FY17 Q3 REPORT

Quarterly Report for the Period April 1 – June 30, 2017

CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)

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EXECUTIVE SUMMARY

During the third quarter of fiscal year 2017 (Q3 FY17), the International Space Station (ISS) U.S. National Laboratory, managed by the Center for the Advancement of Science in Space (CASIS), saw several high-profile achievements. The National Institutes of Health's National Center for Advancing Translational Sciences (NIH-NCATS) announced five awards for flight projects as part of a collaboration with CASIS to advance tissue-on-chip research. In addition to these awardees, CASIS selected five flight projects from commercial investigators, including projects from three new-to-space Fortune 500 companies and their subsidiaries. Commercial resupply vehicles also delivered a record number of payloads to the ISS National Lab in Q3. Including the payloads launched onboard Orbital ATK CRS-7 and SpaceX CRS-11 in Q3, more than 100 experiments have been flown to the ISS National Lab in FY17 alone, demonstrating increased demand from the U.S. R&D community to utilize our nation's orbiting outpost.

KEY HIGHLIGHTS FROM Q3 INCLUDE:

- **CASIS and NCATS Announce Five Projects in Human Physiology:** As part of a four-year partnership with NIH-NCATS, five projects were awarded flight opportunities to perform tissue engineering research onboard the ISS National Lab. NCATS is contributing up to $12 million toward these projects, which will help scientists develop and advance novel technologies to improve human health on Earth.
- **New R&D Projects Diversify the ISS National Lab Portfolio and Build Sustainability:** Including the NCATS awards, CASIS selected ten new flight projects in Q3, nine of which are from new-to-space academic research institutions and commercial companies—including Fortune 500 companies Anheuser-Busch InBev (plant biology research) and The Goodyear Tire & Rubber Company (materials science research), as well as a subsidiary of the Fortune 500 company EcoLab, Nalco Champion (corrosion research). More than half of the ten awardees required no CASIS funding, and only one required funding for more than one-third of their total project costs. Such cost sharing by awardees and third parties builds sustainability and is a positive indicator of the ISS National Lab's perceived value.
- **Record Number of Payloads Delivered in a Quarter:** The 32 payloads delivered this quarter contained more than 80 experiments, representing the largest number of payloads to date delivered to the ISS National Lab in a single quarter. Payloads included a fluid physics investigation from repeat customer Procter & Gamble, a new commercially operated facility to support advanced Earth imaging, and semiconductor research that will use a newly refurbished furnace on the ISS National Lab to improve materials for homeland security applications.
- **Enhanced Media and Public Engagement:** The ISS National Lab was featured in major publications in Q3, including Fortune and Forbes. Moreover, the successes of both Q3 launches stimulated the largest ISS National Lab social media engagement numbers to date, with more than 675,000 people viewing CASIS videos promoting the R&D delivered by the launch vehicles. This R&D also received coverage beyond social channels; for example, the most recent rodent research investigation was discussed by *The New York Times, PBS NewsHour*, and the *Associated Press.*

In addition, six recently published life science journal papers detail results from flight projects and preflight optimization studies associated with ISS National Lab projects. One paper detailing results from an ISS National Lab study on flatworm regeneration was covered by *Gizmodo, CNET, CBS News, Fox News, Engadget, Yahoo! Tech,* and *Smithsonian Magazine.* In the experiment, an amputated flatworm fragment sent to space regenerated into a double-headed worm, a rare spontaneous occurrence of double-headedness that the principal investigators had never seen in their 18 years studying flatworm regeneration. Understanding the molecular events involved in regeneration and rare events like these may yield insights important not only to flatworm biology, but also to wound healing and regenerative medicine in humans—made possible by R&D on the ISS National Lab.

ISS NATIONAL LAB PORTFOLIO

MAXIMIZE UTILIZATION AND DEMONSTRATE MEASURABLE IMPACT

NEWLY SELECTED PROJECTS

Ten projects were awarded in Q3: six to commercial companies and four to academic institutions. Eight states are represented by these selections (TX, CA, PA, MA, WA, CO, OH, and MN), with multiple new projects in California and Massachusetts. Nine of the awardees are new to the ISS National Lab, two are Fortune 500 companies, and five represent the winners of the first joint solicitation between CASIS and the NIH.

Life Sciences

CASIS and 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. Five of six life sciences projects selected in Q3 are part of this four-year collaboration, through which 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 a subsequent two years of funding (again up to $6 million) and a second flight opportunity.

Microgravity enhances the growth and survival of certain stem cell populations, promotes differentiation into specific cell types, and supports organization of individual cells into tissue-like structures. The ISS National Lab R&D portfolio contains a growing number of projects that use these effects to improve tissue-on-a-chip technology for disease modeling, drug testing, and translational research, and this type of R&D is one of the main CASIS focus areas in support of low Earth orbit (LEO) commercialization. NCATS awardees will perform 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 final life sciences awardee in Q3 was Fortune 500 company Anheuser-Busch, for a project that will study various barley strains exposed to the space environment.

Physical Sciences

Two physical sciences awards in Q3 went to projects from Fortune 500 companies and their subsidiaries. Goodyear, a Fortune 500 company, will analyze silica fillers when formulated in microgravity, with the goal of improving materials for commercially available tires and other products. Nalco Champion, an EcoLab company, will assess the corrosive impact of biofilms, which are responsible for 20–50% of corrosion in the oil and gas industry.

Technology Development

Two technology development projects were awarded in Q3, one each to Audacy Corporation and LaMont Aerospace, Inc. (a returning ISS National Lab customer), for satellite-related projects.

For more information on all newly awarded projects, see the table beginning on page 15.

OPERATIONAL UPDATE FOR Q3FY17

Orbital ATK (and launch partner United Launch Alliance) launched its seventh commercial resupply mission (CRS OA-7), carrying more than 40 sponsored investigations to the ISS National Lab. Some highlights from this launch are detailed below.

- Two investigations are taking advantage of recent refurbishments made to the Solidification Using a Baffle in Sealed Ampoules (SUBSA) hardware. SUBSA is a furnace that enables the study of melt convection in microgravity, which is beneficial for R&D to improve semiconductor and scintillator crystal quality. The goal of these first two experiments in the refurbished hardware is to improve the radiation detection capabilities of such crystals, for homeland security applications.
  - ***Detached Melt and Vapor Growth of Indium Iodide in SUBSA Hardware.*** *PI: Dr. Aleksandar Ostrogorsky, Illinois Institute of Technology, Chicago, IL. Payload Developer: Teledyne Brown Engineering.*
  - ***Crystal Growth of Cs2LiYCl6:Ce Scintillators. PI:*** *Dr. Alexei Churilov, Radiation Monitoring Devices, Inc., Watertown, MA. Payload Developer: Teledyne Brown Engineering.*
- **Antibody Drug Conjugates (ADCs) in Microgravity** will test the efficacy and drug metabolism of azonafide ADCs in microgravity 3D cell cultures. ADCs are class of chemotherapeutic drugs designed to specifically target only cancer cells, minimizing side effects. PI: Sourav Sinha, Oncolinx Pharmaceuticals LLC, Boston, MA. Payload Developer: Bioserve Space Technologies.
- **Genes in Space-2,** sponsored by the Boeing Company as part of an annual competition (in which students in grades 7–12 compete to send DNA experiments to the ISS), may help researchers gain a better understanding of aging and disease development. PI: Julian Rubinfien, Boeing Company, New York, NY. Payload Developer: Boeing.
- **ALTAIR Pathfinder** will test new platform technologies developed by Millennium Space Systems, a private firm that offers satellites for missions in LEO, geostationary orbit, and deep space. PI: Griffith Russell, Millennium Space Systems, El Segundo, CA. Payload Developer: NanoRacks, LLC.
- **SG-100 Cloud Computing** will advance the technology readiness level (TRL) of SG100, a single-board computer platform that can support much higher processing demands for future applications in LEO. PI: Trent Martin, Business Integra, Houston, TX. Payload Developer: Business Intregra.
- **Magnetic 3D Cell Culture for Biological Research in Microgravity** is incorporating magnetic cell culture technology into existing flight hardware to support improved 3D cell growth. PI: Dr. Glauco Souza, Nano3D Biosciences, Inc., Houston, TX. Payload Developer: Bioserve Space Technologies.
- The **QB50 Program** is the result of an international collaboration involving academia and research institutes from 15 different countries, funded by the European Union's Seventh Framework Programme for Research and Technological Development. The project involves monitoring different gaseous molecules and electrical properties of the thermosphere and taking coordinated measurements via SmallSats to better understand space weather. Payload Developer: NanoRacks, LLC.

Additionally, the SpaceX-11 CRS mission also carried more than 40 investigations to the ISS National Lab. Selected highlights from this launch are:

- The **Advanced Colloids Experiment** will use confocal microscopy to study the 3D behavior of microscopic particles in gels and creams, toward improved shelf-life of commercial products. PI: Dr. Matthew Lynch, Procter & Gamble, West Chester, OH. Payload Developer: NASA Glenn Research Center and Zin Technologies, Inc.

- **Functional Effects of Spaceflight on Cardiovascular Stem Cells** will investigate how microgravity alters stem cells as it relates to their roles in cardiac biology, tissue regeneration, and aging. PI: Dr. Mary Kearns-Jonker, Loma Linda University, Loma Linda, CA. Payload Developer: BioServe Space Technologies.
- **The Systemic Therapy of NELL-1 for Osteoporosis** (Rodent Research-5), funded by the National Institute of Arthritis and Musculoskeletal and Skin Diseases (part of the NIH), will test a new drug that can both rebuild bone and prevent bone loss. PI: Dr. Chia Soo, University of California, Los Angeles, Los Angeles, CA. Payload Developer: NASA Ames Research Center and BioServe Space Technologies.
- **Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators** seeks to produce high-quality large crystals of a medically important enzyme, acetylcholinesterase, toward improved neurotoxin treatments. PI: Andrey Kovalevsky, Oak Ridge National Lab, Oak Ridge, TN.
- **Student Spaceflight Experiments Program (SSEP) - Mission 10** includes the NanoRacks-National Center for Earth and Space Science Education-Odyssey (NanoRacks-NCESSE-Odyssey) investigation, consisting of 24 student experiments studying plants, algae and bacterial growth, polymers, multi-cellular organism development, chemical and physical processes, antibiotic efficacy, and allergic reactions. PI: Dr. Jeff Goldstein, National Center for Earth and Space Science Education, Washington, DC. Payload Developer: NanoRacks, LLC.

