CASIS™

FY17 Q4 REPORT

Quarterly Report for the Period July 1 – September 30, 2017

CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)

CASIS™

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EXECUTIVE SUMMARY

The fourth fiscal quarter (Q4) marks the end of the International Space Station (ISS) U.S. National Laboratory's 2017 fiscal year, wrapping up an unparalleled year of progress for the Center for the Advancement of Science in Space (CASIS) as managers of the ISS National Lab. Over the past quarter, CASIS engaged in a variety of high-profile opportunities to advocate for and advance the mission of the ISS National Lab, ranging from successful cargo resupply missions, to the 2017 ISS Research and Development (ISSR&D) Conference, to partnering with NASA on the cultural phenomenon of the total solar eclipse, and announcing collaborations with high-profile organizations such as Google, Lucasfilm, and Target.

KEY HIGHLIGHTS FROM Q4 INCLUDE:

- The annual ISSR&D Conference was held in July, and with record-breaking attendance and luminary speakers, this conference generated a buzz about the benefits of our orbiting laboratory in an action-filled week in our nation's capital. Located in Washington, D.C., the conference attracted several policymakers and government representatives as attendees and many more who participated in a Capitol Hill reception focused on the importance of the ISS.
- The ISSR&D Conference also provided a strong backdrop for many announcements from CASIS, such as the Target ISS Cotton Sustainability Challenge—a Sponsored Program that formally opened in September—and an announcement that Google Street View is now going beyond the boundaries of Earth. These and other announcements garnered mainstream media coverage in *Forbes, TechCrunch, The Verge, Scientific American,* and many other outlets.
- New high-profile project awards in Q4 span multiple scientific disciplines, and include awards to Time Inc., Fortune 500 pharmaceutical giants AstraZeneca-MedImmune and Sanofi Pasteur, and three academic institutions as part of the joint CASIS–National Science Foundation solicitation focused on combustion and thermal transport.
- In notable project progress, four CASIS-sponsored principal investigators published academic research articles about the results from their projects, and one company, Business Integra Technology Solutions, achieved the maximum technology readiness level (TRL 9) for their new single-board computer, SG100. The TRL advancement gained using the ISS National Lab has allowed Business Integra to begin actively marketing this new product, which has 12 times the processing capability of common low Earth orbit processors at 40% of the cost.
- CASIS and design partner Lucasfilm revealed the newest mission patch in the CASIS yearly series—a *Star Wars™*-themed mission patch. Each year, CASIS seeks to bring public visibility to the ISS National Lab through such exciting partnerships. The newest patch, featuring characters and space ships from the *Star Wars™* movie franchise, achieved enormous public visibility from *The Verge, Engadget, SyFy, ABC News, Good Morning America, GeekWire,* and others, and the announcement created a positive disturbance in the science fiction community. More from this partnership will be unveiled going into FY18.
- Finally, SpaceX's 12th cargo resupply mission lifted off and ultimately splashed down in Q4, carrying a variety of major payloads to the ISS National lab, including payloads from The Michael J. Fox Foundation, Fortune 100 company Hewlett Packard Enterprise, and a NanoRacks-sponsored commercial collaboration with the U.S. Department of Defense. Additionally, the launch included multiple payloads focused on stem cells and regenerative medicine and the fourth payload from Fortune 500 pharmaceutical company Eli Lilly & Company. Mainstream media including *Popular Science, Engadget, CNET, and CNN* wrote feature stories on various ISS National Lab payloads associated with this launch.

Overall, Q4 successes punctuate the continued productivity of existing CASIS partnerships and accentuate the services, engagement, and programmatic efforts that CASIS and the ISS National Lab can offer to new collaborators. However, although tremendous progress was made during this quarter, we were equally reminded of the sheer forces of nature that our planet can create. Hurricanes Harvey and Irma were strong reminders that family and friends are paramount. Through these ordeals, CASIS and the ISS National Lab family have grown even stronger in our compassion for one another and for those in need, and our hearts go out to those affected by the storms as we continue to move forward into fiscal year 2018.

In the spirit of family, we would like to recognize CASIS Director of Operations and Education Ken Shields, who was awarded an Outstanding Public Leadership medal by NASA in Q4, in honor of his "exceptionally high-impact leadership achievements in achieving results, serving as a role model, leading people, and influencing change." We are also honored to welcome two new members of our family: Dr. Ken Savin (formerly of Eli Lilly & Company) joined the CASIS staff, and Dr. Michael Snyder (world leader in omics research) joined our Science and Technology Advisory Panel. We are excited to begin 2018 with a strong team of motivated and experienced thought leaders, and we look forward to what is ahead.

ISS NATIONAL LAB PORTFOLIO

MAXIMIZE UTILIZATION AND DEMONSTRATE MEASURABLE IMPACT

NEWLY SELECTED PROJECTS

Eleven projects were awarded in Q4, six to commercial entities, two to academic institutions, and three in association with other government agencies. For full details on newly awarded projects, see the table beginning on page 19.

Nine states were represented in the Q4 project selections (TX, WA, MD, AL, OH, NY, GA, FL, and IN), with three new projects in Maryland. Nine of the awardees are new to the ISS National Lab. Of these, two are Fortune Global 500 companies, and three resulted from a combustion and thermal transport joint solicitation in collaboration with the National Science Foundation (NSF).

Physical Sciences

In the second of a series of yearly joint research competitions, CASIS and NSF collaborated in 2017 to facilitate research on the ISS National Lab in the fields of combustion and thermal transport. Three of the five physical sciences projects selected in Q4 are part of this collaboration, through which NSF is providing up to $900,000 to advance fundamental science and engineering knowledge in these fields to help drive the U.S. economy, enhance national security, and maintain America's position as a global leader in innovation. One project focuses on studying the physics of how flame spreads in confined spaces (such as buildings or vehicles), which could lead to better infrastructure design and improved fire codes; another seeks to enable a better understanding of cool flame propagation, which could improve combustion engine efficiency and reduce emissions; and the third will study movement of vapor bubbles using textured surfaces for heat removal, which could advance technologies for heat sinks used in electronics. This collaboration with NSF continues a strong year of working with other government agencies for CASIS, which helps maximize resources and outcomes for ISS National Lab R&D.

Additional Q4 physical sciences awards went to an industrial carbon capture project from a student startup company selected through the Rice Alliance Business Plan Competition and to a materials science project from the University of Notre Dame that may enable diverse applications in cancer therapy, energy production, and water purification.

Life Sciences

Four life sciences projects were selected in Q4, three of which are from Fortune Global 500 pharmaceutical companies AstraZeneca-MedImmune and Sanofi Pasteur. One AstraZeneca-MedImmune project is focused on a new drug delivery system using nanoparticles, and the other will study the production and stability of a specific biologic drug class during spaceflight. The project from Sanofi Pasteur seeks to improve vaccine design through advancing understanding of how the immune system works at a molecular level. An additional flight project from Emory University will build on a ground validation study that focused on using cardiac stem cells for disease modeling and personalized medicine.

Technology Development

bSpace Corporation received a technology development award in Q4 for a project that will transform a current ISS single payload site into a modular multi-use laboratory facility and CubeSat deployment system.

Education

An education project from Time Inc. was selected in Q4. Time is one of the most highly recognized names in media, encompassing iconic brands like *People, Sports Illustrated*, and *Fortune*. The project will create a new video series that builds on Time's Emmy-nominated "A Year in Space" series, taking viewers through a virtual reality-enabled first-person experience of training for and executing a spacewalk. The content will be distributed through Time's print, digital, and social media platforms and will include classroom integration with *TIME for Kids*.

For more information on all newly awarded projects, see the table beginning on page 19.

OPERATIONAL UPDATE FOR Q4FY17

Q4 marked the closing of Increment 51/52, in which the ISS National Lab set new records for payload upmass (931 kg) to the ISS and crew time utilization for payload operations (446 hours).

SpaceX launched its 12th cargo resupply mission in Q4, carrying more than 20 sponsored payloads to the ISS National Lab—including payloads from The Michael J. Fox Foundation, Fortune 500 company Eli Lilly & Company, Fortune 100 company Hewlett Packard Enterprise, and a NanoRacks-sponsored commercial collaboration with the U.S. Department of Defense. Selected highlights from the launch are detailed below.

- **Crystallization of LRRK2 under Microgravity Conditions** will optimize the crystallization of Leucine-rich repeat kinase 2 (LRRK2), a key signaling molecule in neurons tightly associated with the development of Parkinson's Disease. Solving the crystal structure of LRRK2 would provide valuable insight into the regulation of this protein and the role of mutations and would provide a template for the development of new drugs. *PI: Marco Baptista, The Michael J. Fox Foundation; Payload Developer: Bionetics Corporation*

- **Lyophilization in Microgravity: Impact on Physical Properties and Critical Quality Attributes** will examine the influence of gravity on the physical state and properties of lyophilized materials of interest to the pharmaceutical industry. Lyophilization (i.e., freeze-drying) is a common method for formulating pharmaceutical drug products with improved chemical and physical stability, and is applicable to both small and large molecule pharmaceutical products. *PI: Jeremy Hinds, Eli Lilly & Company; Payload Developer: Zin Technologies*
- **Spaceborne Computer** will entail a year-long experiment of high-performance commercial off-the-shelf computer systems on the ISS and will verify if the systems can still operate correctly during high radiation events by lowering their power and speed. *PI: David Petersen, Hewlett Packard Enterprise; Payload Developer: Hewlett Packard Enterprise*
- **NanoRacks-SMDC-Kestrel Eye IIM** is a microsatellite carrying an optical imaging system payload, including a Commercial Orbital Transportation System telescope. This investigation seeks to validate the concept of using microsatellites in low Earth orbit to support critical operations, and it is the second flagship satellite in NanoRacks' Kaber Deployment Program. *PI: U.S. Army Space and Missile Defense Command (SMDC) and Adcole-Maryland Aerospace; Payload Developer: NanoRacks, LLC*
- **Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes** seeks to evaluate a new approach to growing human tissue for transplant by using microgravity to improve cell growth and development and 3D tissue formation, enabling discoveries that will advance translational disease treatments. *PI: Robert Schwartz, University of Houston; Payload Developer: Techshot, Inc.*
- **The Effect of Microgravity on Stem Cell Mediated Recellularization** will study the effects of microgravity and radiation on mesenchymal stem cells grown on a novel scaffold of acellularized human lung tissue. A deeper understanding of the kinetics and mechanisms of delivery and bio-distribution of particles used for nanovector delivery of critical growth factors may affect ways of administering these particles on Earth. *PI: Alessandro Grattoni, Houston Methodist Research Institute; Payload Developer: Bioserve Space Technologies*
- **Intraterrestrial Fungus Growth in Space (iFUNGiS)** seeks to validate a fast-track hardware capability for molecular biology projects on the ISS, and will determine the response of a deep subsurface fungus *Penicillium chrysogenum* to growth in microgravity at a molecular level. This fungal species produces a novel penicillin-like antibiotic natural product, giving the fungus a high commercial value. *PI: Brandi Reese, Texas A&M Corpus Christi; Payload Developer: STaARS*

Student experiments launched to the ISS National Lab on SpX-12 include the following:

- A **Genes in Space** high-school science experiment from the first United Arab Emirates Genes in Space contest, sponsored by Boeing, will examine gene expression related to special repair proteins known as heat shock proteins. Many organisms manufacture heat shock proteins to protect cells from heat, cold, radiation, or other stresses, but scientists need a better understanding of the genetic switches that activate these proteins. This experiment uses a well-studied roundworm species and an advanced miniaturized DNA identification system to detect genetic expression of heat shock proteins in the high-radiation microgravity environment of space.
- **Student Spaceflight Experiments Program (SSEP) Mission 11** included MixStix investigations from 21 communities across the U.S. and Canada. A total of 22,277 students were involved in experiment design, proposal writing, and mission patch design for this mission, which results from a commercial Science, Technology, Engineering, and Math (STEM) education program overseen by the National Center for Earth and Space Science Education. (Student teams from across the U.S. design their own experiments using flight-approved fluids and materials, and the final payload consists of multiple different science experiments flown in a NanoRacks Module.)

- **National Design Challenge-3** is one of two winning experiments from a joint CASIS–Boy Scouts of America contest representing the ideas of a Chicago team made up of approximately 40 Boy Scouts and Explorers. The experiment will study how microgravity affects bacterial mutation, with potential applications in tissue growth and cancer research.

The following projects returned from the ISS on SpX-12:

- **Efficacy and Metabolism of Azonafide Antibody-Drug Conjugates (ADCs) in Microgravity** will test the efficacy of Azonafide ADCs in 3D cell cultures in microgravity, which serve as better in vivo models of tumors than terrestrial cultures and, as such, accelerate the timeline to translation applications. ADCs are toxic therapeutics that target tumors through surface receptors on cancer cells, thereby reducing toxicity and increasing the effectiveness of the therapy. *PI: Sourav Sinha, Oncolinx; Payload Developer: Bioserve Space Technologies*
- **Magnetic 3D Cell Culture for Biological Research in Microgravity** will incorporate magnetic cell culture technology into existing spaceflight hardware and optimize platform operation to support continued 3D cell growth. This endeavor will lay the foundation for a flight experiment to explore the use of magnetic nanoparticles and magnetic fields to culture cells on the ISS. *PI: Glauco Souza, Nano3D Biosciences, Inc.; Payload Developer: Bioserve Space Technologies*

Q4 also encompassed the following activities for spaceflight commercial facilities.

