



FY16 Q2 REPORT

Quarterly Report for the Period Jan 1 – Mar 31, 2016

CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)





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EXECUTIVE SUMMARY

As NASA and commercial cargo providers focused on getting regular transportation to and from the International Space Station (ISS) up to full speed, the ISS U.S. National Laboratory continued to make rapid progress, attracting leading thinkers, communicators, and innovators to actively contribute to its mission. In the second quarter of fiscal year 2016 (Q2 FY16), CASIS deepened engagement with Fortune 500 companies, developed new and noteworthy publications, expanded opportunities with non-NASA government research organizations, and selected meaningful research proposals that leverage the unique capabilities of the ISS.

KEY HIGHLIGHTS FROM Q2 FY16 INCLUDE:

- ▶ **New research awards** – CASIS awarded 11 projects across multiple scientific disciplines, including seven awards to commercial entities and four to returning CASIS customers.
- ▶ **Sponsored research program response** – The joint CASIS and National Science Foundation Sponsored Research Program call for papers (in the field of fluid dynamics), and multiple projects were invited to submit full proposals.
- ▶ **Expanding government agency collaboration** – CASIS signed a memorandum of understanding with the National Center for Advancing Translational Sciences at the National Institutes of Health outlining future collaborative opportunities.
- ▶ **Visibility and outreach** – The upcoming ISS R&D Conference secured newsworthy and influential keynote speakers, including CNN Chief Medical Correspondent Dr. Sanjay Gupta, NASA Astronaut Scott Kelly, and Director of the Scripps Translational Science Institute Dr. Eric Topol.
- ▶ **STEM education engagement** – The ISS National Lab was featured at the first-ever “National Week at the Labs,” launched by the White House in February to promote student interest in science, technology, engineering, and mathematics (STEM) careers.
- ▶ **STEM education summit** – CASIS hosted its annual STEM Education Workshop, at which STEM education and outreach experts discussed the new CASIS strategic plan for education initiatives and outreach concepts, scheduled to publicly launch in Q3.
- ▶ **Commercial engagement** – CASIS continued to widen its commercial customer outreach, engaging with the technology, retail, and physical sciences industries, including several Fortune 500 companies.
- ▶ **Project success** – ISS National Lab projects demonstrated measurable success through both publications and industry product enhancement, with an academic research article challenging widespread assumptions about plant growth and an improved algae detection algorithm being adopted by the remote sensing community.

With regard to ISS operations, experiments delivered to the ISS in December 2015 were successfully completed on schedule. In March, new scientific payloads were delivered to the ISS by a United Launch Alliance Atlas V rocket carrying Cygnus cargo vessel OA-6—a Commercial Resupply Services program mission. Payloads included multiple satellite technology projects from NanoRacks, LLC, an advanced manufacturing facility from the company Made In Space (which will expand commercial capabilities for in-orbit 3-D printing and materials testing), and several others. Finally, CASIS launched *Upward* magazine, the ISS National Lab's official quarterly publication, signifying a major new pathway for communicating the scientific achievements of ISS National Lab initiatives. The first issue featured the above-mentioned newly published research on root development in plants, details about rodent research onboard the ISS, and insights into ISS-inspired commercial product development.



ISS NATIONAL LAB PORTFOLIO

ESTABLISH INNOVATION CYCLES AND UTILIZE THE ISS FOR DEVELOPING NEW CAPABILITIES

AWARDS AND OPPORTUNITIES

Physical Sciences

Q2 marked the close of the submission period for the joint CASIS–National Science Foundation (NSF) research competition to support fluid dynamics investigations on the ISS National Lab. After a review of the submissions, multiple projects were invited to submit full proposals. This is the largest sponsored program for CASIS to date and the first in partnership with a non-NASA government agency. NSF is committing up to \$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, allowing the study of phenomena of interest without gravitational interference. The results from NSF's investment in fundamental research could create pathways for commercial applications in industries including consumer products, electronics, manufacturing, medical devices and pharmaceuticals, and oil and gas.

Life Sciences

CASIS has established a memorandum of understanding with the National Center for Advancing Translational Sciences (NCATS) at the National Institutes of Health (NIH). In this partnership, CASIS and NCATS will work together to facilitate space-related research aimed at better mimicking human physiology, with the goal of improving our understanding of human health and disease.

In addition, four new ISS National Lab life sciences projects were awarded in Q2—one from a commercial entity and three from academic institutions. These awarded projects are part of 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. Two of the projects are technology based—an implantable drug delivery system and a system for evaluating drug safety and effectiveness—and two others explore new therapeutic approaches to heart and musculoskeletal disease. Of note, the drug delivery system project represents a collaboration between two customers returning to CASIS: the Houston Methodist Research Institute (an academic medical center in Houston, Texas, focused on translational research and precision medicine) and the Novartis Institutes for BioMedical Research (a global pharmaceutical research organization based in Cambridge, Massachusetts, that had more new drugs approved by the U.S. Food and Drug Administration in 2015 than any other company).

Technology Development

CASIS awarded five technology development projects—all from commercial entities—in Q2. The projects include a new laser communications system, light-weight cables that could help reduce spacecraft weight, and two projects involving in-orbit manufacturing of improved optical fibers for telecommunications, medical devices, and sensors for aerospace and defense. These latter two projects support long-term goals toward the commercialization of low Earth orbit (LEO), which CASIS seeks to enable through the support of research areas with shared public-private benefit—including use of the ISS to demonstrate the utility of spaceflight for manufacturing of materials. The ISS National Lab is a critical platform to stimulate the use of LEO for sustained economic activity, and through support of key projects, CASIS hopes to build commercial interest in the future of LEO commercialization. Of note, these two optical fiber projects involve almost \$1.5 million in company contributions toward project cost.



The final technology-related project awarded in Q2 resulted from \$1.1 million in funding from Space Florida, Florida's aerospace economic development organization committed to attracting and expanding the next generation of space industry businesses. This external funding was awarded to Craig Technologies for a project focused on rapid development and testing of space hardware utilizing additive manufacturing technology. Such external financial support of projects demonstrates the growing value proposition of the ISS National Lab.

Earth Observation

In the area of Earth observation, CASIS awarded one project in Q2—to a commercial entity. This project seeks to utilize the LEO vantage point of the ISS to improve tropical cyclone intensity measurements through improved modeling. Another returning customer, this company will be performing its third round of CASIS-sponsored observations from the ISS. This project is part of Campaign Good Earth, an initiative to maximize ISS Earth observation capabilities through the development and deployment of next-generation sensors.

Education

CASIS awarded one education project in Q2 for support of a program that allows students to examine how the space environment affects tomato plant growth. CASIS is committed to inspiring students through innovative STEM programs, such as this one, that provide students with invaluable hands-on research experiences.

For more information on newly awarded projects, see the Projects Awarded in Q2 FY16 table on page 12.

In additional research opportunities, Q2 marked the official start of the 2016 MassChallenge Accelerator Program in Boston, Massachusetts. MassChallenge is the largest-ever startup accelerator and the first to support high-impact, early-stage entrepreneurs without taking any equity. Its four-month accelerator program offers world-class mentorship, free office space, \$1 million in cash awards, and up to \$10 million through in-kind support. To date, 835 MassChallenge alumni have raised more than \$1.1 billion and created more than 6,500 jobs. For the fourth year in a row, the ISS National Lab is supporting a Sponsored Program for a "Technology in Space" prize associated with the MassChallenge Program. For the third year in a row, Boeing will be a co-sponsor with CASIS for this prize, which will provide funding to technical, out-of-the-box concepts for research on the ISS National Lab.

PROJECT STATUS

With the successful launch of OA-6, nine payloads were delivered to the ISS National Lab. These include a variety of commercial satellite technology projects from the payload developer NanoRacks, LLC, as well as the following projects across multiple scientific disciplines:

Technology Development

- The **Additive Manufacturing Facility** project will bring a fully operational 3-D printer to the ISS to enable hardware manufacturing services in space for both NASA and commercial users of the ISS National Lab. Testing and operating a 3-D printer on the ISS using relatively low-temperature plastic feedstocks is the first step toward establishing an on-demand machine shop in space—a critical enabling component for in-space manufacturing and processing. This project follows from a Made In Space proof-of-concept payload flown in 2014, in which a small demo unit 3-D printer was successfully operated in space. This project also represents an example of how the ISS can foster the emerging LEO commercial market. (Principal Investigator: Michael Snyder; Payload Developer: Made In Space, Inc.)

