ISS National Laboratory
CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE

International Space Station National Laboratory
Annual Report for Fiscal Year 2021

Published January 31, 2022

Authorized for submission to NASA by: *Ramon Lugo III*

Contents

About the International Space Station National Laboratory: The International Space Station (ISS) is a one-of-a-kind laboratory that enables research and technology development not possible on Earth. As a public service enterprise, the ISS National Lab allows researchers to leverage this multiuser facility to improve quality of life on Earth, mature space-based business models, advance science literacy in the future workforce, and expand a sustainable and scalable market in low Earth orbit. Through this orbiting national laboratory, research resources on the ISS are available to support non-NASA science, technology, and education initiatives from U.S. government agencies, academic institutions, and the private sector. The Center for the Advancement of Science in Space, Inc. (CASIS) manages the ISS National Lab, under Cooperative Agreement with NASA, facilitating access to its permanent microgravity research environment, a powerful vantage point in low Earth orbit, and the extreme and varied conditions of space. To learn more about the ISS National Lab, visit www.ISSNationalLab.org.

Mission: We manage the International Space Station National Laboratory as a public service in order to benefit the U.S. taxpayer and to foster a scalable and sustainable low Earth orbit economy. We leverage our core competencies, facilitate public-private partnerships, and utilize the platform capabilities and unique operating environment of the space station. We stimulate demand, incubate in-space business ventures, provide access for and awareness of fundamental science and technological innovation, and promote science literacy of the future workforce.

Vision: To be the Center of Excellence advancing U.S. leadership in commercial space, fostering science and innovation in microgravity and inspiring the next generation.

Executive Summary

Fiscal year 2021 (FY21) began with a significant milestone for the International Space Station (ISS)—a transition into the third decade of crewed space operations. Reflecting on the past 20 years of continuous human presence on the ISS, it is humbling to see how much has been accomplished through this powerful space-based laboratory. Research and technology development (R&D) on the ISS has provided tangible benefit for people on Earth through the advancement of research, exploration, and the industrialization of low Earth orbit (LEO). The ISS National Laboratory plays a critical role both in demonstrating the value of space-based R&D to improve life on Earth and in driving a sustainable and robust market in LEO. The many accomplishments of the ISS National Lab in FY21 showcase our continued progress in fulfilling this incredible mission.

FY21 Successes

In the 10 years of the Center for the Advancement of Science in Space, Inc. (CASIS) Cooperative Agreement with NASA to manage the ISS National Lab, more than 500 ISS National Lab-sponsored payloads, representing more than 600 investigations, have launched to the space station. This includes 88 payloads delivered FY21—the second most ever launched in a single fiscal year. Commercial interest in leveraging the ISS National Lab continues to increase, with more than 75% of payloads delivered in FY21 representing R&D from the private sector. This year, commercial partners included multiple Fortune 500 companies such as Colgate-Palmolive, Target Corp., Eli Lilly & Co., Bristol Myers Squibb, GlaxoSmithKline, Lockheed Martin Corp., and Hewlett Packard Enterprise. This was also a robust year in terms of R&D progress, with 27 peer-reviewed articles detailing results related to ISS National Lab-sponsored research—tying last year for the highest number of publications in a fiscal year. Additionally, a new patent was filed by Emulate, Inc. for tissue chip technology developed in part through the company's ISS National Lab-sponsored R&D.

> ***"We are now entering the third and most productive decade of the ISS—a decade of results that will provide valuable benefits for humanity. The ISS National Lab has played a key role in stimulating demand for space-based R&D, which is critical as we work to establish the commercial LEO destinations of the future."***
>
> *– Robyn Gatens, NASA Director of the International Space Station*

Several FY21 achievements highlight the success of the ISS National Lab in stimulating expansion of the LEO economy. A record-setting 85% of total costs for ISS National Lab-sponsored projects selected this year were externally funded, demonstrating an increasing demand for space-based R&D among both commercial entities and academic research institutions. To date, more than $240 million in external, non-NASA funding has been committed in support of ISS National Lab-sponsored investigations. The ISS National Lab has continued to foster supply-side growth of the LEO economy through support of a diverse and growing community of Implementation Partners. In FY21, nearly 95% of CASIS funding was put toward Implementation Partner costs for ISS

National Lab-sponsored projects. In-orbit capabilities also expanded this year with a new commercial ISS facility joining the 17 commercial facilities already on station. ISS National Lab utilization is also generating significant investment—to date, nearly $1.2 billion in cumulative funding has been raised by startup companies following ISS National Lab-sponsored flight projects. Moreover, the ISS National Lab Investor Network continues to grow by more than 20% each year, reaching 245 members in FY21.

The ISS National Lab has continued efforts to advance science literacy in the future workforce, leveraging the space station as a powerful platform for science, technology, engineering, and mathematics (STEM) education. In FY21, Space Station Explorer education partner programs engaged nearly 3.8 million people. Furthermore, 70% of the participants in Space Station Explorers partner programs this year were female, and 40% represented underserved communities. Also, in FY21, the Space Station Ambassador program grew to more than 1,600 ambassadors—doubling in size since FY19. These volunteers share information about Space Station Explorers resources in their communities, helping to further extend the reach of ISS National Lab education initiatives.

A Decade of Evolution

All of these ISS National Lab successes reflect a decade of guidance from CASIS, which celebrated the 10-year anniversary of its management of the ISS National Lab in FY21. Over this 10-year period, CASIS has built the foundation for the successes achieved today. Powerful partnerships developed by CASIS have continued to mature, serving to expand the ISS National Lab portfolio and further drive demand. Through multiyear partnerships with CASIS, the National Institutes of Health (NIH) and the National Science Foundation (NSF) have provided more than $35 million in funding, supporting nearly 50 ISS National Lab-sponsored investigations to advance fundamental and translational research in both the physical and life sciences. Additionally, CASIS has partnered with Boeing for multiple years in collaboration with MassChallenge to support innovative startup companies through the Technology in Space Prize. Since its inception in 2013, the prize has provided $8.8 million in funding to 27 startups for R&D sponsored by the ISS National Lab.

In the last 10 years, the strategic areas of focus for the ISS National Lab have evolved to center on key research areas that have shown the most potential to provide value to our nation. In FY21, CASIS released a new series of ISS National Lab Research Announcements (NLRAs) focused on these targeted areas, which include technology development and demonstration, in-space production applications (in advanced manufacturing and materials as well as tissue engineering and biomanufacturing), and STEM education (both kindergarten through 12th grade and higher education).

FY21 also marked the 10th anniversary of the annual ISS Research and Development Conference (ISSRDC). Over the last decade, ISSRDC has played a crucial role in bringing together researchers, engineers, entrepreneurs, thought leaders, investors, and the public to discuss the value of space-based R&D now and in the future.

Looking to the Future

CASIS continues to evolve as we begin to bring the ISS National Lab into a new era—transitioning from a decade of utilization to a decade of results guiding us toward the robust LEO economy of the future. Part of this evolution included review from an Independent Review Team appointed by NASA to help guide the future of the ISS National Lab. Actions addressing recommendations from this review included the development of a new CASIS Board of Directors, the establishment of a new ISS National Lab User Advisory Committee (UAC), and the assignment of an ISS National Lab program executive at NASA Headquarters as the primary liaison to CASIS. These actions have served to streamline communication between CASIS, NASA, and the ISS National Lab user community as we work together to maximize the science return of the ISS National Lab.

"The UAC was established to provide an organized framework and independent vehicle for interaction between ISS National Lab management and users to ensure effective use of the national laboratory by the research community. Working together, we all have a voice in optimizing ISS National Lab utilization, allowing for the maximization of science return from this powerful research platform in low Earth orbit."

– Douglas Matson, ISS National Lab User Advisory Committee Chair and Science Subcommittee Chair

CASIS will continue to build on the accomplishments and knowledge gained over the last 10 years to accelerate growth and investment in the LEO economy, focusing on the opportunities with the most promise to provide value to people on Earth. In the years to come, CASIS is dedicated to carrying out the important mission of the ISS National Lab and paving the way for a future national laboratory in LEO that provides a continuing capability for space-based R&D that benefits the nation.

A Personal Note From Ramon Lugo, Principal Investigator and Acting CEO of CASIS

I am honored to have joined CASIS as principal investigator and acting chief executive officer this year. Moving into our second decade of management of the ISS National Lab, I have great optimism as we continue our mission to advance science in space to benefit life on Earth and drive a robust and scalable market in LEO. Over the past 10 years, we have achieved remarkable results, facilitating the flight of more than 500 ISS National Lab-sponsored payloads, spurring more than $1 billion in private investment following ISS National Lab-sponsored flight projects, and impacting millions of people through our powerful education initiatives.

These achievements provide a solid base on which to build as we enter the third decade of continuous ISS operations. CASIS looks forward to continuing to work with our stakeholders to deliver valuable results, build a sustainable model for a space-based national laboratory in this decade and beyond, and inspire both the current and future generations.

