



Space Technology

Game Changing Development Highlights



TECHNOLOGY DRIVES EXPLORATION

May-June 2014

Robotics Research FY15 Grants Review
Entry Systems Modeling Delivers Next-Gen CFD Software
Game-Changing Projects and People: an Emmy-Winning Combination
Space Tech Reaches Out From Classroom to Capitol Hill

Space Tech Reviews Robotics Grants

HRS

The Human Robotic Systems (HRS) project hosted a two-day review of its Space Technology Mission Directorate-funded National Robotics Initiative (NRI) grants June 5-6, 2014, at NASA's Johnson Space Center.

HRS is a Game Changing Development (GCD) Program project that strives to employ a balanced approach of

guided technology development efforts and competitively selected efforts from across academia, industry, NASA, and other government agencies.

“Rob Ambrose and his team should be commended for implementing this robotic incubator approach which allows NASA to stay involved with the academic



A number of tours of JSC technology were conducted in the afternoons during the NRI reviews, which fostered communication and provided the PIs a better understanding of HRS project needs. A number of the NRI grant PIs and speakers are shown here in the Robonaut lab. From left, Jerry Pratt, IHMC; Steve Pekarek, Purdue; Brian Gerkey, OSRF; Sarah Bergbrieter, University of Maryland; Kevin Peterson, Astrobiotics; Ken Pasch, MIT; Ian Walker, Clemson; Scott Sudhoff, Purdue. Photo courtesy of Mary Beth Wusk.

Principal Investigators and Grant Titles

Principal Investigator	Grant Title
Ian D. Walker, Ph.D. Clemson University	Long, Thin Continuum Robots for Space Applications
Hugh Herr, Ph.D. Massachusetts Institute of Technology	A Novel Powered Leg Prosthesis Simulator for Sensing and Control Development
William Whittaker, Ph.D. Carnegie-Mellon University	Long-range Prediction of Non-Geometric Terrain Hazards for Reliable Planetary Rover Traverse
Sarah Bergbreiter, Ph.D. University of Maryland College Park	Active Skins for Simplified Tactile Feedback in Robotics
Steven Pekarek, Ph.D. Purdue University	Actuators for Safe, Strong, and Efficient Humanoid Robots
Robert Platt, Ph.D. Northeastern University	Manipulating Flexible Materials Using Sparse Coding
Luis Sentis, Ph.D. (Presented by students) University of Texas at Austin	Whole-Body Telemanipulation of the Dreamer Humanoid Robot on Rough Terrains Using a Hand Exoskeleton (EXODREAM)
Jerry Pratt, Ph.D. Florida Institute for Human & Machine Cognition (IHMC)	Toward Humanoid Avatar Robots for Co-exploration of Hazardous Environments
Brian P. Gerkey, PhD Open Source Robotics Foundation (OSRF)	Building the Robotic Commons

community and supports NASA's commitment to develop robotic technology in the robotic community," said Mary Beth Wusk, project element manager with GCD.

Current NASA grantees include seven U.S. universities, one research institute, and one nonprofit organization. Researchers presented the past year's research and accomplishments, and FY15 plans. In addition, the principal investigator of a unique and innovative Broad Agency Announcement, managed under HRS and funded through STMD/GCD, presented his FY14 robotics research results via telecom.

The review panel was chaired by Rob Ambrose, principal investigator for Revolutionary Robotics and Autonomous Systems, and included Mary Beth Wusk; Bill Bluethmann, project manager for HRS; Bob Savely, chief scientist for Software, Robotics and Simulation Division; and Kim Hambuchen, Robotic Systems Technology Branch.