The **STaARS-1 Research Facility**, operated by Space Technology and Advanced Research Systems, Inc., was installed on the ISS in Q4. STaARS-1 is a multi-purpose research platform that will enable a broad range of experiments on the ISS, with the capacity to support physical science, life science, and advanced biotechnology research. STaARS-1 will facilitate novel drug discovery, drug compound production, and virulence modeling, and will support biomedical therapeutic markets through drug delivery system development, regenerative tissue engineering (stem cell technologies), and biofilm formation prevention. STaARS-1 will also support energy markets by hosting studies targeting novel biofuel production through enhanced quality and quantity of multiple compounds.

Additionally, Space Tango, Inc., installed **a second TangoLab facility**, TangoLab-2, on the ISS in Q4. The TangoLab facilities are general research platforms that hold individual CubeLab modules that support a wide range of experiments, including engineering, life sciences, and exomedicine research. TangoLab-2 joins TangoLab-1, which was installed in 2016 and will remain on the ISS, doubling Space Tango's CubeLab capacity to meet customer demand. TangoLab-2 will have minor upgrades to its airflow and heat rejection systems to enable larger heat load experiments, but its ISS interfaces will remain the same as TangoLab-1. Both facilities will be fully compatible with one another for operational flexibility.

The **ADvanced Space Experiment Processor (ADSEP)**, a new ISS biotechnology facility operated by TechShot, Inc., was launched and returned on SpX-12 to host an ISS National Lab investigation evaluating a new approach to growing human tissue for transplant. ADSEP, which contains three independent cassettes for processing biological or chemical samples in space, is not yet a permanent facility on the ISS, but it can be launched and returned allowing it to host experiments requiring a variety of capabilities such as cell culturing, bioseparation, microencapsulation, crystal growth, and fluid processing. The cassettes can be programmed for fully automated operation or remotely controlled for real-time operation, and the temperature of each cassette can be independently monitored and controlled.

In an update to their Q2 announcement regarding plans to partner with Boeing to develop the first privately funded commercial airlock for the ISS, NanoRacks, LLC, successfully closed a Bridge Round led by Space Angels, the leading source of capital for early-stage space ventures. The Space Angels investment in NanoRacks will lead to the acceleration of the **NanoRacks Commercial Airlock Module** manufacturing and increase the level of quality assurance.

PROJECT STATUS

Life Sciences

CASIS and the National Institutes of Health's National Center for Advancing Translational Sciences (NIH-NCATS) are collaborating to facilitate space-related research aimed at better mimicking human physiology, with the goal of improving our understanding of human health and disease. In Q3, five awardees were selected as part of this collaboration for spaceflight studies of tissue-on-a-chip platforms that model various health conditions, such as musculoskeletal disease, wound healing, infection, kidney dysfunction, and disease progression. The NIH-NCATS Kick-off Meeting was held in Q4 at NASA's Kennedy Space Center, which hosted the five NCATS-awarded research teams, their implementation partners, and NIH-NCATS program officials, including NCATS Director Dr. Christopher P. Austin, Associate Director for Special Initiatives Dr. Danilo A. Tagle, and Tissue Chips Program Director Dr. Lucie Low. The continued collaboration between CASIS and NIH-NCATS demonstrates further progress toward building strong partnerships with other government agencies.

Through this four-year collaboration, NCATS will provide two years of initial funding (approximately $6 million) to use tissue chip technology for translational research onboard the ISS National Lab. Awardees will be eligible for an additional two years of funding (again up to $6 million) and a second flight opportunity—the first multi-flight program of its kind. The ISS National Lab R&D portfolio contains a growing number of projects that use the effects of microgravity to advance tissue engineering efforts, including tissue-on-a-chip technology. This type of R&D is one of the main CASIS focus areas in support of low Earth orbit (LEO) commercialization, as it may enable groundbreaking advancements in healthcare, pharmaceutical effectiveness, and personalized medicine.

Two of four academic journal publications in Q4 originated from CASIS-sponsored life sciences projects. Both research teams have previously published results from their experiments, and these additional publications add further details from their findings.

- An article by Emory Researcher Dr. Chunhui Xu, published in *Stem Cell Reports*, details the critical role of an important signaling molecule—leucine-rich repeat-containing G-protein coupled-receptor (LGR5)—in the development of human pluripotent stem cells (hPSCs) into cardiomyocytes (heart cells) and endothelial (blood vessel) cells. Previous research indicates that cardiomyocyte and endothelial cell development is influenced by Wnt signaling in both the early and late stages of development. LGR5 is known to facilitate Wnt signaling, but in this report, Xu and her team connected the role of LGR5 in regulating the development of hPSCs into endothelial cells and cardiomyocytes. When levels of LGR5 were reduced, there were fewer markers indicating cardiomyocyte development, and cardiac cells differentiated poorly. In contrast, decreasing LGR5 increased the expression of endothelial cell markers and promoted the differentiation of cells into endothelial cells. Endothelial cells were also better able to form tube-like structures and take up acetylated low-density lipoproteins, processes essential for blood vessel formation. Additionally, decreasing LGR5 led to an increase in Wnt signaling genes, further decreasing the ability of hPSCs to differentiate into cardiomyocytes. Understanding the process through which the cardiovascular system develops can advance the potential for drug development and cell therapy to treat a variety of cardiovascular conditions. *(Note: Dr. Xu was also awarded a flight project in Q4 based on the success of her preflight optimization studies.)*
- An article published in *Frontiers in Microbiology* by BioServe Space Technologies researcher Dr. Luis Zea at the University of Colorado Boulder examines how space affects the growth of *E. coli* by comparing bacteria grown onboard the ISS to bacteria grown on Earth. Bacteria are a substantial component of the human body, with bacterial cells outnumbering human cells, and although some bacteria are harmless or even beneficial, other bacteria can cause disease. In individuals with suppressed immunity, such as astronauts in space, the elderly, cancer patients, or those with immunodeficiencies,

bacteria can pose an increased risk for infection. This study found that microgravity affects how cells grow as well as their resistance to antibiotics. When treated with gentamicin sulfate, an antibiotic that normally inhibits growth on Earth, *E. coli* cultured in space was still able to grow. Further, there was a 13-fold increase in the number of cells cultured in space, but they were smaller than their Earth counterparts. This decrease in cell volume has the potential to decrease the interaction between cells and molecules. Additionally, cell envelopes thickened in space, which makes bacteria more resistant to antibiotics. Space also affected how the cells grew in relation to each other. Cells on Earth were more uniformly distributed, whereas cells grown in space formed clusters. Understanding how microgravity affects bacteria can help researchers prevent bacterial infections and develop treatments for use in space and on Earth.

Also related to the life sciences, a study published in *PLOS ONE* by Dr. Macarena Parra detailed the validation of an ISS National Lab facility. This study evaluated WetLab-2, a suite of tools designed to give scientists the ability to study gene expression in orbit, which has been challenging in the past. The size of the necessary lab equipment and the complexity of transferring and mixing liquids in microgravity meant that samples needed to be returned to Earth before they could be processed and genetic analyses could be performed. WetLab-2 allows real-time analysis of samples, meaning researchers on the ground can readily know the results of their experiments. With WetLab-2, researchers can use techniques commonly employed in experiments on the ground to assess gene expression, such as reverse transcriptase quantitative polymerase chain reaction (RT-qPCR), which amplifies targeted genes so researchers can study them. Bubbles often present complications in RT-qPCR, and keeping bubbles out of samples in microgravity is challenging. Parra and her team successfully prevented bubble formation in the samples by pressurizing PCR tubes and reducing gas released during RT-qPCR. This experiment illustrates the feasibility of using WetLab-2 and processing genetic samples in microgravity, paving the way for future genetic research in LEO.

Remote Sensing

An article by Dr. Karl Fred Huemmrich published in the *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* demonstrated the success of the Hyperspectral Imager for the Coastal Ocean (HICO) instrument onboard the ISS in understanding carbon uptake in ecosystems and ecosystem productivity. Existing satellite data is infrequently collected and thus not dense enough to adequately characterize changes in carbon uptake and provide precise long-term measurements, but Huemmrich and his team showed that HICO can provide the necessary data. Archived HICO imagery from four study sites in three vegetation types (grassland, shrubland, and forest) were matched with ground tower data on atmospheric carbon and carbon storage. Data were collected throughout growing seasons from different vegetation types over several years, making measurements more robust and predictive. The data were used to develop an algorithm that relates spectrometer imagining to carbon dioxide uptake in an ecosystem, and the study demonstrated that imagery from the ISS can be used to map spatial patterns and improve understanding of ecosystem and agricultural productivity.

Technology Development

In addition to publications, ISS National Lab investigators were also successful in the commercial realm. Business Integra Technology Solutions (BI Tech), a company whose 100% commercially funded payload launched in April, achieved technology readiness level 9 (TRL 9) for their radiation-tolerant single-board computer platform, the SG100, in Q4. The primary goal of BI Tech's ISS National Lab project was to reach this TRL (possible only by testing in LEO), which allows the company to now actively market the device. The technology will provide a low-risk solution to satellite and experiment developers in all aerospace sectors at a lower cost than current, less-capable systems. The SG100 is radiation-tolerant for LEO and can function both inside and outside of the ISS as well as within LEO satellites.

It is conductively cooled, requiring only limited power use, yet its processing capabilities are 12 times faster than the common radiation-hardened computing platforms currently in use in LEO. Moreover, it will be available at 40% of the cost of these current common technologies. The market for space processors is approximately $1 billion per year, with a large percentage of that market addressable by this technology. The product is applicable to all LEO satellites, and BI Tech is now currently marketing the SG100 to both satellite manufacturers and ISS researchers. Moreover, the SG100 is ruggedized to meet the needs of applications in harsh radiation environments on the ground, and thus may be useful in defense applications.

For more information on these publications and products, see the Contributions to Scientific Knowledge and Commercial Impact tables beginning on page 18.

Portfolio Value and Impact

Last year, CASIS reported on a new initiative to better understand and characterize the value and impact of the ISS National Lab R&D portfolio, including that included the evolution of CASIS' selection methodology and criteria that were customized based on best practices across federal laboratories, commercial companies, and leading nonprofit research organizations.

The assessment model is based on relevant industry standards and best practices for evaluating outcomes in two framework dimensions:

- **Impact** – The economic value, innovation, and humankind/social benefit resulting from research conducted in space.
- **Feasibility** – The technical and commercialization challenges with the research and the overall probability of success in achieving R&D objectives.

More details can be found at http://www.spacestationresearch.com/research-on-station/proposal-process/.

For the second year in a row, CASIS assembled a panel of unpaid public and private sector R&D experts with extensive experience performing value/impact assessments for both government and commercial technology portfolios to independently evaluate the ISS National Lab portfolio using the evolved value and impact framework. This panel was held in late September, and results from this assessment (currently in preparation) will be shared in conjunction with the 2017 CASIS Annual Report release.

STIMULATING AND CULTIVATING DEMAND FOR THE ISS AND BEYOND

EXPAND THE ISS NATIONAL LAB NETWORK AND DRIVE COMMERCIAL UTILIZATION

OPEN AND UPCOMING OPPORTUNITIES

In Q4, CASIS and Target Corporation launched the ISS Cotton Sustainability Challenge. This Sponsored Program (a research competition wholly or partially funded by a third party) is a joint research solicitation allowing researchers and innovators to propose ISS National Lab R&D solutions to improve crop production on Earth. A leading retailer, Target collaborated with CASIS to invite researchers from around the country to submit concepts from the life sciences, remote

sensing, and other disciplines on how the ISS can improve cotton sustainability. Target recently pledged to source 100% sustainable cotton products by 2022, and this challenge will provide another avenue to achieve these goals. The ISS National Lab partnership with Target was announced at the 2017 ISS R&D Conference, and the ISS Cotton Sustainability Challenge was officially opened in September. Nearly 100 researchers from around the U.S. attended a CASIS-organized webinar following the launch of the challenge to learn how the ISS could be used to develop novel cotton sustainability concepts. See more at https://www.iss-casis.org/cottonsustainabilitychallenge/.

In addition, tthree projects from the joint CASIS-NSF research solicitation discussed on page 18 were awarded, and Boeing and CASIS continue to down-select candidates for flight awards made as a sidecar prize in association with MassChallenge, the largest-ever startup accelerator and the first to support high-impact, early-stage entrepreneurs without taking any equity. For the fifth year in a row, the ISS National Lab is supporting a "Technology in Space" prize associated with the MassChallenge program. For the fourth year in a row, Boeing will co-sponsor this prize, which will provide funding to technical, out-of-the-box concepts for research on the ISS National Lab. Seven companies are currently developing full proposals for consideration, and awards are expected next quarter.

