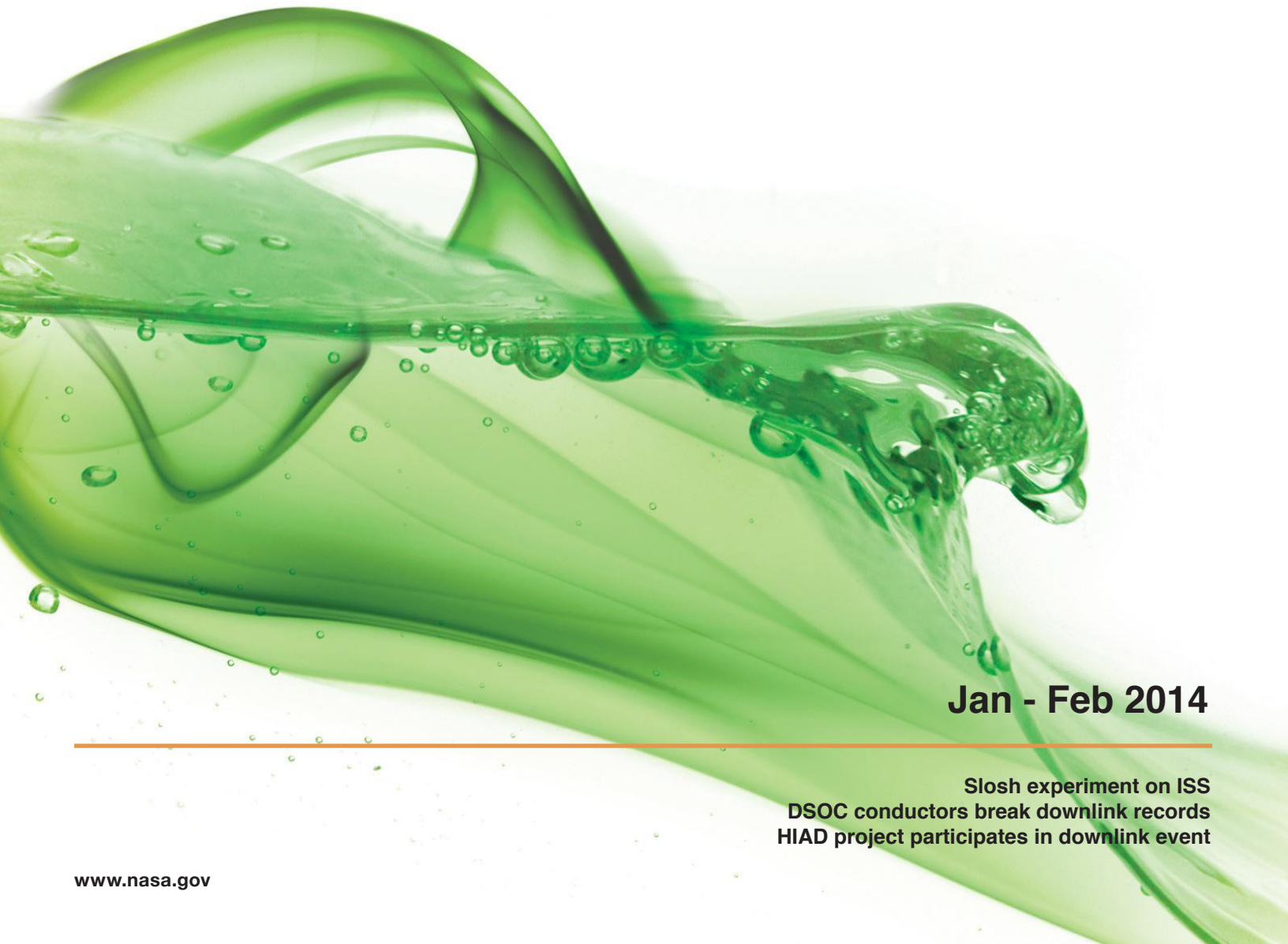
National Aeronautics and Space Administration

Space Technology

Game Changing Development Highlights



Jan - Feb 2014

Slosh experiment on ISS
DSOC conductors break downlink records
HIAD project participates in downlink event

www.nasa.gov

SLOSH

”We feel that it is a great boost for our experiment that the astronauts have shown great interest in Slosh and find it enjoyable to operate.” —Jacob Roth, Slosh project manager.

