



FY18 Q3 REPORT

Quarterly Report for the Period April 1 – June 30, 2018

CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE (CASIS)





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EXECUTIVE SUMMARY

The third quarter of fiscal year 2018 (Q3FY18) was the most active quarter of the year with respect to launched and awarded projects. Three commercial resupply services missions carried 45 payloads to the International Space Station (ISS) U.S. National Laboratory, many containing multiple projects. Project objectives range from sustainability and bioproduction to drug development and student engagement. More than 70% of these payloads represent commercial use of the ISS. Additionally, CASIS formalized more than 20 new awarded projects, programs, and partnerships in Q3 from organizations across 12 states—two thirds of which represent commercial space-based research and development (R&D) activities from new and returning ISS National Lab users.

Among the launched payloads to the ISS National Lab this quarter were two new commercially operated facilities: the Multi-use Variable-gravity Platform (MVP), operated by Techshot, Inc. for support of experiments requiring fractional gravity control in orbit, and the Materials ISS Experiment Flight Facility (MISSE-FF), operated by Alpha Space Test and Research Alliance for space environment testing and exposure. In-orbit commercial facility managers provide users with operational experience and engineering expertise to address unique research needs and serve as pathfinders for economic development in low Earth orbit. The ISS National Lab now houses 14 of these commercially operated facilities managed by eight companies. Additionally, dozens of innovative commercial service providers also support the growing demand for space-based research. To support these providers, CASIS released a web portal for ISS National Lab partners in April, providing information about future and current opportunities.

Existing ISS National Lab projects also continue to progress and succeed, with three academic journal articles and one patent application published in Q3 based on CASIS-sponsored investigations. Two of the three publications relate to a rodent research investigation in collaboration with the U.S. Department of Defense (focused on wound healing), and the third details results from spaceflight studies to improve a nanofluidics system that has applications in next-generation fuel cells, batteries, filtration systems, and precision drug delivery. The patent application was published in relation to manufacturing hardware for ZBLAN production on the ISS by Fiber Optics Manufacturing in Space (FOMS). The optical fiber ZBLAN may exceed the performance of other fibers in common use across many sectors—including medical devices, sensors for the aerospace and defense industry, and telecommunications—and the patent describes operational methods that may appear in future commercial microgravity ZBLAN production systems.

In June, Apple (number four on Fortune's 500 List for 2018) previewed new aerial images of Earth in a Keynote during their Worldwide Developers Conference, one of Apple's marquee events—specifically acknowledging CASIS support during this reveal. The images were taken by astronauts on the ISS in cooperation with CASIS and will be available to Apple users in the fall of 2018.

Also in June, CASIS participated in a hearing for the Senate Subcommittee on Space, Science, and Competitiveness titled "Examining the Future of the International Space Station: Stakeholder Perspectives." At this second in a series of hearings to examine the role of the space station, ISS stakeholders discussed the value of the ISS to the U.S. national space program and the future of human space exploration. CASIS Director of Commercial Innovation Cynthia Bouthot shared CASIS data on commercial demand for space-based R&D and highlighted examples of commercial results that are returning value back to the U.S. taxpayer.

Also to highlight impactful results, CASIS presented four "Pioneer Awards" at this year's BIO International event to companies that have utilized spaceflight R&D in a series of groundbreaking pharmaceutical experiments. Awardees included Eli Lilly and Company, Merck & Co., Novartis, and Amgen. These and many other companies are returning critical value back to the nation through their cutting-edge research in space.

Finally, CASIS announced the appointment of new President and Executive Director Dr. Joseph Vockley in Q3. Over the past 30 years, Dr. Vockley built and led multi-disciplined scientific and bioinformatic research teams in the public and biotechnology sectors and in the healthcare and pharmaceutical industries. Within his new role at CASIS, Dr. Vockley will be responsible for driving the CASIS mission, enabling space-based science and technology opportunities that benefit life on Earth while maximizing U.S. taxpayer investment in the ISS National Lab. CASIS thanks Interim Executive Director Lt. General James A. Abrahamson (Ret.) for his skilled guidance during the leadership transition.



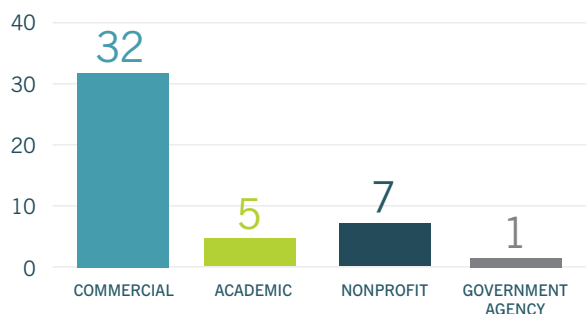
RECENT ACTIVITIES WITHIN THE ISS NATIONAL LAB R&D PORTFOLIO

MAXIMIZING UTILIZATION AND DEMONSTRATING MEASURABLE IMPACT

As manager of the International Space Station (ISS) U.S. National Laboratory, CASIS seeks to maximize both utilization of in-orbit resources and downstream value to life on Earth. To support these efforts, CASIS developed a methodology to assess the value creation of the projects in its portfolio. Working with external subject matter experts in an annual meeting, CASIS estimated (as of year-end FY17) the future value of the ISS National Lab portfolio will exceed \$900 million in incremental revenue from addressable markets totaling more than \$110 billion. Additional parameters indicating positive value to the nation include a time-to-market acceleration of 1–3 years and the development of more than 20 new solution pathways (a measure of innovation that can lead to a major advance in knowledge or new intellectual property). These data are updated annually but included in each quarterly report.

Operational Update

FIGURE 1: PAYLOADS LAUNCHED IN Q3 – BY PRINCIPAL INVESTIGATOR AFFILIATION



Two SpaceX and one Orbital ATK commercial resupply services (CRS) missions launched to the ISS in Q3, delivering science research and crew supplies to the ISS. Example ISS National Lab payloads onboard these vehicles are highlighted below.

**FIGURE 2: SELECTED HIGHLIGHTS FROM LAUNCHED PAYLOADS
ONBOARD SPACEX CRS-14 (APRIL 4, 2018)**

PROJECT INFORMATION	DESCRIPTION AND POTENTIAL IMPACT
Crystal Growth STEM 2017 Ilia Guzei, University of Wisconsin - Madison (Madison, WI) <i>Payload Developer: CASIS</i>	<i>Improving Science, Technology, Engineering, and Mathematics (STEM) Literacy</i> This project provides an opportunity for the winning team of students from the 2017 Wisconsin Crystal Growing Competition to grow their crystals onboard the ISS National Lab to test their optimized conditions for Earth-based crystallization against microgravity-based crystallization. Through this education project, students learn about crystallization techniques and the importance of microgravity when conducting crystal growth studies.
Comparative Real-time Metabolic Activity Tracking Dr. Gary Saylor, 490 Biotech, Inc. (Knoxville, TN) <i>Payload Developer: BioServe Space Technologies</i>	<i>Greater Success for Drug Discovery and Development</i> This investigation will specifically examine anti-cancer therapeutics using 490 Biotech's reporter-gene system for substrate-free bioluminescent human cell lines. The failure of new drug entities upon reaching the preclinical or clinical trial testing phases is greater than 50%, representing an expensive burden for both consumers and companies. Microgravity promotes superior 3D cell-growth conditions, enabling evaluations (using this cell line) that may better mimic the cellular response of human tissues. This project may thus significantly reduce the failure rate of current drug discovery efforts, and if validated, may have a high impact on the estimated \$12 billion market for this technology.



PROJECT INFORMATION

DESCRIPTION AND POTENTIAL IMPACT

**Neutron Crystallographic Studies
of Human Acetylcholinesterase**

Dr. Andrey Kovalevsky,
UT-Battelle / Oak Ridge National Lab
(Oak Ridge, TN)

Payload Developer: CASIS

Antidotes for Pesticide Exposure and Chemical Warfare

This project is a follow-on to the first Oak Ridge National Lab project and will run for a minimum of 6 months, aiming to grow crystals large enough for macromolecular neutron crystallography (MNC) analysis of the medically important enzyme acetylcholinesterase. 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. Microgravity uniquely facilitates the production of large high-quality protein crystals, which may provide structural information to enable the development of safe and effective antidotes.

**FIGURE 3: SELECTED HIGHLIGHTS FROM LAUNCHED
PAYLOADS ONBOARD OA CRS-9 (MAY 21, 2018)**

PROJECT INFORMATION

DESCRIPTION AND POTENTIAL IMPACT

**Enhance the Biological Production of the
Biofuel Isobutene**

Brandon Briggs,
University of Alaska - Anchorage
(Anchorage, AK)

*Payload Developer: Space Technology and
Advanced Research Systems Inc. (STaARS)*

Bioproduction of Plastics and Rubber

This project seeks to examine genetically engineered *E. coli* in microgravity to better understand the metabolic pathways involved in the bacteria's production of isobutene (a key precursor for numerous products such as plastics and rubber), primarily produced through petrochemical processes. Bacteria found in manure, such as *E. coli*, can also produce isobutene, but the metabolic process is inefficient. This project seeks to identify metabolic pathways that can be genetically modified to increase bioproduction rates of isobutene. Economically viable bioproduction of isobutene from renewable resources such as manure can reduce the energy needed for production and decrease dependence on oil. More than 10 million tons of isobutene are processed each year, with a market value of \$19 billion per year.

**FIGURE 4: SELECTED HIGHLIGHTS FROM LAUNCHED
PAYLOADS ONBOARD SPACEX CRS-15 (JUNE 29, 2018)**

PROJECT INFORMATION

DESCRIPTION AND POTENTIAL IMPACT

**Orbital Sidekick ISS Hyperspectral
Earth Imaging System Trial**

Daniel Katz,
Orbital Sidekick (San Francisco, CA)

Payload Developer: Nanoracks, LLC

Sustainability and Environmental Monitoring

This project seeks to use the NanoRacks External Platform on the ISS to validate the technical feasibility and fidelity of operating a compact, commercial, hyperspectral, remote sensing system in low Earth orbit. The system will monitor above-ground, buried, and submerged energy infrastructure, specifically pipelines and refineries for highly volatile liquids and gases. Environmental monitoring of energy infrastructure and transportation, mining and extraction, and forestry are vital to sustainable life on Earth. Satellite-based hyperspectral imaging provides data-rich hyperspectral imaging information to customers in the \$30-billion resource monitoring market, with a focus on the \$9-billion energy infrastructure monitoring market. Hyperspectral technology also can be used for defense applications aimed at detecting chemical weapon signatures, identifying military resources and troop movement, and aiding relief efforts.

**Microgravity Crystal Growth for
Improvement in Neutron Diffraction**

Timothy Mueser,
University of Toledo
(Toledo, OH)

Payload Developer: CASIS

Prevention of Salmonella Contamination

This investigation seeks to produce larger and higher quality crystals of three medically relevant proteins for neutron diffraction, with an aim to improve the structure determination of the proteins. The three proteins being crystallized are *Salmonella typhimurium* tryptophan synthase (TS), cytosolic aspartate aminotransferase (AST), and a protein complex of a bacteriophage RNase H and single stranded DNA binding protein. Improved structure determination of these proteins could help control *Salmonella* contamination in the food industry, aid in the development of compounds to help monitor treatment progress in patients with heart or liver disease, and provide insight into how DNA repair could be optimized to prevent diseases caused by damage to DNA.

**Endothelial Cells In Microgravity for
Evaluation of Cancer Therapy Toxicity**

Dr. Shou-Ching Jaminet,
Angiex (Cambridge, MA)

*Payload Developer:
BioServe Space Technologies*

Reduced Side Effects from Cancer Drugs

This project will evaluate a novel cancer therapy targeting a protein involved in the proliferation of endothelial cells (ECs), which line the walls of blood vessels. However, researchers lack a model of normal endothelium to test drug toxicity in cell culture. Microgravity-cultured ECs could constitute an important model system for evaluating the action of any vascular-targeted drug, potentially enabling the development of drugs with lower toxicity. Cancer is the second leading cause of death in the U.S. and is expected to surpass heart disease as the leading killer by 2030. This cancer therapy aims to target both the tumor blood vessels and tumor cells and could potentially treat more than 90% of all cancers.

PROJECT INFORMATION

DESCRIPTION AND POTENTIAL IMPACT

Quantifying Cohesive Sediment Dynamics for Advanced Environmental Modeling

Dr. Paolo Luzzatto-Fegiz,
University of California,
Santa Barbara (Santa Barbara, CA)

Payload Developer: Zin Technologies, Inc.

Increased Precision in Oil and Gas Exploration

This project is focused on the study of forces between quartz and clay particles that cluster together. By conducting the research on the ISS, investigators can observe how particles cluster over long time scales without gravitational settling, which complicates measurements taken on Earth. The project will improve our fundamental understanding of physical interactions between soil and sediment particles. It has important applications on Earth for geologists and engineers who work in the Earth's surface sediments and for oil companies, which spend millions of dollars per well to fund exploratory drilling operations. Results from this project may lead to better computation models that will allow oil companies to more precisely find deep-sea sites for drilling productive oil wells.

In addition to serving demand for the ISS National Lab platform by supporting the flight of new projects, detailed above, CASIS advances U.S. leadership in commercial space by building demand, enabling supply, and facilitating investment. The continued expansion of commercially operated facilities onboard the ISS National Lab cultivates the supply side of economic development in low Earth orbit (LEO). In-orbit facility managers provide users with operational experience and engineering expertise to address unique research needs and are the pathfinders for a LEO marketplace. With the addition of two new facilities and one new facility manager in Q3, the ISS National Lab now supports 14 commercially operated user facilities from eight facility managers.

New Commercial Facility: The Multi-use Variable-gravity Platform (MVP)

- The MVP, operated by facility manager Techshot, Inc., consists of experiment modules with the ability to create artificial gravity in a temperature-controlled environment. The MVP is designed to collect and share data in near real-time from diverse research sample types, including cells, protein crystals, and fruit flies among others. Imagery and video of experiments will be readily available for viewing. *Additional information:* <http://www.techshot.com/documents/MVP.pdf>

New Commercial Facility and Facility Manager: The Materials ISS Experiment Flight Facility (MISSE-FF), managed by Alpha Space Test and Research Alliance (Alpha Space)

- The MISSE-FF platform was developed by Alpha Space under a Cooperative Agreement with NASA. This commercially available materials-science and component-testing platform provides data collection capabilities for passive and active material samples as well as other experiments and component testing in the extreme LEO environment. MISSE-FF allows for testing in four directions (ram, wake, zenith, and nadir [limited]) on the ISS simultaneously. *Additional information:* www.alphaspace.com/docs/Alpha_Space-MISSE_Slick-for-web.pdf
- A woman- and minority-owned company, new facility manager Alpha Space serves the space research, testing, and materials science communities with turn-key, fixed price services that make getting science and test elements safely into space, and data and materials back to Earth, simple and inexpensive.

Also in Q3, Twyman Clements of facility manager Space Tango was named one of the Top 100 “Most Creative People in Business 2018” by *Fast Company*, a progressive business media brand with an editorial focus on innovation in technology, leadership, and design. Space Tango is an in-orbit facility manager and the implementation partner for several ISS National Lab activities and Space Station Explorers (SSE) partner programs.

To support the growing and dynamic community of commercial service providers serving the ISS National Lab community (i.e., Implementation Partners), CASIS released a web portal for these partners in April, providing Implementation Partners information about future and current opportunities. Through this portal, Implementation Partners can ask questions, submit quotes and proposals, and work directly with CASIS and investigators.



FIGURE 5: CONTRIBUTIONS TO SCIENTIFIC KNOWLEDGE – RESULTS PUBLISHED

Three peer-reviewed academic journal articles in Q3 resulted from CASIS-sponsored R&D. One shared results from R&D performed onboard the ISS National Lab and two described insights gained from ground validation studies performed in preparation for flight.