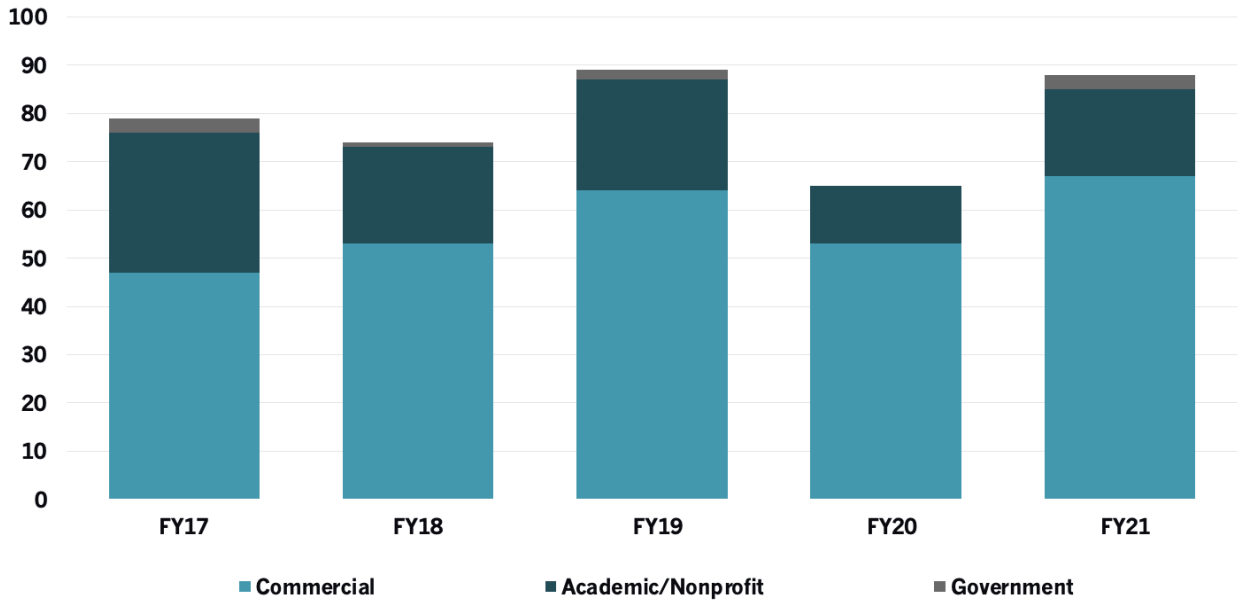
In-Orbit Activities: The ISS as a Research Platform

At a Glance

- More than 500 ISS National Lab-sponsored payloads have launched to the ISS in the last 10 years, including 88 payloads delivered this year.
- A significant number of payloads delivered in FY21 were from private-sector partners, including Colgate-Palmolive, Target Corp., Eli Lilly & Co., Bristol Meyers Squibb, GlaxoSmithKline, Lockheed Martin Corp., and Hewlett Packard Enterprise.
- Top research institutions such as Notre Dame University, Cornell University, Stanford University, and the Palo Alto Veterans Research Institute leveraged the ISS National Lab this year to advance their R&D.
- This year's nearly 950 hours of crew-time utilization is the second highest in a single fiscal year and almost 200 more hours than in FY20.

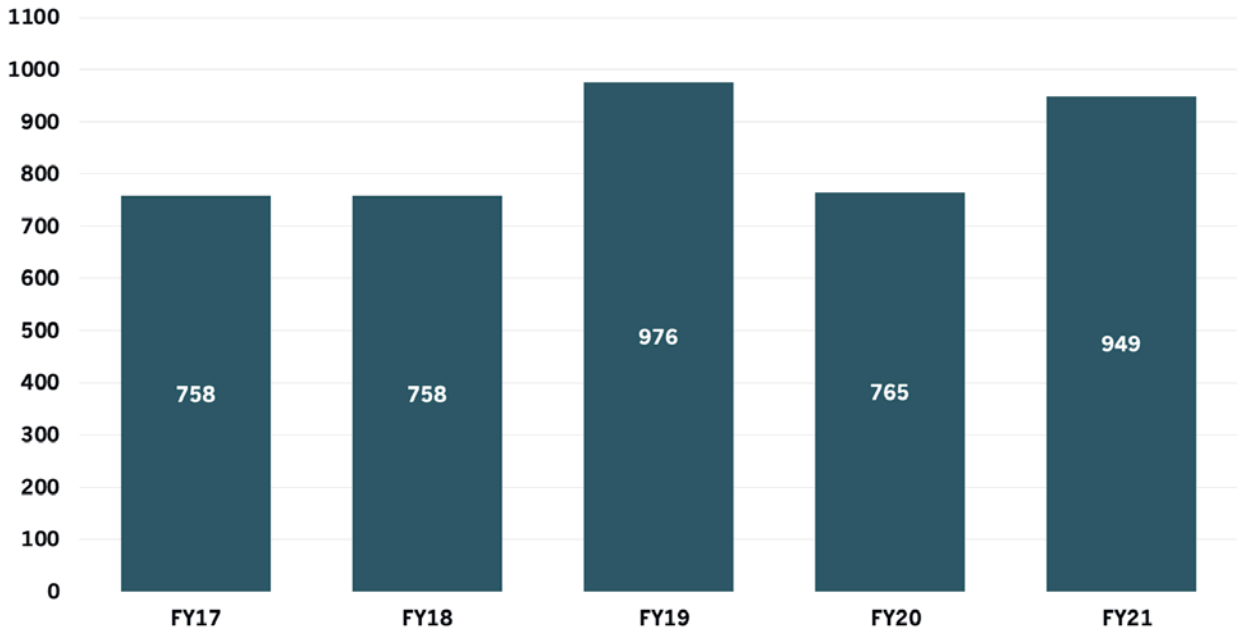
The ISS National Lab continued to maximize utilization and science return in FY21. This year, the number of ISS National Lab-sponsored payloads delivered was the second highest number ever in a single fiscal year (88 payloads). This brings the total number of ISS National Lab-sponsored payloads delivered to the space station to 538, representing more than 600 investigations launched in the 10 years of CASIS management. Private-sector utilization of the ISS National Lab has been steadily increasing over the past decade, and more than 75% of the payloads delivered this fiscal year represent projects from industry partners.

Five-Year Trend in Payloads Delivered



In FY21, the ISS National Lab utilized nearly 950 crew-time hours, the second highest number of hours ever used in a single fiscal year. The availability of crew time fluctuates depending on a variety of factors, and the addition of an unanticipated fifth U.S. crew member in FY21 resulted in a significant increase in crew-time hours available this fiscal year. In FY19 and FY20, the ISS National Lab has utilized more than 100% of its NASA-allocated crew time. While the percentage of crew-time utilization this year is a bit lower (76%), the number of crew-time hours used in FY21 surpassed FY20 by almost 200 hours.

Five-Year Trend in Crew-Time Utilization (Hours)



In-orbit activities associated with FY21 payloads included the following:

- A project from the University of Maryland awarded through an NSF/CASIS solicitation made headlines when unusual "cool flames" were discovered during in-orbit activities. Results could lead to advancements in future engine production on Earth.
- Hewlett Packard Enterprise's Spaceborne Computer-2 (SBC-2) was installed on the ISS and began operations. Following SBC-1's successful 1.5-year technology demonstration on the ISS, SBC-2 enables in-space data processing and analysis.
- Global consumer care company Colgate-Palmolive launched the first private-sector oral health care investigation to the ISS. Results could help the company develop more effective products for consumers on Earth.
- Three large pharmaceutical companies (Bristol Myers Squibb, GlaxoSmithKline, and Eli Lilly and Company) launched investigations aimed at informing drug development.

- ISS crew members worked on an investigation from startup Kernal Biologics that could help lead to new treatments for leukemia; the project was funded by Boeing and CASIS through the Technology in Space Prize in partnership with the MassChallenge startup accelerator.
- The first project from the NSF/CASIS collaboration supporting tissue engineering R&D on the ISS launched; the project is aimed at developing a tissue-engineered model of sarcopenia (age-related muscle loss).
- Several companies continued investigations focused on producing high-quality ZBLAN optical fiber in space, including a project from Physical Optics Corporation (acquired by Mercury Systems Inc. in December 2020) using the company's Orbital Fiber Optic Production Module.
- Lockheed Martin Corporation (in collaboration with StemRad) tested the performance of the AstroRad radiation shielding vest on ISS crew members.

Payloads are delivered to the ISS as part of Commercial Resupply Services (CRS) and Commercial Crew missions. In FY21, five CRS missions and two Commercial Crew missions launched:

- SpaceX Crew-1 carried the first ISS National Lab-sponsored payload delivered by the Commercial Crew Program—a student experiment from the Genes in Space program.
- SpaceX CRS-21 included several NIH-funded Tissue Chips in Space investigations, a protein crystallization experiment from Bristol Meyers Squibb, a brain organoid investigation from the University of California San Diego, multiple student-led experiments, and a project to map the distribution of bacteria and their metabolites in the ISS.
- Northrop Grumman CRS-15 delivered Hewlett Packard Enterprise's Spaceborne Computer-2, Redwire Space's Industrial Crystallization Facility, and several projects leveraging the MISSE Flight Facility.
- SpaceX Crew-2 astronauts supported numerous ISS National Lab-sponsored projects while on station, including several NIH- and NSF-funded regenerative medicine experiments, multiple investigations from the private sector, and student-led research.
- SpaceX CRS-22 included investigations from several well-known private-sector companies (Colgate-Palmolive, Target Corporation, and Eli Lilly & Co.), a fundamental physics project from the University of Notre Dame, and an NSF-funded fluid dynamics investigation.
- Northrop Grumman CRS-16 carried an NSF-funded tissue engineering investigation and a Genes in Space student experiment.
- SpaceX CRS-23 payloads included multiple investigations leveraging the MISSE Flight Facility and a new biological experiments facility from BioServe Space Technologies.

> ***"The International Space Station is an unparalleled and unique research platform in low Earth orbit that enables scientific research not possible on our planet. Through the ISS National Laboratory, scientists are provided an avenue to access the orbiting platform. ISS National Lab researchers are able to address a myriad of scientific questions through space-based research and development that drive advancements that can benefit life on Earth."***
>
> *– Kate Rubins, NASA Astronaut*

R&D Progress and Successes

At a Glance

- This year, 27 peer-reviewed publications detail results related to ISS National Lab-sponsored R&D, with a majority related to investigations funded by NIH and NSF.
- Since 2016, joint CASIS/NSF solicitations have resulted in more than $22 million in funding awarded to investigators via NSF grant awards and funding for Implementation Partner costs to support ISS National Lab flight projects.
- CASIS released four NLRAs this year to support advancement of ISS National Lab R&D strategic focus areas.