Earth and Space Science

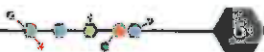
- The flight of *Project Meteor* represents the second re-flight of a payload that was previously lost during the OA-3 and SpX-7 launch anomalies. The mission objective is to fly a visible spectroscopy instrument to the ISS to observe meteors in Earth orbit. This project will continuously monitor meteor interaction with Earth's atmosphere without the limitations of ozone absorption. The resulting data will be the first measurement of meteor flux and will allow for monitoring of carbon-based compounds. Investigation of meteor elemental composition is important to our understanding of how the planets in our solar system developed. Southwest Research Institute will serve as the U.S. host for this project and will conduct this experiment on behalf of the Chiba Institute of Technology, which is based in Japan. (Principal Investigator: Michael Fortenberry; Payload Developer: Southwest Research Institute)

Education

- The *Protein Crystallization in Space* student project from Valley Christian High School in San Jose, California, will crystallize the protein SOD1, which is linked to amyotrophic lateral sclerosis (ALS, also known as Lou Gehrig's disease). Microgravity has been shown to enable the formation of larger, more perfect crystals that may allow scientists to better determine a protein's structure, potentially leading to new methods for treating this debilitating disease. (Student Investigators; Payload Developer: NanoRacks, LLC)

With respect to other projects in the ISS National Lab pipeline, a journal article published in Q2 by University of Florida researchers Drs. Anna-Lisa Paul and Robert Ferl reflects results from an ISS National Lab-sponsored project investigating spaceflight's effect on the gravity-sensing system in the root tips of plants. The paper's findings challenge underlying assumptions about the role of gravity in root development. Paul and Ferl compared the distribution pattern of auxin (a plant hormone involved in orienting roots to grow in the direction of the pull of gravity) in the root tips of plants grown on the ISS against ground controls. They found that plants grown on the ISS have the same pattern of auxin distribution as plants grown on Earth. These results demonstrate that the flow and distribution of auxin in the root tip is not dependent on gravity, as scientists had long assumed. Instead, the pattern of auxin flow is a fundamental mechanism of root growth inherent in plants. By conducting plant research in microgravity, scientists can study mechanisms involved in plant growth and development without the influence of gravity, which allows them to see things not possible on Earth. Such research can contribute to a better understanding of how to grow stronger crops on Earth and how to prepare to grow plants in space during long-term spaceflight missions. For more details on this published article, see the Contributions to Scientific Knowledge table on page 12.

In another recent success, an ISS National Lab project has led to the improvement of a custom algorithm associated with detecting of harmful algal blooms (HABs), which present serious environmental problems in coastal areas. Various space-based sensors are capable of monitoring HABs, but environmental variables (e.g., correction for cloud cover) hamper effective bloom detection. CASIS sponsorship allowed Principal Investigator Dr. Ruhul Amin (BioOptoSense, LLC) to refine a custom algorithm for using red band difference (RBD) methodology to detect HABs, which allowed study of hourly HAB dynamics for the first time. Best known as the cause of "red tide," HABs are toxic to humans, and monitoring the trends in the presence and movement of these HABs may help us better combat their harmful health effects. More than 10 articles (excluding those from Amin) cite this RBD algorithm, which is being used in its current form by downstream external customers including the University of Mississippi, the City College of New York, and the Naval Research Lab (in their Automated Processing System). Algorithms like these improve effective monitoring of regional HABs, benefiting both the economy and public health. For example, the more than 40 species of toxic microalgae in the Gulf of Mexico cause millions of dollars in socioeconomic damage each year, threatening marine life (fish, birds, and marine mammals) and human health. RBD detection methodology not only improves HAB detection



in these areas but also may help us better understand the environmental processes that contribute to such events. This would ultimately benefit human health and the multibillion-dollar fishing and tourism industries. For more information on this product, see the Commercial Impact—Products or Services Created table on page 12.

BUSINESS DEVELOPMENT AND PARTNERSHIPS

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

STRATEGIC AREAS OF FOCUS

In addition to the awarded projects discussed above and the more than 120 projects currently in the ISS National Lab portfolio, CASIS is pursuing more than 140 targeted opportunities across the physical sciences, life sciences, technology development, and remote sensing sectors. Additionally, CASIS continues to improve its strategic direction via formal workshops and analyses with thought leaders in various fields, including both traditional R&D and STEM education experts.

Remote Sensing

In FY15, CASIS commissioned a study to evaluate the capabilities and limitations of the ISS as an operational host for commercial remote sensing payloads and the products and needs of the data analytics community. A gap analysis of these two areas was completed in Q1, and in Q2, a formal report describing the results of this gap analysis was finalized, with formal distribution planned for Q3. This study was part of an overall implementation strategy for Campaign Good Earth. 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.

Life Sciences

As part of Campaign Good Health, CASIS hosted subject matter expert workshops in Q1 in the areas of organ bioengineering and protein crystal growth (PCG). These are priority ISS research areas identified as having both high likelihood for rapid knowledge advancement and potential promise in supporting future LEO commercialization efforts. In Q2, the reports for both workshops were completed, and large-scale electronic distribution of the reports is planned for Q3 (at which time more details will be included in this quarterly reporting document as well). In March, CASIS presented the results of the Organ Bioengineering Workshop at the Regenerative Medicine Workshop in Hilton Head, SC and issued a limited hard-copy release of the Organ Bioengineering Workshop report. In addition, as an action item coming out of the PCG Workshop, a robust long-term protein crystallization research program on the ISS National Lab is currently under development.

In Q3, CASIS will host an additional Campaign Good Health subject matter expert workshop exploring the links between the microbiome (microbes living in the body) and human disease. 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, and recommending best practices for methodology and analysis approaches).



PARTNERSHIPS AND COLLABORATIONS

In addition to the new partnership with NCATS discussed in the Awards and Opportunities section on page 4, CASIS continues to pursue collaborations with multiple OGAs. In Q2 alone, CASIS met with the Department of Defense, the Department of Energy, the White House Office of Science Technology and Policy, the National Institute of Standards and Technology, and the Department of Commerce. Through partnerships with OGAs, CASIS can improve awareness of the value of the ISS research platform and augment the accessibility of this platform to the R&D community beyond the capabilities of CASIS alone.

Similarly, for the third year in a row, CASIS is leveraging external financial contributions to ISS research by continuing its partnership with Boeing for the MassChallenge annual business accelerator competition, described on page 5. Again this year, Boeing has committed to provide \$250,000 to support a joint Sponsored Program with CASIS for innovative flight projects. In addition, Space Florida awarded \$1.1 million in funding in Q2, discussed on page 5, through a collaborative effort with CASIS.

During Q2, CASIS also continued to expand commercial market engagement through industry events and meetings with targeted companies. CASIS held site visits with seven key accounts (Fortune 500 companies and other strategic partners with R&D that can be enabled by space) and is working to finalize proposals with five of these organizations. In addition, CASIS met with five aerospace companies as part of a targeted outreach strategy for technology development in California. These companies possess the resources to financially support their own internal development costs as well as costs associated with space hardware and implementation partner cost, helping the ISS National Lab to leverage its inherent value with external investment.

With respect to such leveraging, on average, CASIS will contribute approximately 40% in seed funding toward projected total costs for projects awarded in Q2. While this is slightly higher than the average CASIS seed funding from previous quarters, substantial external contributions continue to support project costs. Thirty percent of the projects awarded in Q2 required only CASIS support services and facilitation—no CASIS funding. In addition, projects awarded to commercial entities in Q2 involve almost \$4.5 million in total matching funding from either the awarded entity or third-party investors.

OUTREACH AND EDUCATION

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

INCREASING AWARENESS

The second quarter of FY16 saw a strong surge in outreach activities focused on both the general public and the scientific research community. CASIS participated in 29 conferences and events, highlighted by a strong presence at the American Association for the Advancement of Science (AAAS) annual meeting. AAAS is the largest multidisciplinary science meeting in the world, and the CASIS team had an opportunity to interact with more than 5,000 scientists, policymakers, R&D professionals, and educators at the meeting.

Additional conference attendance is planned throughout FY16, and planning for the ISS R&D Conference, organized by the American Astronautical Society, CASIS, and NASA, is well underway. In an exciting development early in Q2, Dr. Sanjay Gupta, CNN's chief medical correspondent, was announced as a keynote speaker for this year's ISS R&D



Conference. This conference serves as a catalyst for engaging new and nontraditional users of the ISS National Lab, and securing high profile speakers such as Dr. Gupta will continue to raise the profile of space research among the broader research community and the general public.

