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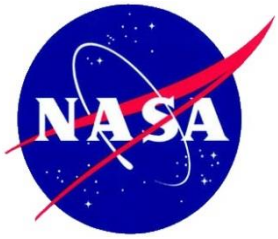
NASA's Management of the Center for the Advancement of Science in Space

January 11, 2018

Report No. IG-18-010



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RESULTS IN BRIEF

NASA's Management of the Center for the Advancement of Science in Space

January 11, 2018 IG-18-010 (A-17-003-00)

WHY WE PERFORMED THIS AUDIT

Since 1993, the United States has spent approximately $87 billion to build and operate the International Space Station (ISS or Station), and is projected to spend between $3 and $4 billion annually to support the Station's operations through 2024. In August 2011, the Agency awarded a 10-year, $136 million cooperative agreement to the Center for the Advancement of Science in Space (CASIS) to manage non-NASA research activities on the U.S. portion of the ISS known as the National Laboratory (National Lab). In July 2017, NASA extended the CASIS cooperative agreement to September 2024, increasing its total cost to $196 million.

In prior reports we raised concerns about CASIS's performance and its challenges spurring commercial and non-Government research on the ISS. Specifically, in 2013 we found that fostering a commercial interest in ISS-based research and recruiting users for the National Lab remained a significant challenge for CASIS. Furthermore, in 2014 we found that NASA and CASIS continued to face challenges maximizing ISS research capabilities and that much of the ISS's future success as a research platform for non-Government entities hinged on CASIS's ability to attract sufficient funding from private users.

Given NASA's investment in and the importance of the National Lab, together with issues raised in our prior reports, we initiated this audit to examine CASIS's progress in meeting its performance goals and assess the quality of NASA's oversight of the organization. To complete this work, we reviewed performance plans, annual reports, and other documentation; interviewed CASIS and NASA officials; and conducted surveys of CASIS programs and National Lab users.

WHAT WE FOUND

Although CASIS awarded $21.7 million in grants to 140 projects between fiscal years (FY) 2013 and 2016, the organization has underperformed on tasks important to achieving NASA's goal of building a commercial space economy in low Earth orbit. From 2011 through 2014, CASIS concentrated on standing up its organization and filling leadership positions. Consequently, after more than 5 years of operation CASIS has not fully met a majority of the goals and expectations set out by NASA. Of the nine performance categories we assessed, CASIS met expectations in only two: research pathways and science, technology, engineering, and mathematics (STEM) education. For example, the STEM education performance category required CASIS to increase interest in using the National Lab as a platform for STEM education. CASIS met expectations for this performance category by funding 14 STEM education programs in FY 2016 with more than 325,000 participants.

For five of the remaining seven performance categories – grant awards and project portfolio, recruitment of National Lab users, matching research projects and investors, Implementation Partners, and fundraising – CASIS only partially met expectations. For example, in the grant awards and project portfolio performance category, CASIS awarded more than $3 million annually in research grants between FYs 2013 and 2016 but failed to ensure a balanced portfolio of research projects from theoretical to basic to applied research as required by the cooperative agreement. CASIS failed to meet expectations in the remaining two categories: utilization of crew time for National Lab research and outreach. With

respect to crew utilization, between September 2013 and April 2017 CASIS was allocated 2,915 crew research hours on the National Lab, but CASIS-managed projects used only 1,537 (52.7 percent) of these hours. Although CASIS officials attributed the organization's limited success in this area to three failed ISS resupply missions in FY 2015, given its performance to date, CASIS utilization rates for the National Lab will likely further diminish when NASA adds an additional crew member to the Station in late 2018.

In addition, we found NASA failed to actively oversee CASIS's technical performance and instead took a largely "hands-off" approach to managing CASIS that has contributed to the organization's inability to meet expectations. For example, NASA has not developed an overall strategy identifying the achievements or outcomes expected from CASIS through the end of its cooperative agreement nor has the Agency provided guidance or set expectations for CASIS's performance. Instead, NASA has accepted CASIS's slow improvement over the first 5 years of the cooperative agreement without requiring corrective action plans or offering suggestions to improve performance. Although FY 2016 marked the first year CASIS's performance plan included metrics and quantifiable targets for several performance categories, these metrics and targets were not included for all performance categories.

WHAT WE RECOMMENDED

NASA acknowledges that CASIS plays an important role in helping promote a commercial economy in low Earth orbit, but the Agency needs to increase its oversight of the organization's performance. To help improve the effectiveness of NASA's cooperative agreement with CASIS, we made seven recommendations to the Associate Administrator for Human Exploration and Operations, including four recommendations specific to improving the research pathways, grant awards and project portfolio, Implementation Partners, and fundraising performance categories. We also recommended that the Associate Administrator develop a performance strategy for CASIS through the end of the cooperative agreement in 2024, evaluate CASIS's performance semiannually, and ensure performance plans include metrics and targets for all performance categories.

In response to a draft of this report, NASA management concurred or partially concurred with our recommendations and described its planned actions. However, in its response, Agency management took exception with our methodology that assessed CASIS's performance in nine categories, stating that CASIS's performance should only be reviewed against the operating model defined by the cooperative agreement. Moreover, in response to our recommendation concerning CASIS fundraising, the Agency explicitly stated that CASIS is not required to raise non-NASA funds to offset its operating expenses and declined to indicate if or when it plans to reassess the issue.

As noted in our report, we did not limit our audit solely to whether CASIS complied with the terms of its cooperative agreement; instead, since metrics within the agreement are decidedly vague, we also evaluated the organization's performance against other Agency expectations. For example, expectations for CASIS fundraising are documented in NASA's July 2011 decision memorandum; NASA's Strategic Plan and its annual CASIS assessment letters provide support for CASIS's role in contributing to the development of an economy in low Earth orbit; and annual assessment letters illustrate the Agency's interest in CASIS broadening its use of Implementation Partners. In addition, we believe fundraising should be a key Agency expectation for CASIS, which is the genesis of our recommendation that NASA "establish goals for CASIS raising non-NASA funds to offset operating expenses." However, NASA management's comments – although labeled as "concur" – are unresponsive to the recommendation; therefore, this recommendation remains unresolved pending further discussion with Agency officials. In light of management's response to the other six recommendations, those are resolved and will be closed upon verification and completion of the proposed corrective actions.

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Acronyms

CASIS	Center for the Advancement of Science in Space
CATO	Cooperative Agreement Technical Officer
EXPRESS	Expedite the Processing of Experiments to Space Station
FY	Fiscal Year
GAO	Government Accountability Office
ISS	International Space Station
OIG	Office of Inspector General
STEM	Science, Technology, Engineering, and Mathematics

INTRODUCTION

As a platform for scientific investigation and research, the International Space Station (ISS or Station) plays a vital role in advancing NASA's long-term, deep space exploration goals. Since 1993, the United States has spent approximately $87 billion to build and operate the ISS, and is projected to spend between $3 and $4 billion annually supporting the Station's operations through 2024.[1]

To maximize the Nation's investment in the ISS, Congress enacted several laws to increase ISS utilization and generate commercial interest in the Station as a research platform. First, in 2005 Congress designated the U.S. portion of the ISS research facilities as a National Laboratory (National Lab).[2] Then in 2010, legislation directed NASA to choose a not-for-profit entity to manage the National Lab, and in August 2011 the Agency awarded a 10-year, $136 million cooperative agreement to the Center for the Advancement of Science in Space (CASIS) to manage the Lab.[3] In July 2017, NASA extended the CASIS cooperative agreement to September 2024, increasing its total cost to $196 million.

In prior reports, we raised concerns about CASIS's performance and its impact on ISS research. In 2013, we found that fostering a commercial interest in ISS-based research and recruiting users for the National Lab remained a significant challenge for CASIS.[4] Furthermore, in 2014 we found that NASA and CASIS continued to face challenges maximizing ISS research capabilities. In particular, CASIS had difficulty attracting commercial companies because ISS research costs were significantly higher than ground-based research.[5] As we reported in 2014, much of the ISS's future success as a research platform for non-Government entities hinges on CASIS's ability to attract sufficient funding from private users.

Given NASA's investment in and the importance of the National Lab, the issues raised in our prior reports, and the expectation that NASA would extend its agreement with CASIS through 2024, we initiated this audit to examine CASIS's progress in meeting the Agency's goals and expectations as well as the quality of NASA's CASIS oversight. See Appendix A for details on our scope and methodology.

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1 NASA estimates the United States has spent approximately $70 billion to build and operate the ISS, which includes funds for the commercial cargo and crew programs for transporting cargo, and eventually crew, to and from the ISS. However, the Agency relies on Section 202 of the NASA Authorization Act for fiscal year 2000, which established general cost limitations on the ISS and Space Shuttle Programs. These limitations capped the Shuttle costs at $380 million per launch and NASA applied it to all 37 launches between fiscal years 1999 and 2011. Pub. L. No. 106-391, "National Aeronautics and Space Administration Authorization Act of 2000," November 16, 2000. In August 2001, the Government Accountability Office (GAO) determined actual costs were closer to $759 million per launch. GAO, "NASA: International Space Station and Shuttle Support Cost Limits" (GAO-01-1000R, August 31, 2001). We used the GAO estimate (adjusted for inflation) in our cost calculation.

2 Pub. L. No. 109-155, "National Aeronautics and Space Administration Authorization Act of 2005," December 30, 2005.

3 Pub. L. No. 111-267, "National Aeronautics and Space Administration Authorization Act of 2010," October 11, 2010.

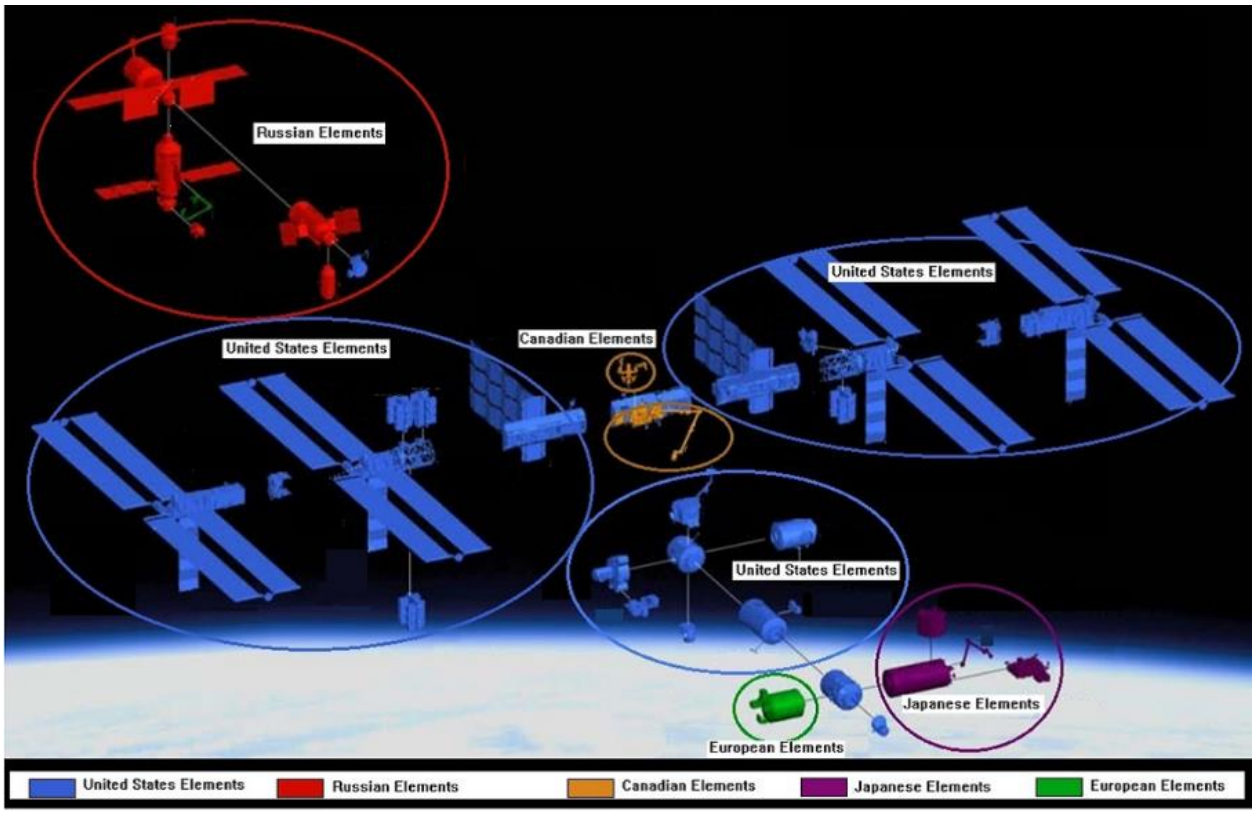
4 NASA Office of Inspector General (OIG), "NASA's Efforts to Maximize Research on the International Space Station" (IG-13-019, July 8, 2013).

5 NASA OIG, "Extending the Operational Life of the International Space Station Until 2024" (IG-14-031, September 18, 2014).

Background

In the mid-1980s, the United States began negotiating with the Canadian, European, and Japanese space agencies to build and operate a space station in low Earth orbit. Russia joined the partnership in 1993, and in 1998 assembly of the ISS began with the U.S., European, Japanese, and Russian space agencies each building modules (see Figure 1).[6] Assembly of the ISS was completed in July 2011. Through fiscal year (FY) 2017, NASA has spent approximately $87 billion for ISS development, operations, research, and associated Space Shuttle flights. For FY 2018, NASA's total projected ISS budget is $3.4 billion, including roughly $318 million for research efforts.