Finally, in association with the NIH-NCATS Sponsored Program discussed on page 18, CASIS held a Chips in Space Mission Patch Design Challenge during Q4, open to multiple submission groups of varying ages and highlighting the promising new area of tissue-chip research. Hundreds of online submissions were received between August 9 and September 8, and almost 1,000 online votes were cast to select the top three crowd favorites from each submission group, which are now viewable online: http://www.spacestationexplorers.org/crowd-favorite-chips-in-space-mission-patch/. The official design will be selected later this year.

STRATEGIC AREAS OF FOCUS

As part of ongoing efforts to expand the ISS National Lab's network into scientific and technological communities throughout the country (such as Silicon Valley, Boston, and other established regional ecosystems), CASIS increased targeted outreach in the New York City area in 2017. In addition to locally-based ISS National Lab Fortune 500 industry partners and the recent proliferation of new space organizations, NYC is actively prioritizing economic development in commercial space and is a key geographical hub to promote space-based R&D. According to the New York City Economic Development Corporation, NYC's tech ecosystem accounts for more than 291,000 jobs and $124.7 billion in economic output and is one of the highest ranked startup ecosystems in the world. Specific ISS National Lab NYC activities in Q4 included the following.

- CASIS formed a new partnership with the New York Space Alliance (NYSA), which will connect the ISS National Lab to commercial partners, entrepreneurs, and investors. In collaboration with NYSA, CASIS hopes to establish partnerships with industry leaders and government agencies in the NYC community and mobilize support for space activities. NYSA is developing a platform to connect space entrepreneurs, mentors, and investors and provide educational tools. In addition to a recently organized virtual accelerator, NYSA is partnering with various organizations to develop customized programs. For example, the Founders Institute boot camp is a 3.5-month program that started on August 2 and is attended by space startups NYSA selected through the virtual accelerator as Star Fellows.
- CASIS attended the NYSA Board of Directors meeting and the NYSA Night of Astropreneurship Official Launch event held at Ogilvy Headquarters. At the event, NYSA unveiled its new brand and partners and hosted a panel discussion (including ISS National Lab commercial service provider NanoRacks) on NewSpace's role in tackling the challenges facing humanity.

- CASIS attended the World Maker Faire NYC, engaging with current CASIS partners (e.g., education partner Magnitude.io) and industry leaders involved in the "maker movement," a tech-influenced do-it-yourself community. Held at the New York Hall of Science, Maker Faire is primarily designed to be forward-looking, showcasing innovation and experimentation across the spectrum of science, engineering, art, performance, and craft. Maker Faire exhibitions include innovative technologies such as the Arduino microcontroller and personal 3D printing, which are driving innovation in manufacturing, engineering, industrial design, hardware technology, and education. Although many makers are hobbyists, enthusiasts, or students, many become entrepreneurs and start companies. The launch of Maker Faire in the Bay Area in 2006 demonstrated the popularity of the hands-on activities at this event, and its expansion to NYC provides an opportunity for CASIS to tap into both amateur and entrepreneurial innovation.

Additionally in Q4, CASIS planned and executed Destination Station Charleston in conjunction with NASA. Destination Station Charleston was held at the South Carolina Research Authority during the recent solar eclipse, which reached totality in this region of the U.S. The audience included representatives from commercial companies, academia, and research labs, and CASIS organized an additional industry day meeting in conjunction with the event. In support of these events, NASA and CASIS officials worked with multiple local media affiliates to promote the ISS National Lab.

For more information about these and other Q4 events, see the Conferences and Events table on page 31.

PARTNERSHIPS AND COLLABORATIONS

In Q4, CASIS staff participated in the NASA Ames Research Center 2017 Biology Workshop with the U.S. Department of Defense. The purpose of the workshop was to build interagency partnerships in the life sciences, with scientists and program leaders from both agencies presenting their research interests. This was the second in a series of three scheduled meetings, the first of which was held at the Kennedy Space Center in 2015 and the next of which is planned for 2018.

CASIS and NASA also co-sponsored a rodent research workshop during the 2017 ISSR&D Conference that focused on accomplishments in the rodent research field to date and identifying ways to advance a critical model for improving crew health in space and human health on Earth through rodent research. Attendees discussed future pathways for improving and sustaining sponsored research programs on the ISS National Lab that focused on the use and possible expansion of the rodent research model.

In addition, a Capitol Hill reception was also held during the ISSR&D conference. Congressman Babin (TX - 36th district), Congressman Bera (CA - 7th district), and Senator Markey (MA) spoke about their support of the ISS National Lab to more than 400 attendees, including approximately 70 House and Senate federal representatives and staffers. The reception featured exhibits of spaceflight hardware and promoted networking between scientists, students, and legislators.

Also in Q4, CASIS participated in the America Makes and the American National Standards Institute (ANSI) kick-off meeting to launch the second phase of ANSI's Additive Manufacturing Standardization Collaborative (AMSC). As the national accelerator for additive manufacturing (i.e., 3D printing), America Makes is driven by the National Center for Defense Manufacturing and Machining under the U.S. Department of Commerce and is the nation's leader in additive manufacturing technology research, discovery, creation, and innovation. In partnership with the private non-profit organization ANSI, America Makes seeks to tap into ANSI's network of more than 125,000 organizations and 3.5 million professionals worldwide. The AMSC kick-off meeting attended by CASIS staff included breakout discussions with stakeholders from the government and several industry sectors, including aerospace/defense, medical, ground vehicle/heavy equipment, energy, and industrial and commercial machinery.

Further strengthening ISS National Lab outreach to other government agencies, the CASIS Executive Director and Director of Commercial Innovation met with the honorable Secretary Wilbur L. Ross, Jr., Department of Commerce, in September to discuss the value of the ISS National Lab as a platform for R&D, the impact of the ISS National Lab portfolio on Earth, and the potential for future innovations as it relates to Department of Commerce mission objectives. The Department of Commerce encompasses the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and various other groups that may benefit from partnering in future ISS National Lab activities.

Investor Forum

The CASIS investor network is now at 67 members and growing. In Q4, CASIS hosted a space investment pitch event in conjunction with the ISS R&D conference. This session included a panel of experienced space investors discussing critical topics related to funding of commercial space entities and their vision on how commercial space will change in the coming years. CASIS hosted 12 commercial space startups that pitched to approximately 20 investors in attendance. A similar pitch event organized by CASIS in 2016 facilitated multiple investments representing more than $500,000 in funding.

OUTREACH AND EDUCATION

PROMOTE THE VALUE OF THE ISS AS A LEADING ENVIRONMENT FOR R&D AND STEM EDUCATION

INCREASING AWARENESS AND POSITIVE PERCEPTION

Media

During Q4, CASIS unveiled a mission patch representing all ISS National Lab research from the 2017 calendar year. Partnering with Lucasfilm, the *Star Wars*™-themed mission patch was announced, generating record visibility for CASIS in the public sector. The mission patch engaged millions over multiple platforms and received coverage from *The Verge, ABC/ ABC News, Engadget, StarWars.com, GeekWire, CNET, Yahoo, SyFy*, and others. Moving into FY18, Lucasfilm will showcase the ISS through its "Science and Star Wars" series exploring the technology introduced in the *Star Wars*™ films. One of the upcoming episodes in the 10-episode series will be dedicated to the unique capabilities and living conditions of the ISS.

Also during Q4, CASIS developed multiple launch videos in support of SpaceX CRS-12 for dissemination by NASA in advance of the launch, ultimately reaching hundreds of thousands of people around the world. Featured payloads from this mission include Hewlett Packard Enterprise's Spaceborne Computer, the Michael J. Fox Foundation's protein crystallography experiment, a lung tissue payload from a consortium of researchers headed by the Houston Methodist Research Institute, and an international Genes in Space education payload sponsored by the Boeing Company. During this launch, media outlets such as *TechCrunch, The Verge, CNN, Engadget, Tech Republic, Mashable*, and others covered this research sponsored by the ISS National Lab.

In partnership with NanoRacks, a total of 28 DreamUp student payloads were launched to the ISS National Lab on SpaceX CRS-12, and since the return of the Dragon capsule, DreamUp achievements have also received comprehensive news coverage:

- *The Ocean City Patch* and *The Current of Galloway, Egg Harbor City, & Port Republic* shared stories on Stockton University students who worked with the Student Spaceflight Experiments Program (SSEP) on "Spores in Space: The Effects of Microgravity on Endomycorrhizae."

- Rochester SSEP students were also featured in *The Democrat* and *Chronicle* (part of the *USA TODAY* network) and *News 10 WHEC* in Rochester, New York, for their experiment determining the speed of chlorophyll deterioration in microgravity.
- *News 6 WATE* out of Knoxville, Tennessee, covered the Vine Middle School student experiment, selected by SSEP, to test how microgravity affects the separation of blue-green algae from water.
- *The Chicago Tribune, CBS Chicago*, and the *Daily Herald* highlighted the design and launch of the first Boy Scout experiment ever sent into space, conducted by Troop 209 from Palatine, Illinois.

DreamUp also had several of its educational activities discussed in op-eds in several outlets, including STEM Connector (a comprehensive website and project portfolio), SpaceNews.com, Space.com, and DATAVERSITY, all promoting DreamUp's vision for building the workforce of the future by engaging students in space research.

Events

The 6th annual ISS Research and Development (ISSR&D) Conference took place this July in Washington, D.C., and the conference was the most well attended to date. More than 1,000 registrants gathered to participate in numerous forums for information exchange, including technical sessions, networking receptions, and poster presentations. A marketplace expo provided a setting for implementation partners and company representatives to discuss opportunities and capabilities that support research and development activities on the ISS. Notable speakers included Elon Musk, founder, CEO, and lead designer at SpaceX, and co-founder, CEO, and Product Architect at Tesla; Kate Rubins, NASA astronaut and molecular biologist; Robert T. Bigelow, founder and president of Bigelow Aerospace, LLC; Robert Lightfoot, NASA acting administrator; Brian Babin, U.S. representative (R-TX); Gary Peters, U.S. senator (D-MI); and Samantha Cristoforetti, European Space Agency astronaut. Leaders in the fields of space commercialization, research and development, and science and education served as expert panelists in discussions and workshops on ISS innovation and collaboration throughout the conference.

During the conference, CASIS made several major announcements that garnered national visibility, including the Target-sponsored ISS Cotton Sustainability Challenge, the award of an ISS National Lab flight project to esteemed nonprofit organization The Michael J. Fox Foundation, and the unveiling of Google's ISS Street View. The conference received media recognition from outlets including *Bloomberg, Fox Business Insider, Yahoo, Engadget, CNN, The Verge, Scientific American, The Washington Post*, and many others.

The science, technology, engineering, and mathematics (STEM) day at the ISSR&D Conference provided educational activities for local students while garnering attendee visibility for CASIS and more than a dozen Space Station Explorer consortium partners. Specific activities included:

- The Amateur Radio on the International Space Station (ARISS) program hosted a live radio chat with the ISS, and local-area students chatted with ISS crew members about living and working in space and the importance of advancing science on the orbital laboratory.
- Story Time From Space hosted a meet-and-greet with Andrea Beaty, author of *New York Times* bestselling book, "Rosie Revere, Engineer," and Astronaut Kate Rubins, who read the book during her time onboard the ISS. Story Time From Space offers a combination of science, literacy, and entertainment through its library of free, family-friendly videos. Both inside and outside the classroom, kids and families can enjoy watching and reading along with the British, French, Japanese, and American astronauts who present these stories. Thirteen children's books have flown to the space station so far.
- During the SPACE2ENGAGE session, students learned about careers in the aerospace industry, including careers not only as an astronaut but also in mission control, communications, rocket propulsion, and astronaut exercise and nutrition. Individuals currently working in the space industry shared what they love about their work, what courses and training

they received, and what advice they had that would spark student interests and help students learn more about the various aerospace-related employment positions available to them in the future.

- Additionally, a plenary session titled "How the ISS National Lab is Influencing Students and Educators" highlighted inspiring and motivated students from across the country and their experiences with the ISS.

Also in Q4, the National Scout Jamboree, held in July, showcased the broad range of activities available within Scouting. CASIS and various partner programs, including NanoRack's DreamUp, developed and participated in STEM events and activities in the CASIS tent at the Jamboree. Hundreds of scouts visited the STEM Quest tent as a part of the Space Station Explorers program.

For more information about these and other Q4 events, see the Conferences and Events table on page 31.

