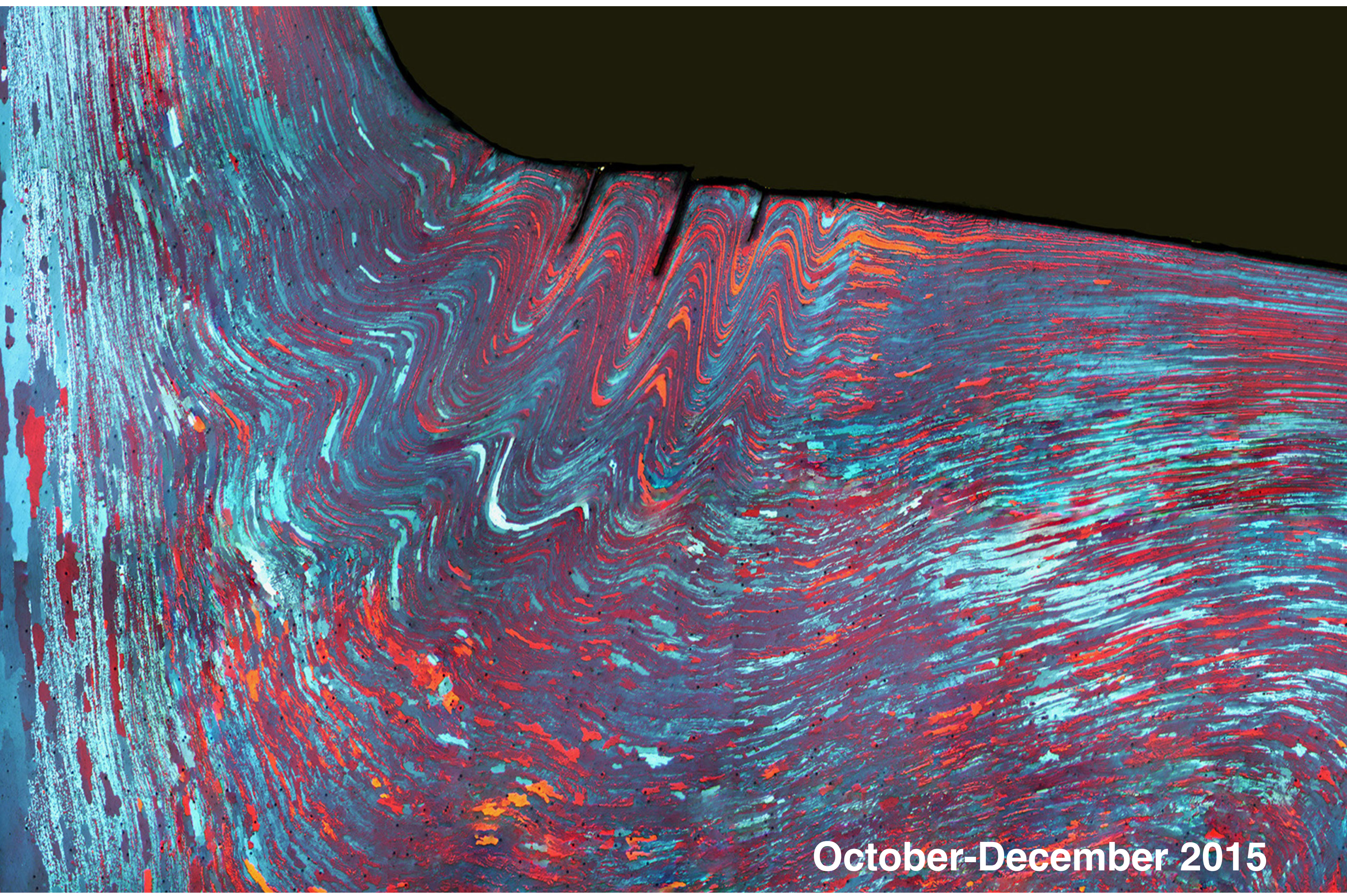
National Aeronautics and Space Administration

Space Technology

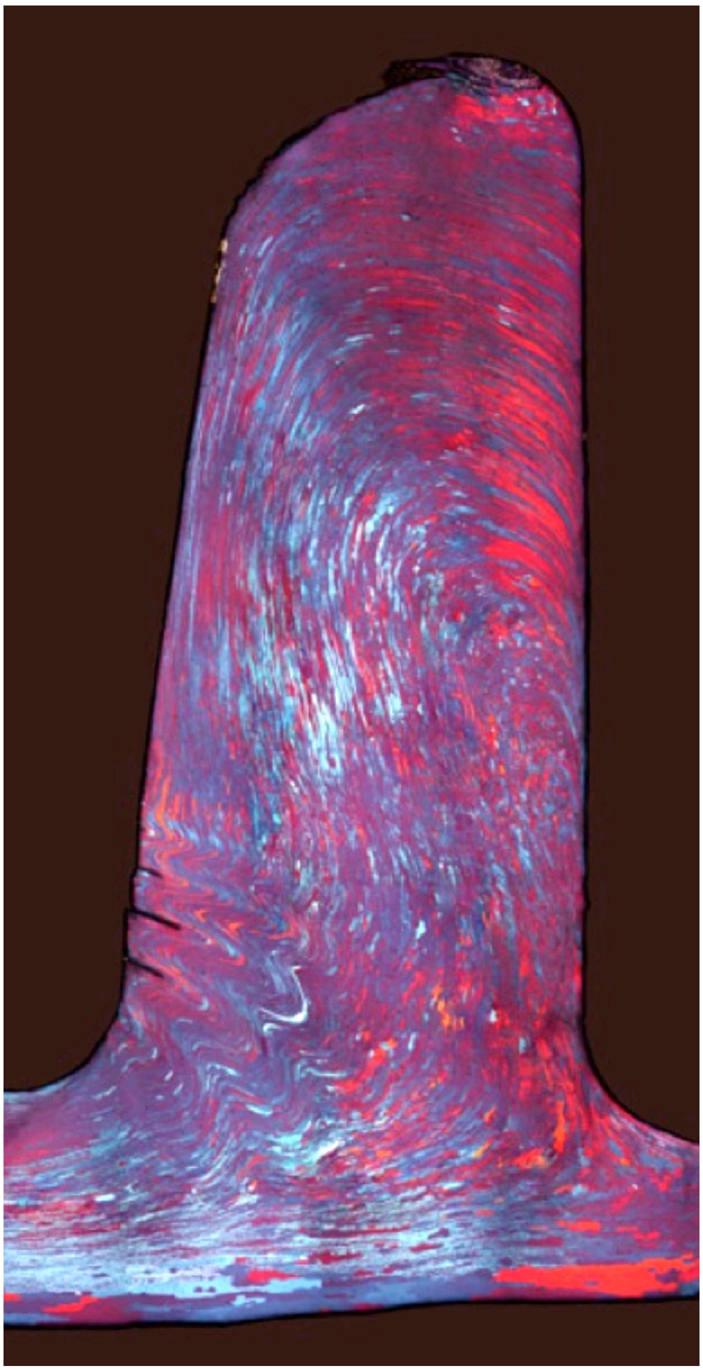
Game Changing Development Highlights



October-December 2015

Additive manufacturing processes advantageous to multiple projects
Packing HIAD's 'chute'
Robotics and robots: award-winning technologies
Game Changing's first BIG Idea Challenge

ANNST Project Image Selected for the 2016 Buehler Microstructure Calendar



An optical micrograph prepared in NASA Langley Research Center's Light Alloy Lab was selected for the 2016 Buehler Calendar. The image is from the Integrally Stiffened Cylinder (ISC) process development being performed in the Advanced Near Net Shape Technology (ANNST) project element, funded by the Game Changing Development Program. The competition was open to all of Buehler's worldwide customers, and only 12 images were selected. This is the second year in a row that an image taken in the Light Alloy Lab is being published.

The Buehler Microstructure Calendar contest is a recognized forum for excellence in a unique area of technical expertise and is open to anyone who has achieved a level of excellence in materials preparation. Submission composition is of microstructural details or hardness indents of any metallic, nonmetallic, geological, or biorelated materials obtained through a light optical microscope or hardness tester.