Figure 1: ISS Partner Contributions



Source: NASA.

The ISS provides a unique setting for scientific research because of its location in low Earth orbit and the Station's microgravity environment. A large part of the research on the ISS seeks to help mitigate the astronaut health risks associated with long-duration exploration missions, including visual impairment and muscle maintenance.

[6] Modules built by the partner space agencies are Destiny (United States), Columbus (European), Kibo (Japanese), and Zvezda, Rassvet, Poisk, Pirs, and Zarya (Russian).

The National Lab consists of 24 internal laboratory bays that house a variety of research projects in racks, lockers, gloveboxes, and freezers on the Destiny (13 bays), Columbus (5 bays), and Kibo (6 bays) modules (see Appendix B for additional details). Other ISS research makes use of the extreme conditions outside the ISS to test materials for satellites and other spacecraft.[7]

NASA Astronaut Conducting Research in the Destiny Module

Source: NASA.

Framework and Organizational Model to Manage National Lab

In 2005, Congress designated the U.S. segment of the ISS as a National Laboratory and directed the NASA Administrator to "seek to increase the utilization of the ISS by other Federal entities and the private sector through partnerships, cost-sharing agreements, and other arrangements that would supplement NASA funding of the ISS."[8] Around 2008, amid growing concern that possible budget reductions could interfere with its efforts to maintain ISS operations, NASA began exploring ways to raise funds to help operate the National Lab. Consequently, in 2010 NASA hired ProOrbis, LLC to develop an organizational model for managing the National Lab and to develop strategies for maximizing the value of the U.S. Government's investment in the ISS.[9] ProOrbis provided NASA with an organizational model that outlined a variety of strategies that, if adopted, would enable NASA to increase the number of researchers and commercial firms using the National Lab, raise funds from outside entities, and increase the likelihood of developing commercial applications that would result in jobs or produce financial gains.[10] The model also recommended NASA hand off management of the National Lab to a nonprofit organization.

In October 2010, Congress passed the NASA Authorization Act of 2010 that, among other things, directed NASA to enter into a cooperative agreement with a nonprofit organization to manage at least 50 percent of the Agency's available research capacity on the ISS as defined in terms of power, stowage, or crew time.[11] Under the statute, the nonprofit was required to plan non-NASA research activities on the National Lab, develop guidelines and selection criteria for non-NASA research, coordinate transportation requirements for National Lab research, and develop scientific outreach and education.

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[7] External ISS temperatures range from -200 to 200 degrees Fahrenheit (-129 to 93 degrees Celsius.)

[8] Pub. L. No. 109-155.

[9] ProOrbis, LLC is a strategy and management consulting firm founded in 1998 located in Malvern, Pennsylvania. NASA contracted with The Boeing Company (Boeing) to study and develop an organizational model for the National Lab. Boeing awarded a subcontract for this work to ProOrbis.

[10] The "Reference Model for the International Space Station for the U.S. National Laboratory" was the result of a 90-day study by ProOrbis that combined independent research with working sessions and more than 200 interviews with former and current NASA managers and ISS users, including academic, industrial, and Government scientists; payload developers and integrators; research organizations; astronauts; education experts; and potential funding sources (both private and philanthropic).

[11] Pub. L. No. 111-267.

Selection of Space Florida Proposal

NASA issued a cooperative agreement notice in February 2011 soliciting proposals for a nonprofit entity to implement research and development projects utilizing the National Lab. NASA chose a proposal submitted by Space Florida that was developed in conjunction with ProOrbis and included the firm as a major subcontractor to "stand-up" a new organization known as the Center for the Advancement of Science in Space (CASIS). In a July 2011 decision memorandum, the NASA Associate Administrator for Human Exploration and Operations stated that this selection required him to make a tradeoff between a traditional model to manage the National Lab, where the potential was limited by the amount of available Government funding, against an innovative method with more risk but also where the actualization of potential did not rely on Government funding. The memorandum stated that the Space Florida proposal was selected because it better met the intent of the 2010 NASA Authorization Act and had a better likelihood of increasing ISS utilization.

CASIS Cooperative Agreement

NASA and Space Florida initially signed a cooperative agreement, effective October 2011 through September 2020, authorizing CASIS to manage the National Lab. In July 2017, NASA extended its agreement with CASIS through 2024, the date through which Congress has authorized ISS operations, although NASA is considering extending operation of the Station an additional 4 years.[12] According to the agreement, CASIS has a variety of responsibilities, including

1. stimulating interest in and use of the National Lab,
2. developing the National Lab, and
3. managing the National Lab.

The agreement also identified a liaison officer to consult with CASIS on executing the agreement and a cooperative agreement technical officer responsible for assessing CASIS's performance.

The performance assessment process involves CASIS, the cooperative agreement technical officer, and the NASA liaison officer. NASA and CASIS collaboratively develop annual and quarterly performance goals, metrics used to measure performance, and targets that define the level of acceptable performance. Goals, metrics, and targets are included in the CASIS annual performance plan with results reported by CASIS in its annual report. NASA assesses CASIS's performance based on the annual report, site visits and observations, discussions with CASIS leadership, and supporting data and issues a written assessment memorandum annually signed by the NASA liaison officer. See Appendix C for details of the assessment process.

CASIS Organization and Funding

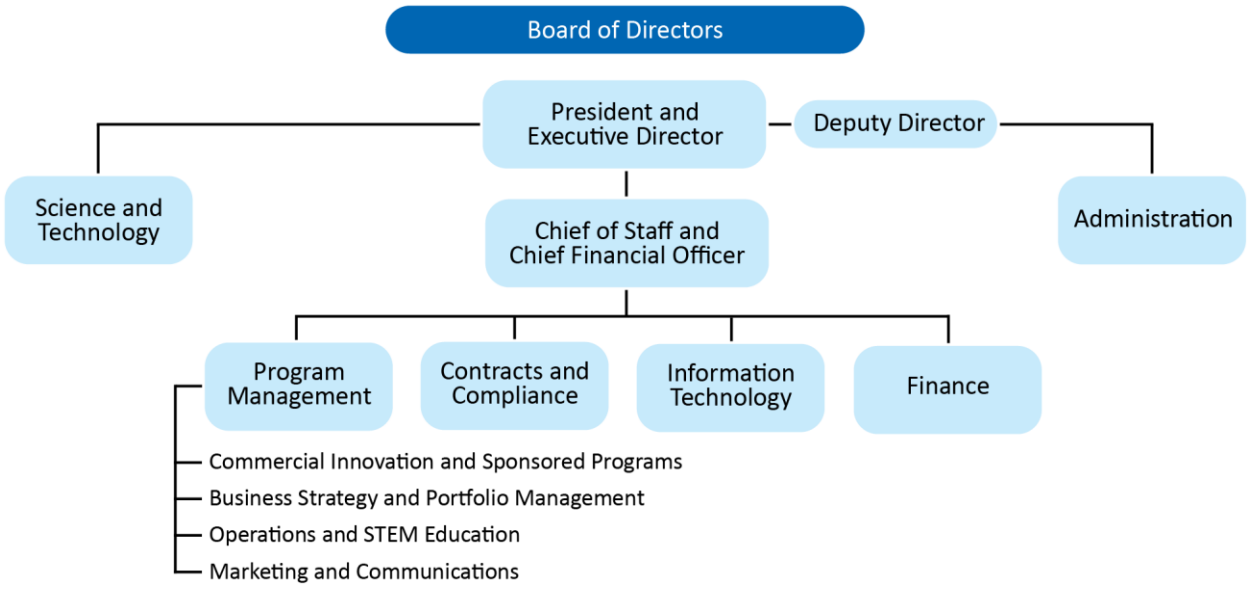
CASIS is headquartered in Melbourne, Florida, and maintains satellite offices in Boston, Massachusetts; Houston, Texas; and Washington, D.C. The President and Executive Director (a single individual) provides overall leadership and direction to the organization and reports to a Board of Directors that is

[12] Pub. L. 114-90, "U.S. Commercial Space Launch Competitiveness Act," November 25, 2015, extended Station operations from 2020 through at least 2024.

comprised of scientists, scholars, and former military officers.[13] The Board is responsible for providing management advice advocating for the National Lab and helping CASIS target potential sources of funds, including Government grants, foundation funding, charitable contributions, private equity, venture financing, and private investors.

CASIS is organized into six functional units – Science and Technology, Program Management, Contracts and Compliance, Information Technology, Finance, and Administration (see Figure 2).

Figure 2: CASIS Organization, as of October 2017



Source: NASA OIG representation of CASIS information.

Note: As of October 2017, the Deputy Director position was vacant.

As of October 2017, CASIS had 65 positions comprised of 3 executives, 43 onboard employees, and 19 vacancies. Employees are located throughout the six functional units:

- The **Science and Technology** unit identifies and prioritizes the national science and technology research objectives that require and enable use of the National Lab to provide the greatest scientific, economic, and social value to the United States (6 employees and 2 vacancies).
- The **Program Management** unit consists of four separate divisions:
    - The *Commercial Innovation and Sponsored Programs* division manages activities related to business development, which includes identifying firms to target for investing in research projects (4 employees and 6 vacancies).
    - The *Business Strategy and Portfolio Management* division reviews and competitively selects research proposals and matches research projects and funding sources (6 employees and 2 vacancies).

[13] As of October 2017, the Board was comprised of 10 personnel; however, it is authorized to be up to 15 persons.

- The *Operations and STEM Education* division ensures research experiments meet the safety requirements of the National Lab and serves as liaison among NASA, Implementation Partners, and research projects.[14] Additionally, the division promotes the use of the National Lab for science, technology, engineering, and mathematics (STEM) programs and supports teachers in improving STEM education (10 employees and 3 vacancies).
- The *Marketing and Communications* division manages external communications, including social media, scientific writing, conferences, and press releases (9 employees and 2 vacancies).

- The **Contracts and Compliance** unit administers all company agreements (from pre-award through award closeout) and addresses compliance with applicable contract and grant requirements (2 employees and 2 vacancies).
- The **Information Technology** unit provides internal support for phones, networks, and data systems (3 employees).
- The **Finance Department** is responsible for all accounting activities, such as cash management, accounts receivable, accounts payable, monthly closing and reporting, and budgeting. It is comprised of the organization's comptroller and an administrative assistant (1 employee and 1 vacancy).
- The **Administration** unit manages benefits, payroll, and other human resources issues, and provides administrative support to executives, managers, and the Board of Directors (3 employees).

Since FY 2012, NASA has provided CASIS with approximately $15 million annually to fund its operations. In addition, through the end of FY 2016 CASIS raised an additional $1.11 million from a variety of sources:

1. *Dues* from its membership program collected in FYs 2012 through 2014.[15] The paid membership model was discontinued at the beginning of FY 2014 because of low participation.
2. *Restricted funds* to be used solely for research projects designated by the funding entity. Most of the restricted funds raised by CASIS are classified as sponsored program funds and cannot be used by CASIS to offset ordinary operating expenses.
3. *Direct contributions* from foundations, Federal agencies, and commercial entities that CASIS can use for any purpose.

[14] Implementation Partners provide specialized services that National Lab researchers need to prepare their experiments for the ISS environment. These services include payload development and integration, flight hardware development and integration, software development, payload safety certification, and end-to-end mission management support services.

[15] In its 2011 proposal, CASIS described a plan to generate funds by collecting membership fees from individuals and entities, including investigators, research institutions, universities, Implementation Partners, and others with an interest in the National Lab. In exchange, CASIS members would be able to connect with a network of individuals, institutions, and companies with shared interests. Additionally, CASIS members would receive discounts and invitations to special events, opportunities for professional networking, tickets to an annual luncheon, email updates, and access to an online forum. The membership program raised only $3,455 before it was discontinued.

As shown in Table 1, CASIS has received total funding of $76.2 million through FY 2016.

Table 1: CASIS Funding

Source	Fiscal Year						Total
	2011	2012	2013	2014	2015	2016	
NASA	$2,177,624	$11,544,789	$15,274,726	$15,273,635	$14,836,610	$15,992,117	**$75,099,501**
Interest Income	212	1,774	2,414	2,525	5,351	4,940	**$17,216**
Membership Income	–	3,210	210	35	–	–	**$3,455**
Contributions	–	–	5,000	9,193	807,430	269,182	**$1,090,805**
Total Funding	**$2,177,836**	**$11,549,773**	**$15,282,350**	**$15,285,388**	**$15,649,391**	**$16,266,239**	**$76,210,977**

Source: NASA OIG analysis of CASIS tax returns and annual reports.