In addition, student experiments from the **National Design Challenge** program (NDC-2) that were lost in the SpaceX-7 launch anomaly were re-flown on both resupply missions in Q3, with projects studying sustainable biofuel production in space, employing composting as a form of recycling on future long-duration space missions, and bacterial lag phase in microgravity. PIs: Brian Thomas, Bell Middle School, Golden, CO; Joel Bertelsen, Chatfield Senior High school, Littleton, CO; and Shanna Atzmiller, Centaurus High School, Lafayette, CO.

Q3 also encompassed the following activities for spaceflight commercial facilities.

The Multiple User System for Earth Sensing (MUSES, an Earth imaging platform) launched to the ISS in Q3. MUSES was developed by Teledyne Brown Engineering as part of the company's new commercial space-based digital imaging business. MUSES will host Earth-viewing instruments, such as high-resolution digital cameras and hyperspectral imagers, and provide precision pointing and other accommodations. MUSES also provides a test bed for technology demonstration and maturation by providing long-term access to the space environment on the ISS. MUSES is ideal for Earth observation missions—currently estimated to be a $43 billion market—from assessing weather patterns and climate to driving business intelligence. Moreover, it will enable environmental monitoring by hosting instruments able to detect flooding, coastal erosion, water pollution, harmful algal blooms (e.g., red tide), and landslides. Teledyne Brown Engineering will operate this new commercially available facility onboard the ISS National Lab.

In Q3, Space Tango, an ISS National Lab implementation partner that designs and builds integrated systems facilitating microgravity research and manufacturing focused for application on Earth, delivered their TangoLab-2 facility to NASA for launch to the ISS on the upcoming SpaceX-12 mission. The TangoLab-2 facility will be the second commercial facility to be deployed by Space Tango aboard the ISS National Lab. TangoLab-2's architecture minimizes astronaut interaction, reduces complexity while increasing scalability, and enables users to interact with and retrieve their data through a web-based customer portal.

The Additive Manufacturing Facility (AMF) operated by Made In Space continues to operate onboard the ISS National Lab and was featured this quarter in *Upward*, the quarterly magazine of the ISS National Lab. The feature highlighted the innovation of the facility and the powerful partnerships fostered between Made In Space and nonconventional space users such as Lowe's Innovation Labs. After of a year of continual in-orbit operations, the AMF has printed and assembled multi-part designs, tried advanced optimized geometries, enhanced intricate features, advanced crew operations, and more. AMF users continue to increase the complexity and size of in-orbit prints, and in June, the AMF completed its longest print to date, measuring more than 200 grams.

Commercial service provider NanoRacks, LLC, also had an active quarter onboard the ISS National Lab:

- In Q3, NanoRacks successfully deployed the company's 171st CubeSat via the NanoRacks CubeSat Deployer (NRCSD) on the ISS, and the company's 182nd space station CubeSat deployed overall. This cycle completes the NRCSD-11 and NRCSD-12 missions, which consisted of satellites from more than 15 countries, including universities across five continents, U.S. government organizations, and commercial companies.
- NanoRacks was also the launch services provider for the CubeSats selected through the NASA CubeSat Launch Initiative as part of the seventeenth installment of the Educational Launch of Nanosatellites. NanoRacks offers this CubeSat deployment opportunity via the company's Space Act Agreement with NASA as part of the ISS National Lab in coordination with CASIS. The program is commercially funded, meaning there is no government funding and it is sustained by customer revenue.
- More than 25 investigations from DreamUp, the NanoRacks educational nonprofit organization, were launched on the SpaceX-11 mission, ranging from middle school to graduate level students from the U.S. and other countries. Astronaut Peggy Whitson activated multiple students' experiments that were viewed live by DreamUp customer, International Space School Educational Trust (ISSET). Whitson's well-coordinated activities were on time and nominal, providing instant feedback, photos, and results for the student researchers.

PROJECT STATUS

Six new research papers resulting from ISS National Lab investigations have recently been published—all in the life sciences.

- In an article published in *Regeneration*, Principal Investigators Drs. Michael Levin and Mahendra Jain described the effects of the low Earth orbit environment on flatworms and their ability to regenerate. Flatworms can restore parts of their body, including organs, and learning more about this process may help scientists better understand the molecular mechanisms behind it. Fifteen flatworms were cut in half on Earth to separate heads from tails and placed onboard the ISS National Lab for five weeks. One of these flatworms returned to Earth having regenerated a second head in place of the missing tail—a rare occurrence on Earth. Even after bisecting the worm with two heads yet again on Earth, both heads grew back, suggesting a permanent change that may yield insights into the regenerative process relevant not only to worms but also to wound healing in humans. This work also provides insights into other physiological effects of spaceflight over time, some of which persisted in the worms for as long as 20 months after returning to Earth. (For more information on this publication, see the Contributions to Scientific Knowledge table on page 15.)
- In an article published in *PLoS ONE*, Dr. Anna-Lisa Paul and her team describe the differences in gene expression in *Arabidopsis*, a plant genus frequently used as a model to study genetic pathways. This study compares plants grown on Earth to those grown on the ISS National Lab under different lighting conditions. Like all organisms, plants adapt to their environment. The effects of spaceflight on gene expression in plants has been well studied, but this study explores

whether some genetic responses can be avoided without negatively affecting plant survival. The study found that altering the lighting within the spaceflight plant habitat affects gene expression and the development of unnecessary genetic and physiological changes that impact plant resource allocation. Further, the study demonstrated that a difference in a single gene can improve the plant's response to spaceflight, reducing the negative impacts of these metabolically costly adaptations to spaceflight. The work of Dr. Paul and her team informs how plant genetic responses can be controlled to improve the health of plants under stress—knowledge translatable to the adaptation of crop plants to changing environments on Earth.

- In an article published in the *Journal of Biological Chemistry*, University of Toledo researcher Dr. Constance Schall investigated one of the many chemical reactions of pyridoxal 5'-phosphate (PLP), the active form of vitamin B-6. PLP is involved in the metabolism of amino acids to make proteins. Disruption of amino acid metabolism negatively affects human health and contributes to some hereditary diseases. Dr. Schall and her team focused on understanding the chemical relationship between PLP and the enzyme aspartate aminotransferase (AAT) during amino acid metabolism. This study sheds light on how this chemical process is regulated and discusses precise structural details around the site on PLP where the reactions occur. This ground study by the Schall lab builds upon findings from her recent flight project on the ISS National Lab, in which the microgravity environment was leveraged to create large, high-quality AAT crystals for analysis by neutron diffraction. (For more information on this publication, see the Contributions to Scientific Knowledge table on page 15.)
- An article published in the *International Journal of Molecular Science* by Dr. Glauco Souza demonstrates how a magnetic 3D cell culture can be used to assemble liver cells (hepatocytes) in microgravity. Cell cultures are often used to better understand how drugs harm tissues and cells like hepatocytes. On Earth, cells are often cultured in the lab in a two-dimensional environment that is not representative of the 3D environment in living organisms where hepatocytes aggregate. The microgravity environment of the ISS promotes a natural aggregation of cells into 3D structures. Although more biologically representative, this 3D structure can be difficult to create and maintain. This preflight study demonstrates that using a magnetic cell culture to assemble the cells in microgravity will provide an effective means of manipulating the cells to form aggregates in culture that are more like hepatocytes in a living organism. The paper builds on two previous publications and there is also a commercial product related to the company's CASIS-sponsored project. (For more information on this publication, see the Contributions to Scientific Knowledge table on page 15.)
- Another article by Dr. Souza published in the *International Journal of Molecular Science* assesses a model to understand contractility in human uterine cells. Dysfunctions in the contractility of uterine cells in humans can lead to conditions such as infertility, preterm labor, and irregular menstrual cycles. In the body, uterine cells coordinate spatially in three dimensions to induce contraction. The microgravity environment on ISS allows these cells to be grown in a three-dimensional environment that results in the formation of tissue-like structures. In this paper, Dr. Souza and his team propose using magnetic 3D printed uterine cells to build a robust 3D test to better understand the mechanisms behind uterine contractility. The paper describes preflight ground testing of this technique, where cells are printed in contractible ring patterns and then evaluated for reaction to various pharmaceuticals and changes over time. (Note: This article was published in the final week of Q2FY17 but did not appear in the Q2 report.)
- Finally, a paper published in Q3 in *PLoS One* details results from an ISS National Lab commercial investigation developed by U.S. commercial services providers NanoRacks, LLC and Airbus Defense and Space. The paper discusses a cell culture investigation, in collaboration with commercial and academic organizations from multiple countries, that evaluated the effects of spaceflight on macrophages, a critical cell type on the front lines of the human immune system.

STIMULATING AND CULTIVATING DEMAND FOR ISS AND BEYOND

EXPAND THE ISS NATIONAL LAB NETWORK AND DRIVE COMMERCIAL UTILIZATION

OPEN AND UPCOMING OPPORTUNITIES

The 2017 MassChallenge Accelerator Program continued progress in Q3, and the ISS National Lab interfaced with the final list of 128 competing companies to discuss potential opportunities. MassChallenge is the largest-ever startup accelerator and the first to support high-impact, early-stage entrepreneurs without taking any equity. This is the fifth year that CASIS is supporting a Sponsored Program for a "Technology in Space" prize associated with the MassChallenge Program. Co-sponsored by Boeing, the prize will provide funding to technical, out-of-the-box concepts for research on the ISS National Lab.

With respect to additional Sponsored Programs (research competitions sponsored in part or in whole by third-parties), a series of awards were made in Q3 resulting from a collaboration with the NIH-NCATS Tissue Chip for Drug Screening program (see page 11 for more details). This announcement is part of a four-year collaboration, through which NCATS will provide up to $12 million. Additionally, a second joint solicitation, in collaboration with the National Science Foundation (NSF), is expected to announce awardees in the fields of fundamental combustion science and thermal transport in Q4. NSF is committing grant funding of up to $1.8 million toward this new suite of ISS National Lab flight projects.

