication, science, and weather monitoring. These high-cost assets eventually fail or run out of fuel. Refueling and maintaining these costly spacecraft can keep them operating longer in space in the right orbit, giving the nation more value from its initial investment.

Servicing can also help make space more sustainable. Broken and drifting satellites take up valuable GEO real estate and pose a risk to their space neighbors. A multi-capability servicer spacecraft could help mitigate the looming orbital debris problem.

As part of its technology development campaign, SSCO is advancing technologies such as dexterous robotics, autonomous rendezvous and docking systems, hypergolic propellant transfer systems, contact dynamics simulation platforms, and sophisticated tools and grippers. SSCO's Robotic Refueling Mission (RRM), an external International Space Station experiment, is currently demonstrating and testing the tools, technologies, and techniques needed to robotically refuel and repair satellites in space, especially spacecraft that were not designed to be serviced. A joint effort between NASA and the Canadian Space Agency, RRM launched on the last shuttle mission, STS-135.

Satellite servicing technologies are truly cross-cutting, as they offer a suite of capabilities applicable to such diverse missions as assembling an observatory or habitat in space, catching up with an asteroid, or fixing a spacecraft or ground station on a trip to Mars. They are also game changing, as they allow developing missions a considerably larger trade space to make cost-efficient decisions on redundancy, fault tolerance, and mass allocation.

For more information about SSCO, visit their website at http://ssco.gsfc.nasa.gov.

Space Technology In The Community: NASA Partners with Community to Demonstrate Hydrogen Bus

Reprinted from Nancy Smith Kilkenny, SGT Inc.
NASA's Glenn Research Center

What swallows Lake Erie water, motors quietly through the streets of Cleveland, and expels water good enough to drink from its tailpipe? It's a brand new Greater Cleveland Regional Transit Authority (RTA) bus, part of a demonstration of clean, alternative transportation.

NASA's Glenn Research Center is supporting a community-based partnership with RTA, the Cleveland Foundation, the Ohio Aerospace Institute and several technology development companies, to add a hydrogen-fueled demonstration bus to the RTA fleet. It will transport passengers 60-80 miles a day along various routes with emissions of only water and heat, and will be refueled at a station at RTA's Hayden bus garage equipped with technologies developed at Glenn.

"What makes this project unique is that Glenn has installed the first electrolysis-based refueling station in Ohio," says Carolyn Mercer, manager of the Space Power Systems Project. "This means we don't have to transport hydrogen tanks; we make the fuel on site, which is safer and more cost-effective."

The electrolysis unit takes in city water, purifies it via an internal de-ionizing process and uses electricity to split the water into hydrogen and oxygen gases. The generated hydrogen is then stored in tanks ready for use.

Research at Glenn is focused on improving the reliability and efficiency of fuel cells and electrolysis systems. NASA's Space Power System supports the hydrogen bus effort, which is a NASA Space Technology Game Changing Development project. These projects focus

Continued on page 13.

PHOTO CREDIT: NASA

Cleveland's Regional Transit Authority is carrying passengers on a hydrogen fuel cell powered bus along the Euclid Corridor.

The Team Trek Experience

By Aaron Morris

PHOTO CREDIT: TEAM TREK

In early October the Game Changing Program Office braved the brisk fall air and carsick inducing roads that weave through the foothills of the Arkansas Ozarks to attend Team Trek. If one can stomach the motion sickness, the scenery is quite stunning with low rock cliffs, multi-hued leaves of new growth hardwood forests, and deep canyons with cold, blue rivers that pool into world class fishing lakes. Now look, I know what you're thinking and we've had one too many banjo jokes about Arkansas already, so just hold your peace. As a matter of fact, many of my formative childhood years were spent in the Ozarks and I never once saw an overall clad, toothless, banjo player. Never. Not one.

Members of the Game Changing Program Office (above) participated in a weeklong leadership and team building training program.