STEM INITIATIVES

The ISS continues to serve as a platform for the facilitation of student scientific inquiry and experimentation, thus providing an authentic connection to space for students and educators. Robust partner programs maintain their effectiveness in Q4. Selected highlights include:

- The Genes in Space Annual Competition named two winners of its third U.S. competition. In an unprecedented tie, Sophia Chen from Washington and Elizabeth Reizis from New York will both have their experiments performed aboard the International Space Station (ISS) using miniPCR technology. The innovative Genes in Space contest calls for students in grades 7–12 to design an experiment to solve a real-life space exploration challenge through DNA analysis. The competition was founded by miniPCR and Boeing and is sponsored by Math for America, CASIS, New England Biolabs, and FedEx.
  - → *Sophia Chen (age 14) from Lakeside School, Washington, will measure cancer-inducing genomic instability in astronauts. She was mentored by her ninth-grade teacher David Joneschild.*
  - → *Elizabeth Reizis (also age 14) from Stuyvesant High School, New York, will assess the effects of microgravity on the differentiation of immune system cells. Elizabeth is a student of MƒA Master Teacher Jessica Quenzer, who served as her mentor throughout the Genes in Space application process.*
- The Zero Robotics Middle School Summer Program held their program finals in August, with a tournament where the winning teams' Synchronized Position Hold, Engage, and Reorient Experimental Satellites (SPHERES) operated in space while students watched via a live feed with NASA astronauts providing real-time commentary. The program is a five-week STEM curriculum that introduces students to computer programming, robotics, and space engineering and provides hands-on experience programing SPHERES. The Zero Robotics Middle School Summer Program is provided through a partnership between the Massachusetts Institute of Technology Space Systems Lab, the Innovation Learning Center, and Aurora Flight Sciences, and is sponsored by NASA, CASIS, and the Northrup Grumman Foundation.
- The solar eclipse event on August 21 brought together CASIS Space Station Explorers program staff with author Jeffrey Bennett (from Story Time From Space) for a series of special events in Idaho Falls, Idaho over the preceding weekend and on the day of the eclipse. Other guest speakers included NASA Astronaut Alvin Drew, University of Colorado planetary scientist Nick Schneider, and University of Colorado astronomer Erica Ellingson.
- The Boston Red Sox held their annual STEM day at Fenway Park on September 14, with more than 2,500 middle and high school students from throughout New England in attendance. The highlight of the event was an ARISS ham radio conversation with European Space Agency Astronaut Paolo Nespoli. Twelve students asked Nespoli questions about life on

the ISS, what inspired him, science experiments, Earth observations, and other topics. Nespoli's picture appeared on the Jumbotron as students and teachers looked on and listened to his answers. The students also attempted to determine how hard retired Boston Red Sox star David Ortiz, also known as Big Papi, would have to hit a baseball to put it into orbit.

In addition, two new Space Station Explorer Consortium member memoranda of understanding were executed in Q4:

- Sally Ride EarthKAM (Knowledge Acquired by Middle school students) at Space Camp enables middle school students, teachers, and the public to learn about Earth from the unique perspective of space. This NASA outreach program is administered by the U.S. Space & Rocket Center, the University of Alabama in Huntsville, and Teledyne Brown Engineering. The week-long Sally Ride EarthKAM mission consists of setting up an automated camera in the Window Observational Research Facility of the ISS Destiny module. When one of these missions is announced (about four times a year), teachers register for free, and then their students submit the latitude-longitude coordinates of locations they would like photographed. After the image collection period, students receive the requested images. The student-requested images from past missions are publicly available at EarthKAM's website, www.earthkam.org.
- Higher Orbits' Go for Launch! program is an intense three-day experience that introduces students to astronauts, engineers, and other space and STEM experts. Inspired and encouraged by these mentors, students team up to solve challenges creatively and collaboratively, with the program culminating in a competition to design a science experiment that flies to the ISS. Higher Orbits is a non-profit organization that helps launch students' interests in STEM and build leadership and teamwork.

Q4 FY17 METRICS

SECURE STRATEGIC FLIGHT PROJECTS: Generate stimulated significant, impactful, and measurable demand from customers willing to cover their costs and therefore recognize the value of the ISS as an innovation platform.

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL TO DATE	TARGETS FY17
ISS National Lab payloads manifested	17	16	15	16	**64**	**100**
ISS National Lab payloads delivered	8	14	32	22	**76**	**100**
Solicitations / Competitions	1	2	0	1	**4**	**4**
Project proposals generated	31	56	11	4	**102**	**100**
Projects awarded	16	6	10	11	**43**	**40**
ISS National Lab return customers	4	4	1	2	**11**	**20**
ISS National Lab new customers	12	2	9	9	**32**	**20**
Total Value of CASIS Grants Awarded*	$1,986,869	$252,938	$669,250	$3,169,135	**$6,078,192**	**$5,000,000**
CASIS seed funding toward total project cost	29%	24%	10%	38%	**26%**	**20%**
Peer-reviewed scientific journal publications	5	1	5	4	**15**	**as they occur**
Products or services created/enhanced	1	0	0	1	**2**	**as they occur**

* Grants include awards to projects and programs as well as modifications and extensions.

SECURE INDEPENDENT FUNDING: Leverage external funding through Sponsored Programs to support ISS National Lab projects.

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL TO DATE	TARGETS FY17
Sponsored Program/external funding for grants	$1,800,000	$500,000	$0	$4,000,000	**$6,300,000**	**$5,000,000**

BUILD REACH IN STEM: Create STEM programs, educational partnerships, and educational outreach initiatives using ISS National Lab-related content.

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL TO DATE	TARGETS FY17
STEM programs (active, cumulative)	17	18	18	19	**19**	**15**
Number of students, educators, and other participants engaged in STEM initiatives	94,457	253,616	207,028	222,056	**777,157**	**500,000**
Total value of CASIS STEM grants awarded***	$205,656	$50,000	$186,317	$232,845	**$674,818**	**$400,000**

*** Total STEM grants awarded included in the Total Value of CASIS Grants Awarded figure above

INCREASE AWARENESS: Build positive perception of the ISS National Lab within key audience communities.

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL TO DATE	TARGETS FY17
Outreach events						
Conferences and industry event sponsorships	7	2	4	1	**14**	**12**
Speaking engagements	29	17	24	9	**79**	**68**
Subject matter expert workshops	1	0	1	1	**3**	**4**
Total media impact						
Thought leadership publications (white papers, trade articles, etc.)	0	0	0	0	**0**	**5**
News mentions (clips, blogs)	616	968	2,383	2,246	**6,213**	**5,000**
Twitter followers ^	103,426	106,703	109,994	114,696	**114,696**	**114,000**
Website visitors	22,353	32,788	37,046	90,530	**182,717**	**129,000**
Social media engagement (Facebook, Twitter, and Instagram)	157,250	183,105	262,250	419,278	**1,021,883**	**180,000**

^ Cumulative

MAXIMIZE UTILIZATION: CASIS to use 50% of U.S. allocation onboard the ISS.

INCREMENT	UPMASS (KG)	DOWNMASS (KG)	CREWTIME (HRS)			
	ACTUALS+	ACTUALS+	ALLOCATION*	ACTUALS++	RESERVE	USAGE**
Inc 37/38 (Sep 2013-Mar 2014)	334.7	7.9	427	78.42	-	18%
Inc 39/40 (Mar 2014-Sep 2014)	389.1	197.8	386	70.75	-	18%
Inc 41/42 (Sep 2014-Mar 2015)	716	705.5	346	130.29	-	38%
Inc 43/44 (Mar 2015-Sep 2015)[1]	538.3	165.93	229	223.33	-	98%
Inc 45/46 (Sept 2015-Mar 2016)	384.6	0	293	125.75	-	43%
Inc 47/48 (Mar 2016-Sept 2016)	760.9	313.54	356	314.25	-	88%
Inc 49/50 (Sept 2016-Mar 2017)	392	83	403[2]	311.58	-	77%
Inc 51/52 (Mar 2017-Sept 2017)	931	300	328	446.58	-	136%
Inc 53/54 (Sept 2017-Mar 2018)	***1580***	***358***	***503***	***349***	***165***	***54%***

Data through 7/5/2017

\+ *"Actuals"* are based on the summation of payload mass for ascent and descent as reported by the NASA ORBIT RIFD tool for the National Lab sponsor.

* *"Allocation"* is defined as the baseline number of crew time hours allocated by NASA at increment minus 3 months to the ISS National Lab for prioritized utilization to directly support in-orbit ISS National Lab payload utilization operations.

++ *"Actuals"* are defined as the definite and verified number of crew time hours that were utilized to support in-orbit ISS National Lab payload utilization operations. This data is collected, reported, and verified by NASA after the actual in-orbit operations have been completed. The crew time hours do not include crew time spent on shared resources or facilities.

** *"Usage"* is defined as the percentage of ISS National Lab allocated crew time hours that were actually utilized during a given increment pair.

Notes:

1. Incudes SpaceX CRS-7 upmass/downmass
2. Inc 49/50 I-3 crew time allocation was 312 hours. Additional crew time allocation was added over the course of the increment pair.

CONTRIBUTIONS TO SCIENTIFIC KNOWLEDGE – RESULTS PUBLISHED

Title: Downregulation of LGR5 Expression Inhibits Cardiomyocyte Differentiation and Potentiates Endothelial Differentiation from Human Pluripotent Stem Cells **Principal Investigator:** Dr. Chunhui Xu **Institution:** Emory University School of Medicine **Location:** Atlanta, GA **Resulted from:** A preflight validation project awarded as part of CASIS RFP 2013-3 "The Impact of Microgravity on Fundamental Stem Cell Properties"	**Description:** This study focused on the role of a leucine-rich repeat-containing G-protein coupled receptor (LGR5) in the differentiation of cardiomyocytes and endothelial cells from human pluripotent stem cells (hPSCs). Previous research has indicated the importance of Wnt signaling pathways, which are potentiated by LGR5 during the early and late stages of differentiation. This study found that down regulation of LGR5 reduced the presence of markers associated with cardiomyocyte differentiation but increased differentiation in endothelial-like cells, confirming the role of LGR5 in the development of cardiomyocytes and endothelial cells. **Earth Benefit:** Better understanding how hPSCs differentiate into endothelial cells and cardiomyocytes can offer key insights into how the cardiovascular system develops. With heart disease being one of the leading causes of death in the United States, understanding the development of the cardiovascular system is critical, and findings can be applied to regenerative medicine, disease modeling, and drug discovery.
Title: Phenotypic Changes Exhibited by E. coli Cultured in Space **Principal Investigator:** Dr. David Klaus **Institution:** University of Colorado Boulder **Location:** Boulder, CO **Resulted from**: CASIS-awarded Proposal "Using the International Space Station to Evaluate Antibiotic Efficacy and Resistance"	**Description:** This paper identified the phenotypic differences between a bacterium, *Escherichia coli*, grown in space and on Earth, specifically looking at changes in cell density, cell size, cell envelope thickness, cell ultrastructure, and cell morphology. Bacteria may not be directly impacted by microgravity, but changes in the fluid boundary layer surrounding the cell cause cells to alter how they interact with each other and their environment (e.g., instead of convection, diffusion becomes the primary means of transport and communication). Compared with ground controls, this study reported a 13-fold increase in cell count in the bacteria cultured in space when treated with a normally inhibitory amount of the antibiotic gentamicin, a 37% decrease in cell volumes, a 25% to 43% increase in cell envelope thickness, and a shift from being homogenously distributed in culture to forming clusters. **Earth Benefit:** With bacterial cells outnumbering human cells in the body, gaining knowledge about the growth patterns of *E. coli* in space can have significant impacts on the health of astronauts in space and people on Earth. In microgravity, bacteria are generally less susceptible to antibiotics, so observing their growth in space helps to identify new molecular targets for drugs to combat infections and antibiotic resistance here on Earth.

Title: Microgravity validation of a novel system for RNA isolation and multiplex quantitative real time PCR analysis of gene expression on the International Space Station **Principal Investigator:** Dr. Julie Schonfeld **Institution:** NASA Ames Research Center **Location:** Moffett Field, CA **Resulted from:** A validation study associated with an enabling technology onboard the ISS National Lab	**Description:** This paper validates WetLab-2, a suite of molecular biology laboratory tools and reagents, including a novel fluidic RNA sample preparation module and fluid transfer devices, all-in-one lyophilized PCR reagents, centrifuge, and a real-time PCR thermal cycler designed to analyze and process genetic samples in real time onboard the ISS. This study demonstrates the use of WetLab-2 onboard the ISS by performing quantitative PCR (qPCR) and reverse transcriptase-qPCR on RNA extracted and purified from the bacterium *E. coli* and from mouse liver tissue while on the ISS. Multiplex analysis of the samples was completed in 3 hours, and data was transmitted in 2 hours, while bubble formation was successfully suppressed using pressurized PCR tubes, thus indicating the potential for WetLab-2 use in future genetic studies onboard the ISS. **Earth Benefit:** Research in microgravity using new molecular biology tools can offer insight into how microgravity affects gene expression for a range of health applications, from bacterial virulence to changes in muscle mass in rodents, and can help researchers understand diseases affecting people on Earth. The WetLab-2 suite validated in this experiment streamlines the process of answering these research questions because samples can be processed onboard the ISS rather than being sent back to Earth, saving both time and money.
Title: ISS as a Platform for Optical Remote Sensing of Ecosystem Carbon Fluxes: A Case Study Using HICO **Principal Investigator:** Dr. Karl Fred Huemmrich **Institution:** University of Maryland, Baltimore County **Location:** Baltimore, MD **Resulted from:** A project that was awarded as part of a 2013 CASIS research solicitation	**Description:** This study uses data collected from the Hyperspectral Imager for the Coastal Ocean (HICO) onboard the ISS to better understand how ecosystems respond to environmental stress by monitoring carbon fluxes and how efficiently plants use light during photosynthesis. A total of 26 HICO images from four study sites in three vegetation types (grassland, shrubland, and forest) were used to compare gross ecosystem production (GEP) estimated from eddy covariance data to data from HICO-derived spectra. This study confirmed the robustness of several algorithms used to analyze HICO spectral data—including spectral vegetation indices and data collected and integrated from different observation angles, growing seasons, times of day, and years —to successfully map spatial patterns of GEP. **Earth Benefit:** Observations gained from remote sensing provide insight into the productivity and health of ecosystems and agriculture over various time scales, such as diurnal and seasonal, as well as fluctuations in carbon dioxide as it relates to climate change. Because the ISS flight path covers densely populated and agricultural areas, remotely measuring carbon dioxide uptake in ecosystems from the ISS provides a global perspective on overall changes in the system across time.