CASIS Payload Integration Process

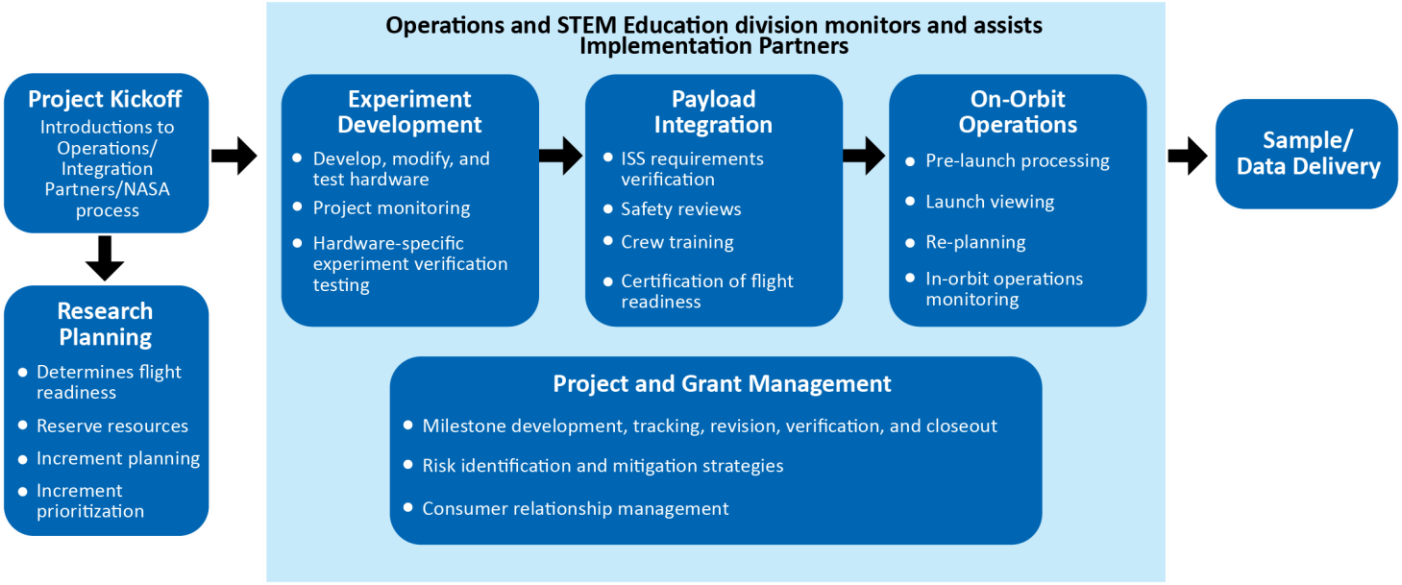
CASIS has adopted a five-step process for transporting a user's research experiment – also known as a payload – from the ground to the National Lab and back. These steps are managed by CASIS's Operations and STEM Education division and include project kickoff and planning, experiment development, payload integration, on-orbit operations, and sample/data delivery.

The process begins with *project kickoff* during which researchers and the Implementation Partners are introduced to CASIS Operations and STEM Education division staff and the payload integration process. During this step, the parties determine the experiment's flight readiness and resource needs. Operations and STEM Education division staff assist Implementation Partners during the next three steps:

1. *experiment development* involves hardware development and testing,
2. *payload integration* includes safety reviews and certification that hardware components meet ISS flight requirements, and
3. *on-orbit operations* include pre-launch processing and activities needed to operate and monitor the experiment in orbit.

During these steps, tracking project milestones and other activities related to project and grant management are critical. In the final step – *sample/data delivery* – experiment samples and data are transferred from the ISS to ground-based laboratories. See Figure 3 for a visual depiction of the payload integration process.

Figure 3: Payload Integration Process



Source: NASA OIG presentation of CASIS information.

NASA's Expectations for CASIS

From NASA's perspective, the primary role of CASIS is to maximize non-NASA use of the National Lab. However, while this goal is listed as a requirement in the cooperative agreement, NASA has not identified any specific performance targets in the agreement to gauge CASIS's success in this effort. Other NASA expectations in the cooperative agreement are described using broad, descriptive language and generally do not include quantifiable performance targets. As such, for the purposes of this report, we divided the cooperative agreement requirements into nine categories that we identified as NASA's expectations for CASIS. These categories align with annual performance goals agreed to by NASA and CASIS or are part of NASA's performance assessments of the organization.

1. *Research Pathways.* The agreement requires CASIS to develop research pathways that depict the continuum of research within a given research category (theoretical, basic, and applied research).[16] The agreement specifically requires CASIS to (a) compile research categories suitable for the National Lab, (b) collect evidence to gauge the potential value and feasibility of research categories for the National Lab environment, (c) screen application opportunities for each research category, and (d) map each research pathway.
2. *STEM Education Programs.* The agreement requires CASIS to increase interest in using the National Lab as a platform for STEM education and to increase STEM education experiments.

[16] Theoretical research uses hypothetical examples and formulates theories to explain, predict, and understand phenomena. Basic research is performed without thought of practical ends and results in the growth of general knowledge and understanding of nature and its laws. Applied research is used to answer a specific question that has practical applications of science.

3. *Grant Awards and Project Portfolio.* The agreement requires CASIS to annually award at least $3 million in research grants. In addition, CASIS must ensure a balanced portfolio of research projects from theoretical to basic to applied research.
4. *Recruitment of National Lab Users.* CASIS is required to engage in a targeted advocacy campaign to stimulate interest by researchers and research entities in using the National Lab for research and technology projects.
5. *Matching Research Projects and Investors.* The agreement requires CASIS to develop a mechanism for identifying appropriate funding sources and match those sources with researchers seeking funding.
6. *Implementation Partners.* The agreement requires CASIS to engage Implementation Partners to free itself from maintaining a wide variety of expertise in-house. According to CASIS officials, the vast majority of its grant awards are made to researchers who have little to no experience with the technical requirements of conducting research in space. To ensure a new user is successful, CASIS has agreements with 33 private companies they refer to as Implementation Partners who provide specialized services National Lab researchers need to prepare their experiments for the ISS.
7. *Fundraising.* Although NASA did not specify fundraising goals in the terms and conditions of the cooperative agreement, NASA expects CASIS to raise funds as described in its 2011 proposal. According to the proposal, CASIS's fundraising efforts should raise a sufficient amount to offset NASA's $15 million annual investment and become self-sustaining within 5 years of the original cooperative agreement.
8. *Use of Crew Time for National Lab Research.* The agreement requires CASIS to maximize utilization of the National Lab. Although there are a variety of ways to measure utilization (e.g., upmass and downmass), crew time is the primary metric used by NASA.[17]
9. *Outreach.* CASIS is required to perform outreach activities to various groups that promote the benefits and unique advantages of using the National Lab. These groups include National Lab users, the White House, Congress, media, educators and students, and the general public.

In addition to these nine requirements, NASA expects CASIS to serve an important role in facilitating and promoting a commercial space economy, a major goal identified in the NASA Authorization Act of 2010.[18] Additionally, in each of their annual assessment memoranda to CASIS, NASA oversight officials emphasized the importance of developing a commercial space economy in low Earth orbit and CASIS's role in that endeavor. In the Agency's FY 2015 assessment memorandum, the NASA liaison officer stated, "it is encouraging to see the strong emphasis on stimulating demand for a sustained commercial economy in low Earth orbit. This is of critical importance to the fulfillment of one of NASA's strategic goals, and CASIS is playing the leading role." Similarly, the Agency's FY 2016 assessment memorandum emphasized the importance of CASIS to achieving a commercial space economy, citing the organization's work with grant awards, commercial users, and applied research; support to commercial service providers; and utilization of the National Lab.

[17] Upmass is the amount of equipment and supplies delivered to the Station – typically expressed in kilograms – and conversely, downmass is the amount of equipment and experiments returned to Earth.

[18] Pub. L. No. 111-267. The NASA Authorization Act of 2010 requires NASA to seek and encourage, to the maximum extent possible, the fullest commercial use of space. NASA Strategic Goal 1, Objective 1.2 aligns with the United States National Space Policy, which is committed to encouraging and facilitating the growth of a U.S. commercial space sector that is globally competitive and advances U.S. leadership in developing new markets.

CASIS Has Fallen Short of Meeting NASA's Goals and Expectations

After more than 5 years of operation, CASIS has not met a majority of the expectations set out in its cooperative agreement with NASA. Specifically, through FY 2016 CASIS only met expectations in two of nine categories – research pathways and STEM education programs – and did not meet or only partially met expectations in the remaining seven categories, including recruitment of users, outreach, and utilization of the National Lab. More importantly, although CASIS awarded $21.7 million in grants to 140 projects between FYs 2013 and 2016, the organization has underperformed on tasks important to achieving NASA's goal of building a commercial space economy in low Earth orbit. From 2011 through 2014, CASIS was standing up their organization and filling leadership positions rather than creating specific, quantifiable metrics. In our judgment, this factor contributed to CASIS not meeting NASA's goals and expectations. NASA shares responsibility for CASIS's failure to meet expectations because during this period the Agency did not actively oversee the organization's technical performance and generally allowed CASIS to operate on its own accord. Even though in recent years NASA has become more involved in measuring CASIS's performance, the Agency still has not developed a performance strategy for the remaining 7 years of the agreement or provided quantifiable metrics by which to assess CASIS and help improve the organization's performance.

CASIS Has Not Fully Met Expectations in Seven of Nine Performance Categories

Our 2013 report found, among other things, that CASIS suffered a series of organizational issues early on that affected its initial fundraising efforts.[19] For example, CASIS signed the cooperative agreement with NASA and appointed its first Executive Director in August 2011; however 7 months later, the Executive Director resigned, and as of May 2013 CASIS had no permanent Executive Director. In addition, at the time of our 2013 audit, only 7 of the 15-member Board of Directors had been selected. Finally, although the organization met most of its early performance metrics, these metrics were focused primarily on achieving organizational milestones rather than measuring how successful CASIS had been encouraging research on the ISS, and CASIS and NASA had yet to create specific, quantifiable metrics to measure CASIS's ability to meet Agency goals.

In the 4 years since our 2013 report, CASIS has awarded more than $3 million in grants annually and made progress each year. However, CASIS's performance has continued to fall below NASA's expectations. Specifically, of the nine performance categories we examined, CASIS met NASA's expectations in only two: research pathways and STEM education programs. For research pathways, CASIS developed an alternative approach that met the intent of the agreement but not its specific terms, an approach NASA has accepted. For STEM education programs, although CASIS did not meet all of its performance targets, we consider CASIS's efforts for FY 2016 to be successful. For the remaining seven categories, CASIS partially met expectations in five categories – grant awards and project

[19] IG-13-019.

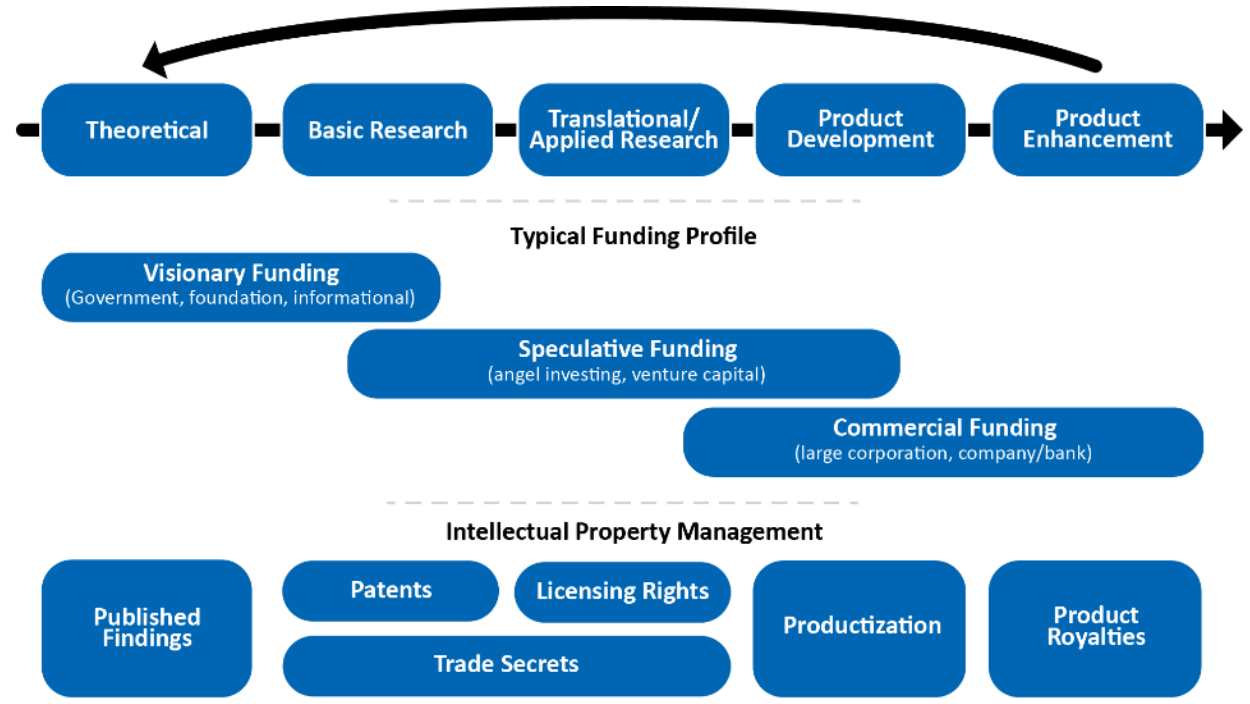
portfolio, recruitment of National Lab users, matching research projects and investors, Implementation Partners, and fundraising – and failed to meet expectations in two – use of crew time for National Lab research and outreach.

Research Pathways

The cooperative agreement includes specific requirements for CASIS to develop research pathways that would show the continuum of research (theoretical to applied). Instead, CASIS developed vertical areas as a substitute, an approach NASA accepted. While CASIS met NASA's expectations in this area, the Agency has not formally assessed the differences between the two approaches or documented its rationale for accepting the change in methodology.