Team Trek offers custom courses oriented towards team building and leadership development. The owner of the company tailored the course to our particular needs. He was fascinated by the NASA brand and a chance to work directly with high performing engineers. The course consisted of reading assignments given weeks in advance of the trip, classroom lectures while onsite at Team Trek, outdoor team building exercises, and ultimately a team engineering challenge. The lodging was bunkhouse style with rows of bunk beds and shared restrooms. It was comfortable, but I can state with confidence that Steve snores. Night noises notwithstanding, the week at Team Trek was not easy. In fact, the GCD Program Office was up before 6:00 am every day, and we often did not complete our tasks until after 11:00 p.m. It was mentally and physically arduous. The rigor was interrupted once with a stuffed bobcat.

Let's just say that PI Ryan Stephan is frightened of bobcats in the bathroom.

Our first outdoor exercise was called "The Leap of Faith." In short, a rope was fastened to the participant's waist and held by GCD teammates. Then, we were called upon to climb a thirty-foot tall telephone pole and jump off; trusting all the while that our teammates would hold fast to the rope and safely lower us to the ground. Suffice it to say, those of us with any trepidation about heights found this exercise difficult. Ultimately, we all came through with flying colors and met the goal for 100% success. (On a somber side note, SETA Harvey Willenberg experienced a serious health issue during this first exercise. He's all right now and back to work, but he gave us quite a scare. Harvey — we're all glad you're healthy again).

We weren't 100% successful on all of the outdoor exercises. Our penultimate challenge involved a faux nuclear reactor on the brink of a meltdown. It was a communications exercise, which required the participants to communicate with a variety of leadership chains in order to learn how to diffuse the reactor. Ultimately, we failed and millions of people died in this simulation. I shoulder much of the blame, but I haven't lost too much sleep. The instructors told us in confidence after the course that 400 out of 400 teams had failed this exercise. For you Star Trek fans it was a Kobayashi Maru. I should have asked Bob, with his Vulcan-esque Chief Engineer logic, to simply cheat and climb the wall. Alas, maybe next time.

The final challenge was an engineering exercise. With some modesty I can say we knocked it out of the park. The task was to build a raft constructed of rope, fifty-five gallon drums, and assorted lumber. After constructing the raft, we were given a challenge to navigate a slalom course in the cold water in less than five minutes. We were told that the previous record was around four and a half minutes. Our raft design and construction, led by the capable hands of Daryl, was one of the tightest rafts the instructors had witnessed. Not only did our rowing team navigate the slalom in less than five minutes, but also we absolutely shattered the previous record by almost a minute. The number of three minutes and forty-three seconds is embedded in our brains with pride. Our trophy and team picture (left) will be displayed at Team Trek. Please note that it is the second team picture, since shirtless engineers who haven't seen the sun in months don't make an attractive photo. We're a much more photogenic group with our shirts on.

PHOTO CREDIT: GARRY QUALLS

A stuffed bobcat made quite the impact on one PI.

PHOTO CREDIT: GARRY QUALLS

Pete Lillehei (from left), Aaron Morris and Neil Cheatwood look on as a teammate prepares to take a leap.

Ultimately, we learned a lot about leadership and each other. We accomplished difficult, at times seemingly impossible, tasks and shattered records in the process. It was a tough week, but we can look back with fondness now. This is very similar to what we need to do in GCD. Remaking NASA culture is difficult, and on most days it seems impossible. However, I know we can accomplish the impossible together. I know because I've seen our team exhausted on a beach, with our fists raised triumphant, shouting "3:43 baby"!!!

Game Changing People: Jennifer Noble

By Brian Marcolini, LARSS Intern
Reprinted from Researcher News

For some, the impact of their work at NASA can be tense. Jennifer Noble, a space systems engineer, was no exception as she tried to keep things from going awry on a space station 250 miles above Earth.

Noble worked as a space flight trainer and mission controller at NASA's Johnson Space Center (JSC). She taught astronauts how to work both the thermal and electrical systems on the International Space Station and then monitored those systems as a flight controller in the mission control room.

