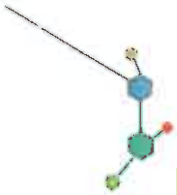

# FY16 Q1 REPORT

*Quarterly Report for the Period Oct 1 – Dec 31, 2015*

CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)

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# EXECUTIVE SUMMARY

The first quarter of fiscal year 2016 (Q1 FY16) was characterized by an array of positive opportunities for the International Space Station (ISS) U.S. National Laboratory. The Center for Advancement in Science in Space (CASIS) continues to penetrate both non-traditional and established research sectors by participating in industry forums and conferences—taking advantage of more than 33 speaking opportunities at such events in Q1 alone. These opportunities are a strong signal of the growing interest from new communities in ISS National Lab research.

The defining moment for Q1 was the launch of the OA-4 resupply mission, which signified the successful return to flight for Orbital-ATK. This delivery included 12 ISS National Lab payloads, including a powerful new bioprocessing facility from BioServe Space Technologies that will enable a wide variety of fundamental, applied, and commercial life sciences research as well as education-based investigations onboard the ISS. Additional payloads included new commercial innovations, educational projects, and a variety of satellite technology efforts (nanosatellite development, microsatellite deployment, and in-orbit assembly) enabled by the payload developer NanoRacks, LLC.

## OTHER KEY HIGHLIGHTS FROM Q1 INCLUDE:

- **Government agency collaboration** – CASIS and the National Science Foundation (NSF) released a joint research solicitation for projects seeking to benefit life on Earth through the study of fluid dynamics in space. $1.8 million in NSF funding will support awarded flight projects destined for the ISS National Lab.
- **Recognition of ISS National Lab education efforts** – CASIS was honored to be recognized by the Boy Scouts of America (BSA) in November 2015, presented with an "Innovation in STEM Education" award.
- **Commercial engagement** – The ISS National Lab continues to attract commercial projects in life sciences, Earth observation, physical sciences, and technology development. In Q1, this was reflected in seven awarded projects and a pipeline of more than 100 potential proposals currently in development.
- **Continued publication of ISS National Lab results** – Two articles appeared in peer-reviewed journals in the field of remote sensing, supporting the CASIS Good Earth Campaign. This brings the total number of publications from CASIS-sponsored research to 14, with more research papers across various research disciplines expected in the coming months.
- **New visibility in the public** – The ISS virtual tour, an interactive educational tool co-developed by CASIS and NASA, debuted at the Kennedy Space Center Visitor Complex (KSC VC) in December 2015—with additional displays at other venues planned for the future. The tour provides an incredible look at the exterior and interior of the ISS. Through this initial partnership with the KSC VC, which has an annual attendance of more than one million people, the ISS National Lab will be able to engage and excite audiences of all ages.

Finally, three highly successful subject matter expert workshops held in Q1 brought together thought leaders in key areas of interest for ISS National Lab research and development (R&D), particularly for CASIS Campaign Good Health. These workshops will help shape the ability of CASIS to tackle today's most pressing research questions via ISS utilization—keeping pace with cutting edge techniques and discoveries in areas that promise to improve the quality of life for those of us here on Earth. CASIS was excited to see the execution of these workshops come to fruition with impressive attendance from many leading minds in the fields of disease research (including representatives from other government agencies). The acumen of the attendees not only lends weight to the recommendations resulting from the workshops—it also demonstrates the growing credibility and influence of the ISS National Lab in the global scientific community. We look forward to a new year of continuing these trends and executing our mission to maximize use of our nation's unique orbiting laboratory.

# ISS NATIONAL LAB PORTFOLIO

ESTABLISH INNOVATION CYCLES AND UTILIZE THE ISS FOR DEVELOPING NEW CAPABILITIES

## AWARDS AND OPPORTUNITIES

### *Physical Sciences*

In December 2015, CASIS released a joint research competition with the National Science Foundation (NSF) to support investigations on the ISS National Lab in the field of fluid dynamics. This is the largest Sponsored Program for CASIS to date and the first in partnership with a non-NASA government agency. NSF is committing $1.8 million in grant funding toward the suite of ISS National Lab flight projects that will be selected in response to this solicitation.

The long-duration microgravity environment provided by the ISS National Lab has unique benefits for the study of fluid dynamics. Many processes that affect the behavior of fluids on Earth (e.g., thermal convection, sedimentation, and buoyancy) are absent in microgravity. The elimination of these variables allows phenomena of interest to be studied without gravitational interference, the results from which could have applications in industries including consumer products, electronics, manufacturing, medical devices and pharmaceuticals, and oil and gas. To be eligible for award through this current competition, proposals must demonstrate a tangible benefit to improving life on Earth through advancement of fundamental science and engineering knowledge.

The partnerships and external financial support that comprise Sponsored Programs promote awareness of the value of the ISS research platform and augment the accessibility of this platform to the R&D community. For more information on this currently open opportunity (*Fluid Dynamics Research on the International Space Station to Benefit Life on Earth*), see www.iss-casis.org/Opportunities/Solicitations/FluidDynamics2015.aspx.

### *Life Sciences*

Four life sciences projects were awarded in Q1—three from commercial entities and one from another National Lab, sponsored by the National Institutes of Health. Of the four projects, one is in the field of plant biology, one seeks to study a medically relevant protein, and two are biotechnology projects that resulted from an ISS National Lab joint Sponsored Program with the Boeing Company (as part of the MassChallenge business accelerator competition). This is the third year the ISS National Lab has partnered with MassChallenge, the world's largest startup accelerator to support early-stage entrepreneurs without taking any equity, and the second year it has partnered with Boeing for this competition. The repeated financial commitment from Boeing to support ISS National Lab flight projects is an additional example of success in expanding the ISS community by leveraging external funding—in this case, to identify nontraditional flight projects through innovative start-up company ideas. For information on this year's awarded projects and their potential impact on human health, see the Awarded Projects table on page 12.

In addition, there was a strong response to the CASIS research competition *3D Microphysiological Systems for Organs-On-Chips Research* issued in Q4FY15, with proposals submitted from leading academic institutions and commercial companies in the field of tissue engineering. Respondents will be selected to share an award of up to $1 million in research grant sponsorship to support an ISS National Lab project.

The project(s) awarded in response to this competition will use or improve upon organs-on-chips research models for fundamental discovery and translational research, with the goal of providing superior models of how diseases afflict human tissues, thus accelerating research toward disease prevention and novel treatment approaches. The awarded

project(s) will add to the more than 40 flight experiments currently sponsored by CASIS that fall under Campaign Good Health—a strategic initiative to impact human health on Earth by using the ISS to study disease transitions (such as osteoporosis and muscle wasting) and develop means to avert them.

### *Remote Sensing*

In FY15, CASIS commissioned a study to evaluate (1) the capabilities and limitations of the ISS as an operational host for commercial remote sensing payloads and (2) the products and needs of the data analytics community. A gap analysis of these two areas was completed in Q1FY16, and distribution of a final report from this analysis is planned for Q2 2016. This study was part of an overall implementation strategy for Campaign Good Earth, an initiative to maximize ISS Earth observation capabilities via the development and deployment of next-generation sensors. The report will inform future ISS National Lab remote sensing and Earth science R&D opportunities as well as engagement approaches with other government agencies (OGAs) and aerospace and data analytics companies.

### *Technology Development*

Three projects were selected in Q1 in the area of technology development—two from commercial entities and one hardware enhancement in collaboration with NASA. All three projects seek to expand the technology and research capabilities of spaceflight R&D, with one potentially improving satellite technology and thus falling within Campaign Good Earth as well. For information on this year's awarded projects and their expected Earth benefits, see the Awarded Projects table on page 12.