Under the agreement, CASIS was to (1) compile research categories suitable for the National Lab, (2) collect evidence that gauges the potential value and feasibility of research categories for the National Lab environment, (3) vet application opportunities for each research category, and (4) map out the pathway – from theoretical to basic to applied research – for each research category. A research pathway should describe the continuum of research along with potential applications for that research, funding profiles, and intellectual property management. Figure 4 illustrates a research pathway contained in the original ProOrbis model.

Figure 4: Research Pathways



Source: NASA OIG presentation of ProOrbis information.

Instead of developing research pathways, CASIS established four vertical areas – life sciences, physical sciences, remote sensing, and technology – identifying the broad scientific and technical subjects, known as value propositions, the organization intends to pursue along with the research topics related to those subjects. For example, Table 2 illustrates value propositions and research topics in the life sciences vertical area, which includes the pharmaceutical, biotechnology, agriculture, and medical devices industries – all potential users of the National Lab.

Table 2: Life Sciences Vertical Area

Value Proposition	Research Topic
Drug discovery and development	Protein crystallization
Accelerated models of aging	Cell-based and rodent research
Disease modeling	Cell-based and rodent research
Regenerative medicine	Stem cells, organs-on-chips, tissues-to-organs research
Drug delivery, stabilization, shelf-life, and transport	Microencapsulation, formulations
Manufacturing and process optimization	Chinese hamster ovary used in research and studies of genetics, toxicity screening, and nutrition; and microfluidic and macromolecules
Crop science	Plant/microbe/insect, formulations, shelf-life/transport, and remote sensing

Source: CASIS.

Developing pathways for the major research issues in a microgravity environment was one of the requirements in CASIS's cooperative agreement with NASA. Instead, CASIS developed the vertical area concept. According to CASIS officials, vertical areas allow the organization to target potential customers and identify potential research areas for these customers to consider. For example, in FYs 2015 and 2016, CASIS contacted a total of 110 commercial and noncommercial entities that conduct research in the four vertical areas to discuss their interest in the National Lab. Using the vertical areas, CASIS works directly with customers to develop project concepts and map these concepts to National Lab capabilities, assisting customers in prioritizing projects best matched with current National Lab availability and hardware. Although research pathways and vertical areas provide different information, a NASA oversight official for the agreement accepted CASIS's approach even though the Agency has not formally evaluated the differences or documented its assessment that CASIS met the intent of the research pathways goal.

Stem Education Programs

CASIS exceeded its target for the number of participants in its STEM education programs. Although CASIS did not meet all of the performance targets in this category, we consider the organization's efforts for FY 2016 to be successful.[20] Specifically, CASIS provided funding to 14 active STEM education programs with more than 325,000 participants, and funded approximately $377,000 in STEM grants. These accomplishments come close to, or in some cases exceeded, the performance targets stipulated in the performance plan, as shown in Table 3.

[20] CASIS was required to meet specific performance targets for STEM Education in FYs 2015 and 2016 only. We based our conclusion on FY 2016 performance since it reflects the organization's progress from the start of the agreement. In FY 2017 quarterly reports, CASIS reported exceeding targets for these metrics.

Table 3: STEM Education Programs, FY 2016

Metric	Target	Actual
Active STEM programs	15	14
Number of students, educators, and other participants engaged in STEM initiatives	180,000	328,077
Amount of STEM grants	$388,000	$377,222

Source: CASIS.

CASIS officials stated that educational proposals submitted to the organization for financial or operational support go through formal reviews by at least three subject matter experts before approval. In addition, CASIS has formal agreements with member partners, reviews partner programs to ensure their educational value for participants, reviews participant metrics quarterly, and requires partners to count only participants who directly engage in learning activities.

We reviewed a sample of seven CASIS-established STEM education programs active in FY 2016 and found each program aligned with NASA's objective for these programs and involved a broad range of user groups and a large number of program participants (see Appendix D for details).[21] According to CASIS officials, program participants included students and educators who participated in STEM-related education programs, projects, meetings, and events. CASIS educational specialists report quarterly to NASA the number of participants in the STEM education programs it manages, such as the 72 students that participated in its National Design Challenge.[22] In addition, CASIS reports on participants in STEM education programs managed by other organizations, including high schools and elementary schools.

Grant Awards and Project Portfolio

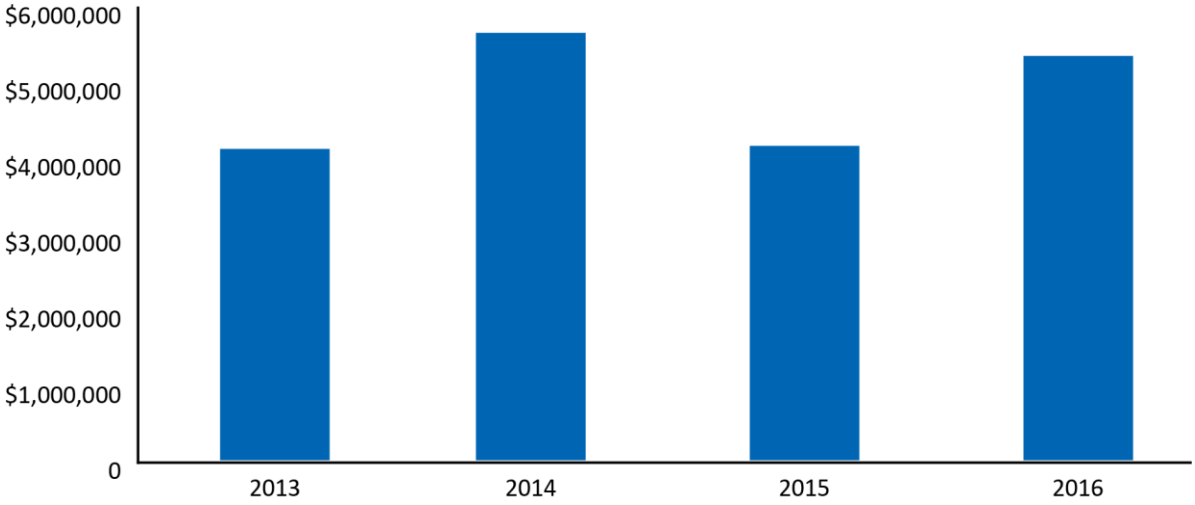
CASIS only partially met the requirement to annually award at least $3 million in research grants to ensure a balanced portfolio of research projects encompassing theoretical, basic, and applied research. Although the organization awarded more than $3 million annually in research grants between FYs 2013 and 2016 (see Figure 5), CASIS has not ensured a balanced portfolio of research projects along the research spectrum as required by the cooperative agreement.[23]

[21] NASA's Strategic Objective 2.4 states, "advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets."

[22] In the National Design Challenge program, high school students studied the effects of microgravity on the electrolysis of silver nitrate crystals and compared those results to crystals grown on Earth.

[23] In FY 2017, CASIS awarded more than $6 million in research grants, which surpassed the target of $5 million in research grant awards.

Figure 5: CASIS Research Grants



Source: NASA OIG presentation of CASIS information.

Between FYs 2013 and 2016, CASIS awarded $21.7 million in grants to 140 projects in life sciences, physical sciences, remote sensing, and technology development. Although the majority of projects selected by CASIS are flight projects that will eventually launch to the ISS, some awards were for ground-based research that may lead to a flight project, ground-based analyses of ISS flight samples, and ground-based technology development projects that may lead to new analytical capabilities on the Station. Four examples of CASIS research grants are summarized below:

- In FY 2013, CASIS awarded $49,400 to a professor from the University of Florida whose project investigated how plant roots know which direction to grow in the absence of gravity.
- In FY 2014, a project designed by a researcher from Texas A&M University received a $299,869 grant to examine bone tumor cell interactions with the goal of developing drugs to target cancer cells.
- In FY 2015, CASIS made a no-cost award to a project from Vision Engineering Solutions to test new approaches for tracking orbital debris difficult to observe with radar to mitigate collision risks with spacecraft and satellites.
- In FY 2016, a project sponsored by Delta Faucet received $169,100 to evaluate water droplet formation, water flow, and water pressure to create a better-performing shower device for the ISS and for use on Earth.

However, with respect to the balance of research projects, NASA performance assessments for FYs 2015 and 2016 advised CASIS that basic research was over-represented in its project portfolio. Specifically, the FY 2015 assessment memorandum noted that education and academic research comprised 38 and 24 percent respectively, of the total project portfolio for FY's 2011 through 2015. The FY 2016 assessment noted a similar over-representation of STEM education projects in the CASIS portfolio. The NASA official who oversaw CASIS's performance in FYs 2015 and 2016 said STEM projects should be the smallest discipline represented – in his view, 10 percent or less of total crew time – since those projects represent basic research unlikely to stimulate commercially-viable demand for research on the Station and, therefore, do not further the Agency's goal of promoting a commercial economy in low Earth orbit.

We reviewed CASIS's portfolio for FYs 2013 through 2016 and found that educational institutions performed 38 percent of all research experiments (62 of 162) through FY 2016. The remaining 62 percent was distributed among university, non-NASA Government agencies, and commercial researchers. Research by educational institutions aligns with National Lab research objectives while stimulating students' interest in STEM and though worthwhile, we believe that NASA would be better served with a CASIS portfolio weighted more toward basic and applied research by university, non-NASA Government agencies, and commercial researchers since that research is more likely to promote a commercial space economy in low Earth orbit. Although NASA viewed STEM-related research by educational institutions as over represented in the CASIS portfolio, the Agency had not established a formal target for this activity through FY 2016.

CASIS officials explained that they view a balanced research portfolio as one that weighs and considers investments to increase user demand for the National Lab, makes optimal use of the National Lab, and establishes a basis for a sustainable commercial enterprise in low Earth orbit. According to NASA and CASIS officials, in FY 2017, CASIS began selecting research proposals on a framework based on impact and feasibility. Officials believe the framework will favor high-impact/high-feasibility proposals, avoid low-impact/low-feasibility proposals, and then select low-impact/high-feasibility proposals typical of STEM projects to fill out capacity.[24]

Recruitment of National Lab Users

CASIS executed a campaign to recruit new and repeat users for the National Lab through its Commercial Innovation and Sponsored Programs division, but the organization only partially met this requirement because recruitment failed to meet performance targets. Recruiting fewer users will negatively impact CASIS's ability to meet the National Lab's goal of 50 percent utilization when NASA adds an additional crew member, currently projected for late 2018.

Recruitment of New and Repeat Users

CASIS recruits users for the National Lab from the commercial sector – companies seeking an opportunity to test their applied research experiments in a microgravity environment – and the noncommercial arena – academia, non-NASA Government agencies, and participants in STEM education programs, which generally perform basic research. For FYs 2015 and 2016, CASIS had a total of 39 distinct commercial and 27 distinct noncommercial users with experiments on the National Lab. However, in FY 2016 CASIS recruited only 16 new users, falling short of its performance target of 20. Additionally, CASIS has been unsuccessful in recruiting repeat users, especially repeat commercial users. Over a 4-year period, CASIS recruited 13 repeat users, of which only 4 were from the commercial sector. According to CASIS officials, these low retention rates could partially be attributed to three failed ISS resupply missions in FY 2015.[25] Specifically, the failed missions created concerns among commercial companies that insurance protection would be cost prohibitive and resulted in companies needing assurance that CASIS would be able to return to a normal flight schedule.

[24] In FY 2016, CASIS began studying the impacts of their funded research projects and estimating the value of those impacts.

[25] In October 2014, the third in a series of NASA-contracted resupply missions to the ISS by Orbital Sciences Corporation failed during lift-off, causing the vehicle to crash near the launch pad destroying the company's Antares rocket and Cygnus spacecraft as well as all cargo aboard. In April 2015, a Russian Progress cargo spacecraft with food, fuel, and supplies failed to rendezvous with the Station and was destroyed. In June 2015, the Space Exploration Technologies Corporation's seventh cargo resupply mission to the Station failed during launch, destroying all cargo onboard.

For FY 2017, CASIS officials reported that it exceeded its target for new users but fell below the target for repeat users.[26] Although user recruitment may have improved in FY 2017, in our opinion, a longer-term trend is needed to ensure maximum use of the National Lab. Specifically, from FYs 2012 through 2016, CASIS had used about 53 percent of its allocated crew time hours. In its FY 2016 assessment memorandum, NASA noted that absent growth in the project pipeline, the crew utilization rate for three crewmembers could drop below 50 percent. NASA intends to increase the number of crew aboard the U.S. segment of the ISS from three to four in late 2018 and plans to allocate a portion of the additional crew hours available to CASIS who, in turn, will need to recruit additional users. Consequently, without sustained increases in the number of new and repeat users, CASIS's crew time utilization could fall even further when the fourth crew member is added.

Activities by Commercial Innovation and Sponsored Programs Division

From the outset, CASIS has struggled to create interest in ISS research. For example, in a 2016 meeting of the NASA Advisory Council, members stated that expectations for the National Lab were for it to become self-supporting, for private companies to pay for their own research, and for NASA's payments to CASIS be eliminated by 2024. Members were concerned about future demand for research from the private sector and stated users should be "beating the door down" to use the National Lab since NASA is providing free transportation to the ISS and free crew time to conduct the research. In response, CASIS officials admitted that while this has not been the case so far, the organization had evaluated more than 200 proposals for commercial research since its inception in 2012.

Our 2013 report identified two factors that make attracting private funding for ISS research a challenge.[27] First, NASA historically received little interest from the private sector unless the Agency promised a substantial infusion of funds. For example, despite NASA covering the cost for payload integration, transportation, and ISS resources, between 1998 and 2010 commercial entities funded only 9 percent of experiments conducted aboard the U.S. segment of the ISS. Second, ground-based research can provide similar results at significantly less expense than research on the ISS. Our report noted that the cost of conducting research on the ISS can exceed $250,000 and identified CASIS's challenge to demonstrate that the advantage of microgravity research was worth the extra cost.