Fluid Slosh Results Begin Pouring In

—Denise M. Stefula

The SPHERES-Slosh investigation currently underway on the International Space Station seeks to improve our understanding of how liquids behave when there is little to no gravity. STMD’s Game Changing Development project, ISS Fluid Slosh, has successfully gathered its first run data checking system functionality in preparation for the actual science runs.

“This data will help engineers and designers build a better, safer, and quite possibly a lighter rocket,” said Steve Gaddis, Game Changing Development’s program manager. “Experimental results will help future rockets and missions like the Space Launch System and deep space robotic missions.”

Project Manager Jacob Roth, NASA’s Kennedy Space Center, took a few moments to share a status update.

Q: Have you been able to look at any test results yet?

A. The results from our first checkout run are proving interesting. While not too unexpected, the bubble/liquid interaction behavior appears to be exhibiting a slightly different interaction than current models predict. Our two science runs, which are designed to produce the type of data needed for computer model verification, are scheduled for the end of February and the end of March.

Q: Do you have any preliminary thoughts based on the data you are getting?

A. We are very happy so far with the quality of the data, and believe it’s more than sufficient for providing us with a good baseline for model verification. Due to the slightly different nature of the gas/liquid interactions than we previously thought, some of the runs within the science sessions are being altered to better capture the phenomenon.

Q: What knowledge have you gained (or believe you will) about the interaction between the sloshing fluid and tank/vehicle dynamics?

A. We have not yet begun to explore the dynamic interactions between the fluid slosh and the vehicle. Currently, we are focused on the behavior of the fluid by itself before we discuss its impacts on the system as a whole. We do believe, however, that this data will provide us with a good baseline for estimating the slosh behavior dynamically with the vehicle’s behavior.

Q: What surprises have come from the testing?

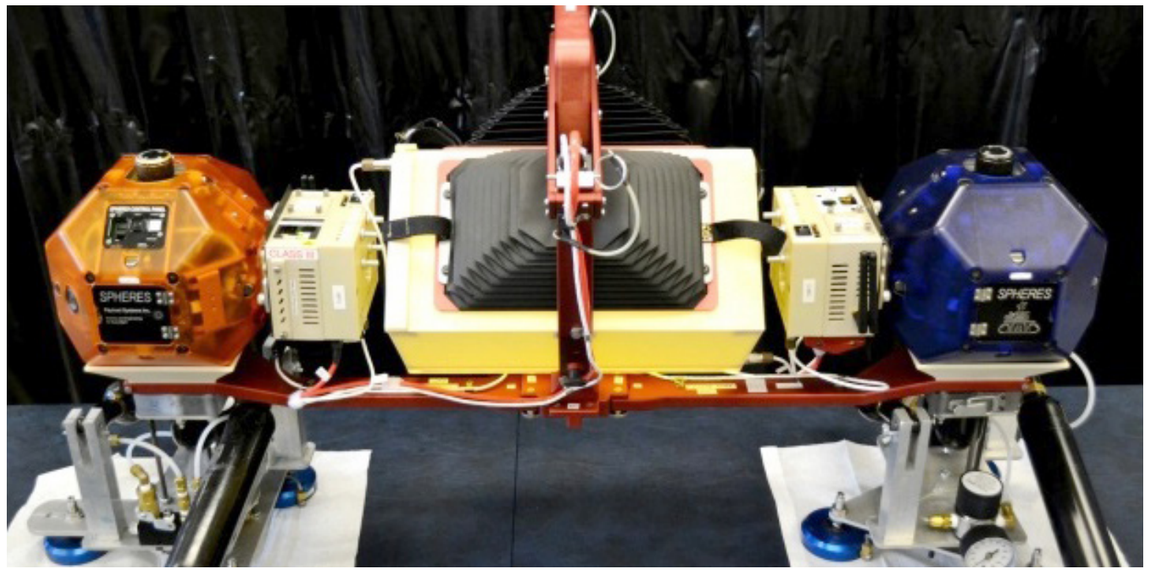
A. In terms of actual fluid behavior, the bubble/liquid interaction has proven to be quite interesting. It seems the system acts more viscously than expected, more like gelatin than water. Otherwise, there have not been any major surprises in the actual testing itself. Most of the system has performed flawlessly and we have received enough data for a decent reconstruction of the tests.

Q: In what specific ways will the test results be of importance to future missions?