## PROJECT STATUS

The successful launch of OA-4 in Q1 signifies the return to flight of Orbital-ATK, which suffered a destructive launch anomaly with Orb-3 in October 2014. The OA-4 mission also represents two firsts for Cygnus: the first Cygnus mission utilizing the Atlas V launch system and the first Cygnus mission to launch from the Kennedy Space Center in Florida. With the successful launch of OA-4, delivery of 12 ISS National Lab payloads was completed, including but not limited to the following projects:

### *Physical Sciences*

- **Vertical Burn (Dr. Jeff Strahan, Milliken and Company; Spartanburg, SC):** Evaluate flame-resistant (FR) textiles as a mode of personal protection from fire-related hazards. Studying FR behavior of different materials in microgravity will aid in better designs for future FR textiles and will benefit those who wear FR protective apparel, such as military personnel and civilian workers in the electrical and energy industries. (Payload developer: Zin Technologies)

### *Technology Development (including Campaign Good Earth)*

- **Zero-G Characterization & On Orbit Assembly for Cellularized Satellite Tech (Talbot Jaeger, NovaWurks; Los Alamitos, CA):** Design and demonstrate a technology for in-orbit assembly and deployment of the HISat system, a Hyper-Integrated Satellite that provides complete satellite functionality in a nanosatellite-scale package. This system should substantially reduce the costs of developing satellite systems for space-based R&D. (Payload developer: NanoRacks)
- **Kaber Microsat Deployer (Michael Lewis and Kirk Woellert, NanoRacks, LLC; Webster, TX):** A reusable Kaber microsatellite deployment system, which will enable a class of payload deployments (50–100 kg range) from the ISS that would normally rely on an expendable launch vehicle for space access. (Payload developer: NanoRacks)

- **Planet-Labs Dove cube sats (Robbie Schingler, Planet Labs; San Francisco, CA):** Commercially developed nanosatellites deployed from the ISS to take images of Earth for humanitarian and environmental applications. (Payload developer: NanoRacks)
- **Space Automated Bioproduct Lab (Dr. Louis Stodieck, BioServe Space Technologies; Boulder, CO):** A single locker-sized facility that provides a temperature-controlled chamber that can house a variety of passive or active life science experiments that can be automated or remotely operated. (Payload developer: BioServe Space Technologies)

### *Education*

- **Story Time From Space-3 (Patricia Tribe, T2 Science and Math Education Consultants; League City, TX):** The third iteration of a CASIS-sponsored education project that includes a variety of instructive stories to be read by astronauts and videotaped from the cupola of the ISS. In addition to the stories, the astronauts perform simple physics demonstrations that complement the science, technology, engineering, and mathematics (STEM) concepts discussed in each of the books.
- **Silver Crystal Growth (a student project from Valley Christian High School; San Jose, CA):** An experiment exploring what happens to silver crystals when a gravitational field does not impact their growth. (Payload developer: NanoRacks, LLC)

### *Remote Sensing*

With respect to other projects in the ISS National Lab pipeline, two journal articles published in Q1 by BioOptoSense, LLC reflect results from a project sponsored by the ISS National Lab. The project was originally awarded to the Naval Research Lab in response to a CASIS research solicitation promoting Earth observation from space (i.e., Campaign Good Earth). Principal investigator Dr. Ruhul Amin has since started his own company to continue this line of research, publishing multiple papers from his findings, filing patents related to similar investigations using ISS data, and even receiving the "2015 NASA Group Achievement Award" for his contributions to the 2014 NASA Glenn Research Center's airborne hyperspectral campaign on harmful algae blooms. For details on the Q1-published articles and their expected Earth benefits, see the Contributions to Scientific Knowledge table on page 11.

# BUSINESS DEVELOPMENT AND PARTNERSHIPS

EXPAND THE CASIS NETWORK, LEVERAGE FUNDING, AND DRIVE COMMERCIAL UTILIZATION

## STRATEGIC AREAS OF FOCUS

CASIS hosted three subject matter expert workshops in Q1 as part of Campaign Good Health. These workshops bring together experts from industry, academia, and OGAs to gather input and guidance on how best to utilize the ISS National Lab to advance R&D in targeted sectors (e.g., prioritizing science questions and objectives, identifying new laboratory hardware needs, recommending best practices for methodology and analysis approaches, etc.).

- **Protein Crystallization Workshop:** Many crystals grown in microgravity are larger and more uniformly organized than those grown on Earth, providing protein structures that are more accurate. This allows better structure-based drug design while also informing improved strategies for drug manufacturing—with the end goal of more effective and affordable pharmaceuticals. Although protein crystal growth on the ISS has already attracted many preeminent academic and industry researchers, the ISS National Lab seeks to develop a reliable program to support robust ongoing investigations in this field—including considerations of accessibility and timing, flight and ground resources, parallel education initiatives, and funding. More than 40 renowned contributors to protein crystallization research in microgravity and on Earth met for this workshop to discuss their current research efforts and current technologies and capabilities in the field.

- **Musculoskeletal Disease Research in Space Workshop:** The responses of humans and model organisms to spaceflight in many cases mimic the onset of health-related outcomes associated with aging and debilitating chronic human diseases on Earth. Skeletal remodeling mimics bone loss seen in osteoporosis, and loss of muscle mass/strength is similar to disuse and age-driven muscle atrophy. These outcomes occur rapidly in human, animal, and cell-based models onboard the ISS National Lab—providing accelerated models of Earth-based human disease and aging. Given that osteoporosis alone affects more than 200 million people worldwide, advancements in the understanding of musculoskeletal disease and improvements in interventions for prevention and healing are of global interest. CASIS met with subject matter experts, including NIH representation, to discuss R&D goals and formulate an implementation plan for a robust musculoskeletal disease research program on the ISS National Lab.
- **Organ Bioengineering Workshop:** Microgravity enhances the growth and survival of particular stem cell populations, promotes differentiation into specific cell types, and supports organization of individual cells into tissue-like structures. Organ and tissue bioengineering (e.g., growth of artificial organs for next-generation transplantation approaches) may directly benefit from near-term investment in space-based tissue-growth technologies and R&D. This workshop involved 37 thought leaders from academia, industry, government, and other organizations (e.g., the California Institute for Regenerative Medicine, the New York Stem Cell Foundation, and the Maryland Stem Cell Foundation) in a round-table discussion of how best to leverage the ISS National Lab to advance regenerative medicine.

CASIS also co-facilitated an Advanced Manufacturing industry round-table session in conjunction with the inaugural Space Commerce Conference and Exposition (SpaceCom) in November 2015. Half-day sessions with more than 50 industry thought leaders provided examples of technology transfer case studies impacting the industry. Discussion involved case study merits and opportunities for further economic development in this field, including robotics, durable materials testing, packaging, clothing, agriculture, and additive manufacturing.

In addition, the ISS National Lab continues commercial market penetration through conference attendance, industry events, and brainstorming sessions with key targeted companies. Conferences and trade association events in Q1 included the World Stem Cell Summit, the Industrial Research Institute annual meeting, and various space industry conferences—including two Destination Station events involving formal Industry Days with key accounts (Fortune 500 companies and other strategic partners).

For more information on industry outreach and events involving ISS National Lab representation, see the Conferences and Events table on page 21.

## PARTNERSHIPS AND COLLABORATIONS

Q1 held two important developments for ISS National Lab Education initiatives: CASIS secured agreements with three Boys and Girls Clubs of America in Florida to feature CASIS-provided educational programming (Space Station Academy) in their centers, and CASIS executed a memorandum of understanding with a new strategic partner, Destination Imagination (headquartered in Cherry Hill, NJ).

Destination Imagination is a student multidisciplinary competition that takes place at regional, state, country, and global levels. Students compete across seven challenge areas ranging from technical, scientific, structural, fine arts, improvisational, and service learning. Students are encouraged to improve creative and critical thinking skills while the challenges reinforce team building and project management skills. National partnership developments like this help to maximize the inspiration and research capabilities of the ISS for students and educators across the country.

In addition, as part of growing CASIS/NASA efforts to present a unified voice regarding the value of the ISS, an ISS National Lab Benefits for Humanity video was unveiled at the SpaceCom conference. This video provides a compelling introduction to the ISS National Lab, describing the variety of users and capabilities of the platform. Through such NASA collaborations, CASIS hopes to simplify the education process for new users.

# OUTREACH AND EDUCATION

PROMOTE THE VALUE OF THE ISS TO THE NATION AND ESTABLISH IT AS A LEADING ENVIRONMENT FOR STEM EDUCATION

## INCREASING AWARENESS

CASIS outreach efforts in Q1 were bolstered by participation in four key research and development conferences: The American Society for Gravitational and Space Research annual meeting, SpaceCom, the International Symposium for Personal and Commercial Spaceflight, and the World Stem Cell Summit (see the Conferences and Events table on page 21). These conferences were strategically important in positioning the ISS National Lab within the established microgravity research community. The conferences also served to introduce the benefits of microgravity research to other scientific communities in which space research could accelerate innovations and breakthroughs.

Additionally, at the MassChallenge awards ceremony in October 2015, CASIS presented about the ISS National Lab and its value to more than 5,000 attendees—including the 128 finalists from this year's competition, keynote speakers Gov. Charlie Baker (MA) and Mayor Marty Walsh (Boston), and a variety of MassChallenge partners (e.g., Verizon, Microsoft, Bose, IBM, American Airlines, Pfizer, John Hancock, CVS Health, and Honda).

Also in October, CASIS Deputy Chief Scientist Dr. Michael Roberts wrote an article for *R&D Magazine* called "Microgravity: Reaching Beyond Earth's Horizons for Better Genomics Research," which discusses how CASIS has enabled greater and more cost-effective access to the ISS National Lab. More importantly, the article explains how genomics studies conducted onboard the ISS National Lab are improving genomics technologies and research processes, as epitomized by human research currently being conducted during NASA's One-Year mission. As microgravity has proven to be an ideal environment for the study of disease and for advancing drug discovery, expanding opportunities to conduct genomics studies in space could have a substantial impact toward improving health on Earth.