FY21 was a robust year for ISS National Lab R&D progress, with 27 peer-reviewed publications on investigations sponsored by the ISS National Lab, tying last year's record for most publications in a single fiscal year. This brings the total number of peer-reviewed articles resulting from ISS National Lab-sponsored R&D to more than 150, and the total number of internationally published articles from ISS research to nearly 3,000. These publications complement the 15 products, multiple spinoff companies, and 5 patents to date resulting from ISS National Lab-sponsored research.

Most of this year's peer-reviewed publications (citations for which can be found in Appendix E) were related to investigations funded through joint solicitations with NSF and NIH, with the majority focused on aspects of tissue engineering and regenerative medicine. Peer-reviewed journal articles such as these are a critical means to disseminate findings from fundamental R&D activities. Journal publications not only advance scientific knowledge but also lend credibility, prestige, and merit to investigators who test hypotheses and demonstrate the capabilities of research platforms such as the ISS.

Further bolstering the ISS National Lab focus area of regenerative medicine, the Cell Press publishing company released a special collection of 23 articles on the biology of spaceflight. Several of these articles mentioned ISS National Lab R&D, and one was authored by ISS National Lab staff highlighting open-source spaceflight data. Additionally, a perspective paper was published in Preprints discussing the goals and outcomes of a Biomanufacturing in Space Symposium co-hosted by the ISS National Lab and the University of Pittsburgh's McGowan Institute for Regenerative Medicine. The symposium

"The ISS National Lab is an unparalleled testing ground that is advancing science in numerous fields. From tissue engineering and regenerative medicine to technology development, in-space production applications, and advanced materials, scientists are leveraging the ISS National Lab for research activities that impact the future value of LEO to the nation."

– Elizabeth Cantwell, CASIS Board of Directors Chair

gathered more than 130 thought leaders in regenerative medicine and space-based R&D as a first step in developing a roadmap to establish a sustainable biomanufacturing market in LEO.

FY21 peer-reviewed publications include the following:

- Two peer-reviewed publications detail results from a rodent research investigation examining the effects of microgravity on wound healing. The articles discuss how spaceflight provides a unique environment to identify key biomolecular processes that facilitate tissue regeneration.
- An investigator from Loma Linda University published a new paper detailing the impact of microgravity on cardiac progenitor cells (early-stage heart cells). This marks the fifth publication on results from this investigation, which is leveraging microgravity to improve cell-based therapies for heart conditions on Earth.
- An Emory University researcher, working with ISS National Lab Commercial Service Provider Techshot, Inc., published a paper on a new protocol for cryopreserving cardiac progenitor cells, transporting them to the ISS, and cultivating them in space. The protocol makes it easier to deliver cells to the ISS, provides more flexibility in preparing for launch, reduces the impact of launch loads on the cells, and allows for changes in astronaut schedules. Such protocols are critical to achieving the long-term goals of in-space biomanufacturing.
- Student researchers published results from their ISS National Lab-sponsored investigation in the open access journal PLOS One. Their project, awarded through the Genes in Space program, was the first to utilize CRISPER/Cas9 gene editing techniques in space.
- This year, 11 published papers detailed work on projects sponsored through the NIH Tissue Chips in Space initiative. An additional 11 papers discussed investigations awarded through NSF/CASIS joint solicitations (five on tissue engineering and six in the physical sciences area of transport phenomena).

"NCATS' collaboration with the ISS National Lab exemplifies how novel partnerships with nontraditional NIH partners can lead to truly catalytic and transformative outcomes that have direct benefits to public health as well as biomedical research here on Earth.

For example, we learned that tissue chips can robustly model the physiological changes under microgravity exposure which are now being pursued as models of accelerated aging that could eventually lead to the development of countermeasures. Moreover, the requirements for spaceflight payload development have led our tissue chip scientists to miniaturize their instruments towards a smaller footprint, and also to automate the operations, leading to turnkey technologies.

These advances would have taken considerably longer without the collaboration with the ISS National Lab."

– Danilo Tagle, National Center for Advancing Translational Sciences (NCATS) Director, Office of Special Initiatives

Additionally, in FY21, biotechnology company Emulate, Inc. filed a patent related to its Intestine On-Chip, developed in part through company's NIH-funded Tissue Chips in Space research. This marks the second patent Emulate has filed for this technology. Additionally, the company released its commercially available Brain-Chip this year, also developed through Tissue Chips in Space research. The Brain-Chip provides a model to study diseases involving neuroinflammation, such as Alzheimer's and Parkinson's, and to test potential new therapeutics. Emulate plans to fly a version of the Brain-Chip to the space station in another ISS National Lab-sponsored investigation scheduled to launch in FY22.

To support the full R&D life cycle (from fundamental research to product commercialization), multiple ISS National Lab solicitations were released in FY21. On the front end of the research life cycle, two FY21 NSF-funded solicitations continued to support fundamental science that leverages the persistent microgravity environment of the ISS to advance scientific discovery for the benefit of Earth. Since 2016, CASIS has partnered with the NSF Engineering Directorate on these annual research solicitations, including six solicitations in the physical sciences area of transport phenomena (2016 through 2021) and four solicitations in the biomedical area of tissue engineering and mechanobiology (2018 through 2021). In total, these solicitation cycles have resulted in the award of 38 NSF peer-reviewed proposals representing 40 payloads—and the infusion of more than $22 million of non-NASA grant funding to the principal investigators via the NSF grant awards and funding for the Implementation Partners supporting their spaceflight investigations.

"Our collaborative work with CASIS has stimulated fundamental advances in tissue engineering and mechanobiology that are only possible with experiments done in true microgravity. The results of these projects will benefit life on Earth."

- Stephanie George, NSF Program Director, Engineering of Biomedical Systems and Laurel Kluxhaus, NSF Program Director, Biomechanics and Mechanobiology

In support of the later stages of product development, CASIS released a new series of NLRAs during FY21 to advance ISS National Lab R&D strategic focus areas. One NLRA sought flight projects within applied research and development, translational science, technology readiness level maturation, and technology demonstrations. Two additional NLRAs were focused on in-space production applications, one in advanced manufacturing and materials and the other in tissue engineering and biomanufacturing. Another NLRA was centered on STEM education, specifically focusing on digital engagement and higher education. In total, $3.4 million was committed in support of these new initiatives, and during FY21, 25 projects were selected under these NLRAs. (For a full list of FY21 solicitations, see Appendix A. For a full list of all selected ISS National Lab-sponsored projects, see Appendix F).

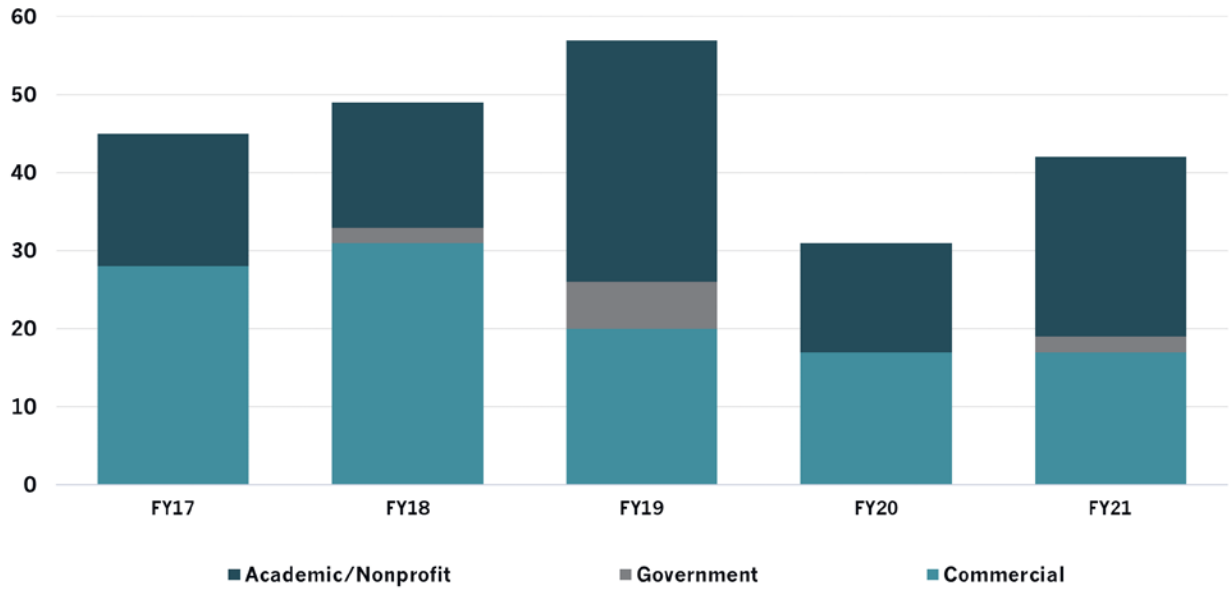
LEO Economy: Demand for Space-Based R&D

At a Glance

- In FY21, a record-setting 85% of total costs for newly selected projects were externally funded.
- More than $240 million in external, non-NASA funding has been committed to date in support of specific ISS National Lab-sponsored R&D projects.
- Of the newly selected projects this year, nearly 65% represent new-to-space users.
- CASIS received 185 proposals in FY21, the most ever received in a single fiscal year.

The ISS National Lab is a multiuser platform for research, technology development, and educational outreach to improve life on Earth, drive a sustainable and robust market in LEO, and bring value to the nation. Demand for this valuable research facility continues to rise among users from industry, academia, research institutions, and government agencies. In FY21, more than 40 projects were selected for flight opportunities through the ISS National Lab, an increase from last year as we continue to rebound from the effects of the COVID-19 pandemic. Of the total projects selected this year, nearly 65% represent new-to-space users, demonstrating the success of ISS National Lab solicitations in reaching new audiences (for more information on FY21 selected projects, see the map on page 25).