Although market demand and the added cost of ISS research can be factors in attracting users, we believe CASIS could improve its recruitment practices. CASIS recruits new users by issuing public solicitations and through personal outreach by staff in its Commercial Innovation and Sponsored Programs division and its Board of Directors. After an initial contact, the division may conduct an in-person meeting or presentation that aims to explain how the microgravity environment of the National Lab benefits the researcher's area of interest. The Board of Directors, in addition to providing management advice and advocating for the National Lab, is responsible for helping CASIS recruit new users with individual board members providing CASIS staff access to contacts from their professional networks who may be interested in conducting research on the National Lab.

We surveyed 27 entities contacted by the Commercial Innovation and Sponsored Programs division during FYs 2015 and 2016 to ask about the nature of the division's contact and whether the division's presentations were tailored to the entity's research needs. Of the 11 responses, the majority said they

[26] Through September 2017, CASIS had a total of 43 commercial users with experiments on the National Lab, which exceeded the target of 40 commercial users, and recruited 32 new users, which exceeded the target of 20 new users. However, CASIS recruited only 11 repeat customers compared to the target of 20 repeat users.

[27] IG-13-019.

were generally satisfied with the nature and content of the contact. However, 4 of 11 respondents (36 percent) said CASIS staff did not make an in-person presentation or did not target their presentation to the respondent's research needs.

We noted that CASIS has too few staff engaged in user-recruitment activities compared to staff engaged in education and outreach. Specifically, as of October 2017 the Commercial Innovation and Sponsored Programs division had 10 positions (4 employees and 6 vacancies), while the two divisions that support education and outreach programs – the Operations and STEM Education division and Marketing and Communications division – had a total of 24 positions (19 employees and 5 vacancies). In our judgment, the imbalance in resource allocation to these activities has contributed to the organization's inability to consistently recruit new and repeat users who can help fully utilize the National Lab's research potential. In addition, we found many CASIS recruitment activities rely on telephone or email contacts rather than in-person meetings, which would appear to be more effective in recruiting new users. Recruitment of new and repeat users is critical to maximizing non-NASA use of the National Lab – the statutory purpose for establishing CASIS. Therefore, we believe NASA would be better served if CASIS rebalanced staff between these divisions. CASIS officials stated that they recognize the need to expand staffing and are currently recruiting additional staff for the Commercial Innovation and Sponsored Programs division.

Matching Research Projects and Investors

CASIS partially met the agreement requirement to develop an effective mechanism for matching National Lab researchers seeking funding with funding sources.[28] Specifically, CASIS did not fully develop its investor network until FY 2016 – 4 years into the cooperative agreement – and the resulting mechanism has facilitated only four successful matches between researchers and funding sources since 2012.

Before FY 2016, CASIS pursued support from foundations and partnered with existing venture capital networks such as the Houston Angel Network to connect investors with researchers seeking funding.[29] However, beginning in FY 2016, CASIS shifted their strategy to focus on sponsored programs and evolve their investor network. By the end of FY 2017, CASIS had doubled its investor network – from 33 potential funding sources to 67 – compared to the end of FY 2016. CASIS manages its investor network through a database that tracks industries of interest, average investment size, assets under management, and stage of investment. When a researcher requests funding assistance, staff in the Business Strategy and Portfolio Management division screen the investor database to identify investors with strategies that align with the researcher's proposal. Although CASIS staff facilitate introductions, they do not take part in the funding conversation between researchers and potential investors since the parties are responsible for negotiating and completing funding agreements.[30] CASIS staff will intermittently contact the researchers and investors to check on whether an agreement has been formed.

According to CASIS officials, the matching mechanism has successfully introduced researchers and potential investors, and officials pointed to four investments in two companies since the start of FY 2016 totaling about $1 million. CASIS officials project growth in the number of investors, introductions, and total investment funding as they seek to build a robust investor network throughout the country.

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[28] According to the cooperative agreement CASIS is responsible for identifying "funding opportunities from appropriate sources and facilitate matching of projects that meet the research objectives with those qualified funding sources."

[29] The Houston Angel Network is a nonprofit association located in Houston, Texas, whose members are investors interested in providing capital and coaching to start-up companies.

[30] CASIS facilitates introductions between the parties but is not further involved in discussions between the parties regarding funding agreements.

Currently, about half of its investor network is located in Silicon Valley, California, which CASIS officials view as an area with high potential for investment. For example, officials stated that in FY 2017 CASIS hosted 12 commercial space startups that presented their products and services to approximately 20 investors in attendance. A similar introduction event organized by CASIS in 2016 facilitated multiple investments representing more than $500,000 in funding. In addition to growth in its investor network, CASIS officials stated that they have increased the number of introductions between researchers and potential investors to 216 in FY 2017 compared to 70 in FY 2016.

The prior NASA cooperative agreement technical officer confirmed that NASA expected CASIS to develop a viable matching mechanism but was unaware that CASIS had developed its own investor network or successfully matched researchers and potential investors. Although NASA included requirements for a matching mechanism in the initial agreement, subsequent performance plans did not include a performance goal connected to this objective.

Support for Implementation Partners

CASIS maintains agreements with commercial firms – known as Implementation Partners – who perform payload integration and other support services required by the user to transition their research projects into the space environment. CASIS is required under the cooperative agreement to stimulate commerce in space by advancing and developing research capable of enabling commercial Implementation Partners to operate in, on, or around the ISS. Although CASIS developed mechanisms to engage Implementation Partners, it awarded the majority of the contracts for their services to a relatively small number of partners. In addition, CASIS only partially met requirements under this objective since it failed to attract enough small businesses and start-up firms – a strategy central to NASA's goal of building a commercial economy in low Earth orbit.[31] All of the small businesses and start-up firms CASIS partnered with had been evaluated as having the technical skills and capabilities to provide implementation services.

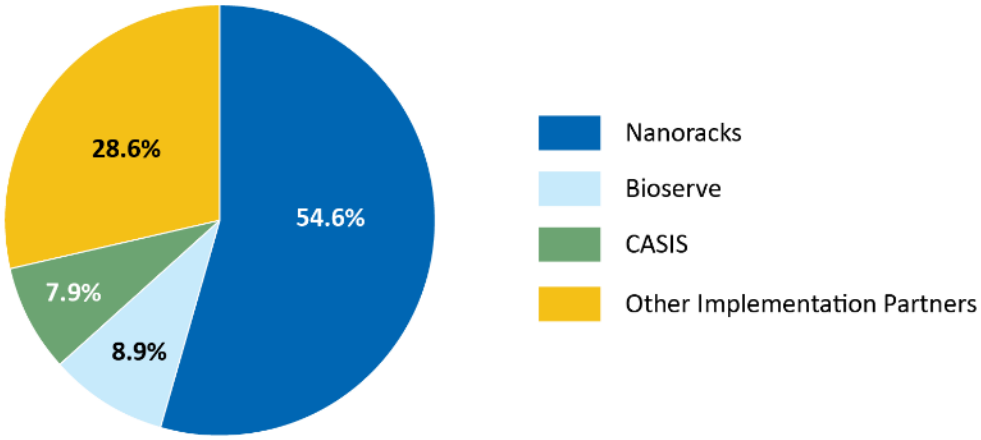
According to CASIS officials, Implementation Partners are selected based on various factors, including competitive pricing or their skill and proficiency in technical areas such as developing space flight hardware to support life science research in space or designing integrated systems that facilitate microgravity research.[32] Although CASIS has fostered and developed a number of partnerships for implementation services, the organization has failed to fully utilize all of these partnerships. Specifically, between FYs 2012 and 2016, CASIS managed 280 contracts for implementation services, but 178 (64 percent) were awarded to just two Implementation Partners – Nanoracks and Bioserve. Of the remaining 102 contracts, CASIS performed implementation services for 22 of the contracts (8 percent),

[31] In NASA's March 2016 and May 2017 assessment memoranda to CASIS, the Agency encouraged CASIS to focus on enabling commercial service providers and emphasized that CASIS find and facilitate the development of new users for those providers.

[32] CASIS developed a website database and guidebook – "The CASIS Directory of Implementation Partners" – to assist new users in identifying potential partners. Implementation Partners are selected and managed in four ways: (1) business-to-business transaction in which the National Lab customer/awardee contracts directly with the Implementation Partner for the required services, (2) NASA services contract where the cost is included in the budget for the CASIS-approved award, (3) CASIS agreement or task order made directly with the Implementation Partner, and (4) CASIS grantee agreement made with the Implementation Partner.

while the remaining 80 contracts were spread between 30 Implementation Partners, including both larger firms as well as small businesses and start-ups.[33] The breakdown in contracts among Implementation Partners is illustrated in Figure 6.

Figure 6: Distribution of Implementation Service Contracts, FYs 2012 through 2016



Source: NASA OIG analysis of CASIS data.

Our analysis of contracts awarded between FYs 2012 and 2016 showed that only 14 to 21 percent of available Implementation Partners received contracts in any given year. The actual number of contract awards and the percentage of Implementation Partners that received awards is shown in Table 4.

Table 4: Number of Contract Awards and Percentage of Implementation Partners with Awards, FYs 2012 through 2016

Fiscal Year	Implementation Partners Available	Number of Implementation Partners Awarded Contracts[a]	Percentage of Partners Contracted
2012	29	4	14%
2013	29	6	21%
2014	29	4	14%
2015	29	6	21%
2016	31	6	19%

Source: NASA OIG analysis of CASIS data.

[a] Implementation Partners with contracts do not include CASIS, NASA Centers, or companies that served as their own Implementation Partner.

[33] CASIS officials explained they performed services on 8 percent of contract awards because in those situations researchers had low-level requirements such as completing paperwork that could be performed by CASIS staff. For example, CASIS performed all steps needed to ensure books were transferred to the ISS for a project in which an astronaut reads to children from the ISS.

CASIS officials explained that researchers selected Implementation Partners based on costs, hardware, and expertise and that CASIS was not involved in the selection. For example, lower bids by certain firms – generally, the two firms that received the majority of contracts – eliminated some of the more expensive partners. In addition, some researchers required Implementation Partners with specific hardware or other potential partners failed to submit bids in response to solicitations from CASIS for new projects.

We agree with CASIS that costs and technical expertise are valid criteria when selecting an Implementation Partner and that a firm's failure to respond to a solicitation is not within CASIS's control. However, NASA considers the viability of small businesses and start-up firms key to its goal of building a commercial space economy in low Earth orbit. Although researchers may ultimately select the firm for a contract, the award of less than 30 percent of contracts to 28 of the 30 potential Implementation Partners shows that CASIS has yet to develop effective processes that foster a competitive market. We believe CASIS should provide assistance to small businesses and start-up firms to ensure they receive contracts and more fully participate in the payload integration process.[34] To date, NASA has not addressed this goal in the CASIS performance plan, but instead has communicated its expectations in its FY 2015 and FY 2016 performance assessments.

Fundraising

Through FY 2016, CASIS has raised $9.1 million, partially meeting fundraising expectations. As described in CASIS's 2011 proposal, the original intent was to raise a sufficient amount of funds to offset NASA's $15 million annual investment and become self-sustaining within 5 years. However, of the $9.1 million raised in the past 5 years, only $1.7 million are unrestricted funds that can be spent on ordinary operating expenses. The remaining $7.4 million are considered restricted funds, that is, funds obtained from a non-NASA sponsor for a specific purpose that cannot be spent on ordinary operating expenses. Most of the restricted funds raised by CASIS are classified as sponsored program funds shown in Table 5.

Table 5: Sponsored Program and External Funding for Grants

Sponsor	Solicitation	Amount
Massachusetts Life Science Center	Galactic Grant Competition	$500,000
Massachusetts Life Science Center	ISS STEM Challenge	50,000
The Boeing Company	Mass Challenge	500,000
The Boeing Company	Genes in Space	500,000
National Institutes of Health/National Center for Advancing Translational Sciences	Funding Opportunity Focused on Human Physiology	3,000,000
National Science Foundation	Fluid Dynamic Research	1,500,000
Space Florida	Craig Technologies	1,100,000
University of Florida	CASIS Research Initiative	250,000
Total		**$7,400,000**

Source: CASIS.

[34] "NASA Intentions for Commercial Low Earth Orbit," a March 2016 presentation by the ISS Director, describes the Agency's vision for low Earth orbit as one of sustained economic activity enabled by human spaceflight and driven by private and public investments.

Given its fundraising history, CASIS is likely to fall far short of the goal of raising enough non-NASA funds to be self-sustaining prior to the end of the agreement in 2024. In its initial proposal to NASA, CASIS described five approaches it would use to raise between $30 million and $50 million in non-NASA funds over its first 5 years of operation. However, one of the approaches – grant origination fees – was subsequently prohibited under the terms of the cooperative agreement.[35] Furthermore, as of 2016 the four other approaches have not proven to be productive sources of non-NASA funds. For example, CASIS implemented a membership structure with fees similar to a professional society for individuals and organizations interested in conducting research in low Earth orbit. The membership-fee approach was ended in 2014 after CASIS raised less than $4,000 in 3 years. CASIS also proposed campaigns to solicit funds from charitable foundations and the public, but the organization has not raised a material amount of funding from this approach. CASIS and NASA officials attributed the lack of success to intense competition for research funds.