Another major outreach achievement in Q1 was the deployment of a new public education resource co-developed by NASA and CASIS—the ISS virtual tour. This interactive display debuted at the Kennedy Space Center (KSC) Visitor Complex in December, and there are now three mobile displays stationed in high traffic areas throughout the complex, with an additional unit to be used by KSC as a traveling exhibit during presentations at local area schools. The ISS virtual tour is an interactive educational tool that allows audiences to experience the ISS in incredible detail, complete with views of the interior and exterior of the ISS. Additionally, the tour details the scientific capabilities of the ISS and shows how astronauts live and work in space. The deployment of this interactive display will help amplify CASIS outreach and promote the unique capabilities of the ISS National Lab to new communities by leveraging new forums and platforms.

CASIS also showcased the public outreach value of the ISS virtual tour display at the U.S. House of Representatives Science Committee's ISS downlink event (with in-orbit NASA astronauts Scott Kelly and Kjell Lindgen) in December 2015. CASIS participated in the downlink event in Washington, D.C., along with myriad ISS researchers and implementation partners. This event provided a critical opportunity to interact with congressional leaders, updating them

on new ISS R&D and the expanding scientific capabilities of the ISS National Lab.

## STEM INITIATIVES

The CASIS team supported various educational outreach events across the country in addition to the active STEM education programs that CASIS continually manages and supports. World Space Week and Brevard Space Week (see the Conferences and Events table on page 21) were significant events that garnered participation from a large number of educators, parents, and students. Through programs and educational outreach activities in Q1, CASIS reached nearly 30,000 students, educators, and members of the public.

Additionally, CASIS was recognized as the Innovation Partner of the Year at the LaSalle Street Trading Tech Awards for supporting Chicago-area Boy Scouts groups. This award recognizes the efforts of partners that were instrumental in furthering learning opportunities for youth in STEM areas. CASIS Board Member Dr. Philip Schein accepted this award on behalf of the ISS National Lab, while a representative from Microsoft accepted a parallel award for Technology Partner of the Year. The partnership between CASIS and the Boy Scouts of America represents an exciting opportunity to broaden the user base and maximize the reach of ISS National Lab education products and programming.

The CASIS Education team was also presented with a $15,000 award at SpaceCom by the conference organizers. Receiving this award provided visibility for ISS National Lab education programming and resources to an audience of industry and aerospace professionals. CASIS will use the award to support Story Time From Space, an ISS National Lab sponsored-program that advocates literacy through interactive media featuring astronauts on the ISS. The award will help offset the costs of rebuilding the Story Time From Space payload that was destroyed during the Orb-3 launch anomaly.

# Q1 FY16 METRICS

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

| | Q1 FY16 | Q2 FY16 | Q3 FY16 | Q4 FY16 | FY16 TOTAL TO DATE | TARGETS FY16 |
|---|---|---|---|---|---|---|
| Solicitations/Competitions | 1 | | | | 1 | 5 |
| Project proposals generated | 30 | | | | 30 | 100 |
| Projects awarded | 7 | | | | 7 | 40 |
| *Return customers: Projects awarded to previous CASIS customers pursuing a new opportunity* | 0 | | | | 0 | 10 |
| *New customers: Projects awarded to principal investigators that have never flown* | 3 | | | | 3 | 20 |
| *Customers who are new to CASIS but not to spaceflight R&D* | 4 | | | | 4 | 10 |
| Total Value of CASIS Grants Awarded | $470,199 | | | | $470,199 | $4,000,000 |
| CASIS seed funding toward total project cost | 22% | | | | 22% | 20% |
| Flight projects manifested * | 20 | | | | 20 | 70 |
| Flight projects delivered to the ISS National Lab * | 12 | | | | 12 | 72 |
| Results published in scientific journals | 2 | | | | 2 | As they occur |
| Products or services created | 0 | | | | 0 | As they occur |

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

| | Q1 FY16 | Q2 FY16 | Q3 FY16 | Q4 FY16 | FY16 TOTAL TO DATE | TARGETS FY16 |
|---|---|---|---|---|---|---|
| Sponsored Program/external funding for grants | $1,800,000 | | | | $1,800,000 | $3,000,000 |

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

| | Q1 FY16 | Q2 FY16 | Q3 FY16 | Q4 FY16 | FY16 TOTAL TO DATE | TARGETS FY16 |
|---|---|---|---|---|---|---|
| STEM programs (active) | 12 | | | | 12 | 15 |
| Number of students, educators, and other participants engaged in STEM initiatives | 29,717 | | | | 29,717 | 180,000 |

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

| | Q1 FY16 | Q2 FY16 | Q3 FY16 | Q4 FY16 | FY16 TOTAL TO DATE | TARGETS FY16 |
|---|---|---|---|---|---|---|
| Outreach events | | | | | | |
| *Conferences and industry event sponsorships* | 4 | | | | 4 | 18 |
| *Speaking opportunities* | 33 | | | | 33 | 95 |
| *Subject matter expert workshops* | 3 | | | | 3 | 8 |
| Total media impact | | | | | | |
| *Thought leadership publications (white papers, trade articles, etc.)* | 1 | | | | 1 | 5 |
| *News mentions (clips, blogs)* | 410 | | | | 410 | 5,000 |
| *Twitter followers ^* | 82,001 | | | | 82,001 | 107,000 |
| *Website visitors* | 50,414 | | | | 50,414 | 256,500 |
| *YouTube views* | 132,810 | | | | 132,810 | 700,000 |
| *Social media engagement (Facebook, Twitter, and Instagram)* | 16,193 | | | | 16,193 | 100,000 |



* All National Lab Payloads
^ Cumulative

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

| INCREMENT | UPMASS (KG) | | | DOWNMASS (KG) | | | CREWTIME (HRS) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ALLOCATION | ACTUALS | USAGE | ALLOCATION | ACTUALS | USAGE | ALLOCATION | ACTUALS | RESERVE | USAGE |
| 37/38 | 287 | 334.7 | 117% | 6 | 7.9 | 132% | 427 | 78.42 | - | 18% |
| 39/40 | 766 | 389.1 | 51% | 307 | 197.8 | 64% | 386 | 70.75 | - | 18% |
| 41/42 | 539 | 716 | 133% | 498 | 705.5 | 142% | 346 | 130.29 | - | 38% |
| 43/44* | 906 | 538.3 | 59% | 534 | 165.93 | 31% | 229 | 223.33 | - | 98% |
| 45/46 | 553 | 860.6 | 156% | 269 | 85.67 | 32% | 293 | 256.59 | 104.33 | 88% |
| 47/48 | 978 | 1008.2 | 103% | 703 | 222.88 | 32% | 356 | 345.04 | 133.65 | 97% |
| 49/50 | 1675 | 1448.6 | 86% | 326 | 388.79 | 119% | 271 | 367.81 | 54.66 | 136% |

Data through 1/5/2016

*Includes SpX-7 upmass/downmass

## CONTRIBUTIONS TO SCIENTIFIC KNOWLEDGE – RESULTS PUBLISHED

### Remote Sensing

| | |
|---|---|
| **Title: Comparative Analysis of GOCI Ocean Color Products**<br><br>**Citation:** Amin R, Lewis MD, Lawson A, Gould Jr RW, Martinolich P, Li RR, Ladner S, and Gallegos S (2015) Sensors 15: 25703-25715. | **Description:** This project was awarded in response to a CASIS solicitation promoting the use of imagery from the ISS-based sensor Hyperspectral Imager of the Coastal Ocean (HICO). When HICO became dysfunctional during the study period, the authors used other space-borne sensors, such as the Geostationary Ocean Color Imager (GOCI), to continue the research. In this paper, the authors compared ocean color data retrieved from GOCI and processed through the GOCI data processing system (GDPS) with data processed using the current standard for ocean color measurement, the Automated Processing System developed by the Naval Research Laboratory (collected from low Earth polar-orbiting satellite sensors, such as the Moderate Resolution Imaging Spectroradiometer [MODIS] and the Medium Resolution Imaging Spectrometer).<br><br>**Earth Benefit:** Validating the statistical accuracy of GDPS relative to APS is critical to ensure that data from the more timely collections of GOCI are applicable to the development of primary production models, carbon budgets, hypoxia, and eutrophication—the fundamental measures important to the study of water quality in coastal regions. While the results of this study were inconclusive, ongoing studies to develop and validate improved methods of monitoring water quality promise to ultimately benefit human health and the multibillion-dollar fishing and tourism industries. |
| **Title: Occurrence and Spatial Extent of HABs on West Florida Shelf 2002-Present.**<br><br>**Citation:** Amin R, Penta B, and deRada S (2015) IEEE Geoscience and Remote Sensing 12(10): 2080-2084. | **Description:** As described above, this project was awarded in response to a CASIS solicitation promoting the use of imagery from HICO, which became dysfunctional during the study period, prompting the authors used other space-borne sensors, such as MODIS, to continue the research. In this letter, the authors report results on the seasonal formation of harmful algal blooms (HABs; e.g., red tide) off the Gulf Coast of Florida. Using the red band difference (RBD) bloom detection technique and conducting time-series analyses of the spatial extent of these blooms using MODIS data from July 2002 through September 2014, the authors show that the RBD successfully detects the documented HABs in the region, illustrating the seasonal and inter-annual variability. The results complement previous research from this team showing that the RBD technique is an effective detection tool for the species that cause HABs. The results also demonstrate the value of including the chlorophyll fluorescence channel in future satellite sensors such as those being planned for NASA's hyperspectral PreAerosol-Cloud-Ecosystem (PACE) missions.<br><br>**Earth Benefit:** HABs in the Gulf of Mexico, particularly on the West Florida Shelf, cause millions of dollars in socioeconomic damage each year, threatening marine life and human health. The results of this study can be further examined not only to improve HAB detection techniques but also to understand the environmental processes that contribute to such events, ultimately benefiting human health and the multibillion-dollar fishing and tourism industries. |