Notably, the focal point of CASIS outreach in Q2 centered on the debut of *Upward*¹—the new quarterly magazine of the ISS National Lab. Geared toward current and future ISS users, *Upward* highlights R&D results and achievements from ISS National Lab experiments. The inaugural issue was published in February and highlights publications, products, and education initiatives resulting from ISS National Lab projects. In addition, *Upward* is part of a global initiative to advance strategic scientific communication and improve thought leadership in the scientific community. *Upward* provides a platform to highlight some of the more technical aspects of ISS National Lab research than is possible through CASIS public outreach.

The Orbital ATK ISS resupply mission brought significant media opportunity for the ISS National Lab and its payloads. Prior to the launch, CASIS released a video highlighting multiple payloads, which, to date, has received approximately 45,000 views. Additionally, ISS National Lab-sponsored payloads received significant media coverage from major news outlets such as *Wired* and *The Verge*, along with other mainstream and space-focused publications. Lastly, in preparation for the eighth SpaceX resupply mission to the ISS, CASIS held a media call featuring investigators from Eli Lilly & Co. and the student winner of the Boeing Genes In Space competition, which was covered by major media outlets such as *USA Today*, the *Associated Press*, and *Reuters*.

STEM INITIATIVES

In February, CASIS participated in the White House “Day at the Labs,” a kickoff event for National Week at the Labs—a White House initiative focused on engaging students across the country in STEM fields by featuring the work being conducted at various federal laboratories. This year more than 50 federal labs across 20 states participated in National Week at the Labs. At the White House event, CASIS showcased the ISS Virtual Tour, an interactive, touchscreen mobile exhibit that highlights the space station’s interior and exterior components in stunning 3-D detail. Zero Robotics, an ISS National Lab education partner, also attended the White House Day at the Labs event to demonstrate how SPHERES robots operate on the space station and inform students about exciting opportunities to participate in real-life robotics and coding on ISS. Hundreds of local Washington, DC/Baltimore-area students were involved in the White House event, which emphasized the importance of STEM careers and the valuable science being conducted on the ISS National Lab and at other federal laboratories. As highlighted by CASIS participation in this event, the ISS National Lab is aligned with key national education goals to inspire more U.S. students to pursue STEM careers and to provide new resources for teachers to utilize in the classroom. CASIS involvement in the White House Day at the Labs was also featured in an *Education Week* article.²

In additional event participation, CASIS interacted with more than 3,000 students, parents, and members of the general public at the AAAS Family Science Days expo held in conjunction with the AAAS annual meeting. CASIS also participated in Astronomy Days at the North Carolina Museum of Natural Sciences (see the description on page 21), which attracted more than 15,000 attendees. To complement the presence of the CASIS exhibit at STEM and public outreach events, the CASIS communications team has made a concerted effort to highlight event participation through

¹See *Upward*: <http://www.iss-casis.org/NewsEvents/OnStation/tabid/113/ArticleID/200/ArtMid/570/CASIS-Introduces-Upward---the-quarterly-magazine-of-the-ISS-National-Lab.aspx>.

²See *Education Week*: http://blogs.edweek.org/edweek/curriculum/2016/03/obama_effort_brings_students_to_federal_science_lab.html



social media. Events such as the White House "Day at the Labs," AAAS Family Science Days, and Astronomy Days were chronicled across various CASIS social media platforms, including Twitter, Facebook, and Instagram. Amplifying the CASIS presence at events through social media coupled with coordinating social media efforts with NASA have resulted in more than 90,000 engagements across CASIS social media platforms in Q2.

In February, CASIS hosted its annual STEM Education Partner Workshop, which was attended by 22 ISS National Lab education partners, including Boys & Girls Clubs of America, National Geographic Learning, Challenger Center for Space Science Education, and PBS SciGirls. The workshop addressed how CASIS and the ISS National Lab can unify, mature, and scale existing STEM education programs to reach a national audience. Key topics centered around synergizing efforts among current ISS National Lab education partners; providing pathways for teachers, students, and after-school program coordinators to participate in multiple ISS National Lab education programs in a streamlined manner; and measuring the increased reach of students served and the impact of ISS National Lab education programs.

The workshop was timely, as CASIS is primed to launch Space Station Explorers—a cohesive, overarching education program that will provide coordinated pathways for students to experience a range of ISS-related learning activities over a multiyear time frame. CASIS is finalizing the strategic plan for Space Station Explorers and developing a new website around this new, multifaceted program. The Space Station Explorers program and website will publicly debut at the 2016 USA Science and Engineering Festival in April.



Q2 FY16 METRICS

SECURE STRATEGIC FLIGHT PROJECTS: Generate 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			2	5
Project proposals generated	30	56			86	100
Projects awarded	7	11			18	40
<i>Return customers: Projects awarded to previous CASIS customers pursuing a new opportunity</i>	0	4			4	10
<i>New customers: Projects awarded to principal investigators that have never flown</i>	3	4			7	20
<i>Customers who are new to CASIS but not to spaceflight R&D</i>	4	3			7	10
Total value of CASIS grants awarded	\$470,199	\$2,647,327			\$3,117,526	\$4,000,000
CASIS seed funding toward total project cost	22%	40.8%			33.2% ¹	20%
Flight projects manifested*	20	29			49	70
Flight projects delivered to the ISS National Lab*	12	9			21	72
Results published in scientific journals	4	1			5	As they occur
Products or services created	0	1			1	As they occur

* All National Lab Payloads. ¹ This is not an average of the quarterly percentages, but an average across the total number of projects, which varies from quarter to quarter.

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	\$1,350,000			\$3,150,000	\$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
Active STEM programs	12	12			12	15
Number of students, educators, and other participants engaged in STEM initiatives	29,717	35,200			64,917	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						
<i>Conferences and industry event sponsorships</i>	4	4			8	18
<i>Speaking opportunities</i>	33	17			50	95
<i>Subject matter expert workshops</i>	3	0			3	8
Total media impact						
<i>Thought leadership publications (white papers, trade articles, etc.)</i>	1	0			1	5
<i>News mentions (clips, blogs)</i>	410	484			894	5,000
<i>Twitter followers ^</i>	82,001	85,145			85,145	107,000
<i>Website visitors</i>	50,414	22,744			73,158	256,500
<i>YouTube views</i>	132,810	77,888			210,698	700,000
<i>Social media engagement (Facebook, Twitter, and Instagram)</i>	16,193	90,799			106,992	100,000

^ Cumulative

MAXIMIZING 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)	1373.3	310.11	356	485	125.82	136%
Inc 49/50 (Sept 2016-Mar 2017)	491.1	232	271	169.26	47.41	62%

Data through 3/11/2016

*Includes SpX-7 upmass/downmass

CONTRIBUTIONS TO SCIENTIFIC KNOWLEDGE – RESULTS PUBLISHED

<p>Title: The effect of spaceflight on the gravity-sensing auxin gradient of roots: GFP reporter gene microscopy on orbit</p> <p>Citation: Ferl RJ and Paul A-L (2016) <i>npj Microgravity</i> 2: 15023.</p>	<p>Description: This study sought to determine gravity's role in establishing the auxin-mediated gravity sensing system in primary plant roots. Drs. Ferl and Paul examined green fluorescent protein-reporter gene expression in the plant <i>Arabidopsis thaliana</i> and found that plants grown on the ISS exhibit the same pattern of auxin distribution in the root tip as plants on Earth. Thus, auxin distribution in root tips is not guided by gravity, as scientists had long assumed, and is instead an inherent developmental feature of root growth. The results presented in the paper are a compilation of imaging data from two experiments—the CASIS-funded CARA experiment (Characterizing Arabidopsis Root Attractions) flown to the ISS in 2014 and the NASA Space Biology-funded APEX03-2 experiment (Advanced Plant Experiments) flown to the ISS in 2015.</p> <p>Earth Benefit: An understanding of plant structure and behavior from spaceflight experiments allows researchers to better elucidate the inherent mechanisms involved in plant growth and development. Such knowledge can contribute to growing stronger crops on Earth as well as preparations to grow plants in space on long-term spaceflight missions.</p>
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COMMERCIAL IMPACT – PRODUCTS OR SERVICES CREATED