Although CASIS has not been successful in meeting external funding expectations to offset operating costs, the organization met its FY 2016 target of raising $5 million for sponsored program funding. Moreover, according to CASIS FY 2017 quarterly reports, CASIS exceeded its FY 2017 fundraising target of $5 million, raising $6.3 million in sponsored programs funds.

Despite CASIS's recent progress, FY 2017 fundraising is still far below the amounts discussed in the original CASIS proposal. CASIS officials stated that they replaced the fundraising model in the reference model and original proposal with a sponsored program model, which focuses on obtaining external funding to directly support research and STEM projects. Officials explained that CASIS was not able to pursue all fundraising sources described in the reference model and proposal such as royalty fees, which were prohibited in the agreement, and the membership structure that was found to be unsuccessful. NASA oversight officials stated that NASA is not measuring CASIS performance against goals stated in its proposal, but rather that performance is measured on the cooperative agreement. While we understand the natural evolution of the cooperative agreement arrangement, in our judgment NASA should continue to encourage CASIS to strive for the goal on which the organization based its original proposal and the Agency awarded funding.

Use of Crew Time for National Lab Research

From September 2013 through April 2017, CASIS used less than 53 percent of the 2,915 crew hours allocated as its portion of the National Lab. NASA manages the use of crew time in 6-month increments and allocates 50 percent of all available time (measured in hours) to CASIS in support of National Lab research projects. However, CASIS failed to develop a sufficient number of research projects to fully utilize its portion of the National Lab.

NASA divides each 24-hour period on the ISS into 11 hours for work activities and 13 hours for other activities. Of the 11 work hours, 2.5 hours are set aside for crew exercise and 2 hours for planning and work preparation. Of the remaining 6.5 hours, NASA allocates 2.5 hours per crew member per day for research-related efforts. From September 2013 through April 2017, NASA allocated 2,915 crew research hours to the National Lab and, therefore, to CASIS. However, CASIS-managed projects used only

[35] CASIS proposed grant origination fees that would charge users 10 to 30 percent of the total grant award for administrative costs. However, the cooperative agreement prohibited such fees stating, "the membership structure and fee schedule shall ensure that no interested individual or organization shall be required to pay a fee in order to submit a grant proposal to CASIS or to use the ISS [National Lab]."

1,537 (52.7 percent) of the allocated crew hours.[36] Table 6 shows the amount of crew time available for the National Lab and the amount of time actually used to support CASIS-managed research.[37]

Table 6: Utilization of Allocated Crew Time

Period	Crew Time (Hours)		Percentage of Crew Hours Used	Percentage of Crew Hours Not Used
	Allocated	Used		
September 2013 – March 2014	418	186	44.6%	55.4%
March 2014 – September 2014	397	132	33.2%	66.8%
September 2014 – March 2015	352	201	57.2%	42.8%
March 2015 – September 2015	428	228	53.3%	46.7%
September 2015 – March 2016	394	137	34.8%	65.2%
March 2016 – September 2016	469	341	72.8%	27.2%
September 2016 – April 2017	458	312	68.1%	31.9%
Total/Average	**2,915**	**1,537**	**52.7%**	**47.3%**

Source: NASA OIG analysis of NASA data.

As discussed previously, CASIS will be allocated additional research hours when NASA adds an additional crew member to the Station in late 2018. However, given its performance to date, CASIS utilization rates for the National Lab will likely further diminish.

Outreach

CASIS met only one of nine metrics related to outreach publicizing the unique benefits of using the National Lab to potential users, the White House, Congress, non-NASA Government agencies, commercial companies and researchers, media, kindergarten through grade 12 educators and students, and the general public.[38]

The metrics used by NASA to measure CASIS outreach activities related to conferences, speaking opportunities, white papers, news mentions, and social media. Actual contacts and impacts in FY 2016 for seven of the eight metrics that did not meet the NASA-CASIS developed performance targets ranged from a low of 20 percent to three categories that ranged between 87 and 89 percent. CASIS exceeded its performance target in only one metric – social media engagement. (See Table 7.)

[36] CASIS officials stated that the three failed ISS resupply missions in FY 2015 adversely affected CASIS's ability to maximize National Lab utilization, though we were unable to validate the impact.

[37] NASA and CASIS provided differing allocation and utilization data that we were unable to resolve. We chose to rely on NASA's data because it included supporting documentation and had been used as the basis for presentations to the ISS Program Science Control Board – an executive level decision-making board co-chaired by the ISS Program Manager and ISS Chief Scientist.

[38] For FY 2017, targets for six of nine metrics were lower or the same as targets in FY 2016. For example, targets were lower for conferences, speaking opportunities, subject matter expert workshops, and website visitors while the targets remained the same for thought leadership and news mentions. Targets for Twitter followers and social media engagement were higher and the target for YouTube views was eliminated. Consequently, in FY 2017, CASIS reported meeting six of eight targets related to outreach.

Table 7: Outreach Activities, by Metric (FY 2016)

Metric	Target	FY 2016	Percentage
Conferences and industry events	18	16	89%
Speaking opportunities	95	82	87%
Subject matter expert workshops	8	3	38%
Thought leadership publications (white papers, trade articles, etc.)	5	1	20%
News mentions (clips, blogs, etc.)	5,000	3,223	65%
Twitter followers	107,000	94,500	88%
Website visitors[a]	256,500	251,051	98%
YouTube views	700,000	–[b]	–[b]
Social media engagement on Facebook, Twitter, and Instagram	100,000	295,402	295%

Source: NASA OIG analysis of CASIS documentation.

[a] During FY 2016, CASIS revised the methodology used to calculate website visitors; hence, the number we report differs from what is reported on their website, but is consistent with methodology used to establish the FY target.

[b] CASIS did not provide reporting data for this metric.

Each outreach metric differs with respect to its design, participants, and methods for counting participants (see Appendix E for details). Since CASIS met its target in only one of nine metrics, NASA lacks assurance that CASIS outreach programs are successfully advocating the benefits and unique advantages of using the National Lab to the broad range of constituency groups identified in the cooperative agreement. Although each of the nine metrics (excluding YouTube views) are weighed equally in the performance plan, we believe that formats such as "attendance at conferences and industry events" or "subject matter expert workshops" are more relevant to CASIS achieving its research goals than social media formats such as "Twitter followers" and, therefore, warrant more rigorous evaluation by NASA. However, as we discuss later in the report, NASA failed to address performance targets for these metrics in CASIS's FY 2015 and FY 2016 performance assessments, did not request an improvement plan from CASIS, or offer suggestions for improvement.

NASA Failed to Exercise the CASIS Oversight Needed to Ensure Sustained Progress

NASA has not developed an overall performance strategy that identifies the achievements or outcomes expected from CASIS through the end of its cooperative agreement in 2024. The Agency has also failed to provide direction or guidance or set expectations for CASIS's performance on outcomes needed to develop a commercial economy in low Earth orbit. As a result, CASIS has made little progress to date in achieving its goals. Moreover, NASA agreed to performance plans that lacked metrics and quantifiable performance targets and did not include important outcomes such as recruitment of commercial users in those performance plans. Instead, NASA has accepted CASIS's slow improvement over the first 5 years of the agreement – particularly with regard to minimal increases in use of the National Lab by private industry and the number of repeat customers – without requiring corrective action plans or offering suggestions to improve performance.

NASA Largely Has Taken a Hands-off Approach to Managing CASIS

From FYs 2012 through 2014, NASA failed to conduct any meaningful performance assessments of CASIS and therefore CASIS essentially operated independently. Specifically, CASIS's performance plans contained goals but lacked metrics or quantifiable targets to describe how NASA would measure its performance. Metrics and quantifiable targets are essential since the broad, descriptive language of the cooperative agreement is insufficient to determine whether CASIS's performance met expectations.

In our 2013 audit, we found that despite delays in filling key executive and board member positions, NASA officials determined that CASIS met all five performance metrics in FY 2012.[39] We reported that CASIS launched a website, was active on Facebook and Twitter, and designed an awareness campaign to encourage American companies to conduct product development and testing aboard the ISS. NASA considered these activities as meeting the goal of establishing a focused marketing and outreach campaign, although the goal was not specific or quantifiable. In addition, our analysis determined that the FY 2013 performance plan included a goal to demonstrate an effective plan to identify and attract CASIS customers to the National Lab. Although the performance plan described metrics such as the diversity of new users (commercial and noncommercial), it again did not include a quantifiable target indicating the percentage of commercial or noncommercial users CASIS was expected to attract.

For FYs 2014 and 2015, we found CASIS's performance plans and performance assessments to be deficient. Specifically, the plans for both years excluded metrics to address support for Implementation Partners, development of research pathways, matching of researchers and funding sources, recruitment of commercial users, and the balance between basic and applied research. In addition, all of the metrics for both years lacked quantifiable targets. For example, for FY 2014 the Business Development goal included the number of unsolicited proposals as a metric but did not identify the number of unsolicited proposals CASIS needed to meet the goal. Furthermore, in the assessment memorandum for FY 2015 NASA strongly encouraged CASIS to increase the number of commercial service providers that offer capabilities on the ISS and to develop commercial and noncommercial participation in ISS research. However, the performance plan excluded metrics related to these service providers. Moreover, the assessment memorandum did not suggest ways to increase participation by the service providers or request an action plan from CASIS to improve performance. Finally, for FY 2014 NASA did not formally document or advise CASIS on the results of its overall performance assessment or areas in which it needed to improve.

Performance plans for FYs 2016 and 2017 improved in that NASA included metrics and quantifiable targets in several performance areas. However, goals and metrics remained missing for support of Implementation Partners, development of research pathways, matching of researchers and funding sources, recruitment of commercial users, and striking a balance between basic and applied research. For FY 2016, the performance plan included 5 performance goals and 22 metrics with targets. Our analysis showed that CASIS reported statistics for 4 of those 5 performance goals and met 9 of 22 targets. In addition, CASIS met between 12.5 and 100 percent of targets for each of the 4 goals.

[39] IG-13-019. Metrics included (1) establishing a payload prioritization process and demonstrating its functionality for Expeditions 37 and 38, scheduled to launch in September 2013; (2) obtaining full funding for three flight research projects from outside sources; (3) demonstrating functioning of the membership model by enrolling 50 paid members; (4) developing transparent economic evaluation framework, tools, and processes and establishing functionality in test cases; and (5) establishing a focused marketing and outreach campaign.

CASIS did not report statistics for the "Utilization" performance goal. Targets that CASIS did not meet included the numbers of project proposals generated, new and repeat users, and active STEM programs, and the amount of funding for STEM grants. (See Table 8.)

Table 8: FY 2016 CASIS Performance Goals

Performance Goal	Number of Targets	Targets Met	Percentage of Targets Met for Goal
Secure strategic flight projects (unmet targets include project proposals generated, new users, repeat users, and flight projects delivered to the National Lab)	10	6	60.0%
Secure independent funding (sponsored programs)	1	1	100.0%
Build research in STEM (unmet targets include active STEM programs and value of funded STEM grants)	3	1	33.3%
Increase awareness (unmet targets include all metrics shown in Table 7 except for YouTube views)[a]	8	1	12.5%
Utilization	Not started		
Total	**22**	**9**	**40.9%**

Source: NASA OIG analysis of CASIS data.

[a] In FY 2017, CASIS met six of eight targets under increase awareness; however, five of those six targets were lower than in FY 2016.

Similar to previous years, NASA's assessment of CASIS's performance in FY 2016 was not linked to goals identified in its performance plan. For example, in the assessment memorandum for FY 2016 NASA strongly encouraged CASIS to increase support of the growing number of commercial service providers actively marketing their own research hardware on the ISS and to speed development of the commercial sector providing services and hardware to ISS researchers, which NASA viewed as underrepresented in the group's research portfolio. However, CASIS's performance plan for FY 2016 did not include a goal or metric to address these issues. Moreover, NASA's year-end assessment memorandum made no suggestions for increasing support to commercial service providers and did not require an action plan from CASIS to address the issue. In addition, the assessment memorandum did not note that CASIS met only one of eight metrics for increasing awareness even though the metrics were included in the performance plan.

Similarly, CASIS's FY 2017 performance plan remains deficient with respect to several metrics and targets. Much like the previous year, FY 2017 metrics do not address recruitment of commercial users, support to commercial service providers, the balance between different types of research, and the mechanism to match projects seeking funding with funding sources. Additionally, CASIS is expected to meet a target of 20 new National Lab users in FY 2017 – the same target CASIS failed to meet the previous year. That said, we believe a target for 20 new users will prove insufficient to meet the increased utilization requirements when CASIS receives additional crew research hours in late 2018 given that CASIS's recruitment of 16 new users in FY 2016 resulted in an average utilization of 50 percent.

NASA asserts that CASIS plays an important role in helping build a commercial economy in low Earth orbit. To make good on that assertion, the Agency needs to increase its oversight and management of the organization.

CONCLUSION

Approximately halfway through its 13-year cooperative agreement with NASA, CASIS has made progress on STEM education, annual grant awards, recruitment of users, mechanisms to match researchers and investors, and use of private firms in payload integration services. However, CASIS has not met expectations in its efforts to achieve the most important outcomes and overriding purpose of the agreement – maximum utilization of the National Lab, a balanced project portfolio, and a robust market for small business commercial providers – and NASA has abandoned its original intent for having the organization become financially self-sufficient.