Five-Year Trend in Projects Selected



Projects from new-to-space users that were selected this year include the following:

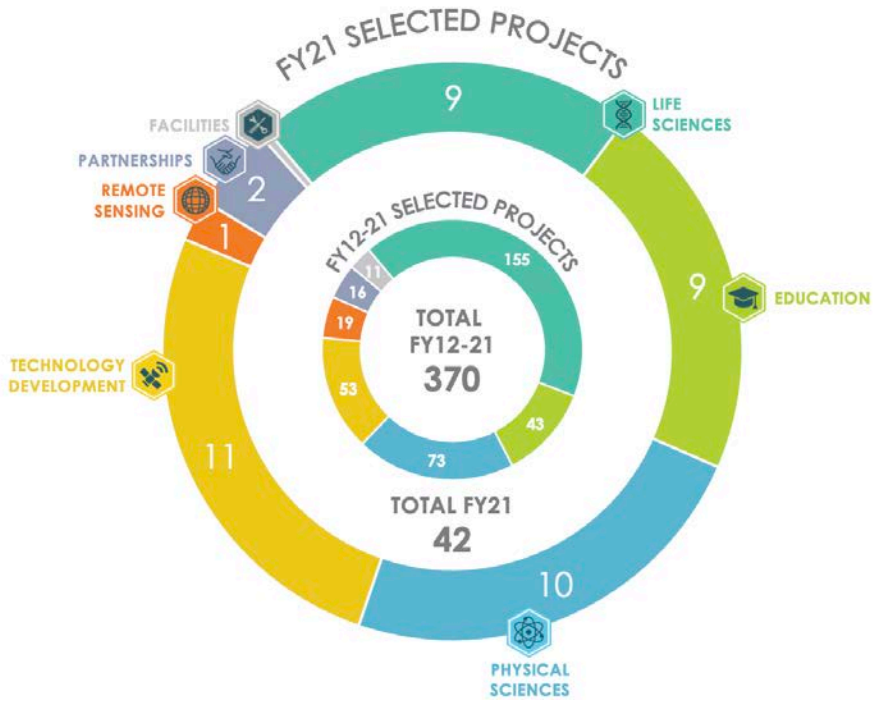
- Nikon Instruments will launch a technology development project seeking to advance tissue chip technology for biomedical research.

- Launchspace Technologies Corporation aims to demonstrate technology for a multilayered structure to be installed outside the ISS for capturing small debris.
- Sandia National Laboratories and SpaceLink Corporation will both fly technology development projects aimed at advancing satellite technology.
- Lehigh University and the University of California, Santa Barbara will conduct fundamental research experiments with applications in virus detection and respiratory illness treatments.

Selected projects from investigators that had previously completed an ISS National Lab-sponsored investigation include the following:

- Bristol Myers Squibb will launch a second ISS National Lab-sponsored investigation on protein crystallization to improve drug delivery methods and treatments for diseases such as cancer.
- The Rensselaer Polytechnic Institute, which has conducted previous research funded through NSF/CASIS solicitations, received a new award for a physical sciences project on flow boiling (a process that plays a critical role in removing heat from energy-intensive systems, with applications in multiple industries).
- The National Stem Cell Foundation will fly a second project that builds on a previous ISS National Lab-sponsored investigation to study neuroinflammation using 3D models of Parkinson's disease and primary progressive multiple sclerosis.
- LambdaVision, a previous recipient of the Technology in Space Prize in partnership with Boeing and MassChallenge, will launch follow-on R&D to advance the manufacturing process for the company's artificial retina.

Projects Selected
FY21-Selected and Total to Date



About 60% of the proposals selected in FY21 resulted from four NLRAs targeting ISS National Lab strategic focus areas. Two NLRAs were focused on in-space production applications—one in advanced manufacturing and materials (4 selected projects) and the other in tissue engineering and biomanufacturing (3 selected projects). An additional NLRA was centered on technology advancement and applied research (9 selected projects) and another focused on digital engagement and higher education (9 selected projects).

The multiyear, multiproject collaboration between CASIS and NSF continued this year, leveraging the ISS National Lab to advance fundamental research in both the physical and life sciences. In FY21, 11 projects were selected through NSF/CASIS joint solicitations in the biomedical area of tissue engineering and the physical sciences area of transport phenomena.

"The progress made by the ISS National Lab over the past year is incredible. We have arrived at the point we envisioned years ago: more users than assets to accommodate them and a groundswell of respected companies, researchers, and institutions speaking out about how essential a laboratory in low Earth orbit is for research and the nation's economy. These accomplishments are a testament to the strong partnership between NASA and CASIS in the management of this one-of-a-kind national asset. I look forward to celebrating the evolution of the CASIS-NASA partnership and everything we will accomplish together in the years to come."

- Joel Montalbano, NASA ISS Program Manager

In FY21, the trend of significant cost-sharing for newly selected projects continued. This year, CASIS funding was matched at a ratio of 1:10 by committed funding from non-NASA, third-party entities and the selected institutions themselves. To date, more than $240 million in external, non-NASA funds have been committed in support of specific ISS National-Lab sponsored R&D projects. This year also set a new record, with more than 85% of the total costs for newly selected projects externally funded. Furthermore, almost half of the projects selected this year were to academic organizations that found creative funding streams to fund their ISS National Lab-sponsored R&D.

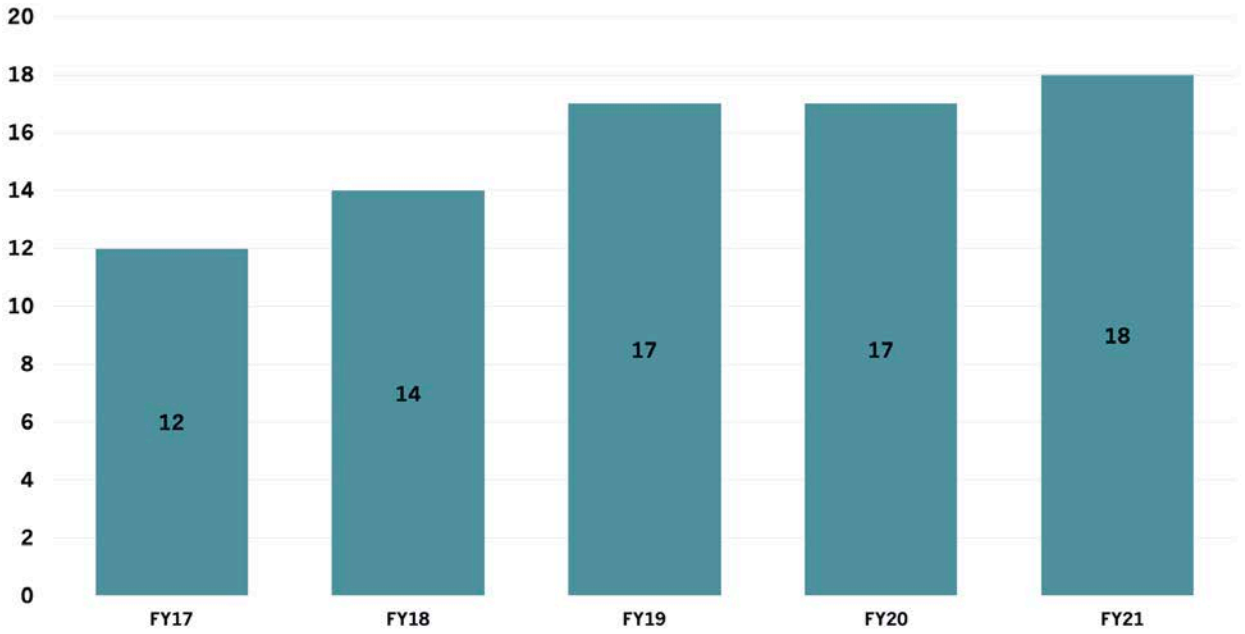
LEO Economy: Supply-Side Activities Support Market Growth

At a Glance

- One new commercial ISS facility was installed in FY21, bringing the number to 18 permanent commercial facilities operated by 10 Commercial Service Providers.
- In FY21, nearly 95% of CASIS funding was used to cover Implementation Partner costs for ISS National Lab-sponsored R&D, representing the highest percentage in a single fiscal year.
- Several Implementation Partners achieved important company milestones and expanded ISS capabilities this year.

In the 10 years since completion of the assembly of the space station, the ISS National Lab has worked alongside a growing network of Implementation Partners (see Appendix B for a full list) to expand the research and commercial capabilities onboard station for the benefit of Earth. Today, the 39 ISS National Lab Implementation Partners represent a broad range of organizations, from well-established aerospace companies with decades of experience to small innovative startups pushing space research boundaries. These companies continue to provide a full spectrum of payload services to an ever-growing number of ISS National Lab researchers. With the addition of one new ISS facility in FY21, there are now 18 permanent commercial facilities on station operated by 10 institutions (see Appendix C for a full list).

Five-Year Trend in Permanent Commercial Facilities on Station



Since the founding of CASIS, the organization has recognized the importance of creating pathways to increase ease of access to the ISS for ISS National Lab Implementation Partners and their customers. In FY21 alone, nearly 95% of CASIS funding was used to cover Implementations Partner costs for researchers, the highest percentage in CASIS history. Additionally, CASIS has put into place contractual mechanisms that provide Commercial Service Providers (the subset of Implementation Partners that own and operate facilities on the ISS) with quicker access to their facilities on station, further helping these companies to grow and operate at the speed of business. The ingenuity and passion of our Implementation Partners is accelerating the goal of the ISS National Lab to drive a thriving and sustainable LEO economy.

Key Commercial Service Provider facility updates from FY21 include the following:

- BioServe Space Technologies launched and validated a new facility: the Space Automated Laboratory Incubator (SALI), which will be used to incubate biological experiments in the microgravity environment. SALI is the 18th permanent commercial facility on the ISS.