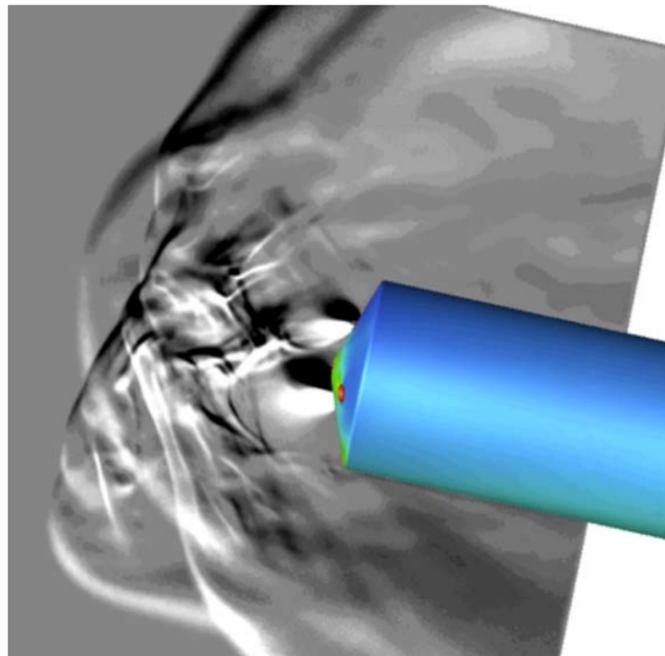
Ambrose and Wusk both recommended all grants be continued in FY15, completing a major milestone for FY14.

ESM Delivers Next-Generation Computational Fluid Dynamics Software

The Entry Systems Modeling (ESM) project has delivered two new modeling and simulation tools for modeling aerothermodynamic environments of entry vehicles. The new codes, called US3D and FUN3D, utilize unstructured meshes to greatly ease the cost of grid generation on complex configurations, while introducing multiple innovative features to enhance accuracy, improve ease-of-use, and reduce computational cost.

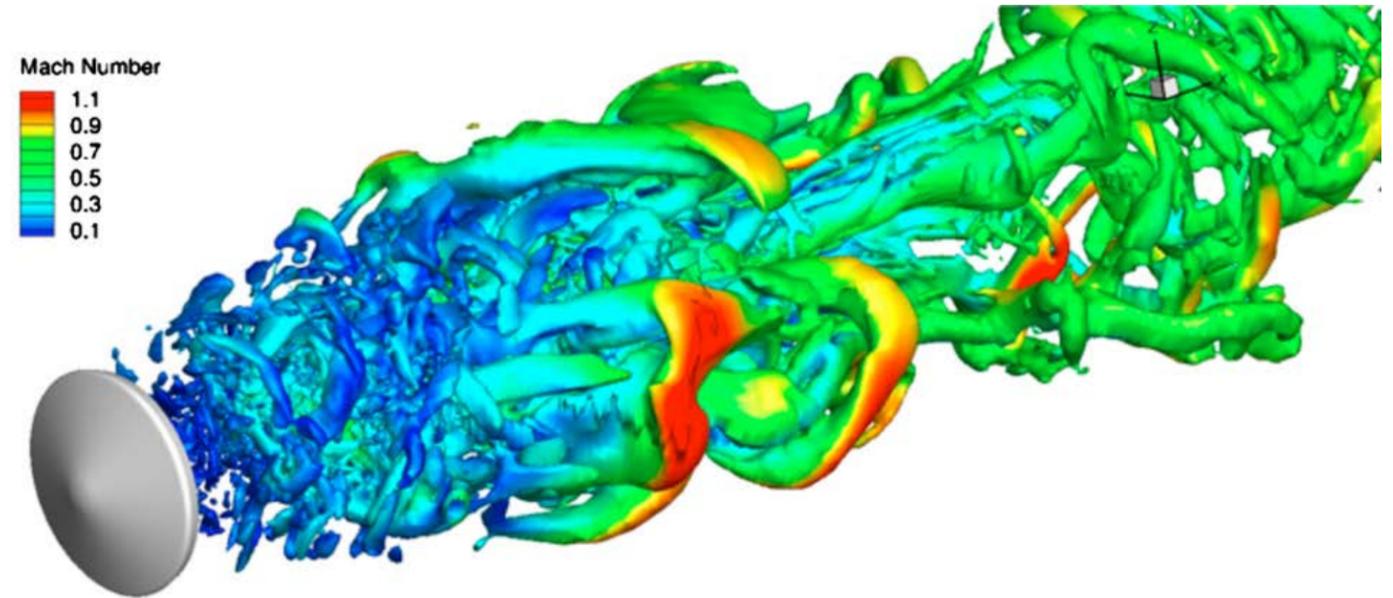
As part of Space Technology's Game Changing Development Program, the ESM project delivers cutting-edge customer-driven research in two areas: aerosciences and entry, descent and landing (EDL) materials. Aerosciences includes the completion and delivery of these two new aerothermal computational fluid dynamics (CFD) codes, a first ever validated shock-layer radiation model and an experimental validation database, at flight-relevant enthalpy, for current and future generations. EDL materials includes the development and delivery of two new flexible thermal protection systems (TPS) to enable Hypersonic Inflatable Aerodynamic Decelerator missions, vastly improved ablator modeling capability, and improved polymer resins to enhance or enable future developments in woven, flexible and conformal TPS.