STRATEGIC AREAS OF FOCUS

In Q3, the ISS National Lab was represented at multiple conferences, targeting new partners within key stakeholder groups. At these events, CASIS engaged in discussions regarding the ISS National Lab and possible utilization with R&D leaders across industry. For example, in late June, CASIS participated in the BIO International Convention in San Diego, California, hosted by the Biotechnology Innovation Organization, which represents more than 1,100 biotechnology companies, academic institutions, state biotechnology centers, and related organizations in the U.S. and around the world. CASIS met with a variety of biotechnology and pharmaceutical organizations and companies to discuss research possibilities available through the ISS National Lab. **Details about this event and other strategic industry event participation can be found in the Events table beginning on page 26.**

CASIS also held a Bone and Muscle Planning Exercise workshop in Boston, Massachusetts, in Q3 to discuss opportunities for musculoskeletal research onboard the ISS using innovative noninvasive (wearable) methods to collect physiological data. The invite-only meeting included technical experts from NASA and CASIS as well as eminent scientists from academia and industry. Discussions focused on the musculoskeletal system and technologies to improve the utility of space-based research for advancing musculoskeletal disease research on Earth. Among other topics addressed during the planning exercise, the participants identified the need for additional controlled studies in microgravity using experimental designs to accommodate larger numbers of rodents than the current limit of 40 mice per mission. Based on this discussion, NASA is currently working to explore future operational concepts for rodent research missions to the ISS that will enable significant increases in the number of mice or rats that can be flown on a single mission. CASIS is working in partnership with NASA to assess near-term demand among industry partners and other government agencies for enhanced rodent research capabilities on the ISS National Lab.

LEO Commercialization

Newly selected flight projects in Q3 further diversify the ISS National Lab portfolio, promoting utilization and innovation within priority R&D areas that provide value to the nation. The ISS National Lab is a critical platform to stimulate the use of LEO for sustained economic activity, and through the inclusion of Fortune 500 companies such as Goodyear and Anheuser-Busch—both selected for new flight projects in Q3—CASIS hopes to continue building commercial interest in the future of LEO commercialization.

Additional Q3 awardees representing nontraditional commercials users include Nalco Champion (a subsidiary of the Fortune 500 company Ecolab), which provides sustainable chemistry services to the oil and gas industry; and Emulate, a privately held company that holds an exclusive license from Harvard University to a broad intellectual property portfolio for Organs-on-Chips technology.

CASIS also continued to expand engagement activities in Silicon Valley, holding multiple meetings with industry leaders and speaking at the Space 2.0 conference, which brought together public, private, and investment sectors of the commercial space industry (satellite operations and manufacturing as well as data intelligence providers). CASIS also held a second "Salon" industry day event with key thought leaders in the region, including investors, strategic partners, science, technology, engineering, and mathematics (STEM) educators, and potential commercial users. At the Salon event, these groups discussed collaborative opportunities for innovation on the ISS National Lab and how to drive the commercial development of LEO. CASIS also attended seven additional events addressing topics including fundamental physics, remote sensing, life sciences, and commercial space industry development.

Also on the West Coast, in conjunction with NASA, CASIS planned and executed two Destination Station events, leveraging these events to meet with industry stakeholders (including two Fortune 100 companies and one Fortune 500 company) and discuss opportunities for flight projects and space-based STEM education initiatives.

Building Sustainability

Of the 10 projects awarded in Q3, more than half required no CASIS funding, needing only ISS National Lab allocation and administrative support services. Moreover, only one project required more than one-third of their total project cost. The continued trend toward cost-sharing by awardees and third parties is a positive indicator of the ISS National Lab's perceived value as an R&D platform and progress toward future sustainability of a LEO market.

PARTNERSHIPS AND COLLABORATIONS

Education

AA new partnership between the Scobee Education Center (SEC) and the CASIS Space Station Explorers (SSE) consortium was formed in Q3. The Challenger Learning Center of San Antonio (CLCSA) is part of the Scobee Education Center at San Antonio College, a unique facility that includes a planetarium, learning center, and rooftop observatory. Challenger Learning Centers use space-themed simulated learning environments to engage students and encourage them to pursue STEM careers. The partnership will provide SSE educational content, including the use of the ISS Virtual Tour, which will remain as a feature in the CLC for more than 28,000 unique visitors each year. Many community and planetarium events also occur at the SEC, and access to the interactive exhibit provided by CASIS will draw a great deal of attention from these visitors. The partnership will further facilitate scholarships for 256 under-represented students to participate in CLC mission experiences.

Life Sciences

As mentioned on page 3, awardees from the joint CASIS-NCATS Sponsored Program were announced in Q3—and awardees from the joint CASIS-NSF Sponsored Program are expected to be announced in Q4. CASIS continues to build relationships with non-NASA government agencies to expand the reach of the ISS National Lab and leverage limited resources. In Q3, CASIS held roundtable discussions with the National Institute of Food and Agriculture (part of the United States Department of Agriculture) and the National Cancer Institute (part of the National Institutes of Health) to discuss opportunities for collaboration. CASIS also engaged with other federal labs in Q3 as part of the Federal Labs Consortium National Meeting, discussing common challenges related to commercialization and technology transfer as well as opportunities for public-private partnership.

Physical Sciences

Additionally, CASIS attended the Multifunctional Integrated System Technology (MIST) Center Industry Advisory Board Spring Meeting in Q3. The MIST Center is a collaborative research group funded through the NSF, University of Florida, and University of Central Florida to advance research integration of novel materials, processes, devices, and circuits into multi-functional systems through partnerships between university, industry, and government stakeholders.

OUTREACH AND EDUCATION

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

INCREASING AWARENESS AND POSITIVE PERCEPTION

Events

ISS National Lab activities in Q3 were highlighted by major outreach efforts targeting STEM education and the commercial innovation community. CASIS participated in or sponsored 29 conferences and events in Q3 and attended various other events to interact with strategic partners.

Life Sciences

BIO International was again a major business development destination for the CASIS team, and for the third year in a row CASIS has created meaningful content to drive the awareness of the ISS and its capabilities for the life science community. NASA Astronaut Kate Rubins joined the CASIS team at BIO International and participated in a featured Fireside Chat session (with The Verge's Loren Grush) to talk about her time on the ISS and the types of breakthroughs that can be advanced by spaceflight R&D.

Education

At the American Seed Trade Association annual meeting, CASIS interfaced with top agriculture research companies performing plant trait development. CASIS highlighted proteomics studies of current ISS National Lab researchers that have demonstrated significant changes in plant gene expression, which can lead to the development of seeds with improved traits for Earth grown crops, improving commercial return for agriculture. First the Seed Foundation and CASIS held discussions with a commercial global leader in advanced plant genetics regarding curriculum development

collaboration for the next phase of the ISS National Lab Tomatosphere program. Such collaborations could result in significant new pathways to expand Tomatosphere as well as expanded agriculture genomics curriculum to engage middle school and high school students.

Details about these events and other event participation and sponsorship can be found in the Events table beginning on page 26.

Media

Social media continues to be a versatile, timely, and far-reaching communication channel for the CASIS team that amplifies the benefits of ISS National Lab research. A strong social media presence is an important factor in shaping corporate branding and influencing public perception and trust, and over the past four years, CASIS has made a concerted effort to strengthen engagements with the public and key stakeholders through improved social media messaging and strategy. This strategy has played an important role in elevating CASIS and the ISS National Lab as thought leaders within the space science community by providing our online audience with multiple access points to engage with the ISS National Lab. The updates, compelling stories and pertinent information disseminated through social media have helped increase our online following more than five-fold since 2013. By communicating ISS National Lab science, successes, and innovations through social media, CASIS has fostered an active and online community to amplify the value of the ISS National Lab.

In Q3, CASIS increased focus on the development and distribution of social media communication products and digital assets in response to the positive trend of social media engagement driven by a robust communications calendar that included the debut of a new quarterly magazine, enhanced video content, and other communications that leveraged social media to catalyze engagement with ISS National Lab content. Specifically, key social media highlights this quarter included the Orbital ATK CRS-7 and SpaceX CRS-11 social media campaigns. CASIS coordinated with various NASA social media teams and our commercial resupply partners to distribute six videos, various blogs, animations, and supplemental content. The CRS-7 campaign garnered 269,136 views and 19,763 engagements across all channels including Facebook, Twitter, and Instagram; and the CRS-11 campaign amassed 414,938 views and 26,419 engagements across all channels—a 53% increase in views following the CRS-7 campaign. Additionally, Oncolinx Pharmaceuticals, Genes in Space (in partnership with Boeing), and Oak Ridge National Lab (all featured in promotional materials around the launch) all saw tremendous regional and national media coverage focusing on their microgravity investigations. The rodent research investigation from the University of California, Los Angeles received particularly noteworthy news coverage from outlets such as *The New York Times, PBS NewsHour,* and *the Associated Press*.

Similarly, a recently published paper from a CASIS-sponsored investigation studying flatworm regeneration (in which one worm in the study grew two heads; discussed on page 15) drew major acclaim through the general and science communities, appearing in outlets such as *Gizmodo, CNET, CBS News, Fox News, Engadget, Yahoo! Tech,* and *Smithsonian Magazine.*

Looking forward to Q4, the ISS Research and Development conference continues to see positive trends in the planning process and has already eclipsed its sponsorship goals for 2017, including welcoming several new companies that have not sponsored in the past. Early registration has also exceeded previous years, with a 21% increase over Q3FY16. Approximately a third of the technical session presenters this year will be discussing ISS National Lab projects or capabilities, and members of the CASIS investor network will participate in an invite-only event where more than ten companies will pitch to investors. This session will be formatted like the 2016 inaugural session, which received positive participant feedback and resulted in multiple investments valued at more than $500,000.

STEM INITIATIVES

In Q3, CASIS continued to promote the SSE brand through attendance at multiple educational conferences and recruitment of Space Station Ambassadors.

- CASIS participated in the Destination Imagination Global Finals Expo in Knoxville, Tennessee, which was attended by more than 17,000 students, educators, and parents. SSE had a booth during the event; SSE partner Zero Robotics introduced students to coding Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) robots on the ISS; and NASA education teams took students on guided virtual reality tours of the ISS.
- CASIS participated in the Global STEM Talent Summit, during which corporations with significant STEM workforce needs shared their strategies, challenges, and opportunities. CASIS focused on the aerospace domain and how SSE can help reach a broad audience.
- At the U.S. News STEM Solutions National Leadership Conference in San Diego, California—an event that reached more than 1,500 participants—corporate sponsor ViaSat approved scholarships for students to participate in the Space Station Academy, which takes them on a simulated space mission.