## PROJECTS AWARDED IN Q1 FY16

### *Life Sciences*

| | |
|---|---|
| **Title: Assessing Osteoblast Response to Tetranite**<br><br>Principal Investigator<br>Dr. Nikolaos Tapinos<br><br>Affiliation: LaunchPad Medical<br><br>Location: Boston, MA | **Description:** The goal of this investigation is to explore the ability of Tetranite™, a synthetic bone material capable of adhering bone to metal within minutes, to accelerate bone repair. It is well known that microgravity affects bone cell growth and healing, mimicking the symptoms observed in osteoporosis. The investigators seek to evaluate the response of osteoblasts (a bone cell subtype responsible for renewing bones) to Tetranite™. Understanding bone cell–Tetranite™ interactions could provide insight into the post-fracture bone healing response and assist in the development of more effective treatments for patients with osteoporosis. In addition, this cell culture project should provide the basis for follow-on studies of the bone healing response in small rodents.<br><br>**Earth Benefit:** Currently, 10 million Americans suffer from osteoporosis, and this number is growing rapidly as the population ages. LaunchPad Medical licensed a newly developed bone adhesive from Stryker called Tetranite™ that is expected to significantly benefit osteoporotic patients, improve patient outcomes for those who experience a bone fracture, and reduce the overall cost of healthcare. |
| **Title: Implantable Glucose Biosensors**<br><br>Principal Investigator:<br>Dr. Michail Kastellorizios<br><br>Affiliation: Biorasis, Inc.<br><br>Location: Storrs/Mansfield, CT | **Description:** This project seeks to improve the accuracy of a wireless medically implantable continuous glucose biosensor (Glucowizzard™) for day-to-day diabetes management. Slow glucose transport within human tissue (through the capillary walls and surrounding tissue toward the sensing site of the biosensor) can create delays of up to 20 minutes in real-time monitoring of glucose levels. This delay can be detrimental in achieving tight glycemic control, which has been linked to serious secondary complications in patients with diabetes. The ISS provides a microgravity environment in which reduced fluid movement allows precise monitoring of the role of diffusion in glucose transport, thus improving the mathematical models that determine the accuracy of the Glucowizzard™ continuous glucose monitoring biosensor.<br><br>**Earth Benefit:** The World Health Organization projects that the global diabetic population will reach 366 million by 2030. In order to prevent serious health problems, many people with diabetes currently rely on delayed and inaccurate biosensors measuring their glucose levels prior to self-administering insulin. Biorasis is addressing this critical need by studying fluid movement onboard the ISS in order to optimize the Glucowizzard™ continuous glucose monitoring biosensor. |
| **Title: Mutualistic Plant/Microbe Interactions**<br><br>Principal Investigator<br>Dr. Gary W. Stutte<br><br>Affiliation: SyNRGE, LLC<br><br>Location: Titusville, FL | **Description:** This project, a re-flight of the SyNRGE3 payload flown by NanoRacks on SpX-4, seeks to study mutualistic plant-microbe interactions in microgravity. Most land plants establish physical interactions with fungi that increase uptake of nutrients and improve stress resistance. This process is directly or indirectly responsible for producing 20% of the protein consumed in the human diet. Previous SyNRGE experiments performed on STS-135 demonstrated that the symbiosis between plant and bacterial partners is affected by microgravity, potentially increasing the ability for infection to occur. SyNRGE3 sought to determine if certain changes in this mutualistic relationship were associated with molecular changes that could be exploited to identify and select more effective plant strains for use on Earth. *(The initial flight of SyNRGE3 suffered several technical issues on orbit, so the primary objectives of the experiment were not completed.)*<br><br>**Earth Benefit:** The agricultural biostimulant market is a multi-billion dollar global industry expanding into areas of biological control and growth enhancement traditionally occupied by growth regulators and fertilizers. As a technology validation project, this experiment will demonstrate a reliable and effective microgravity platform to support commercialization of microgravity-induced modifications to organisms to increase bio-protective and bio-stimulatory effects of plant-microbe interactions. |
| **Title: Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators**<br><br>Principal Investigator:<br>Dr. Andrey Kovalevsky<br><br>Affiliation: Oak Ridge National Lab<br><br>Location: Oak Ridge, TN | **Description:** This project seeks to produce crystals of suitable size and quality for macromolecular neutron crystallography (MNC) analysis of the medically important enzyme acetylcholinesterase. In humans, this enzyme is responsible for degrading a specific neurotransmitter in the brain, and malfunction of the enzyme leads to a fatal increase of this neurotransmitter. Analysis using MNC has the unique ability to locate the position of hydrogen atoms within a crystal structure, providing essential insights into how an enzyme functions in the human body and how it might be altered by nerve agents to become toxic. However, even with recent advances in instrumentation, MNC still requires very large crystals for analysis—the production of which may be enabled by microgravity, which allows for more uniform crystal growth.<br><br>**Earth Benefit:** In order to decrease the mortality and morbidity rates for both livestock and human life from overexposure to pesticides or potential chemical warfare attacks that affect acetylcholinesterase, novel therapeutics are needed. The microgravity environment onboard the ISS uniquely facilitates the production of large high-quality protein crystals, which may provide structural information to enable the development of safe and effective antidotes. |

## Technology Development

| | |
|---|---|
| **Title: Additive Manufacturing Operations Program Proposal**<br><br>Principal Investigator:<br>Michael Snyder<br><br>Affiliation: Made in Space<br><br>Location: Moffett Field, CA | **Description:** The Additive Manufacturing Operations Program will allow ISS user communities to use the Made In Space Additive Manufacturing Facility. Through this program, objects for experiments and technology demonstrations will be produced onboard the ISS in a fraction of the time currently required to have such objects manifested and delivered to the ISS using traditional ground preparation and launch. Made in Space hopes to use this program to develop a commercial market for in-space manufacturing.<br><br>**Earth Benefit:** The ability to create on-demand hardware on the ISS would benefit crew and researchers interested in space-based R&D—as well as advancing the field of additive manufacturing, enabling systems that are more efficient and generate less waste on Earth. This program allows 3D-printing projects from commercial, educational, and government entities on Earth to utilize the ISS Additive Manufacturing Facility. |
| **Title: Validation of WetLab-2 System for qRT-PCR Capability on ISS**<br><br>Principal Investigator:<br>Julie Schonfeld<br><br>Affiliation: NASA Ames Research Center<br><br>Location: Moffett Field, CA | **Description:** WetLab-2 is an ISS National Lab suite of scientific instrumentation that provides improved research capabilities for ISS investigators. The WetLab-2 system enables investigators working with cell cultures or animal and plant tissues to process samples and extract purified high-quality RNA (a nucleic acid involved in gene expression), which can then be returned to Earth for analysis or directly analyzed in orbit using a technique called quantitative Real Time Polymerase Chain Reaction. WetLab-2 tools also provide individual experimental capabilities for a variety of other research-enabling improvements related to sample preparation and analysis for both biological samples and fluids systems. *(Note: Project awarded ISS National Lab resource allocation only.)*<br><br>**Earth Benefit:** The WetLab-2 platform system is an enabling technology that provides onboard gene expression analysis, reducing the time it takes to complete biomedical experiments from months to days. This could eliminate millions of dollars in costs and bring potential therapeutics to market more rapidly. |
| **Title: Operationally Responsive Subsystem**<br><br>Principal Investigator:<br>Dr. Jason Held<br><br>Affiliation: Saber Astronautics<br><br>Location: Boulder, CO | **Description:** This project seeks to advance the technology readiness level (TRL) of a spacecraft subsystem controller, the Operationally Responsive Subsystem (ORS), which can autonomously reconfigure its avionics to optimize performance during various mission conditions. ORS is a critical enabler for a wide range of missions and is especially useful for increasing reliability of commercial small satellites. It has the potential to improve the survivability of spaceflight hardware, which speaks directly to downstream terrestrial applications, such as improved GPS accuracy, remote sensing, and communications. Long-duration testing of an ORS onboard the ISS will directly measure survivability and other performance metrics to validate preflight models and test manufacturing assumptions. Successful testing onboard the ISS will demonstrate the technology in an operational environment (TRL 7).<br><br>**Earth Benefit:** Current static computing architectures are brittle and limit the ability of space systems, such as communications and GPS, to respond or adapt to the space environment. Saber's autonomous computing systems reconfigure themselves, thus providing significant increases in system flexibility, robustness, and resilience. These improved systems will find utility in both space-based applications, such as satellites, and in terrestrial applications, such as factory automation and fleet vehicle logistics. |