The stitched image, entitled "Integral Stiffener in a Flow Formed Al-Li Alloy 2195 Cylinder," employed electrolytic etching and cross-polarized illumination techniques and was submitted by Stephen J. Hales, Harold 'Clay' Claytor (AMA, Inc.) and Marcia S. Domack, all with the Research Directorate's Advanced Materials and Processing Branch. Domack, who specializes in aerospace metallic materials, describes the composition:

"This image is a metallurgical section through a stiffener of a subscale cylinder fabricated using the integrally stiffened cylinder process that we are developing in our ANNST project element. The image shows the grain structure associated with flow of material into grooves on the forming mandrel. The colors reflect texture with grains of similar color having the same crystallographic orientation."

Left: Submitted image.
Cover: Image as it appeared in the 2016 Buehler Calendar.
Back cover: Also captured in Langley's Light Alloy Lab, and published as Buehler's April 2015 calendar image, was Brandon Saller, Clay Claytor, and Stephen Hales' photomicrographic of abnormal grain growth in a double-pass friction stir weld in Al-Li alloy 2195 plate with polarized light.

Above: ACME's contour-crafted, Martian simulant concrete subscale walls completed. Straight wall (inset) is 3 feet long, 2.25 inches thick, and 1 foot high; curved wall is 56 inches long and 9 inches high with a curvature radius of 18 inches.

ACME Scales Capabilities for Martian Applications

—Denise M. Stefula

Extending the human presence into deep space requires the advancement of many existing Earth-based technologies.

Game Changing's Additive Construction with Mobile Emplacement (ACME) project based out of NASA's Marshall Space Flight Center (MSFC) in Huntsville, Ala., is doing just that by maturing the technology readiness of Contour Crafting—an additive construction process that uses concrete to build walls.

ACME Project Manager Jennifer Edmunson believes the advancement of Contour Crafting technology holds great promise as a feasible approach for building full-scale structures and habitats on Mars or other planets.

"This technology could allow NASA to build roads, berms, garages, and habitats by launching little to no building materials except the ACME system itself. The combined cost savings through the reduction in up-mass and the capability to print multiple types of structures using a single piece of hardware will be truly game changing for NASA," says Edmunson.

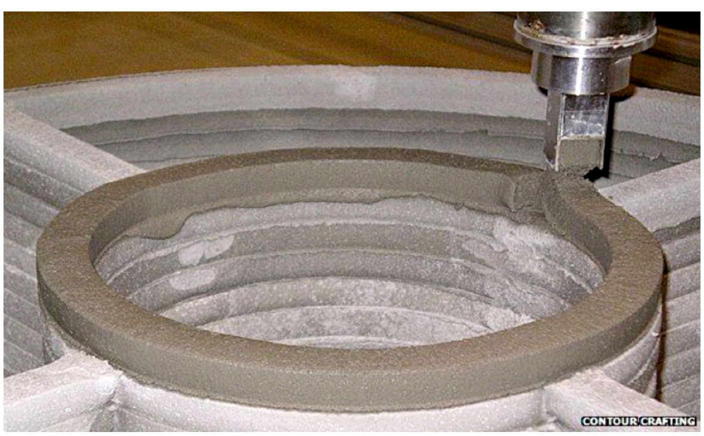
The ACME project element reached two technical milestones during the fall of 2015 during its demonstrations to additively construct straight and curved subscale wall segments using regolith simulant materials. On September 25, the "martian simulant" concrete straight wall was completed followed by the curved wall segment on November 4.

"These tests are important because they provide lessons learned for geometry of additively constructed structures," says John Fikes, deputy project manager for AMT. In the most recent ACME project update, Fikes provides an example from the curved wall demonstration: "The wall developed numerous cracks on the convex surface. This indicates the extrusion rate of the Contour Crafting machine needs to be adjustable to accommodate curves in structure, or that limits must be applied to the radius of curvature to mitigate cracking."

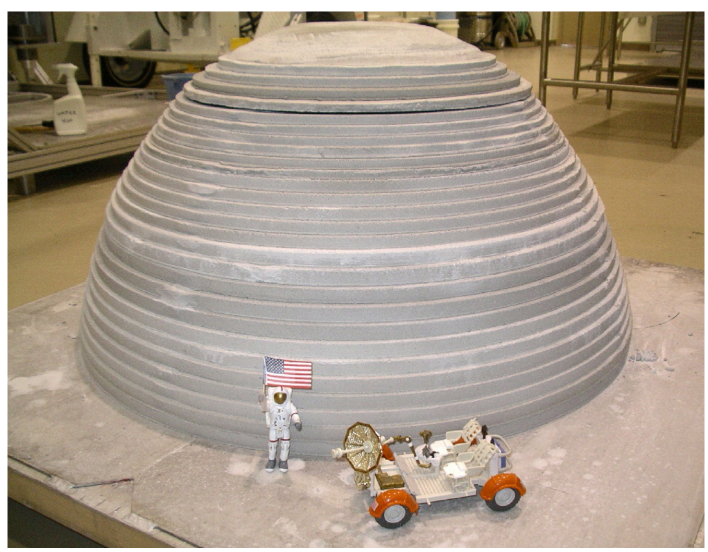
In this first phase of the project's additive construction development, the ACME team employed current Contour Crafting capabilities using an extrudable mixture of martian regolith simulant (a nontraditional aggregate) and Portland cement to construct the subscale walls. Both the materials and structures will be evaluated for architectural strength and damage resistance, radiation protection potential, and reaction to the extreme temperature swings typical of lunar or martian surfaces. Edmunson says they will also look at how cements cure in the temperatures and pressures of other atmospheric environments.

Behrokh Khoshnevis *is a Dean's Professor of Industrial and Systems Engineering, Aerospace and Mechanical Engineering, Astronautics Engineering, Biomedical Engineering, and Civil and Environmental Engineering at University of Southern California and is the Director of the Center for Rapid Automated Fabrication Technologies (CRAFT). An inductee of the National Academy of Inventors, he is active in robotics, and mechatronics related research and development projects that include the development of novel additive manufacturing (3D Printing) processes such as Contour Crafting.*

Invented by Dr. Behrokh Khoshnevis of the University of Southern California, Contour Crafting was originally conceived as a method to construct molds from materials such as polyethylene for creating industrial parts. Khoshnevis saw excellent potential in the method to handle construction



Close-ups of subscale concrete dome under construction (above) using Contour Crafting method, then completed (right), at MSFC Additive Construction Research and Development Laboratory.
Image credits: Contour Crafting.

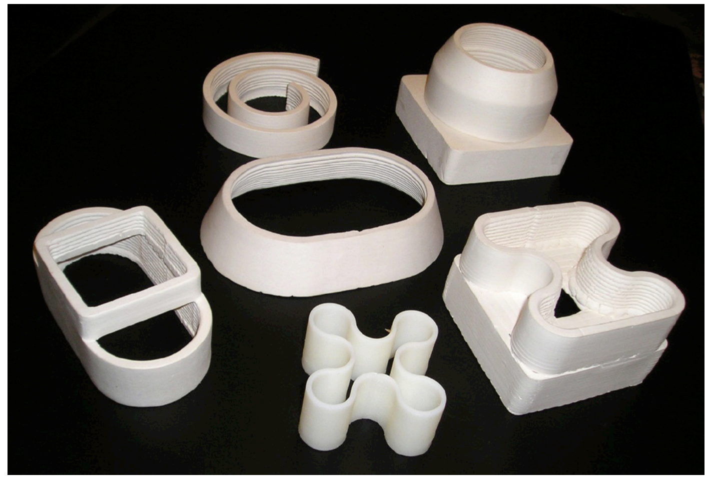


material and created a larger machine that can operate using concrete and can make walls. ACME is using a version of the larger machine at MSFC's Additive Construction Research and Development Laboratory for the demonstrations.