Additionally, on May 4, CASIS President and Executive Director Greg Johnson was a featured presenter on the NASA Digital Learning Network special "May the 4th Be With You" virtual visit. This event celebrated space films and examined the science behind the Star Wars movies while comparing them to actual ISS science.

For information on these and other Q3 STEM-related events, see the Conferences and Events table beginning on page 26.

SSE Partner Program Progress in Q3

- In June, SpaceX CRS-11 carried almost 6,000 lbs. of supplies and payloads to the ISS National Lab (see page 23 for more details), many of which contained student experiments and assets for various partner programs, including 24 student experiments from the Student Spaceflight Experiment Program (SSEP). SSEP also held its annual conference in Q3, at which CASIS presented to 200 student scientists, all of whom are designing, building, and launching experiments.
- The Tomatosphere program, which launched its second batch of CASIS-sponsored seeds to the ISS National Lab in Q3, was featured in the June issue of *Upward*, the quarterly magazine of the ISS National Lab. The article highlighted the power of the program—which has reached more than 20,000 classrooms and 500,000 students so far in 2017—for project-based learning and interdisciplinary instruction.
- The CASIS-sponsored Crystal Growing Competition among Wisconsin middle and high school students was successfully concluded in Q3, having inspired participation of more than 700 students (378 teams) and teachers from 33 middle schools, 27 high schools, on-line academies, and home schools. The awards ceremony took place in May at the University of Wisconsin–Madison. The winners will participate in a space crystal project to convert the ground crystallization experiment into a flight-ready payload that will fly to the ISS National Lab.
- Frank Bauer, director of the Amateur Radio on the International Space Station (ARISS) program, received the honor of being named the Amateur Radio Operator of the Year at Hamvention, the largest amateur radio convention in the U.S., based on his long-term leadership and success connecting students and astronauts via ham radio on the ISS. NASA also awarded Bauer the NASA Distinguished Public Service Medal for his broader work to enable U.S. technological advances in next-generation GPS systems for satellites.

Q3 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		**48**	**100**
ISS National Lab payloads delivered	8	14	32		**54**	**100**
Solicitations / Competitions	1	2	0		**3**	**4**
Project proposals generated	31	53	9		**93**	**100**
Projects awarded	16	8	10		**34**	**40**
ISS National Lab return customers	4	3**	1		**8**	**20**
ISS National Lab new customers	12	4	9		**25**	**20**
Total Value of CASIS Grants Awarded*	$1,986,869	$701,879	$669,250		**$3,357,998**	**$5,000,000**
CASIS seed funding toward total project cost	29%	33%	9.9%		**24.6%**	**20%**
Peer-reviewed scientific journal publications	5	1	5		**11**	**As they occur**
Products or services created/enhanced	1	0	0		**1**	**As they occur**

* Grants include awards to projects and programs as well as modifications and extensions
** In Q2, two awards were made to the same investigator

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		**$2,300,000**	**$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)	17	18	18		**18**	**15**
Number of students, educators, and other participants engaged in STEM initiatives	71,523	253,581	213,596		**538,700**	**500,000**
Total value of CASIS STEM grants awarded***	$205,656	$50,000	$186,317		**$441,973**	**$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		**13**	**12**
Speaking engagements	29	17	24		**70**	**68**
Subject matter expert workshops	1	0	1		**2**	**4**
Total media impact						
Thought leadership publications (white papers, trade articles, etc.)	0	0	0		**0**	**5**
News mentions (clips, blogs)	616	968	2,383		**3,967**	**5,000**
*Twitter followers^*	103,426	106,703	109,994		**109,994**	**114,000**
Website visitors	22,358	32,788	35,000		**90,146**	**129,000**
Social media engagement (Facebook, Twitter, and Instagram)	150,842	178,796	242,517		**572,155**	**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)*	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)	***1585***	***354***	***331***	***441.2***	***177.51***	***133%***
Inc 53/54 (Sept 2017-Mar 2018)	***1348***	***909***	***503***	***270***	***66***	***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 from CASIS-sponsored Projects in Q3FY17

Title: Planarian regeneration in space: Persistent anatomical, behavioral, and bacteriological changes induced by space travel

Principal Investigators: Drs. Michael Levin and Mahendra Jain

Institutions: Tufts University and Kentucky Space, LLC

Resulted from: A CASIS-sponsored flight project

Citation: Morokuma J, et al. Regeneration. 2017;4:85-102. doi: 10.1002/reg2.79.

Description: The repair and regeneration of tissues is regulated not only by chemical signals between cells but also by physical processes, such as electrochemical and electrical gradients. How these may change in the absence of the normal gravitational and geo-magnetic fields on Earth is largely unknown. Planarian flatworms were grown on the ISS in spring water for 5 weeks, after bisecting worms into two sections, one with a head and one with a tail. A bisected control group in spring water remained on Earth. No manipulation of the planaria occurred while they were in orbit, and live space-exposed worms were returned to the laboratory for analysis. One animal out of 15 regenerated into a double-headed phenotype—normally an extremely rare event. Remarkably, bisecting this double-headed worm again resulted in the double-headed phenotype. Moreover, even when tested 20 months after returning to Earth, the space-exposed worms displayed significant quantitative differences in both behavior and their microbiome. These observations have implications for human space travelers and may also elucidate how microgravity and hypomagnetic environments can trigger desirable morphological, neurological, and physiological changes for the maintenance, repair, and regeneration of damaged tissues.

Earth Benefit: Observing how damaged, diseased, and aging tissues heal is important to human health and regenerative medicine, a therapeutic approach to induce organisms to repair damage to their bodies. Utilizing a relevant model organism such as planaria in the unique environment of the ISS revealed significant differences between the groups. Based on these findings, future studies will focus on how these differences could be harnessed to advance regenerative medicine as well as bioengineering applications in human health.

Title: Genetic dissection of the Arabidopsis spaceflight transcriptome: Are some responses dispensable for the physiological adaptation of plants to spaceflight? **Principal Investigator:** Dr. Anna-Lisa Paul **Institution:** University of Florida **Resulted from:** A CASIS-sponsored flight project **Citation:** Paul A-L, et al. PLoS ONE. 2017;12(6): e0180186. doi: 10.1371/journal.pone.0180186.	**Description:** Experimentation on the ISS has reached the stage where repeated transcriptome studies illuminate the physiological, structural, and metabolic differences between plants grown in microgravity and plants on Earth. Many of the genes important in spaceflight responses have been identified, the roles of some in physiological adaptation are understood, and the fact that different genotypes adapt differently is well characterized. However, the basic question of whether these spaceflight responses are actually required for survival has yet to be defined. Therefore, the experiments presented here were designed to ask if some of the plant spaceflight response can be removed without causing reduced survival and increased stress. The CARA experiment compared the spaceflight transcriptome responses in the root tips of two Arabidopsis ecotypes, Col-0 and WS, as well as that of a PhyD mutant of Col-0. These differential genotypic responses suggest that genetic manipulation could further reduce and/or eliminate the metabolic cost of plant adaptation to stressful environments. **Earth Benefit:** Plants as well as other organisms adapt to changes in an environment over time in order to survive. Typically, these changes are evolutionary and the adaptions are made to optimize the long-term survival of the plant. However, understanding how to control and potentially maximize the adaptive response of plants to a truly novel environment such as microgravity may provide insights in how to control and measure the adaptive response of plants moved to a novel environment here on Earth.
Title: Direct Evidence That an Extended Hydrogen Bonding Network Influences Activation of Pyridoxal 5'-Phosphate in Aspartate Aminotransferase **Principal Investigator:** Dr. Constance Schall **Institution:** University of Toledo **Resulted from:** A project awarded as part of The CASIS Request for Proposals "Advancing Protein Crystallization Using Microgravity" **Citation:** Dajnowicz S, et al. J Biol Chem. 2017;292(14):5970-5980. doi: 10.1074/jbc.M116.774588.	**Description:** Pyridoxal 5'-phosphate (PLP) is a fundamental, multifunctional enzyme cofactor used to catalyze a wide variety of chemical reactions involved in amino acid metabolism. PLP-dependent enzymes optimize specific chemical reactions by modulating PLP through distinct active site environments. In aspartate aminotransferase (AAT), an extended hydrogen bond network is coupled to the pyridinyl nitrogen of the PLP, influencing the electrophilicity of the cofactor. The work reported here demonstrated that this hydrogen bond network directly influences the proto-nation state of the pyridine nitrogen of PLP, which affects the rates of catalysis. Thus, PLP activation is controlled by the proximity of the pyridinyl nitrogen to the hydrogen bond microenvironment and indicates that the second shell residues directly enhance the rate of catalysis in AAT. Earth Benefit: Amino acid metabolism is critical for human health and a number of hereditary human diseases are caused by a disruption in normal amino acid metabolism. Understanding the role and mechanism of action for the enzyme cofactor Pyridoxal 5'-phosphate (PLP) with aspartate aminotransferase (AAT) furthers our understanding of this vital system.
Title: Assembly of Hepatocyte Spheroids Using Magnetic 3D Cell Culture for CYP450 Inhibition/Induction **Principal Investigator:** Dr. Glauco R. Souza **Institution:** Nano3D Biosciences **Resulted from:** Preflight validation studies associated with a CASIS-sponsored flight project **Citation:** Desai PK, et al. Int. J. Mol. Sci. 2017, 18, 1085.; doi:10.3390/ijms18051085	**Description:** There is a need for in vitro methods to study drug-induced liver injury that are rapid, reproducible, and scalable for existing high-throughput systems. However, traditional monolayer and suspension cultures of hepatocytes are difficult. Generally, three-dimensional (3D) cell culture platforms may recapitulate a native liver tissue phenotype, but suffer from technical limitations for high-throughput screening, including scalability, speed, and handling. Here, the authors developed a novel assay for cytochrome P450 (CYP450) induction/inhibition using magnetic 3D cell culture that overcomes the limitations of other platforms by aggregating magnetized cells with magnetic forces. With this platform, spheroids can be rapidly assembled and easily handled, while replicating native liver function. Positive staining in spheroids for albumin and multidrug resistance-associated protein 2 (MRP2) indicates the preservation of hepatocyte function within spheroids. The study presents a proof-of-concept for the use of magnetic 3D cell culture for the assembly and handling of novel hepatic tissue models. **Earth Benefit:** There is a significant need for in vitro methods to study drug-induced liver injury that are rapid, reproducible, and scalable for existing high-throughput systems. However, traditional monolayer and suspension cultures of hepatocytes are difficult to handle and risk the loss of phenotype. This study presents a proof-of-concept for the use of magnetic 3D cell culture for the assembly and handling of novel hepatic tissue models.