# Q1 FY16 PROJECT PIPELINE

## GROUND PROJECTS

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | STATUS UPDATE |
|---|---|---|---|
| Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight | Dr. Clifford Dasco | Baylor College of Medicine | (b) (4) |
| Spacecraft-on-a-Chip Experiment Platform | Dr. Mason Peck | Cornell University | The Sprite hardware is under development, with multiple designs being considered. The design is intended to balance reusability of hardware, ease of use by astronauts, and minimal change from the KickSat architecture. For the Spacecraft-on-a-Chip Experiment Platform, the team is considering a programmer with minimal changes from that used by KickSat. |
| Generation of Cardiomyocytes from Human iPS Cell-derived Cardiac Progenitors | Dr. Chunhui Xu | Emory University | (b) (4) |
| Improving Astronaut Performance of National Lab Research Tasks | Dr. Jayfus Doswell | Juxtopia, LLC | (b) (4) |
| Great Lakes Specific HICO Water Quality Algorithms | Dr. Robert Shuchman | Michigan Technological University | HICO experienced a fatal malfunction shortly after the initiation of this project. The team acquired preexisting HICO data from 2014 as well as a number of passes in the summers of 2012 and 2013, along with a series of near and coincident in situ measurements in the Western Basin of Lake Erie to adequately address project goals of monitoring the Great Lake ecosystem and drinking/recreational water sources. (b) (4) (b) (4) |
| Examine Bone Tumor and Host Tissue Interactions Using Microgravity Bioreactors | Dr. Carl Gregory | Texas A&M Health Science Center | (b) (4) |
| Generation of Mesendoderm Stem Cell Progenitors in the ISS-National Laboratory | Dr. Robert Schwartz | University of Houston System | (b) (4) |

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | STATUS UPDATE |
|---|---|---|---|
| Hyperspectral Remote Sensing of Terrestrial Ecosystem Carbon Fluxes | Fred Huemmrich | University of Maryland Baltimore County | HICO experienced a fatal malfunction shortly after the initiation of this project.(b) (4) (b) (4) |
| HICO Identification of Harmful Algal Blooms | Dr. Richard Becker | University of Toledo | HICO experienced a fatal malfunction shortly after the initiation of this project. The team acquired preexisting HICO data from 2014 as well as a number of passes in the summers of 2012 and 2013, along with a series of near and coincident in situ measurements in the Western Basin of Lake Erie to adequately address project goals of monitoring Great Lake ecosystem and drinking/recreational water sources (b) (4) (b) (4) |
| Hyperspectral Mapping of Iron-bearing Minerals | Dr. William H. Farrand | Space Science Institute | (b) (4) |
| Commercial Space-Borne Hyperspectral Harmful Algal Bloom (HAB) Products | Dr. Ruhul Amin | United States Naval Research Laboratory | (b) (4) |
| Architecture to Transfer Remote Sensing Algorithms from Research to Operations | Dr. James Goodman | HySpeed Computing | The Hyperspectral Imager for the Coastal Ocean (HICO) Image Processing System (IPS) is now online: http://hyspeedgeo.com/HICO/. HICO IPS is a prototype cloud computing application for on-demand remote sensing image analysis and data visualization. Users can interactively select images and algorithms, dynamically launch analysis routines in the cloud, and see results displayed directly in an online map interface. |

## IN PREFLIGHT DEVELOPMENT

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | LAUNCH VEHICLE | ESTIMATED LAUNCH DATE |
|---|---|---|---|---|
| Eli Lilly PCG | Kristofer R. Gonzalez-DeWhitt, Michael Hickey | Eli Lilly and Company | SpX-8 | 3/20/16 |
| Eli Lilly-RR3 Myostatin | Dr. Rosamund Smith | Eli Lilly and Company | SpX-8 | 3/20/16 |
| SSEF-Odyssey | Dr. Jeff Goldstein | NCESSE/Tides Center | SpX-8 | 3/20/16 |
| HUNCH Chlorella/Billings Central Catholic High | Dr. Florence Gold | Rocky Mountain College | SpX-8 | 3/20/16 |
| Decoupling Diffusive Transport Phenomena in Microgravity | Dr. Alessandro Grattoni | The Methodist Hospital Research Institute | SpX-8 | 3/20/16 |
| Validation of WetLab-2 System for qRT-PCR capability on ISS | Ms. Julie Schonfeld | NASA ARC | SpX-8 | 3/20/16 |
| Mutualistic Plant/Microbe Interactions | Dr. Gary W. Stutte | SyNRGE, LLC | SpX-8 | 3/20/16 |
| Corrosion Inhibitor Exposed to the Extreme Environments in Space | Lauren Thompson Miller | A-76 Technologies, LLC | OA-6 | 3/10/16 |
| Materials Testing: The Evaluation of Gumstix Modules in Low Earth Orbit | Dr. Kathleen Morse | Advanced Materials Applications, LLC | OA-6 | 3/10/16 |
| Development and Deployment of Charge Injection Device Imagers | Dr. Daniel Batcheldor | Florida Institute of Technology | OA-6 | 3/10/16 |
| Materials Testing – Earth Abundant Textured Thin Film Photovoltaics | Dr. Jud Ready | Georgia Institute of Technology | OA-6 | 3/10/16 |
| Honeywell/Morehead-DM Payload Processor | Dr. Benjamin Malphrus | Honeywell/Morehead State University | OA-6 | 3/10/16 |
| Demonstration and TRL Raising of the Net Capture System on the ISS | Ron Dunklee | AIRBUS DS Space Systems, Inc | SpX-9 | NET 5/7/16 |
| Global AIS on Space Station (GLASS) | Robert Carlson | JAMSS America, Inc. (JAI) | SpX-9 | NET 5/7/16 |
| Molecules Produced in Microgravity from the Chernobyl Nuclear Accident | Dr. Kasthuri Venkateswaran | Jet Propulsion Laboratory/ Caltech | SpX-9 | NET 5/7/16 |
| Project Meteor | Michael Fortenberry | Southwest Research Institute | SpX-9 | NET 5/7/16 |
| MultiLab: Research Server for the ISS | Twyman Clements | Space Tango, Inc | SpX-9 | NET 5/7/16 |
| Effects of Microgravity on Stem Cell-Derived Heart Cells | Dr. Joseph Wu | Stanford University | SpX-9 | NET 5/7/16 |
| Genes In Space | Anna-Sophia Boguraev | The Boeing Company (sponsor) | SpX-9 | NET 5/7/16 |
| NIH-Osteo | Dr. Bruce Hammer | University of Minnesota | SpX-9 | NET 5/7/16 |
| Eli Lilly_Dissolution of Hard to Wet Solids | Dr. Richard Cope, Dr. Alison Campbell, Dr. Kenneth Savin | Eli Lilly and Company | SpX-10 | 6/10/16 |
| Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples | Dr. Edward Snell | Hauptman Woodward Medical Research Institute, Inc. | SpX-10 | 6/10/16 |
| Rodent Research-4 Validation Study | Dr. Melissa Kacena | Indiana University School of Medicine | SpX-10 | 6/10/16 |
| Application of Microgravity Expanded Stem Cells in Regenerative Medicine | Dr. Abba Zubair | Mayo Clinic | SpX-10 | 6/10/16 |
| The Effect of Macromolecular Transport on Microgravity PCG | Dr. Lawrence DeLucas | University of Alabama at Birmingham | SpX-10 | 6/10/16 |
| Controlled Dynamics Locker for Microgravity Experiments on ISS | Dr. Scott A. Green | Controlled Dynamics Inc. | OA-5 | 7/7/16 |
| Functional Effects of Spaceflight on Cardiovascular Stem Cells | Dr. Mary Kearns-Jonker | Loma Linda University | SpX-11 | 8/15/16 |
| Magnetic 3-D Cell Culture for Biological Research in Microgravity | Dr. Glauco Souza | Nano3D Biosciences, Inc. | SpX-11 | 8/15/16 |
| MUSES Imaging Platform | Bill Corley | Teledyne Brown Engineering | SpX-11 | 8/15/16 |
| NDC-3: Chicagoland Boy Scouts and Explorers | Christie Capelety | Three Fires Council of Chicago | SpX-11 | 8/15/16 |
| NDC-3: Chicagoland Boy Scouts and Explorers | Norman McFarland | Three Fires Council of Chicago | SpX-11 | 8/15/16 |

