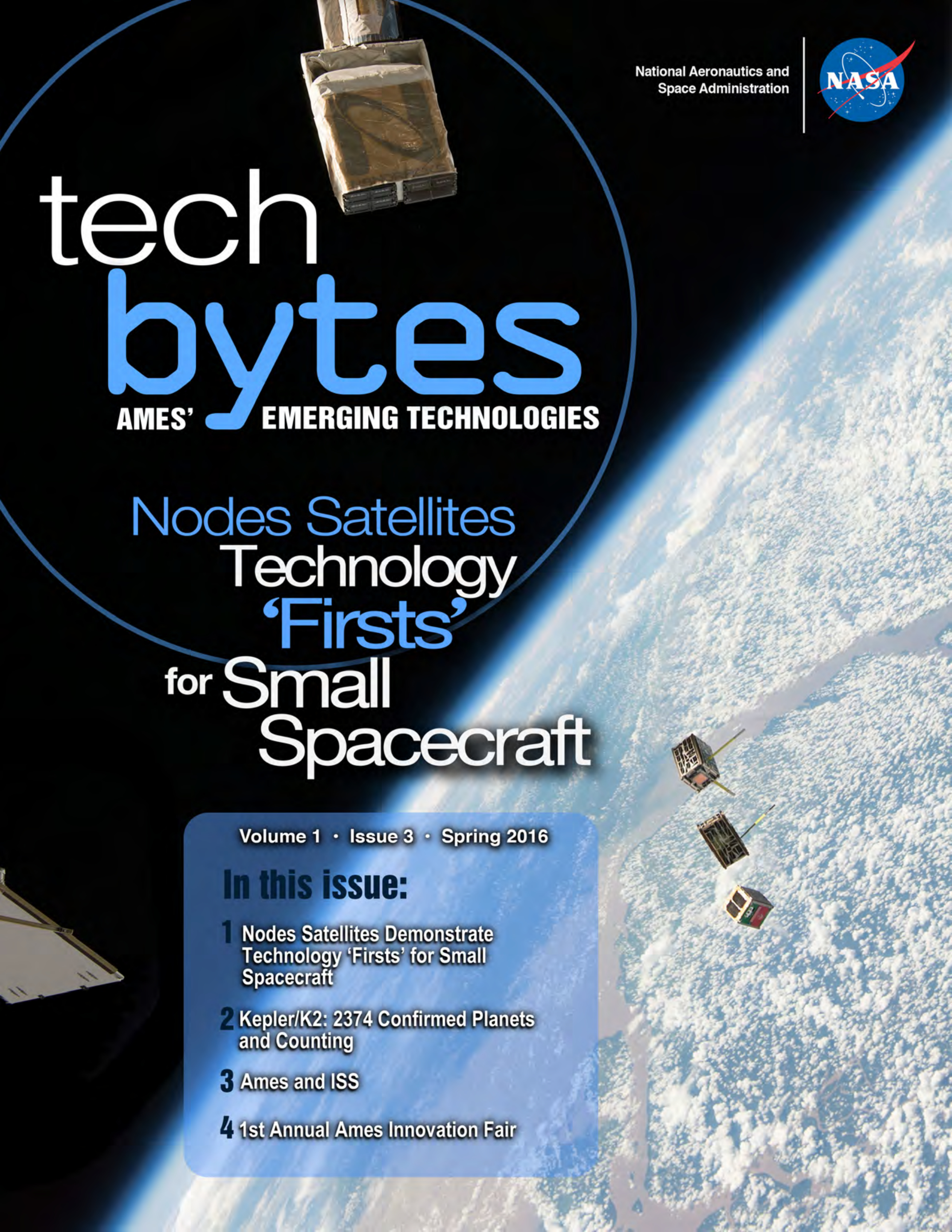

National Aeronautics and Space Administration

tech bytes

AMES' EMERGING TECHNOLOGIES

Nodes Satellites Technology 'Firsts' for Small Spacecraft

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Nodes Satellites Demonstrate Technology Firsts for Small Spacecraft

After a five-month stay aboard the International Space Station, NASA Ames' two Nodes satellites were deployed on May 16 from the NanoRacks platform and into low-Earth orbit to begin their much anticipated two-week technology demonstration. Nodes demonstrated the ability to receive and distribute commands in space from the ground, while periodically exchanging scientific data from their onboard radiation instruments, a first for small satellites. The satellites configured their data network autonomously by determining the best-suited of the two spacecraft to communicate with the ground each day of the mission. These demonstrations will enable a path toward new network capabilities for operating swarms of small spacecraft in the future.