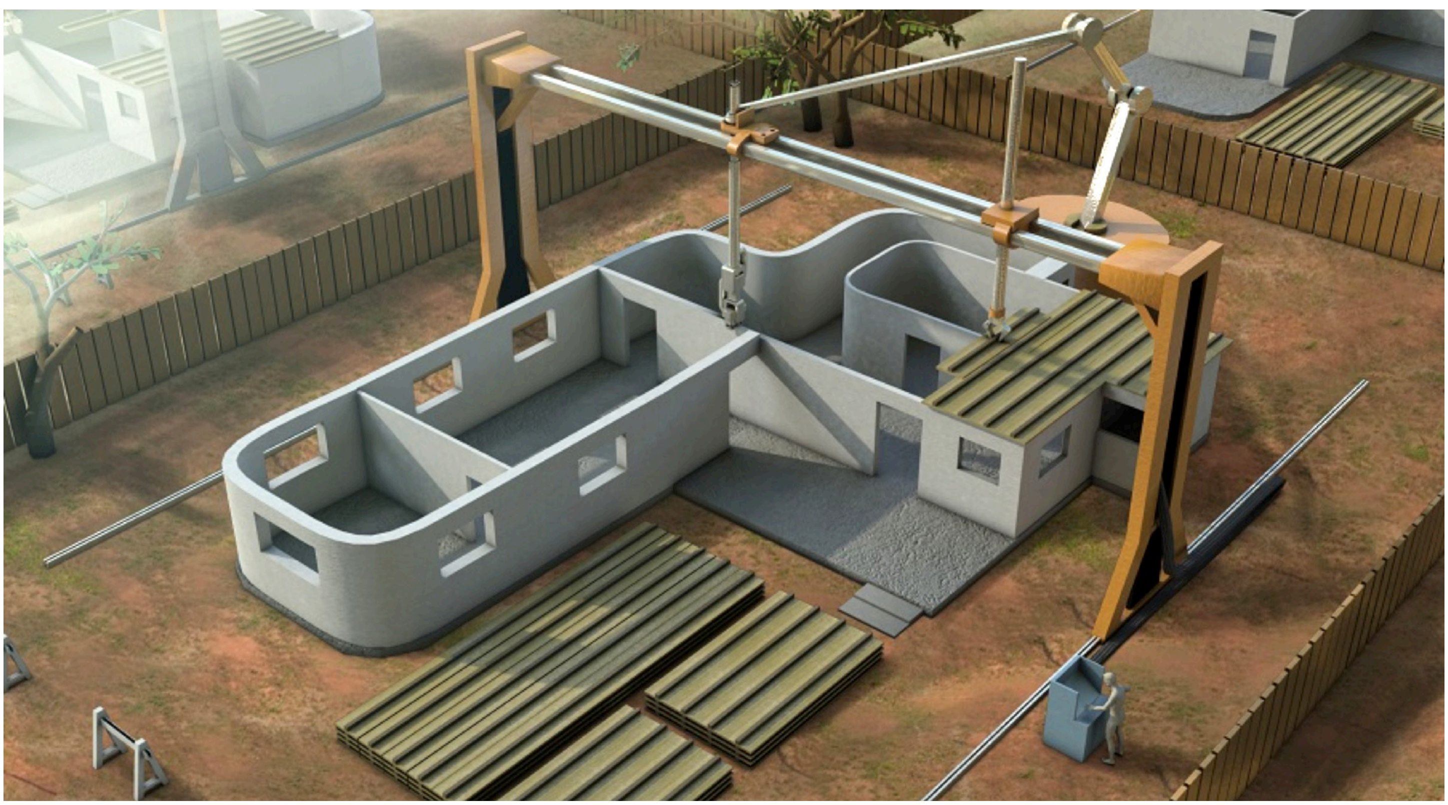
NASA and the U.S. Army Corps of Engineers are working with Contour Crafting Corporation so the technology will have benefits in space and on Earth. In a March 2015 interview with 3DPrint.com, Dr. Khoshnevis shared that much of recent progress in advancing the technology is a result of the partnership.

"We have managed to demonstrate the viability of variations of the technology for lunar and martian applications," says Khoshnevis. "It is not impossible to see the technology being deployed on the Moon in 10 years."

This technology will reduce launch mass and allow for manufacturing of full-scale structures in situ. The potential structures may include planetary surface infrastructure such as landing pads, roads, blast walls and hangars, along with homes or other buildings and fabrications necessary for colonization.



Molded industrial pieces from Contour Crafting.
Image credit: Contour Crafting.



Contour Crafting is the first and only large-scale 3D printing technology that can rapidly construct complete buildings. Artist concept image courtesy of Contour Crafting.

NASA's Latest Rocket Nozzle Technology Makes the Rounds

—Denise M. Stefula

Without even leaving the launch pad, NASA's latest innovation in rocket nozzle technologies has already traveled many a mile.

On December 9, 2015, a team at Langley Research Center completed the application of a nickel jacket onto the first functionally graded rocket nozzle demonstrator, and advanced the Electron Beam Freeform Fabrication (EBF3) manufacturing technology, under the Game Changing Development Program's Low Cost Upper Stage Propulsion project. Building this new rocket concept culminated from 18 months of development work—across multiple NASA centers—using a combination of additive manufacturing processes.

Above: The Low Cost Upper Stage Propulsion project's rocket nozzle demonstrator on Langley's EBF3 machine after the first jacket application.

"This is the first time EBF3 application of a nickel alloy jacket on copper alloy has been attempted," says Tony Kim, LCUSP task manager at Marshall Space Flight Center. "This provides a valid option in NASA's tool belt for fabrication of rocket engine combustion chambers that can be cost effective and time saving compared with other conventional fabrication methods."

EBF3 advances the state of the art in freeform fabrication with its ability to build complex components with internal structure, previously unobtainable through traditional machining operations, and its components have mechanical properties and quality exceeding that of castings. Significant cost and resource savings are realized because EBF3 uses less raw materials, energy, cutting fluids and lead time.

"The technology has potential to help industry with reducing development time and cost for rocket components that require the heat transfer qualities of copper and strength of nickel alloys," says Karen Taminger, a materials research engineer at Langley Research Center.

The inner liner of the rocket nozzle demonstrator was built in a commercial selective laser melting machine at Marshall Space Flight Center and has internal cooling passages using a high strength, high conductivity, copper-based alloy developed at Glenn Research Center. The copper alloy, referred to as GRCop-84, has a good combination of increased thermal and mechanical properties, making it well-suited for rocket thrust chambers. The nickel alloy used in this demonstration, Iconel 625, is one of a wide range of metals possible for use depending upon output need.

After the inner liner was built, the rocket nozzle traveled to Glenn where it underwent hot isostatic pressing, a form of heat treatment using high pressure to improve material properties and workability. GRCop-84 is described by researchers as having excellent workability and can be readily fabricated into complex components using conventional metallurgy processes.

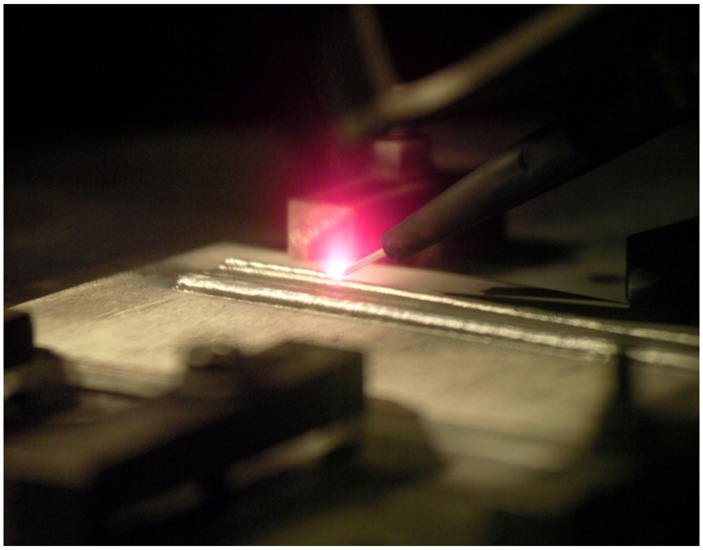
The nozzle's next stop was Langley Research Center where it was fitted with a structural jacket, manifolds, and flanges using the EBF3 process. EBF3 uses an electron beam gun, a dual wire feed, and computer controls to manufacture metallic structures for building parts or tools, and does so in hours rather than days or weeks.