PROJECT INFORMATION	KEY MESSAGES
<p>ISS National Lab Project Title: Remote Controlled Nanochannel Implant for Tunable Drug Delivery</p> <p>Principal Investigator: Dr. Alessandro Grattoni, Houston Methodist Research Institute (Houston, Texas)</p> <p>Article Citation: Bruno G, Di Trani N, Hood RL, Zabre E, Filgueira CS, Canavese G, Jain P, Smith Z, Demarchi D, Hosali S, Pimpinelli A, Ferrari M, Grattoni A. Unexpected behaviors in molecular transport through size-controlled nanochannels down to the ultra-nanoscale. Nat Commun. 2018 Apr 27;9(1):1682. doi: 10.1038/s41467-018-04133-8.</p>	<p>Summary: An article published in <i>Nature Communications</i> by Alessandro Grattoni expands on previous research on molecular transport mechanisms of fluids through ultra-nanoscale (< 5 nm) channels, processes essential for cell survival. This study examines both charged and neutral molecules in a nanofluidic platform with ultra-nanoscale channels. The study found that at the ultra-nanoscale, neutral molecules behaved like charged molecules, and the ability of the molecule to diffuse was lowered significantly for all molecules. Previous studies focused on slightly larger scales, which do not fully represent the complexity seen at smaller scales because fluids may not have uniform properties, such as density, throughout.</p> <p>Potential Earth Benefit: This study provides a better understanding of the mechanisms involved in molecular transport of fluids through nanofluidic channels at the ultra-nanoscale, in which the size of the channel is approximately the same size as the molecules in the solution. In addition to providing insight on ionic transport in biological systems, results from this study have applications in desalination (removal of salt and minerals from a solution), fuel cells, batteries, filtration, and drug delivery.</p>
<p>ISS National Lab Project Title: Rodent Research-4 Validation Study</p> <p>Principal Investigator: Dr. Melissa Kacena, Indiana University (Indianapolis, Indiana)</p> <p>Article Citation: Scofield DC, Rytlewski JD, Childress P, Shah K, Tucker A, Khan F, Peveler J, Li D, McKinley TO, Chu TG, Hickman DL, Kacena MA. Development of a step-down method for altering male C57BL/6 mouse housing density and hierarchical structure: Preparations for spaceflight studies. Life Sci Space Res (Amst). 2018 May;17:44-50. doi: 10.1016/j.lssr.2018.03.002</p>	<p>Summary: An article published in <i>Life Science in Space Research</i> by Melissa Kacena describes results from ground-based validation study for a larger rodent investigation examining the effects of microgravity on bone healing. The study validated a new method to co-house male mice onboard the ISS at varying densities. Male mice are preferred over females for bone healing research because of their larger bones; however, males can be more aggressive than females when housed together. This validation study found that male mice co-housed using the new method showed no significant difference in activity, aggression, body weight, or organ weight than mice in a standard ground-based housing schematic.</p> <p>Potential Earth Benefit: This study is part of a larger rodent investigation on the ISS examining the effects of microgravity on bone healing. The use of mice models in microgravity allow researchers to study bone healing that more closely resembles the healing process of human patients on Earth with injuries requiring prolonged bedrest. The successful results from this validation study enable future investigations using co-housed male mice at varying densities onboard the ISS.</p>
<p>ISS National Lab Project Title: Rodent Research-4 Validation Study</p> <p>Principal Investigator: Dr. Melissa Kacena, Indiana University (Indianapolis, Indiana)</p> <p>Article Citation: Rytlewski JD, Childress PJ, Scofield DC, Khan F, Alvarez MB, Tucker AT, Harris JS, Peveler JL, Hickman DL, Chu TG, Kacena MA. Cohousing Male Mice with and without Segmental Bone Defects. Comp Med. 2018 Apr 2;68(2):131-138.</p>	<p>Summary: A second article by Melissa Kacena published in <i>Comparative Medicine</i> describes additional results from a ground-based validation study for a larger rodent investigation examining the effects of microgravity on bone healing. This study examined whether co-housing male mice with surgically induced segmental bone defects with mice that had not undergone surgery would result in increased aggressive behavior toward the mice that had undergone surgery. The study found that mice that did and did not have surgery could be successfully co-housed, with no increased aggression and no evidence of stress, if they had been housed together since birth and were exposed to the same pre-operative and post-operative conditions.</p> <p>Potential Earth Benefit: This study is part of a larger rodent investigation on the ISS examining the effects of microgravity on bone healing. The use of mice models in microgravity allow researchers to study bone healing that more closely resembles the healing process of human patients on Earth with injuries requiring prolonged bedrest. The successful results from this validation study enable future investigations on the ISS that involve co-housing male mice that have undergone surgery with male mice that have not.</p>

Also in Q3, a special space issue of *Stem Cells and Development* included articles highlighting previously published work from several CASIS researchers on the analysis of stem cells under simulated microgravity, microgravity, and hypergravity conditions. *Stem Cells and Development* is globally recognized as the premier source of clinical, basic, and translational research on stem cells of all tissue types and their potential therapeutic applications.

Additionally, in August 2017, a patent application was published regarding manufacturing hardware to be utilized for future ZBLAN production research on the ISS National Lab by Fiber Optics Manufacturing in Space (FOMS). Although ZBLAN has the potential to far exceed the performance of other fibers in common use across many sectors, terrestrially



produced fiber suffers from impurities that reduce performance. Microgravity has been shown to significantly reduce these imperfections, and production of fibers in space may not only enable improved materials but also create a new frontier in manufacturing and space utilization. The ISS allows FOMS to pilot their hardware to further evaluate the best method for producing ZBLAN. The patent describes operational methods that may appear in commercial microgravity ZBLAN production systems in the future.

Finally, a new \$300,000 investment was reported from an ISS National Lab investigator, increasing the total external capital investment from the CASIS Investor Network to \$1,635,000. At the ISSR&D Conference in July, Silicon Valley Bank will co-host and sponsor an annual pitch event connecting these investors interested in space-related business ventures with entrepreneurs.

STIMULATING AND CULTIVATING DEMAND FOR THE ISS AND BEYOND

EXPANDING THE ISS NATIONAL LAB NETWORK AND DRIVING COMMERCIAL UTILIZATION

Opportunities for Idea Submission

The 2018 MassChallenge Accelerator Sponsored Program was announced in Q3. MassChallenge is the largest-ever startup accelerator and the first to support high-impact, early-stage entrepreneurs without taking any equity. This is the sixth year that CASIS is supporting a Sponsored Program for a “Technology in Space” prize associated with the MassChallenge Program. Co-sponsored by Boeing, the prize will provide funding to technical, out-of-the-box concepts for research on the ISS National Lab.

Additionally, awardees from a research opportunity issued in collaboration with Alpha Space Test and Research Alliance were announced in Q3. This Request for Proposals, detailed in Figure 6, represented a collaboration with in-orbit commercial facility manager Alpha Space to accelerate R&D return from use of their new platform, the Materials International Space Station Experiment (MISSE) external facility. Of the four Sponsored Programs that officially closed in Q2, awards from two of these programs were announced in Q3. All awarded project details can be found in Figure 9.

A Sponsored Program is a research competition funded, either in whole or in part, by a non-CASIS, non-NASA organization. For FY18, such organizations include the National Institutes of Health (NIH), the National Science Foundation (NSF), and Target Corporation. These FY18 collaborations represent more than \$11 million in committed funding toward ISS National Lab research and continue a growing trend of commercial and non-NASA government partnerships to advance space-based R&D. The total committed funding to date through the Sponsored Program model is more than \$30 million. Although the majority of these sponsored programs are closed and no longer accepting applications, they are considered ongoing until the announcement of awards and are therefore included in Figure 6.

FIGURE 6: RECENT AND UPCOMING OPPORTUNITIES

TITLE OF RESEARCH OPPORTUNITY (STATUS)	Technology in Space Prize (in association with MassChallenge Boston) (OPEN)
SPONSOR ORGANIZATION AND FUNDING DETAILS	Co-sponsors: Boeing and CASIS commit up to \$500,000 in grants for ISS National Lab experiments.

CHART CONTINUED ON NEXT PAGE



GOALS	<p>MassChallenge is the largest-ever startup accelerator and the first to support high-impact, early-stage orbital entrepreneurship 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, MassChallenge alumni have raised more than \$1.8 billion and created more than 60,000 jobs. As MassChallenge's flagship location, MassChallenge Boston has accelerated more than 1,000 startups from across the country. For the sixth 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 fifth 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.</p> <p><u>Related links:</u></p> <p>► masschallenge.org/media/masschallenge-boston-awards-15m-equity-free-prizes-top-startups-its-eighth-cohort</p>
IMPORTANT DATES	<p>MassChallenge Boston Pitch Competition: 8/29/2018; Applications Open for Technology in Space Prize: 8/30/2018; Applications Close: 9/21/2018; Review of Applications: 9/22/2018–10/10/2018; Finalist Announcement: 10/17/2018</p>
TITLE OF RESEARCH OPPORTUNITY (STATUS)	<p>Request for Proposals Utilizing the MISSE platform Materials Science Research in Space (CLOSED: Winners announced in Q3)</p>
SPONSOR ORGANIZATION AND FUNDING DETAILS	<p>In collaboration with Alpha Space Test and Research Alliance, CASIS will support selected projects in executing mission objectives onboard the MISSE external platform (i.e., launch, payload development, payload integration, in-orbit mission costs, data return, and payload return if appropriate).</p>
GOALS	<p>CASIS has partnered with Alpha Space Test and Research Alliance to support use of their MISSE External facility, toward utilization by commercial and academic investigators in materials science. The extreme conditions of the space environment are demonstrably hostile to many materials. Atomic oxygen, the most prevalent atomic species encountered in low Earth orbit, is highly reactive with plastics and some metals, causing severe erosion. Outside the Earth's atmospheric filter, extreme ultraviolet radiation deteriorates and darkens many plastics and coatings. The vacuum of the space environment alters the physical properties of many materials. Finally, impacts from meteoroids and orbiting human-made debris can damage exposed materials in space. The combined effects of these conditions can be investigated only in space—providing a mechanism for rapid failure mode analysis.</p> <p>The MISSE facility, launching on SpaceX CRS-14 in April, provides an in-orbit platform deployed externally aboard the ISS with high data rates, payload return, human payload interface, and no extravehicular activity required. This research opportunity sought proposals for devices and trays compatible with the MISSE platform and for projects that will use the extreme conditions of space for development and testing of new materials, components, and systems with Earth-based applications.</p> <p><u>Related links:</u></p> <p>► www.iss-casis.org/research-on-the-iss/solicitations/materials-science-2018</p>
IMPORTANT DATES	<p>Open Date: 2/1/2018; Step 1 Proposal/Feasibility Form Due: 3/1/2018; Step 2 Proposals Due: 3/30/2018 Winners announced in Q3</p>
TITLE OF RESEARCH OPPORTUNITY (STATUS)	<p>ISS Cotton Sustainability Challenge (CLOSED: Winners announced in Q3)</p>
SPONSOR ORGANIZATION AND FUNDING DETAILS	<p>Target Corporation has committed up to \$1 million to support flight projects resulting from this solicitation.</p>
GOALS	<p>Cotton is a natural plant fiber produced in many countries and one of the most important raw materials required for the production of textiles and clothing. Cotton cultivation requires sustainable access to natural resources, such as water, that are increasingly threatened. This challenge sought to engage the creative power of the research community to leverage the ISS National Lab and generate ideas across multiple sectors that may improve the utilization of ground-based natural resources for sustainable cotton production.</p> <p><u>Related links:</u></p> <p>► www.iss-casis.org/cottonsustainabilitychallenge</p>
IMPORTANT DATES	<p>Open Date: 9/5/2017; One-Pagers Due: 11/08/2017; Full Proposals Due: 2/16/2018; Finalists Announcement: 03/09/2018 Winners announced in Q3</p>

TITLE OF RESEARCH OPPORTUNITY (STATUS)	National Science Foundation (NSF)/CASIS Collaboration on Fluid Dynamics and Particulate and Multiphase Processes Research on the International Space Station to Benefit Life on Earth (CLOSED: Winners announced in Q3)
SPONSOR ORGANIZATION AND FUNDING DETAILS	NSF has committed up to \$2 million for flight projects resulting from this solicitation.
GOALS	<p>CASIS and NSF are sponsoring a joint solicitation wherein researchers can leverage resources onboard the ISS National Lab for R&D in fluid dynamics and particulate and multiphase processes. This is the second collaboration between NSF and CASIS dedicated to the funding of fluid dynamics and multiphase process concepts in space to benefit life on Earth, and one of four total collaborations to date between NSF and CASIS to fund ISS National Lab R&D, following a successful first solicitation in 2016. There is also the possibility that projects awarded from this solicitation will lead to the development of new hardware that can be used not only for these studies but also for future experiments onboard the ISS.</p> <p><u>Related links:</u></p> <ul style="list-style-type: none"> ▶ www.iss-casis.org/research-on-the-iss/solicitations/fluid-dynamics-2017 ▶ www.nsf.gov/pubs/2018/nsf18521/nsf18521.htm
IMPORTANT DATES	Open Date: 11/29/2017; Feasibility Form Due: 01/24/2018; Full Proposals Due: 03/05/2018 Winners announced in Q3
TITLE OF RESEARCH OPPORTUNITY (STATUS)	National Institutes of Health (NIH)-CASIS Coordinated Microphysiological Systems Program for Translational Research in Space (CLOSED)
SPONSOR ORGANIZATION AND FUNDING DETAILS	NIH has committed up to \$7.6 million, subject to funding availability, to support flight projects resulting from this solicitation.
GOALS	<p>CASIS, the National Center for Advancing Translational Sciences (NCATS), and the National Institute of Biomedical Imaging and Bioengineering (NIBIB) are collaborating to support a funding opportunity focused on human physiology and disease onboard the ISS National Lab. Both NCATS and NIBIB are part of NIH. Data from this research—which will feature tissue chips—will help scientists develop and advance novel technologies to improve human health. This announcement is part of a four-year collaboration through which NCATS and NIBIB will provide funding for space-based research investigations to benefit life on Earth.</p> <p>This is a reissue of the opportunity released in FY16 that subsequently resulted in the award of five projects. Recent advances in bioengineering have enabled the manufacture of microphysiological systems using human cells on chips representing functional units of an organ, which replicate the physical and biochemical environment in tissues. In parallel, recent developments in stem cell technology now make it possible to cultivate tissues from humans with specific genotypes and/or disease phenotypes. Advancing this research on the ISS National Lab promises to accelerate the discovery of molecular mechanisms that underlie a range of common human disorders, as well as improve understanding of therapeutic targets and treatments in a reduced fluid shear, microgravity environment that recapitulates cellular and tissue matrices on Earth.</p> <p><u>Related links:</u></p> <p>Information on this opportunity:</p> <ul style="list-style-type: none"> ▶ casistissuechip.blogspot.com ▶ grants.nih.gov/grants/guide/rfa-files/RFA-TR-18-001.html <p>Information on the previous program and awards:</p> <ul style="list-style-type: none"> ▶ grants.nih.gov/grants/guide/rfa-files/RFA-TR-16-019.html ▶ ncats.nih.gov/tissuechip/projects/space2017
IMPORTANT DATES	Posted Date: 11/30/2017; Open Date: 12/15/2017; Application Due: 02/08/2018 Awards expected in Q4