NET = no earlier than

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | LAUNCH VEHICLE | ESTIMATED LAUNCH DATE |
|---|---|---|---|---|
| NDC-3: Chicagoland Boy Scouts and Explorers | Dr. Sandra Rogers | Three Fires Council of Chicago | SpX-11 | 8/15/16 |
| Detached Melt and Vapor Growth of InI in SUBSA Hardware | Dr. Aleksandar Ostrogorsky | Illinois Institute of Technology | OA-7 | 10/4/16 |
| Intuitive Machines-ISS Terrestrial Return Vehicle (TRV) | Steve Altemus | Intuitive Machines | OA-7 | 10/4/16 |
| Crystal Growth of Cs2LiYCl6 Ce Scintillators in Microgravity | Dr. Alexei Churilov | Radiation Monitoring Devices Inc. | OA-7 | 10/4/16 |
| Electrolytic Gas Evolution under Microgravity | Larry Alberts | Cam Med LLC | SpX-12 | 12/15/16 |
| Systemic Therapy of NELL-1 for Osteoporosis | Dr. Chia Soo | UCLA | SpX-12 | 12/15/16 |
| Characterizing Arabidopsis Root Attractions (CARA) grant extension request | Dr. Anna-Lisa Paul | University of Florida | SpX-12 | 12/15/16 |
| Nanobiosym- Galactic Grant | Dr. Anita Goel | Nanobiosym | SpX-13 | 2/13/17 |
| Zero Robotics – Middle School Competition | Dr. Alvar Saenz Otero | Massachusetts Institute of Technology | yearly | |
| Zero Robotics – High School Competition | Dr. Alvar Saenz Otero | Massachusetts Institute of Technology | yearly | |
| Capillary-Driven Microfluidics in Space | Dr. Luc Gervais | 1Drop Diagnostics US Inc. | TBD | |
| SiC Microgravity Enhanced Electrical Performance (MEEP) | Rich Glover | ACME Advanced Materials | TBD | |
| The Universal Manufacture of Next Generation Electronics | Dr. Supriya Jaiswal | Astrileux Corporation | TBD | |
| Use of Boron-Enhanced High-Density Polyethylene for Radiation Shielding – NDC Pilot potential reflight | Angela Glidewell | Awty International School | TBD | |
| Carbon Dioxide Emissions of Yeast Cells in Microgravity Environment – NDC Pilot potential reflight | Jessika Smith | Awty International School | TBD | |
| NDC-2 (Denver) – potential reflight | Shanna Atzmiller | Bell Middle School | TBD | |
| Cranial bone marrow stem cell culture in space | Dr. Yang (Ted) D. Teng | Brigham and Women's and Space Bio Laboratories Co. Ltd | TBD | |
| SG100 Cloud Computing Payload | Mr. Trent Martin | Business Integra | TBD | |
| NDC-2 (Denver) – potential reflight | Brian Thomas | Centaurus High School | TBD | |
| NDC-2 (Denver) – potential reflight | Joel Bertelsen | Chatfield Senior High School | TBD | |
| NDC Pilot Program – potential reflight | Rev. Brian Reedy | Cristo Rey Jesuit College Preparatory of Houston | TBD | |
| NDC Pilot Program - potential reflight | Greg Adragna | Cristo Rey Jesuit College Preparatory of Houston | TBD | |
| Providing Spherical Video Tours of ISS | Mr. David Gump | Deep Space Industries | TBD | |
| The Effects of Microgravity and Light Wavelength on Plant Growth – NDC Pilot potential reflight | Kathy Duquesnay | Duchesne Academy | TBD | |
| The Effects of Different Wavelengths of Light on Algae Oxygen Production in Microgravity – NDC Pilot potential reflight | Susan Knizner | Duchesne Academy | TBD | |
| Survivability of Variable Emissivity Devices for Thermal Control Applications | Dr. Hulya Demiryont | Eclipse Energy Systems, Inc | TBD | |
| Eli Lilly – Lyophilization | Jeremy Hinds, Dr. Evan Hetrick | Eli Lilly and Company | TBD | |
| Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment | Dan O'Connell | HNu Photonics | TBD | |
| Nemak Alloy Solidification Experiments | Dr. Glenn Byczynski | NEMAK | TBD | |
| Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System | Dr. Robert Applegate | Novopyxis | TBD | |

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | LAUNCH VEHICLE | ESTIMATED LAUNCH DATE |
|---|---|---|---|---|
| Efficacy & Metabolism of Azonafide Antibody-Drug Conjugates (ADCs) | Sourav Sinha | Oncolinx | TBD | |
| Intracellular Macromolecule Delivery and Cellular Biomechanics in Microgravity | Harrison Bralower | SQZ Biotechnologies | TBD | |
| Soluble Corn Fiber to improve bone mineral density | Patricia Williamson | Tate & Lyle | TBD | |
| The effect of microgravity on stem cell mediated recellularization | Jason Sakamoto | The Methodist Hospital Research Institute | TBD | |
| Faraday Waves and Instability-Earth and Low G Experiments | Dr. Ranga Narayanan | University of Florida | TBD | |
| Space Based Optical Tracker | Dr. John Stryjewski | Vision Engineering Solutions | TBD | |
| Zaiput Flow Technologies-Galactic Grant | Dr. Andrea Adamo | Zaiput Flow Technologies | TBD | |

## CURRENTLY IN ORBIT

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | RETURN VEHICLE | RETURN DATE | STATUS UPDATE |
|---|---|---|---|---|---|
| Synthetic Muscle: Resistance to Radiation | Dr. Lenore Rasmussen | Ras Labs | SpX-9 | 4/22/16 | (b) (4) |
| Binary Colloidal Alloy Test – Low Gravity Phase Kinetics Platform | Dr. Matthew Lynch | Procter & Gamble, with Zin Technologies, Inc. | TBD | TBD | (b) (4) |
| Milliken Vertical Burn | Dr. Jeff Strahan | Milliken | TBD | TBD | Recently delivered |
| Zero-G Characterization & OnOrbit Assembly for Cellularized Satellite Tech | Talbot Jaeger | NovaWurks, Inc | N/A | N/A | Recently delivered. |
| Windows On Earth | Dan Barstow | TERC | N/A | N/A | The WinEarth software continues to perform optimally and is providing the ISS crew with a valuable tool to facilitate Crew Earth Observations and Imaging |
| National Lab Project: AMS | Dr. Samuel Ting | Department of Energy | N/A | N/A | The Alpha Magnetic Spectrometer continues to operate nominally and collect data on board the ISS. Dr. Ting's team continues to analyze data. |
| National Lab Projects: ISERV | Burgess Howell | Disaster Relief Charter | N/A | N/A | The ISERV camera is currently in stowage onboard the ISS awaiting required use in response to humanitarian or disaster response |

## IN POSTFLIGHT ANALYSIS/COMPLETED

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | STATUS UPDATE |
|---|---|---|---|
| Ants in Space, CSI-06 | Stefanie Countryman | BioServe Space Technologies | The flight portion of this STEM program was completed in 2014. This is now a ground-based STEM program that leverages the data/findings/results of the flight project. A FY15 publication in Frontiers in Ecology and Evolution resulted from this project. |
| Osteocytes and Mechanomechano-transduction (Osteo-4) | Dr. Paola Divieti Pajevic | Boston University | (b) (4) |
| PCG-Crystallization of Huntington Exon-1 Using Microgravity | Dr. Pamela Bjorkman | California Institute of Technology | (b) (4) |
| PCG - IPPase Crystal Growth in Microgravity | Dr. Joseph Ng | iXpressGenes, Inc. | (b) (4) |
| Kentucky Space Exomedicine Lab – Flatworm | Dr. Mahendra Jain | Kentucky Space, LLC | (b) (4) |
| Merck PCG-1 and -2 | Dr. Paul Reichert | Merck Pharmaceuticals | (b) (4) |
| T-Cell Activation in Aging-1 and -2 | Dr. Millie Hughes-Fulford | Northern California Institute for Research and Education, Inc. | (b) (4) |
| Novartis Rodent Research-1 and -2 | Dr. David Glass | Novartis Institute for Biomedical Research | (b) (4) |
| PCG - Crystallization of Human Membrane Proteins in Microgravity | Dr. Stephen Aller | University of Alabama at Birmingham | (b) (4) |

| PROJECT | PRINCIPAL INVESTIGATOR | AFFILIATION | STATUS UPDATE |
|---|---|---|---|
| Antibiotic Effectiveness in Space-1 | Dr. David Klaus | University of Colorado Boulder | (b) (4) |
| Molecular Biology of Plant Development (Petri Plants) | Dr. Anne-Lisa Paul | University of Florida | (b) (4) |
| Protein Crystal Growth for Determination of Enzyme Mechanisims | Dr. Constance Schall | University of Toledo | (b) (4) |
| Drug Development and Human Biology: Use of microgravity for drug development | Dr. Timothy Hammond | Veterans Administration Medical Center | (b) (4) |
| Cyclone Intensity Measurements from the International Space Station (CIMISS) | Dr. Paul C. Joss | Visidyne, Inc. | (b) (4) |