A. The ability to understand the motion of the fluid in the tank and to anticipate its forces and locations allows for much greater confidence in the safety of missions. The increased confidence and knowledge can be leveraged as a reduction in risk or it can be utilized to more intelligently calculate performance and therefore, hopefully, increase margins on everything from structural limits to helium usage. The margins can then be kept for better mission assurance or used for increased performance or lift capability depending on the design of the vehicle. Incorporating this knowledge at an earlier stage, like in current Space Launch System design, can better maximize any benefits that our results may produce.

Once the science runs are complete, and more results come pouring in, researchers will compare computer models with actual data. The investigation will increase understanding of the behavior of liquids in microgravity and how rocket fuels move around inside their tanks when motor thrusts are applied, ultimately informing future mission planning and design.

For more information on ISS Fluid Slosh, visit: http://gameon.nasa.gov



The Fluid Slosh experiment.

SLOSH
A Lot to "like" on ISS

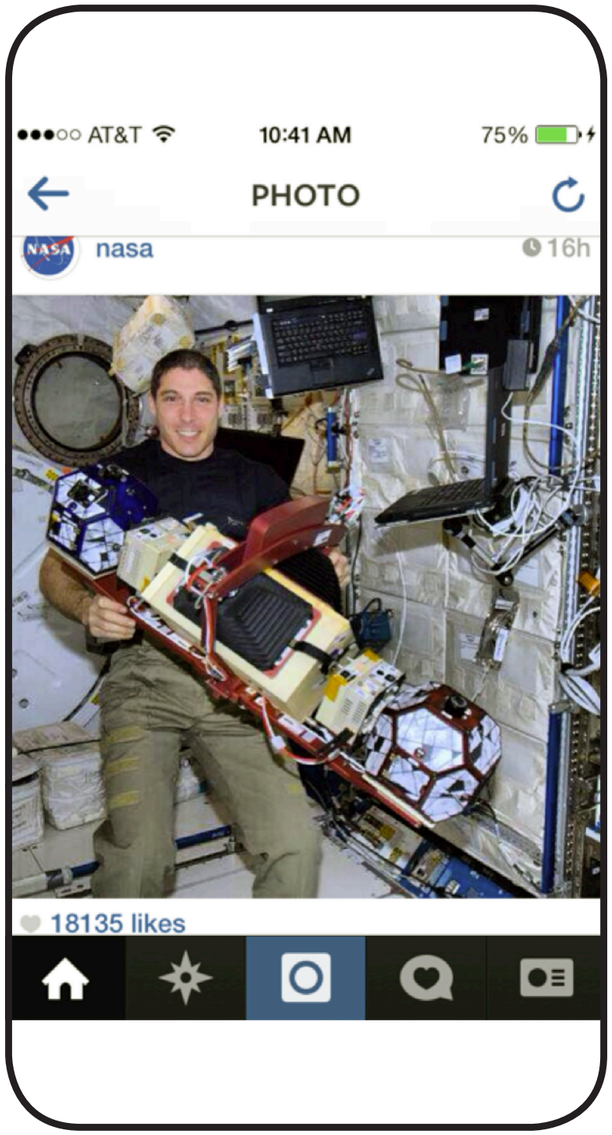
The first STMD project to make it on NASA's Instagram account is Fluid Slosh! The image garnered over 18,000 "likes" and 188 comments. Here, astronaut Michael Hopkins holds one of the SPHERES-Slosh assemblies used to look at how fluids move around inside their tanks.

Studying the physics of liquid motion in microgravity is important to expanding our understanding of how rocket propellants respond to thrust. Rocket propellants are used to send our spacecraft and satellites into orbit, and a better understanding may lead to improved fuel efficiency and lower mission costs.

Another first to "like" here is that the Slosh project used 3D printed materials in space for its experiments. "It was not our original intention to be first in this matter," said Jacob Roth, project manager with Slosh. "Our tanks are 3D printed in order to minimize the number of seams and to give the best optical quality we could get."

The remaining nonmetallic parts are mostly 3D printed so the project could realize a quick turnaround on parts development. Those parts include the saddles for the SHERES to sit in, the avionics box, and the light box, which can be seen in the Instagram image.

"Because we were first, we also participated with JSC in a number of tests, including flammability since they had a particular interest in whether the manufacturing method would change the material's behavior," Roth said. "We were not looking for any direct results from 3D printing, but sort of backed into being the first."