TITLE OF RESEARCH OPPORTUNITY (STATUS)	NSF/CASIS Collaboration on Tissue Engineering on ISS to Benefit Life on Earth (CLOSED)
SPONSOR ORGANIZATION AND FUNDING DETAILS	NSF has committed up to \$1.8 million to support flight projects resulting from this solicitation.
GOALS	<p>CASIS and NSF are sponsoring a joint solicitation wherein researchers can leverage resources onboard the ISS National Lab for R&D to support enhancements in the fields of transformative tissue engineering. Any research that fits within the scope of NSF's Engineering of Biomedical Systems Program and requires access to experimental facilities on the ISS may be considered. This includes cellular engineering, tissue engineering, and modeling of physiological or pathophysiological systems in topic areas that include but are not limited to scaffolds and matrices, cell-cell and cell-matrix interactions, stem cell engineering and reprogramming, cellular immunotherapies, cellular biomanufacturing, and system integration between biological components and electromechanical assemblies. As noted above, this is one in a series of four collaborations between NSF and CASIS to explore research concepts on the ISS National Lab, with the other three focused on the physical sciences (fluid dynamics and thermal combustion).</p> <p><u>Related links:</u></p> <ul style="list-style-type: none"> ▶ www.iss-casis.org/research-on-the-iss/solicitations/tissue-engineering-2017 ▶ www.nsf.gov/pubs/2018/nsf18514/nsf18514.pdf
IMPORTANT DATES	Open Date: 11/8/2017; Feasibility Form Due: 01/5/2018; Full Proposals Due: 02/12/2018; Awards expected in Q4

Four new partnerships in Q3 will enable additional LEO activities and opportunities:

- ▶ **Axiom Space, LLC** – Axiom Space will utilize the ISS National Lab to test and develop the critical technologies needed to build a privately-funded, for-profit, international commercial space station. Initially, Axiom plans to dock multiple modules to the ISS that can ultimately become a stand-alone station. Axiom will serve six emerging markets through its commercial station, including sovereign astronauts, spaceflight participants, researchers, manufacturers, deep-space exploration companies, and advertisers/sponsors. The station will consist of at least seven elements, including multipurpose research, industrial, habitation, power, and propulsion modules and nodes. Axiom hopes to stimulate growth of the LEO user community by providing additional and expanded services to the ISS National Lab while allowing a seamless transition of ISS users to the company's commercial station when the ISS is retired. According to Axiom, a private space station (for both commercial and government uses) could address a market of up to \$37 billion between 2020 and 2030.
- ▶ **IBM** – The “Watson in Space” program is a high-profile, multi-faceted campaign consisting of research, development, and outreach projects that apply artificial intelligence research and IBM's Watson cognitive computing technology onboard the ISS. The overall campaign will consist of interactive, educational experiences backed by industry-leading research and development professionals in artificial intelligence applications. Key objectives of the program include building STEM skills in students, advancing space research, and promoting cognitive technology.
- ▶ **ProXopS, LLC** – Through this partnership, ProXopS will provide a commercial multipurpose research platform, the Faraday Research Facility, for customers to fly their experiments to the ISS. The Faraday Research Facility holds μ Labs, enclosures approximately 10 cm x 10 cm x 15 cm (1.5 U) or 10 cm x 10 cm x 30 cm (3 U) that house experiments. The facility can hold up to twelve 1.5 U μ Labs or up to six 3 U μ Labs. Faraday utilizes commercial-off-the-shelf modular components to provide a standardized multipurpose platform for a variety of research. The facility will be launched and returned in one piece with different experiments each time, with no crew access to the internal experiments or components. The Faraday Research Facility provides a flexible design to support a wide variety of research on the ISS at an economical price point. Faraday will also help to refine requirements for other platforms that can be used for commercial space stations, habitats, and launch vehicles. Such information will be crucial to the commercialization of LEO.
- ▶ **SEOPS, LLC** – Through this collaboration, the SlingShot deployment system will be installed on the outside of the Northrop Grumman Cygnus spacecraft. SlingShot is an enabling technology platform that offers customers the ability to deploy CubeSats and MicroSats from Cygnus after it fulfills its primary cargo mission to the ISS. After undocking from the ISS, Cygnus will move to an altitude of 450–550 km to deploy the satellites. Deploying satellites from this higher altitude

improves the orbital lifespan and safety of CubeSat deployments. SlingShot deployers can accommodate any CubeSat up to 27 U and can be customized to accommodate larger satellites with thicknesses less than 200 mm. The demand for small satellites has grown significantly over the last several years due to miniaturization technologies and the availability of deployment from the ISS. As a result, small satellites have become valuable for technology demonstrations, gap fillers for larger satellites, and revenue-generating operational satellite constellations. Data produced from these satellites has a significant social and economic impact on life on Earth. The global small satellite market, valued at \$2.7 billion in 2017, is expected to grow at a CAGR of 21% and exceed \$7 billion by 2022. With the number of small satellites launches over the next decade expected to surpass 5,000, the global market value could exceed \$20 billion.

Also during Q3, Apple announced a new collaboration with CASIS during their Worldwide Developers Conference (WWDC) held in San Jose, California, on June 4, 2018. The WWDC is one of Apple's marquee events highlighting operating systems upgrades and new features for their products. Apple TV Lead Designer Jen Folse previewed new aerial images of Earth in her recent WWDC Keynote and specifically thanked CASIS during this reveal. These stunning 4K images were taken by astronauts on the ISS in cooperation with CASIS. Because the ISS orbits the Earth every 90 minutes, the crew members are able to capture different areas around the globe, from Sicily to Tokyo to San Francisco, during the day and night for an array of images. All of these images and more will be available to Apple users in the Fall later this year.

CASIS seeks to fully utilize the ISS National Lab, enabling cutting-edge research on the ISS from every corner of the country. In support of the ISS National Lab mission, CASIS partners to support the formal solicitations and programs listed above and works with investigators to develop additional project ideas and proposals, which are accepted as part of a rolling submission process. CASIS-selected projects for flight (discussed in the next section) result from these two inroads, and CASIS further manifests additional ISS National Lab payloads from commercial service providers through a separate process.

Newly Selected Projects

Seventeen newly selected projects this quarter represent diverse R&D objectives from both academic and commercial investigators across 12 states. Eight of the selected projects this quarter are to new users of the ISS, approximately half are funded through Sponsored Program awards, and one is in collaboration with another U.S. National Lab.

FIGURE 7: R&D OBJECTIVES OF NEW PROJECTS

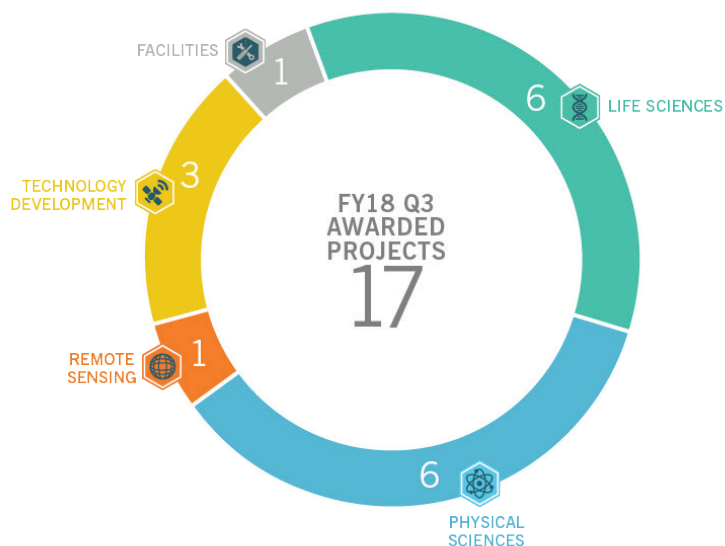


FIGURE 8: NEW PROJECTS, BY ORGANIZATION TYPE

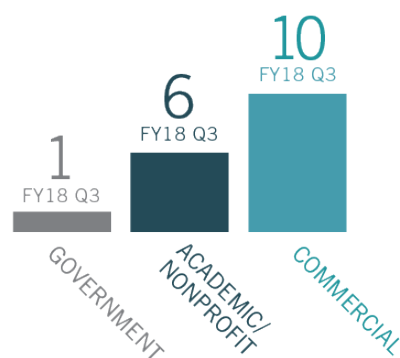


FIGURE 9: NEW PROJECT DETAILS

PROJECT INFORMATION	DESCRIPTION	EARTH BENEFIT
IBM Watson – Multi Modal AI (Astrobee Project) Christopher Durham, IBM (Austin, TX) 	This ground project seeks to develop technology using Watson, IBM's artificial intelligence (AI) technology, for use on the ISS with NASA's Astrobee vehicle, a mobile robotic platform designed to operate in microgravity. The project aims to combine multiple AI technologies to match images and text, support action recognition, and process instructions given through natural language. This project is part of the larger Watson in Space program.	Cognitive computing technology on the ISS could potentially assist crew members with experiments, complicated tasks, and procedures as well as answer questions from people back on Earth about living and conducting research in space. Research on cognitive computing technology could lead to a new form of cognitive compliance/verification assistant capable of operating in remote locations—both in space on future space stations, space-borne vehicles, and deep space exploration missions and on Earth in remote locations such as oil rigs and construction sites.
Targeted Nanoparticles for Orphan and Chronic Diseases Trevor Castor, Aphios Corporation (Woburn, MA) 	This project aims to investigate the manufacture of targeted nanoparticles that encapsulate drugs in tiny cell-like bubbles called nanosomes for use against Alzheimer's and other diseases. Manufacturing the nanosomes in microgravity produces particles that are smaller and more uniform, reducing the required dose per treatment and increasing product value. This initial study will examine nanoparticle behavior in microgravity. A follow-on study may include precision manufacturing of nanoparticles on the ISS.	Although this investigation focuses specifically on novel therapeutics for Alzheimer's disease, the same methods of studying nanosome efficacy can be applied to other cell types and other diseases such as cancers, HIV, multiple sclerosis, Parkinson's disease, and other chronic disorders. The manufacturing process that could result from this research could also be applied to other types of precision manufactured targeted therapies. The global market for Alzheimer's disease drugs was valued at approximately \$3.42 billion in 2016 and is expected to reach \$5.09 billion by the end of 2022.
Three-dimensional Microbial Mapping (3DMM) of ISS Environment Dr. Kasthuri Venkateswaran, Jet Propulsion Laboratory/ Caltech (Pasadena, CA) 	This project seeks to analyze swab samples of a thousand locations within the space station to explore the spatial relationship between bacteria and their metabolites (chemicals produced by their growth). The project will translate molecular information in high-spatial 3D resolution to understand the distribution of microbes and metabolites associated with the built environment of the ISS, a nearly closed ecosystem.	Understanding the microbiome of built environments and how it affects human health is a growing field of research that is particularly important in hospitals, nursing homes, and places where people are immuno-compromised. This project includes the development of new technologies that will enhance pathogen detection capabilities onboard the ISS as well as on Earth, including hospitals, commercial airplanes, and other closed environments where pathogens thrive.
Targeting the Roots of Cotton Sustainability Dr. Simon Gilroy, University of Wisconsin – Madison (Madison, WI) 	This project will examine how cotton plants respond to the stress of microgravity and its effects on growth and root behavior. Despite the central role of water stress in limiting cotton yields, the physiological traits and molecular causes of cotton's response to limited water availability remain poorly understood. Removing gravity allows researchers to study the underlying genetic elements of root system development, which could eventually lead to the development of cotton plants that use water more efficiently.	Each year, 25 million metric tons of cotton are grown around the world, and each kilogram requires thousands of liters of water to produce. In 2016, the U.S. cotton crop was valued at more than \$5 billion, but the larger economic activity linked to this crop is estimated to be more than 20 times that amount. Environmental stressors such as drought and salt limit stable crop production and result in an estimated depreciation in crop yield of up to 70% compared to yield under favorable conditions. Thus, improving yields under drought conditions has the potential to create a significant economic impact.
Unlocking the Cotton Genome to Precision Genetics Christopher A. Saski, Clemson University (Pendleton, SC) 	This project seeks to examine gene expression patterns in tissues from cotton plants exposed to spaceflight to better understand the molecular mechanisms involved in plant regeneration. Genome engineering holds the potential to revolutionize commercial agriculture and address global agricultural sustainability concerns. However, the ability to regenerate whole plants from individual plant cells remains a bottleneck and the mechanisms of plant regeneration are not well understood. This project will improve our understanding of these underlying molecular mechanisms, which may lead to significant improvements in the genome editing of cotton and other crops.	With human population estimated to reach 9 billion by 2040, thus increasing pressure on our planet's water and food resources, agricultural production must evolve to feed more people using less water and the same amount of land. A fundamental understanding of plant regeneration has the potential to impact plant breeding and seed production for designer cotton varieties that can grow in sub-optimal conditions and have improved fiber characteristics such as antimicrobial properties, fire retardance, or improved strength. The outcomes of this project are directly translatable to other crops to increase food production, enhance nutritional value, and improve pathogen resistance.

PROJECT INFORMATION	DESCRIPTION	EARTH BENEFIT
Field Scale Aggregated Best Management Practice Verification and Monitoring Marshall Moutenot, Upstream Tech (Boston, MA) 	This project will leverage remote sensing data from the ISS to expand the capabilities of Upstream's "Best Management Practice Assessment and Real-time Monitoring" platform to enable automated monitoring and analysis of cotton production-related water use. Upstream combines remote sensing data from numerous satellite sources with diverse spectral ranges, orbital frequencies, and spatial resolutions to cover large geographical areas with a high temporal resolution. Using machine learning algorithms to integrate and analyze the data, Upstream will provide real-time information to the farmer to better manage water use and crop production.	Upstream's strengthened platform could help cotton producers more effectively plan and implement water conservation efforts and as well as quantitatively measure progress toward goals in near real time. Upstream anticipates evolving the platform into a flexible, multi-crop tool aimed at enhancing global agricultural sustainability and climate resilience. The initial emphasis will be on high-value, water-intensive crops in water-stressed geographies both in the U.S. and around the world.
SCORPIO-V ISS LaserComm (SILC) System Dr. Dan O'Connell, HNu Photonics (Wailuku, HI) 	This project aims to validate the in-orbit performance of a laser communications system for commercial utilization by satellite developers and as a commercial data service for ISS National Lab customers. Higher-bandwidth data communication is a critical need to handle current and upcoming demands on the ISS. Current data transmission from the ISS can involve delays of two weeks or more for users to receive their data. Integrating a laser communications transmitter on the ISS will increase the volume of data downlinked by a factor of 40 and significantly reduce delays in data transmission to users.	A laser communications system would enable users to get more data faster, allowing the ISS to function as a commercial remote sensing platform rather than just a laboratory and testbed. A higher data rate could lead to not only more customers but also new classes of customers who have high-volume, near-real-time data downlink needs.
3-D Printed RF Systems and Materials for High Frequency Communications Dr. Arthur Paollela, Harris Corporation (Melbourne, FL) 	This project seeks to test 3D-printed radio frequency (RF) circuits, RF communications systems, and other materials for small satellites in the harsh space environment. The project will use the MISSE Flight Facility, a commercial materials research facility on the ISS. Exposure to ultraviolet radiation, vacuum-induced outgassing, and micrometeoroid/space debris will allow durability testing of the materials; exposure to large variations in temperature will allow testing for changes in the materials due to temperature; and exposure to highly reactive atomic oxygen will allow testing of the materials' reactivity.	The global small satellite market, valued at \$2.7 billion in 2017, is expected to grow at a CAGR of 21% and exceed \$7 billion by 2022. With the number of small satellites launches over the next decade expected to surpass 5,000, the global market value could exceed \$20 billion. However, design-related limitations, including size, weight, power use, and cost of RF systems, could act as restraints for growth in the small satellite market. 3D printing allows for a reduction in circuit size and the production of complex shapes unachievable through traditional manufacturing. It also involves shorter production cycles than traditional manufacturing and enables responsiveness to critical market changes. Testing on the ISS allows Harris Corporation to qualify the 3D-printed materials and raise the technology readiness level of their product to bring it to market more quickly.
Utilizing the MISSE Platform Materials Science In Space Eric Joyce, Made In Space (Moffett Field, CA) 	This project aims to test the performance and accelerated degradation of materials for use in-orbit manufacturing and spacecraft. The project will use the MISSE Flight Facility, a commercial materials research facility on the ISS, to identify and quantify preflight to postflight changes in the mass, mechanical performance, surface integrity, and types of damage to materials after six months of exposure to the space environment. Materials being tested include nonlinear optical crystals, solar cell alternatives, space-grade thermoplastics, and dielectric materials.	The materials tested address a wide range of applications for in-orbit manufacturing of systems and spacecraft for LEO. In-orbit manufacturing could revolutionize spacecraft design because spacecraft structures would no longer be required to fit inside a rocket or withstand the force of gravity before launch and vibration and acoustic forces during launch. The global small satellite market, valued at \$2.7 billion in 2017, is expected to grow at a CAGR of 21% and exceed \$7 billion by 2022. With the number of small satellites launches over the next decade expected to surpass 5,000, the global market value could exceed \$20 billion.