"It was a very rewarding job," Noble said. "You were able to see your work and hard labor into fruition as the astronauts went into orbit and performed their jobs well."

But that sense of reward also came with a great deal of responsibility. Day-to-day life in mission control is constantly full of prospective crisis management situations, never knowing if a problem will arise.

"Everyday life in mission control can be stressful, because things do fail," Noble said. "Any day where there is not a major failure is a good day."

After nearly seven years of training crews, and work in a control room, Noble made the personal choice to add a little more normalcy to her life.

She took a job with NASA Langley's Game Changing Program Office, moving from Houston, the fourth largest city in America, to Virginia's middle peninsula. Such a move might be a culture shock to some, but it was something Noble was used to.

Born to an American father and a German mother, Noble spent the majority of her youth growing up in Colorado. She also spent many summer vacations visiting family in Germany, giving her the opportunity to experience a different culture.

The opportunity not only presented itself in her travels, but also at home, where she learned to speak both German and Spanish fluently.

These early lessons sparked her passion for language and inspired Noble to study new dialects. She took four years of Russian while at NASA Johnson, to better communicate with the Russian cosmonauts who she was training in Houston.

PHOTO CREDIT: NASA/SEAN SMITH

Jennifer Noble from NASA Langley's Game Changing Program Office is currently working on next generation electric propulsion vehicles, a technology used to ferry humans into deep space.

"[Taking Russian] wasn't a requirement, but I've always loved languages and Russian seemed very interesting," Noble said.

Her study of the language proved not only interesting, but also necessary in order to easily communicate with her Russian counterparts in the space industry.

Noble has not only been able to work with different people from different nations, but also different localities. After graduating from the University of Colorado Boulder she took a job in California, and from there moved to Houston.

"Growing up in Colorado, there are two states that you don't like the most: California and Texas," Noble said jokingly. "But every time you get used to a new place."

And again, she is getting used to a new place and a new job. Although she is still working within the space industry, she now goes out into the field to investigate new technologies.

Her team then takes on new technologies, developing and passing them on in order to be sent into space. Currently, she is working on next generation solar electric propulsion vehicles, a technology used to ferry humans into deep space.

Noble relishes the opportunities that NASA Langley provides her, and she hopes to become a leader within the organization. What she really enjoys, however, is the chance to step foot outside training an d mission control and gain a broader understanding of NASA's work.

Working at Langley has given Noble a new form of responsibility – one that deals with developing new technologies here on Earth.

New Faces

Ron Litchford

arrived in August to serve as a Principal Investigator in the Game Changing Development Program. His domains of technical expertise include launch and spacecraft vehicle systems, science instruments and sensors, and advanced propulsion technologies.

Amy McCluskey

joined Game Changing in July as the new communications manager. Ms. McCluskey previously worked as a public affairs specialist at NASA Langley Research Center.

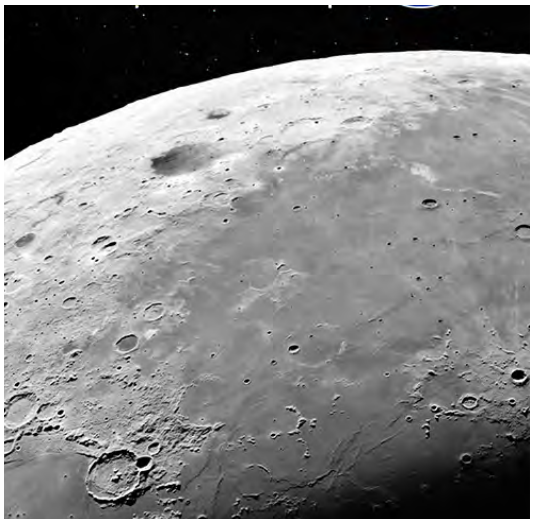
Parth Punjabi

started working at GCD in May of 2012 as SETA support. His role in the organization is to support program office activities for leadership. Parth is currently a PhD student in the school of business at Hampton University.