STMD Participates in NIA Nanotechnology Workshop

The National Institute of Aerospace, in Hampton, Va., held a workshop February 21, 2014, *Nanomaterials for Aerospace*. STMD's Mike Meador, project manager for Nanotechnology, was key note speaker for the workshop, held for the purpose of bringing together "thought leaders" from NIA partners to share ideas.

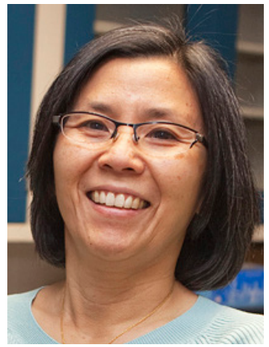
In his speech, Meador gave an overview of NASA's perspective on the "Future Needs and Opportunities in Nanotechnology for Aerospace Applications." Following Meador were two Langley researchers who work on projects in nanotechnology.

Mia Siochi, a research materials engineer who is looking into stronger, lighter materials for use in planes and spaceships, gave a talk on "Structural Carbon Nanotube Composites for Aerospace Applications."

Rounding out the one-day session's opening talks was Catharine Fay, a polymeric materials researcher who discussed "BNNT (boron nitride nanotubes) Synthesis and Applications."

Topic areas for the workshop covered experimental and theoretical aspects of synthesis and processing of nanomaterials for aerospace application. The afternoon topped off with a break-out session during which four groups focused discussions on specific research areas and then shared their deliberations.


Mike Meador.

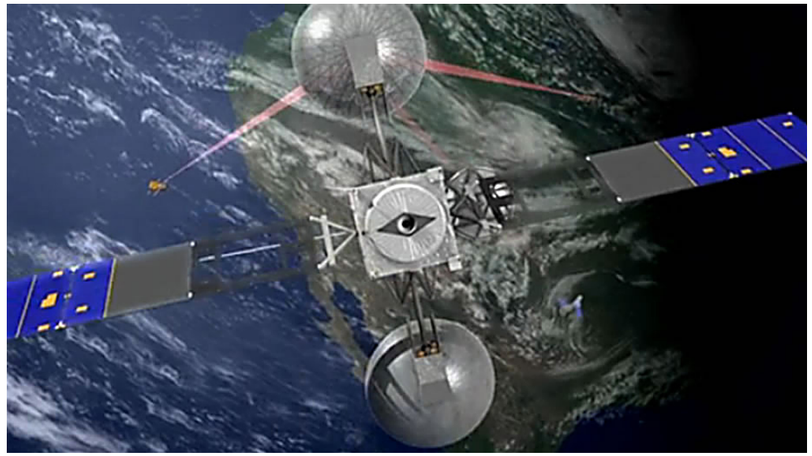

Mia Siochi.

NIA workshop planners hope the gathering will be "the starting point of identifying areas and possible partners across the NIA consortium members for large scale, muliti-University project partners" and, depending upon need, to plan follow-on sessions in the future.

A Peek Inside the 5.5

Officials from NASA's Space Technology Mission Directorate (STMD) and NASA's Marshall Space Flight Center (MSFC) recently visited Boeing's facility in Tukila, Wa., where work is wrapping up on the 18-foot (5.5-meter) cryotank.Boeing is NASA's prime contractor for the Composite Cryotank and Technologies Demonstration (CCTD) project, which is funded by STMD's Game Changing Development Program Office. The project is proving out the technology for out-of-autoclave composite cryogenic tanks, which will greatly reduce the cost and weight for future launch vehicles, enabling NASA's mission to explore deep space. The tank will soon leave the Boeing facility to head to NASA Marshall for further testing.

Pete Lillehei, principal investigator for materials and structures, takes a peak inside the tank.



Artist's rendition of optical communications.

Collaboration Key to Successful Technology "Push"

DSOC

—Denise M. Stefula

The Lunar Laser Communications Demonstration (LLCD) mission made history in October 2013 when it succeeded in transferring data at 622 Megabits per second (Mb/s), a rate six times that of comparable radio frequency systems, like going from dial up to a high-speed Internet connection. But this technological achievement in laser communications was at risk had it not been for the "push" researchers experienced when an important component, a photodiode detector, failed to perform as necessary during testing.