<p>Product: Remote Sensing Algorithm</p>	<p>Description: As part of an ISS National Lab project, Dr. Ruhul Amin of BioOptoSense, LLC, improved a custom algorithm associated with detection of harmful algal blooms (HABs), with the goal of early identification, quantification, and classification of such algae. While many space-based sensors are capable of monitoring HABs to some degree, various uncertainties (e.g., atmospheric correction and calibration) hamper effective bloom detection. Red band difference (RBD) methodology for HAB detection is one way to overcome some of these uncertainties, and CASIS sponsorship supported Amin in refining his custom RBD algorithm, allowing study of hourly HAB dynamics for the first time. In its current form, the algorithm is being used by downstream external customers including the University of Mississippi, the City College of New York, and the Naval Research Lab (in their Automated Processing System). <i>Of note, the Hyperspectral Imager of the Coastal Ocean (HICO, the ISS-based sensor originally proposed for use in this project) became dysfunctional during the study period for this project, so Dr. Amin used other space borne sensors to complete his CASIS-sponsored research. The resulting algorithm can now be used to analyze data from multiple space-based Earth observation sensors.</i></p> <p>Earth Benefit: HABs can be devastating for coastal tourism and fishery industries, and human exposure can be potentially fatal. This improved algorithm is an important application that may benefit the economies and public health in both domestic and international communities.</p>
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PROJECTS AWARDED IN Q2 FY16

<p>Title: Tropical Cyclone Intensity Measurements from the ISS (CyMISS) – Season 3</p> <p>Principal Investigator: Dr. Paul Joss</p> <p>Affiliation: Visidyne, Inc.</p> <p>Location: Burlington, MA</p>	<p>Description: This project seeks to improve intensity measurements, and subsequently, path predictions of strong tropical cyclones (also known as hurricanes or typhoons) through improved modeling using a measurement technique from the low Earth orbit vantage point of the ISS. Improving intensity measurements requires accurate measurements of the altitude of eyewall clouds (the clouds surrounding the eye of a storm). For tropical cyclones of interest, a camera is mounted on a selected Cupola window and programmed to capture high-resolution exposures of the storm. The resulting sequence of digitally processed images allows Visidyne to develop algorithms necessary to determine the altitude of the storm's eyewall clouds.</p> <p>Earth Benefit: On average, tropical cyclones cause around 19,000 deaths and \$26 billion in property damage worldwide each year, and account for 9 of the 10 costliest inflation-adjusted insurance natural disaster losses between 1970 and 2009. This project aims to provide accurate intensity information for strong tropical cyclones in order to predict, with high confidence, the landfall location and potential impacts much earlier than with existing technology, thus reducing the human and financial costs associated with tropical cyclones.</p>
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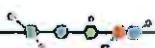
<p>Title: Comparative Real-Time Metabolic Activity Tracking for Improved Therapeutic Assessment Screening Panels</p> <p>Principal Investigator: Dr. Gary Saylor</p> <p>Affiliation: 490 BioTech, Inc.</p> <p>Location: Knoxville, TN</p>	<p>Description: 490 Biotech's reporter-gene system for substrate-free bioluminescent human cell lines is an enabling technology for evaluation of drug safety and effectiveness. Cellular response to drug samples is observable via visible data acquisition in both tissues and small animal models. The microgravity environment onboard ISS promotes superior 3-D cell growth conditions, enabling evaluations (using this cell line) that may better mimic the cellular response of human tissues. This investigation will specifically examine anti-cancer therapeutics with downstream applications to other drugs.</p> <p>Earth Benefit: The failure of new drug entities (i.e., upon reaching the preclinical or clinical trial testing phases) is greater than 50%. This represents an expensive burden for both consumers and companies. Economic models suggest that a mere 10% improvement in failure prediction rates prior to enacting clinical trials could save \$100 million in development costs per drug. This project looks to utilize a novel bioluminescent assay tool kit that may significantly reduce the failure rate of current drug discovery efforts. Additionally, if validated, the tool kit should have a high impact on the estimated \$12-billion market for this technology.</p>
<p>Title: Fiber Optics Manufacturing in Space (FOMS)</p> <p>Principal Investigator: Dr. Dmitry Starodubov</p> <p>Affiliation: FOMS, Inc.</p> <p>Location: San Diego, CA</p>	<p>Description: This project seeks to demonstrate the technical and commercial feasibility of in-orbit manufacturing of optical fibers for data transmission. Fluoride optical fibers have demonstrated a 10- to 100-fold signal loss reduction compared with traditional silica optical fibers, which could dramatically improve the cost and efficiency of communications systems and the internet. However, imperfections that occur during manufacturing on Earth prevent fluoride optical fibers from achieving this reduction in signal loss. Such imperfections appear to be reduced in microgravity, and this project will test ISS capabilities for in-orbit production of ZBLAN optical fibers, a type of fluoride optical fibers.</p> <p>Earth Benefit: FOMS has developed a fiber optic pulling facility capable of manufacturing high-quality ZBLAN optical fibers without imperfections, thereby improving communication system capabilities. Importantly, preliminary data suggest that in-orbit production of ZBLAN optical fibers is economically feasible and may present itself as the first in-orbit manufacturing application.</p>
<p>Title: Space Development Acceleration Capability (SDAC)</p> <p>Principal Investigator: Philip Bryden</p> <p>Affiliation: Craig Technologies</p> <p>Location: Cape Canaveral, FL</p>	<p>Description: This project aims to accelerate flight hardware development and test schedules utilizing additive manufacturing technologies and a Flight Test Platform (FTP) to support low Earth orbit and ISS missions and experiments. The FTP will integrate into the MISSE or NREP external platforms and provide new capabilities to support the evaluation of materials and subsystems all focused on additive manufacturing. This project aims to transition into a marketable capability that will increase the opportunity for multiple industries to develop, test, and fly hardware and experiments on the ISS or low Earth orbit spacecraft at reduced cost and schedule.</p> <p>Earth Benefit: There is growing demand for use of external platforms on the ISS for testing materials and subsystems. Craig Technologies plans to provide commercial customers with an end-to-end solution utilizing additive manufacturing technology in their ground facilities and providing access to the new FTP, which will improve the capabilities of testing additive manufactured products on external ISS platforms. Additive manufacturing and the capability in development by the Craig Technologies team is expected to greatly reduce the cost and timeframes of developing spaceflight hardware.</p>
<p>Title: Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes in the ISS National Laboratory</p> <p>Principal Investigator: Dr. Robert Schwartz</p> <p>Affiliation: University of Houston</p> <p>Location: Houston, TX</p>	<p>Description: This project seeks to evaluate a new approach, which has proven practical in ground-based simulated microgravity, to growing human tissue for transplant. This project will exploit microgravity onboard ISS to improve cell growth and development and 3-D tissue formation, enabling discoveries that will advance translational disease treatments. Specifically, this project will further refine tissue growth processes and identify the role of several cell proteins in growth, development, and disease (specifically, ischemic heart disease).</p> <p>Earth Benefit: Myocardial muscle cell death resulting from acute ischemic injury is the most prevalent adult heart disorder. In the U.S., heart failure results in 3.6 million hospitalizations and \$29 billion to \$56 billion in disbursements per year. This project aims to impact the patient population by developing methods for transplantation of exogenous stem cells, or mobilization of endogenous cardiac stem cells that may eventually be used to regenerate cardiomyocytes and repair damaged hearts.</p>
<p>Title: High Data Rate Polarization Modulated Laser Communication System</p> <p>Principal Investigator: Dr. Eric Wiswell</p> <p>Affiliation: Schafer Corporation</p> <p>Location: Huntsville, AL</p>	<p>Description: This project involves development of a laser communications system for transmitting very large data files—in the range of 10 Gbps to 40 Gbps—from space to the ground. Earth-sensing instruments produce large amounts of data that are currently constrained by the slow uplink and downlink rates of antiquated radio frequency technology, which severely limits space-based operations. Schafer's next-generation laser communications technology will help increase the uplink rate 10- to 200-fold and the downlink rate 1,000- to 20,000-fold, improving transmission of high-quality remote sensing data from satellite constellations back to the ground. This preflight development project will involve designing and producing of a form fit unit, including all external system interfaces, to support ground and airborne testing. Pending success of this ground demonstration, a future ISS flight project is planned.</p> <p>Earth Benefit: With many new companies pursuing large constellations of small satellites (smallsats and CubeSats weighing less than 50 kg) for Earth observation, communications, and space exploration, high-data-rate laser communications offer a technology breakthrough to maximize the utility of these systems. Recent forecasts indicate that 2,000 to 2,750 small satellites will be launched between 2014 and 2020—more than four times the number launched between 2000 and 2012. Additionally, the number of Earth observation satellites (non-meteorology) launched by civil government and commercial entities over the next eight years are projected to result in \$19.1 billion in manufacturing revenue. This preflight project proposed by Schafer Corporation represents the first step in drastically improving communication capabilities in the emerging space industry.</p>