- BioServe also launched an upgraded version of its Space Automated Bioproduct Laboratory (SABL). Known as SABL-4, this facility will build on the success of the previous three versions, which have supported more than 40 different complex payloads representing NASA, commercial, academic, and other government agency research interests.
- Redwire Space launched its sixth manufacturing facility to the ISS, the Industrial Crystallization Facility (ICF). The ICF is a commercial platform to support the growth and formulation of inorganic crystals for industrial applications such as high-power laser systems. Current ISS facilities for crystal growth are too small to accommodate large industrial crystals, and the ICF will fill this gap.
- The Redwire Ceramic Manufacturing Module (CMM) successfully manufactured a ceramic part in space for the first time. Ceramic manufacturing in microgravity could enable the production of temperature-resistant, reinforced ceramic parts with better performance for space and terrestrial applications such as turbines and internal combustion engines.

"Our long-standing partnership with the ISS National Lab enables the conduct of cutting-edge fundamental and applied research in the area of life sciences. Our collaboration has laid the foundation for the development of in-space manufacturing in the areas of stem cell culture and tissue engineering. We look forward to our continued partnership and, as a result, the future discoveries that will positively impact humanity."

- Stefanie Countryman, BioServe Space Technologies Director

Examples of company milestones among Implementation Partners in FY21 include the following:

- Alpha Space, owner and operator of the MISSE Flight Facility, and MEI Technologies merged to create a new company, Aegis Aerospace Inc. Aegis is a woman-owned company that will offer commercial space services, flight and ground system development, systems engineering and integration, and modeling, simulation, and analysis.
- Voyager Space Holdings, Inc. announced that it acquired a majority of stake in X.O. Markets, whose largest subsidiary is Nanoracks. This was the fourth majority stake acquisition of a space company by Voyager, which will invest growth capital into Nanoracks to support its continued expansion.
- Redwire began trading on the New York Stock Exchange under the ticker symbol RDW after a merger with special-purpose acquisition company (SPAC) Genesis Park Acquisition Corporation.
- The Sierra Nevada Corporation spun off its Space Systems division into a separate company called Sierra Space. The new company's portfolio will include Dream Chaser®, a reusable space plane, and a commercial space station, among a host of other products and services. With the establishment of this subsidiary, company leadership expects to grow its current $400 million in revenue to $4-5 billion over the next 5 to 10 years.

Other key Implementation Partner activities from FY21 include the following:

- Axiom Space, Inc. announced the signing of an order with NASA for the first private crew visit to the ISS in early 2022. The Axiom Mission (Ax-1) will carry four crew members for an eight-day stay on station. The ISS National Lab has sponsored more than 30 payloads tied to the Ax-1 mission.
- Felix & Paul Studios won an Outstanding Interactive Program Emmy at the 73rd Annual Emmy Awards for its virtual reality (VR) series "Space Explorers: The ISS Experience," produced in collaboration with TIME. The series—which is being filmed onboard the space station through a project sponsored by the ISS National Lab—uses special VR cameras designed to operate in microgravity to capture what it is like to live and work in space. Episode 1 of the series also won two Webby Awards.
- Nanoracks launched the first commercially funded airlock to the ISS: the Bishop Airlock, which provides five times the current volume to move items in and out of the ISS.
- Using the Nanoracks CubeSat Deployer, the company launched its 20th CubeSat mission from the ISS.

"The ISS National Lab is a one-of-a-kind asset, providing access to the ISS that isn't available anywhere else and enabling Axiom to test and validate new commercial applications for microgravity ahead of launching its own space station. Leveraging this access allows us to develop sustainable and scalable commercial demand for low Earth orbit, which will drive new economic activity that benefits every human, everywhere."

- Christian Maender, Axiom Director, In-Space Manufacturing and Research

LEO Economy: Investor Network and Capital Connections

At a Glance

- To date, nearly $1.2 billion in funding has been raised by startups post-ISS National Lab flight projects, including funds raised from public equity markets, venture/private capital, and via public and private grants.
- FY21 was a record-setting year for capital raising activity by startup companies in the ISS National Lab ecosystem.
- The ISS National Lab Investor Network grew to include 245 members in FY21, and CASIS has facilitated nearly 1,000 introductions to date in support of capital-raising efforts in our ecosystem.

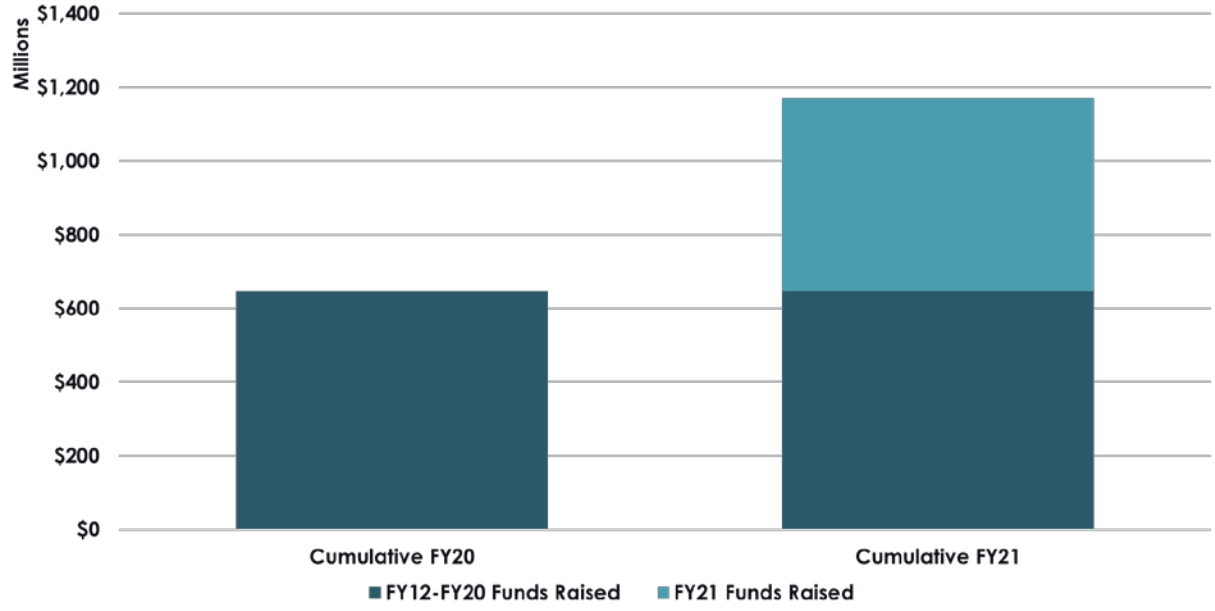
The ISS National Lab startup ecosystem has grown to include more than 125 early-stage companies that either have been awarded a flight project, have flown under the ISS National Lab allocation, or are in the various stages of dialogue toward such a future engagement. A key indicator of economic value creation by startup companies using ISS National Lab R&D capabilities is their ability to raise third-party capital subsequent to an award of a flight project

and after execution of their technology or science investigation on station. FY21 was a record year of capital raising by startups in the ISS National Lab ecosystem, benefiting from growing public market appetite and expanding private capital inflows as well as the maturation of technologies and business models in our startup user base.

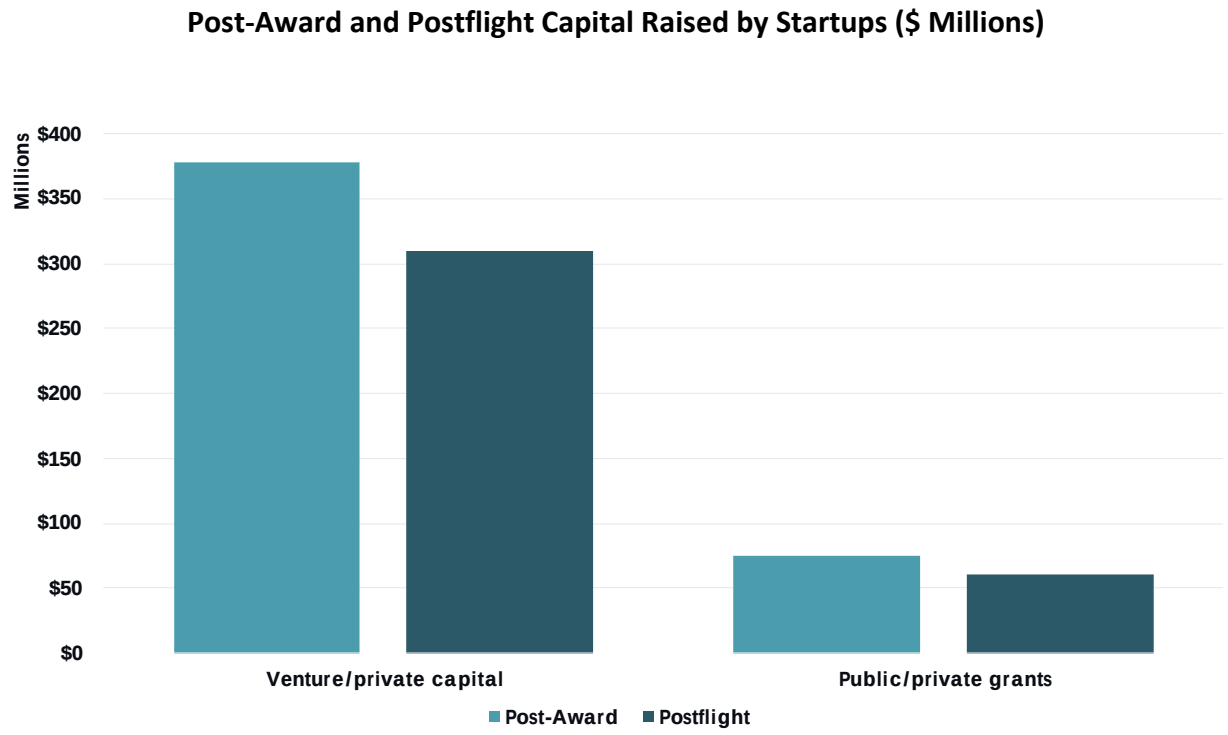
ISS National Lab Utilization Generates Significant Investment

Based on publicly available data, $523 million of private and public capital, as well as grant funding, was raised during FY21 by startups that have completed one or more flight projects through the ISS National Lab (including projects awarded by CASIS as well as projects from ISS National Lab Commercial Service Providers). More than $380 million of this private and public capital as well as grant funding was raised during the fourth quarter of FY21. The year's capital-raising successes included Angiex, Emulate, Lynk, Kernal Biologics, Orbital Sidekick, Orbit Fab, Redwire Space, RevBio, and Spire Global, among others. To date, nearly $1.2 billion total of such startup funding has been raised post-ISS National Lab flight projects.