In the world of emerging technologies, a "push" is any activity attempting to expand on advancements to current challenges or limitations. Within NASA's Space Technology Mission Directorate (STMD), projects like Deep Space Optical Communications (DSOC) seek to do just that. When LLCD was faced with the detector failure, a potential replacement was identified—one with a challenge: it was still under development with DSOC.

The LLCD experiment, now well known for its achievement, launched onboard the Lunar Atmosphere and Dust Environment Explorer (LADEE) from NASA's Wallops Flight Facility in Virginia on September 6, 2013. A series of LLCD experiments began in late September with the first successful downlink from LADEE on September 28, just before LADEE reached lunar orbit. LLCD mission operations began in mid-October, and by October 21 six links were successfully completed.

Getting to that successful point, however, was not a straightforward path and required numerous collaborative efforts among individuals and organizations across NASA and industry.

An optical ground station is a facility designed to work in conjunction with a space-based terminal to send and receive data signals and communications.

Early in the mission life cycle, it became evident that there was a high probability of limited or no communications link opportunities for the LADEE launch due to clouds or inclement weather during the monsoon season at the optical ground station at White Sands Center in New Mexico. NASA's Space Communications and Navigation (SCaN) Office stepped in by funding a back-up ground station at the NASA/Jet Propulsion Laboratory (JPL) Optical Communications Telescope Laboratory. The JPL back-up ground station project is referred to as LLOT, or the Lunar Lasercom OCTL Terminal.

The JPL ground station has a telescope specifically designed for space optical communications experiments. The back-up station project required a demonstration only at the lowest downlink rate of 39 Mb/s. During early testing of that capability, the baselined commercial intensified photodiode detector failed to adequately detect data at 39 Mb/s.

The need to overcome this limitation was clear; fortunately the answer was already in the works.

Back in the summer of 2011, under SCaN funding, Bill Farr and Jeff Stern of JPL had begun WSi detector development in collaboration with the National Institute of Standards and Technology, building on what Farr described as NIST's "ground-breaking achievements."

"This naturally flowed into STMD's Game Changing Development DSOC project starting in the fall of 2011," said Farr. "Our DSOC project goal has been to make large arrays of WSi detectors to go behind 5- to 12-m diameter telescopes. We are presently fabricating 64-pixel arrays. At an interim step we fabricated the 8- and 12-pixel devices, which were suitable for use behind a 1-m telescope, such as at the JPL ground station."

Farr and Stern fabricated and began testing their first WSi devices at the start of March 2012.

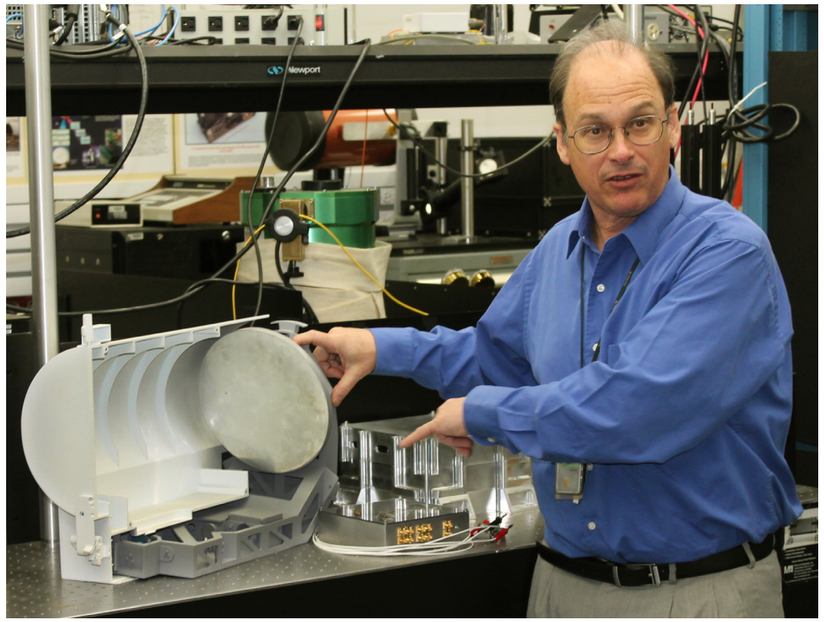
"In collaboration with NIST, by the end of April 2012 we had a record setting 93-percent system detection efficiency with single-pixel devices, and under the DARPA-funded InPho program performed a record setting 13-bits per photon demonstration using pulse-position-modulation (the preferred deep-space optical communications modulation format) with one of these devices," Farr said of the testing results.