<p>Title: Interrogating the Unfolded Protein Response in Microgravity-Induced Osteoporosis and Sarcopenia</p> <p>Principal Investigator: Dr. Imran N. Mungrue</p> <p>Affiliation: Louisiana State University Health Science Center</p> <p>Location: New Orleans, LA</p>	<p>Description: This study examines the role of the unfolded protein response (UPR) as an important contributor to osteoporosis and muscle atrophy. Untangling this cellular pathway's connection with musculoskeletal disease will provide important knowledge for developing targeted therapies. Previous experiments have shown UPR's increased activity in microgravity, making this phenomenon more accessible for investigation in a spaceflight rodent model. In addition to musculoskeletal diseases, over-activation of UPR has also been implicated in neurodegenerative disorders such as Alzheimer's, Parkinson's, and Huntington's diseases.</p> <p>Earth Benefit: Worldwide, osteoporosis causes more than 8.9 million fractures annually, resulting in an osteoporotic fracture every 3 seconds. Additionally, roughly 45% of the U.S. population is sarcopenic, and it is estimated that a 10% reduction in the sarcopenic population could save \$1.1 billion. Results from this proposal could lead to the discovery of novel drug targets for these common ailments, potentially reducing medical and economic burdens.</p>
<p>Title: Implantable Nanochannel System for the Controlled Delivery of Therapeutics for Muscle Atrophy</p> <p>Principal Investigator: Dr. Alessandro Grattoni</p> <p>Affiliation: Houston Methodist Research Institute</p> <p>Location: Houston, TX</p>	<p>Description: An implantable drug delivery system that circumvents the need for daily injections will be tested in a rodent model with microgravity-induced muscle atrophy. Specifically, the drug formoterol (an adrenalin substitute) will be administered by controlled release from a nanochannel implant to achieve a constant and reliable dosage. If successful, this system could serve as a universal technology for drug delivery and animal testing. In collaboration with Novartis and NanoMedical Systems, this validated system may rapidly translate into a commercial product.</p> <p>Earth Benefit: Sarcopenia, or muscle wasting, is a condition that affects more than 50% of the geriatric population, however therapeutics used to treat this condition are limited to physical activity or generic hormones. The most commonly used pharmaceutical intervention for sarcopenia is formoterol, but administering these drugs requires a daily injection, which can be inconvenient. This collaboration between The Houston Methodist Research Institute, Novartis, and NanoMedical Systems plans to develop an implantable device that will safely administer formoterol over a long period of time, without patients needing a daily injection, improving quality of life.</p>
<p>Title: DexMat CASIS CNT Cable Project</p> <p>Principal Investigator: Dr. Alberto Goenaga</p> <p>Affiliation: DexMat, Inc.</p> <p>Location: Houston, TX</p>	<p>Description: Carbon nanotube (CNT) technology allows for lighter weight cables that have electromagnetic interference (EMI) benefits over conventional metallic coaxial cables that use a tin-copper shielding braid. Research in low Earth orbit will accelerate the near-term insertion of CNT cables in satellite systems, with a long-term potential for a two-thirds weight savings for CNT coax cables and power harnesses. Exposing this experiment to the extreme conditions on the ISS will provide long-term performance data and showcase DexMat's ability to design and implement the technology on spacecraft. The successful completion of this in-orbit testing will raise the Technology Readiness Level of the products (a Department of Defense requirement for adoption of new technologies by the aerospace industry).</p> <p>Earth Benefit: Aerospace companies have a huge need to reduce the weight of their aircraft, as higher weight leads to increased fuel consumption. Currently, aerospace companies are willing to spend approximately \$10,000 on materials to shed 1 pound of weight on a spacecraft, and \$500 on materials to save 1 pound of weight on commercial aircraft. DexMat plans to commercialize CNT coatings as an alternative to metallic braids used to shield coaxial cables from EMI. Substituting metallic braiding with carbon nanotubes can help reduce the weight of a commercial Boeing 747 aircraft by 2,000 pounds, saving the company approximately \$6 million over the lifetime of the plane due to decreased weight and fuel consumption.</p>
<p>Title: Demonstration and Exploration of the Effects of Microgravity on Production of Fluoride-Based Optical Fibers for Science, Technology, Education and Commercialization on the International Space Station</p> <p>Principal Investigator: Michael Snyder</p> <p>Affiliation: Made In Space, Inc.</p> <p>Location: Moffett Field, CA</p>	<p>Description: High-performance optical fiber has been extensively used for efficient and compact ultraviolet, visible, and infrared fiber lasers due to its low intrinsic loss, wide transparency window, and small phonon energy. This technology enables advances in many different sectors, including medical devices such as laser scalpels and endoscopes, sensors for the aerospace and defense industry, and telecommunications applications. The optical fiber ZBLAN has the potential to far exceed the performance of other fibers in common use. Despite this, the terrestrially produced fiber suffers from glass impurities and microcrystal formation which contribute to scattering and absorption loss, reducing performance. Microgravity has been shown to significantly reduce these imperfections, and production of fibers in space may enable not only improved materials but also a new frontier in manufacturing and space utilization.</p> <p>Earth Benefit: ZBLAN optical fibers have been shown to perform 10 to 100 times better in signal transduction compared traditional silica optic fibers due to low loss attenuation; however, ZBLAN is not used in applications such as telecommunications and medical devices because the manufacturing process results in many imperfections. Researchers have previously demonstrated microgravity as effective at eliminating imperfections in ZBLAN fibers, and Made In Space plans to develop and send their optical fiber production facility to the ISS to produce ZBLAN fibers in space.</p>
<p>Title: Tomatosphere™</p> <p>Principal Investigator: Ann Jorss</p> <p>Affiliation: First the Seed Foundation</p> <p>Location: Alexandria, VA</p>	<p>Description: Tomatosphere™ is an educational program started in 1999 in which students investigate how the space environment affects tomato plant growth. Each participating class is sent two packages of tomato seeds—one package of seeds that has been sent into space and one package of control seeds that have not been in space. Students and teachers compare the germination rates of the two groups of seeds, not knowing which seeds went to space and which are the control seeds. This project will provide transportation of 1.2 million seeds to and from the ISS (the seeds will remain in orbit between 10 and 60 days). The project will also include monitoring and data tracking (temperature, humidity, and pressure) for both the seeds sent to the ISS and the control seeds.</p> <p>Earth Benefit: Tomatosphere™ is a hands-on student research experience with a standards-based curriculum guide that provides students the opportunity to investigate, create, test, and evaluate a solution for a real world case study. It is particularly valuable in urban school settings where students have little connection to agriculture. The Tomatosphere™ program has grown from 2,700 classes in 2001 to more than 19,000 classes in 2015. In its 15-year existence, the program has reached approximately 3.3 million students, mostly in Canada. However, 3,838 of the classes that participate in the Tomatosphere™ program (20.2%) are from schools in the United States.</p>

Q2 FY16 PROJECT PIPELINE

GROUND PROJECTS

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	STATUS UPDATE
Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight	Dr. Clifford Dacso	Baylor College of Medicine	(b) (4)
Commercial space-borne hyperspectral harmful algal bloom (HAB) products	Dr. Ruhul Amin	BioOptoSense, LLC	(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)
Architecture to Transfer Remote Sensing Algorithms from Research to Operations	Dr. James Goodman	HySpeed Computing, LLC	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.
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 and recreational water sources. (b) (4) (b) (4)



PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	STATUS UPDATE
Hyperspectral Mapping of Iron-bearing Minerals	Dr. William H. Farrand	Space Science Institute	(b) (4)
Examine Bone Tumor and Host Tissue Interactions Using Micro-Gravity 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)
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. The PI requested archived HICO imagery and examined the quality of images from 2012 to 2014 around the Lethbridge grassland site, comparing it with ground measurements. (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 and recreational water sources (b) (4) (b) (4)

IN PREFLIGHT DEVELOPMENT

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	ESTIMATED LAUNCH DATE
Demonstration and TRL Raising of the Net Capture System on the ISS	Ron Dunklee	AIRBUS DS Space Systems, Inc.	SpX-8	4/8/16
Eli Lilly PCG	Kristofer R. Gonzalez-DeWhitt and Michael Hickey	Eli Lilly and Company	SpX-8	4/8/16
Eli Lilly-RR3 Myostatin	Dr. Rosamund Smith	Eli Lilly and Company	SpX-8	4/8/16
Genes In Space	Anna-Sophia Boguraev	The Boeing Company (sponsor)	SpX-8	4/8/16
HUNCH Chlorella/Billings Central Catholic High	Dr. Florence Gold	Rocky Mountain College	SpX-8	4/8/16
Mutualistic Plant/Microbe Interactions	Dr. Gary W. Stutte	SyNRGE, LLC	SpX-8	4/8/16