Cumulative Capital Raised Post ISS National Lab Flights ($ Millions)



Looking specifically at the performance of startups awarded by CASIS, based on our estimates and publicly available data, these companies have raised more than $450 million (combined) of private and public funding to date following CASIS flight project award announcement, including close to $370 million following actual flight to the ISS. In addition, several ISS National Lab Commercial Service Providers have flown payloads and launched CubeSats with successful early-stage enterprises. Excluding overlapping engagements, and primarily driven by successes of two companies, Planet and Spire Global, we estimate from public data sources that these startups have raised around $800 million of capital to date following their respective flight projects.



Source: Data from Discovery, Crunchbase, sec.gov, sbir.gov; ISS National Lab data and analysis

Investor engagement continued to expand during FY21, with the ISS National Lab Investor Network reaching 245 venture capital, private equity, corporate, angel, and other financial investors, up 23% year-over-year. To date, CASIS has facilitated nearly 1,000 capital introductions between startups and investors in the ISS National Lab ecosystem. These introductions are complementary to a multitude of startup funding strategies. The feedback received from the ISS National Lab startup community indicates high value added from such connections.

In FY21, the ISS National Lab hosted its sixth annual startup and investor networking event, "Space Investment 2021: Innovation at the ISS National Lab." This year's presenters included a mix of companies across the communications, Earth observation, space R&D and manufacturing technologies, advanced materials, and life sciences sectors. All presenting companies had already conducted or are scheduled to conduct R&D studies or technology demonstrations on the ISS. The event resulted in an active dialogue and in several investor follow-ups.

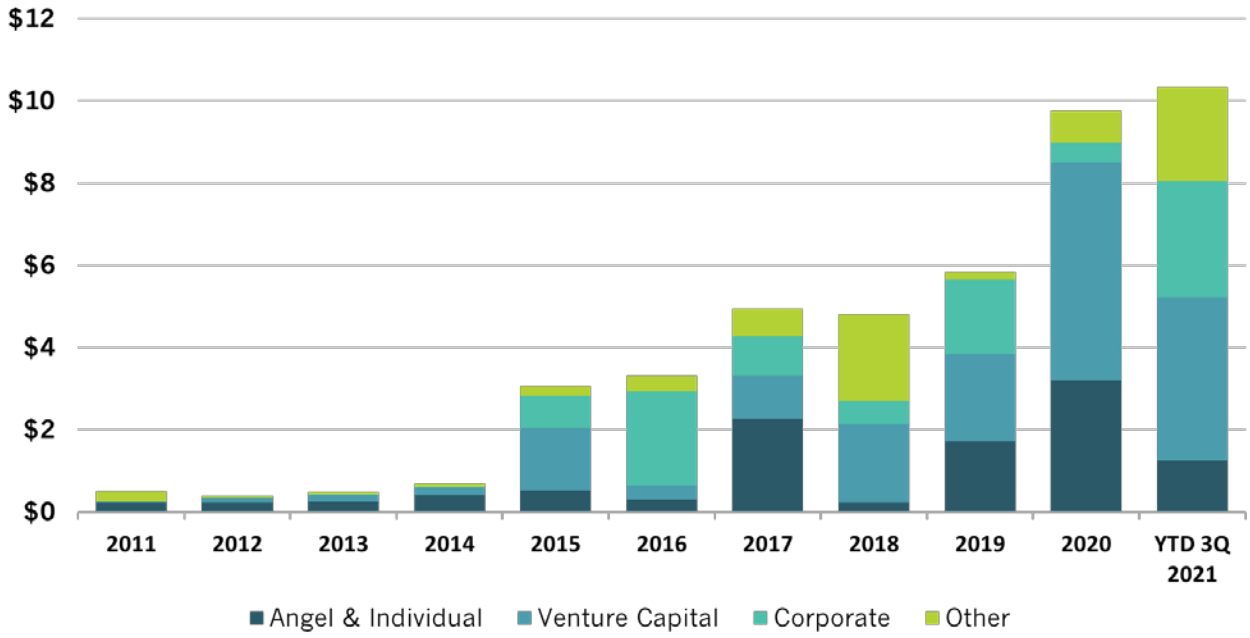
Industry Context: Strong Tailwinds from Financial Markets

Following the rebound of space sector investment activity during a volatile 2020, 2021 began with positive expectations, and the year unfolded with highly favorable capital access conditions. The key development for the space industry has been the announcement and completion of several emerging space company public listings via special purpose acquisition company (SPAC) transactions. These long-awaited exits to public markets providing return validation on earlier years' investments have clearly caught the attention of the broader investor community. While some have raised questions around the sustainability of the recent SPAC valuations and activity levels, more broadly, the number of investors in our ecosystem has continued to grow and

additional earlier-stage capital has become available to space companies. Such expanded access to capital has supported the pace of innovation in the industry, including continued emergence of new startups seeking to address a range of market opportunities.

To provide additional context on just how robust the funding environment has been this year, we have included below the recently published data from Space Capital through the third quarter of 2021. Indicative of the pace of acceleration in capital inflows, the reported infrastructure segment totals in the first half of 2021 exceeded the respective investment totals for the full calendar year of 2019, and the first nine-month totals for 2021 exceeded the comparable metric for full 2020.

Space Economy Investment
(Infrastructure, $ billions)



Source: Space Capital data; ISS National Lab analysis

In addition to the SPAC activity, the broader merger and acquisition market continued its momentum well into 2021, creating further exit opportunities. The spectrum of deals included private equity roll-up transactions as well as strategic combinations, including some transactions using the liquidity and currency from the recently closed SPAC deals. At the same time, easing funding conditions have delayed some of the previously expected consolidation, and investor views on the merits of vertical integration have remained mixed.

While the funding dollars have historically been concentrated primarily in the launch, communications, and Earth observation satellite value chains, the range of investable opportunities in the space sector continued to expand in FY21. For example, some of the in-space activities mentioned during the ISSRDC investor panel this year included commercial

destinations, orbital travel, satellite servicing, space-based manufacturing, logistics, and infrastructure. There is also increased industry discussion around the potential of microgravity-based production. In recent months, there have also been several key announcements around plans to build commercial space stations, potentially addressing infrastructure bottlenecks.

Regarding prospects for various business opportunities that target in-space activities, the investor sentiment still ranges from being very bullish to questioning the current maturity of such opportunities in terms of ability and time needed to reach paying customers, revenues, and acceptable investment returns. In general, views on the demand formation and outlook, as well as recognition of the potential size of the opportunity, are getting more positive compared with prior years.

Educational Outreach and Engagement

At a Glance:

- In FY21, ISS National Lab Space Station Explorers partner programs engaged more than 3.8 million people.
- This year, 70% of the participants in Space Station Explorers partner programs were female and 40% represented underserved communities.
- Nine new organizations were selected for ISS National Lab-sponsored projects to advance STEM education through an FY21 NLRA focused on digital engagement and higher education.
- The Space Station Ambassador Program has doubled in size since FY19, growing to more than 1,600 members this year.

Advancing science literacy in the future workforce continues to be a key focus area for the ISS National Lab, with an emphasis on both K-12 students and higher education. Each year, the ISS National Lab engages students and adults in powerful educational programs through Space Station Explorers—a community of educators, learners, and organizations that leverage the unique platform of the ISS National Lab to provide valuable STEM educational experiences. In FY21 alone, more than 3.8 million people engaged with the 23 partner programs within the Space Station Explorers community. Furthermore, 70% of participants in Space Station Explorers partner programs this year were female and 40% represented underserved communities.

In FY21, six new partners joined the Space Station Explorers community: Advancing X, Space Foundation, SpaceKids Global, Center for Applied Space Technology (CAST), Discovery Education, and the American Institute of Aeronautics and Astronautics (AIAA). The Space Station Ambassador program also expanded this year. Through this program, educators, leaders, and lifelong learners share information on Space Station Explorers activities with their communities. The program grew to more than 1,600 members in FY21, doubling in size since FY19.