In September 2012, after the critical nature of issues with the commercial photodiode detector was deemed insurmountable, the challenge was firmly set. The LLOT project found that to succeed, it would be necessary to switch to the WSi detector and moving forward was review-board approved.

With that approval, the push was now truly on.

Farr's own words best describe the dynamic collaborative efforts:

"I knew a local vendor, Photon Spot, Inc., (Monrovia, Ca.) starting a business in superconducting nanowire detectors. The LLOT project worked with Photon Spot to quickly assemble and lease a cryostat that would achieve the required 1-K operating temperature for the WSi detectors.



Former DSOC project manager Bill Farr in his lab at NASA JPL.

"The cryostat was delivered to JPL in April 2013. Matt Shaw and Kevin Birnbaum at JPL then led the effort under the LLOT project to get the detector array installed into this cryostat and then interfaced to the data acquisition system, which was originally selected to operate with the photodiode detector. Kevin came up with a novel interface using only off-the-shelf electronic modules in order to meet the tight project schedule and budget."

By June, the LLOT project demonstrated error-free communications and successfully completed compatibility testing of the WSi-based LLOT receiver with the Lunar Lasercomm Space Terminal engineering unit.

"An amazing 2-month integration effort by Matt and Kevin and the rest of the LLOT team," said Farr.

John Rush, director for the Technology and Standards Division of NASA's Space Communications Office, visited the JPL ground station for a final check before the LLCD experiment started. Discussions included the list of challenges the team faced in getting ready on time. "The biggest challenge was the detectors where everyone agreed that the original detectors would not have worked. But the tungsten silicide detectors that STMD invested in saved the day," Rush said.

"The new detectors now hold the world record for efficiency at 93 percent and for a mind-boggling 13 bits per photon," Rush added. "This is an excellent example of how working together we can achieve things that we can't achieve by ourselves."

Aviation Academy students visiting the HIAD exhibit flocked to play an iPad game, the object of which is to land the HIAD on a target. The first step is to slow down the spacecraft by firing thrusters to hit a window to reenter the atmosphere. Then the craft deploys the HIAD and floats down to the ground. Players can vary the parameters of the HIAD, the burn duration in re-entry, and the deployment point during descent.

Space Tech Represented at Downlink Event

HIAD

—Denise M. Stefula

Education specialists from NASA Langley visited high school students at the Denbigh Aviation Academy in Newport News, Va., on January 7 to answer questions about science and technology.

The forum offered exciting learning opportunities, one being a downlink event during which students chatted with astronauts on the International Space Station. “This is the first time we’ve ever done anything like this,” said Aaron Smith, director of the Denbigh Aviation Academy. “Every single kid I’ve talked to has been excited.”

“Kids can see what kind of jobs are out there besides the traditional professionals,” Smith continued. “For example, they actually see that there are engineers who need piloting experience. Events like this change the dynamics of a child’s enthusiasm. It allows them to create and be a part of the future.”

Among the displays and activities illustrating some of today’s groundbreaking concepts was Space Technology’s Game Changing Development project, the Hypersonic Inflatable Aerodynamic Decelerator, or HIAD.

The project focuses on developing and demonstrating inflatable aeroshell technologies, which includes flexible materials for thermal protection systems (TPS) that can withstand the high temperature conditions experienced during hypersonic entry.

Nearly 350 students participated in the event, and Project Manager Melinda Cagle was on hand to share information about HIAD. “We had almost 30 minutes with each group of students that came through the HIAD exhibit,” said Cagle.

Cagle presented a video overview of HIAD and the problem the technology hopes to solve, then interacted with students as they explored the exhibit stations. “We discussed TPS systems, how heat is generated upon reentry, and I answered questions on flexible TPS and the materials used to make them.”

NASA officials and educators are hoping that events such as these, held throughout the country each year, will encourage kids to enter fields of Science, Technology, Engineering and Mathematics, or STEM.

An Aviation Academy student reviews the vision for HIAD mission infusion while, in the background, students interact with hypersonic entry stages playing a HIAD game set up on iPads.