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	ESTIMATED LAUNCH DATE
Decoupling Diffusive Transport Phenomena in Microgravity	Dr. Alessandro Grattoni	The Methodist Hospital Research Institute	SpX-8	4/8/16
SSEP-Odyssey	Dr. Jeff Goldstein	NCESE/Tides Center	SpX-8	4/8/16
Validation of WetLab-2 System for qRT-PCR capability on ISS	Julie Schonfeld	NASA ARC	SpX-8	4/8/16
Controlled Dynamics Locker for Microgravity Experiments on ISS	Dr. Scott A. Green	Controlled Dynamics, Inc.	OA-5	6/24/16
Corrosion Inhibitor Exposed to the Extreme Environments in Space	Lauren Thompson Miller	A-76 Technologies, LLC	OA-5	6/24/16
Development and Deployment of Charge Injection Device Imagers	Dr. Daniel Batchelder	Florida Institute of Technology	OA-5	6/24/16
Honeywell/Morehead-DM Payload Processor	Dr. Benjamin Malphrus	Honeywell/Morehead State University	OA-5	6/24/16
Story Time from Space - 2	Patricia Tribe	T2 Science and Math Education Consultants	OA-5	6/24/16
Effects of Microgravity on Stem Cell-Derived Heart Cells	Dr. Joseph Wu	Stanford University	SpX-9	7/5/16
Eli Lilly – Dissolution of Hard to Wet Solids	Dr. Richard Cope, Dr. Alison Campbell, and Dr. Kenneth Savin	Eli Lilly and Company	SpX-9	7/5/16
GLASS AIS Transponder Global AIS on Space Station (GLASS)	Robert Carlson	JAMSS America, Inc.	SpX-9	7/5/16
Materials Testing – Earth Abundant Textured Thin Film Photovoltaics	Dr. Jud Ready	Georgia Institute of Technology	SpX-9	7/5/16
Materials Testing: The Evaluation of Gumstix Modules in Low Earth Orbit	Dr. Kathleen Morse	Yosemite Space	SpX-9	7/5/16
Molecules Produced in Microgravity from the Chernobyl Nuclear Accident	Dr. Kasthuri Venkateswaran	Jet Propulsion Laboratory/ Caltech	SpX-9	7/5/16
MultiLab: Research Server for the ISS	Twyman Clements	Space Tango, Inc.	SpX-9	7/5/16
NIH-Osteo	Bruce Hammer	University of Minnesota	SpX-9	7/5/16
The Behavior of Slime Molds (Physarum) in Microgravity – NDC Pilot Reflight	Rev. Brian Reedy	Cristo Rey Jesuit College Preparatory of Houston	SpX-9	7/5/16
Use of Boron-Enhanced High-Density Polyethylene for Radiation Shielding – NDC Pilot Reflight	Angela Glidewell	Awty International School	SpX-9	7/5/16
Carbon Dioxide Emissions of Yeast Cells in Microgravity Environment – NDC Pilot Reflight	Jessika Smith	Awty International School	SpX-9	7/5/16
The Effects of Microgravity and Light Wavelength on Plant Growth – NDC Pilot Reflight	Kathy Duquesnay	Duchesne Academy	SpX-9	7/5/16
The Effects of Different Wavelengths of Light on Algae Oxygen Production in Microgravity – NDC Pilot Reflight	Susan Knizner	Duchesne Academy	SpX-9	7/5/16
Application of Microgravity Expanded Stem Cells in Regenerative Medicine	Dr. Abba Zubair	Mayo Clinic	SpX-10	12/1/16
Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples	Dr. Edward Snell	Hauptman Woodward Medical Research Institute, Inc.	SpX-10	12/1/16
The Effect of Macromolecular Transport on Microgravity PCG	Dr. Lawrence DeLucas	University of Alabama at Birmingham	SpX-10	12/1/16
Crystal Growth of Cs ₂ LiYCl ₆ :Ce Scintillators in Microgravity	Dr. Alexei Churilov	Radiation Monitoring Devices, Inc.	OA-7	12/30/16
Detached Melt and Vapor Growth of InI in SUBSA Hardware	Dr. Aleksandar Ostrogorsky	Illinois Institute of Technology	OA-7	12/30/16
Intuitive Machines-ISS Terrestrial Return Vehicle (TRV)	Steve Altmanus	Intuitive Machines	OA-7	12/30/16
SG100 Cloud Computing Payload	Trent Martin	Business Integra	OA-7	12/30/16
Functional Effects of Spaceflight on Cardiovascular Stem Cells	Dr. Mary Kearns-Jonker	Loma Linda University	SpX-11	3/13/17

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	LAUNCH VEHICLE	ESTIMATED LAUNCH DATE
Magnetic 3D Cell Culture for Biological Research in Microgravity	Dr. Glauco Souza	Nano3D Biosciences, Inc.	SpX-11	3/13/17
MUSES Imaging Platform	Bill Corley	Teledyne Brown Engineering	SpX-11	3/13/17
NDC-3: Chicagoland Boy Scouts and Explorers	Christie Capelety	Boy Scouts of America	SpX-11	3/13/17
NDC-3: Chicagoland Boy Scouts and Explorers	Dr. Sandra Rogers	Boy Scouts of America	SpX-11	3/13/17
NDC-3: Chicagoland Boy Scouts and Explorers	Norman McFarland	Boy Scouts of America	SpX-11	3/13/17
Characterizing Arabidopsis Root Attractions (CARA) Grant Extension Request	Dr. Anna-Lisa Paul	University of Florida Board of Trustees	SpX-12	7/1/17
Electrolytic Gas Evolution Under Microgravity	Larry Alberts	Cam Med LLC	SpX-12	7/1/17
Systemic Therapy of NELL-1 for Osteoporosis (RR-5)	Dr. Chia Soo	UCLA	SpX-12	7/1/17
Nanobiosym- Galactic Grant	Dr. Anita Goel	Nanobiosym	SpX-13	8/6/17
SPHERES Zero Robotics High School	Dr. Alvar Saenz Otero	Massachusetts Institute of Technology	yearly	
SPHERES Zero Robotics Middle School	Dr. Alvar Saenz Otero	Massachusetts Institute of Technology	yearly	
Capillary-Driven Microfluidics in Space	Dr. Luc Gervais	1Drop Diagnostics US Inc.	TBD	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	TBD
Efficacy & Metabolism of Azonafide Antibody-Drug Conjugates (ADCs)	Sourav Sinha	Oncolinx Pharmaceuticals, LLC	TBD	TBD
Eli Lilly – Lyophilization	Jeremy Hinds	Eli Lilly and Company	TBD	TBD
Faraday Waves and Instability-Earth and Low G Experiments	Dr. Ranga Narayanan	University of Florida Board of Trustees	TBD	TBD
Implantable Glucose Biosensors	Dr. Michail Kastellorizios	Biorasis, Inc.	TBD	TBD
Intracellular Macromolecule Delivery and Cellular Biomechanics in Microgravity	Harrison Bralower	SQZ Biotechnologies	TBD	TBD
Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System	Dr. Robert Applegate	Novopyxis	TBD	TBD
Milliken: Vertical Burn	Dr. Jeff Strahan	Milliken	TBD	TBD
Nemak Alloy Solidification Experiments	Dr. Glenn Byczynski	Nemak	TBD	TBD
Providing Spherical Video Tours of ISS	David Gump	Deep Space Industries	TBD	TBD
SIC Microgravity Enhanced Electrical Performance (MEEP)	Rich Glover	ACME Advanced Materials	TBD	TBD
Space Based Optical Tracker	Dr. John Stryjewski	Vision Engineering Solutions	TBD	TBD
Survivability of Variable Emissivity Devices for Thermal Control Applications	Dr. Hulya Demiryont	Eclipse Energy Systems, Inc.	TBD	TBD
Effect of Microgravity on Stem Cell Mediated Recellularization	Jason Sakamoto	The Methodist Hospital Research Institute	TBD	TBD
The Universal Manufacture of Next Generation Electronics	Dr. Supriya Jaiswal	Astrileux Corporation	TBD	TBD
Tomatosphere™	Ann Jorss	First the Seed Foundation	TBD	TBD
Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment	Dan O'Connell	HNu Photonics	TBD	TBD
Zaiput Flow Technologies – Galactic Grant	Dr. Andrea Adamo	Zaiput Flow Technologies	TBD	TBD
NDC-2 (Denver) – Potential Reflight	Joel Bertelsen	Chatfield Senior High School	TBD	TBD
NDC-2 (Denver) – Potential Reflight	Shanna Atzmilller	Bell Middle School	TBD	TBD
NDC-2 (Denver) – Potential Reflight	Brian Thomas	Centaurus High School	TBD	TBD
Cellular Formation and Self-Assembly in Lipids – NDC Pilot Potential Reflight	Greg Adragna	Cristo Rey Jesuit College Preparatory of Houston	TBD	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-8	5/11/2016	(b) (4)
Additive Manufacturing Facility	Michael Snyder	Made In Space, Inc.	N/A	N/A	Recently delivered.
Project Meteor	Michael Fortenberry	Southwest Research Institute	N/A	N/A	Recently delivered.
Zero-G Characterization & OnOrbit Assembly for Cellularized Satellite Tech	Talbot Jaeger	NovaWurks, Inc.	N/A	N/A	The payload has been delivered to the ISS and is currently waiting on a deployment opportunity through the JEM airlock.
Space Automated Bioproduct Lab	Dr. Louis Stodieck	BioServe Space Technologies	N/A	N/A	Both SABL units have been installed and checked out. They are ready to accommodate future investigations.
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 onboard the ISS. Dr. Ting's team continues to analyze data.
National Lab Project: 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, and results of the flight project. A FY15 publication in Frontiers in Ecology and Evolution resulted from this project.
Osteocyte response to mechanical forces	Dr. Paola Divieti Pajevic	Boston University	
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)