The effort represents several technological firsts at NASA:

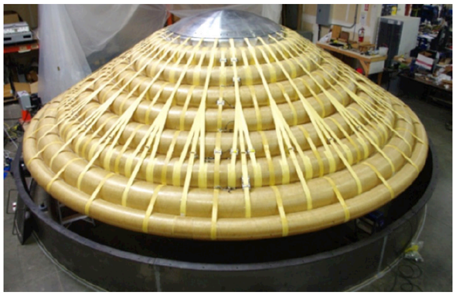
1. *Using a combination of commercial and developmental additive manufacturing processes to produce a large, complex component*
2. *First functional part built using graded metals that transition from copper (for thermal conductivity) to nickel (for structural strength)*
3. *Largest part ever built on Langley's EBF3 machine*
4. *Demonstration of deposition of major structural components directly onto a complex geometry (rather than building the entire part up on a flat plate)*

From Langley, the part will be shipped back to Glenn for more heat treatment, then to Marshall for final machining. Researchers are excited about future possibilities for GRCop-84 and that its fabrication methods require no special techniques; the alloy can be manufactured in a variety of shapes and the process can be easily scaled to produce large components.

"This has been a great team effort across the Centers, one that overcame many technical challenges to get to this point," says John Vickers, Advanced Manufacturing Technologies project manager at Marshall. "The fabrication method had advantages over other methods as well potential disadvantages that need to be evaluated, and that is what this technology effort is addressing. Right now we are working toward a hot fire test later this year."



EBF3 works in a vacuum chamber, where an electron beam is focused on a constantly feeding source of metal wire, which is melted and applied by drawing one layer at a time on a computer-controlled positioning table until the part is complete. By controlling the raster pattern, the e-beam selectively heats the outer edges of the wire if it strays from the melt zone. With such selective heating, the wire automatically curls away from the high heat outer edge and back into the region of the molten pool. (technology.nasa.gov/patent/LAR-TOPS-164)



Inflatable structure before testing.

F-TPS integrated over inflatable structure.

Preliminary lifting and folding.

Initial packing to required shape.

HIAD-2 Packs Up Technology Gap

—Denise M. Stefula

A race car's drag chute knows only two things: speed and weight.

Having the right-sized chute for a race car's speed and weight is easily determined mathematically. Having the chute packed correctly and ready to go when needed? Well, practice makes perfect: How does the tether attach to the car? How does the packed chute bag attach to the pack mount? Which corner gets folded in first?

More importantly, how does one pack that chute for the next quarter mile pass?

Race teams establish meticulous methods for packing drag chutes and oftentimes superstitiously allow only one team member to do so. There's a certain touch to getting the fold just right so the chute will deploy efficiently without the straps snarling and reducing the parachute's capability to slow the vehicle.

As with the race car, speed, weight and proper packing are important to the Hypersonic Inflatable Aerodynamic Decelerator-2 project, or HIAD-2. But the HIAD's 'chute' is hardly as simple or small as what you will see deployed at the race track. It is made up of a large, complicated inflatable structure requiring a flexible thermal protection system (F-TPS) to insulate against the extreme heat during atmospheric entry, on top of being sized appropriately to control the vehicle's speed and weight.

And for that reason, without question, packing the HIAD's inflatable aeroshell structure must be a well-tuned procedure, one with just the right touch.

Earlier this year, the HIAD-2 team reengaged its aeroshell pack and deployment testing to get to that 'right touch' by achieving higher pack density and improve on processes.

The latest demonstrations of a pack and deployment larger in scale than the IRVE-3 article follows on from preliminary pack studies using the 6-m article initiated during the HIAD project's final year. When these studies weren't

Installation of restraint bag.

Placing article into packing fixture.

Restraint bag removal after packing.

completed at the project's closeout, a critical technology gap remained. Lessons learned from the previous year's packing efforts were applied to the HIAD-2 tests as the team picked back up to obtain a greater understanding of packing methods and procedures for future large scale systems.

"HIADs provide the capability to deliver larger payloads to Mars and other planetary bodies than current rigid heat shield and parachute entry and descent systems. HIADs can be readily integrated with existing launch vehicle mass and volume constraints," says Keith Johnson, HIAD project IS lead with NASA Langley Research Center's Atmospheric Flight Entry Systems Branch, Engineering Directorate.

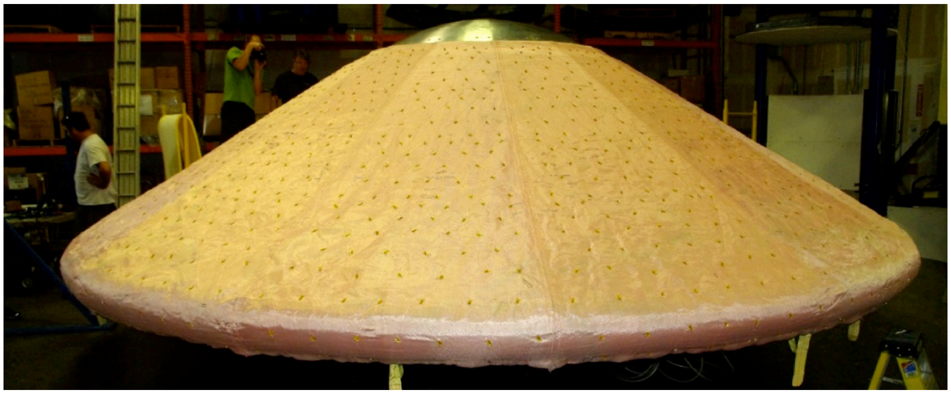
To help fill that technology gap, research included developing aeroshell packing procedures, identifying pack volume and density metrics, and establishing relevant design margins. As the size of an aeroshell is increased, as is necessary for deployment during missions to distant planets, so too does the technical complexity of packing the article. Packing studies on an intermediate sized article is an effective approach to better understanding what packing larger scale aeroshell articles entails.

Performed at Airborne Systems facility in Lake Elsinore, California, the most recent test performed second and third pack and deploy cycles to achieve higher pack densities. Second pack tests achieved the specified density of 20 lb/ft^3. With the third pack test, the density was increased to 24 lb/ft^3 to demonstrate an upper limit for this particular HIAD design and packing volume geometry.

With the large size of this article, the test team needed to address new challenges for lifting and handling the cumbersome fabric structure. New procedures and handling equipment were developed to fold and shape the materials to fit within the restraint bag. For final packing operations, a large compression fixture with a hydraulic actuator was designed and fabricated. To reach the desired pack densities, a combination of vacuum and compressions loads were used. After each pack, the article was deployed and inflated to inspect for leaks and damage.

"The results of these pack and deploy tests provided a significant gain in experience and lessons learned that can be applied to future HIAD system design and integration with launch vehicle constraints. The HIAD materials survived the packing with minimum damage," says Johnson. "All of the unique construction features—such as stitching in the F-TPS layer and attachments between the IS and F-TPS—sustained the three pack and deploy cycles with no damage. Improvements in folding and packing methods and installation of a restraint bag were demonstrated."

The 6-m packing tests provided significant insight into the handling equipment, compressions and vacuum packing equipment, and packing procedures required for larger scale HIADs. HIAD-2 will use the experiences gained for design and development of 10- to 15-m diameter HIADs.