PROJECT INFORMATION	DESCRIPTION	EARTH BENEFIT
MISSE Variant 2 Exposure of Photovoltaic Cells on the ISS Jud Ready, Georgia Institute of Technology (Atlanta, GA) 	This project seeks to test the performance of three-dimensionally textured photovoltaic cells (solar cells) in orbit. The project will use the MISSE Flight Facility, a commercial materials research facility on the ISS, to test solar cells made using common thin film photoabsorbers and other novel materials designed with a novel light-trapping texture shown to more efficiently capture photons from the sun to produce energy. The MISSE Flight Facility provides exposure to rapidly varying angles of solar flux, and the research team will assess the temperature and electrical output of the textured solar cells as well as traditional untextured silicon solar cells to compare performance.	Textured solar cells could provide a more efficient and less costly alternative to traditional nontextured solar cell technologies. Successful demonstration of textured solar cells could lead to greater uptake of solar cell technology to support the U.S. electrical grid, reducing dependence on foreign sources of energy. The technology could also be of key importance in remote areas of the world with no electrical grid. The global thin film solar cell market was valued at \$11.4 billion in 2016 and is expected to reach \$39.5 billion by 2023.
Metal Additive Manufacturing Aluminum Alloy Satellite Antennas Michael Hollenbeck, Optisys (West Jordan, UT) 	This project aims to measure performance degradation in a small satellite antenna array resulting from exposure to the space environment. The project will use the MISSE Flight Facility, a commercial materials research facility on the ISS. Higher-performance antennas for small satellites are desired but increasing capability is challenging due to volume and weight constraints. Through metal additive manufacturing using aluminum alloys, Optisys is able to produce significantly smaller and lighter antenna structures compared to traditional manufacturing. Optisys fabricated a 30 GHz monopulse tracking array, and testing on the MISSE Flight Facility will allow exposure to atomic oxygen, which is expected to cause a degradation of performance of the structure.	Results from this project will shed light on the anticipated performance degradation and life cycle of aluminum antennas for small satellite applications produced using metal additive manufacturing. The satellite antenna market was \$2.1 billion in 2017 and is expected to grow significantly in coming years.
A SiC UV Sensor for Reliable Operation in Low Earth Orbit Jim Holmes, Ozark Integrated Circuits, Inc. (Fayetteville, AR) 	This project seeks to demonstrate the in-orbit performance of an integrated, high-gain, low-noise, wide-temperature silicon carbide (SiC) photo-transistor for UV sensing applications (SiC UV-PT). The project will use the MISSE Flight Facility, a commercial materials research facility on the ISS. The MISSE Flight Facility has built-in standard UV detectors in each orientation that provide a reference signal against which the SiC UV-PT can be compared to provide a qualitative understanding of how the SiC UV-PT improves sensitivity, responsivity, durability, temperature stability, and overall efficacy.	The high responsivity of the SiC UV-PT means that amplification, which is currently standard in UV detectors, is no longer necessary, thus reducing the cost of UV detection. SiC UV-PT technology has many applications. For example, the high responsivity of SiC UV-PT technology could improve detection of ocean-based oil spills and enable early fire detection in remote areas. Results from this research could also help improve techniques involving UV radiation to kill pathogens in water, food, and air.
Furphy-Residual Momentum and Tank Dynamics Daniel Faber, Orbit Fab (Cupertino, CA) 	This project aims to test the functionality of a tanker that can refuel spacecraft in orbit from a collapsible fuel tank called FlexTank™ that can be launched compressed then filled in orbit. Orbit Fab will validate the transfer of fluid from the tanker to the FlexTank in orbit, raising the technology readiness level (TRL) of the system from TRL-4 to TRL-8. Orbit Fab will also verify the dynamics of the FlexTank and test how well the internal baffling (panels that direct flow and help prevent sloshing) in the tanker is able to reduce motion from the flow of liquid as the tanker empties.	Launch vehicles have unused launch mass due to contingency mass held in reserve for potential changes to primary payloads. This unused launch mass could be used to launch fuel for spacecraft, such as satellites. Spacecraft could save on launch mass and volume by launching with compressed tanks that are filled once in orbit. The satellite servicing industry is estimated to be worth \$3 billion by 2027.
Microgravity as Disruptor of the 12-hour Circatidal Clock Dr. Brian York, Baylor College of Medicine (Houston, TX) 	This rodent research experiment aims to explore the role of regulatory genes in metabolic disorders such as liver disease, diabetes, and other illnesses associated with obesity. In addition to the circadian rhythm that governs biological functions in a 24-hour cycle, many genes involved in metabolism oscillate over 12 hours, termed circatidal rhythm, particularly under conditions of cellular stress. This circatidal clock functions even when circadian rhythm is disrupted. Characterizing circatidal gene expression in mouse tissues such as the liver under the stress of spaceflight may inform methods for modulating these gene pathways in the treatment of metabolic disorders.	Genes expressed with a circatidal rhythm are associated with one of the most common forms of liver disease, nonalcoholic fatty liver disease, as well as general metabolism. Obesity affects nearly 70% of the adult U.S. population and is associated with yearly medical costs of more than \$150 billion, so identifying new methods of treating metabolic disorders could not only improve patient health but also influence healthcare costs.

PROJECT INFORMATION	DESCRIPTION	EARTH BENEFIT
Commercialization of the Global AIS on Space Station (GLASS) Payload Ken Bocam, Adcole Maryland Aerospace (Crofton, MD) 	This project aims to continue processing and distribution of data from the Global AIS on Space Station (GLASS) hardware currently operating on the ISS and expand commercialization of the payload. GLASS includes a single software programmable radio attached to an antenna on the ISS that collects Automatic Identification System (AIS) signals which are used to monitor worldwide shipping traffic. Adcole Maryland Aerospace plans to reconstitute the GLASS ground-based system for AIS data collection, processing, storage, and dissemination. The company also seeks to isolate other signals of interest within the AIS frequency range and make them available to potential customers.	Commercial GLASS has many important applications, including environmental protection (e.g., sustainable fishing, illegal dumping, and responsible ship operations), safety and security (e.g., piracy, trafficking, and navigation), and commercial maritime operation (e.g., efficiency of vessels, ports, and supporting services). This project could impact the hundreds of millions of people who work in the maritime industry as well as the billions of people whose diets include significant amounts of seafood (both animal and plant) as important sources of protein and nutrients.
Crystallization of RAS in Space Dhirendra Simanshu, Frederick National Laboratory for Cancer Research (Frederick, MD) 	This project, which is part of the RAS Initiative at the Frederick National Laboratory for Cancer Research, seeks to utilize the microgravity environment of the ISS to crystallize the KRAS gene—mutations of which account for many cancers, including 95% of pancreatic ductal adenocarcinoma, a third of non-small cell lung cancer, and up to half of colorectal tumors. Obtaining high-quality crystals of full-length KRAS proteins on the ground has been difficult, and crystals grown in microgravity are often larger and more well-ordered than Earth-grown crystals. The research team aims to crystallize unmodified full-length KRAS as well as cancer-causing KRAS mutants and KRAS proteins complexed with various small molecule inhibitors.	Mutations in of the RAS family of genes are responsible for more than 30% of all human cancers, including some of the deadliest (and most costly to treat) cancers such as pancreatic, lung, and colon cancers. However, after decades of research, there are no RAS-targeting inhibitors in clinical use. KRAS is the most frequently mutated member of the RAS family. Determining the structure of KRAS could lead to novel innovative approaches to prevent and treat cancers associated with this gene. Each year, cancer costs \$895 billion globally.
ISS: GOALI: Nonequilibrium Processing of Particle Suspensions with Thermal and Electrical Field Gradients Boris Khuisid, New Jersey Institute of Technology (Newark, NJ) 	This project seeks to use the microgravity environment of the ISS to address both fundamental and technological questions in the science of colloids, suspensions, and slurries aimed at understanding the equilibrium and dynamics of various materials used in additive manufacturing. Colloidal suspensions and denser slurries are used as malleable materials to make paints, ceramics, and, more recently, elements for 3D printing. This project could result in advances in 3D printing technology that uses the microgravity environment to eliminate undesirable effects from gravity and, thereby, allows guided assembly of colloidal particles with different densities, sizes, and properties into unique functional materials.	Knowledge gained from this research, developed with funding from NSF's Grant Opportunities for Academic Liaison with Industry (GOALI) program, could help develop in-orbit additive manufacturing capabilities, with the strong potential for cost savings. Leveraging the advantages of microgravity, this project could drastically improve 3D printing capabilities, leading to radically new products that cannot be fabricated on Earth. This, in turn, could lead to a sustainable market for orbital manufacturing.

Strategic Areas of Focus

Through Sponsored Programs and individual outreach to new customers, CASIS is accelerating success for a diverse range of ISS National Lab users, providing tangible return to U.S. taxpayers. To maximize this return, CASIS has developed a methodology to quantitatively assess value and impact of potential projects and has applied this knowledge to its targeted outreach strategy for both users and sponsor organizations. Ideal research areas have high feasibility for technical execution and downstream commercialization as well as high potential impact in the realms of innovation, economic value, and humanitarian application. To build a balanced portfolio of projects, drive utilization, and optimize resources, CASIS developed research focus areas for outreach that correlate with established customer needs and the value-impact assessment framework. Some examples are listed below.



Life sciences

- ▶ Drug discovery, development, and delivery (including manufacturing and process optimization)
- ▶ Cell biology and higher models of aging and chronic disease
- ▶ Regenerative medicine (e.g., stem cell biology, tissue engineering, and 3D bioprinting)
- ▶ Crop science



Physical sciences

- ▶ Novel materials development and improved manufacturing
- ▶ Telecommunication materials
- ▶ Semiconductor manufacturing
- ▶ Fluid dynamics and transport phenomena
- ▶ Reaction chemistry
- ▶ Combustion science



Technology development

- ▶ In-orbit production
- ▶ Additive manufacturing
- ▶ Quantum satellite technology
- ▶ Information technology and communications
- ▶ Robotics
- ▶ Technology readiness level (TRL) advancement



Remote sensing

- ▶ Data collection (e.g., applications for weather, agriculture, energy, and urban development)
- ▶ Infrastructure development for image tracking (e.g., maritime security)
- ▶ Smallsat deployment

CASIS executes individual targeted outreach to potential new customers in these sectors and participated in a variety of industry events in Q3 to increase outreach and awareness in these communities.

FIGURE 10: CASIS-ORGANIZED EVENTS

EVENT INFORMATION	Destination Station Salt Lake City » 5/14 – 5/17 (Salt Lake City, UT)
PARTICIPANTS/AUDIENCE	<p>Multiple site visits involved the following attendees:</p> <ul style="list-style-type: none"> ▶ At the Governor's Energy Summit, approximately 500 audience members ▶ At the Natural History Museum of Utah, approximately 150 attendees, including University of Utah researchers and professors ▶ At the Huntsman Cancer Institute (HCI), approximately 25 attendees, including researchers and employees ▶ At Dell EMC, approximately 250 attendees, including senior leadership, employees, and family members
GOALS AND OUTCOMES	<p>As part of NASA's Destination Station outreach initiative, CASIS met with businesses, educators, and law makers in the state of Utah to highlight the capabilities of the ISS. Over the past three years, CASIS has become increasingly involved in the development and implementation of these Destination Station events, as a business development tool to reach new companies and research institutions. CASIS made valuable connections with business leaders, educators, researchers, and energy industry leaders, began discussions concerning several project concepts, and laid the groundwork for future collaborations.</p>
EVENT INFORMATION	Expanding Horizons Silicon Valley Salon » 5/23 (San Jose, CA)
PARTICIPANTS/AUDIENCE	<ul style="list-style-type: none"> ▶ More than 30 luminaries, subject matter experts, key opinion leaders, venture capitalists, potential clients, and partners
GOALS AND OUTCOMES	<p>The CASIS Expanding Horizons Salon was an invitation-only event that gathered thought leaders to make new connections, share ideas, and potentially spark unexpected project ideas for the ISS National Lab. CASIS engaged with local senior executives, investors, and trendsetters to increase awareness of ISS National Lab activities and network and brainstorm potential project and program ideas in health, medical, engineering, consumer products, and other markets.</p>

FIGURE 11: INDUSTRY OUTREACH THROUGH EVENT SPONSORSHIP

EVENT INFORMATION	Dawn of Private Space Symposium 2018 » 6/2 – 6/3 (New York, NY)
PARTICIPANTS/AUDIENCE	► More than 150 attendees from commercial industry, academic institutions, government agencies, entrepreneurs, venture capitalists, United Nations representatives, ISS National Lab implementation partners, and launch providers; including more than 100 viewers via livestream
GOALS AND OUTCOMES	CASIS co-sponsored and presented an ISS National Lab overview titled, “Commercial Innovation in Space to Benefit Life on Earth” at the Dawn of Private Space Symposium, an event facilitating discussion and collaboration between businesses, policy makers, scientists, foundations, and other entities to further scientific research in space. Discussions throughout the symposium generated potential project opportunities and established new contacts with corporate partners, academia, and the United Nations Office for Outer Space Affairs. <u>Related link:</u> www.privatespacescience.com
EVENT INFORMATION	34th Space Symposium » 4/16 – 4/20 (Colorado Springs, CO)
PARTICIPANTS/AUDIENCE	► Representatives and staff from space agencies; commercial space businesses and associated subcontractors; military, national security and intelligence organizations; cyber security organizations; federal and state government agencies and organizations; research and development facilities; think tanks; educational institutions; and media
GOALS AND OUTCOMES	Existing partners, NASA, Implementation Partners, and new targets represented some of the 26 organizations and businesses CASIS representatives met with throughout the symposium. The meetings generated new ISS National Lab project opportunities and business relationships and strengthened existing business relationships, with overall efforts resulting in several new project discussions. <u>Related link:</u> www.spacesymposium.org
EVENT INFORMATION	BIO International 2018 » 6/4 – 6/7 (Boston, MA)
PARTICIPANTS/AUDIENCE	► Biotechnology and pharmaceutical industry leaders and executives; conference attendees
GOALS AND OUTCOMES	CASIS moderated a panel discussion and exhibited at BIO International, a convention that represents more than 1,100 biotechnology companies, academic institutions, state biotechnology centers and related organizations across the United States. New project opportunities were generated during the more than 20 meetings held throughout the convention, including early-stage discussions with new companies concerning potential flight projects and sponsored programs. <u>Related link:</u> convention.bio.org

Of note, at this year’s BIO International event, the CASIS Interim Executive Director presented four “Pioneer Awards” to companies that have been doing pioneering pharmaceutical research in space. Awardees included Eli Lilly and Company, Merck & Co., Novartis, and Amgen. In addition to benefits these companies are seeing for their respective organizations and the value they are returning back to the nation, it is important to recognize these nontraditional space organizations as pioneers in doing cutting edge research in LEO.