# CONFERENCES AND EVENTS IN Q1 FY16

## CONFERENCE AND INDUSTRY EVENT SPONSORSHIPS

| EVENT | LOCATION | DATE | AUDIENCE | DESCRIPTION |
|---|---|---|---|---|
| ISPCS 2015 | Las Cruces, NM | 10/7/15 | Contractors, suppliers, government partners, and entrepreneurs | CASIS sponsored the 2015 International Symposium for Personal and Commercial Spaceflight conference. During this conference, CASIS Executive Director Greg Johnson had multiple speaking roles, including a keynote address to the more than 200 aerospace executives in attendance on how the ISS National Lab is enabling opportunity in low Earth orbit. |
| American Society for Gravitational and Space Research (ASGSR) Annual Meeting | Alexandria, VA | 11/10/15 | Scientists, researchers, engineers, and academics | CASIS actively participated in and was an organizational sponsor for the 2015 ASGSR Annual Meeting, which brought together over 500 scientists and engineers to encourage an exchange of ideas, bridging basic and applied biological and physical sciences research and technology in space with gravitational sciences. ASGSR members represent academia, government, and industry interests bonded by a common issue – how living organisms and physical systems respond to gravity. CASIS developed a funding panel that featured one-on-one lightning sessions for more 30 research scientists and four investment specialists. |
| Space Commerce Conference and Exposition (SpaceCom) | Houston, TX | 11/17/15 | Aerospace professionals, business executives, and researchers | CASIS was a founding sponsor of the inaugural Space Commerce Conference and Exposition (SpaceCom). The three-day event focused on engineering business innovation across the aerospace, medical, energy, transportation, maritime, communications, and advanced manufacturing industries. SpaceCom distinctly unites public and private stakeholders involved in domestic and international space commerce with a new group of global business executives looking for competitive advantage through the application of space technology to their industries. The CASIS team presented at several sessions during SpaceCom focused on a variety of topics including: new business opportunities in low Earth orbit, accessing the ISS National Lab, and biological research on the ISS. Additionally, CASIS presented at the Innovation Theater on the exhibit floor and also showcased the ISS Virtual Display at the CASIS booth. |
| World Stem Cell Summit | Atlanta, GA | 12/10/15 | Scientists, researchers, and academics specializing in stem cell and regenerative medicine research | CASIS sponsored the 2015 World Stem Cell Summit, produced by the Genetics Policy Institute (GPI). This summit is the largest interdisciplinary networking meeting of stem cell science and regenerative medicine stakeholders, uniting this diverse community. The summit's overarching purpose is to foster biomedical research as well as funding and investments that target cures. It is the single conference charting the future of this burgeoning field. |

## SUBJECT MATTER EXPERT WORKSHOPS

| EVENT | LOCATION | DATE | AUDIENCE | DESCRIPTION |
|---|---|---|---|---|
| Protein Crystal Growth Workshop | Huntsville, AL | 10/22/15 | Protein crystallization researchers | CASIS hosted an expert advisory workshop to determine the needs of the protein crystallization community in the near- to mid-term. The results generated from this meeting will guide the formation of an ongoing program to provide frequent, reliable access for protein crystal growth research onboard the ISS National Lab. |
| Musculoskeletal Disease Research in Space Workshop | Alexandria | 11/11/15 | Musculoskeletal researchers and subject matter experts | CASIS hosted a half-day workshop in conjunction with the 2015 ASGSR Annual Meeting focused on musculoskeletal disease research in space. The CASIS team and eight subject matter experts (forming a musculoskeletal disease science definition team) conducted the workshop to develop the R&D goals for CASIS to formulate and implement a robust musculoskeletal disease research program on the ISS National Lab that would support the needs of academic, commercial, and government entities. |
| LEO Commercialization Organ Bioengineering Roundtable | Atlanta, GA | 12/11/15 | Thought leaders in stem cell/tissues to organs research | In conjunction with the World Stem Cell Summit, CASIS hosted a round-table discussion featuring many thought leaders to identify current challenges and opportunities to leverage the microgravity platform to accelerate regenerative medicine. |

## ADDITIONAL CONFERENCE AND EVENT PARTICIPATION

| EVENT | LOCATION | DATE | AUDIENCE | DESCRIPTION |
|---|---|---|---|---|
| Educational skype session | Knoxville, TN | 10/6/15 | High school students | A CASIS representative conducted a Skype call with 100 high school students in Knoxville, TN to discuss microbes in space. |
| Biomedical Engineering Society Annual Meeting | Tampa, FL | 10/7/15 | Biomedical researchers, including subject matter experts in organ-on-a-chip | The CASIS team presented at an innovation session at the 2015 Biomedical Engineering Society Annual Meeting. Many attendees were organ-on-a-chip researchers from both academic and the commercial entities. Participation in this meeting resulted in numerous inquiries around the CASIS Organ-on-a-Chip Grand Challenge. BMES represents biomedical engineering and technology segments in medicine and biotechnology. |
| World Space Week | Tampa, FL | 10/15/15 | Middle school students | As part of World Space Week, CASIS Executive Director Greg Johnson spoke to 1,060 middle school students at Stewart Middle Magnet School about the ISS and CASIS. |
| Nalco Champion Industry Day | Houston, TX | 10/15/15 | Nalco Champion R&D leadership | A CASIS representative led the Nalco Champion R&D executives through the ISS National Lab value proposition and an initial ideation session to discuss how Nalco Champion and CASIS could work together more closely. There is strong interest in generating an internal ideas competition and joining a potential pre-competitive consortia for surfactants research. |
| Moffitt Cancer Center | Tampa, FL | 10/15/15 | Moffitt Cancer Center research and investment team | CASIS hosted a seminar with CASIS Executive Director Greg Johnson and key leaders of the research and investment team at Moffitt Cancer Center. Moffitt's key research areas may benefit from further research onboard the ISS National Lab by taking advantage of the unique cell culture environment. Both teams discussed sponsored programs and other collaborative project ideas. |
| Lights On | Kennedy Space Center, FL | 10/16/15 | Elementary School Students | CASIS supported the Lights On STEM event at the Center for Space Education. The CASIS STEM team advocated for the ISS and CASIS by performing the ISS fly-around and the quantum levitation demonstrations. 150 students participated in this event. |
| The Scripps Research Institute of Florida | Jupiter, FL | 10/16/15 | Scripps' research team | The CASIS team gave a presentation at the Scripps Research Institute (TSRI) to more than 60 members of their research staff from various scientific disciplines who use a diverse set of model organisms. TSRI is one of the world's largest private non-profit research organizations and stands at the forefront of basic biomedical science, a vital segment of medical research seeks to comprehend the most fundamental processes of life. |
| Industrial Research Institute Member Summit | Chicago | 10/19/15 | Corporate R&D professionals | CASIS presented at the LEO Commercialization Activity Drivers & Dimensions of Agile Growth session at the Industrial Research Institute Member Summit. The session focused on the drivers and trends behind the rising emphasis on agile growth strategies, e.g., reduced barriers to entry, shortened product business life cycles, the increasing reliance on data mining and analytics, and the impact of social media on the pace of change. |
| NewSpace Business Plan Competition | New York | 10/22/15 | Entrepreneurs, venture capitalists, and corporate sponsors | CASIS participated in the NewSpace Business Plan Competition. This competition is the premiere space start-up event, connecting entrepreneurs with established industry mentors and resources. Chosen competitors attend a private two-day boot camp session to prepare for their shark tank-style pitch to investors. Companies are judged on their investment potential, and cash prizes are awarded to the most promising teams. |
| Family STEM Night | Oviedo, FL | 10/22/15 | Parents, students, and educators | The CASIS education team gave a presentation and held a Q&A session about the ISS and CASIS at Family STEM Night, a STEM outreach event at Stenstrom Elementary School in Oviedo, FL. More than 300 parents, students, and teachers participated in this event. |
| Florida Association of Science Teachers Conference | Tallahassee, FL | 10/22/15 | Science educators and administrators | CASIS distributed educational materials to science educators and administrators at the 2015 Florida Association of Science Teachers Annual Conference. Approximately 500 people were in attendance. |
| Dow Seminar | Marlborough, MA | 10/27/15 | Dow Chemical scientists and engineers | CASIS hosted a seminar at Dow Chemical discussing the ISS National Lab and potential project opportunities. Additionally, a CASIS representative discussed his career and research background to a group of young scientists and engineers at Dow. This meeting was arranged by a CASIS Science and Technology Advisory Panel member. |