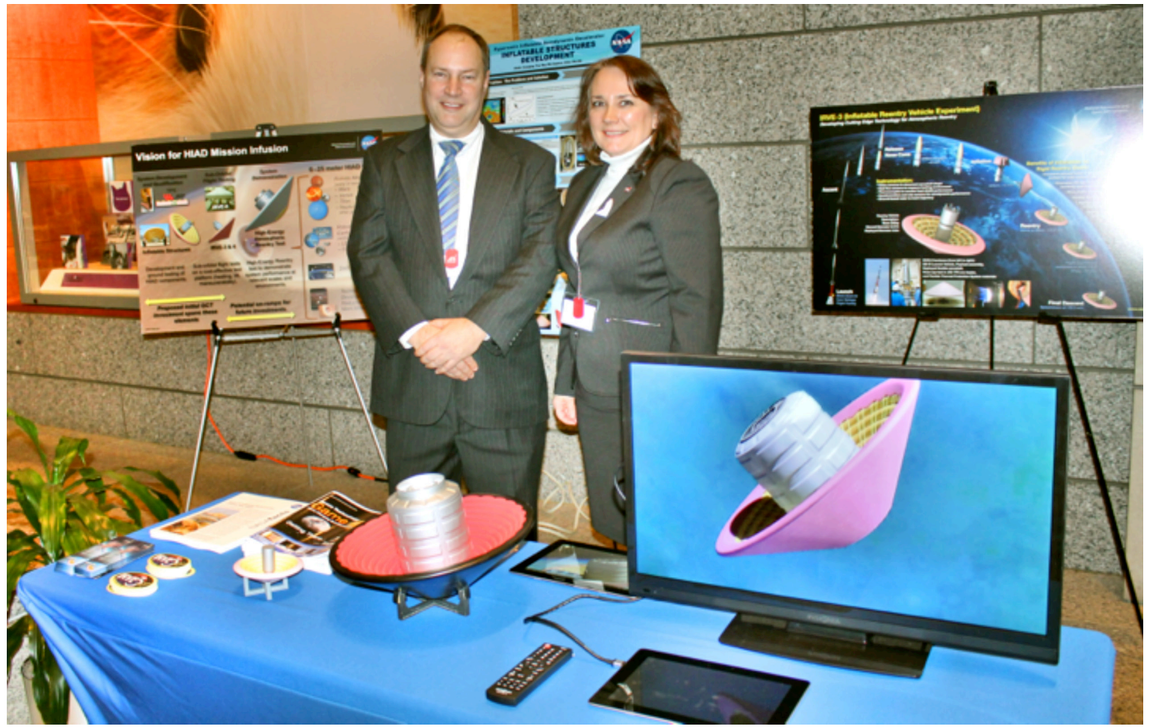
Denbigh High School’s Aviation Academy

is a specialized 4-year program to prepare highly motivated and successful high school students for a rewarding and well-paying career in engineering, aviation, electronics and technology with an emphasis on aerospace, piloting and mechanics.

HIAD Project Manager Melinda Cagle explains features of a test sample and how flexible thermal protection systems work.

Education & Public Outreach

The Advanced Space Power Systems project recently supported the Northern Ohio Energy and Innovation Summit held at NASA's Glenn Research Center in Cleveland, Oh. The summit, sponsored by Congresswoman Marcy Kaptur and the Department of Energy National Laboratories in partnership with NorTech and Case Western Reserve University, drew more than 200 representatives from nearby companies and universities. The summit showcased regional energy and manufacturing activities, highlighted federal energy resources, and pursued input on strengthening regional and national energy initiatives.



Melinda F. Cagle and Dr. F. McNeil Cheatwood represented the Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project at the 9th Annual Aerospace Day Reception in Richmond, Va., February 5-6. Cagle was part of the NASA Langley delegation, which visited members of the General Assembly. The event highlighted the important contributions Virginia is making to the aerospace community currently valued at $7.6B. Above, Cagle and Cheatwood staff the HIAD exhibit during the Aerospace Day Reception, which drew a crowd of 450.

NASA's Space Technology Mission Directorate (STMD) supported SciTech 2014 at the National Harbor, January 13-17. Keyke Reed with Technology Demonstration Missions and Amy McCluskey with Game Changing Development staffed an STMD exhibit, which included a Robonaut 2 model, Green Propellant Infusion Mission model, and 3D printed materials. SciTech, short for science and technology forum and exposition, is considered the largest event for aerospace research, development and technology in the world. More than 3,000 attended the forum, including Dr. Michael Gazarik, associate administrator for STMD, who was a speaker at the event.

http://gameon.nasa.gov

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