Looking forward to Q4, CASIS will exhibit at the following events:

- **The ISS National Lab Research and Development (ISSR&D) Conference** (July 23–26 » San Francisco, CA)
- **Destination Station Boston** (August 20–23 » Boston, MA)
- **Destination Station Pittsburgh** (September 18–21 » Pittsburgh, PA)
- **American Institute of Aeronautics and Astronautics (AIAA) Space Forum** (September 17–19 » Orlando, FL)

FIGURE 12: ADDITIONAL STRATEGIC EVENT PARTICIPATION

EVENT INFORMATION	Space 2.0 » 4/3 – 4/5 (San Jose, CA)
PARTICIPANTS/AUDIENCE	► Executives from small/start-up aerospace and big data management firms; business development managers from large aerospace companies
GOALS AND OUTCOMES	<p>With its rich audience of investors (venture capital, equity, incubators, and investment banks), aerospace prime contractors, government agencies, and incumbent players from the satellite operator and manufacturing sectors, Space 2.0 provided a unique opportunity for CASIS to showcase the commercial space industry for accelerating business plans in technology innovation. CASIS moderated a panel discussion titled, “Partnering with Government to Ease R&D and Testing Risks for Startups,” which led to multiple leads for flight projects, as well as new partnerships forged through the successful identification of new project opportunities in remote sensing and aerospace.</p> <p><u>Related link:</u> infocastinc.com/event/space-2-0</p>
EVENT INFORMATION	Lunch and Learn at Perkin Elmer » 4/4 (Waltham, MA)
PARTICIPANTS/AUDIENCE	► Approximately 50 Perkin Elmer employees
GOALS AND OUTCOMES	<p>CASIS representatives engaged with Perkin Elmer, an American multinational corporation with a focus on human and environmental health. Productive discussions centered on ISS National Lab research opportunities and future plans for a Destination Station event in Boston, MA.</p>
EVENT INFORMATION	U.S. Army Medical Research and Materiel Command and the Medical Technology Enterprise Consortium (MTEC) » 4/10 – 4/11 (Rochester, MN)
PARTICIPANTS/AUDIENCE	► MTEC members, industry thought leaders, government research sponsors, and philanthropic leaders
GOALS AND OUTCOMES	<p>CASIS gave a 30-minute podium talk discussing CASIS, the ISS National Lab, and research efforts relevant to MTEC. CASIS also hosted a meet-and-greet table presented a poster.</p> <p><u>Related link:</u> mtec-sc.org/event/third-annual-membership-meeting</p>
EVENT INFORMATION	Rapid + TCT Conference » 4/24 – 4/26 (Dallas, TX)
PARTICIPANTS/AUDIENCE	► Corporate executives and business owners, product design and research and development professionals, design engineers, manufacturing engineers and managers, software developers, investors, and entrepreneurs
GOALS AND OUTCOMES	<p>The Rapid +TCT Conference is the most prominent 3D manufacturing conference in North America, providing attendees with the opportunity to learn how to use 3D technologies improve efficiencies, product quality, and reduce both waste and time to market, produce to reduce time to market. The event provided CASIS representatives with an opportunity to consult with industry experts and network with the 3D manufacturing community. Based on event activities, CASIS is exploring corporate partnership and sponsored program opportunities, as well as STEM education initiative participation.</p> <p><u>Related link:</u> rapid3devent.com</p>
EVENT INFORMATION	Global Conference 2018 Milken Institute » 4/29 – 5/3 (Los Angeles, CA)
PARTICIPANTS/AUDIENCE	► More than 4,000 international leaders in business, government, science, philanthropy, academia, arts, and culture. Confirmed attendees include current and former senior U.S. government officials, CEOs, philanthropists, investors, innovators, and medical researchers
GOALS AND OUTCOMES	<p>CASIS participated in a panel discussion and engaged with business, government, technology, philanthropy, academia, and media leaders at the 2018 Global Conference, an event centralized around Milken’s mission to advance collaborative solutions that widen access to capital, create jobs, and improve health. Networking efforts generated multiple leads and sponsored program interest with corporate partners (particularly in technology development).</p> <p><u>Related link:</u> www.milkeninstitute.org/events/conferences/global-conference/2018</p>
EVENT INFORMATION	MIT Solve Conference » 5/16 – 5/18 (Boston, MA)
PARTICIPANTS/AUDIENCE	► Leaders from corporations, foundations, nonprofit organizations, government, academia, and the media
GOALS AND OUTCOMES	<p>CASIS engaged with the Solve Community, all of whom are interested in finding the best solutions to the world’s most pressing challenges and participated in a panel discussion, positioning the ISS National Lab as a platform for identifying potential solutions for issues such as sustainability, education, and health.</p> <p><u>Related link:</u> solve.mit.edu/events/solve-at-mit-2018</p>

EVENT INFORMATION	IBM Center for Open-Source Data & AI Technologies (CODAIT) Brown Bag Lunch Presentation » 5/22 (San Francisco, CA)
PARTICIPANTS/AUDIENCE	► Data scientists and open source developers
GOALS AND OUTCOMES	CASIS presented an ISS National Lab technology and development overview, highlighted National Lab capabilities and offerings, and initiated collaboration on space-based research with the IBM CODAIT team. <u>Related link:</u> developer.ibm.com/code/open/centers/codait/about
EVENT INFORMATION	Women in Aerospace » 5/31 (Palo Alto, CA)
PARTICIPANTS/AUDIENCE	► Doctoral and postdoctoral researchers
GOALS AND OUTCOMES	CASIS presented at a panel titled, “Building a Thriving Research Career in Industry or Government Laboratory” to inspire and engage with the next generation of women in aerospace and related fields. New business connections resulted from the successful exchange of information on the future of aerospace engineering. <u>Related link:</u> aa.stanford.edu/wia
EVENT INFORMATION	National Geographic Symposium, Technology & Data Presentation » 6/14 – 6/15 (Washington, DC)
PARTICIPANTS/AUDIENCE	► Approximately 500 corporate partners, venture capital, academia attendees, and 1000+ via livestream
GOALS AND OUTCOMES	CASIS engaged with and presented at the National Geographic Symposium, sharing ISS National Lab technology development project information with a community of commercial partners, funders, and mentors, all of whom are interested in creating a more sustainable future. The event and presentation positioned the ISS National Lab as a platform for addressing the world's grandest challenges and several potential sponsored program partners were identified. <u>Related link:</u> www.nationalgeographic.org/festival
EVENT INFORMATION	NASA Ames Astrobee Working Group Quarterly Meeting » 6/19 (Palo Alto, CA)
PARTICIPANTS/AUDIENCE	► NASA employees
GOALS AND OUTCOMES	CASIS presented an ISS National Lab robotics update (including information on SPHERES and Astrobee), promoting information sharing and generating interest in ISS facility utilization. <u>Related link:</u> www.nasa.gov/content/spheresastrobee-working-group
EVENT INFORMATION	Celgene Campus Point Science Meeting » 6/22 (San Diego, CA)
PARTICIPANTS/AUDIENCE	► Approximately 100 Celgene employees
GOALS AND OUTCOMES	CASIS introduced scientists at Celgene to R&D opportunities with the ISS National Lab and generated interest and excitement in potential projects on protein crystal growth, rodent research (e.g., immune system studies), and binding affinity.

CASIS staff also participated in a variety of industry events and networking opportunities, including:

- **NASA Innovation Consortium Quarterly** (May 23; NASA Johnson Space Center, Houston, TX)
- **Space Solar Power Symposium and International Space Development Conference** (May 23–26; Los Angeles, CA) » isdc2018.nss.org
- **SoCal Innovation Showcase** (May 24; Mountain View, CA) » www.alliancesocal.org/events/socal-innovation-showcase
- **Innovation Research Interchange (IRI) Annual Conference** (June 4–7; Atlanta, GA) » www.iriweb.org
- **Space Computing and Connected Enterprise Resiliency Conference** (June 4–8; Bedford, MA) » www.patriotsroostaoc.org/Space_Conference/#about
- **Social Innovation Summit** (June 5–6; Redwood, CA) » www.socinnovation.com/ehome/index.php?eventid=290119&
- **Indiana Biosciences Research Institute** (June 13; Indianapolis, IN) » www.indianabiosciences.org



OUTREACH AND EDUCATION

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

Increasing Awareness and Positive Perception

FIGURE 13: THOUGHT LEADERSHIP PRODUCTS

PUBLICATION/PRODUCT INFORMATION	DESCRIPTION AND PURPOSE
<p><i>Upward</i> (Volume 3, Issue 2)</p> <p><i>Authors:</i> Multiple, including CASIS staff and external contributors</p> <p><i>Publisher:</i> CASIS</p>	<p>In this issue of <i>Upward</i>, magazine of the ISS National Lab, Kathleen Fredette, Director of STEAM Initiatives at iLEAD Schools, which has locations in several U.S. states, shared her perspective on how a partnership with DreamUp is helping to inspire students and engage them in STEM topics. A feature story in this issue expanded on DreamUp's role in improving science literacy in the next generation. This issue's cover story highlighted the successful results of a flatworm regeneration investigation from researchers at Tufts University—aside from the two-headed flatworm that garnered significant media attention. This issue also discussed a rodent research experiment aimed at testing a new osteoporosis therapy that both prevents further bone loss and builds new bone.</p> <p>► upward.iss-casis.org/volume-3/issue-2</p>

CASIS and NASA continuously collaborate in communication and marketing efforts that also include content sharing. Content created by CASIS is used by NASA on a variety of social platforms and NASA TV. For example, CASIS promotion of CRS launch activities and related ISS National Lab projects includes custom CASIS content videos, social media campaigns, and an email marketing blast to the CASIS customer database—much of which is co-promoted by NASA. In Q3, such activities led to more than 420,000 video views on Facebook and more than three million impressions on Twitter and Instagram.

Additionally, CASIS teamed up with Nickelodeon for the Science and Engineering Festival held in Washington, D.C.—bringing the excitement of “slime and space” to more than 3,000 students. Teen star Alex Hook from Nickelodeon's series *I am Frankie* signed autographs at the CASIS booth and co-hosted a stage segment with CASIS staff that featured three ISS student investigators. The show announced a new collaboration between CASIS and Nickelodeon to focus on non-Newtonian fluid flow on the ISS.

Finally, in an effort to inform and excite the general public about the benefits of ISS research, Seeker announced in Q3 their launch of Seeker Universe, a multiplatform channel dedicated to covering all things space, including research highlights from the ISS National Lab. This collaboration was announced at Group Nine Media's NewFront (an event designed to create an upfront marketplace for digital video, where media companies present upcoming programming to advertisers) in New York City. The collaboration was announced by former NASA Astronaut Leland Melvin.

Events and activities such as these helped result in the ISS National Lab and CASIS being mentioned in more than 2000 mainstream media articles during Q3. Example coverage is highlighted below.

FIGURE 14: HIGHLIGHTS FROM MAINSTREAM MEDIA COVERAGE

NATIONAL LAB TOPIC	MEDIA OUTLETS	KEY POINTS
ISS National Lab Projects from Merck & Co., Oak Ridge National Laboratory, and The Michael J. Fox Foundation	► Popular Mechanics	Highlighted the importance of growing crystals in space and how this leads to better therapeutics and biomedical discoveries
CASIS staff participation at the 34th Space Symposium in Colorado	► The Verge ► Spacenews.com	Coverage of Director of Operations Kenneth Shields' participation on a panel discussing the future of the ISS and the National Lab



NATIONAL LAB TOPIC	MEDIA OUTLETS	KEY POINTS
Launch Promotion of SpaceX CRS-14	<ul style="list-style-type: none"> ▶ SpaceX.com ▶ The Verge ▶ Seeker ▶ Space Flight Insider ▶ NASA TV 	<p>Various highlights of National Lab payloads, including projects from 490 Biotech and the Genes in Space program as well as the Multi-use Variable-gravity Platform, MISSE platform, and CubeSats</p> <p> www.youtube.com/watch?v=NLnivCZRbEg&t=5s www.youtube.com/watch?v=HONUBLHJ--w www.youtube.com/watch?v=T3wlpDv3ZKY&t=1s </p>
CASIS and Apple Partnership	<ul style="list-style-type: none"> ▶ Apple's WWDC18 Keynote (webcast) ▶ Advanced television.com ▶ MSN News 	<p>At the Apple WWDC18 Keynote, Apple announced that its 4K imagery for Apple TV will include Earth imaging from the ISS via a partnership with CASIS</p>
Launch Promotion of Orbital ATK CRS-9	<ul style="list-style-type: none"> ▶ Seeker Universe ▶ satnews.com 	<p>Highlighted ISS National Lab payloads including those from NanoRacks, Zaiput, University of Alaska, and the Quest Institute (student investigations)</p> <p> www.youtube.com/watch?v=X9rXoSIJmnE&t=5s www.youtube.com/watch?v=wXeUB-mXhsU www.youtube.com/watch?v=uDvmVK3Pozc&t=100s </p>
Guardians of the Galaxy Space Station Challenge (Marvel and CASIS partnership)	<ul style="list-style-type: none"> ▶ Space.com ▶ pddnet.com ▶ prnewswire.com ▶ greenevillesun.com ▶ geek.com ▶ citizentribune.com ▶ mynews13.com 	<p>Broad coverage of the winners of the Guardians of the Galaxy Space Station challenge and their projects</p>
CASIS staff participation in a U.S. ISS Stakeholder Senate hearing	<ul style="list-style-type: none"> ▶ rollcall.com ▶ houstonchronicle.com ▶ Al.com ▶ Democratic Underground 	<p>U.S. Sen. Ted Cruz (R-Texas), chairman of the Subcommittee on Space, Science, and Competitiveness, convened a hearing titled "Examining the Future of the International Space Station: Stakeholder Perspectives," on June 6, 2018; the second in a series of hearings to examine the role of the ISS, at which ISS stakeholders discussed the value of the ISS to the U.S. national space program and the future of human space exploration</p> <p> www.commerce.senate.gov/public/index.cfm/2018/6/examining-the-future-of-the-international-space-station-stakeholder-perspectives </p>
2018 ISS National Lab Mission Patch Announcement (Collaboration with Ridley Scott)	<ul style="list-style-type: none"> ▶ Space.com ▶ Space Flight Insider ▶ Orlando Sentinel ▶ Baltimore Sun ▶ Collect Space ▶ Bay News 9 	<p>The 2018 mission patch designed by famous filmmaker Ridley Scott will represent all ISS National Lab research for 2018</p>
Launch Promotion of SpaceX CRS-15	<ul style="list-style-type: none"> ▶ SpaceX ▶ NSF ▶ Bloomberg ▶ Seeker ▶ Space Ref ▶ Space Daily ▶ Aerotech News ▶ Spaceflight.com ▶ Space Flight Insider 	<p>Highlighted ISS National Lab payloads including those from University of Florida, Angiex, and the University of California Santa Barbara (in partnership with NSF)</p>

Additionally, digital media successes in Q3 continued the trend of key partners amplifying CASIS-developed content (e.g., ISS360 blog posts, *Upward*, and launch videos) to communicate the ISS National Lab's value to new communities. This positive trend directly correlates to the improved CASIS content strategy, which focuses on providing deeper insights into ISS National Lab science and daily web and social media updates to engage our digital audiences.

- ▶ During SpaceX CRS-15, NSF leveraged their social community channels (Facebook, Twitter, Instagram, and YouTube) to discuss the first in a series of new NSF-funded ISS National Lab payloads launching to space.
- ▶ The release of the latest *Upward* garnered support from Tufts University and the Broad Center of Regenerative Medicine & Stem Cell Research at UCLA on social media (Twitter specifically), promoting stories in the latest issue that chronicled their respective research investigations on ISS National Lab.
- ▶ The current ISS crew has been very involved in promoting ISS National Lab science. For example, NASA Astronaut Serena Auñón-Chancellor tweeted a video, produced by CASIS, that highlighted a commercial payload that is evaluating a novel cancer treatment on the ISS National Lab.