Space Station Explorers partner programs provide a wealth of STEM education curricula, kits, and hands-on learning activities—including opportunities for students to design and launch their own research to the ISS (for more information on Space Station Explorers partner programs, see Appendix D and the map on page 25). FY21 educational activities from our partner programs include the following:

- Through the Student Spaceflight Experiments Program (SSEP), 27 student-led experiments that involved more than 16,000 students launched to the ISS on SpaceX CRS-21. SSEP allows students to design spaceflight experiments in both the physical and life sciences using MixStix testing tubes from ISS National Lab Commercial Services Provider Nanoracks.
- The Genes in Space program, funded by Boeing and miniPCR Bio™, announced the 2021 winner of its annual research competition, a high school student who will test a new technique for detecting water pathogens in space. Through this free program, students in grades 7 through 12 design DNA experiments that utilize the unique environment of the ISS. Also, in FY21, last year's Genes in Space winning experiment examining the effects of spaceflight on drug metabolism launched to the ISS, and results from a prior Genes in Space student experiment were published in the journal PLOS One.
- As part of the free Story Time From Space program, NASA astronaut Shannon Walker read the book "Give Me Some Space" from onboard the ISS, and the recording reached approximately 2 million viewers worldwide. Story Time From Space also did its first live reading from the ISS, in which Walker read "Willow the Water Bear" as students from around the world tuned in.
- During Sally Ride EarthKAM Mission 72 this year, more than 7,000 student-requested images were taken by a camera onboard the ISS. Through this free program, students submit requests to capture imagery of specific geographic areas, allowing them to learn about Earth from the perspective of space.
- The Zero Robotics program released a documentary film this year called "Zero Gravity" that follows a group of middle school students as they compete in a Zero Robotics tournament. Through this free program, students write coding to maneuver small satellites to complete objectives, and the finalists' coding is run on satellites onboard the ISS in a championship match.

"As an education program provider to hundreds of schools around the world, inspiring and capturing a student's attention, imagination, and curiosity is one of the most crucial starts to their learning and continued growth. The ISS National Laboratory provides the most unique opportunity for students of all socioeconomic backgrounds and ethnicities to universally be drawn to and inspired to do experiments on the ISS. Our ISS-based programs have proven over the years to be the most sought after and most life-changing programs in our education portfolio."

- Danny Kim, Quest Institute for Quality (Space Station Explorers partner program) Education Chief Technology Officer

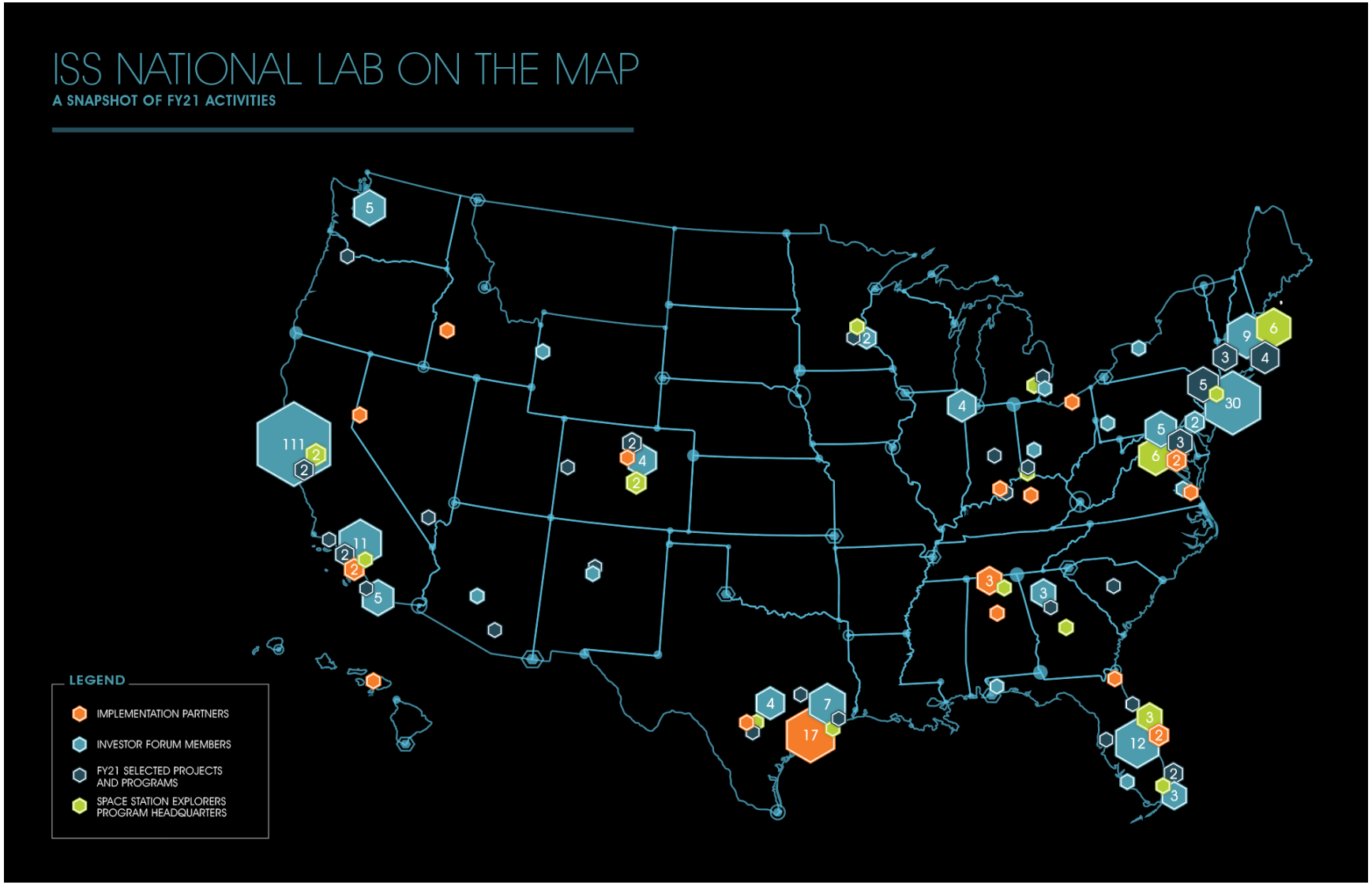
Additional ISS National Lab educational activities in FY21 include the following:

- This year, students launched experiments to the ISS through several Space Station Explorers partner programs, including Higher Orbits, SSEP, and DreamUp. ISS National Lab Youth Launch Events, held at the Kennedy Space Center Visitor Complex, provide students with a once-in-a-lifetime opportunity to watch their experiments launch. Students also have an opportunity to share their science with the public through presentation and poster sessions.
- An NSF grant awarded to CASIS in FY21 is providing $298,000 in funding for the ISS National Lab to work with University of California, Berkeley on a Student Mission Control program designed for use in high school computer science courses. The program will provide high school students with direct access to data and experiments on the ISS, helping them develop valuable skills in data collection and analysis.
- This year, CASIS selected nine new ISS National Lab-sponsored projects to advance STEM education through an NLRA focused on digital engagement and higher education. Selectees include the University of Arizona, Georgia Tech Applied Research Corporation, Orion's Quest, Mattel, and the Massachusetts Institute of Technology, among others.
- In FY21, multiple ISS National Lab education initiatives engaged Girl Scouts around the country. The Amateur Radio on the ISS (ARISS) program held three events with Girl Scout groups, one of which included more than 15,000 participants. Additionally, in FY21, winners were announced for the "Making Space for Girls Challenge," organized by Space Kids Global and the Girl Scouts of Citrus Council, with support from ISS National Lab Implementation Partner ProXops. Generating nearly 700 entries, the challenge provided an avenue for Girl Scouts across the nation to demonstrate skills in science, art, and writing by designing experiments to be conducted on the ISS, creating space-themed art, or writing space-related essays.

> ***"A valuable national asset for research and inspiration, we have found that the ISS National Lab is not only a platform for science and engineering but also for curiosity and wonder."***
>
> *- Ted Tagami, Magnitude.io CEO; ISS National Lab User Advisory Committee Educational Outreach Subcommittee Chair*

- The Space Station Ambassador program gained visibility in FY21 when Space Station Ambassador Sian Procter embarked on Inspiration4, the world's first all-civilian orbital mission. Procter, one of four civilians selected for the mission to low Earth orbit, has been a member of the Space Station Ambassador program since 2017, helping to share the many educational opportunities available through the ISS National Lab.
- In FY21, TIME magazine selected its first ever "Kid of the Year"—15-year-old Gitanjali Rao, a past participant of the Genes in Space Program. Rao was part of a team of students that won a Junior Scientist Award at the 2018 Genes in Space competition for their experiment to study the genetics of plant growth regulation in microgravity.
- STEM education was also the focus at multiple ISS National Lab events this year, including an International Destination Station virtual session for educators on "Taking STEM Education to a Higher Level." Representatives from the ISS National Lab and NASA discussed the many

ways the ISS can be leveraged to inspire the next generation of explorers. In addition, the 2021 ISS Research and Development Conference included a virtual session called “Making Space for All in STEM.” The session was moderated by Emily Callandrelli, host and co-executive producer of Emily’s Wonder Lab, and panelists included NASA astronaut Serena Auñón-Chancellor; Gitanjali Rao, TIME’s 2020 Kid of the Year; and two young female researchers. The all-woman panel, which discussed diversity in STEM and the future of STEM education, served as a powerful inspiration for young girls to pursue interests in STEM fields.


ISS NATIONAL LAB ON THE MAP
A SNAPSHOT OF FY21 ACTIVITIES
LEGEND
IMPLEMENTATION PARTNERS
INVESTOR FORUM MEMBERS
FY21 SELECTED PROJECTS AND PROGRAMS
SPACE STATION EXPLORERS PROGRAM HEADQUARTERS

Outreach and Stakeholder Engagement

At a Glance

- In FY21, ISS National Lab representatives participated in more than 75 virtual speaking engagements to highlight valuable R&D done on station and raise awareness of research opportunities available through the orbiting laboratory.
- The 10th annual ISSRDC was held virtually this year, bringing together researchers, engineers, entrepreneurs, investors, and the public to discuss the benefits of space-based R&D on the ISS.
- ISS National Lab-sponsored research was highlighted by several high-visibility media outlets, including CNN, Scientific American, USA Today, Fortune, CNBC, and The Today Show.

In FY21, the ISS National Lab continued to evolve digital-friendly ways to engage with researchers, stakeholders, and the general public amidst the ongoing COVID-19 pandemic. Insight gained in 2020 on how to conduct virtual outreach initiatives led to several impactful engagements this year that served to further our mission priorities and objectives. Additionally, virtual opportunities allowed the ISS National Lab to collaborate with NASA in new ways to communicate the critical research being done on station and the ISS capabilities available to investigators. Moreover, increased cooperation between the ISS National Lab and NASA led to several media engagements, many of which included astronauts who helped execute research on station, garnering national and worldwide coverage.