COMMERCIAL IMPACT – PRODUCTS OR SERVICES CREATED OR ENHANCED

Product: SG100 **Principal Investigator:** Trent Martin **Institution:** Business Integra Technology Solutions **Location:** Houston, TX **Resulted from:** A 100% commercially funded ISS National Lab payload	**Description:** The SG100 is a radiation-tolerant single-board computer platform that can support the much higher processor demands of current and future scientific and aerospace applications in low Earth orbit (e.g., satellite and experiment developers). The ISS National Lab project advanced the product's technology readiness level (TRL) from TRL 7 to TRL 9 (the highest level), enabling the principal investigator and his company to actively market the product. **Earth Benefit:** For satellite developers and investigators using the ISS for R&D, the SG100 will remove limitations in processing capability imposed by the radiation-hardened computer platforms currently in use in low Earth orbit—improving processing capability 12-fold at 40% of the cost. The market for space processors is approximately $1 billion per year, with more than 50% of that market addressable by this technology. Moreover, the advancement of the SG100 to TRL 9 required ruggedizing the technology, which makes it additionally capable of operating in high-radiation environments on Earth.

PROJECTS AWARDED IN Q4 FY17

Title: Design of Scalable Gas Separation Membranes via Synthesis under Microgravity **Principal Investigator:** Negar Rajabi **Affiliation:** Cemsica **Location:** Houston, TX	**Description:** Membrane separation is among the most energy-efficient and cost-effective technologies for removing carbon dioxide from waste gases to reduce greenhouse gas emissions. Cemsica has developed a novel approach to synthesize *de novo* nanoporous membranes using particles of calcium-silicate (C-S) to separate carbon dioxide gas molecules from air or other gases. By leveraging microgravity onboard the ISS to synthesize nanoporous C-S materials, this project aims to resolve existing challenges in membrane manufacturing to develop lower cost membranes with improved flux and high-temperature stability. **Earth Benefit:** By applying lessons learned from the synthesis and performance of C-S nanoporous membranes in microgravity, Cemsica aims to improve manufacturing on Earth to make flawless, high-performance membranes for use under extreme conditions on Earth. This project may lead to improvements in the design and manufacture of cost-effective, eco-friendly membranes that significantly benefit fossil-fuel power plants and gas separation technologies, resulting in reduced greenhouse gas emissions by separating and capturing carbon dioxide.

Title: ARQ: A Platform for Enhanced ISS Science and Commercialization **Principal Investigator:** Jason Budinoff **Affiliation:** bSpace Corporation **Location:** Seattle, WA	**Description:** The bSpace ARQ is an external commercial platform for small satellite deployment and hosting. ARQ is launched to the ISS on commercial resupply services (CRS) contract launches and is berthed to the exterior of the space station with the Special Purpose Dextrous Manipulator robotic arm. ARQ can deploy single satellites or entire constellations—up to 200 small satellites per launch—with no crew time needed. ARQ can also host several experiment payloads on the exterior surface of the platform and within the thermally controlled interior. ARQ generates virtual reality video, providing visual assessment of satellite launches and hosted payloads. Experiment data is downlinked from ARQ the same day it is collected via a dedicated high-speed laser communications terminal, allowing users to rapidly access data. **Earth Benefit:** ARQ is a cost-effective platform in space for the launch of small satellites and satellite constellations. As a platform for technology development and commercial innovation, ARQ can be leveraged by a wide variety of markets for a multitude of applications, including Earth survey imagery (UV/infrared/optical/radar), Earth and atmospheric spectroscopy, global weather mapping (enabling more accurate predictions that provide more time for disaster preparedness, reducing loss of life and property and saving insurance companies billions of dollars), global infrastructure management, global data and communications access (delivering internet access to billions of people in data-poor regions), precision Earth and astronomical observation, materials science testing, technology validation, and exploration of biological phenomena in the space environment. The overall space economy, the satellite service sector, and Earth observation data collection are all growing, and the sizes of small satellites are increasing; however, delays by launch providers and satellite operators remain, highlighting the need for frequent dedicated small satellite launch vehicles.
Title: Spherical Cool Diffusion Flames Burning Gaseous Fuels **Principal Investigator:** Peter Sunderland **Affiliation:** University of Maryland, Department of Fire Protection Engineering **Location:** College Park, MD	**Description:** Cool diffusion flames (flames burning at temperatures below 400°C) were first observed in space during experiments onboard the ISS in 2012. Although cool diffusion had been observed in earlier drop tower experiments, cool flames had never been observed as steady spherical flames because drop tower experiments had uneven burn rates. This project seeks to increase a fundamental understanding of the physics of cool diffusion flames by observing quasi-steady spherical flames on porous burners in microgravity. **Earth Benefit:** Internal combustion engines burning fossil fuel power most of the world's transportation and manufacturing. Most of these engines are designed for efficiency using computer models that neglect cool flame chemistry because the phenomenon is not well known or characterized. An improved understanding of combustion processes incorporating cool flame propagation will improve combustion engine efficiency and reduce emissions on Earth.
Title: Thermally Activated Directional Mobility of Vapor Bubbles in Microgravity **Principal Investigator:** Sushil Bhavnani **Affiliation:** Auburn University **Location:** Auburn, AL	**Description:** This project will use small textured surfaces to passively move vapor bubbles (gas) in microgravity to test the hypothesis that some surfaces passively enable and enhance the mobility of vapor and thereby increase the removal of heat from surfaces. The textured surfaces here take the form of repeating millimeter-scale asymmetric ratchets with 30°–60° faces. **Earth Benefit:** As electronics become smaller and more densely packed, removing heat becomes more difficult. This work will advance fundamental knowledge of boiling (bringing a liquid to the temperature at which it bubbles and turns to vapor) under the influence of surface-tension-dominated and gravity-dominated regimes. The long-term goal is to develop simple, passive, self-regulating, micro-structured surface technologies for heat sinks used in consumer electronics and electronics for military and commercial aircraft.
Title: Study of the Interactions between Flame and Surrounding Walls **Principal Investigator:** Dr. Ya-Ting Liao **Affiliation:** Case Western Reserve University **Location:** Cleveland, OH	**Description:** This project aims to study flame spread in confined spaces—specifically the interactions between spreading flames and surrounding walls. Flame spread in confined spaces (such as buildings and vehicles) may pose a more serious fire hazard than flame spread in open spaces because of acceleration caused by radiative heat feedback from the surrounding walls and a tunnel flow acceleration effect. However, several aspects of flame spread are difficult to study in normal gravity conditions. Gravity-driven buoyancy flow complicates the fire growth process and prohibits a fundamental understanding of the underlying physics. However, in microgravity, buoyancy is eliminated, allowing scientists to better study the physics of flame spread. **Earth Benefit:** A better fundamental understanding of flame spread in confined spaces could lead to better infrastructure design and improved fire safety codes, which could help prevent injury, save lives, and reduce property loss from fire. The results of this project may be applicable to multiple markets, from consumer products to construction of structures and vehicles, and any application in which fire may damage property or affect the safety of human occupants.
Title: Spacewalk: A Virtual Reality Experience **Principal Investigator:** Mia Tramz **Affiliation:** Time Inc. **Location:** New York, NY	**Description:** This project will build on TIME's Emmy-nominated "A Year in Space" series to create a new virtual reality (VR) and video series called "Spacewalk: A VR Experience" that will document the journey of astronauts as they train for and then execute a spacewalk from the ISS. TIME and LIFE VR will use specialized VR camera systems to capture ground footage of astronauts training in the Neutral Buoyancy Lab and flight footage on the ISS of crew members going through the airlock and completing tasks during a spacewalk. The video series will not only be entertaining but also educational, and the project includes the development and distribution of complementary curriculum through *TIME for Kids* for classroom integration. The series will be promoted and distributed across TIME's print, digital, and social media platforms, which achieved more than 1 billion streams in April 2017. The goal is to provide TIME's vast audience with multiple entry points to the intimate first-person experience of a spacewalk. **Earth Benefit:** This project will create an unprecedented evergreen educational tool to inspire and educate children and adults about the mechanics of preparing for and conducting a spacewalk, life on the ISS, and the important work being done on the space station. The series will be distributed across multiple VR and 360 platforms for maximum exposure, leveraging TIME's expected 10 billion video views in 2017.

Title: Generation of Cardiomyocytes from Human Induced Pluripotent Stem Cell-Derived Cardiac Progenitors Expanded in Microgravity **Principal Investigator:** Dr. Chunhui Xu **Affiliation:** Emory University **Location:** Atlanta, GA	**Description:** This project will study the generation of cardiomyocytes, specialized heart muscle cells, for use in research and clinical applications. Specifically, the team is studying the differentiation of these heart cells from induced pluripotent stem cells (iPSCs), adult cells that have been altered to reinstate characteristics of natural stem cells. Simulated microgravity studies have allowed the team to increase the yield, purity, and survival of cardiomyocytes derived from iPSCs, and true spaceflight conditions are expected to further enhance these effects. Understanding how microgravity improves cardiomyocyte differentiation will enable the team to create clinically relevant heart tissue for use in regenerative medicine, disease modeling, and drug discovery. **Earth Benefit:** Cardiovascular disease is the number-one cause of death worldwide, and cardiomyocytes derived from human iPSCs represent a promising cell source for cardiovascular disease modeling, regenerative medicine, and drug discovery. Ground studies using simulated microgravity demonstrated improved cardiomyocyte growth and differentiation, and spaceflight experiments promise to enable rapid advancement toward clinical applications for cardiovascular disease, a global market that is expected to grow from $13.7 billion in 2012 to $18.2 billion by 2019.
Title: Preparation of PLGA Nanoparticles Based on Precipitation Technique in Microgravity **Principal Investigator:** Dr. Puneet Tyagi **Affiliation:** AstraZeneca-MedImmune **Location:** Gaithersburg, MD	**Description:** Drug delivery systems that provide targeted and controlled-release have many advantages over conventional multi-dose therapy. This project seeks to advance a novel drug delivery system that uses nanoparticles as carriers for drugs. Small solid particles or liquid droplets containing a therapeutic substance can be enclosed within a shell, providing controlled drug release and targeted drug delivery. Particle size and size distribution are key to improving these particle-based drug delivery systems and can be manipulated in microgravity. This project will evaluate a proprietary method of nanoparticle formation in microgravity to better understand nanoparticle fabrication, particle size, and particle size distribution, toward improved drug formulations with greater uptake and efficacy and tolerability by patients. **Earth Benefit:** Therapeutic cancer vaccines (a type of immunotherapy) treat cancer by strengthening the body's immune response. The ability to further refine the manufacturing process to produce vaccine therapies with improved delivery profiles and efficacy would significantly benefit patients in terms of quality of life and the potential for extended survival. Furthermore, optimized processes for nanoparticle formation may reduce manufacturing costs and provide opportunities for expanded access to these therapeutics, given the reduced costs to patients and healthcare systems. The global immunotherapy drug market is expected to exceed $197 billion by 2020, with the global vaccine market accounting for $60 billion.
Title: Monoclonal Antibody Production and Stability in Microgravity **Principal Investigator:** Dr. Albert Ethan Schmelzer **Affiliation:** AstraZeneca-MedImmune **Location:** Gaithersburg, MD	**Description:** This project aims to study the effect of microgravity on the production of monoclonal antibodies (mAb), a type of therapeutic drug used to treat cancer and autoimmune diseases. Chinese hamster ovary (CHO) cells are the most commonly used host cells for mAb production. Understanding the effect of microgravity on CHO cell gene expression and mAb secretion may have important applications for mAb manufacturing. Microgravity-induced changes in the genetic and secretory pathways of CHO cells could be harnessed to increase antibody production from CHO cells. This project will also study the effects of spaceflight on mAb therapeutic stability to better understand routes of antibody degradation, toward the development of more stable mAb formulations. **Earth Benefit:** Therapeutic antibodies are the fastest growing type of drug treatment, with more than 300 therapeutic antibodies currently entering clinical practice. At the current approval rate of about four new mAb products per year, approximately 70 mAb products will be on the market by 2020, and combined worldwide sales will be nearly $125 billion. A significant percentage of the high consumer cost of biopharmaceuticals is due to the complex and costly manufacturing required. Results from this project could increase understanding of mAb production and stability in microgravity, which could affect biopharmaceutical development and mAb manufacturing.
Title: Influence of Gravity on Human Immune Function in Adults and the Elderly **Principal Investigator:** Dr. Donald Drake **Affiliation:** Sanofi Pasteur **Location:** Orlando, FL	**Description:** This project seeks to gain a broad understanding of how gravity affects overall human immune function and potentially uncover novel pathways of immune function that can be exploited to develop better vaccines and immunobiologics for human use. The project will build on earlier studies that evaluated lymphocyte (a type of white blood cell) function in microgravity. The project will also evaluate whether gravity-regulated immune pathways are affected by age by examining cells from young adult and elderly donors in parallel. **Earth Benefit:** According to the World Health Organization (WHO), the global market for vaccines more than quadrupled in value from $5 billion in 2000 to almost $24 billion in 2013, with the global market projected to rise by $100 billion by 2025. WHO estimates that immunization saves two to three million lives worldwide every year. New insights into vaccine development provide opportunities to eradicate more diseases over time, with significant savings to the healthcare system and improvement in quality of life. In 2013, the economic impact in the U.S. attributable to adult vaccine-preventable diseases for adults ages 50 and older was $26.5 billion ($15.3 billion for those 65 and older). A significant factor contributing to the slow evolution of vaccinations in older adult populations is a lack of understanding of the benefit of vaccines related to aging. A better understanding of the mechanisms involved in vaccines and aging could result in broader vaccination of older adult populations, ultimately resulting in significant savings to the healthcare system and improved quality of life for older adults.