There has been a strong push from NASA flight missions toward increased simulation complexity in recent years. Examples of this are the geometric complexity of damage assessment during the Space Shuttle Program and the fluid-structure interactions inherent to several flexible TPS concepts actively in development at NASA. After two years of STMD funded development, US3D and FUN3D are positioned to become the next workhorse tools at NASA for aerothermodynamic CFD.



Rapid and efficient simulations of complex configurations, like the supersonic retropropulsion test article shown above, are enabled by the unstructured formulations of FUN3D and US3D.

US3D began as a research tool at the University of Minnesota and has since established itself as a platform for cutting-edge CFD development. A major challenge facing the ESM team was to translate the research-based platform into production-level software. To accomplish this goal, ESM formed a collaborative agreement with the University in which both entities co-develop the code for initial release, with NASA stewardship eventually transferring from ESM to the Aerothermodynamics Branch at Ames Research Center. Through this partnership, US3D has successfully met its goal and is now in beta release.

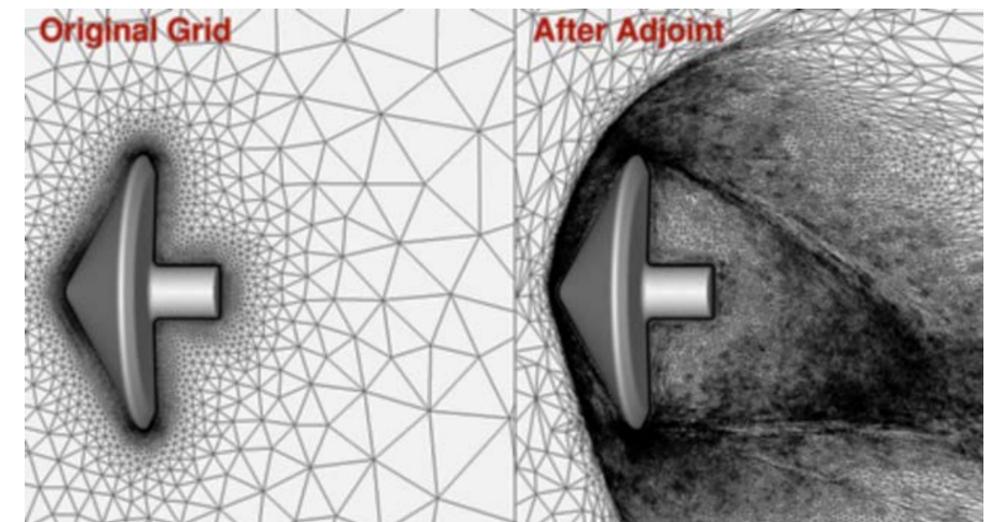


Simulated wake flow behind the ADEPT concept using US3D. Advanced numerical techniques allow unequaled resolution of complex, unsteady turbulent flows.

Initial customers include the Adaptive Deployable Entry Placement Technology (ADEPT), Propulsive Descent Technology (PDT) and Multi-Purpose Crew Vehicle (MPCV) projects. In addition, innovative features like free-flight CFD, fluid-structure interaction modeling, decoupled species mass equations, and a sensitivity solver for shape optimization are included in the package. Using advanced computational methods, US3D opens the door to simulations of unparalleled accuracy, as seen in the simulated wake flow of ADEPT in the figure above.