LaNetra Tate

is Game Changing's new PI for Manufacturing Innovation Projects. Tate previously worked at NASA's Kennedy Space Center as a materials engineer.

Game Changing Engineering Challenge!



U.S. college student teams are invited to design a thermal control system for a manned space station in low lunar orbit. Designs must accommodate a six-person crew, maintain acceptable temperatures for avionics components, and provide a healthy environment for the crew. The contest is open to student teams enrolled at institutions in the United States or its territories. A notice of intent is due Jan. 15, 2013. Final entries are due on April 29, 2013.

Hydrogen Bus

Continued from page 9.

on innovative work that not only changes the way we operate in space but can also change the way we do things here on Earth.

Hydrogen sensors incorporated into the refueling station are spinoffs from NASA research for space launch systems. Makel Engineering, working with Glenn, has commercialized these miniature, high-tech hydrogen gas sensors to detect leaks. Now exposed to Cleveland weather year around, these technologies, originally developed for space and aeronautics, will demonstrate applications in everyday life.

Hitting Our Marks: Composite Cryotank Project Delivers Major Milestone

PHOTO CREDIT: NASA

The largest out-of-autoclave composite cryogenic tank produced to date arrives at NASA Marshall.

"With the arrival of the CCTD 2.4m tank at NASA Marshall, we draw a technology line in the sand that irrevocably changes the way we do business for NASA. Cryogenic propellants will be made out-of-autoclave, and this will significantly reduce manufacturing costs. This will have a 'game changing' effect throughout the aerospace industry."
—Steve Gaddis

A 2.4-meter-diameter propellant tank made of composite materials arrived on Nov. 20, 2012 at NASA's Marshall Space Flight Center in Huntsville, Ala., where engineers are preparing it for testing. Composite tanks have the potential to significantly reduce the cost and weight for heavy-lift launch vehicles and for other future in-space missions. The tank's arrival marks a significant milestone that was made possible because of contributions made over the last year by multiple NASA centers and The Boeing Company, the prime contractor for the project. This is the largest composite tank ever produced with new materials that do not require autoclave processing. Complex autoclaves for processing large composite structures are high-pressure furnaces. Boeing used a novel automated fiber placement technique to manufacture the tank in Tukwila, Washington. Marshall is leading the Composite Cryotank Technologies and Demonstration project with support from NASA's Glenn Research Center in Cleveland; NASA's Langley Research Center in Hampton, Va.; and NASA's Kennedy Space Center in Florida through funding provided by the NASA Space Technology's Game Changing Development program.

Public Outreach

The Game Changing Development Program took its outreach component to a new level in 2012 with projects attending a myriad of events, all designed to educate the public about space technology. New exhibits emerged and entirely new subsets of the general public, including science school students in Los Angeles, Calif., learned what NASA is doing to further technology development.

The IRVE-3 team spoke with Girl Scouts about NASA and new inflatable heat shield technology.

Public Outreach

Steve Gaddis and Mary Beth Wusk welcome congressional staffers from Washington D.C. on Aug. 23.