Title: The Impact of Nanostructure Geometry on Photo-Thermal Evaporation Processes **Principal Investigator:** Dr. Tengfei Luo **Affiliation:** University of Notre Dame **Location:** Notre Dame, IN	**Description:** This project seeks to understand the fundamental relationship between geometry (i.e., size, shape, and inter-particle spacing) and the process of bubble formation during evaporation in very small (i.e., nano) particles with interesting structures. Nanoparticles with a high electron density may form plasmonic nanostructures (NSs) that promote bubble formation when heated by light (or optical excitations due to localized surface plasmon resonance effects). This experiment will observe bubble dynamics in the NS-assisted photo-thermal phase change process in the absence of gravity. **Earth Benefit:** Plasmonic NS-assisted photo-thermal liquid-to-vapor phase transition is fundamental physics research that may one day enable many groundbreaking applications. For example, this physical process can be used to develop highly selective new cancer therapies and new processes for distillation-based desalination and water purification utilizing solar irradiation as the photoexcitation source.

Q4 FY17 PROJECT PIPELINE

VALIDATION STUDIES AND GROUND TESTING

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	CITY	STATE
3D Neural Microphysiological System	Dr. Michael Moore	AxoSim Technologies	New Orleans	LA
National Design Challenge-4: Space Station STEM Challenge	Mathew Weaver	Collins Middle School	Salem	MA
Remote Controlled Nanochannel Implant for Tunable Drug Delivery	Dr. Alessandro Grattoni	Houston Methodist Research Institute	Houston	TX
Improving Astronaut Performance of National Lab Research Tasks	Dr. Jayfus Doswell	Juxtopia, LLC	Baltimore	MD
Interrogating the Protein Response in Microgravity-Induced Osteoporosis	Dr. Imran Mungrue	Louisiana State University Health Sciences Center	New Orleans	LA
Classrooms in Space ExoLab	Ted Tagami	Magnitude.io Inc.	Berkeley	CA
Orion's Quest-Student Research on the ISS	Peter Lawrie	Orions Quest	Canton	MI
Combined Evaluation of Mouse Musculoskeletal Data	Dr. Virginia Ferguson	University of Colorado Boulder	Boulder	CO
Faraday Waves and Instability-Earth and Low G Experiments	Dr. Ranga Narayanan	University of Florida Board of Trustees	Gainesville	FL
3D Organotypic Culture System	Dr. Rocky S. Tuan	University of Pittsburgh	Pittsburgh	PA

PREFLIGHT

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) Tether – Slosh	Hans-Juergen Zachrau	AIRBUS DS Space Systems, Inc.	SpX-13	11/28/17	Webster	TX
Materials International Space Station Experiment (MISSE) Flight Facility	LD Stevenson	Alpha Space	SpX-13	11/28/17	Houston	TX
Barley Germination and Malting in Microgravity	Gary Hanning	Anheuser-Busch	SpX-13	11/28/17	New York	NY
Implantable Nanochannel System for Delivery of Therapeutics for Muscle Atrophy	Dr. Alessandro Grattoni	Houston Methodist Research Institute	SpX-13	11/28/17	Houston	TX
Assessing Osteoblast Response to Tetranite	Dr. Nikolaos Tapinos	LaunchPad Medical	SpX-13	11/28/17	Boston	MA
Optical Fiber Production in Microgravity	Michael Snyder	Made In Space, Inc.	SpX-13	11/28/17	Moffett Field	CA
Characterizing Arabidopsis Root Attractions (CARA) grant extension	Dr. Anna-Lisa Paul	University of Florida Board of Trustees	SpX-13	11/28/17	Gainesville	FL
Comparative Real-time Metabolic Activity Tracking	Dr. Gary Sayler	490 Biotech	SpX-14	2/9/18	Knoxville	TN

National Design Challenge - 3: Chicagoland Boy Scouts and Explorers	Norman McFarland	Boy Scouts of America	SpX-14	2/9/18	Chicago	IL
Fiber Optics Manufacturing in Space	Dr. Dmitry Starodubov	FOMS, Inc.	SpX-14	2/9/18	San Diego	CA
Microbial Corrosion from Biofilms	Vic Keasler	Nalco Champion	SpX-14	2/9/18	St. Paul	MN
Microgravity Crystal Growth for Improvement in Neutron Diffraction	Dr. Timothy Mueser	University of Toledo	SpX-14	2/9/18	Toledo	OH
Capillary-Driven Microfluidics in Space	Dr. Luc Gervais	1Drop Diagnostics US, Inc.	TBD	TBD	Boston	MA
Corrosion Inhibitor Exposed to the Extreme Environments in Space	Lauren Thompson Miller	A-76 Technologies, LLC	TBD	TBD	Houston	TX
SiC Microgravity Enhanced Electrical Performance	Rich Glover	ACME Advanced Materials	TBD	TBD	Albuquerque	NM
Multi-purpose Active-target Particle Telescope on the ISS	Hans-Juergen Zachrau	AIRBUS DS Space Systems, Inc.	TBD	TBD	Webster	TX
Endothelial Cells In Microgravity for Evaluation of Cancer Therapy Toxicity	Dr. Shou-Ching Jaminet	Angiex	TBD	TBD	Cambridge	MA
Preparation of PLGA Nanoparticles Based on Precipitation Technique in Microgravity	Dr. Puneet Tyagi	AstraZeneca-MedImmune	TBD	TBD	Gaithersburg	MD
Monoclonal Antibody Production and Stability in Microgravity	Dr. Albert Ethan Schmelzer	AstraZeneca-MedImmune	TBD	TBD	Gaithersburg	MD
The Universal Manufacture of Next Generation Electronics	Dr. Supriya Jaiswal	Astrileux Corporation	TBD	TBD	La Jolla	CA
Thermally Activated Directional Mobility of Vapor Bubbles in Microgravity	Sushil Bhavnani	Auburn University	TBD	TBD	Auburn	AL
Audacy Lynq	Ellaine Talle	Audacy Corporation	TBD	TBD	Mountain View	CA
Implantable Glucose Biosensors	Dr. Michail Kastellorizios	Biorasis, Inc.	TBD	TBD	Storrs/ Mansfield	CT
Cranial Bone Marrow Stem Cell Culture in Space	Dr. Yang D. Teng	Brigham and Women's Hospital	TBD	TBD	Boston	MA
ARQ: A Platform for Enhanced ISS Science and Commercialization	Jason Budinoff	bSpace Corporation	TBD	TBD	Seattle	WA
Electrolytic Gas Evolution under Microgravity	Larry Alberts	Cam Med, LLC	TBD	TBD	West Newton	MA
Study of the Interactions between Flame and Surrounding Walls	Dr. Ya-Ting Liao	Case Western Reserve University	TBD	TBD	Cleveland	OH
Design of Scalable Gas Separation Membranes via Synthesis under Microgravity	Negar Rajabi	Cemsica	TBD	TBD	Houston	TX
Unmasking Contact-line Mobility for Inertial Spreading using Drop Vibration	Dr. Paul Steen	Cornell University	TBD	TBD	Ithaca	NY
Inertial Spreading and Imbibition of a Liquid Drop Through a Porous Surface	Dr. Michel Louge	Cornell University	TBD	TBD	Ithaca	NY
Space Development Acceleration Capability	Philip Bryden	Craig Technologies	TBD	TBD	Cape Canaveral	FL

Providing Spherical Video Tours of ISS	David Gump	Deep Space Industries	TBD	TBD	Moffett Field	CA
Droplet Formation Studies in Microgravity	Paul Patton	Delta Faucet	TBD	TBD	Indianapolis	IN
Rodent Research - 4 (Wound Healing) Post Flight Analysis	Dr. Rasha Hammamieh	Department of Defense	TBD	TBD	Fort Detrick	MD
DexMat CNT Cable Project	Dr. Alberto Goenaga	DexMat	TBD	TBD	Houston	TX
Microgravity Crystalization of Glycogen Synthase-Glycogenin Protein Complex	Dr. David S. Chung	Dover Lifesciences	TBD	TBD	Dover	MA
Survivability of Variable Emissivity Devices for Thermal Control Applications	Dr. Hulya Demiryont	Eclipse Energy Systems, Inc.	TBD	TBD	St. Petersburg	FL
Generation of Cardiomyocytes from Human Induced Pluripotent Stem Cells	Dr. Chunhui Xu	Emory University	TBD	TBD	Atlanta	GA
Effects of Microgravity on Human Physiology: Blood-Brain Barrier Chip	Dr. Christopher Hinojosa	Emulate, Inc.	TBD	TBD	Cambridge	MA
Pushing the Limits of Silica Fillers for Tire Applications	Derek Shuttleworth	Goodyear Tire & Rubber Co.	TBD	TBD	Akron	OH
Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment	Dan O'Connell	HNu Photonics	TBD	TBD	Wailuku	HI
Influence of Microgravity on T-Cell Dysfunction and Neurogenesis	Dr. Caitlin O'Connell-Rodwell	HNu Photonics	TBD	TBD	Wailuku	HI
Ionic Liquid CO2 Scrubber and Liquid Containment in Microgravity	Phoebe Henson	Honeywell International	TBD	TBD	Glendale	AZ
Intuitive Machines-ISS Terrestrial Return Vehicle (TRV)	Steve Altemus	Intuitive Machines	TBD	TBD	Houston	TX
Enhancement of Performance and Longevity of a Protein-Based Retinal Implant	Dr. Nicole L. Wagner	LambdaVision	TBD	TBD	Farmington	CT
Remote Manipulator Small-Satellite System	Craig Walton	LaMont Aerospace Inc.	TBD	TBD	Houston	TX
SPHERES Zero Robotics Middle School	Dr. Alvar Saenz Otero	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
SPHERES Zero Robotics High School	Dr. Alvar Saenz Otero	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
Cartilage-Bone-Synovium Microphysiological System: Musculoskeletal Disease Biology in Space	Dr. Alan Grodzinsky	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
Development and Validation of a Microfluidic Lab-on-a-chip	Dr. Siobhan Malany	Micro-gRx, Inc.	TBD	TBD	Orlando	FL
The Effects of Microgravity on Synovial Fluid Volume and Composition	Dr. Richard Meehan	National Jewish Health	TBD	TBD	Denver	CO
Nemak Alloy Solidification Experiments	Dr. Glenn Byczynski	NEMAK	TBD	TBD	Southfield	MI
Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System	Dr. Robert Applegate	Novopyxis	TBD	TBD	Boston	MA
Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators - 2	Dr. Andrey Kovalevsky	Oak Ridge National Lab	TBD	TBD	Oak Ridge	TN

Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators - 3	Dr. Andrey Kovalevsky	Oak Ridge National Lab	TBD	TBD	Oak Ridge	TN
Microgravity Investigation of Cement Solidification	Dr. Aleksandra Radlinska	Penn State University	TBD	TBD	University Park	PA
Constrained Vapor Bubbles of Ideal Mixtures	Dr. Joel Plawsky	Rensselaer Polytechnic Institute	TBD	TBD	Troy	NY
Influence of Gravity on Human Immune Function in Adults and the Elderly	Dr. Donald Drake	Sanofi Pasteur	TBD	TBD	Orlando	FL
Stability of the Human Virome during Space Flight	Dr. Kristian Andersen	Scripps Translational Science Institute	TBD	TBD	LaJolla	CA
The Influence of Spaceflight on Biological Age	Dr. Ali Torkamani	Scripps Translational Science Institute	TBD	TBD	LaJolla	CA
International Space Station Bioprinter Facility	Dr. Eugene Boland	Techshot, Inc.	TBD	TBD	Greenville	IN
Genes in Space - 4 Lakeside	Sophia Chen	The Boeing Company	TBD	TBD	Chicago	IL
Genes in Space - 4 Stuyvesant	Elizabeth Reizis	The Boeing Company	TBD	TBD	Chicago	IL
Lung Host Defense in Microgravity	Dr. George Worthen	The Children's Hospital of Philadelphia	TBD	TBD	Philadelphia	PA
Spacewalk: A Virtual Reality Experience	Mia Tramz	Time Inc.	TBD	TBD	New York	NY
Investigation of the Effects of Microgravity on Controlled Release of Antibiotics and Curing Mechanism of a Novel Wound Dressing	Dr. Elaine Horn-Ranney	Tympanogen, LLC	TBD	TBD	Norfolk	VA
Spherical Cool Diffusion Flames Burning Gaseous Fuels	Peter Sunderland	University of Maryland	TBD	TBD	College Park	MD
Microgravity Model for Immunological Senescence on Tissue Stem Cells	Dr. Sonja Schrepfer	University of California, San Francisco	TBD	TBD	San Francisco	CA
Quantifying Cohesive Sediment Dynamics for Advanced Environmental Modeling	Dr. Paolo Luzzatto-Fegiz	University of California, Santa Barbara	TBD	TBD	Santa Barbara	CA
Kinetics of Nanoparticle Self-assembly in Directing Fields	Dr. Eric Furst	University of Delaware	TBD	TBD	Newark	DE
An ISS Experiment on Electrodeposition	Dr. Kirk Ziegler	University of Florida	TBD	TBD	Gainesville	FL
Spaceflight Effects on Vascular Endothelial and Smooth Muscle Cell Processes	Dr. Josephine Allen	University of Florida	TBD	TBD	Gainesville	FL
Domesticating Algae for Sustainable Production of Feedstocks in Space	Dr. Mark Settles	University of Florida	TBD	TBD	Gainesville	FL
The Impact of Nanostructure Geometry on Photo-Thermal Evaporation Processes	Dr. Tengfei Luo	University of Notre Dame	TBD	TBD	Notre Dame	IN
Effects of Microgravity on the Structure of Proximal and Distal Tubule Microphysiological Systems	Dr. Jonathan Himmelfarb	University of Washington	TBD	TBD	Seattle	WA
Crystal Growth STEM 2017	Ilia Guzei	University of Wisconsin - Madison	TBD	TBD	Madison	WI
Space Based Optical Tracker	Dr. John Stryjewski	Vision Engineering Solutions	TBD	TBD	Orlando	FL
Continuous Liquid-Liquid Separation in Microgravity	Dr. Andrea Adamo	Zaiput Flow Technologies	TBD	TBD	Cambridge	MA

IN-ORBIT

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	LAUNCH DATE	CITY	STATE
National Lab Project: Alpha Magnetic Spectrometer - 02 (AMS-02)	Dr. Samuel Ting	Massachusetts Institute of Technology	STS-134	5/16/11	Cambridge	MA
Bone Densitometer	John Vellinger	Techshot, Inc.	SpX-4	9/21/14	Greenville	IN
NanoRacks External Platform	Michael Johnson	Nanoracks, LLC	HTV5	8/16/15	Houston	TX
Zero-G Characterization & OnOrbit Assembly for Cellularized Satellite Tech	Talbot Jaeger	NovaWurks, Inc.	Orb-4	12/6/15	Los Alamitos	CA
Additive Manufacturing Operations Program	Michael Snyder	Made In Space, Inc.	OA-6	3/23/16	Moffett Field	CA
Project Meteor	Michael Fortenberry	Southwest Research Institute	OA-6	3/23/16	Boulder	CO
GLASS AIS TransponderGlobal AIS on Space Station (GLASS)	Robert Carlson	JAMSS America, Inc.	SpX-9	7/18/16	Houston	TX
MultiLab: Research Server for the ISS	Twyman Clements	Space Tango, Inc.	SpX-9	7/18/16	Lexington	KY
Story Time from Space - 2	Patricia Tribe	T2 Science and Math Education Consultants	SpX-9	7/18/16	Penticton	BC
Dependable Multi-processor Payload Processor - Technology Readiness Level 7 (TRL7) Validation	Dr. John Samson and Dr. Benjamin Malphrus	Honeywell Aerospace and Morehead State University	HTV6	12/9/16	Morehead	KY
Development and Deployment of Charge Injection Device Imagers	Dr. Daniel Batcheldor	Florida Institute of Technology	SpX-10	2/19/17	Melbourne	FL
SG100 Cloud Computing Payload	Trent Martin	Business Integra Technology Solutions	OA-7	4/18/17	Houston	TX
Detached Melt and Vapor Growth of Indium Iodide	Dr. Aleksandar Ostrogorsky	Illinois Institute of Technology	OA-7	4/18/17	Chicago	IL
Crystal Growth of Cs2LiYCl6:Ce Scintillators in Microgravity	Dr. Alexei Churilov	Radiation Monitoring Devices, Inc.	OA-7	4/18/17	Watertown	MA
Advanced Colloids Experiment-Temperature Controlled - 6	Dr. Matthew Lynch	Procter and Gamble Company	SpX-11	6/3/17	West Chester	OH
Multi-User System for Earth Sensing (MUSES) Imaging Platform	Bill Corley	Teledyne Brown Engineering	SpX-11	6/3/17	Huntsville	AL
Spaceborne Computer	David Petersen	Hewlett Packard	SpX-12	8/14/17	Milpitas	CA
TangoLab-2	Twyman Clements	Space Tango, Inc.	SpX-12	8/14/17	Lexington	KY
STaARS-1 Research Facility	Dr. Heath Mills	Space Technology and Advanced Research Systems, Inc. (STaARS)	SpX-12	8/14/17	Houston	TX
Story Time from Space - 4	Patricia Tribe	T2 Science and Math Education Consultants	SpX-12	8/14/17	Penticton	BC
ARISS (Amateur Radio from ISS)	Frank Bauer	AMSAT (Radio Amateur Satellite Corporation)	N/A	N/A	Kensington	MD
Windows On Earth	David Libby	T E R C	N/A	N/A	Cambridge	MA
Tropical Cyclone Intensity Measurements from the ISS (CyMISS) 2017 Season	Dr. Paul Joss	Visidyne, Inc.	N/A	N/A	Burlington	MA

POSTFLIGHT/COMPLETE

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	CITY	STATE
Demonstration and Technology Readiness Level Raising of the Net Capture System on the ISS	Ron Dunklee	AIRBUS DS Space Systems, Inc.	Webster	TX
Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight	Dr. Clifford Dacso	Baylor College of Medicine	Houston	TX
National Design Challenge - 2 Bell	Shanna Atzmiller	Bell Middle School	Golden	CO
Optimizing Jammable Granular Assemblies in a Microgravity Environment	Jason Hill	Benevolent Technologies for Health	Boston	MA
Protein Crystal Growth to Enable Therapeutic Discovery (Joint Collaboration)	Dr. Matt Clifton	Beryllium Discovery Corp.	Bedford	MA
Commercial Space-borne Hyperspectral Harmful Algal Bloom (HAB) Products	Dr. Ruhul Amin	BioOptoSense, LLC	Metairie	LA
Ants in Space	Stefanie Countryman	BioServe Space Technologies	Boulder	CO
Osteocyte Response to Mechanical Forces	Dr. Paola Divieti Pajevic	Boston University	Boston	MA
National Design Challenge - 3: Chicagoland Boy Scouts and Explorers	Dr. Sandra Rogers	Boy Scouts of America	Chicago	IL
Crystallization of Huntington Exon-1 Using Microgravity	Dr. Pamela Bjorkman	California Institute of Technology	Pasadena	CA
National Design Challenge - 2 Centaurus	Brian Thomas	Centaurus High School	Lafayette	CO
National Design Challenge - 2 Chatfield	Joel Bertelsen	Chatfield Senior High School	Littleton	CO
Microgravity Electrodeposition Experiment	Michael Yagley	Cobra Puma Golf	Carlsbad	CA
Controlled Dynamics Locker for Microgravity Experiments on ISS	Dr. Scott A. Green	Controlled Dynamics Inc.	Huntington Beach	CA
Spacecraft-on-a-Chip Experiment Platform	Dr. Mason Peck	Cornell University	Ithaca	NY
National Design Challenge - 1: Pilot Program	Rev. Brian Reedy	Cristo Rey Jesuit College Preparatory of Houston	Houston	TX
National Lab Project: ISS SERVIR Environmental Research and Visualization System (ISERV)	Burgess Howell	Disaster Relief Charter; NASA Marshall Space Flight Center	Huntsville	AL
National Design Challenge - 1: Pilot Program	Susan Knizner	Duchesne Academy of the Sacred Heart	Houston	TX
National Design Challenge - 1: Pilot Program	Kathy Duquesnay	Duchesne Academy of the Sacred Heart	Houston	TX
High School Students United with NASA to Create Hardware (HUNCH) Extreme Science-3	David Schlichting	Eaglecrest High School	Centennial	CO
Rodent Research - 3	Dr. Rosamund Smith	Eli Lilly and Company	Indianapolis	IN
Eli Lilly - Protein Crystal Growth	Kristofer R. Gonzalez-DeWhitt and Michael Hickey	Eli Lilly and Company	Indianapolis	IN
Dissolution of Hard-to-Wet Solids	Dr. Richard Cope, Dr. Alison Campbell, and Dr. Kenneth Savin	Eli Lilly and Company	Indianapolis	IN
Lyophilization in Microgravity: Impact on Physical Properties and Critical Quality Attributes	Jeremy Hinds	Eli Lilly and Company	Indianapolis	IN
Generation of Cardiomyocytes from Human iPS Cell-derived Cardiac Progenitors	Dr. Chunhui Xu	Emory University	Atlanta	GA
Testing TiSi2 Nanonet Based Lithium Ion Batteries for Safety in Outer Space	Emily Fannon	EnerLeap	Newton	MA
Tomatosphere	Ann Jorss	First the Seed Foundation	Alexandria	VA
Tomatosphere - 2	Ann Jorss	First the Seed Foundation	Alexandria	VA
Materials Testing - Earth Abundant Textured Thin Film Photovoltaics	Dr. Jud Ready	Georgia Institute of Technology	Atlanta	GA
Exploiting On-orbit Crystal Properties for Medical and Economic Targets	Dr. Edward Snell	Hauptman Woodward Medical Research Institute, Inc.	Buffalo	NY

Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples	Dr. Edward Snell	Hauptman Woodward Medical Research Institute, Inc.	Buffalo	NY
Decoupling Diffusive Transport Phenomena in Microgravity	Dr. Alessandro Grattoni	Houston Methodist Research Institute	Houston	TX
The Effect of Microgravity on Stem Cell Mediated Recellularization	Dr. Alessandro Grattoni	Houston Methodist Research Institute	Houston	TX
Architecture to Transfer Remote Sensing Algorithms from Research to Operations	Dr. James Goodman	HySpeed Computing	Miami	FL
Rodent Research-4 Validation Study	Dr. Melissa Kacena and Dr. Rasha Hammamieh	Indiana University Research	Indianapolis	IN
Espresso Cup	Dr. Mark Weislogel	IRPI, LLC	Wilsonville	OR
IPPase Crystal Growth in Microgravity	Dr. Joseph Ng	iXpressGenes, Inc.	Huntsville	AL
Molecules Produced in Microgravity from the Chernobyl Nuclear Accident	Dr. Kasthuri Venkateswaran	Jet Propulsion Laboratory/Caltech	Pasadena	CA
Role Of Gravity And Geomagnetic Field In Flatworm Regeneration	Dr. Mahendra Jain	Kentucky Space, LLC	Lexington	KY
Omega Hydrofuge Plant Growth Chamber - High School Students United with NASA to Create Hardware (HUNCH) Extreme Science - Lakewood	Matthew Brown	Lakewood High School	Lakewood	CO
Functional Effects of Spaceflight on Cardiovascular Stem Cells	Dr. Mary Kearns-Jonker	Loma Linda University	Loma Linda	CA
Viral Infection Dynamics and Inhibition by the Vecoy Nanotechnology	Dr. Drew Cawthon	Lovelace Respiratory Research Institute	Albuquerque	NM
Application of Microgravity Expanded Stem Cells in Regenerative Medicine	Dr. Abba Zubair	Mayo Clinic	Rochester	MN
Merck Protein Crystal Growth - 1	Dr. Paul Reichert	Merck Pharmaceuticals	Whitehouse Station	NJ
Merck Protein Crystal Growth - 2	Dr. Paul Reichert	Merck Pharmaceuticals	Whitehouse Station	NJ
Merck Protein Crystal Growth - 3	Dr. Paul Reichert	Merck Pharmaceuticals	Whitehouse Station	NJ
Crystallization of LRRK2 under Microgravity Conditions	Dr. Marco Baptista	Michael J. Fox Foundation	New York	NY
Great Lakes Specific HICO Water Quality Algorithms	Dr. Robert Shuchman	Michigan Technological University	Houghton	MI
Vertical Burn	Dr. Jeff Strahan	Milliken	Spartanburg	SC
Magnetic 3D Cell Culture for Biological Research in Microgravity	Dr. Glauco Souza	Nano3D Biosciences, Inc.	Houston	TX
Proof-of-Concept for Gene-RADAR Predictive Pathogen Mutation Study	Dr. Anita Goel	Nanobiosym	Cambridge	MA
Validation of WetLab-2 System for qRT-PCR capability on ISS	Julie Schonfeld	NASA ARC	Mountain View	CA
Student Spaceflight Experiments Program 5a - Falcon I	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 5b - Falcon II	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 6 - Orion	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 7 - Charlie Brown	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 8 - Yankee Clipper	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 9 - Odyssey	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 10 - Kitty Hawk	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Student Spaceflight Experiments Program 11 - Endeavor	Dr. Jeff Goldstein	NCESSE/Tides Center	Capitol Heights	MD
Impact of Increased Venous Pressure on Cerebral Blood Flow Velocity Morphology	Dr. Robert Hamilton	Neural Analytics	Los Angeles	CA
T-Cell Activation in Aging - 1	Dr. Millie Hughes-Fulford	Northern California Institute for Research and Education, Inc.	San Francisco	CA