STEM Initiatives

CASIS began support of three new Space Station Explorers (SSE) consortium partners in Q3:

- ▶ **Concord Consortium** – A nonprofit educational and research development organization aimed at improving educational technology's reach and exploring new curriculum ideas and concepts will take advantage of ISS capabilities and offerings.
- ▶ **Paine College** – A historically black college that provides engaging STEM programs for regional K-12 students will include SSE partner programs.
- ▶ **Alpha Space** – A new ISS facility manager (MISSE-FF) will support one new student experiment, with more to follow.

Additionally, one new education-related grant was signed this quarter. This partnership will help broaden reach and deepen engagement with this organization.

- ▶ **Asbury Park Boys and Girls Club** – This organization will promote an after-school program taking under-represented students on a simulated space mission using Virtual High School's on-line Space Station Academy.

FIGURE 15: PARTNER PROGRAM UPDATES

SSE supports 23 active programs, most in collaboration with partner organizations who manage these programs nationwide. The ISS is a powerful platform for engaging and inspiring learners of all ages. CASIS works with partners throughout the U.S., to provide hands-on and inquiry-based learning that features the unique environment of space. Many of the programs use real experiments on ISS and all support core concepts and skills in STEM education. Q3 highlights from some of these partner programs are detailed below.

PROGRAM INFORMATION	Growing Beyond Earth » Fairchild Tropical Botanic Garden » <i>Miami, FL</i>
EVENT/ACTIVITY	Fairchild Garden won \$749,220 award from NASA's TEAMS II program to expand educational programs that highlight plants in space. Students will conduct experiments at the museum and in-orbit on the ISS. On Apr 25, 2018, Fairchild also held a live video Q&A with astronauts on the ISS.
RELATIONSHIP TO CASIS MISSION	▶ Students explore how plants grow in space.
PROGRAM INFORMATION	ISS-Above » <i>Los Angeles, CA</i>
EVENT/ACTIVITY	At the Maker Faire Bay Area, May 18–20, four SSE partners had a major booth highlighting "Experiments in Space." Make Magazine gave it an "Editor's Choice" award. Partners were: Chabot Space and Science Center, Magnitude.io, ISS Above, Quest Institute, and the SSE overall program. More than 100,000 people attended the Maker Faire.
RELATIONSHIP TO CASIS MISSION	▶ "Makers" learn how to build and use experiments on the ISS.

PROGRAM INFORMATION	Tomatosphere » First the Seed Foundation » <i>Alexandria, VA</i>
EVENT/ACTIVITY	Fairchild Garden won \$749,220 award from NASA's TEAMS II program to expand educational programs that highlight plants in space. Students will conduct experiments at the museum and in-orbit on the ISS. On Apr 25, 2018, Fairchild also held a live video Q&A with astronauts on the ISS.
RELATIONSHIP TO CASIS MISSION	► Students explore how plants grow in space.
PROGRAM INFORMATION	Guardians of the Galaxy Space Station Challenge » Space Tango » <i>Lexington, KY</i> ; DreamUp » <i>Washington, DC</i>
EVENT/ACTIVITY	In partnership with Marvel Entertainment, CASIS and partners ran a competition themed around “Groot” (plant experiments) and “Rocket” (new technologies). In total, 155 students submitted entries and the winners were announced on June 6. Two students were awarded flight experiments: Sarina Kopf of Golden, CO, with an experiment on aeroponic farming, and Adia Bulawa of Greeneville, TN, with an experiment on dental health.
RELATIONSHIP TO CASIS MISSION	► Students develop in-depth skills of experiment design, testing, and operation.
PROGRAM INFORMATION	Genes in Space » <i>Cambridge, MA</i>
EVENT/ACTIVITY	On April 11, Astronaut and educator Ricky Arnold initiated the first of two student experiments that won the 2017 Genes in Space competition. The high school students who designed the winning projects are Elizabeth Reizis from New York (immune system cell differentiation) and Sophia Chen (cancer-inducing genomic instability) from Washington state. Genes in Space also distributed 20 miniPCR devices (identical to those on the ISS) to 20 teams selected from 559 submissions.
RELATIONSHIP TO CASIS MISSION	► High school students and teachers learn about genetics and biology in space.
PROGRAM INFORMATION	Sally Ride EarthKAM » U.S. Space and Rocket Center » <i>Huntsville, AL</i>
EVENT/ACTIVITY	Sally Ride EarthKAM offers middle school students a wonderful opportunity to select targets for Earth photography from the ISS. During the most recent mission (Apr. 10–16), they photographed 16,186 locations and then analyzed the Earth systems, science, and geography in the images.
RELATIONSHIP TO CASIS MISSION	► Students learn Earth system science and skills of image analysis.
PROGRAM INFORMATION	Amateur Radio on the ISS (ARISS) » <i>Silver Spring, MD</i>
EVENT/ACTIVITY	At the 15th International Conference on Space Operations (May 29, 2018), Frank Bauer, ARISS International Chair, presented an overview of ARISS and its more than 1,000 contacts between students and ISS astronauts. It received the best paper award for education and outreach.
RELATIONSHIP TO CASIS MISSION	► Students learn about life on the ISS and about communications technology.

Several SSE partners offered outstanding opportunities for students to do authentic research experiments on the ISS during Q3. Magnitude.io offered ExoLab On the ISS experiences in seed germination; Quest Institute launched several student experiments this quarter; Zero Robotics announced their middle school competition for in-orbit robotics; Genes in Space selected finalists for genetic research on the ISS; and Orion's Quest enabled students to support scientists doing ISS research on microbes. In total, 93 student experiments launched to the ISS in Q3. Students also presented posters of their experiments in special pre-launch events. Through such hands-on learning, students develop skills in authentic science research.

Finally, several SSE partners were honored with awards in Q3. As mentioned earlier, Space Tango's Twyman Clements was recognized by *Fast Company* as one of the Top 100 Most Creative People in Business. Additionally, at the MakerFaire Bay Area, the SSE “Experiments in Space” booth won an “Editor's Choice” award, and at SpaceOps 18, the ARISS paper (ham radio with ISS) won a “Best Paper” award.



FIGURE 16: STEM ENGAGEMENT THROUGH EVENT OUTREACH

CASIS presented or exhibited at the following events in Q3.

EVENT INFORMATION	U.S. News STEM Solutions » Apr 4–6 (Washington, DC)
PARTICIPANTS/AUDIENCE	► STEM education leaders from around the U.S., including representatives from government, academia, business and philanthropic foundations
GOALS AND OUTCOMES	Network with these education leaders, build partnerships for SSE, and fund-raising <u>Related link:</u> usnewsstemsolutions.com
EVENT INFORMATION	USA Science & Engineering Festival » Apr 6–8 (Washington, DC)
PARTICIPANTS/AUDIENCE	► Students, parents, educators, and business leaders learning about STEM education resources and opportunities
GOALS AND OUTCOMES	High visibility for SSE STEM education programs, partners and resources <u>Related link:</u> usasciencefestival.org
EVENT INFORMATION	Maker Faire Bay Area » May 18–20 (San Mateo, CA)
PARTICIPANTS/AUDIENCE	► Students, parents, educators, and business leaders learning about STEM education resources and opportunities
GOALS AND OUTCOMES	High visibility for SSE STEM education programs, partners and resources <u>Related link:</u> usasciencefestival.org
EVENT INFORMATION	Maker Faire Bay Area » May 18–20 (San Mateo, CA)
PARTICIPANTS/AUDIENCE	► The “maker” community—creative people of any age with interests in exploring, learning, and using innovative tools and ideas
GOALS AND OUTCOMES	Expose the maker community to ISS experiments, resources and other ways for them to connect with the ISS <u>Related link:</u> makerfaire.com/bay-area
EVENT INFORMATION	Destination Imagination Global Finals » May 23–25 (Knoxville, TN)
PARTICIPANTS/AUDIENCE	► Winning teams from Destination Imagination groups around the country
GOALS AND OUTCOMES	Exposing bright, curious, and engaged youth to learning opportunities from SSE and partners <u>Related link:</u> www.globalfinals.org

In addition, CASIS education staff participated in a variety of industry events and networking opportunities, including:

- **STEMconnector Summit** (May 18, Washington, DC) » www.stemconnector.com/may-18-summit-landing-page
- **Alliance for Girls Summit** (May 23, San Francisco, CA) » www.alliance4girls.org/index.php?option=com_content&view=article&id=295:2018-may-members-meeting-thank-you&catid=20:site-content
- **Michigan Space Forum** (June 8–9, Traverse City, MI) » www.michiganspaceforum.com
- **International Society for Technology in Education** (June 24–27, Chicago, IL) » conference.iste.org/2018

Looking forward to Q4, the CASIS Education Team will exhibit at the following events:

- **World Maker Faire New York 2018** (September 22–23; Queens, NY) » makerfaire.com/new-york
- **The Association of Science-Technology Centers (ASTC) Annual Conference** (September 29–October 2; Hartford, CT) » www.ctconventions.com/event/astc-annual-conference



Q3 FY18 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.

	Q1FY18	Q2FY18	Q3FY18	YTD FY18	TARGETS FY18
ISS National Lab payloads manifested	15	29	16	60	80
ISS National Lab payloads delivered	24	–	45	69	80
Research Procurement					
Solicitations / Competitions	3	1	1	5	5
Number of days from project concept submission to formal proposal submission (cumulative YTD)	82	82	86	86	***
Number of days from formal proposal submission to project selection (cumulative YTD)	29	38.5	39	39	68
Project proposals generated	23	87	14	124	100
Projects awarded	7	7	17	31	50
By customer type					
ISS National Lab return customers	2	3	9	14	***
ISS National Lab new customers	5	4	8	17	***
By entity type					
Commercial	6	3	10	19	***
Academic / Nonprofit	0	4	6	10	***
Government agency	1	0	1	2	***
Total Value of CASIS Grants Awarded*	\$1,085,639	\$1,898,015	\$1,663,718	\$4,647,372	\$5,750,000
Peer-reviewed scientific journal publications	4	5	3	12	***
Products or services created/enhanced	0	0	0	0	***
In-orbit commercial facilities	12	12	14	14	***
In-orbit commercial facility managers	7	7	8	8	***
Projected Incremental Revenue**	~\$900M	~\$900M	~\$900M	~\$900M	***

Secure Independent Funding: Leverage external funding to support ISS National Lab projects through collaborative sponsorships and third-party investments.

	Q1FY18	Q2FY18	Q3FY18	YTD FY18	TARGETS FY18
Sponsored Program/external funding for grants	\$11,400,000	\$250,000	\$250,000	\$11,900,000	\$7,500,000
Investor network participants (cumulative)	80	84	88	88	90
Investments reported from network (cumulative)	\$1,285,000	\$1,335,000	\$1,635,000	\$1,635,000	***

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

** Estimates are based on annual subject matter expert review of self-reported projections from principal investigators. It includes all projects that provide data for the analysis.

*** Informational trend as they occur, not target.



Build reach in STEM: Create STEM programs, educational partnerships, and educational outreach initiatives using ISS National Lab-related content.

	Q1FY18	Q2FY18	Q3FY18	YTD FY18	TARGETS FY18
STEM programs (active)	22	23	23	23	20
<i>Participation in ISS National Lab STEM Programs and educational outreach activities</i>					
Students	117,528	194,753	107,134	419,415	400,000
Educators	6,129	28,144	20,064	54,337	22,000
Mixed Audience	143,279	171,601	748,272	1,063,152	328,000
Total STEM engagement via programs and outreach activities	266,927	518,533	577,136	1,362,596	750,000
Total value of CASIS STEM grants awarded ****	\$0.00	\$231,299	\$5,000	\$236,299	\$400,000

Increase Awareness: Build positive perception of the ISS National Lab within key audience communities.

	Q1FY18	Q2FY18	Q3FY18	YTD FY18	TARGETS FY18
<i>Outreach events</i>					
Conferences and industry event sponsorships	4	4	7	15	20
Speaking engagements	20	18	22	60	85
Subject matter expert workshops	1	0	1	2	8
<i>Total media impact</i>					
Thought leadership publications (e.g., white papers, trade articles, technical papers, magazine issues)	2	2	1	5	5
News mentions (clips, blogs)	4,142	1,478	2,100	7,720	5,000
Twitter followers	117,833	123,166	127,523	127,523	125,000
Website unique visitors	27,077	52,007	61,072	140,156	200,000
Social media engagement, cumulative (Facebook, Twitter, and Instagram)	40,386	102,685	76,655	219,726	1,250,000

Maximize Utilization: CASIS to use 50% of U.S. allocation onboard the ISS.

	Q1FY18	Q2FY18	Q3FY18	YTD FY18	TARGETS FY18
<i>Crew Time</i>					
Actual vs. Increment pair-3 months allocation	***	84%	***	84%	100%
Actual vs. post-increment available	***	49%	***	49%	***

Note: These data are calculated every six months.

*** Informational trend as they occur, not target.

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

FINANCIALS

Business Status Report (unaudited)

APRIL 1 TO JUNE 30, 2018	ACTUAL Q3FY18	BUDGET Q3FY18	VARIANCE Q3FY18	ACTUAL YTD FY18	BUDGET YTD FY18	VARIANCE YTD FY18
Direct Labor	\$1,897,496	\$2,112,699	\$215,203	\$5,160,735	\$6,020,802	\$860,067 ¹
Subcontracts	\$302,335	\$460,475	\$158,140	\$910,671	\$1,507,065	\$596,394 ²
Permanent Equipment	\$13,993	\$42,750	\$28,757	\$40,265	\$158,250	\$117,985
Office Supplies & Equipment	\$52,101	\$69,126	\$17,025	\$177,570	\$205,986	\$28,416
Travel	\$373,481	\$304,660	\$ (68,821)	\$940,791	\$872,515	\$(68,276)
Grants	\$1,569,049	\$2,200,723	\$631,674	\$3,936,343	\$6,991,738	\$3,055,395 ³
Other	\$476,264	\$392,340	\$ (83,924)	\$1,332,465	\$1,297,293	\$(35,172)
Total	\$4,684,719	\$5,582,773	\$898,054	\$12,498,840	\$17,053,649	\$4,554,809

(1) Direct Labor: Actual headcount was 54 versus a budget of 62.

(2) Subcontracts: Lower than budget for Portfolio Management, Science and Technology, Business Development, and Legal.

(3) Grants: Recipient milestone payments shifted based on actual spend or delay in flights.