PROJECTS AWARDED IN Q3 FY17

Title: Barley Germination & Malting in Microgravity **Principal Investigator:** Gary Hanning **Affiliation:** Anheuser-Busch InBev **Location:** Fort Collins, CO	**Description:**This project will explore the effects of spaceflight on the germination of strains of an important food crop, barley (*Hordeum vulgare*), including proprietary strains under development. Observing changes in gene expression and germination after exposure to microgravity contributes to knowledge about how different cultivars (individuals of the same plant species that possess genetic differences) that are better prepared to handle Earth-based stress, such as temperature extremes or water scarcity. **Earth Benefit:** Barley is the 4th largest cereal grain grown in the world and is grown in diverse environments. Barley is not only a human food source; it is also used in beer production and animal feed. Potential changes in climate may impact where barley can be grown, as well as the amount of starch and the balance of proteins within the grain. Studying barley in microgravity may reveal new information regarding the germination process and identify key genes that enable some cultivars to survive in stressful environments.

Title: Audacy Lynq **Principal Investigator:** Ellaine Talle **Affiliation:** Audacy Corporation **Location:** Mountain View, CA	**Description:** This project will conduct two demonstrations of Audacy communications services onboard the ISS: a direct user-gateway service followed by a user-relay-gateway service. Both will make use of Audacy ground facilities, and the latter demonstration will show the feasibility and utility of continuous communications onboard the ISS with data rates up to 1 Gbps. If successful, the Audacy network would provide LEO satellite missions with a downlink capability currently not available. **Earth Benefit:** Unprecedented demand for satellite data and services has led to a 35% annual industry growth, causing traditional ground-based spacecraft communication solutions to reach their limit. Without scalable connectivity, communications for commercial use remains severely constrained by polar spatial crowding and spectrum scarcity. The Audacy communications network will service the growing needs of six customer segments: deep space operations, human space flight, low Earth orbit constellations, launch operators, non-geostationary orbit constellations, and SmallSat constellations.
Title: Lung Host Defense in Microgravity **Principal Investigator:** Dr. George Worthen **Affiliation:** Children's Hospital of Philadelphia **Location:** Philadelphia, PA	**Description:** This project will test engineered microphysiological systems (tissue-on-chip or organs-on-chips) that model the airway and bone marrow and then combine the models to emulate and understand the integrated immune responses of the human respiratory system in microgravity. Through the use of this system in microgravity, it is anticipated that a greater understanding of immune dysfunction will be uncovered. Infections are commonly reported onboard spacecraft, where the environment causes human immune dysfunction, though the mechanisms are not well understood. **Earth Benefit:** Understanding the mechanism between infections and the health of our immune system is critical for the development of appropriate countermeasures. Further understanding is needed regarding the link between the health of our immune systems and our susceptibility to infections. Ultimately this work could lead to novel therapeutics for Earth-based patients with compromised immune systems as well as preventive measures for space-based personnel.
Title: Effects of Microgravity on Human Physiology: Blood-Brain Barrier-Chip **Principal Investigator:** Dr. Christopher Hinojosa **Affiliation:** Emulate, Inc. **Location:** Cambridge, MA	**Description:** This project seeks to understand how the unique environment of the ISS National Lab affects blood-brain barrier (BBB) physiology. Researchers will validate and develop Emulate's proprietary organs-on-chips technology platform for experimentation with human cells. The BBB is a semi-permeable barrier that allows selective passage of certain molecules and gases while preventing the passage of others. It is a critical component involved in maintaining homeostasis, and disruption of the barrier can lead to or cause neurological dysfunction or disease. **Earth Benefit:** This technology will become available to the broader scientific community for studies on human physiology and disease in space. The BBB tissue chip is a prototype for an organ system critical to homeostasis and involved in the pathogenesis of multiple health conditions including neurodegeneration, traumatic injury, and cancer.
Title: Pushing the Limits of Silica Fillers for Tire Applications **Principal Investigator:** Derek Shuttleworth **Affiliation:** The Goodyear Tire & Rubber Co. **Location:** Akron, OH	**Description:** This project will evaluate the creation of novel silica morphologies in microgravity, not available on Earth, using silica fillers formed through traditional synthesis techniques. This data will inform future efforts to improve the silica deposition process to improve tire performance by the development of new manufacturing technologies on the ground. **Earth Benefit:** Recent experiments in microgravity have demonstrated the ability to generate novel mixtures of solids and liquids that could potentially show promise in delivering better performance in the tire industry by improving silica morphologies in tires. A breakthrough in the research of the effect of silica morphology on rubber compound properties will lead to significant improvements in fuel efficiency and transportation cost savings, and perhaps more importantly, better the environment.
Title: Remote Manipulator Small-Satellite System (RM3S) **Principal Investigator:** Craig Walton **Affiliation:** LaMont Aerospace Inc. **Location:** Houston, TX	**Description:** This project will provide support for the final stages in the construction and manifest of a small-satellite dispenser. Satellite dispensers range from 3U, 6U, 12U, 27U, and 54U in size; clients may choose satellites with a mass of 2–4 kg/U, with the 27U and 54U satellites having a maximum mass of 6–8 kg/U meaning 360.0 lbm (pound mass) and 960.0 lbm, respectively. The Remote Manipulator Small-Satellite System (RM3S) is based on the Planetary Systems Corporation's satellite dispenser system, which has a long flight history of reliability and success and will provide government, academic, and industry satellite clients and researchers a platform that allows for proper reliability controls. The system also has the capacity to deploy a large volume of nanosatellites within a single deployment cycle, supporting frequent and reliable deployment opportunities with proven and trusted hardware. **Earth Benefit:** The addition of the LaMont RM3S small-satellite dispenser will enable LaMont to provide capability to customers to reliably deploy constellations of nano- (1–10 kg) and small-satellites (200–500 kg). Mounting the system externally to the launch vehicle will eliminate the need for additional crew time, airlock cycles, long-duration deployment windows, intravehicular activity safety compliance, and similar payload subsystem issues. By integrating this component into their portfolio, LaMont believes they will provide a more reliable, capable, small-satellite deployment option at a lower cost than what is presently available.
Title: Cartilage-Bone-Synovium MPS: Musculoskeletal Disease Biology in Space **Principal Investigator:** Dr. Alan Grodzinsky **Affiliation:** Massachusetts Institute of Technology **Location:** Cambridge, MA	**Description:** This project will study the effects of spaceflight on musculoskeletal disease biology, specifically, post-traumatic osteoarthritis and bone loss using a tissue-on-a-chip cartilage-bone-synovium joint model. Researchers will co-culture primary human explants of intact (native) cartilage, bone, and synovial joint capsule tissue (obtained from a long-standing collaborating human donor bank). The effects of pharmacological agents to ameliorate bone and cartilage degeneration will be tested on Earth and onboard the ISS, using a quantitative and high-content experimental and computational approach. **Earth Benefit:** Post-traumatic osteoarthritis causes about 12% of osteoarthritis of the hip, knee, and ankle, and is a common condition in otherwise healthy (young to middle-aged) individuals, affecting about 5.6 million people in the United States. This project represents a relevant human tissue-on-chip platform with the potential to provide several pharmacological treatment options for osteoarthritis patients.

Title: Linking Biofilm Thickness and Viability to an Elevated Microbial Corrosion Risk **Principal Investigator:** Vic Keasler **Affiliation:** Nalco Champion **Location:** St. Paul, MN	**Description:** This project will establish biofilms on Earth and in space on the ISS to observe and quantify the rate of microbial corrosion as a function of cell density and activity. Based on previous work reporting enhanced biofilm formation in microgravity, these results will provide insight into the degree to which the actual biofilm size or viability impacts the corrosion rate. **Earth Benefit:** It is well established that localized corrosion caused by microorganisms (referred to as microbiologically influenced corrosion, or MIC) is responsible for 20–50% of all damage caused by corrosion (according to the National Association of Corrosion Engineers (NACE) International, 2016), and translates to $485 billion–$1.5 trillion in annual costs globally. One of the challenges in preventing MIC has been to define the conditions when a biofilm is likely to cause localized corrosion versus when it is not. By conducting an experiment where biofilms are established on Earth and in space (on the ISS) and monitoring the rate of microbial corrosion, investigators expect to gain insight into the degree to which the density of cells in the biofilm or the activity of individual cells impacts the corrosion rate. This data will inform new methods on how to effectively mitigate against MIC on Earth and on the ISS.
Title: Microgravity Model for Immunological Senescence on Tissue Stem Cells **Principal Investigator:** Dr. Sonja Schrepfer **Affiliation:** University of California, San Francisco **Location:** San Francisco, CA	**Description:** This tissue chip project aims to investigate the relationship between an individual's immune aging and healing outcomes, and to investigate the biology of aging from two perspectives—one during observations of immune function in microgravity and then during recovery of the cells after return to a 1g environment. Aging is associated with dysregulation of the immune response (termed immunosenescence), a condition that may also be accelerated by prolonged exposure to microgravity. **Earth Benefit:** The older adult population accounts for more than 90% of influenza-related deaths, in part a result of increasing dysregulation of the immune system with age. Utilizing this unique platform, the investigators hope to understand the dysregulation of the immune system more fully with the goal of developing additional treatment options for the elderly and immuno-compromised patient populations.
Title: Effects of Microgravity on the Structure of Proximal and Distal Tubule MPS **Principal Investigator:** Dr. Jonathan Himmelfarb **Affiliation:** University of Washington **Location:** Seattle, WA	**Description:** This project aims to develop physiologically relevant proximal and distal tubule tissue-on-a-chip systems and deploy them to the ISS National Lab. Through these systems, investigators will study Vitamin D bioactivation and homeostasis as well as disease models that promote proteinuria and the formation of kidney stones. **Earth Benefit:** Kidney dysfunction can precipitate serious medical conditions including proteinuria, osteoporosis, and the formation of kidney stones. These conditions occur more frequently, and progress faster, in astronauts onboard the ISS. This tissue chip project uses a kidney model to understand how microgravity and other factors affect kidney function and uses these discoveries to design improved patient treatment options.