By 2024, NASA will have invested $196 million in CASIS. In our opinion, weaknesses in performance measurement and the lack of an overall strategy have created an environment in which NASA continues to accept incremental improvement rather than more tangible attainment of agreed-upon goals. Consequently, without significant change, CASIS likely will fall short of advancing NASA's goal for a commercial economy in low Earth orbit.

NASA needs to engage more substantively with CASIS and exercise more effective oversight of the cooperative agreement to clarify CASIS's role in helping build a robust economy in low Earth orbit.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To help improve the effectiveness of NASA's cooperative agreement with CASIS, we made the following recommendations to the Associate Administrator for Human Exploration and Operations:

1. Conduct an assessment of CASIS-developed vertical areas by the NASA cooperative agreement technical officer to determine whether they are an acceptable replacement for research pathways. Subsequently, enforce or modify requirements of the cooperative agreement to support the articulated goals.

2. Require CASIS to evaluate the feasibility of redeploying resources from activities in the Operations and STEM Education division and Marketing and Communications division to activities in the Commercial Innovation and Sponsored Programs division while maintaining the overall resource level of the agreement. The evaluation should include an assessment of outsourcing some external communications activities, such as website maintenance, for potential cost savings.

3. Require CASIS to review and revise its practices for awarding implementation service contracts to provide smaller, start-up commercial firms access to contract awards.

4. Establish goals for CASIS raising non-NASA funds to offset operating expenses.

5. Develop a performance strategy for CASIS through the end of the current agreement that reflects the organization's role in helping NASA build a commercial economy in low Earth orbit. The strategy should clarify CASIS's role in NASA Strategic Plan Objective 1.2 and outcomes expected from CASIS to advance this objective.

6. Evaluate CASIS performance semiannually.

7. Ensure annual metrics and targets are quantifiable and address recruitment of commercial users, the balance of applied research, support to commercial service providers, a mechanism to match projects seeking funding with funding sources, and soliciting funds other than sponsored program funds.

We provided a draft of this report to NASA management who concurred or partially concurred with our recommendations and described actions the Agency plans to take to address them. In its response, Agency management took exception with our methodology that assessed CASIS's efforts in nine categories, stating that CASIS's performance should only be reviewed against the operating model defined by the cooperative agreement. Moreover, in response to recommendation 4, the Agency explicitly stated that CASIS is not required to raise non-NASA funds to offset its operating expenses and declined to indicate if or when it plans to reassess the issue.

As noted in our report, we did not limit our audit solely to whether CASIS complied with the terms of its cooperative agreement; instead, since metrics within the agreement are decidedly vague, we also

evaluated its performance against other Agency expectations. For example, expectations for CASIS fundraising are documented in NASA's July 2011 decision memorandum; NASA's Strategic Plan and its annual CASIS assessment letters provide support for CASIS's role in contributing to the development of an economy in low Earth orbit; and annual assessment letters illustrate the Agency's interest in CASIS broadening its use of Implementation Partners. All of these expectations are further supported by NASA Advisory Council meeting minutes and NASA cooperative agreement technical officer statements communicated to CASIS leadership.

We believe that fundraising should be a key Agency expectation for CASIS, which is the genesis of our fourth recommendation that NASA "establish goals for CASIS raising non-NASA funds to offset operating expenses." However, NASA management's comments – although labeled as "concur" – are unresponsive to the recommendation; therefore, this recommendation remains unresolved pending further discussion with Agency officials. In light of management's response to the other six recommendations, those are resolved and will be closed upon verification and completion of the proposed corrective actions.

Management's comments are reproduced in Appendix F. Technical comments provided by management have also been incorporated, as appropriate.

Major contributors to this report include Raymond Tolomeo, Science and Aeronautics Research Directorate Director; Nora Thompson, Project Manager; Amy Bannister; Barbara Moody; James Pearce; Jim Richards; and Robert Rose. Sarah McGrath provided editorial and graphic assistance.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from December 2016 through December 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

To determine whether CASIS made progress in achieving NASA's goals and expectations, we grouped requirements from the agreement into nine categories. We based our assessment of each category on performance plans, CASIS annual reports, and other documentation through FY 2016. CASIS provided quarterly performance data for FY 2017, and when appropriate we included this data in our report, although the data was not included in our original audit scope. Our methodology for each category follows.

Research Pathways. We reviewed the ProOrbis reference model, cooperative agreement, and documentation of CASIS vertical areas and interviewed CASIS and NASA oversight officials.

STEM Education Programs. We assessed a judgmental sample of seven of CASIS's STEM education programs that were active in FY 2016 against NASA's objectives for STEM, compared FY 2016 actual performance to targets in the performance plan, and obtained a description of how CASIS determines the number of program participants.

Grant Awards and Project Portfolio. We determined the value of grants awarded for FYs 2012 through 2016 from CASIS annual reports and tax forms for those years, compared the value of annual grant awards to targets in the performance plan, reviewed descriptions of project awards, determined the percentage of STEM projects in the project portfolio, and obtained the desired percentage of research projects from the NASA cooperative agreement technical officer.

Recruitment of National Lab Users. We interviewed CASIS officials, CASIS board members, and NASA oversight officials; reviewed user recruitment data, National Lab utilization, and staffing for user recruitment; reviewed market studies by ProOrbis and McKinsey and Company; and surveyed a sample of 27 entities that were contacted by CASIS in FYs 2015 and 2016.

Mechanism to Match Research Projects and Investors. We interviewed the CASIS Director of Portfolio Management, reviewed the policy for matching researchers with investors, and reviewed progress on development of the matching mechanism progress since the start of FY 2016.

Implementation Partners. We obtained a universe of Implementation Partner contracts from FYs 2012 through 2016, reviewed a description of the selection process CASIS uses to select Implementation Partners, interviewed CASIS and NASA oversight officials, identified descriptions of services provided by Implementation Partners, and determined the distribution of contracts awards.

Fundraising. We reviewed non-NASA revenue reported in tax forms and CASIS documentation, including annual reports, financial statements, and other supporting documents for FYs 2012 through 2016; the cooperative agreement; documentation of the membership structure; and interviewed CASIS and NASA oversight officials. We compared non-NASA revenue to the goal established by CASIS in its April 2011 proposal.

Utilization. We interviewed CASIS and NASA oversight officials and reviewed and analyzed allocation and utilization data provided by both CASIS and NASA. We attempted to reconcile CASIS and NASA data; however, we found significant differences that we were unable to resolve. We chose to rely on NASA's data because it included supporting documentation and had been used as the basis for presentations to the ISS Program Science Control Board. We compared CASIS utilization of their allocated crew time to their target of 50 percent.

Outreach. We interviewed CASIS and NASA officials, reviewed program plans, and compared actual performance to targets in the performance plan.

In addition, to determine whether NASA met its oversight responsibilities, we assessed performance goals, metrics, and targets included in the performance plans for FYs 2013 through 2017, and reviewed NASA's performance assessments for FYs 2015 and 2016, prior reports by the OIG, and NASA's Strategic Plan and other guidance. To assess the reasonableness of CASIS executive and board member compensation, we reviewed salaries, benchmark studies, and board member contributions, as well as interviewed board members and NASA officials.

Use of Computer-Processed Data

We used computer-processed data from CASIS and NASA to perform this audit. Specifically, we used data from the CASIS accounting system as the basis for selecting a sample of 50 cost transactions for detailed review. We also used CASIS data identifying grant awards from inception through FY 2016 as the basis for selecting a sample of 20 awards for review. Lastly, we used computer-processed data from NASA regarding the use of crew time in support of National Lab research projects. Although we did not test general or application controls of the computer systems that generated the data, we did compare test data to supporting documentation and determined that the data was sufficiently valid and reliable to support our objectives and conclusions.

Review of Internal Controls

We evaluated controls used by NASA to oversee performance. Our evaluation included an assessment of performance goals, metrics, and targets included in the performance plans for FYs 2013 through 2017 and NASA's performance assessments for FYs 2015 and 2016. We found that, since FY 2012, performance goals lacked metrics and/or quantifiable performance targets, and requirements in the agreement were not addressed by performance goals. In addition, in FYs 2015 and 2016, NASA strongly encouraged improvement on three areas that were not metrics in the Program Plan and did not address CASIS's failure to meet seven of eight targets to increase awareness. We discuss weaknesses in oversight controls in the finding section of this report.

Prior Coverage

During the last 5 years, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have issued three reports and provided two testimonies of significant relevance to the subject of this report. Unrestricted reports can be accessed at http://oig.nasa.gov/audits/reports/FY18 and http://www.gao.gov, respectively.

NASA Office of Inspector General

Extending the Operational Life of the International Space Station Until 2024 (IG-14-031, September 18, 2014)

NASA's Efforts to Maximize Research on the International Space Station (IG-13-019, July 8, 2013)

Government Accountability Office

International Space Station Challenges to Increased Utilization May Affect Return on Investment (GAO-15-722T, July 10, 2015)

International Space Station Measurable Performance Targets and Documentation Need to Better Assess Management of National Laboratory (GAO-15-397, April 27, 2015)

NASA: Significant Challenges Remain for Access, Use, and Sustainment of the International Space Station (GAO-12-587T, March 28, 2012)

APPENDIX B: DESCRIPTION OF THE NATIONAL LAB

The National Lab includes the Destiny module, internal laboratory bays and multipurpose facilities, and external research sites.

Destiny Module

The Destiny module serves as the primary U.S. research facility. The aluminum module is 28-feet long and 14 feet in diameter and consists of three cylindrical sections and two end cones with hatches that can be mated to other station components. Destiny was designed to hold sets of modular racks that could be added, removed, or replaced as necessary and can contain fluid and electrical connectors, video equipment, sensors, controllers, and motion dampeners to support experiments housed inside. Destiny includes a 20-inch diameter window – which takes up the space of one rack – making possible the ability to shoot very high quality photos and video that can record Earth's ever-changing landscapes. Imagery captured from this window has enabled scientists to study such features as glaciers, coral reefs, urban growth, and wild fires.

Destiny Module

Source: NASA.

Internal Laboratory Bays and Multipurpose Facilities

The National Lab includes 24 internal laboratory bays that house research investigations, which are located on the Destiny (13 bays), Columbia (5 bays), and Kibo (6 bays) modules. Internal laboratory bays contain multipurpose facilities, including racks, lockers, gloveboxes, and freezers, that support research investigations. Racks are modular structures designed to store and support experiments aboard ISS in drawers or lockers. Each rack provides structural interfaces, power, data, cooling, water, and other items needed to operate science experiments on the ISS. For example, the Expedite the Processing of Experiments to Space Station (EXPRESS) rack is one of the primary means of accommodating scientific hardware in the habitable portion of the ISS and is used by NASA and the Japanese and European space agencies. Gloveboxes provide containment for experiments, insuring that small or hazardous materials do not escape or float about the cabin. For example, the Microgravity Sciences Glovebox is the largest glovebox ever flown in space and is used for experiments ranging from combustion science, to the study of complex fluids, to the harvesting of plants. Crewmembers access experiments in the glovebox through ports while wearing heavy, sealed gloves. Figure 7 includes examples of an EXPRESS rack with lockers and the Microgravity Sciences Glovebox with two large ports on the front.

Figure 7: Examples of Internal Laboratory Bays

EXPRESS Rack with Stowage Lockers

Microgravity Sciences Glovebox

Source: NASA.

Freezers allow for cold storage and transportation of science samples collected on the ISS for later return to Earth; often times relating to the biological and life sciences. Freezers store samples at temperatures as low as negative 165 degrees Celsius.

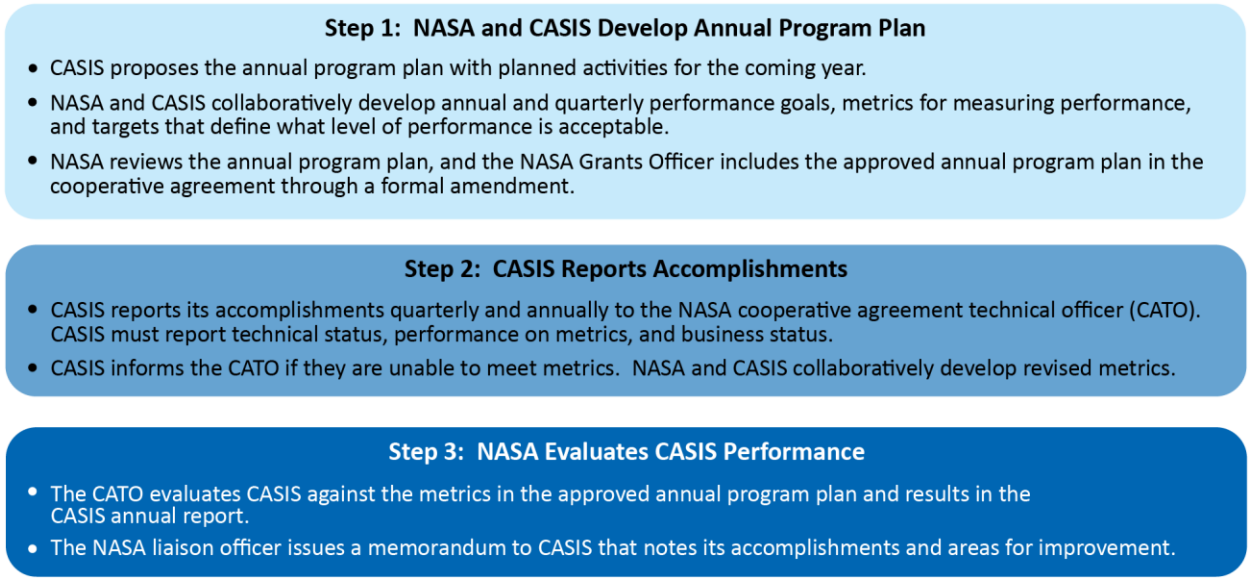
External Research Sites

NASA also has access to 15 research sites mounted on the ISS exterior that have power and data connections to the ISS. For example, the Space Communications and Navigation Testbed provides ground-based mission planners the ability to reconfigure radios on-orbit. The goal of providing this facility is to encourage the development and advancement of software-defined radio technologies for a common, open, space-based architecture standard, in hopes of reducing future developmental risks and costs for NASA space and ground software-defined radios.