T-Cell Activation in Aging - 2	Dr. Millie Hughes-Fulford	Northern California Institute for Research and Education, Inc.	San Francisco	CA
Rodent Research - 1	Dr. David Glass	Novartis Institute for Biomedical Research	Cambridge	MA
Rodent Research - 2	Dr. David Glass	Novartis Institute for Biomedical Research	Cambridge	MA
Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators	Andrey Kovalevsky	Oak Ridge National Lab	Oak Ridge	TN
Efficacy and Metabolism of Azonafide Antibody-Drug Conjugates (ADCs)	Sourav Sinha	Oncolinx Pharmaceuticals, LLC	Boston	MA
Binary Colloidal Alloy Test – Low Gravity Phase Kinetics Platform	Dr. Matthew Lynch	Procter and Gamble Company	West Chester	OH
Protein Crystal Growth to Enable Therapeutic Discovery (Joint Collaboration)	Dr. Cory Gerdts	Protein BioSolutions	Gaithersburg	MD
Microbead Fabrication using Rational Design Engineering	Dr. Brian Plouffe	Quad Technologies	Beverly	MA
Utilize ISS Energy Systems Data for Microgrid Design and Operation	Nicholas Kurlas	Raja Systems	Boston	MA
Synthetic Muscle: Resistance to Radiation	Dr. Lenore Rasmussen	Ras Labs	Hingham	MA
High School Students United with NASA to Create Hardware (HUNCH) Chlorella/Billings Central Catholic High	Andy Wildenberg	Rocky Mountain College	Billings	MT
Crystallization of Medically Relevant Proteins Using Microgravity	Dr. Sergey Korolev	Saint Louis University	Saint Louis	MO
High Data Rate Polarization Modulated Laser Communication System	Dr. Eric Wiswell	Schafer Corporation	Huntsville	AL
Reducing Signal Interruption from Cosmic Ray Background in Neutron Detectors	Dr. Andrew Inglis	Silverside Detectors	Cambridge	MA
Hyperspectral Mapping of Iron-bearing Minerals	Dr. William H. Farrand	Space Science Institute	Boulder	CO
Intraterrestrial Fungus Grown in Space (iFunGIS)	Dr. Heath Mills	Space Technology and Advanced Research Systems, Inc. (STaARS)	Houston	TX
Effects of Microgravity on Stem Cell-Derived Heart Cells	Dr. Joseph Wu	Stanford University	San Francisco	CA
Mutualistic Plant/Microbe Interactions	Dr. Gary Stutte	SyNRGE, LLC	Titusville	FL
Story Time from Space - 1	Patricia Tribe	T2 Science and Math Education Consultants	Penticton	BC
Story Time from Space - 3	Patricia Tribe	T2 Science and Math Education Consultants	Penticton	BC
Examine Bone Tumor and Host Tissue Interactions Using Micro-Gravity Bioreactors	Dr. Carl Gregory	Texas A&M Health Science Center	College Station	TX
National Design Challenge - 1: Pilot Program	Jessika Smith	The Awty International School	Houston	TX
National Design Challenge - 1: Pilot Program	Angela Glidwell	The Awty International School	Houston	TX
Genes In Space	Anna-Sophia Boguraev	The Boeing Company	Chicago	IL
Genes in Space - 2	Julian Rubinfien	The Boeing Company	Chicago	IL
Genes in Space - 3	Alia Almansoori	The Boeing Company	Chicago	IL
Street View Imagery Collect on ISS	Ann Kapusta	ThinkSpace	Mountain View	CA
Crystallization of Human Membrane Proteins in Microgravity	Dr. Stephen Aller	University of Alabama at Birmingham	Birmingham	AL
The Effect of Macromolecular Transport on Microgravity PCG	Dr. Lawrence DeLucas	University of Alabama at Birmingham	Birmingham	AL
Systemic Therapy of NELL-1 for Osteoporosis (Rodent Research - 5)	Dr. Chia Soo	University of California, Los Angeles	Los Angeles	CA
Antibiotic Effectiveness in Space-1 (AES-1)	Dr. David Klaus	University of Colorado Boulder	Boulder	CO
Molecular Biology of Plant Development	Dr. Anna-Lisa Paul	University of Florida Board of Trustees	Gainesville	FL

Generation of Mesendoderm Stem Cell Progenitors in the ISS-National Laboratory	Dr. Robert Schwartz	University of Houston System	Houston	TX
Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes	Dr. Robert Schwartz	University of Houston System	Houston	TX
Hyperspectral Remote Sensing of Terrestrial Ecosystem Carbon Fluxes	Fred Huemmrich	University of Maryland Baltimore County	Baltimore	MD
Effects of Simulated Microgravity on Cardiac Stem Cells	Dr. Joshua Hare	University of Miami	Miami	FL
Gravitational Regulation of Osteoblast Genomics and Metabolism (in Collaboration with the National Institutes of Health)	Dr. Bruce Hammer	University of Minnesota	Minneapolis	MN
Protein Crystal Growth for Determination of Enzyme Mechanisims	Dr. Constance Schall	University of Toledo	Toledo	OH
Hyperspectral Imager for the Coastal Ocean (HICO) Identification of Harmful Algal Blooms	Dr. Richard Becker	University of Toledo	Toledo	OH
Drug Development and Human Biology: Use of Microgravity for Drug Development	Dr. Timothy Hammond	Veterans Administration Medical Center	Durham	NC
Tropical Cyclone Intensity Measurements from the ISS (CyMISS) 2015 Season	Dr. Paul Joss	Visidyne, Inc.	Burlington	MA
Materials Testing: The Evaluation of Gumstix Modules in Low Earth Orbit	Dr. Kathleen Morse	Yosemite Space	Groveland	CA

CONFERENCES AND EVENTS IN Q4 FY17

CONFERENCE AND INDUSTRY EVENT SPONSORSHIPS

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
International Space Station Research and Development (ISSR&D) Conference 2017	Washington, DC	7/17/17–7/20/17	Scientists, researchers, industry experts, academic leaders, service providers, partners, commercial developers, entrepreneurs, and investors	More than 1,000 individuals from industry, academia, and government attended the 2017 ISSR&D Conference. During 3.5 days of keynote presentations, technical sessions, and networking, attendees learned about the vast possibilities for advancing innovation, scientific discovery, and technological development in microgravity. In addition to being a founding conference partner with a significant management role, CASIS also participated in four plenary presentations.

SUBJECT MATTER EXPERT WORKSHOPS

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
Rodent Research Workshop	Washington, DC	7/21/17	Researchers and scientists from academia and government	CASIS and NASA jointly sponsored this workshop to maximize ISS stakeholder access to the rodent research model in space. CASIS has engaged and cultivated commercial interest from multiple companies and organizations and seeks to expand the model for use by the National Institutes of Health and other government agencies. During the workshop, the 50 attendees reviewed accomplishments with rodent research to date and collaborated to identify the critical scientific activities needed to promote high value, productive rodent studies in space and opportunities to maximize the scientific return of rodent research.

ADDITIONAL CONFERENCE AND EVENT PARTICIPATION

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
National Scout Jamboree (Boy Scouts of America)	Glen Jean, WV	7/19/17	Scouts, visitors, volunteers, and staff	CASIS exhibited at the 2017 National Scout Jamboree, the Boy Scouts of America's largest event, with more than 40,000 youth and adults in attendance. During the 10-day event, CASIS featured the Space Station Explorers program, hosted 725 visitors in its exhibit booth and spoke to an additional 500 attendees during presentations.
QED@QB3-University of California-San Francisco Mission Bay	San Francisco, CA	8/10/17	Researchers, entrepreneurs, venture capitalists, industry experts, and students	A CASIS representative presented at QED@QB3, an entrepreneurs' discussion seminar at the University of California-San Francisco, to inspire researchers and startups to develop ISS flight project ideas. QB3 is a hub for innovation and supports California-based research and entrepreneurship in life sciences.

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
Zero Robotics Middle School Competition 2017	Cape Canaveral, FL	8/11/17	Students, parents, and educators	CASIS sponsored the Zero Robotics Middle School Summer Program, a five-week STEM curriculum and tournament that introduces students to computer programming, robotics, and space engineering, and provides hands-on experience programming Synchronized Position Hold, Engage, and Reorient Experimental Satellite (SPHERES) satellites. CASIS President and Executive Director Greg Johnson was the keynote speaker during the tournament finals event. He spoke about his own experiences as an astronaut and encouraged the students to continue their interest in science, technology, engineering, and math.
Destination Station	Charleston, SC	8/22/17	Scientists, researchers, academic leaders, and commercial companies	CASIS and NASA met with the South Carolina Research Authority (SCRA) to discuss opportunities for research on the ISS during its Destination Station visit in Charleston. The event coincided with the total solar eclipse over Charleston on August 21, 2017. NASA scheduled multiple public engagements to discuss the eclipse and the ISS. The visit to SCSR provided roughly 100 attendees the opportunity to learn about the ISS research environment, and upcoming funding initiatives through various CASIS-driven sponsored programs.
CASIS/NCATS Kick-off Meeting	Merritt Island, FL	9/21/17–9/22/17	Scientists, members of NCATS and NIH, commercial companies, and NASA representatives	In connection with its four-year partnership with the National Center for Advancing Translational Sciences (NCATS), part of the National Institutes of Health (NIH), CASIS hosted the first biannual meeting of grant recipients who will use tissue chip technology for translational research onboard the ISS National Lab. The meeting engaged scientists, implementation partners, and CASIS chief scientists and operations staff in a discussion of program goals and timelines.
Florida Afterschool Alliance Conference	Orlando, FL	9/27/17–9/29/17	Educators and students	The Florida Afterschool Alliance Conference draws hundreds of participants from programs serving Florida's children and youth. The speaking engagement and conference allowed CASIS to connect with leaders in afterschool communities, such as the YMCA, the Boys and Girls Clubs of America, and the 21st Century Community Learning Centers.

FINANCIALS

BUSINESS STATUS REPORT (UNAUDITED)

JULY 1 TO SEPTEMBER 30, 2017	ACTUAL Q4FY17	BUDGET Q4FY17	VARIANCE Q4FY17	ACTUAL YTD FY17	BUDGET YTD FY17	VARIANCE YTD
Direct Labor	$1,600,291	$1,690,210	$(89,919)	$6,162,103	$6,627,480	$(465,377) A
Subcontracts	$553,658	$690,686	$(137,028)	$1,577,524	$2,272,330	$(694,806) B
Permanent Equipment	$9,418	$5,000	$4,418	$47,069	$24,000	$23,069
Office Supplies & Equipment	$75,239	$71,224	$4,015	$203,156	$295,298	$(92,142)
Travel	$237,003	$297,928	$(60,925)	$925,369	$1,148,672	$(223,303) A
Grants	$3,763,283	$3,623,528	$139,755	$7,243,314	$9,079,159	$(1,835,845) C
Other	$346,007	$586,324	$(240,317)	$1,614,477	$1,804,492	$(190,015)
Total	**$6,584,899**	**$6,964,900**	**$(380,001)**	**$17,773,012**	**$21,251,431**	**$(3,478,419)**

(A) Salaries and Benefits: Average FY17 headcount was 45 versus a budgeted 49, and health care cost increase was lower than anticipated.
(B) Subcontracts: Lower than budget for Science and Technology, Marketing and Communications, and Business Development.
(C) Grants: Recipient milestone payments shifted based on actual spend or delay in projects; $7.5M in grant obligations carrying over to FY18 ($6M) and FY19 ($1.5M).

BREAKOUT OF COOPERATIVE AGREEMENT FUNDING

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL
Direct	55.2%	46.8%	50.7%	33.5%	**40.7%**
Indirect	19.5%	13.4%	17.0%	8.0%	**13.3%**
Grants	15.3%	39.8%	32.3%	58.6%	**46.0%**

BREAKOUT OF CASIS GRANTS

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17	FY17 TOTAL
Academic	($88,466)	$334,153	$107,520	$1,505,549	**$1,858,756**
Commercial	$421,644	$1,283,955	$1,016,988	$1,949,087	**$4,671,674**
Mission Based Costs	$96,223	$108,843	$199,171	$308,647	**$712,884**
Total	**$429,401**	**$1,726,951**	**$1,323,679**	**$3,763,283**	**$7,243,341**

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