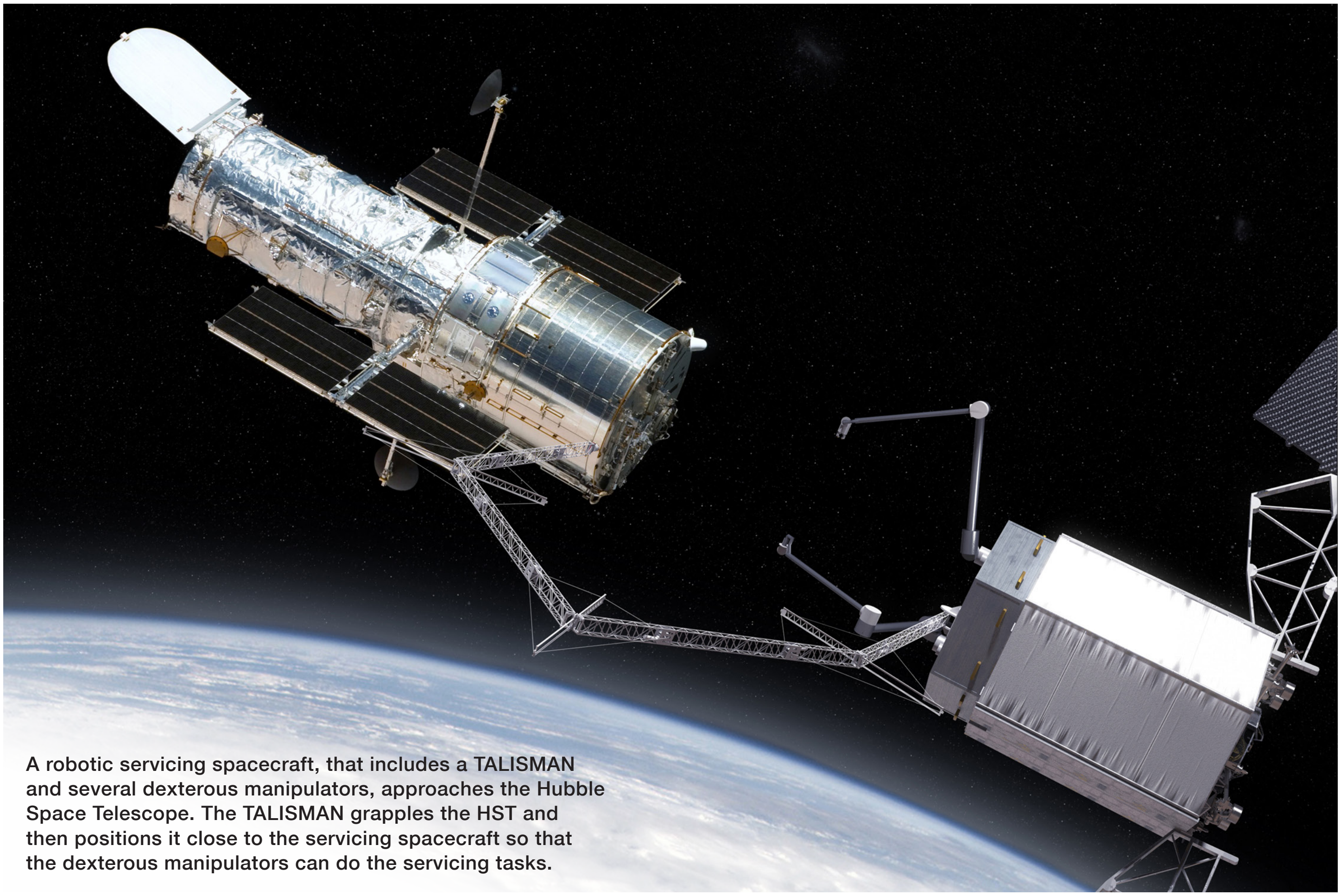


Fully inflated article for post-test inspections.

Article with restraint bag removed.

Beginning of inflation.

Partially inflated article.



A robotic servicing spacecraft, that includes a TALISMAN and several dexterous manipulators, approaches the Hubble Space Telescope. The TALISMAN grapples the HST and then positions it close to the servicing spacecraft so that the dexterous manipulators can do the servicing tasks.

HRS Project Takes Hefty Prize for Lightweight Robotic Arm

—Denise M. Stefula

Typical academic robotics competitions have participants designing, building and programming robots to perform tasks. The competitions culminate into remarkable examples of engineering, creativity, and teamwork—providing experiences similar to that expected in a future professional career.

For NASA researchers and industry professionals already working with high-stakes robotics technologies, competitions operate at a completely different level.

The Human Robotics Systems (HRS) team at NASA's Langley Research Center (LaRC) was awarded first place for "outstanding design and engineering innovation" in September 2015 for its tendon-actuated, long-reach manipulator. The LaRC team received the Tech Briefs Media Group's Create the Future Design Contest 2015 honor in the Machinery/Automation/Robotics category, which recognizes the best in innovative products that speed, improve, and/or automate work, manufacturing, and research and development.

The highly versatile Tendon-Actuated Lightweight In-Space MANipulator (TALISMAN) technology, which was patented on October 27, 2015, is one of NASA's latest innovations in robotic architectures. TALISMAN is being developed for space operations such as satellite servicing, space observatory assembly, and payload delivery as well as asteroid retrieval, redirection or mining. This new technology greatly improves the state-of-the-art in space manipulators by increasing capabilities to extend reach, reduce mass, apply force, and package efficiently.

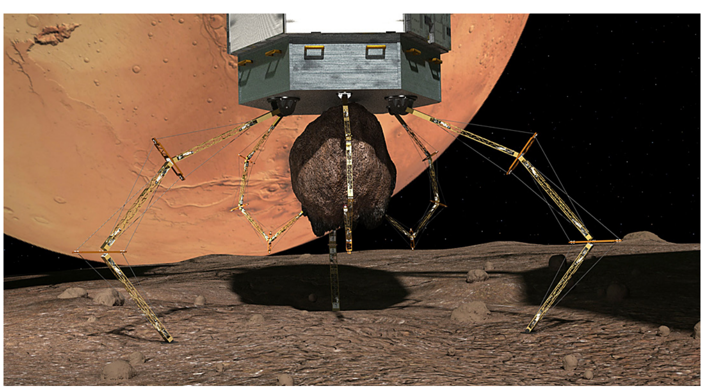
"Winning the award is an honor for our team," says Bill Doggett, a senior research engineer with LaRC, who accepted the team award. "The award and subsequent national recognition are crucial to introducing our technology to a wide audience. Developing the TALISMAN technology was a team effort that sprang from the desire to continue enabling long-reach robots to operate in the space environment."

Retiring the space shuttle fleet resulted in the Shuttle Remote Manipulator System (SRMS) being removed from consideration for new in-space missions, thus creating a capability gap. Recognizing this gap, the long-reach TALISMAN was developed as a part of HRS's asteroid capture technology element within the Game Changing Development Program, which focused on advancing robotic capabilities for capturing asteroids.

Pictured with representatives of contest-sponsoring organizations are John Dorsey (far left) and Bill Doggett (holding plaque) accepting the Create the Future Design Contest 2015 plaque during the awards ceremony in New York City on November 6, 2015. The award included HP Work Stations for all team participants. Image credit: Ellen Dubin Photography.

Though similar in performance to the SRMS, the TALISMAN weighs less, has a longer reach, and is more efficient. TALISMAN has articulating booms connected by active tension elements and a design architecture that efficiently distributes forces within the arm. This increases structural strength and the manipulator's capability to be scaled over a large range. It includes tendon-articulated joints that allow for much smaller and more energy efficient motor systems compared with existing arms using weighty gearboxes and motors. The joints also rotate 360 degrees.

"The TALISMAN architecture incorporates a combination of structural advancements to achieve game-changing performance," explains Doggett. "The improved mechanical advantage for the motors, in turn, reduces the size and power requirements for the motor and gear train."



This graphic shows the Asteroid Redirect Mission concept B with TALISMAN landing legs and grapple arms. The boulder has been plucked from the surface and positioned against the spacecraft and the landing legs are beginning to articulate and push the spacecraft off of the Phobos surface.

Under HRS, TALISMAN-based capture systems were designed and sized to meet with concept needs of NASA's Asteroid Redirect Mission (ARM). The technology's versatility easily allowed landing legs and grapple arms to be designed and incorporated into ARM's "concept B" spacecraft at a very low total mass—only 150.0 to 164.1 kg depending on grapple arm reach. Length, dexterity and structural performance of the TALISMAN-based landing legs and grapple arms are easily updated to accommodate evolving requirements of the mission.

"A first-generation remote manipulator system-class (50-foot) TALISMAN prototype, designed for satellite servicing, has been fabricated and is currently undergoing operational testing," says John Dorsey, Langley's TALISMAN lead.

The hardware design deploys efficiently and can reconfigure dynamically to enable specific maneuvers within a prescribed operation. The prototype's hardware system has been fabricated and is undergoing testing in a new facility at LaRC that has a large enough area in which to simulate operations.

In 2016 TALISMAN advances from the Game Changing Development Program and will continue to be developed in a two-year collaboration with Orbital/ATK, where the technology will be matured, culminating in development of a fully functional protoflight model.

Rocket Launch Demonstrates New Capability for Testing Technologies

UP Aerospace SpaceLoft's sounding rocket soared into the sky Nov. 6 from Spaceport America, New Mexico, carrying four technology experiments for NASA's Flight Opportunities Program that funded the launch of these technologies.