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	STATUS UPDATE
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)
Binary Colloidal Alloy Test - Low Gravity Phase Kinetics Platform	Dr. Matthew Lynch	Procter & Gamble, with Zin Technologies, Inc.	(b) (4)
PCG - Crystallization of Human Membrane Proteins in Microgravity	Dr. Stephen Aller	University of Alabama at Birmingham	(b) (4)
Antibiotic Effectiveness in Space-1 (AES-1)	Dr. David Klaus	University of Colorado Boulder	(b) (4)
Molecular Biology of Plant Development (Petri Plants)	Dr. Anna-Lisa Paul	University of Florida Board of Trustees	(b) (4)
Protein Crystal Growth for Determination of Enzyme Mechanisms	Dr. Constance Schall	University of Toledo	(b) (4)

PROJECT	PRINCIPAL INVESTIGATOR	AFFILIATION	STATUS UPDATE
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 (CyMISS)	Dr. Paul Joss	Visidyne, Inc.	(b) (4)

CONFERENCES AND EVENTS IN Q2 FY16

CONFERENCE AND INDUSTRY EVENT SPONSORSHIPS

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
Astronomy Days	Raleigh, NC	1/29/16-1/31/16	General public as well as local astronomers, North Carolina University professors in space science, and NASA astronauts and representatives	CASIS supported Astronomy Days, a conference and meeting focused on space and space-based science hosted by the North Carolina Museum of Natural Science. The event attracted nearly 16,000 attendees and provided CASIS with a general outreach and STEM education outreach opportunity within a potentially strategic ecosystem.
AAAS Annual Meeting and Family Science Days	Washington, DC	2/11/16-2/14/16	Scientists, engineers, educators, policymakers, and K-12 children and families	CASIS exhibited at the AAAS Annual Meeting, which brings together an interdisciplinary and inclusive community to discuss recent developments in science, and the AAAS Family Science Days that is open to the general public. Visitors to the booths—ranging from scientists, engineers, educators, policymakers, and K-12 children and families—learned about the ISS and research in space through hands-on demonstrations, videos, talks by scientists, and other activities.
White House Day at the Lab	Washington, DC	2/29/16	Area students and educators, congressional staff and White House personnel	CASIS showcased Zero Robotics SPHERES and the ISS virtual tour at the National Week at the Labs kick-off event at the White House. The event hosted hundreds of students from the DC/Baltimore area at the White House, where they learned about STEM initiatives and the exciting work happening in federal science labs.
Frontiers in Structural Biology of Membrane Protein & Pittsburgh Diffraction Conference	Huntsville, AL	3/10/16-3/12/16	Researchers, commercial members, and other governmental agencies	As a presenter and exhibitor, CASIS showcased its mission and interest in membrane protein, crystallography, and PCG microgravity research. It was also an opportunity to connect with researchers, commercial members, and other governmental agencies regarding potential space flight opportunities with CASIS.

ADDITIONAL CONFERENCE AND EVENT PARTICIPATION

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
AIAA SciTech	San Diego, CA	1/5/16-1/6/16	Corporate, academic, and government institutions, students and educators	CASIS President and Executive Director Greg Johnson was a moderator and speaker for a panel at the AIAA Science and Technology Forum and Exposition. He was joined with representatives from NASA, Made In Space, and NanoRacks in discussing the topic of "Innovation in Space: How Researchers Can Leverage the ISS National Laboratory for Pioneering Research & Development."
ISS-NL CASIS Research/Technology Portfolio Seminar	Washington, DC	1/15/16	NASA officials and employees	A broad audience of NASA headquarters employees attended a talk by CASIS Deputy Chief Scientist Michael Roberts, Ph.D. He discussed the CASIS mission to enable academic, commercial, and private institutions, as well as other U.S. government agencies, to access the ISS U.S. National Lab for visionary research and development. NASA Administrator Charlie Bolden and NASA Deputy Administrator Dava Newman attended.
Space Advocate Round Table Presentation	Washington, DC	1/15/16	U.S. House of Representatives Space Advocates group	CASIS Deputy Chief Scientist Michael Roberts, Ph.D., addressed a closed session of the U.S. House of Representatives Space Advocates group to increase awareness of the ISS U.S. National Lab.
Skype with Pasco Middle School	Dade City, FL	1/18/16	Students and educators	CASIS President and Executive Director Greg Johnson held a Skype session with 800 middle school students in the Pasco Middle Cambridge Program at Pasco Middle School.
CONNECT – Innovation Crossroads	San Diego, CA	1/21/16	Technology and life sciences companies and academic institutions	CASIS President and Executive Director Greg Johnson served as a panelist in the Innovation Crossroads series co-presented by CONNECT and the University of California San Diego Extension. The event aired on uctv.tv and has been viewed 10,082 times. Innovation Crossroads explores the importance of the defense and aerospace industries to the region's innovation economy.
Space Walk of Fame Astronaut Dinner	Melbourne, FL	1/21/16	Space industry and nonprofit organizations	CASIS participated with space industry and non-profit organizations at this STEM fundraising event for the Space Walk of Fame Museum.
Zero Robotics High School Finals	Boston, MA	1/25/16	Students and educators	CASIS sponsors this annual competition, in which finalists must program an experimental SPHERES robot to complete a series of tasks on the ISS. This year, the challenge was to simulate imaging a virtual asteroid. Each finalist alliance was composed of teams mostly from the U.S. and European Space Agency member states. The championship prize went to the alliance called LakeElevenVadars.
ARISS Web Chat	Flagstaff, AZ	1/26/16	Students and educators	CASIS STEM Ambassador Kaci Heins hosted a web chat with 22 students, providing education on ISS research and amateur radio.
CASIS Academy Live	Kennedy Space Center, Titusville, FL	1/29/16	Students and educators	CASIS hosted an interactive learning event at Kennedy Space Center for 45 students in grades 6-10 and teachers from Odyssey Charter School. Space station researcher Dr. Lenore Rasmussen gave a presentation on her current science investigation, which was livestreamed through NASA's Digital Learning Network reaching an additional 500 students and educators. Students had an opportunity to learn about current space research and get hands-on with the interactive educational tools at Kennedy Space Center.
Clinton Global Initiative Winter Meeting	New York, NY	2/4/16	Companies, non-governmental organizations, foundations, and Government agencies	The CASIS team met with the senior leadership of the Clinton Global Initiative (CGI), to present the CASIS mission and discuss potential opportunities for CGI commercial members. CGI's meetings have brought together 190 sitting and former heads of state, more than 20 Nobel Prize laureates, and hundreds of leading CEOs, heads of foundations and NGOs, major philanthropists, and members of the media. Meeting participants analyze pressing global challenges, discuss the most effective solutions, and build lasting partnerships that enable them to create positive social change.
Space Explorers Educators Conference	Houston, TX	2/5/16	Students and educators	CASIS STEM Ambassador Kaci Heins spoke to 28 middle school educators about STEM programs from CASIS and ISS research.
2016 NASA Human Research Program Investigators' Workshop	Galveston, TX	2/8/16-2/11/16	Researchers and NASA officials	CASIS Deputy Chief Scientist Michael Roberts, Ph.D., participated in this workshop that featured presentations by PIs aligned with the NASA Human Research Program elements: Behavioral Health & Performance, Exploration Medical Capability, Human Health Countermeasures, Space Human Factors & Habitability, and Space Radiation.