Breakout of Cooperative Agreement Funding

	Q1 FY18	Q2 FY18	Q3 FY18	Q4 FY18	FY18 TOTAL
Direct	53.4%	54.0%	53.8%		53.8%
Indirect	15.5%	17.0%	12.8%		14.8%
Grants	31.1%	29.0%	33.6%		31.4%

Breakout of CASIS Grants

	Q1 FY18	Q2 FY18	Q3 FY18	Q4 FY18	FY18 TOTAL
Academic	\$236,603	\$247,214	\$261,128		\$744,945
Commercial	\$763,120	\$703,360	\$1,115,761		\$2,582,241
Other Government Agency	-	\$35,000	\$50,000		\$85,000
Mission Based Costs	\$178,126	\$203,871	\$142,160		\$524,157
Total	\$1,177,849	\$1,189,445	\$1,569,049		\$3,936,343

APPENDIX 1: FULL CASIS-SELECTED R&D PORTFOLIO

FLIGHT MANIFEST DETAILS AS OF JUNE 30, 2018

Validation Studies and Ground Testing

PROJECT	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
3D Neural Microphysiological System	AxoSim Technologies	Dr. Michael Moore	New Orleans	LA
Microgravity As A Stress Accelerator for Omic Profiling of Human Disease	Baylor College of Medicine	Dr. Clifford Dacso	Houston	TX
Remote Controlled Nanochannel Implant for Tunable Drug Delivery	Houston Methodist Research Institute	Dr. Alessandro Grattoni	Houston	TX
Unfolded Protein Response in Osteoporosis and Sarcopenia	Louisiana State University Health Sciences Center	Dr. Imran Mungrue	New Orleans	LA
Classrooms in Space	Magnitude.io	Ted Tagami	Berkeley	CA
Orion's Quest-Student Research on the ISS	Orions Quest	Peter Lawrie	Canton	MI
National Design Challenge - 4 Talbot	Talbot Innovation Middle School	Benjamin Coleman	Fall River	MA
Combined Evaluation of Mouse Musculoskeletal Data	University of Colorado Boulder	Dr. Virginia Ferguson	Boulder	CO
Faraday Waves and Instability-Earth and Low G Experiments	University of Florida Board of Trustees	Dr. Ranga Narayanan	Gainesville	FL
Microphysiological System for Studying Composite Skeletal Tissues	University of Pittsburgh	Dr. Rocky S. Tuan	Pittsburgh	PA
Field Scale, Aggregated Best Management Practice Verification and Monitoring	Upstream Tech	Marshall Moutenot	Boston	MA

Preflight

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Corrosion Inhibitor Exposed to the Extreme Environments in Space	A-76 Technologies, LLC	Lauren Thompson Miller	NG-10	11/17/18	Houston	TX
Audacy Lynq	Audacy Corporation	Ellaine Talle	NG-10	11/17/18	Mountain View	CA
Space Development Acceleration Capability (SDAC)	Craig Technologies	Ryan Jeffrey	NG-10	11/17/18	Cape Canaveral	FL
Droplet Formation Studies in Microgravity	Delta Faucet	Garry Marty	NG-10	11/17/18	Indianapolis	IN
Fiber Optics Manufacturing in Space (FOMS)	FOMS Inc.	Dr. Dmitry Starodubov	NG-10	11/17/18	San Diego	CA



PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Pushing the Limits of Silica Fillers for Tire Applications	Goodyear Tire & Rubber Co.	Derek Shuttleworth	NG-10	11/17/18	Akron	OH
Commercial Polymer Recycling Facility (CPRS)	Made In Space	Matthew Napoli	NG-10	11/17/18	Moffett Field	CA
Microfluidic Lab-on-a Chip to Track Biomarkers in Skeletal Muscle Cells	Micro-gRx, Inc.	Dr. Siobhan Malany	NG-10	11/17/18	Orlando	FL
Capillary-Driven Microfluidics in Space	1Drop Diagnostics US, Inc.	Dr. Luc Gervais	SpX-16	11/29/18	Boston	MA
Barley Germination and Malting in Microgravity Objective 3 (1 & 2 complete)	Budweiser	Gary Hanning	SpX-16	11/29/18	New York	NY
Microgravity Crystallization of Glycogen Synthase-Glycogenin Protein Complex	Dover Lifesciences	Dr. David S. Chung	SpX-16	11/29/18	Dover	MA
BioChip Spacelab	HNu Photonics	Dr. Dan O'Connell	SpX-16	11/29/18	Wailuku	HI
Enhancement of Performance and Longevity of a Protein-Based Retinal Implant	LambdaVision	Dr. Nicole L. Wagner	SpX-16	11/29/18	Farmington	CT
Monoclonal Antibody Production and Stability in Microgravity	Medimmune, LLC	Dr. Albert Ethan Schmelzer	SpX-16	11/29/18	Gaithersburg	MD
Preparation of PLGA Nanoparticles Based on Precipitation Technique	Medimmune, LLC	Dr. Puneet Tyagi	SpX-16	11/29/18	Gaithersburg	MD
Crystallization of LRRK2 under Microgravity Conditions (Reflight)	Michael J. Fox Foundation	Dr. Marco Baptista	SpX-16	11/29/18	New York	NY
Biofilm Thickness/Viability and Elevated Microbial Corrosion Risk	Nalco Champion	Dr. Vic Keasler	SpX-16	11/29/18	St. Paul	MN
Microgravity Model for Immunological Senescence on Tissue Stem Cells	University of California, San Francisco	Dr. Sonja Schrepfer	SpX-16	11/29/18	San Francisco	CA
Spaceflight Effects on Vascular Endothelial and Smooth Muscle Cell Processes	University of Florida	Dr. Josephine Allen	SpX-16	11/29/18	Gainesville	FL
Design of Scalable Gas Separation Membranes via Synthesis under Microgravity	Cemsica	Negar Rajabi	SpX-17	2/1/19	Houston	TX
Cartilage-Bone-Synovium Microphysiological System	Massachusetts Institute of Technology	Dr. Alan Grodzinsky	SpX-17	2/1/19	Cambridge	MA
Influence of Gravity on Human Immune Function in Adults and the Elderly	Sanofi Pasteur	Dr. Donald Drake	SpX-17	2/1/19	Orlando	FL
Structure of Proximal and Distal Tubule Microphysiological Systems	University of Washington	Dr. Jonathan Himmelfarb	SpX-17	2/1/19	Seattle	WA

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Multipurpose Active Target Particle Telescope on the ISS	AIRBUS DS Space Systems, Inc.	Dr. Hans-Juergen Zachrau	NG-11	4/17/19	Webster	TX
Inertial Spreading and Imbibition of a Liquid Drop Through a Porous Surface	Cornell University	Dr. Michel Louge	SpX-18	5/7/19	Ithaca	NY
Unmasking Contact-line Mobility for Inertial Spreading using Drop Vibration	Cornell University	Dr. Paul Steen	SpX-18	5/7/19	Ithaca	NY
ISS Bioprinter Facility	Techshot, Inc.	Dr. Eugene Boland	SpX-18	5/7/19	Greenville	IN
The Impact of Nanostructure Geometry on Photo-Thermal Evaporation Processes	University of Notre Dame	Tengfei Luo	SpX-18	5/7/19	Notre Dame	IN
Investigating Proliferation of NanoLaze Gene-edited induced Pluripotent	Cellino Biotech, Inc.	Matthias Wagner	SpX-19	10/15/19	Cambridge	MA
SiC Microgravity Enhanced Electrical Performance	ACME Advanced Materials	Rich Glover	TBD	TBD	Albuquerque	NM
Commercialization of the GLASS Payload	Adcole Maryland Aerospace, LLC	Darko Filipi	TBD	TBD	Crofton	MD
Targeted nanoparticles for orphan and chronic diseases	Aphios Corporation	Trevor Castor	TBD	TBD	Woburn,	MA
The Universal Manufacture of Next Generation Electronics	Astrileux Corporation	Supriya Jaiswal	TBD	TBD	La Jolla	CA
Investigation of Deep Audio Analytics On the International Space Station	Astrobotic Technology Inc.	Fraser Kitchell	TBD	TBD	Pittsburgh	PA
Thermally Activated Directional Mobility of Vapor Bubbles	Auburn University	Sushil Bhavnani	TBD	TBD	Auburn,	AL
Microgravity as Disruptor of the 12-hour Circatidal Clock	Baylor College of Medicine	Dr. Brian York	TBD	TBD	Houston	TX
Cranial Bone Marrow Stem Cell Culture in Space	Brigham and Women's Hospital	Dr. Yang (Ted) D. Teng	TBD	TBD	Boston	MA
ARQ: A Platform for Enhanced ISS Science and Commercialization	bSpace Corporation	Jason Budinoff	TBD	TBD	Seattle	WA
Electrolytic Gas Evolution under Microgravity	Cam Med, LLC	Larry Alberts	TBD	TBD	West Newton	MA
Study of the Interactions between Flame and Surrounding Walls	Case Western Reserve University	Ya-Ting Liao	TBD	TBD	Cleveland	OH
Unlocking the Cotton Genome to Precision Genetics	Clemson University	Christopher A. Saski	TBD	TBD	Pendleton	SC
Rodent Research - 4 (Wound Healing) Post Flight Analysis	Department of Defense	Dr. Rasha Hammamieh	TBD	TBD	Fort Detrick	MD

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
DexMat CASIS CNT Cable Project	DexMat, Inc.	Dr. Alberto Goenaga	TBD	TBD	Houston	TX
Survivability of Variable Emissivity Devices for Thermal Control Applications	Eclipse Energy Systems, Inc.	Dr. Hulya Demiryont	TBD	TBD	St. Petersburg	FL
Generation of Cardiomyocytes from Induced Pluripotent Stem Cells	Emory University	Dr. Chunhui Xu	TBD	TBD	Atlanta	GA
Effects of Microgravity on Human Physiology: Blood-Brain Barrier Chip	Emulate, Inc.	Dr. Chris Hinojosa	TBD	TBD	Cambridge	MA
Crystallization of RAS in Space	Frederick National Laboratory for Cancer Research	Dr. Shimanshu Dhirendrea	TBD	TBD	Frederick	MD
MISSE Variant 2 Exposure of Photovoltaic Cells on the ISS	Georgia Institute of Technology	Dr. Jud Ready	TBD	TBD	Atlanta	GA
Convection-Free Synthesis of 2D Nanomaterials	Guardion Technologies	Dan Esposito	TBD	TBD	Boston	MA
3-D printed RF Systems and Materials for High Frequency Communications	Harris Corporation	Dr. Arthur Paolletta	TBD	TBD	Melbourne	FL
Influence of Microgravity on Neurogenesis	HNu Photonics	Dr. Caitlin O'Connell-Rodwell	TBD	TBD	Wailuku	HI
SCORPIO-V ISS LaserComm (SILC) System	HNu Photonics	Dr. Dan O'Connell	TBD	TBD	Wailuku	HI
Ionic Liquid CO ₂ Scrubber and Liquid Containment in Microgravity	Honeywell International	Phoebe Henson	TBD	TBD	Glendale	AZ
IBM Watson-Multi Modal AI (Astrobee project)	IBM	Christopher Durham	TBD	TBD	Austin	TX
Intuitive Machines-ISS Terrestrial Return Vehicle (TRV)	Intuitive Machines	Steve Altemus	TBD	TBD	Houston	TX
Three-dimensional Microbial Mapping (3DMM) of ISS Environment	Jet Propulsion Laboratory/Caltech	Dr. Kasthuri Venkateswaran	TBD	TBD	Pasadena	CA
Remote Manipulator Small-Satellite System (RM3S)	LaMont Aerospace	Craig Walton	TBD	TBD	Houston	TX
AstroRad Vest - ISSNL Co-Sponsored Project	Lockheed Martin Corporation	Jerry Posey	TBD	TBD	Palo Alto	CA
Test Multilayer Polymer Convection and Crystallization Under Microgravity	Lux Labs	Dr. Yichen Shen	TBD	TBD	Cambridge	MA
Utilizing the MISSE Platform Materials Science In Space	Made In Space	Eric Joyce	TBD	TBD	Moffett Field	CA
AmpliRx: A Manufacturing Pharmaceutical Lightweight Instrument	MakerHealth	Anna Young	TBD	TBD	Boston	MA
National Cancer Institute NExT Space Crystallization Program	National Cancer Institute	Dr. Barbara Mroczkowski	TBD	TBD	Frederick	MD

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED LAUNCH VEHICLE	ESTIMATED LAUNCH DATE	CITY	STATE
Nemak Alloy Solidification Experiments	NEMAK	Dr. Glenn Byczynski	TBD	TBD	Southfield	MI
Nonequilibrium Processing of Particle Suspensions	New Jersey Institute of Technology	Boris Khusid	TBD	TBD	Newark	NJ
Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System	Novopyxis	Dr. Robert Applegate	TBD	TBD	Boston	MA
Metal Additive Manufacturing Aluminum Alloy Satellite Antennas	Optisys	Michael Hollenbeck	TBD	TBD	West Jordan	UT
Furphy-Residual Momentum and Tank Dynamics	Orbit Fab	Daniel Faber	TBD	TBD	Cupertino	CA
A SiC UV Sensor for Reliable Operation in Low Earth Orbit	Ozark Integrated Circuits, Inc.	Jim Holmes	TBD	TBD	Fayetteville	AR
Constrained Vapor Bubbles of Ideal Mixtures	Rensselaer Polytechnic Institute	Dr. Joel Plawsky	TBD	TBD	Troy	NY
MDCK Influenza Virus Infection	Sanofi Pasteur	Dr. Philippe-Alexandre Gilbert	TBD	TBD	Orlando	FL
Lung Host Defense in Microgravity	The Children's Hospital of Philadelphia	Dr. G Scott Worthen	TBD	TBD	Philadelphia	PA
Spacewalk: A Virtual Reality Experience	Time Inc.	Mia Tramz	TBD	TBD	New York	NY
Tympanogen - Wound Healing	Tympanogen, LLC	Dr. Elaine Horn-Ranney	TBD	TBD	Norfolk	VA
Kinetics of Nanoparticle Self-assembly in Directing Fields	University of Delaware	Dr. Eric Furst	TBD	TBD	Newark	DE
An ISS Experiment on Electrodeposition	University of Florida	Dr. Kirk Ziegler	TBD	TBD	Gainesville	FL
Spherical Cool Diffusion Flames Burning Gaseous Fuels	University of Maryland	Peter Sunderland	TBD	TBD	College Park	MD
Effects of Microgravity and Magnetic Fields on Motile Magnetotactic Bacteria	University of Nevada, Las Vegas	Dr. Dennis Bazylinski	TBD	TBD	Las Vegas	NV
Crystal Growth STEM 2018	University of Wisconsin - Madison	Ilia Guzei	TBD	TBD	Madison	WI
Targeting the Roots of Cotton Sustainability	University of Wisconsin - Madison	Dr. Simon Gilroy	TBD	TBD	Madison	WI
Growing Quality Crystals for Bio-Macromolecule Neutron Crystallographic Studies	UT Battelle Oak Ridge National Lab	Dr. Andrey Kovalevsky	TBD	TBD	Oak Ridge	TN
Space Based Optical Tracker	Vision Engineering Solutions	Dr. John Stryjewski	TBD	TBD	Orlando	FL

In Orbit

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED RETURN VEHICLE	ESTIMATED RETURN DATE	CITY	STATE
Domesticating Algae for Sustainable Production of Feedstocks in Space	University of Florida	Dr. Mark Settles	SpX-15	7/31/18	Gainesville	FL
Endothelial Cells In Microgravity for Evaluation of Cancer Therapy Toxicity	Angiex	Dr. Shou-Ching Jaminet	SpX-15	7/31/18	Cambridge	MA
Microgravity Crystal Growth for Improvement in Neutron Diffraction	University of Toledo	Dr. Timothy Mueser	SpX-15	7/31/18	Toledo	OH
Bone Densitometer	Techshot, Inc.	John Vellinger	SpX-15	7/31/18	Greenville	IN
Project Meteor	Southwest Research Institute	Michael Fortenberry	SpX-15	7/31/18	Boulder	CO
Additive Manufacturing Operations Program	Made In Space	Michael Snyder	SpX-15	7/31/18	Moffett Field	CA
Effects of Microgravity on Production of Fluoride-Based Optical Fibers	Made In Space	Michael Snyder	SpX-15	7/31/18	Moffett Field	CA
Enhance the Biological Production of the Biofuel Isobutene	University of Alaska - Anchorage	Brandon Briggs	SpX-15	7/31/18	Anchorage	AK
Neutron Crystallographic Studies of Human Acetylcholinesterase	UT Battelle Oak Ridge National Lab	Dr. Andrey Kovalevsky	SpX-16	1/10/19	Oak Ridge	TN
Quantifying Cohesive Sediment Dynamics for Advanced Environmental Modeling	University of California, Santa Barbara	Dr. Paolo Luzzatto-Fegiz	SpX-16	1/10/19	Santa Barbara	CA
TangoLab-2	Space Tango, Inc.	Twyman Clements	N/A	N/A	Lexington	KY
Windows on Earth - Earth Videos with a Related Education Program	T E R C	David Libby	N/A	N/A	Cambridge	MA
SPHERES Tether - Slosh	AIRBUS DS Space Systems, Inc.	Dr. Hans-Juergen Zachrau	N/A	N/A	Webster	TX
STaARS-1 Research Facility	Space Technology and Advanced Research Systems Inc. (STaARS)	Dr. Heath Mills	N/A	N/A	Houston	TX
Tropical Cyclone Intensity Measurements from the ISS (CyMISS) 2017/2018	Visidyne, Inc.	Dr. Paul Joss	N/A	N/A	Burlington	MA
NanoRacks External Platform	Nanoracks, LLC	Michael Johnson	N/A	N/A	Houston	TX
GLASS AIS TransponderGlobal AIS on Space Station (GLASS)	JAMSS America, Inc.	Rob Carlson	N/A	N/A	Houston	TX
Materials International Space Station Experiment (MISSE) Flight Facility	Alpha Space	Stephanie Murphy	N/A	N/A	Houston	TX
SPHERES-ReSwarm	Massachusetts Institute of Technology	David Miller	N/A	N/A	Cambridge	MA