The Nodes mission consists of two 1.5-unit (1.5U) CubeSats, each weighing approximately 4.5 pounds (2 kilograms) and measuring about 4 inches x 4 inches x 6.5 inches (10 centimeters x 10 centimeters x 16 centimeters). The satellite hardware is identical to that Ames developed for the Edison Demonstration of Smallsat Networks (EDSN) mission (a swarm of eight satellites designed to also test satellite swarm capabilities), that was lost on November 3, 2015 in the failure of the launch vehicle that was carrying them to orbit as secondary payloads. Though the hardware for the two missions is analogous, the EDSN software capabilities were enhanced for the Nodes mission. Nodes and EDSN continue the legacy of the Phonesat series that introduced the use of commercial Android smartphone technology to perform many of the spacecraft functions normally accomplished with expensive, customized electronics components.

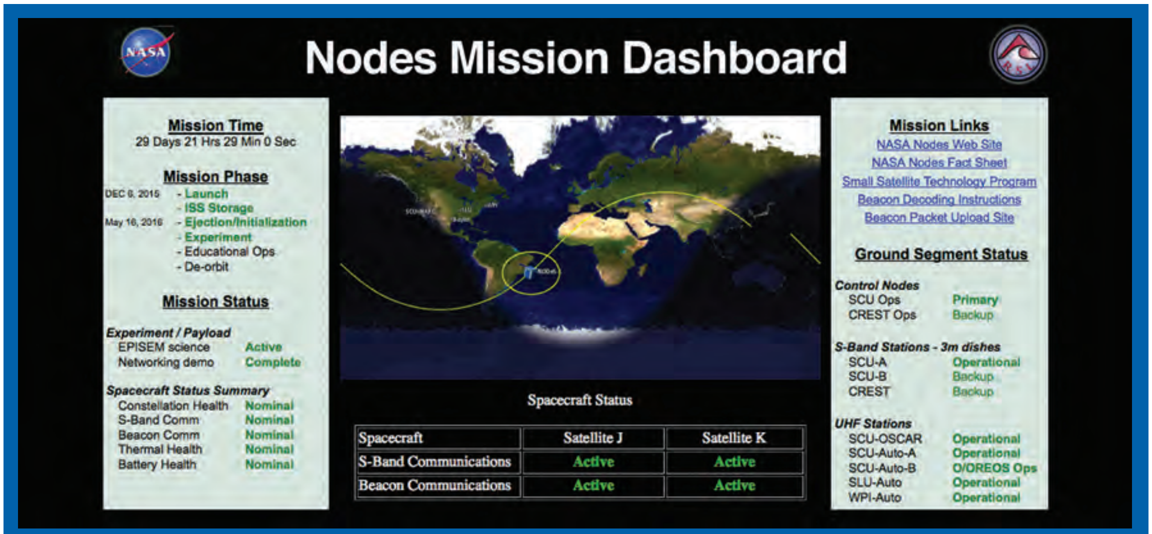
Watson Attai prepares Nodes Satellites for testing.

"The Nodes mission concept was an opportunity to leverage the excellent work done on EDSN, and extend the systems at low cost and effort," said David Korsmeyer, director of engineering at Ames. "This is the value of the small satellite model – quickly adapt to new opportunities and leverage systems for incremental missions."

The Nodes satellites performed to expectation and demonstrated technology 'firsts' that boost the capabilities of this tiny platform. Ground stations at Santa Clara University and Ames, as well as amateur radio operators around the world, received beacon packets from the Nodes containing data on the health and operational status of each satellite. And the satellites demonstrated their planned mission objectives, including three technology 'firsts' for small spacecraft: commanding a spacecraft not in direct contact with the ground by crosslinking

ABOUT THE COVER

The two Nodes CubeSats deploy from the ISS. [The third is STMSat-1, the first CubeSat developed by an elementary school (St. Thomas More Cathedral School in Arlington, Virginia).]



Online mission dashboard.

commands through a space network; cross-linking science data from one Nodes satellite to the second satellite before sending it to the ground; and autonomous reconfiguration of the space communications network using the capability of Nodes to automatically select which satellite is best suited to serve as the ground relay each day. The crosslinking 'firsts' are important milestones from both technical and operational perspectives as NASA continues its interest in developing constellations of small spacecraft for future high value science and exploration missions.