Q3 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	Ted Tagami	Magnitude.io	Berkeley	CA
Orion's Quest-Student Research on the ISS	Peter Lawrie	Orion's 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
Eli Lilly - Lyophilization	Jeremy Hinds	Eli Lilly and Company	SpX-12	8/10/17	Indianapolis	IN
Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes	Dr. Robert Schwartz	University of Houston System	SpX-12	8/10/17	Houston	TX
The Effect of Microgravity on Stem Cell Mediated Recellularization	Dr. Alessandro Grattoni	Houston Methodist Research Institute	SpX-12	8/10/17	Houston	TX
Characterizing Arabidopsis Root Attractions (CARA) grant extension	Dr. Anna-Lisa Paul	University of Florida Board of Trustees	SpX-12	8/10/17	Gainesville	FL
Implantable Glucose Biosensors	Dr. Michail Kastellorizios	Biorasis, Inc.	SpX-12	8/10/17	Storrs/ Mansfield	CT
Intraterrestrial Fungus Grown in Space (iFunGIS)	Dr. Heath Mills	Space Technology and Advanced Research Systems, Inc. (STaARS)	SpX-12	8/10/17	Houston	TX
Genes in Space - 4	Alia Al Mansoori	The Boeing Company	SpX-12	8/10/17	Chicago	IL
Story Time from Space - 4	Patricia Tribe	T2 Science and Math Education Consultants	SpX-12	8/10/17	Penticton	BC
National Design Challenge - 3: Chicagoland Boy Scouts and Explorers	Dr. Sandra Rogers	Boy Scouts of America	SpX-12	8/10/17	Chicago	IL
STaARS-1 Research Facility	Dr. Heath Mills	Space Technology and Advanced Research Systems, Inc. (STaARS)	SpX-12	8/10/17	Houston	TX
Spaceborne Computer	David Petersen	Hewlett Packard	SpX-12	8/10/17	Milpitas	CA
Crystallization of LRRK2 under Microgravity Conditions	Dr. Marco Baptista	Michael J. Fox Foundation	SpX-12	8/10/17	New York	NY
TangoLab-1.1	Twyman Clements	Space Tango, Inc.	SpX-12	8/10/17	Lexington	KY
Optical Fiber Production in Microgravity Experiment	Michael Snyder	Made In Space, Inc.	SpX-13	11/1/17	Moffett Field	CA
Materials International Space Station Experiment - Flight Facility (MISSE-FF)	L.D. Stevenson	Alpha Space	SpX-13	11/1/17	Houston	TX
Assessing Osteoblast Response to Tetranite	Dr. Nikolaos Tapinos	LaunchPad Medical	SpX-13	11/1/17	Boston	MA
Implantable Nanochannel System for Delivery of Therapeutics for Muscle Atrophy	Dr. Alessandro Grattoni	Houston Methodist Research Institute	SpX-13	11/1/17	Houston	TX
National Design Challenge - 3: Chicagoland Boy Scouts and Explorers	Norman McFarland	Boy Scouts of America	SpX-13	11/1/17	Chicago	IL
Microgravity Crystal Growth for Improvement in Neutron Diffraction	Dr. Timothy Mueser	University of Toledo	SpX-13	11/1/17	Toledo	OH
Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System	Dr. Robert Applegate	Novopyxis	TBD	TBD	Boston	MA
Capillary-Driven Microfluidics in Space	Dr. Luc Gervais	1Drop Diagnostics US, Inc.	TBD	TBD	Boston	MA
Multi-purpose Active-target Particle Telescope on the ISS (MAPT-I)	Hans-Juergen Zachrau	AIRBUS DS Space Systems, Inc.	TBD	TBD	Webster	TX
Rodent Research - 4 (Wound Healing)	Dr. Rasha Hammamieh	Department of Defense	TBD	TBD	Fort Detrick	MD
Development and Validation of a Microfluidic Lab-on-a-chip	Dr. Siobhan Malany	Micro-gRx, Inc.	TBD	TBD	Orlando	FL

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Constrained Vapor Bubbles of Ideal Mixtures	Dr. Joel Plawsky	Rensselaer Polytechnic Institute	TBD	TBD	Troy	NY
The Universal Manufacture of Next Generation Electronics	Dr. Supriya Jaiswal	Astrileux Corporation	TBD	TBD	La Jolla	CA
Droplet Formation Studies in Microgravity	Paul Patton	Delta Faucet	TBD	TBD	Indianapolis	IN
Nemak Alloy Solidification Experiments	Dr. Glenn Byczynski	NEMAK	TBD	TBD	Southfield	MI
Cranial Bone Marrow Stem Cell Culture in Space	Dr. Yang D. Teng	Brigham and Women's Hospital	TBD	TBD	Boston	MA
Providing Spherical Video Tours of ISS	David Gump	Deep Space Industries	TBD	TBD	Moffett Field	CA
Space Based Optical Tracker	Dr. John Stryjewski	Vision Engineering Solutions	TBD	TBD	Orlando	FL
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
Enhancement of Performance and Longevity of a Protein-Based Retinal Implant	Dr. Nicole L. Wagner	LambdaVision	TBD	TBD	Farmington	CT
Quantifying Cohesive Sediment Dynamics for Advanced Environmental Modeling	Dr. Paolo Luzzatto-Fegiz	University of California, Santa Barbara	TBD	TBD	Santa Barbara	CA
Global Receive Antenna and Signal Processor (GRASP)	Robert Carlson	JAMSS America, Inc.	TBD	TBD	Houston	TX
International Space Station Bioprinter Facility	Dr. Eugene Boland	Techshot, Inc.	TBD	TBD	Greenville	IN
SPHERES Zero Robotics Middle School	Dr. Alvar Saenz-Otero	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
Continuous Liquid-Liquid Separation in Microgravity	Dr. Andrea Adamo	Zaiput Flow Technologies	TBD	TBD	Cambridge	MA
Fiber Optics Manufacturing in Space (FOMS)	Dr. Dmitry Starodubov	FOMS, Inc.	TBD	TBD	San Diego	CA
DexMat CNT Cable Project	Dr. Alberto Goenaga	DexMat	TBD	TBD	Houston	TX
SPHERES Zero Robotics High School	Dr. Alvar Saenz-Otero	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
Crystal Growth STEM 2017	Ilia Guzei	University of Wisconsin - Madison	TBD	TBD	Madison	WI
Space Development Acceleration Capability (SDAC)	Philip Bryden	Craig Technologies	TBD	TBD	Cape Canaveral	FL
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
Remote Manipulator Small-Satellite System (RM3S)	Craig Walton	LaMont Aerospace, Inc.	TBD	TBD	Houston	TX
Audacy Lynq	Ellaine Talle	Audacy Corporation	TBD	TBD	Mountain View	CA

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Effects of Microgravity on the Structure of Proximal and Distal Tubule Microphysiological Systems	Dr. Jonathan Himmelfarb	University of Washington	TBD	TBD	Seattle	WA
Barley Germination & Malting in Microgravity	Gary Hanning	Anheuser-Busch InBev	TBD	TBD	Fort Collins	CO
Lung Host Defense in Microgravity	Dr. George Worthen	Children's Hospital of Philadelphia	TBD	TBD	Philadelphia	PA
Microgravity Model for Immunological Senescence on Tissue Stem Cells	Dr. Sonja Schrepfer	University of California, San Francisco	TBD	TBD	San Francisco	CA
Cartilage-Bone-Synovium Microphysiological Systems Musculoskeletal Disease Biology in Space	Dr. Alan Grodzinsky	Massachusetts Institute of Technology	TBD	TBD	Cambridge	MA
Pushing the Limits of Silica Fillers for Tire Applications	Derek Shuttleworth	The Goodyear Tire & Rubber Co.	TBD	TBD	Akron	OH
Effects of Microgravity on Human Physiology: Blood-Brain Barrier-Chip	Dr. Christopher Hinojosa	Emulate, Inc.	TBD	TBD	Cambridge	MA
SiC Microgravity Enhanced Electrical Performance (MEEP)	Rich Glover	ACME Advanced Materials	TBD	TBD	Albuquerque	NM
Survivability of Variable Emissivity Devices for Thermal Control Applications	Dr. Hulya Demiryont	Eclipse Energy Systems, Inc.	TBD	TBD	St. Petersburg	FL
Microgravity Crystallization of Glycogen Synthase-Glycogenin Protein Complex	Dr. David S. Chung	Dover Lifesciences	TBD	TBD	Dover	MA
Comparative Real-time Metabolic Activity Tracking	Dr. Gary Sayler	490 Biotech	TBD	TBD	Knoxville	TN
Endothelial Cells In Microgravity for Evaluation of Cancer Therapy Toxicity	Dr. Shou-Ching Jaminet	Angiex	TBD	TBD	Cambridge	MA
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
Kinetics of Nanoparticle Self-assembly in Directing Fields	Dr. Eric Furst	University of Delaware	TBD	TBD	Newark	DE
Stability of the Human Virome during Space Flight	Dr. Kristian Andersen	Scripps Translational Science Institute	TBD	TBD	La Jolla	CA
SPHERES Tether – SLOSH	Hans-Juergen Zachrau	AIRBUS DS Space Systems, Inc.	TBD	TBD	Webster	TX
The Effects of Microgravity on Synovial Fluid Volume and Composition	Dr. Richard Meehan	National Jewish Health	TBD	TBD	Denver	CO
The Influence of Spaceflight on Biological Age	Dr. Ali Torkamani	Scripps Translational Science Institute	TBD	TBD	La Jolla	CA
Microgravity Investigation of Cement Solidification (MICS)	Dr. Aleksandra Radlinska	Penn State University	TBD	TBD	University Park	PA
Ionic Liquid CO2 Scrubber and Liquid Containment in Microgravity	Phoebe Henson	Honeywell International	TBD	TBD	Glendale	AZ
Microbial Corrosion from Biofilms	Vic Keasler	Nalco Champion	TBD	TBD	St. Paul	MN
Influence of Microgravity on T-Cell Dysfunction and Neurogenesis	Dr. Caitlin O'Connell-Rodwell	HNu Photonics	TBD	TBD	Wailuku	HI
Intuitive Machines - ISS Terrestrial Return Vehicle (TRV)	Steve Altemus	Intuitive Machines	TBD	TBD	Houston	TX