FUN3D has been under development at Langley Research Center for a number of years, primarily as a tool encompassing incompressible fluid simulations and up to the low-supersonic regime. The ESM team has expanded the capabilities of this tool by incorporating the thermochemical models from its predecessor LAURA as a shared module. The result is a code capable of functioning

as an unstructured version of LAURA, with the addition of several novel features like adjoint-based grid adaption and fluid-structure interaction modeling. An example of the former is seen in the figure below, which depicts the mesh around a notional flight vehicle before and after adaption. The unstructured formulation of FUN3D coupled with a powerful grid adaption scheme permits extremely efficient resolution of flow features and a greatly reduced simulation time.



Before and after adjoint-based grid adaption for simulated flow around a notional flight vehicle.

Emmy-Winning Episode of NASA X Features Game Changing Projects and People

—Denise M. Stefula

The National Academy of Television Arts and Sciences: National Capital Chesapeake Bay Chapter presented the Emmy® Award on June 14, 2014, to NASA X creators Kevin Krigsvold and Michael Bibbo for the category Informational/Educational Television. The episode winning such prestigious acclaim, “Power and Propulsion,” follows cutting edge research being performed by Space Technology’s Game Changing Development (GCD) Program.

NASA’s GCD Program is working on new ways to move hardware in space. Cutting edge research with battery and fuel cells combined with new solar electric power is revolutionizing methods of space travel. The research offers promise of numerous commercial spin-offs, some that could refashion how we travel here on Earth as well.

“For this episode, we featured GCD researchers from NASA Glenn, Plum Brook Station, and Langley,” said Krigsvold. “We highlighted efforts in the development of new batteries, fuel cells and solar electric propulsion systems to move man and machine through space.”

Guests from NASA’s Glenn Research Center and Plum Brook Station include: Dan Herman, John Liddell, Carolyn Mercer, Meg Nazario, and Bri Scheidegger. Solar Electric Propulsion’s Principal Investigator Chuck Taylor from Langley was also featured in the program.



Michael Bibbo, left, and Kevin Krigsvold holding their 2009 awards.



View NASA X

You can find “Power and Propulsion” at www.youtube.com/watch?v=sQUVMQgog7s&feature=youtube_gdata

Watch a NASA X episode about “Game Changing Technologies” at www.youtube.com/watch?v=w3cAqu4mONA&feature=youtube_gdata

Krigsvold and Bibbo, producers with Analytical Mechanics Associates, Inc., contribute significantly to bringing NASA research, its new technologies, advanced aerodynamics, past achievements and other breakthroughs, to the public.

NASA X was introduced just 2 years ago and this is the second Emmy win for the program.

“We are proud of this program and are happy that it is in demand by our partners and appreciated by our peers,” said Krigsvold. “We are so thankful to have the opportunity to work with the brilliant men and women

of NASA and to highlight the cutting edge research being done at all the field Centers.”

Before NASA X, Krigsvold and Bibbo developed NASA Destination Tomorrow and NASA 360, both of which are also award-winning shows. Destination Tomorrow received a 2006 International Davey Award for its episode highlighting NASA’s radiation protection efforts. NASA 360 won an editing Emmy in 2009, and a number of other awards prior to that, for a segment about an all-electric racecar.



The 56th Annual Emmy® Awards was held June 14, 2014, at the Fillmore Silver Spring in Maryland. The Emmy acknowledges excellence in the television industry, and NASA X’s Power and Propulsion episode was recognized from the National Capital Chesapeake Bay Chapter region, which encompasses Virginia, Washington D.C., Maryland, and Delaware.

GCD Employees of the Month

“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.



May 2014: Adelle Helble, Program Integration

A member of the Game Changing team since 2011, Adelle helps with review planning, publishes the Smart Book, and performs other analysis activities as assigned. From a technical perspective, she has been involved with Astrophysics and Propulsion projects.

“Adelle is a real go getter and can always be counted on to complete the mission,” says Steve Gaddis, GCD program manager. “Her efforts at the Mid-Year Review were indispensable. She helps keep the program office running smoothly with our core data.”