The commercial suborbital space rocket reached a maximum altitude of approximately 75 miles. The experiments were recovered intact 30 miles downrange on the U.S. Army White Sands Missile Range. UP has launched several times from Spaceport but this was the first launch where payloads were ejected separately requiring independent re-entry under individual parachutes into the atmosphere.

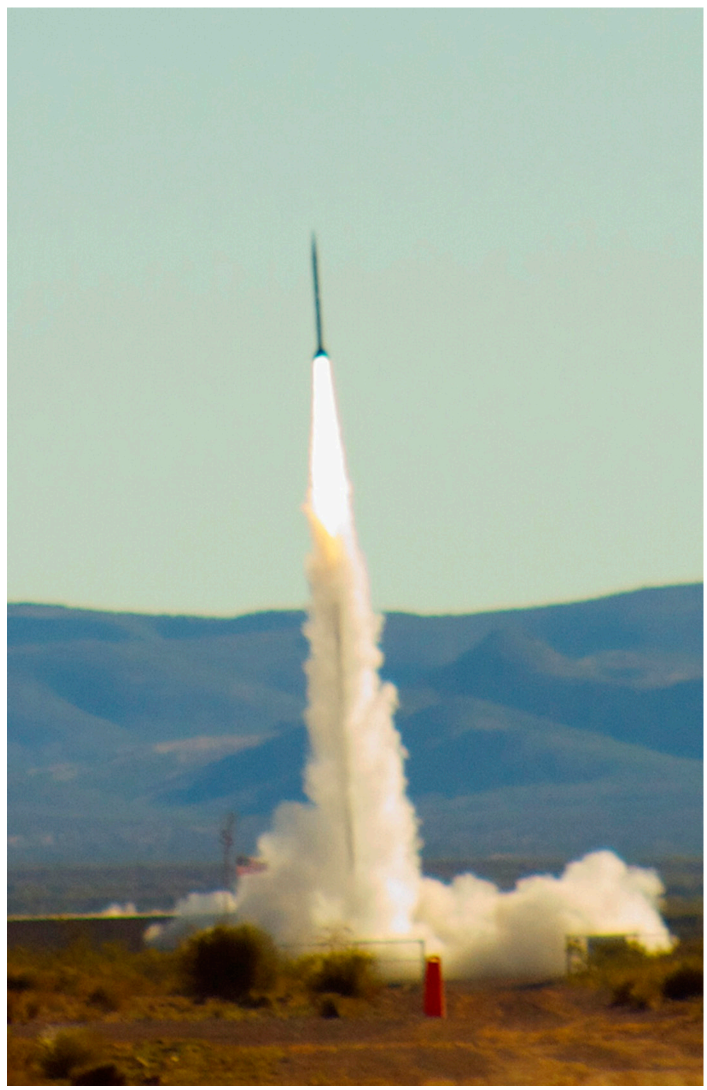
"We had a great launch, all the payloads were exposed to the relevant environments that the researchers were seeking," said Paul De Leon, NASA Flight Opportunities Program campaign manager. "The new payload deployment capability from UP Aerospace was successfully demonstrated, opening the opportunity for future entry, descent and landing technologies to be tested and matured under Flight Opportunities."

NASA's Ames Research Center at Moffett Field, California, tested its Affordable Vehicle Avionics (AVA) project, a suite of avionics that will provide early verification of new software and hardware for delivering an affordable and capable guidance, navigation and control (GNC) system and telemetry avionics. AVVA technology is being advanced under the Space Technology Mission Directorate's Game Changing Development Program.

The avionics project will be applied to multiple nanolaunch vehicles at one percent the cost of current state-of-the-art avionics. Using this new GNC system reduces the cost of launching small payloads into orbit as well as recurring costs of future launches.

The other technologies included in the payload were Purdue University's green propellant, New Mexico State University's robotics-based method of on-orbit identification of spacecraft inertia, and Johnson Space Center's entry, descent and landing technology providing on-demand return of small payloads.

The full story including a video can be seen on the NASA Portal at http://www.nasa.gov/centers/armstrong/features/rocket_demonstrates_new_capability.html.



The UP Aerospace rocket launched experiments to flight test for NASA's Flight Opportunities Program from Spaceport America in New Mexico. Credit: Contributed Photo / Spaceport America

NASA Awards Two Robots to University Groups for R&D Upgrades

Humanoid robots will be helpful to astronauts on our journey to Mars, so NASA has awarded prototypes to two universities for advanced research and development work.

NASA is interested in humanoid robots because they can help or even take the place of astronauts working in extreme space environments. Robots, like NASA's R5, could be used in future NASA missions either as precursor robots performing mission tasks before humans arrive or as human-assistive robots actively collaborating with the human crew. R5 initially was designed to complete disaster-relief maneuvers, however, its main goal is to prove itself worthy of even trickier terrain—deep space exploration.

"Advances in robotics, including human-robotic collaboration, are critical to developing the capabilities required for our journey to Mars," said Steve Jurczyk, associate administrator for the Space Technology Mission Directorate (STMD) at NASA Headquarters in Washington. "We are excited to engage these university research groups to help NASA with this next big step in robotics technology development."

The two university proposals selected are:

- Robust Autonomy for Extreme Space Environments: Hosting R5 at Massachusetts Institute of Technology in Cambridge, Massachusetts, led by principal investigator Russ Tedrake
- Accessible Testing on Humanoid-Robot-R5 and Evaluation of NASA Administered (ATHENA) Space Robotics Challenge—Northeastern University in Boston, Massachusetts, led by principal investigator Taskin Padir

The two university groups were chosen through a competitive selection process from groups entered in the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge. They also will receive as much as $250,000 a year for two years and have access to onsite and virtual technical support from NASA. STMD's Game Changing Development Program, which is charged with rapidly maturing innovative technologies that will one day change the way NASA explores space, is funding the research.

The university principal investigators will serve as critical partners in NASA's upcoming Space Robotics Challenge where the two R5 units will act as instruments. The challenge is part of the agency's Centennial Challenges Program, and is divided into two competitions: a virtual competition using robotic simulations, and a physical competition using the two upgraded R5 robots. The goal of the challenge is to create better software for dexterous humanoid robots used in space missions, giving them more autonomy.

NASA's Langley Research Center in Hampton, Virginia, manages the Game Changing Development Program for NASA's Space Technology Mission Directorate. The Space Technology Mission Directorate is responsible for developing the cross-cutting, pioneering, new technologies and capabilities needed by the agency to achieve its current and future missions.

Originally posted 11/17/2015 on www.nasa.gov.

First-Round Selections Identified in NASA's First BIG Idea Challenge

Five Agency experts on entry, descent and landing technology along with members of the National Institute of Aerospace (NIA) met for a down select meeting November 23 where they considered 13 white papers proposing innovative ideas to generate lift using Hypersonic Inflatable Aerodynamic Decelerator (HIAD) technology.

The papers were submitted from colleges and universities across the United States for NASA's first Breakthrough, Innovative, and Game-changing (BIG) Idea Challenge, a university-level design competition sponsored by NASA's Game Changing Development Program and managed by the NIA. The call resulted in an initial 18 Notice of Intent submissions from universities and colleges across the U.S. Thirteen student teams prepared and submitted papers after which first round selections identified the top 10 ideas to move forward in the competition and announced them November 30, 2015.

Game Changing's Integration Manager Mary Beth Wusk describes one of the Program's goals as to inspire students and spur innovation by having them tackle real-world challenges being worked today.

"We constructed the BIG Idea Challenge to get the best and to control inflatable heat shields successfully through the atmosphere," says Wusk. "Students provide unique perspectives and fresh ideas to solving complex technical challenges associated with advancing space technology."