| EVENT | LOCATION | DATE | AUDIENCE | DESCRIPTION |
|---|---|---|---|---|
| 8th Wernher Von Braun Symposium | Huntsville, AL | 10/28/15 | Aerospace professionals, business executives, and researchers | CASIS Executive Director Greg Johnson presented on a panel at the 2015 Von Braun Symposium, an event sponsored by the American Astronautical Society in conjunction with Marshall Spaceflight Center. |
| MassChallenge Awards Ceremony | Boston, MA | 10/28/15 | Entrepreneurs, investors, and corporate sponsors | CASIS presented the winner of the CASIS / Boeing ISS award in front of an audience of 5,000 at the MassChallenge Awards Ceremony. The CASIS team participated in pre-networking events and gave several interviews with media throughout the event. |
| North Carolina Biotech Center | Research Triangle Park, NC | 10/28/15 | R&D groups, educational outreach professionals | CASIS hosted a session with key leaders within the North Carolina innovation community at the North Carolina Biotech Center in Research Triangle Park. Attendees included representatives from Monsanto, GlaxoSmithKline, Governor's Science, Innovation and Technology Board, local/regional museums and education collaborations. The CASIS team introduced research, technology, and educational opportunities utilizing the ISS National Lab and discussed potential collaborations such as Destination Station, sponsored programs, and targeted visits. |
| Destination Station | New York & Connecticut | 11/2/15 | R&D leadership at GE and Unilever | CASIS and NASA hosted two Destination Station Industry Day events. One event was hosted at General Electrics' New York City facility and the other was held at Unilever's personal care products R&D site in Trumbull, CT. Both visits secured commitments from the companies to explore a deeper relationship with CASIS and the ISS National Lab to advance their R&D portfolios. |
| PepsiCo Webinar | Dallas, TX and other locations | 11/6/15 | PepsiCo R&D fellows | A CASIS representative led PepsiCo Director of R&D Chris Koh and his fellows through the ISS National Lab value proposition and hosted an initial discussion on how CASIS and PepsiCo R&D might work together. The fellows expressed interest in both pathfinder projects as well as an internal competition to generate new ideas. |
| St. Jude Research Hospital | Memphis, TN | 11/18/15 | St. Jude Research Technology office staff | The CASIS team met with the St. Jude Research Technology Transfer office. This meeting resulted in a potential collaboration to explore proton radiation exposures in space versus during cancer treatment. |
| Memphis BioWorks | Memphis, TN | 11/18/15 | Researchers, entrepreneurs, and investors | CASIS and Memphis BioWorks hosted a seminar for Memphis Innovation Center clients, venture capitalists, and local research leaders. Memphis BioWorks is the go-to organization in the mid-South for creating companies, jobs, and investments in bioscience. |
| University of Tennessee Health Science Center | Memphis, TN | 11/18/15 | Vice Chancellor of the University of Tennessee Health Science Center | The CASIS team discussed potential research opportunities on the ISS National Lab with Dr. Kennard Brown, Vice Chancellor of the University of Tennessee Health Science Center. Memphis has a strong history of biomedical innovation with the University of Tennessee Health Sciences Center, Baptist Hospital, and others closely involved in cardiovascular and orthopedic medical advances. |
| AgInnovation Group | Memphis, TN | 11/18/15 | Investors | The CASIS team reviewed potential agriculture biotech collaborative potential with AgInnovation Group, a Memphis BioWorks private equity fund. Both parties discussed next steps to begin formulating best collaborative projects involving agriculture research onboard the ISS National Lab. |
| Boy Scouts of America LaSalle Street - Trading Tech Awards | Chicago, IL | 11/19/15 | Leaders from Chicago's business, finance, and tech sectors | CASIS was recognized as the Innovation Partner of the Year at the Trading Tech Awards. This event brings members of Chicago's financial and banking community together in support of the local Boy Scouts movement in Chicago. The event recognizes the efforts of partners that were instrumental in furthering learning opportunities for youth in the areas of science, technology, engineering, and math. |
| Delta Faucet Industry Day | Indianapolis, IN | 11/20/15 | R&D leadership at Delta Faucet Company and counterparts from Eli Lilly | Together with NASA colleague Dr. Tara Ruttley, the CASIS team led Delta Faucet Company's R&D team through the ISS National Lab value proposition and an energetic brainstorming session that generated more than 20 new ideas for Delta Faucet to utilize the ISS in its research and innovation efforts. |
| Brevard Space Week | Kennedy Space Center, FL | 12/1/15 | 6th grade students | CASIS sponsored the 2015 Brevard Space Week, an engaging hands-on learning experience for students in Brevard County, FL. All sixth grade classrooms in the county were brought to the Kennedy Space Center Visitor Complex to participate in educational games and activities, experience exciting tours, and learn about the space program. More than 6,000 students participated in this event. |

| EVENT | LOCATION | DATE | AUDIENCE | DESCRIPTION |
|---|---|---|---|---|
| ISS Downlink at House Science Committee | Washington, D.C. | 12/2/15 | House of Representatives Science Committee members and congressional staff | CASIS participated in the ISS Downlink event at the U.S. House of Representatives Science Committee meeting. The meeting provided an invaluable opportunity for ISS researchers, implementation partners, and financial accelerators to interact with congressional leaders. CASIS showcased hardware, research, and the new ISS virtual tour interactive display. The highlight of the meeting was a live downlink from the space station with NASA astronauts Scott Kelly and Kjell Lindgren. |
| Space Station Day | Fall River, MA | 12/7/15 | Middle school students | CASIS hosted Space Station Day at Talbot Innovation Middle School, the winner of the Space Station STEM Challenge sponsored by CASIS and the Massachusetts Life Sciences Center. CASIS invited retired astronaut Fred Gregory to speak to more than 200 eighth grade students during the event. |
| Hyde Elementary Space Night | League City, TX | 12/8/15 | Elementary school students | CASIS Executive Director Greg Johnson spoke to 300 elementary students at Hyde Elementary School as part of their Space Night event. |
| University of Florida Meeting | Gainesville, FL | 12/17/15 | University of Florida Office of Research staff, including Dr. David Norton, Vice President for Research | The CASIS team visited the University Florida to explore ways that they could work together in a mutually beneficial way to pool and leverage resources to conduct more research onboard the ISS National Laboratory; promote STEM education; stimulate interest in space exploration; and develop new technologies, applications, and knowledge that will benefit all humankind. |

# FINANCIALS

## BUSINESS STATUS REPORT (UNAUDITED)

| OCT 1-DEC 31, 2015 | ACTUALS Q1 2016 | BUDGET Q1 2016 | VARIANCE | ACTUAL YTD 2016 | BUDGET YTD 2016 | VARIANCE |
|---|---|---|---|---|---|---|
| Direct Labor | $1,278,341 | $1,483,252 | $204,911 | $1,278,341 | $1,483,252 | $204,911[a] |
| Subcontracts | $435,654 | $625,735 | $190,081 | $435,654 | $625,735 | $190,081[b] |
| Permanent Equipment > $5k | $12,652 | $16,700 | $4,048 | $12,652 | $16,700 | $4,048 |
| Expendable Supplies and Equipment | $57,858 | $64,763 | $6,905 | $57,858 | $64,763 | $6,905 |
| Travel | $230,068 | $243,131 | $13,063 | $230,068 | $243,131 | $13,063 |
| Grants Awarded | $1,798,296 | $2,169,421 | $371,125 | $1,798,296 | $2,169,421 | $371,125[c] |
| Other Direct Costs | $283,948 | $484,773 | $200,825 | $283,948 | $484,773 | $200,825[d] |

(a) Budgeted headcount was 42; actual was 38.
(b) Subcontracts were lower in two areas:
- Campaign Good Earth budgeted consultants have been shifted to later in the year as the results of the gap analysis are reviewed and implementation plans are complete.
- Budgeted amounts for legal, STEM, and development have shifted to later in the year.

(c) Mission based costs have shifted to later this year as a result of launch delays.
(d) For advertising, timing of payments for conference sponsorships and registrations have shifted to later this year.

## BREAKOUT OF COOPERATIVE AGREEMENT FUNDING

| | Q1 FY16 | Q2 FY16 | Q3 FY16 | Q4 FY16 |
|---|---|---|---|---|
| Direct | 40% | | | |
| Indirect | 16% | | | |
| Grants | 44% | | | |

## BREAKOUT OF CASIS GRANTS

| | Q1 FY15 | Q2 FY15 | Q3 FY15 | Q4 FY15 |
|---|---|---|---|---|
| Private/Commercial | $1,258,897 | | | |
| Academic | $477,861 | | | |
| Mission Based Costs | $61,538 | | | |