“The part that I like most about my job is the opportunity to learn about multiple areas of space technology and be involved in the development of future ideas for technologies,” says Adelle. “I also enjoy the diverse backgrounds of everyone in the office.”

Within the Game Changing Development Program, projects reach across centers and technical disciplines, affording a rich variety of experiences.

“We see some of the future hardware that might be used for future space missions, and being able to see the many laboratories that each project utilizes also provides valuable insight into what each project is actually doing,” says Adelle.

In her free time Adelle, who is originally from Pennsylvania, loves ice skating and playing ice hockey. If you’re out about town, you might find her on the beach, or attending a Norfolk Admirals game, or maybe packing it up for a road trip.

“Most of my family still lives in Pittsburgh,” says Adelle. “I’m very close with my dad and my grandfather and enjoy seeing them whenever I am home. I travel back frequently since it is not too far away.”

Adelle also enjoys traveling with friends. “I have been to Germany, Peru, Hawaii, and Italy with friends and have had great experiences exploring the different parts of the world.”

When it’s time to relax, Adelle partakes in a nice dinner out of fresh, local seafood, then coming home to curl up with her sweet kitties.

June 2014: Larren Asby, Administrative Specialist/ Office Manager

To say Larren oversees the GCD administrative office duties probably sounds far too simple to accurately describe what she does.

“I am the Organizational Liaison for Human Resources Management activities like staffing, employee relations, performance-plan management, awards, and training,” says Larren. She also coordinates special events and program activities such as Annual and Mid-Year Reviews.

Having been with the Game Changing team since the office was established in November 2010, she “embodies the GCD ‘can do’ attitude,” says Program Manager Steve Gaddis, “because she is willing to help wherever she can.”

What Larren likes best about working with GCD is that it is very busy and she says her coworkers are wonderful. “There is never a dull moment around here! And all of the people that I work with are great! I consider myself very fortunate to work with a great bunch of people.”

Larren and her husband Allen have three sons, Christopher, 22; Jacob, 16; and Logan, 7; and they are all huge sports enthusiasts. “Two of my boys are involved with baseball so we spend a lot of time at baseball games during the spring and summer.”

“I like to keep up with college basketball (specifically Duke, and also UVA only because that’s the team my husband likes) and college baseball,” Larren says.

“My nephew plays baseball for Longwood and he also plays for the Peninsula Pilots, so I try to attend a lot of those games as well.”

Next time you’re in the office and you want an update on college ball or what the Pilots’ stats are for the season, give Larren a nod.

Education & Public Outreach

‘Kinect’-ing with Kids at WPI



NASA Space Technology Mission Directorate programs Game Changing Development and Technology Demonstration Missions supported the Touch Tomorrow event held Saturday, June 14, at Worcester Polytechnic Institute in Worcester, Mass. Touch Tomorrow, a festival of science, technology and robots, featured dozens

of interactive exhibits provided by the college and by NASA. The event was also a part of NASA’s 2014 Centennial Challenges Sample Robot Return. Here, visitors enjoy learning about Robonaut 2 while enjoying an Xbox Kinect game that illustrates the human-like characteristics of the robot.

Education & Public Outreach

Exploration Day on the Hill

Several STMD projects were on display June 11 at the Rayburn Building in Washington, D.C., as part of NASA's Human Exploration Day on the Hill. The event, which featured technologies that will help get humans to Mars, drew around 500 guests including congressional representatives, staffers, NASA stakeholders and industry.

STMD exhibits included: Composite Cryotank Technologies and Demonstration, Additive Manufacturing Technologies, Low-Density Supersonic Decelerator, ADEPT, Hypersonic Inflatable Aerodynamic Decelerators, EVA Gloves, Solar Electric Propulsion and Woven Thermal Protection System.



Ryan Stephan, program executive for the Game Changing Development program office, discusses the benefits of a new type of astronaut glove, right, to staffers.



Photos courtesy of Amy McCluskey



Chief Engineer for STMD's Game Changing Development program Bob Hodson explains the Composite Cryotank Technologies and Demonstration project to a visitor.