In order for humans to safely reach the surface of Mars and return to Earth, greater payload masses are required and the aeroshells needed for these missions must provide enough aerodynamic drag to deliver those masses. Future human Mars missions will require lift to mitigate deceleration loads on the crew, to loft the vehicle, and to

BIG Idea Challenge 2015 First Round Selections

U.S.-Based University Name	Abstract Title
Arizona State University	Multi-Cellular Shape Morphing Entry Vehicle
Embry-Riddle Aeronautical University	Shape Morphing HIAD with Actuator Application
Georgia Institute of Technology	Study of Novel Hypersonic Inflatable Aerodynamic Decelerator Design for High Lift-to-Drag Hypersonic Reentry
Northeastern University	Dynamic Control of Heat Shields Using a Conical Coil
Purdue University	2016 BIG Idea Challenge – White Paper
State University of New York at Buffalo	A Structural Redesign and Elegant Method to Shift the Payload to Generate Lift
University of Alabama Tuscaloosa	University of Alabama Tuscaloosa White Paper
University of California Riverside	Finned HIAD
University of Illinois at Urbana-Champaign	Cable-Controlled Aeroshell Deceleration System White Paper
University of Pittsburgh	HIAD Control Tube Design

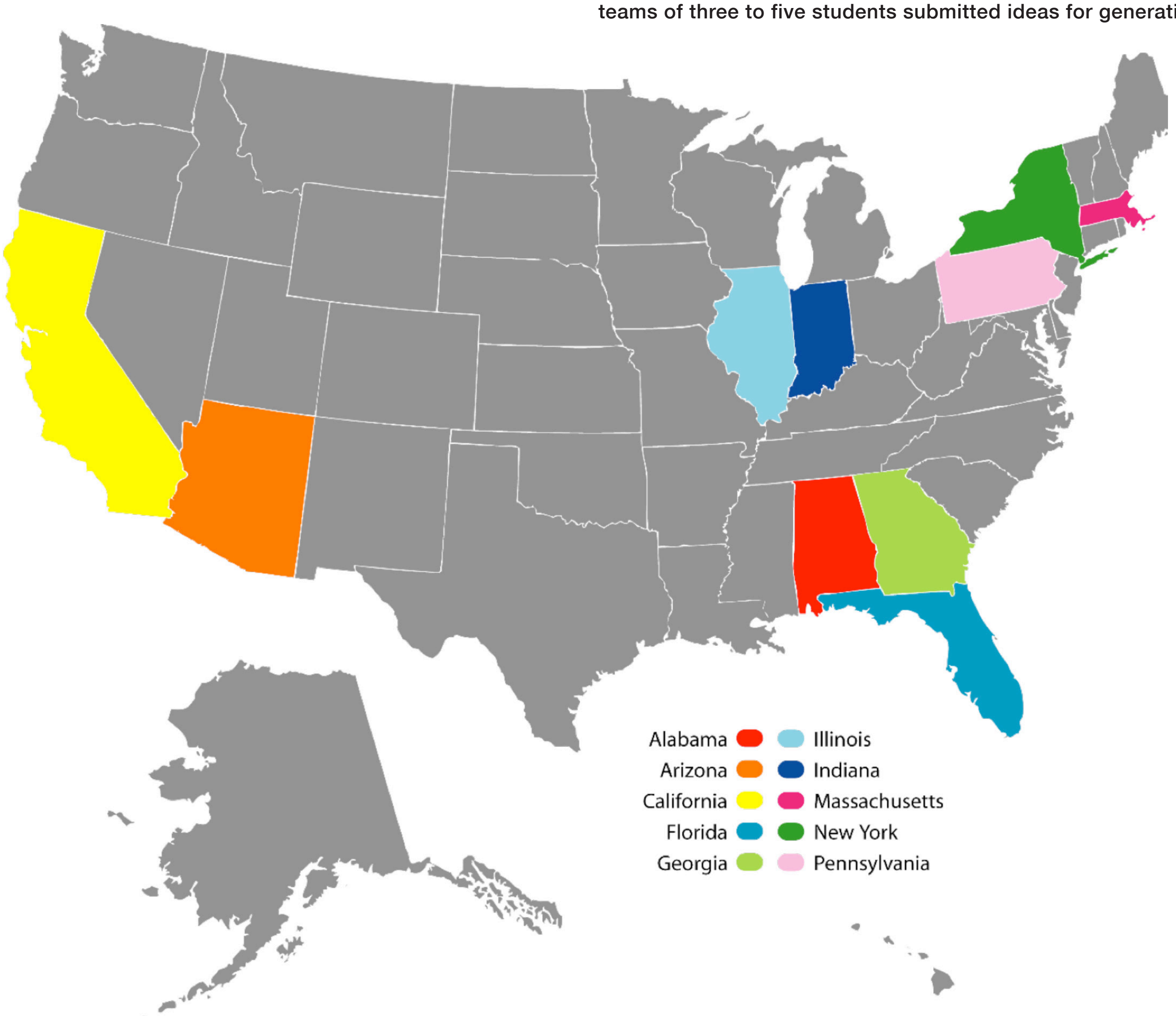
extend the timeline for entry, descent and landing events to enable precision landing.

Student submissions propose innovative approaches for generating lift using the HIAD technology, which is being advanced under the Space Technology Mission Directorate's Game Changing Development Program. NASA is investing in the HIAD technology because it is a leading candidate to enable large aeroshells, and because enhancing HIAD drag with lift holds great potential.

The white papers were evaluated on these criteria: feasibility of proposed concept of idea; innovative, unique and/hance existing HIAD capabilities or technologies; systems analysis of requirements including identification of challenges and issues including technology readiness level of mission-enabling technologies; evidence of credible and implementable project plan; and realistic assessment of project cost/schedule.

First-round teams will submit full technical papers on their concepts from which four finalists will be selected to participate in the BIG Idea Forum at NASA's Langley Research Center in April 2016. A panel of NASA judges will choose the winning concept and team members will receive offers to participate in future internships with the Game Changing Development Program.

Map highlighting states from which eligible submissions were received for the BIG Idea Challenge. To participate, university teams of three to five students submitted ideas for generating



Employees of the month

November: Nancy Hornung
December: Chris Munk

"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

Chris Munk is a senior systems engineer who joined GCD in September 2011, soon after the Program's inception. He's been with Booz Allen supporting NASA clients at different Centers on and off for a little over 25 years.

"The opportunity to work with very talented individuals to further NASA's mission, which I'm passionate about, is what I enjoy most about my work," says Munk. "It's an opportunity to bring new ideas forward and make a positive impact within the Program."

Munk's impacts have reached the Astronaut Flight Training Simulator's hardware/software development and integration at Johnson Space Center, the Space Launch Initiative out of Marshall Space Flight Center, and the Atmospheric Science Data Center at Langley Research Center, to name just a few areas he has supported.

GCD Program Manager Steve Gaddis selected Munk as the December employee of the month to recognize his efforts developing the data visualization tool GCD Mobile/GCD Analytics. GCD Mobile is a 3D interactive mobile visualization tool of the GCD Program's space technology portfolio to support management decision-making as well as support outreach communication about the portfolio. Users have the capability to filter and customize information they wish to see from GCD's portfolio of projects, technologies and tasks.

"Chris led the effort to develop the data visualization tool, which has been extremely beneficial to the program and has been well received by our stakeholders," says Steve. "He was instrumental in getting the final updates completed prior to our annual review, so we were able to announce the tool's completion at that time."

Married with two daughters, one in middle school and the other high school, Munk's family activities often involve trips to the Eastern Shore or the Outer Banks, or a hearty meal of Mexican favorites.

Outside work and family, Munk enjoys volunteering for youth activities. He is a girls' basketball coach in the City of Chesapeake's recreation league citing no championship wins as yet but having lots of fun. Munk also volunteered for the Virginia Regional FIRST Robotics Competition held at Virginia Commonwealth University in Richmond.

FIRST means For Inspiration and Recognition of Science and Technology, and the program engages kids from kindergarten to high school in exciting, mentor-based research and robotics programs that help them become science and technology leaders.

"In both volunteer opportunities it is rewarding to see how positive influence, coaching, and mentoring enable kids to come together in teamwork, battle through adversity, reach greater potential, and achieve inspiring results," says Munk.

Nancy Hornung was selected as the November employee of the month honoree. Hornung provides financial and program analysis support and some other office transactions that Gaddis describes as "quite burdensome," and she does so with a grace and humor that make the work seem less of a bother than generally perceived.

"When we need something, no matter the difficulty in obtaining it, Nancy makes it happen," says Gaddis. "She works very hard, she is very detailed, and always helps with other duties as assigned. Recently, she stood in for Rob Lowe at the GCD Annual Program Review at GSFC. She did a great job presenting and representing the GCD financial folks."

Nancy was previously honored for her work soon after joining the GCD team. See the article in our first 2015 issue of Highlights by pasting the following link in your browser <http://gcd.larc.nasa.gov/wp-content/uploads/2015/04/GCD_HL_Jan-Feb_15_150406.pdf>.