"The technologies demonstrated during this mission are important, as they will show that a network of satellites can be controlled without communicating to each satellite directly," said Roger Hunter, program manager for the Small Spacecraft Technology Program (SSTP). "Nodes will demonstrate inter-satellite communications and autonomous command and control; this will help enable future constellation command and control capabilities."

In addition, the Energetic Particle Integrating Space Environment Monitor (EPISEM) radiation sensor aboard each Nodes satellite collected data on the charged particle environment above Earth. Montana State University in Bozeman provided the EPISEM instruments under contract to NASA. The Nodes satellites demonstrated their networking capabilities through communication of this space environment data with each other and the ground.

As part of a partnership with Ames, Santa Clara University in California conducted ground operations for the mission. Acting as a ground station, the university provided an online mission dashboard (http://nodes.engr.scu.edu/) with current mission status, including operational status of satellite subsystems, ground segment communications status and satellite location tracking. Though the mission was scheduled to last for two weeks, the small satellites will remain in orbit for several more months before the satellites' orbits decay, and they re-enter and burn up in the atmosphere.

Networks of small satellites may open new horizons in astronomy, Earth observation and solar physics. Their range of applications includes multi-satellite science missions, the formation of synthetic aperture radars for Earth-sensing systems, as well as large aperture observatories for next-generation telescopes. They also can serve to collect science measurements distributed over space and time to study the Earth, the Earth's magnetosphere, gravity field, and Earth-Sun interactions.

The Nodes project is sponsored by the SSTP, within NASA's Space Technology Mission Directorate, and received additional funding from the NASA Ames Research Center. ■

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Kepler/K2: 2374 Confirmed Planets and Counting

One of the strange and wonderful things about Kepler is that when this mission launched in March 2009, no one knew for sure what it would find. It was, according to the NASA press release, "the first mission with the ability to find planets like Earth -- rocky planets that orbit sun-like stars in a warm zone where liquid water could be maintained on the surface." Were planets commonplace? If so, Kepler would find "hundreds"; if not, Kepler might find none. Kepler, NASA said, "will be our first step toward answering a question posed by the ancient Greeks: are there other worlds like ours or are we alone?"

It turns out we are most certainly not alone. There are many other worlds, and some may be very much like our own. Kepler and its extended mission, K2, have identified 2374 confirmed planets, including 1284 new planets ("the largest collection of planets ever discovered") announced in May 2016. About 950 of Kepler's confirmed planets have a radius of less than 2 Earth radii (Re) and might be rocky planets like Earth, based on their size – and some of these orbit in their sun's habitable zone. The total number of known, small, possibly rocky exoplanets in the habitable zone now stands at 21. While it was hardly the first planet-finder, Kepler can lay claim to being by far the most prolific. When it launched, a fewer than 300 exo-planets had been identified. Nearly 5000 candidates have now been found, over 3200 have been confirmed, and 2326 of the confirmed planets were found by Kepler. And the mission is far from done: An additional 1,327 of Kepler's candidates don't yet meet the mission's strict criteria for being declared a planet, but are more likely than not to be real planets and are being further investigated. And K2 continues to scan the sky for more.

The May 2016 announcement revealed another Kepler first. In the past, planetary candidates were assessed and confirmed individually. But researchers have devised a statistical analysis method that can be applied to many planet candidates simultaneously to confirm planets, and assigns a probability of planethood to each one.

This artist's concept depicts select planetary discoveries made to date by NASA's Kepler space telescope. Credits: NASA/W. Stenzel

More information about the new validation method, the number and size of exo-planets, and planets in the habitable zone can be found at:

http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=415

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Ames and ISS

Astronaut Steve Smith has traveled 16 million miles. He has performed 7 space walks totaling nearly 50 hours. He worked for IBM for 7 years. But he is still in awe of the spirit of innovation at Ames Research Center.

He arrived at Ames to take on the role of Associate Director for International Space Station (ISS) knowing that the Center had a strong connection to ISS. Nevertheless, he has been astonished at the “incredibly impressive” amount of ISS-related work Ames does, and at its variety -- all done with limited funding.

Some of the work the Center is doing is helping solve problems in space in ways that will also make people’s lives better on the planet. On the SpaceX-8 mission that launched in April 2016, for example, Ames sent 5 experiments to the space station. Among those is the Micro-10 experiment, a collaboration between NASA and the University of Southern California. The experiment attempts to determine if challenging conditions in space, particularly microgravity and high radiation, will stress fungi into developing characteristics that they would not develop on Earth; these new compounds could aid in the fight against diseases such as Alzheimer’s, Parkinson’s and cancer. The research might also lower the cost of the production of medicines.