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Corrosion Inhibitor Exposed to the Extreme Environments in Space	Lauren Thompson Miller	A-76 Technologies, LLC	TBD	TBD	Houston	TX
Electrolytic Gas Evolution under Microgravity	Larry Alberts	Cam Med, LLC	TBD	TBD	West Newton	MA
Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment	Dan O'Connell	HNu Photonics	TBD	TBD	Wailuku	HI

IN-ORBIT

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	LAUNCH DATE	CITY	STATE
Alpha Magnetic Spectrometer - 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	OA-4	12/6/15	Los Alamitos	CA
Project Meteor	Michael Fortenberry	Southwest Research Institute	OA-6	3/23/16	Boulder	CO
Additive Manufacturing Operations Program	Michael Snyder	Made In Space, Inc.	OA-6	3/23/16	Moffett Field	CA
GLASS AIS Transponder—Global 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
Materials Testing - The Evaluation of Gumstix Modules in Low Earth Orbit	Dr. Kathleen Morse	Yosemite Space	SpX-9	7/18/16	Groveland	CA
Materials Testing - Earth Abundant Textured Thin Film Photovoltaics	Dr. Jud Ready	Georgia Institute of Technology	SpX-9	7/18/16	Atlanta	GA
NIH-Osteo	Dr. Bruce Hammer	University of Minnesota	SpX-9	7/18/16	Minneapolis	MN
Controlled Dynamics Locker for Microgravity Experiments on ISS	Dr. Scott A. Green	Controlled Dynamics, Inc.	OA-5	10/16/16	Huntington Beach	CA
Honeywell/Morehead-DM Payload Processor	Dr. Benjamin Malphrus	Honeywell/Morehead State University	HTV6	12/9/16	Morehead	KY
Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples	Dr. Edward Snell	Hauptman Woodward Medical Research Institute, Inc.	SpX-10	2/19/17	Buffalo	NY
Development and Deployment of Charge Injection Device Imagers	Dr. Daniel Batcheldor	Florida Institute of Technology	SpX-10	2/19/17	Melbourne	FL
Efficacy & Metabolism of Azonafide Antibody-Drug Conjugates	Sourav Sinha	Oncolinx Pharmaceuticals LLC	OA-7	4/18/17	Boston	MA
Magnetic 3D Cell Culture for Biological Research in Microgravity	Dr. Glauco Souza	Nano3D Biosciences, Inc.	OA-7	4/18/17	Houston	TX
Genes in Space - 2	Julian Rubinfien	The Boeing Company	OA-7	4/18/17	Chicago	IL
Genes in Space - 3	Dr. Sebastian Kraves	Amplyus, LLC	OA-7	4/18/17	Cambridge	MA
National Design Challenge - 2 Centaurus	Brian Thomas	Centaurus High School	OA-7	4/18/17	Lafayette	CO
Detached Melt and Vapor Growth of Indium Iodide in SUBSA Hardware	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

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	LAUNCH DATE	CITY	STATE
SG100 Cloud Computing Payload	Trent Martin	Business Integra	OA-7	4/18/17	Houston	TX
National Design Challenge - 2 Bell	Shanna Atzmiller	Bell Middle School	SpX-11	6/3/17	Golden	CO
National Design Challenge - 2 Chatfield	Joel Bertelsen	Chatfield Senior High School	SpX-11	6/3/17	Littleton	CO
Advanced Colloids Experiment - Temperature Controlled - 6 (ACE-T-6)	Dr. Matthew Lynch	Procter & Gamble Company	SpX-11	6/3/17	West Chester	OH
Tomatosphere - 2	Ann Jorss	First the Seed Foundation	SpX-11	6/3/17	Alexandria	VA
Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators	Andrey Kovalevsky	Oak Ridge National Lab	SpX-11	6/3/17	Oak Ridge	TN
Functional Effects of Spaceflight on Cardiovascular Stem Cells	Dr. Mary Kearns-Jonker	Loma Linda University	SpX-11	6/3/17	Loma Linda	CA
Multi-User System for Earth Sensing (MUSES) Imaging Platform	Bill Corley	Teledyne Brown Engineering	SpX-11	6/3/17	Huntsville	AL
Systemic Therapy of NELL-1 for Osteoporosis (Rodent Research - 5)	Dr. Chia Soo	University of California, Los Angeles	SpX-11	6/3/17	Los Angeles	CA
Windows On Earth	David Libby	TERC	N/A	N/A	Cambridge	MA
Street View Imagery Collect on ISS	Ann Kapusta	ThinkSpace	N/A	N/A	Mountain View	CA
ARISS (Amateur Radio from ISS)	Frank Bauer	AMSAT (Radio Amateur Satellite Corporation)	N/A	N/A	Kensington	MD
Cyclone Intensity Measurements from the International Space Station	Dr. Paul Joss	Visidyne, Inc.	N/A	N/A	Burlington	MA

POSTFLIGHT/COMPLETE

TITLE	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
Optimizing Jammable Granular Assemblies in a Microgravity Environment	Jason Hill	Benevolent Technologies for Health	Boston	MA
Protein Crystal Growth to Enable Therapeutic Discovery	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
Crystallization of Huntington Exon-1 Using Microgravity	Dr. Pamela Bjorkman	California Institute of Technology	Pasadena	CA
Microgravity Electrodeposition Experiment	Michael Yagley	Cobra Puma Golf	Carlsbad	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: 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

TITLE	PRINCIPAL INVESTIGATOR	AFFILIATION	CITY	STATE
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	Drs. Richard Cope, Alison Campbell, and Kenneth Savin	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
Exploiting On-orbit Crystal Properties for Medical and Economic Targets	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
Architecture to Transfer Remote Sensing Algorithms from Research to Operations	Dr. James Goodman	HySpeed Computing	Miami	FL
Rodent Research - 4 Validation Study	Drs. Melissa Kacena and 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
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
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
Great Lakes Specific HICO Water Quality Algorithms	Dr. Robert Shuchman	Michigan Technological University	Houghton	MI
Vertical Burn	Dr. Jeff Strahan	Milliken	Spartanburg	SC
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 Ames Research Center	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

TITLE	PRINCIPAL INVESTIGATOR	AFFILIATION	CITY	STATE
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
Novartis Rodent Research-2	Dr. David Glass	Novartis Institute for Biomedical Research	Cambridge	MA
Binary Colloidal Alloy Test – Low Gravity Phase Kinetics Platform	Dr. Matthew Lynch	Procter & Gamble Company	West Chester	OH
Collaborative Project-Protein Crystal Growth to Enable Therapeutic Discovery	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
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
Kentucky Space/Exomedicine Lab - Flatworm	Drs. Michael Levin and Mahendra Jain	Tufts University and Kentucky Space, LLC	Medford	MA
Crystallization of Human Membrane Proteins in Microgravity	Dr. Stephen Aller	University of Alabama at Birmingham	Birmingham	AL
The Effect of Macromolecular Transport on Microgravity Protein Crystal Growth	Dr. Lawrence DeLucas	University of Alabama at Birmingham	Birmingham	AL

TITLE	PRINCIPAL INVESTIGATOR	AFFILIATION	CITY	STATE
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	Gainesville	FL
Generation of Mesendoderm Stem Cell Progenitors in the ISS-National Laboratory	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
Protein Crystal Growth for Determination of Enzyme Mechanisms	Dr. Constance Schall	University of Toledo	Toledo	OH
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
CyMISS Grant Proposal for the 2015 Tropical Cyclone Season	Dr. Paul Joss	Visidyne, Inc.	Burlington	MA

CONFERENCES AND EVENTS IN Q3 FY17

CONFERENCE AND INDUSTRY EVENT SPONSORSHIPS

EVENT	LOCATION	DATE	DESCRIPTION
American Crystallographic Association	New Orleans, LA	5/26/2017–5/30/2017	CASIS exhibited at the American Crystallographic Association annual meeting, where scientists from varied disciplines exchanged cutting-edge ideas and techniques in multiple areas of research. Each meeting highlights various aspects of crystallography and demonstrates their significance to the greater scientific community. CASIS focused on microgravity onboard the ISS National Lab as a unique and advantageous environment for crystallization studies.
BIO International 2017	San Diego, CA	6/19/2017–6/22/2017	CASIS exhibited and participated in 25 scheduled commercial business development meetings, key sessions, receptions, and events at the BIO International Convention. As a keynote speaker, Astronaut Kate Rubins spoke about her experiences on the ISS and participated in an autograph session at the CASIS booth.
International Space Development Conference	St. Louis, MO	5/27/17	CASIS organized and led a three-hour session at the National Space Society's International Space Development Conference, a gathering of aerospace industry leaders and startups, space exploration pioneers, academic thought leaders, and space supporters. The session presented an overview on the progress and maturation the ISS National Lab, followed by panel discussions in the areas of commercial operations and STEM education.
Space Symposium	Colorado Springs, CO	4/3/2017–4/6/2017	CASIS exhibited at the Space Symposium, which brings together space leaders from around the world to discuss, address, and plan for the future of space. In addition, CASIS held private meetings with five companies to discuss potential flight projects and presented an overview of the ISS National Lab to more than 300 educators and students.

SUBJECT MATTER EXPERT WORKSHOPS

EVENT	LOCATION	DATE	DESCRIPTION
Bone and Muscle Planning Exercise	Boston, MA	4/14/17	CASIS Chief Scientist Dr. Randy Giles and Deputy Chief Scientist Dr. Michael Roberts led a workshop focused on new approaches to collecting and analyzing musculoskeletal data from crew members onboard the ISS. The objectives of the planning exercise were to develop a meaningful set of physiological measurements of crew bone and muscle conditions during long-term exposure to the microgravity environment, to identify existing or to-be-developed noninvasive wearable technologies that could be worn by station crew members to collect data, and to propose data analysis methods that yield the most informative and actionable insights.

ADDITIONAL CONFERENCE AND EVENT PARTICIPATION

EVENT	LOCATION	DATE	DESCRIPTION
Division of Biochemical Technology 253rd American Chemical Society National Meeting	San Francisco, CA	4/2/2017–4/6/2017	CASIS Chief Scientist Dr. Randy Giles and Deputy Chief Scientist Dr. Michael Roberts served as co-chairs on a panel discussion at a National Meeting of the Division of Biochemical Technology (BIOT) of the American Chemical Society. To an audience of academic and industrial researchers, CASIS presented "Bio-Based Products: Synthesis in Space," focused on accessing the ISS National Lab for research in space to benefit Earth and the future role of biotechnology in low Earth orbit and deep space exploration.