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
IGEW 2016	Melbourne, FL	2/20/16	Students and educators	CASIS sponsored and participated in this engineering-focused event for girls in grades 3-6. Attendees learned about different engineering careers by talking with women practicing in the field and also engaged in hands-on experiments, mini-seminars, and learning modules.
CASIS STEM Education Partner Workshop	Cocoa Beach, FL	2/25/16-2/26/16	Education partners	CASIS met with current and prospective education partners to collaborate on the future of the CASIS STEM strategy. The two-day session included activities, discussion, brainstorming, and a NASA tour to connect and inspire innovative new ideas for transforming STEM education into more of a hands-on curriculum for all children regardless of culture or socioeconomic factors.
Science in Space Workshop with Sanford Burnham Prebys Medical Discovery Institute	Orlando, FL	3/1/16	Researchers, scientists, and members of academia	CASIS partnered with Sanford Burnham Prebys Medical Discovery Institute in conducting this workshop attended by more than 60 researchers, scientists, and members of academia. Through presentations on areas of research, funding opportunities, case histories, and one-on-one discussions, attendees learned how access to the ISS National Lab can accelerate their research.
Concord Library Presentation	Concord, MA	3/1/16	General public	CASIS simulated a visit to the ISS in a presentation to spark excitement about space and Earth observation.
Industry Visit	Minneapolis, MN	3/1/16-3/2/16	Senior leaders in product and design development as well as research and development	The CASIS team met with 125 senior leaders from the areas of product and design development as well as research and development during this Industry Visit. Together, attendees identified multiple flight opportunities, materials and physical sciences projects, innovation challenge collaborations, and STEM education programs.
IRI Spring Networks	Louisville, KY	3/7/16-3/9/16	R&D management community representing more than half of all R&D spending in the U.S.	A CASIS representative participated in Innovation Leadership Network and External Technology Network sessions to learn how current industry leaders develop R&D and innovation portfolios.
Regenerative Medicine Workshop	Hilton Head Island, SC	3/16/16-3/19/16	Academic, industry and governmental research communities interested in organ-on-chip technologies	The CASIS team participated in this workshop to build on relationships with research communities supported by the NIH, the Defense Advanced Research Projects Agency, and other government agencies for tissue engineering and microfabrication R&D focused on the translation of organ-on-chip technologies. Deputy Chief Scientist Michael Robert, Ph.D., gave a presentation called "Advancing Regenerative Medicine using the International Space Station U.S. National Lab" and distributed copies of the CASIS ISS National Lab Good Health workshop report, "Organ Bioengineering Research in Microgravity."
CASIS Academy Live	Kennedy Space Center, Titusville, FL	3/18/16	Students and educators	CASIS hosted an interactive learning event at Kennedy Space Center for 40 students, teachers, and guests from Melbourne High School. Current space station researcher, Dr. Joe Ng discussed his protein crystallization research on the ISS, which was streamed to classrooms across the country via NASA's Digital Learning Network. Attendees also interacted with the ISS Virtual Tour, which provides a detailed look at the structure of the ISS, and learned about living and working in space through the educational tools and the education specialists at Kennedy Space Center.
Boston Camera Club	Boston, MA	3/29/16	Earth photographers	A CASIS representative spoke to a group of Boston Camera Club members interested in Earth photography. The presentation described what it is like to live in space and photograph Earth from space.
Industry Visit	Albany, NY	3/29/16	Leadership of a global commercial research center	The CASIS team presented its mission and the ISS U.S. National Lab capabilities to top leadership of a global commercial research center. The attending executives represented the areas of biology, aviation, and the Internet of Things, and brainstormed with CASIS on potential areas of opportunity.
National Academies Research In Commercial LEO	Washington, DC	3/30/16	Members of the National Academies Committee on Biological and Physical Sciences in Space	As part of the annual Space Sciences Week, CASIS Deputy Chief Scientist Michael Roberts, Ph.D., presented "Perspectives on LEO Ecosystems" to members of the National Academies Committee on Biological and Physical Sciences in Space. The committee, composed of top-level experts from the scientific and policy community, provides policy direction to federal agencies including NASA and NIH.
NASA Advisory Council (NAC) Public Meeting	Washington, DC	3/31/16	Members of the NAC, guest attendees, and online participant	The NAC requested a presentation on the role of CASIS in managing the ISS National Lab and the demand for access to low Earth orbit. The meeting included presentations by NASA Administrator Charles Bolden, NASA Associate Administrator for HEOMD William Gerstenmaier, NASA Deputy Associate Administrator for STMD James Reuter, and NASA Chief Financial Officer David Radzanowski prior to the presentation on CASIS and LEO given by NASA Deputy Chief Scientist Gale Allen, Ph.D., CASIS President and Executive Director Gregory Johnson, and CASIS Deputy Chief Scientist Michael Roberts, Ph.D.

EVENT	LOCATION	DATE	AUDIENCE	DESCRIPTION
NSTA National Conference	Nashville, TN	3/31/16-4/3/16	Educators	CASIS presented at the National Science Teachers Association National Conference and unveiled the Space Station Explorers program.
Mass Bio—Exo Medicine Panel	Boston, MA	3/31/16-4/1/16	Clinicians, surgeons, veterinarians, scientists, and engineers	Deputy Chief Scientist Michael Roberts, Ph.D., participated in a panel discussion for a scientific workshop titled "3-D Human Tissue Models to Study Musculoskeletal Physiology and Pathophysiology" with Dr. Farshid Guilak, Duke University Medical Center; Dr. Rocky S. Tuan, University of Pittsburgh School of Medicine; Dr. Kevin E. Healy, University of California Berkeley; and Dr. Fei Wang, National Institute of Arthritis and Musculoskeletal and Skin Diseases at the National Institutes of Health. The workshop attracted more than 300 participants, including clinicians, surgeons, veterinarians, scientists, and engineers.

FINANCIALS

BUSINESS STATUS REPORT (UNAUDITED)

JAN 1-MAR 31, 2016	ACTUAL Q2 2016	BUDGET Q2 2016	VARIANCE	ACTUAL YTD 2016	BUDGET YTD 2016	VARIANCE
Direct Labor	\$1,358,364	\$1,620,451	\$262,087	\$2,636,706	\$3,103,703	\$466,997 ^(a)
Subcontracts	246,285	708,985	462,700	681,939	1,334,720	652,781 ^(b)
Permanent Equipment	16,899	44,000	27,101	29,551	60,700	31,149
Office Supplies & Equipment	42,167	76,435	34,268	99,530	141,198	41,668
Travel	187,628	282,272	94,644	417,695	525,403	107,708 ^(c)
Grants	1,001,886	1,927,421	925,535	2,800,182	4,066,842	1,266,660 ^(d)
Other Direct Expenses	408,605	457,458	48,853	693,049	972,231	279,182 ^(e)
Total	\$3,261,834	\$5,117,022	\$1,855,188	\$7,358,652	\$10,204,797	\$2,846,145

a) Budgeted headcount was 42; actual was 37.

b) Subcontracts were lower in two areas:

- Campaign Good Earth budgeted consultants have shifted to later in the year.
- Budgeted amounts for legal, STEM, and development have shifted to later in the year.

(c) Travel costs in Q2 were lower than budgeted.

(d) Grant recipient milestones payments have shifted to later in the year due to launch delays.

(e) For advertising, timing of payments for conference sponsorships budgeted during Q1 have shifted to later in the year.

BREAKOUT OF COOPERATIVE AGREEMENT FUNDING

	Q1 FY16	Q2 FY16	Q3 FY16	Q4 FY16
Direct	43%	54%		
Indirect	13%	15%		
Grants	44%	31%		

BREAKOUT OF CASIS GRANTS

	Q1 FY16	Q2 FY16	Q3 FY16	Q4 FY16
Private/Commercial	\$1,258,897	\$595,288		
Academic	\$477,861	\$312,572		
Mission Based Costs	\$61,538	\$94,026		