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	PLANNED RETURN VEHICLE	ESTIMATED RETURN DATE	CITY	STATE
Development and Deployment of Charge Injection Device Imagers	Florida Institute of Technology	Dr. Daniel Batcheldor	TBD	TBD	Melbourne	FL
Orbital Sidekick ISS Hyperspectral Earth Imaging System Trial	Orbital Sidekick	Daniel Katz	TBD	TBD	San Francisco	CA
Spaceborne Computer	Hewlett Packard	David Petersen	TBD	TBD	Milpitas	CA
Detached Melt and Vapor Growth of Indium Iodide	Illinois Institute of Technology	Dr. Aleksandar Ostrogorsky	TBD	TBD	Chicago	IL
Crystal Growth of Cs ₂ LiYCl ₆ :Ce Scintillators in Microgravity	Radiation Monitoring Devices, Inc.	Richard Foresight	TBD	TBD	Watertown	MA

Postflight/Complete

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
Comparative Real-time Metabolic Activity Tracking	490 Biotech, Inc.	Dr. Gary Saylor	Knoxville	TN
Technology Readiness Level Raising of the Net Capture System	AIRBUS DS Space Systems, Inc.	Ron Dunklee	Webster	TX
Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight	Baylor College of Medicine	Dr. Clifford Dacso	Houston	TX
National Design Challenge - 2 Bell	Bell Middle School	Shanna Atzmillier	Golden	CO
Optimizing Jammable Granular Assemblies in a Microgravity Environment	Benevolent Technologies for Health	Jason Hill	Boston	MA
Protein Crystal Growth to Enable Therapeutic Discovery (Clifton)	Beryllium Discovery Corp.	Dr. Matt Clifton	Bedford	MA
Commercial Space-borne Hyperspectral Harmful Algal Bloom (HAB) Products	BioOptoSense, LLC	Dr. Ruhul Amin	Metairie	LA
Implantable Glucose Biosensors	Biorasis, Inc.	Dr. Michail Kastellorizios	Storrs / Mansfield	CT
Ants in Space	BioServe Space Technologies	Stefanie Countryman	Boulder	CO
Osteocyte Response to Mechanical Forces	Boston University	Dr. Paola Divieti Pajevic	Boston	MA
National Design Challenge - 3 McFarland	Boy Scouts of America	Norman McFarland	Chicago	IL
National Design Challenge - 3 Rogers	Boy Scouts of America	Dr. Sandra Rogers	Chicago	IL
SG100 Cloud Computing Payload	Business Integra Technology Solutions (BI Tech)	Trent Martin	Houston	TX
Crystallization of Huntington Exon-1 Using Microgravity	California Institute of Technology	Dr. Pamela Bjorkman	Pasadena	CA
National Design Challenge - 2 Centaurus	Centaurus High School	Brian Thomas	Lafayette	CO

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
National Design Challenge - 2 Chatfield	Chatfield Senior High School	Joel Bertelsen	Littleton	CO
Microgravity Electrodeposition Experiment	Cobra Puma Golf	Michael Yagley	Carlsbad	CA
National Design Challenge - 4 Collins	Collins Middle School	Matthew Weaver	Salem	MA
Controlled Dynamics Locker for Microgravity Experiments on ISS	Controlled Dynamics Inc.	Dr. Scott A. Green	Huntington Beach	CA
Spacecraft-on-a-Chip Experiment Platform	Cornell University	Dr. Mason Peck	Ithaca	NY
National Design Challenge - 1 Cristo Rey	Cristo Rey Jesuit College Preparatory of Houston	Brian Reedy	Houston	TX
Providing Spherical Video Tours of ISS	Deep Space Industries	David Gump	Moffett Field	CA
Providing Spherical Video Tours of ISS	Deep Space Industries	David Gump	Moffett Field	CA
National Design Challenge - 1 Duchesne Duquesnay	Duchesne Academy of the Sacred Heart	Kathy Duquesnay	Houston	TX
National Design Challenge - 1 Duchesne Knizner	Duchesne Academy of the Sacred Heart	Susan Knizner	Houston	TX
Lyophilization in Microgravity (Reflight)	Eli Lilly and Company	Jeremy Hinds	Indianapolis	IN
Rodent Research - 3	Eli Lilly and Company	Dr. Rosamund Smith	Indianapolis	IN
Eli Lilly - Protein Crystal Growth 1	Eli Lilly and Company	Kristofer Gonzalez-DeWhitt	Indianapolis	IN
Dissolution of Hard-to-Wet Solids	Eli Lilly and Company	Alison Campbell	Indianapolis	IN
Eli Lilly - Protein Crystal Growth 2	Eli Lilly and Company	Michael Hickey	Indianapolis	IN
Generation of Cardiomyocytes from Human Induced Pluripotent Stem Cells	Emory University	Dr. Chunhui Xu	Atlanta	GA
Testing TiSi ₂ Nanonet Based Lithium Ion Batteries for Safety in Outer Space	EnerLeap	Emily Fannon	Newton	MA
Tomatosphere Aims 1 & 2	First the Seed Foundation	Ann Jorss	Alexandria	VA
Materials Testing Earth Abundant Textured Thin Film Photovoltaics (Post flight)	Georgia Institute of Technology	Dr. Jud Ready	Atlanta	GA
Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples	Hauptman Woodward Medical Research Institute, Inc.	Dr. Edward Snell	Buffalo	NY
Exploiting On-orbit Crystal Properties for Medical and Economic Targets	Hauptman Woodward Medical Research Institute, Inc.	Dr. Edward Snell	Buffalo	NY
Implantable Nanochannel System for Delivery of Therapeutics for Muscle Atrophy	Houston Methodist Research Institute	Dr. Alessandro Grattoni	Houston	TX
The Effect of Microgravity on Stem Cell Mediated Recellularization	Houston Methodist Research Institute	Dr. Alessandro Grattoni	Houston	TX
Decoupling Diffusive Transport Phenomena in Microgravity	Houston Methodist Research Institute	Dr. Alessandro Grattoni	Houston	TX

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
Architecture to Transfer Remote Sensing Algorithms from Research to Operations	HySpeed Computing	Dr. James Goodman	Miami	FL
Rodent Research-4 Validation Study	Indiana University Research	Dr. Melissa Kacena	Indianapolis	IN
IPPase Crystal Growth in Microgravity	iXpressGenes, Inc.	Dr. Joseph Ng	Huntsville	AL
Global Receive Antenna and Signal Processor (GRASP)	JAMSS America, Inc.	Rob Carlson	Houston	TX
Molecules Produced in Microgravity from the Chernobyl Nuclear Accident	Jet Propulsion Laboratory/ Caltech	Dr. Kasthuri Venkateswaran	Pasadena	CA
Improving Astronaut Performance of National Lab Research Tasks	Juxtopia, LLC	Dr. Jayfus Doswell	Baltimore	MD
Role Of Gravity And Geomagnetic Field In Flatworm Regeneration	Kentucky Space, LLC	Dr. Mahendra Jain	Lexington	KY
Assessing Osteoblast Response to Tetranite	LaunchPad Medical	Dr. Nikolaos Tapinos	Boston	MA
Functional Effects of Spaceflight on Cardiovascular Stem Cells	Loma Linda University	Dr. Mary Kearns-Jonker	Loma Linda	CA
Viral Infection Dynamics and Inhibition by the Vecoy Nanotechnology	Lovelace Respiratory Research Institute	Dr. Drew Cawthon	Albuquerque	NM
Application of Microgravity Expanded Stem Cells in Regenerative Medicine	Mayo Clinic	Dr. Abba Zubair	Rochester	MN
Merck Protein Crystal Growth - 3	Merck Pharmaceuticals	Dr. Paul Reichert	Whitehouse Station	NJ
Great Lakes Specific HICO Water Quality Algorithms	Michigan Technological University	Dr. Robert Shuchman	Houghton	MI
Vertical Burn	Milliken	Dr. Jeff Strahan	Spartanburg	SC
Dependable Multi-processor Payload Processor Validation	Morehead State University	Dr. Benjamin Malphrus	Morehead	KY
Magnetic 3D Cell Culture for Biological Research in Microgravity	Nano3D Biosciences, Inc.	Dr. Glauco Souza	Houston	TX
Proof-of-Concept for Gene-RADAR Predictive Pathogen Mutation Study	Nanobiosym	Dr. Anita Goel	Cambridge	MA
Validation of WetLab-2 System for qRT-PCR Capability on ISS	NASA ARC	Julie Schonfeld	Mountain View	CA
National Ecological Observatory Network (NEON)	National Ecological Observatory Network (NEON)	Brian Penn	Boulder	CO
The Effects of Microgravity on Synovial Fluid Volume and Composition	National Jewish Health	Dr. Richard Meehan	Denver	CO
Impact of Increased Venous Pressure on Cerebral Blood Flow Velocity Morphology	Neural Analytics	Dr. Robert Hamilton	Los Angeles	CA
T-Cell Activation in Aging-1 & 2	Northern California Institute for Research and Education, Inc.	Dr. Millie Hughes-Fulford	San Francisco	CA

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
Rodent Research - 1	Novartis Institute for Biomedical Research	Dr. David Glass	Cambridge	MA
Rodent Research - 2	Novartis Institute for Biomedical Research	Dr. David Glass	Cambridge	MA
Zero-G Characterization & OnOrbit Assembly for Cellularized Satellite Tech	NovaWurks, Inc	Talbot Jaeger	Los Alamitos	CA
Efficacy and Metabolism of Azonafide Antibody-Drug Conjugates (ADCs)	Oncolinx Pharmaceuticals LLC	Sourav Sinha	Boston	MA
Low Phase Gravity Kinetics	Procter and Gamble Company	Dr. Matthew Lynch	West Chester	OH
Protein Crystal Growth to Enable Therapeutic Discovery (Gerdt's)	Protein BioSolutions	Dr. Cory Gerdt's	Gaithersburg	MD
Microbead Fabrication using Rational Design Engineering	Quad Technologies	Dr. Brian Plouffe	Beverly	MA
Utilize ISS Energy Systems Data for Microgrid Design and Operation	Raja Systems	Nicholas Kurlas	Boston	MA
Synthetic Muscle: Resistance to Radiation	Ras Labs	Dr. Lenore Rasmussen	Hingham	MA
Using the ISS to Evaluate Antibiotic Efficacy and Resistance (AES-1)	Regents of the University of Colorado	Dr. David Klaus	Denver	CO
Crystallization of Medically Relevant Proteins Using Microgravity	Saint Louis University	Dr. Sergey Korolev	Saint Louis	MO
High Data Rate Polarization Modulated Laser Communication System	Schafer Corporation	Dr. Eric Wiswell	Huntsville	AL
Reducing Signal Interruption from Cosmic Ray Background in Neutron Detectors	Silverside Detectors	Dr. Andrew Inglis	Cambridge	MA
Hyperspectral Mapping of Iron-bearing Minerals	Space Science Institute	Dr. William H. Farrand	Boulder	CO
TangoLab-1: Research Server for the ISS	Space Tango, Inc.	Twyman Clements	Lexington	KY
Intraterrestrial Fungus Grown in Space (iFunGIS)	Space Technology and Advanced Research Systems Inc. (STaARS)	Dr. Heath Mills	Houston	TX
Intracellular Macromolecule Delivery and Cellular Biomechanics in Microgravity	SQZ Biotechnologies	Harrison Bralower	Watertown	MA
Effects of Microgravity on Stem Cell-Derived Heart Cells	Stanford University	Dr. Joseph Wu	San Francisco	CA
Mutualistic Plant/Microbe Interactions	SyNRGE, LLC	Dr. Gary Stutte	Titusville	FL
Windows On Earth	T E R C	David Libby	Cambridge	MA
Examine Bone Tumor and Host Tissue Interactions Using Micro-Gravity Bioreactors	Texas A&M Health Science Center	Dr. Carl Gregory	College Station	TX
National Design Challenge - 1 Awtry Glidwell	The Awtry International School	Angela Glidwell	Houston	TX
National Design Challenge - 1 Awtry Smith	The Awtry International School	Jessika Smith	Houston	TX

PROJECT NAME	INSTITUTION	PRINCIPAL INVESTIGATOR	CITY	STATE
Genes in Space - 5 Lakeside	The Boeing Company	Sophia Chen	Chicago	IL
Genes in Space - 5 Stuyvesant	The Boeing Company	Elizabeth Reizis	Chicago	IL
Genes In Space	The Boeing Company	Anna-Sophia Boguraev	Chicago	IL
Genes in Space - 2	The Boeing Company	Julian Rubinfiem	Chicago	IL
Street View Imagery Collect on ISS	ThinkSpace	Anna Kapusta	Mountain View	CA
The Effect of Macromolecular Transport on Microgravity PCG	University of Alabama at Birmingham	Dr. Lawrence ("Larry") DeLucas	Birmingham	AL
Crystallization of Human Membrane Proteins in Microgravity	University of Alabama at Birmingham	Dr. Stephen Aller	Birmingham	AL
Systemic Therapy of NELL-1 for Osteoporosis (Rodent Research - 5)	University of California, Los Angeles	Dr. Chia Soo	Los Angeles	CA
Molecular Biology of Plant Development	University of Florida Board of Trustees	Dr. Anna-Lisa Paul	Gainesville	FL
Characterizing Arabidopsis Root Attractions (CARA) grant extension	University of Florida Board of Trustees	Dr. Anna-Lisa Paul	Gainesville	FL
Conversion of Adipogenic Mesenchymal Stem Cells into Mature Cardiac Myocytes	University of Houston	Dr. Robert Schwartz	Houston	TX
Generation of Mesendoderm Stem Cell Progenitors in the ISS-National Laboratory	University of Houston	Dr. Robert Schwartz	Houston	TX
Hyperspectral Remote Sensing of Terrestrial Ecosystem Carbon Fluxes	University of Maryland Baltimore County	Dr. Fred Huemrich	Baltimore	MD
Effects of Simulated Microgravity on Cardiac Stem Cells	University of Miami	Dr. Joshua Hare	Miami	FL
Gravitational Regulation of Osteoblast Genomics and Metabolism	University of Minnesota	Dr. Bruce Hammer	Minneapolis	MN
Protein Crystal Growth for Determination of Enzyme Mechanisms	University of Toledo	Dr. Constance Schall	Toledo	OH
Identification of Harmful Algal Blooms	University of Toledo	Dr. Richard Becker	Toledo	OH
Crystal Growth STEM 2017	University of Wisconsin - Madison	Ilia Guzei	Madison	WI
Drug Development and Human Biology: Use of Microgravity for Drug Development	Veterans Administration Medical Center	Dr. Timothy Hammond	Durham	NC
Tropical Cyclone Intensity Measurements from the ISS (CyMISS)	Visidyne, Inc.	Dr. Paul Joss	Burlington	MA
Tropical Cyclone Intensity Measurements from the ISS (CyMISS) 2015 Season	Visidyne, Inc.	Dr. Paul Joss	Burlington	MA
Materials Testing: The Evaluation of Gumstix Modules in Low Earth Orbit	Yosemite Space	Dr. Kathleen Morse	Groveland	CA
Continuous Liquid-Liquid Separation in Microgravity	Zaiput Flow Technologies	Dr. Andrea Adamo	Cambridge	MA



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