Another current Ames experiment, WetLab-2, is designed to enable a broad range of life science investigations in space, such as the analysis of genes that indicate infectious disease, cell stress, changes in cell cycle growth and development, and/or genetic abnormality. “This system will help researchers identify changes in gene expression. This can help us determine how to mitigate negative effects of spaceflight as well as add to our knowledge about how genes work,” said Julie Schonfeld, WetLab-2 Project Manager. Rodent Research-3 (RR-3), a life science collaboration with the pharmaceutical company Eli Lilly, will study how to counter the changes in muscle

NASA astronaut and Expedition 47 Flight Engineer Jeff Williams works with the WetLab-2 system. Image Credit: NASA

mass and bone density that astronauts experience in orbit. On the ground, the research will aid in combatting numerous diseases or physical impairments that cause bone and muscle loss, including muscular dystrophy, cancer, spinal cord injury and the aging process.

Ames’ contributions to spaceflight beyond LEO and life on Earth transcend life sciences. For example, Ames experience is contributing in multiple ways to habitability in space – e.g., managing trash, washing clothing efficiently, and developing medical systems and nanosensors. On Earth, these technologies will enable people to reduce the amount of trash they produce, compact it, and turn it into reusable material; to use significantly less water to wash clothing; to detect and treat

Ali Guarneros Luna and Elwood Agasid discuss upcoming small satellite mission, including TechEdSat 5, at the 2016 Maker Faire in San Mateo. Image Credit: Julianna Fishman

Ames and ISS (continued)

diseases; and to detect dangerous chemicals and gases.

Ames has also used the ISS for technology development, including small satellites developed by Ames such as the TechEdSat series. Each TechEdSat launched from the ISS represents the culmination of a technology development effort that started with high-altitude balloons, progressed to suborbital flights, and finally graduated to orbital flights. Each iteration tested and validated different technologies: jettisoning of CubeSats from the ISS; transmission of data through an iridium short burst data modem in orbit; deployment of an exo-brake and exo-brake drag modulation; use of a new x-band telemetry system (ISM-band); deployment of a novel space camera and wireless sensor technology. These new technologies are being developed for applications ranging from autonomous on-orbit sample return to nano-sats for Mars exploration.

Smith observes that the people engaged in this research at Ames are highly motivated and stresses that the Ames team is strikingly innovative: out-of-the-box thinking "keeps us trying to do things more quickly and efficiently." ■

Expedition 43 Commander Terry Virts and Flight Engineer Scott Kelly perform operations for Rodent Research-2. Image Credit: NASA

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Techbytes Profile:

Steve Smith, Associate Director for International Space Station, Code S

Astronaut Steve Smith during the STS-103 Hubble Space Telescope servicing mission.

Steve Smith is a veteran of four space flights covering 16 million miles and seven space walks totaling nearly 50 hours. He joined NASA in 1989 in the Mission Operations Directorate. As a Payload Officer, his duties included preflight payload integration and real-time flight controller support in Mission Control. He was selected as an astronaut candidate by NASA in 1992 and then completed one year of astronaut candidate training. He graduated from Leland High School, San Jose, California, in 1977; received a Bachelor of Science degree in Electrical Engineering in 1981; a Master of Science degree in Electrical Engineering in 1982 and a Master's degree in Business Administration in 1987, all from Stanford University. See http://www.jsc.nasa.gov/Bios/htmlbios/smith-s.pdf for more information.

Q & A

TB: Why have you come to Ames?

SS: *I want to help the Ames ISS effort continue to be successful and to grow. There has been great success so far but I want to grow the size of the portfolio. I'm finding that there are 30-40 efforts across Ames – a much bigger and much more diverse portfolio than I'd anticipated.*

In addition to maintaining and increasing portfolio size, I want to grow the image and positive reputation of Ames - both within Ames, with other NASA centers, and with external spaceflight-related organizations.

Ames' location within Silicon Valley should help greatly in this.

TB: What do you perceive your role to be in accomplishing this?

SS: *I bring operational and corporate experience, and relationships with ISS program personnel that will help achieve these goals. For example, I can help to establish more communication channels between personnel at multiple centers, and shield staff from industry and bureaucratic noise.*

TB: What is your biggest challenge?