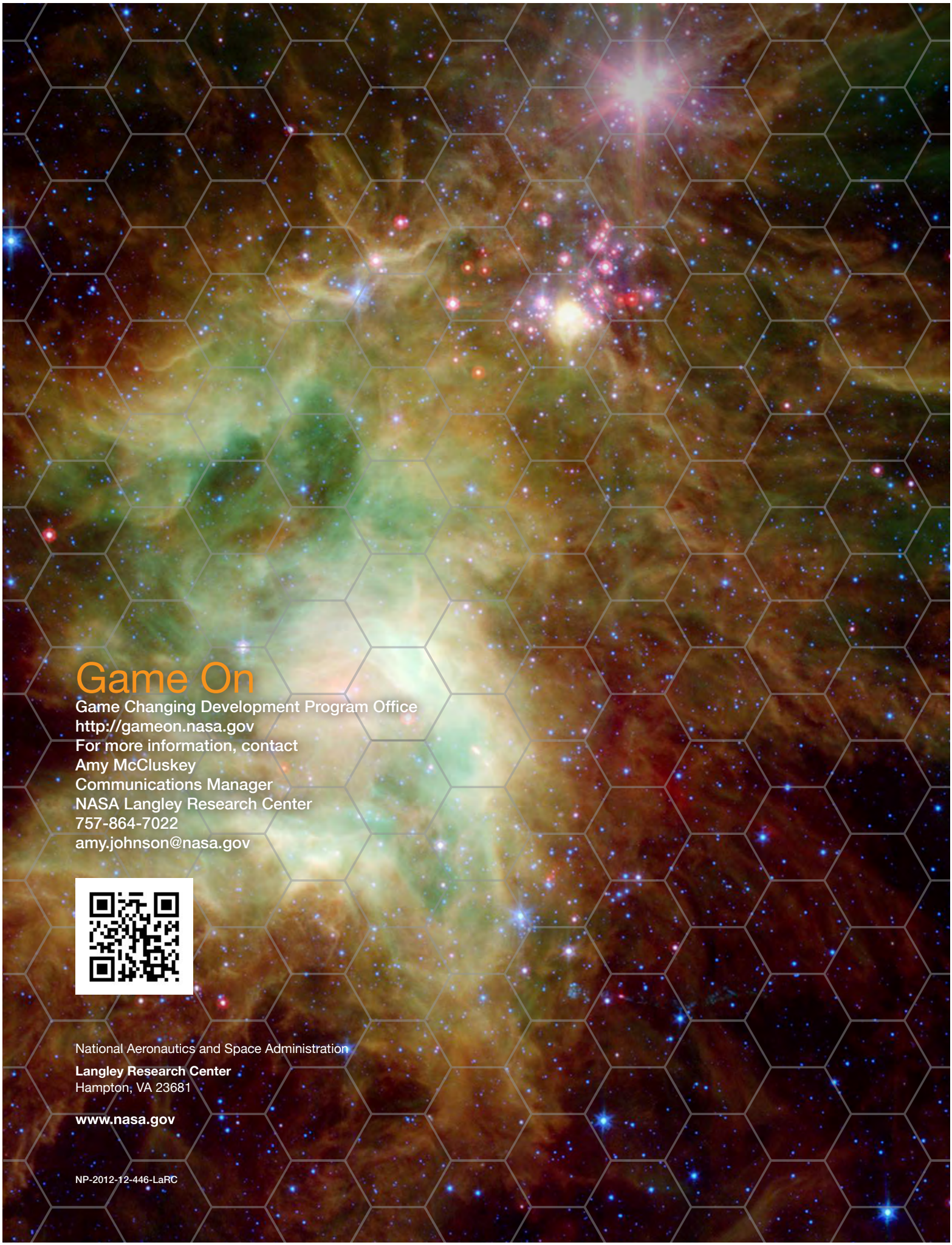
Mairead Stackpoole of NASA Ames explains the history of thermal protection systems, from shuttle tiles to a Woven TPS at SpaceFest.

Carolyn Mercer explains the new 3D Fuel Cell exhibit to Steve Gaddis at NASA Technology Days, held Nov. 28-30 in Cleveland, Ohio.

Composite Cryogenic Tank Demonstration project members Justin Jackson and Lynn Machame at NASA Marshall Space Flight Center's Innovation & Technology Day held Sept. 12.

Neil Cheatwood talks about the IRVE-3 project at SpaceFest, part of the grand opening activities for Space Shuttle Endeavour at the California Science Center at Exposition Park in Los Angeles, Oct. 30-Nov. 4.

PE Tibor Balint gives an overview of the Game Changing Development Program at NASA Technology Days.



Game On

Game Changing Development Program Office
http://gameon.nasa.gov
For more information, contact
Amy McCluskey
Communications Manager
NASA Langley Research Center
757-864-7022
amy.johnson@nasa.gov

National Aeronautics and Space Administration

Langley Research Center
Hampton, VA 23681

www.nasa.gov

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