Education & Public Outreach

Space Tech Outreach Activity Brings Life-Support Technology to Illinois Students

—Denise M. Stefula

Cinda Chullen, of the Crew and Thermal Systems Division at NASA's Johnson Space Center, participated in two educational outreach events in May. A total of 350 Illinois

students attended the presentations, the first being for third to fifth graders at Thompsonville School and the second for sixth to eleventh graders at Frankfort Intermediate School.



Cinda Chullen, right, and fifth-grade Frankfort Intermediate educator Holly Wilburn hold different versions of gloves used with spacesuits.

NASA personnel regularly participate in outreach activities to attract and retain student learning in the areas of science, technology, engineering and mathematics, or STEM, disciplines.

Chullen, who attended school in Benton, Illinois, focused her presentations on spacesuits and the high-tech critical life-support technology to keep astronauts alive. Select items of spacesuit hardware were exhibited and some were available for students to interact with.

Chullen felt the students were very informed. "They covered a space unit earlier in the year and I could tell that the students were educated about space," said Chullen.

And of course: what one question is surely posed from a group of inquisitive students? "They were perplexed with how an astronaut goes to the bathroom in a spacesuit.

When I pulled out the MAG (maximum absorbency garment), they could not believe it was actually an adult diaper. They laughed extensively," said Chullen. "It was delightful to break the ice with them and good to let them know that sometimes we have simple solutions to problems."

Fifth-grade educator Holly Wilburn felt the presentation increased student interest in science and gave them a more realistic view of NASA, something they don't get from textbooks alone.

"I also thought that it was important for these kids to hear that Cinda came from Benton, our neighbor town, and that she is now working for NASA," said Wilburn. "A lot of these children don't think they can be very successful in life because we live in an area that is high in poverty and unemployment. It gave them hope."

"Earlier in the year we had a 12-week unit on space," Wilburn continued. "One part of that unit involved living and traveling in space. We read about spacesuits and the International Space Station, and we watched several YouTube videos from astronauts aboard the ISS. However, for the students to actually get to feel the suits that an astronaut would wear is an experience that teachers would never be able to give to the students without this presentation."



Husband and wife educators at Frankfort Intermediate, Holly and Nathan Wilburn, try on the spacesuit glove. "I was surprised by how well my hand could function in a glove that large," said Nathan. "I thought it would be difficult because it seemed so bulky."

Education & Public Outreach

Siblings STEAM Ahead at Teacher Workshop



When you add the arts to the traditional STEM curriculum you get STEAM (science + technology + engineering + arts + mathematics). Art Professor Carol Hodson and her brother Bob, NASA Game Changing Development Program chief engineer, teamed up with middle school teachers to bring a blended perspective to problem solving. Although reared by the same parents, Carol and Bob travelled vastly different paths in life. Carol started drawing and painting at an early age while Bob was taking things apart in the basement to see how they worked. Carol went on to be a

prolific artist and now teaches art at Webster University. Bob's path led him to degrees in engineering and eventually to a doctorate in information science.

What is interesting is that it took this left and right-brained dominant sibling pair about 50 years to collaborate and bring their skills and backgrounds together. Albeit still having different perspectives, the STEAM workshop allowed them to work toward a common goal and teach others a multidisciplinary approach to problem solving.

3D Printer at White House Maker Faire



A prototype model of the Made In Space 3D printer was on display during the first ever White House Maker Faire Wednesday, June 18, in Washington, D.C. The event brought together students, entrepreneurs, and everyday citizens who are using new tools and techniques to launch new businesses, learn vital skills in science, technology,

engineering, and math (STEM), and fuel the renaissance in American manufacturing. The Made In Space 3D printer was just approved by NASA to be tested on-board the International Space Station (ISS), and NASA announced a challenge for students to design items that would be printed by this first 3D printer to fly in space. NASA/Bill Ingalls



Coming Soon...

NASA LANGLEY TECHNOLOGY DAY

WHEN: Tuesday, July 15

WHERE: The Virginia Air & Space Center

TIME: 11 a.m. to 4 p.m.

Free to NASA employees and NASA interns



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Game On!
<http://gameon.nasa.gov>



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