CASIS commemorated the 10-year anniversary of its creation with a retrospective article looking back on a decade of managing the ISS National Lab. NASA Administrator Bill Nelson and Kathy Lueders, associate administrator for NASA's Space Operations Mission Directorate, amplified the article through their channels, further streamlining NASA and ISS National Lab communications efforts. Additionally, the ISS National Lab celebrated the five-year anniversary of *Upward* magazine in FY21. Over the years, in-depth *Upward* features have showcased both the breadth of R&D enabled by the ISS National Lab and how the results of this valuable research have impacted on life on Earth.

ISSRDC 2021 and Additional Events and Outreach

This year also marked the 10th annual ISSRDC, hosted by CASIS, NASA, and the American Astronautical Society (AAS). The conference was held virtually again due to continuing safety concerns related to the COVID-19 pandemic. Working with a vendor that specializes in virtual engagements, the ISS National Lab provided viewers with an enhanced virtual conference experience. The theme of ISSRDC this year was "Challenge. Partnership. Transformation." The three-day virtual conference, which generated nearly 3,000 registrations, featured sessions with luminary science figures, NASA astronauts, ISS researchers, space investors, Implementation Partners, and other notable leaders and innovators.

ISSRDC 2021 kicked off with a welcome address by NASA Administrator Bill Nelson, followed by a keynote session with NIH Director Francis Collins and NASA astronaut Kate Rubins. The two talked about the benefits of conducting biomedical research on the space station and the NIH-funded Tissue Chips in Space investigations that Rubins worked on during her time onboard the ISS. The conference also featured NASA's Thomas Zurbuchen and the Smithsonian Institute's Ellen Stofan, who discussed the value of space-based R&D and the importance of communicating that science to the general public. On the final day of the conference, the focus shifted to STEM education. Emmy-nominated television host Emily Calandrelli and NASA astronaut Serena Auñón-Chancellor joined young female researchers for a panel session that focused on diversity in STEM and the power of leveraging the ISS for education initiatives.

"AAS has been honored to partner with CASIS and NASA for more than 10 years to bring researchers and the space community together through the ISS Research and Development Conference. This conference has served as a platform to recognize the incredible accomplishments of the orbiting laboratory, discuss science and technology innovations that may have profound impacts on humanity, and promote collaboration that will further our footprint in low Earth orbit and beyond."

- Jim Way, American Astronautical Society Executive Director

Over the course of the fiscal year, ISS National Lab representatives participated in more than 75 virtual speaking engagements to highlight impactful ISS National Lab-sponsored R&D and increase awareness of research opportunities available through the orbiting laboratory. Examples of key events and outreach include the following:

- NASA and the ISS National Lab held two virtual Destination Station outreach events. Traditionally, Destination Station has been a valuable tool for driving demand and interest among targeted companies to utilize the space station to advance their R&D objectives. Due to the COVID-19 pandemic, virtual platforms were used this year to engage a more general audience, providing meaningful information on ISS research capabilities and funding opportunities. One of this year's Destination Station events focused heavily on reaching educators and students to communicate the many STEM education resources available through the ISS National Lab and NASA.
- The ISS National Lab pitched, secured, and coordinated a panel session at the Consumer Electronics Show, the largest technology gathering in the world, which was held virtually this year. The all-female panel, moderated by CNN's Rachel Crane, included NASA astronaut Serena Auñón-Chancellor along with representatives from Commercial Services Provider Space Tango and Fortune 500 company Lockheed Martin.
- The AIAA ASCEND conference featured several panels with ISS National Lab representatives. In a session on ISS National Lab partnership opportunities, Estée Lauder announced the company's plans to partner with the ISS National Lab on a Sustainability Challenge addressing the plastics dilemma, expected to open in early FY22.
- The ISS National Lab hosted a panel at the World Stem Cell Summit, which has been a valuable avenue to reach potential investigators in the area of regenerative medicine. The session,

held virtually, discussed health, aging, and human survival research on the orbiting laboratory and the impact of such research on the development of therapeutics for patients on Earth.

- The ISS National Lab also hosted two sessions of Women Defying Gravity, a virtual space industry women's networking event. One session featured guest speaker Ellen Stofan, under secretary for science and research at the Smithsonian Institution, and the other featured Hanna Steplewska, founder and CEO of Eva Strategies.

Targeted Outreach and High-Visibility Media Coverage

Over the course of FY21, the ISS National Lab tailored its press releases to include more in-depth storytelling of specific research projects as they launched and were carried out on station. This robust content provided ISS National Lab stakeholders, potential investigators, and the public with impactful stories highlighting the value of ISS National Lab-sponsored R&D. Greater emphasis was placed on targeting specific research audiences to bring enhanced visibility to ISS National Lab strategic areas of focus. Also, with the release of multiple NLRAs in FY21, outreach efforts focused on developing relationships with societies and associations that could disseminate information on these valuable opportunities to their communities. This resulted in a strong response to ISS National Lab research solicitations this year, with a record-setting 185 proposals received.

In FY21, high-profile media coverage brought visibility to the many ways in which the ISS National Lab is be leveraged to advance research, technology development, and educational outreach. Examples include the following:

- Consumer goods company Procter & Gamble made big waves when the company announced its plan to launch Tide to the space station under sponsorship of the ISS National Lab. The announcement coincided with the company's Space Act Agreement with NASA. The resulting visibility drew worldwide coverage from outlets including The Today Show, USA Today, Ad Age, CNBC, Fortune, and others.
- Hewlett Packard Enterprise put forth robust marketing and communications on the launch of its Spaceborne Computer-2 to the ISS. A feature article from Microsoft highlighted the power of SBC-2 to provide in-space data processing, enabling quicker results and the potential for iteration of experiments on station.
- Colgate-Palmolive's public awareness campaign on the company's oral care investigation that launched this year drew a lot of attention. Colgate-Palmolive plans to launch a second investigation in FY22, providing additional opportunities to highlight this collaboration.
- A student-led Genes in Space investigation grabbed headlines when results were published in the peer reviewed journal PLOS ONE. NASA astronaut Christina Koch (who worked on the investigation on station) engaged in media opportunities to discuss both the exciting science as well as the educational opportunities provided through the Genes in Space program. This led to an article from CNN's Ashley Strickland emphasizing the importance of student research on the ISS.
- CNN also covered an event facilitated by CASIS that brought together Emory University researchers and NASA astronaut Jessica Meir to discuss the Emory team's heart stem cell investigation.

- *Scientific American* published a comprehensive feature on a first-of-its kind ISS microbial survey that "swabbed" multiple locations within the ISS to understand the distribution of microbes and their metabolites (chemicals produced by bacterial growth). A Boeing-funded microbial investigation was also cited in the *Scientific American* piece and was featured in a United Press International (UPI) story.

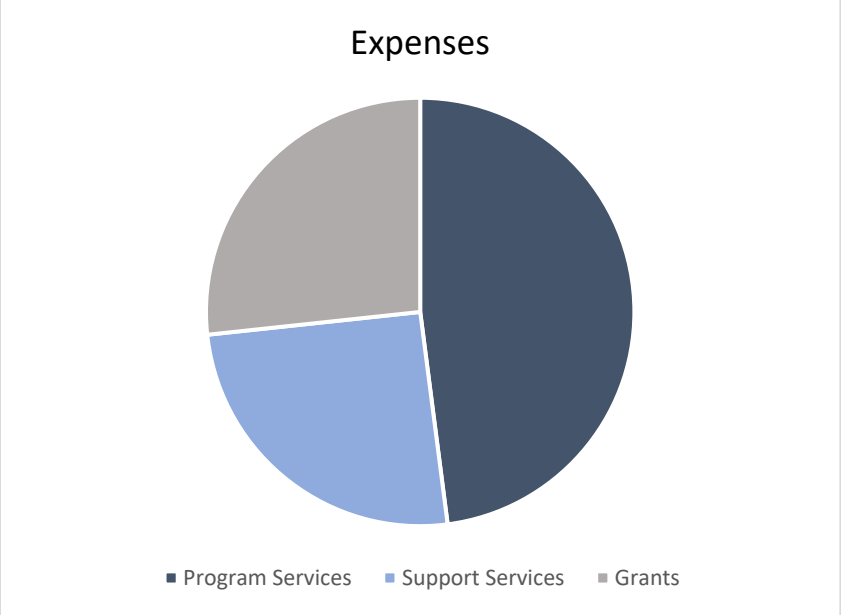
Financials

Unaudited Summary Statement of Financial Position as of September 30

	2021	2020	2019
Total assets	$3,267,484	$3,290,268	$3,068,246
Total liabilities	$958,197	$878,378	$721,220
Total net assets	$2,309,287	$2,411,890	$2,347,026
Total liabilities and net assets	$3,267,484	$3,290,268	$3,068,246

Unaudited Summary Statement of Activities for Years Ended September 30

	2021	2020	2019
Total revenues and other support	$12,176,689	$14,454,605	$15,796,555
Total operating expenses	$12,279,292	$14,389,740	$16,247,889
Change in net assets	($102,603)	$64,865	($451,334)
Net assets, beginning of the year	$2,411,890	$2,347,025	$2,798,360
Net assets, end of the year	$2,309,287	$2,347,026	$ 2,798,360



Appendices (available in a separate document)

To view the full Appendices, visit www.issnationallab.org/ar2021.

A. *Solicitations*
B. *Implementation Partners*
C. *Permanent ISS Commercial Facilities*
D. *Space Station Explorers Partner Programs*
E. *Peer-Reviewed Journal Publications*
F. *Full Project Pipeline*
G. *FY21 Metrics*