Education & Public Outreach

NASA Supports CAMX 2015 in Dallas…

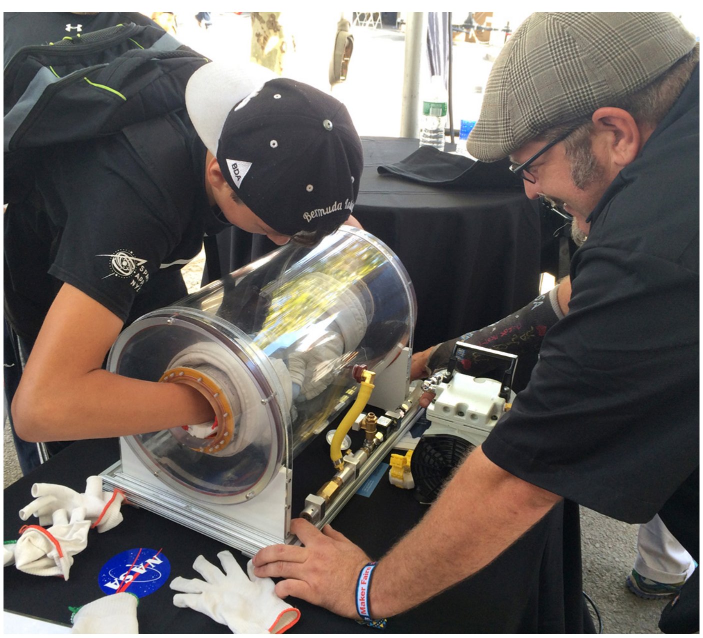
Game Changing's Nanotechnology and Additive Manufacturing Technologies projects supported the Composites and Advanced Materials Expo Oct. 27-29 in Dallas, Texas by providing hardware and videos. NASA Langley's Chauncey Wu and Brian Stewart also supported the booth and highlighted ISAAC. Additionally, GCD project 3D-MAT received the "Outstanding Paper" recognition at the conference. The paper lead author was Jay Feldman. Coauthors included Curt Wilkinson of Bally Ribbon Mills, Ken Mercer of San Diego Composites and NASA Ames' Raj Venkatapathy.

Right: Brian Stewart (from left), John Vickers, and Chauncey Wu staff the STMD booth at CAMX.

…and Maker Faire in New York

GCD participated in its third Maker Faire in September 2015 in New York. Communications Manager Amy McCluskey and Exhibit Support Specialist Brandon Guethe (below left) brought the EVA Glove Box demo, which gave attendees the experience of wearing astronaut gloves in space. Attendees also learned what NASA is doing to improve the glove design for future Mars missions.

GCD Program Manager Steve Gaddis (below right) addressed Maker Faire participants with a talk about game changing technologies that will help get astronauts to Mars. Gaddis emphasized the importance of the relationship between NASA and the Maker community and discussed how the Agency needs innovators and forward-thinkers.



2015 Annual Program Review

The Game Changing Development Program held its Annual Program Review (APR) at Goddard Space Flight Center October 13-16, 2015. Nearly 200 people attended including virtual participation via WebEx and teleconference. The GCD Program Office and project managers provided detailed presentations outlining technical progress for fiscal year 2015. The face-to-face gathering also served as an opportunity to facilitate team building and collaboration. New this year was a virtual EPO presentation. Projects took short "selfie-style" videos describing their projects instead of hand-carrying hardware.

At the APR, 3D-MAT's industry partner San Diego Composites was recognized for its performance and fortitude throughout the partnership (right). "3D-MAT would not be possible without San Diego Composites," said Project Manager Raj Venkatapathy.

The Game Changer of the Year Award goes to…the 3D-MAT team

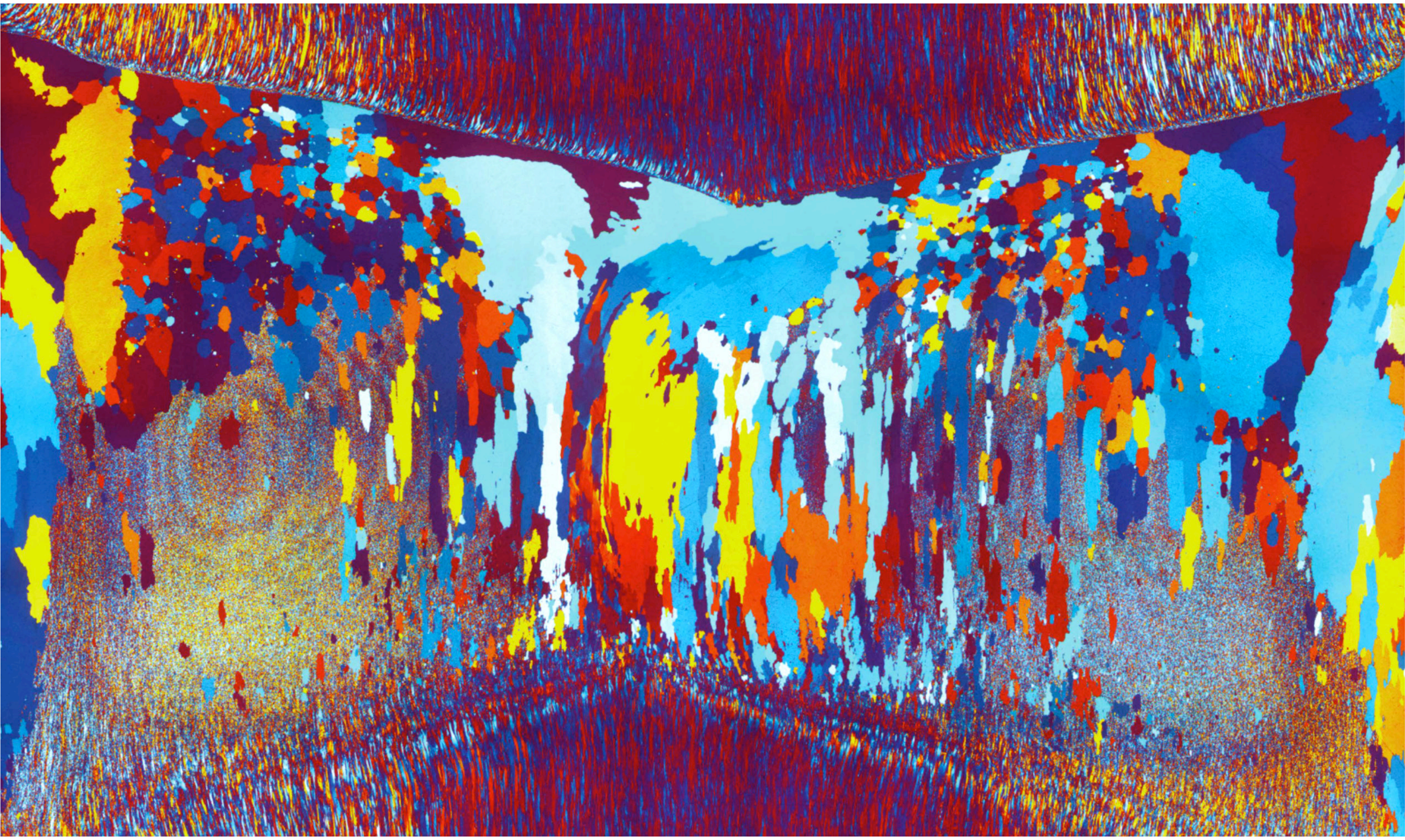
"In recognition of the Thermal Protection Systems-Materials project for its successful transition of 3D-MAT to Orion's baseline design for compression pads. 3D-MAT leveraged the efforts of STMD's investment in Woven TPS to design, manufacture, test and demonstrate a prototype material for Orion compression pads…"

Mary Beth Wusk, GCDP Interim Manager

In October, GCD and NASA Edge released a show on Human Robotics featuring R2 (top left), R5, the MRV (middle left) and Resource Prospector Mission (bottom left). In its first week on youtube, the show was downloaded half a million times.

Administrator Visit

STMD Associate Administrator Steve Jurzyck (below left) began center visits in the fall of 2015. Here, he visited JSC and met with the team working on the new EVA Glove concept.



Game On!

http://gameon.nasa.gov

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