SS: *The biggest challenge in achieving these goals is a tough financial environment and large physical distance from the ISS program.*

Another big issue is that a lot of the worthy work here lacks sufficient funding.

TB: ISS is going away in the not too distant future, and research is a long-term endeavor. How can we adapt?

SS: *Always assume that we will have a place to do microgravity experimentation, assume an ISS or a similar platform will always be there even though they might be provided by a commercial or other partner.*

TB: What did you expect when you came to Ames? How was the reality different from those expectations?

SS: *I expected the work content to be different because I come from a flight/operational/engineering background and this is my first venture into science. The advancement of science is not at the same cadence and predictability as engineering projects. There's more mystery involved.*

This is my first involvement in a research environment and I'm pleasantly surprised by the great breadth of what is done here and its innovative nature. The spirit of moving quickly and creatively ahead on projects is higher than I've experienced in previous jobs.

TB: How can Ames enhance its role in human spaceflight?

SS: *We can enhance our role by finding more funding for worthy projects that improve our ability to fly beyond LEO and improve life on earth. It's a competitive environment out there and we have to prove our worth.*

TB: Anything else you'd like to add?

SS: *I want to increase our visibility - we've got a group effort to raise the awareness of ISS work here with all Ames employees. One of the reasons for this is so that other Ames organizations can understand the capabilities of the ISS to serve as a test platform for both payloads within the pressurized section of the space station and also the external environment. The ultimate goal is to make our lives better through scientific discovery.*

Finally - if you have ideas for using the ISS, even if they seem far out, please contact me! ■

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1st Annual Ames Innovation Fair

The Innovation Fair is a new approach for "seed" funding ideas at Ames and is unique in that it provides an opportunity for NASA Ames employees from all organizations to leverage peer support in order to receive management recognition. In FY2016, Ames will award $175K ($25K per award) and 1 FTE (up to 0.25 FTE per award) in total to Innovation Fair winners to advance their concepts.

Ames' 1st Annual Innovation Fair.

The Innovation Fair is a physical event with a virtual component. The physical event is a poster session style fair which was held on March 3rd. The website provides a location for knowledge sharing, discussion, and voting.

The first annual Innovation Fair was a great success. Forty-nine proposers presented their ideas to attendees outside Building 3, and attendees cast their votes for their favorite concepts. The top vote getters have now been approved for funding.

The Innovation Fair was organized by the 2015 NASA FIRST team. As an element of the agency-wide FIRST program (http://leadership.nasa.gov/nasa_first/home.htm), the Ames participants were tasked with achieving a project that had a high impact at the center. The idea for the fair came after soliciting input from center management about issues that affect the center. The FIRST team concluded that innovation can improve if collaboration is encouraged in new ways. Historically, the agency has operated as a top down organization, where selection of innovative proposals is done at the highest levels of management. However, the views and perspectives of the Ames community are also integral to innovation. While discussing the 20-year vision plan for Ames with Dean Kontinos (TS), he suggested that crowdfunding and crowdsourcing methods used in industry could be an inspiration for new methods at NASA. After several follow up conversations with others in management, the NASA FIRST team proposed to organize and execute an innovation fair where employees across all organization can pitch their innovation for funding.

Planning for the 2nd Annual Innovation Fair will now progress in parallel with innovation development for winners of year one. The FIRST team will be working to integrate with Innovation Fair with other efforts at the center, including Center Innovation Fund (CIF), Science Innovation Fund (SIF), and Convergent Aeronautic Solutions (CAS), among others.

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1st Annual Innovation Fair Winners

INNOVATION TITLE	ORG
Large Diffractive Aperture for NEA Detection *(Anthony Colprete, SST)*	Code S
Project Planning and Control System *(Thomas Paine, CP)*	Code C
ECoII: Escape * Collaborate * Innovate *(Diana Acosta, Code TI)*	Code T
Inside Ames 2.0 *(Vanessa Kuroda, RE)*	Code R
NASA Micro/NanoSatellite Cost Model *(Thomas Paine, CP)*	Code C
ADEPT-based Active Lift Guided Planetary Entry *(Sean Shan-Min Swei, TI)*	Code T
MiDAR UV - Multispectral Detection and Active Reflectance *(Ved Charayith, SG)*	Code S

The complete results can be found at the Innovation Fair website: ***https://intranet.share.nasa.gov/agency/amesinnovationfair***