EVENT	LOCATION	DATE	DESCRIPTION
Congress on the Future of Engineering Software	Scottsdale, AZ	4/6/2017–4/9/2017	CASIS presented about R&D onboard ISS at COFES, the engineering software industry's annual think tank event. Executives from design, engineering, architectural, development, and technology companies came together to understand the role engineering technology will play in the future survival and success of business.
STEM Fiesta	El Paso, TX	4/6/17	CASIS gave a keynote presentation to approximately 1,000 students and 100 educators at an annual event to promote STEM careers for El Paso, TX, middle-school students.
CASIS/ASGSR Science Panel on Capitol Hill	Washington, DC	4/20/17	CASIS and ASGSR co-hosted a breakfast science panel on Capitol Hill, where CASIS and ASGSR scientists presented ISS research projects to Congressional staffers. The mission was to educate staffers firsthand about how ISS National Lab research benefits our nation through "Scientists Bringing International Space Station Research Down to Earth." Staff members heard from ISS project scientists about case studies on the incredible benefits of using microgravity to reveal information about life and physical sciences. U.S. Representative Brian Babin sponsored the event.
Girls STEAM Ahead with NASA	Tampa, FL	4/23/17	CASIS engaged middle school girls in hands-on STEM activities and introduced them to STEM careers as part of the STEAMing to the Stars program. Sponsored by the Museum of Science & Industry, NASA's Space Telescope Science Institute, and CASIS, the program's activities included a viewing of the IMAX documentary *A Beautiful Planet,* Space Station Explorers activities, and video conferencing with a scientist working on the Chandra Telescope.
Federal Labs Consortium National Meeting	San Antonio, TX	4/26/17	CASIS Executive Director Greg Johnson gave a keynote talk at the Federal Laboratory Consortium National Annual Meeting about the mission of CASIS and the ISS National Lab. This meeting included all the National Labs and their related organizations.
Space 2.0	Milpitas, CA	4/26/2017–4/27/2017	CASIS served on two panel sessions at Space 2.0, presented by Infocast. With its rich audience of investors (venture capital, equity, incubators, and investment banks), aerospace prime contractors, government agencies, and incumbent players from the satellite operator and manufacturing sectors, Space 2.0 provided a unique opportunity for CASIS to showcase the commercial space industry for accelerating business plans in technology innovation.
International Space Apps Conference	New York, NY	4/28/17	CASIS participated in a space entrepreneurship panel with *Business Insider* at the International Space Apps Conference. CASIS discussed the ISS National Lab's capabilities and advocated for partnerships and opportunities to collaborate.
2017 X-STEM Symposium	Washington, DC	4/28/17	CASIS Executive Director Greg Johnson spoke at the 2017 X-STEM Symposium, hosted by the USA Science & Engineering Festival. Johnson discussed the ISS and the Space Station Explorers program and shared his unique astronaut perspective to motivate the audience toward careers in STEM.
Fiesta Brevard	Cocoa, FL	4/28/17	CASIS exhibited with more than 30 nonprofit organizations at Fiesta Brevard, attended by more than 1,500 people on the Florida Space Coast. CASIS discussed the ISS National Lab and the Space Station Explorers program as a platform for not only research but also educational activities in science, technology, engineering, and mathematics.
3D Bioprinting Roadmapping Workshop	Winston-Salem, NC	5/1/17	To an audience of senior scientific leaders, researchers, advisors in the research community, other government agencies, and commercial partners, CASIS presented information on how the ISS and microgravity might advance 3D bioprinting capabilities. The event provided an opportunity to collaborate with thought leaders in their efforts to develop standards and best practices.
NASA Digital Learning Network	Houston, TX	5/4/17	CASIS Executive Director Greg Johnson presented to an audience of approximately 500 middle school students and the general public a special "May The 4th Be With You" Virtual Visit, hosted by the NASA Digital Learning Network.
Wisconsin Space Crystal Award Ceremony	Madison, WI	5/19/17	In collaboration with CASIS, the Wisconsin Space Crystal Award Ceremony recognized the 700 middle and high school students participating in the CASIS-sponsored crystal-growing competition. The six top prize winners will participate in a subsequent program to develop a flight experiment.
Hamvention	Xenia, OH	5/20/2017–5/21/2017	Attended by more than 500 people, Hamvention, the National Amateur Radio Convention, was a venue for CASIS to connect with ham operators engaged in education and space communications. CASIS spoke during an awards ceremony for Frank Bauer, director of ARISS.
Destination Station: Seattle	Seattle, WA	5/21/2017–5/26/2017	As part of NASA's Destination Station outreach initiative, CASIS met with large businesses in the Seattle area to highlight the capabilities of the ISS. Over the past two years, CASIS has become increasingly involved in the development and implementation of these Destination Station events to leverage this as a unique business development tool to reach companies and research institutions.
Destination Imagination Global Finals	Knoxville, TN	5/24/2017–5/27/2017	CASIS exhibited at the Destination Imagination Global Finals, the world's largest celebration of creativity, where approximately 5,000 students, educators, and parents visited the CASIS booth to learn about the Space Station Explorers program and to participate in workshops.

EVENT	LOCATION	DATE	DESCRIPTION
JFK 100 Centennial Celebration	Boston, MA	5/29/17	CASIS participated in the JFK 100th Birthday celebration at the John F. Kennedy Presidential Library and Museum, which is spearheading a year-long series of events and initiatives to inspire new generations to find meaning and inspiration in the enduring values that formed the heart of the Kennedy presidency. CASIS was joined by its partner, ARISS, for an audio downlink with astronauts on the ISS. More than 500 students and educators attended.
NASA Fundamental Physics Workshop	Santa Barbara, CA	5/31/2017–6/2/2017	CASIS Chief Scientist Randy Giles presented about the ISS National Lab research portfolio and discussed research ideas for future space experimentation with interested international and U.S. colleagues at a workshop for NASA fundamental physics investigators.
Dawn of Private Space Science Symposium	New York, NY	6/2/2017–6/4/2017	CASIS presented about ISS National Lab capabilities and potential collaboration opportunities to an audience of leading scientists, foundations, policymakers, and commercial entities. The Dawn of Private Space Science Symposium is a new platform to facilitate communication between the private space industry and scientists. The symposium will enable advancement of science that will benefit our species, planet, and existence.
Space Station Explorers Live - Science Institute of Discovery	Cape Canaveral, FL	6/8/17	The Space Station Explorers Live event brought together 40 underserved middle school youth from the Science Institute of Discovery in Vero Beach. The students learned about the ISS and career opportunities in the space industry.
USDA-NASA Meeting	Washington, DC	6/20/17	Deputy Chief Scientist Dr. Michael Roberts of CASIS and representatives from NASA met with the United States Department of Agriculture (USDA) to establish opportunities for collaboration on future sponsored programs for the ISS and the ISS National Lab.
American Seed Trade Association Annual Meeting	Minneapolis, MN	6/21/2017–6/23/2017	CASIS exhibited at the American Seed Trade Association Annual (ASTA) annual meeting to discuss the potential for agriculture research onboard the ISS and featured First the Seed Foundation's Tomatosphere program as a case study. Each year, ASTA gathers more than industry professionals, serving as the crucial annual policy development meeting. Strategic players include Bayer Crop Science, Dow AgroSciences, Monsanto, and 400 other commercial agriculture companies.
Destination Station: Portland	Portland, OR	6/21/2017–6/23/2017	CASIS business development representatives participated in NASA's Destination Station in Portland to present an overview of the research taking place on the ISS National Lab and to explain the physical phenomena of microgravity research. CASIS met with large companies to develop partnerships and potential flight opportunities.
Space Station Explorers Program Annual Conference	Washington, DC	6/29/17	CASIS gave a presentation on CASIS and its Space Station Explorers program to an audience of students, parents, dignitaries, and the public attending the National Center for Earth and Space Science Education National Conference. During the conference, student teams that flew experiments onboard the ISS presented their experiment designs reported preliminary results.

FINANCIALS

BUSINESS STATUS REPORT (UNAUDITED)

APRIL 1 TO JUNE 30, 2017	ACTUAL Q3FY17	BUDGET Q3FY17	VARIANCE Q3FY17	ACTUAL YTD FY17	BUDGET YTD FY17	VARIANCE YTD
Direct Labor	$1,551,976	$1,690,209	$(138,233)	$4,561,812	$4,937,270	$(375,458) A
Subcontracts	$425,628	$554,185	$(128,557)	$1,023,866	$1,581,645	$(557,779) B
Permanent Equipment	$13,149	$5,000	$8,149	$37,651	$19,000	$18,651
Office Supplies & Equipment	$29,400	$74,224	$(44,824)	$127,917	$224,074	$(96,157)
Travel	$262,174	$304,428	$(42,254)	$688,365	$850,744	$(162,379)
Grants	$1,323,679	$1,770,808	$(447,129)	$3,479,990	$5,455,631	$(1,975,641) C
Other	$474,871	$404,624	$70,247	$1,268,437	$1,218,168	$50,269
Total	**$4,080,877**	**$4,803,478**	**$(722,601)**	**$11,188,038**	**$14,286,532**	**$(3,098,494)**

(A) Actual headcount was 46 versus a budgeted 49
(B) Subcontracts were lower than budget for marketing, science, and business development
(C) Grant recipient milestone payments have shifted to Q4 FY17 and into FY18, based on anticipated completion of milestones and projected flight times.

BREAKOUT OF COOPERATIVE AGREEMENT FUNDING

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17
Direct	55.2%	46.8%	50.7%	
Indirect	19.5%	13.4%	17.0%	
Grants	15.3%	39.8%	32.3%	

BREAKOUT OF CASIS GRANTS

	Q1 FY17	Q2 FY17	Q3 FY17	Q4 FY17
Academic	($88,466)*	$334,153	$107,520	
Commercial	$421,644	$1,283,955	$1,016,988	
Other Government Agency			-	
Mission Based Costs	$96,181	$108,843	$199,171	
Total	**$517,825**	**$1,726,951**	**$1,323,679**	

*Negative value due to returned funds from a previous grantee.

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