APPENDIX C: PERFORMANCE ASSESSMENT PROCESS

NASA and CASIS collaboratively develop annual and quarterly performance goals, metrics that will be used to measure actual performance, and targets that define what level of actual performance is acceptable. For each fiscal year, CASIS includes goals, metrics, and targets in the program plan and reports actual results in its annual report to NASA. NASA assesses CASIS's performance based on the annual report and issues an assessment memorandum to CASIS signed by the NASA liaison officer. Performance assessment process steps are described in Figure 8.

Figure 8: Performance Assessment Process Steps



Source: NASA OIG.

APPENDIX D: SAMPLED EDUCATION PROGRAMS

We reviewed a sample of seven FY 2016 STEM education programs and found the programs aligned with NASA's objectives for STEM programs while benefitting a broad range of user groups (see Table 9).

Table 9: Sample of STEM Education Programs, FY 2016

Program	Description	STEM Education Benefits
Ants in Space	Students built their own ant habitat on Earth and compared results in ISS microgravity with a similar ant habitat experiment on National Lab.	Program aligned with all aspects of NASA's objectives. For example, students built their habitat, analyzed data, and learned about ant anatomy and how ants live in colonies and communicate. The program benefitted students in kindergarten through grade 12, and served nearly 45,000 students since 2014.
NASA HUNCH Extreme Science – Crystals	Students studied the effect of microgravity on the electrolysis of silver nitrate crystals and compared results to crystals grown on Earth.	Program aligned with all aspects of NASA's objectives. For example, high school students engaged in research, experiment design, ground testing, experiment fabrication, and data analysis. About 2,500 high school students benefitted from the program in FY 2016.
National Design Challenge	Students investigated the behavior of slime molds in microgravity and compared results to slime molds grown on Earth.	Program aligned with all aspects of NASA's objectives. For example, high school students engaged in research, experiment design, ground testing, experiment fabrication, and data analysis. About 72 high school students benefitted from the program in FY 2016.
Space Station Academy	Program is a CASIS-led initiative in collaboration with a non-CASIS program, the Virtual High School. Teachers integrated a virtual mission to the ISS into their STEM curriculum. The teachers facilitated a safe online environment where students interacted with ISS content.	Program aligned with aspects of NASA's objectives in earth science, life science, physical science, and engineering. Formal and informal groups of middle and high school students and educators for grade levels 4 through 12 benefitted from the program.
Student Spaceflight Experiments Programs (in collaboration with the National Center for Earth and Space Science Education)	Students in grades 5 through 12 designed science investigations that were sent to the ISS. The program gave about 300 students the ability to design and propose actual microgravity investigations to fly in low Earth orbit.	Program aligned with all aspects of NASA's objectives. For example, the program engaged students and teachers in every facet of science and gave students a chance to experience science investigations first hand. Through FY 2016, more than 40,000 children, grades 1 through 12 benefitted from the program.
Windows on Earth	Program used photographs taken by astronauts on the Destiny module of the ISS for educational purposes. Photographs are made available to the public free of charge.	Program provided mostly science and STEM outreach. Since 2013, more than 40,000 students (kindergarten through grade 12), teachers, and citizen scientists benefitted from the program.
Zero Robotics	Program was a collaboration between CASIS and the Massachusetts Institute of Technology. Middle school and high school students wrote programming code for ISS robots in a national competition. Students competed in several phases of virtual competitions that mimicked actual robot satellites. Winners uploaded code to operate small robotic satellites on the ISS.	Program aligned with all aspects of NASA's objectives with a strong emphasis on technology and mathematics. Since 2012, over 7,000 middle school, high school, and college students benefitted from the program.

Source: CASIS.

APPENDIX E: OUTREACH METRICS

CASIS has established nine outreach metrics to advocate the benefits and unique advantages of using the National Lab and communicates its message to a range of constituency groups, including National Lab users, the White House, Congress, NASA, media, kindergarten through grade 12 educators and students, and the general public. The following is a description of each metric provided by CASIS and how participants are counted for that metric.

Conferences and Industry Events. Conferences and industry events include events that provide access to a large number of multi-disciplinary prospects from commercial organizations, academia, and other Government agencies. CASIS involvement can include sponsorship of an event, serving in a planning or execution role, funding an event proceeding, or presenting a major exhibition with multiple ways for the audience to engage with the ISS and CASIS team and partners. Participants in conference and industry events are tracked via the CASIS salesforce enterprise database.

Speaking Opportunities. Speaking opportunities include situations when CASIS participates as a standalone speaker or a panelist to represent the ISS National Lab and CASIS mission, capabilities, and benefits. Speaking opportunities are tracked via the CASIS salesforce enterprise database.

Subject Matter Expert Workshops. Subject matter expert workshops include CASIS-organized, roundtable discussions with leaders from government, academia, and industry who are viewed as experts within their subject area. Workshops are tracked via the CASIS salesforce enterprise database.

Thought Leadership Publications. These publications are CASIS-authored papers and articles published in academic or trade journals and publications.

News Mentions. News mentions include all media that cite CASIS or the National Lab, such as news media or online blogs. CASIS uses Meltwater, an industry standard news monitoring service, to track and measure news mentions.

Twitter Followers. Twitter followers are calculated as a current snapshot of the @ISS_CASIS Twitter account.

Website Visitors. Website visitors are reported as they appear in Google Analytics as unique user sessions over each quarterly period.

YouTube Views. CASIS tabulates video views from both its own social media sites, as well as partner promotion sites, including @NASA, @ISS Research, and @Space Station, that put out their own tweets featuring CASIS video content.

Social Media Engagement. Social media includes Facebook, Twitter, and Instagram, while engagement measures the extent that the online audience interacts with CASIS content for those social media outlets. The number of participants is a total of all likes, shares, and link clicks for content posted on the CASIS Facebook page, Twitter account, and Instagram account. The number of participants is calculated through the Sprout Social dashboard (a paid subscription). To determine the accuracy of those numbers, CASIS staff compare them to individual analytics reports from Facebook, Twitter, and Instagram.

APPENDIX F: MANAGEMENT'S COMMENTS

National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

January 10, 2018

Reply to Attn of: Human Exploration and Operations Mission Directorate

TO: Assistant Inspector General for Audits

FROM: Associate Administrator for Human Exploration and Operations Mission Directorate

SUBJECT: Agency Response to OIG Draft Report, "NASA's Management of the Center for the Advancement of Science in Space" (A-17-003-00)

NASA appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled, "NASA's Management of the Center for the Advancement of Science in Space" (A-17-003-00), dated December 8, 2017.

Before addressing the OIG recommendations and NASA's response, I would like to emphasize a few key points about the ISS National Lab (NL) and the Center for the Advancement of Science in Space (CASIS). Just as the construction of the ISS, a multi-national orbiting laboratory, was an uncharted experience complete with successes and setbacks, so, too, has been the administration of the Nation's first orbiting NL. Expanding the use of the ISS beyond NASA into other Government agencies and into private industry has also been challenging as these other communities are not familiar with the benefits of space research and are not familiar with the rigors of human spaceflight. NASA is enabling CASIS to be innovative and to incorporate commercial practices that traditionally not been within the capability of the Government.

NASA and CASIS have also looked to industry and governmental standard practices as guides, but there are no clear precedents for this type of endeavor to use as a blueprint. NASA and CASIS, along with other Government agencies and private industry, are all continuing to learn, adapt, and innovate as we strive to fully utilize the unique assets of the ISS and its commercial transportation systems.

Additionally, CASIS's function and operating model are solely based on the cooperative agreement (CA) that governs the relationship between NASA and CASIS. There are a number of instances in the report that suggest CASIS is responsible for functions that are not included in the CA. Some concepts contained in the ProOrbis model or CASIS's original proposal that are not part of the CA include replacing NASA operations funding with non-NASA funding, the concept that CASIS is a part of the NASA strategic vision for commercialization, and the idea that CASIS's role is to attract small businesses and start-up firms, just to name three. CASIS's operating model is documented in the CA as modified in

July of 2017. CASIS's performance should be reviewed against this operating model and not against the ProOrbis model or its original proposal.

Furthermore, as recognized in the report, the launch anomalies of Orbital ATK, SpaceX, and Roscosmos, all within an eight-month period beginning in October 2014, had a significant impact on the ability of CASIS and NASA to fully utilize the ISS and the NL due to the loss of research hardware and equipment.

Finally, comparing crew time allocation that is baselined at increment minus six months to actuals, that actually occur on-orbit weeks and months later without taking into account increment changes such as launch delays or unplanned EVA's, misrepresents CASIS' and NASA's performance. NASA does, however, agree that we and CASIS need to improve utilization of available crew time.

In the draft report, the OIG makes seven recommendations to the Associate Administrator for Human Exploration and Operations intended to improve the effectiveness of NASA's CA with CASIS.

Specifically, the OIG recommends the following:

To help improve the effectiveness of NASA's CA with CASIS, the OIG recommends the Associate Administrator for Human Exploration and Operations:

Recommendation 1: Conduct an assessment of CASIS-developed vertical areas by the NASA cooperative agreement technical officer to determine whether they are an acceptable replacement for research pathways. Subsequently, enforce or modify requirements of the cooperative agreement to support the articulated goals.

Management's Response: Concur. NASA will continue to assess the vertical areas and their effect on fully utilizing the NL. Depending on the assessment results, NASA will modify the CA if required.

Estimated Completion Date: June 30, 2018.

Recommendation 2: Require CASIS to evaluate the feasibility of redeploying resources from activities in the Operations and STEM Education division and Marketing and Communications division to activities in the Commercial Innovation and Sponsored Programs division while maintaining the overall resource level of the agreement. The evaluation should include an assessment of outsourcing some external communications activities, such as website maintenance, for potential cost savings.

Management's Response: Concur. NASA will direct CASIS to evaluate the feasibility as described. Based on the results of the evaluation, NASA and CASIS will determine which actions to take.

Estimated Completion Date: June 30, 2018.

Recommendation 3: Require CASIS to review and revise its practices for awarding implementation service contracts to provide smaller, start-up commercial firms access to contract awards.

Management's Response: Partially Concur. Based on the OIG findings and other feedback received from implementation partners, NASA agrees that CASIS needs to review its practices for awarding implementation service contracts to ensure fair competition and protecting proprietary information. There is currently no requirement in legislation or for the CA to award NL activities to small or start-up commercial firms, but NASA will assess if changes are needed.

Estimated Completion Date: June 30, 2018.

Recommendation 4: Establish goals for CASIS raising non-NASA funds to offset operating expenses.

Management's Response: Concur. NASA has set clear expectations, as documented in the CA update from July 2017 that CASIS is NOT required to raise non-NASA funds to offset operating expenses. As non-NASA use of the ISS and the NL increases, NASA will also continue to update the CASIS goals and metrics, and clearly document them in the CA. NASA will continue to clearly communicate these changes to CASIS and to NASA stakeholders as they are implemented.

Estimated Completion Date: Completed.

Recommendation 5: Develop a performance strategy for CASIS through the end of the current agreement that reflects the organization's role in helping NASA build a commercial economy in low Earth orbit. The strategy should clarify CASIS's role in NASA Strategic Plan Objective 1.2 and outcomes expected from CASIS to advance this objective.

Management's Response: Concur. NASA agrees to continually develop and modify criteria to measure CASIS's performance. CASIS's current role, as described in the CA, requires CASIS to fully utilize the NL and promoting business-to-business interactions among NL users and Implementation Partners. As NASA's strategy for supporting a commercial space economy in low-Earth orbit matures, NASA will consider CASIS's role as appropriate and modify the CA when required.

Estimated Completion Date: June 30, 2018.

Recommendation 6: Evaluate CASIS performance semiannually.

Management's Response: Concur. NASA evaluates CASIS performance on an on-going basis and provides routine feedback through discussions on a weekly and monthly basis. NASA will also provide formal feedback on a semiannual basis.

Estimated Completion Date: January 31, 2019.

Recommendation 7: Ensure annual metrics and targets are quantifiable and address recruitment of commercial users, the balance of applied research, support to commercial service providers, a mechanism to match projects seeking funding with funding sources, and soliciting funds other than Sponsored Program funds.

Management's Response: Partially Concur. NASA agrees with the identification of annual metrics and targets that are quantifiable and track to the requirements in the CA. This will be done as part of the annual review and planning for the next year as documented in the annual performance plan. NASA does not require a "balance" of research across fundamental and applied research nor does NASA require that CASIS solicit funds other than Sponsored Program funds as set forth in the CA. The type of research is determined by the priorities of the commercial and other non-NASA users of the NL.

Estimated Completion Date: January 31, 2019.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Michelle Bascoe on (202) 358-1574.

William H. Gerstenmaier

William H. Gerstenmaier

APPENDIX G: REPORT DISTRIBUTION

National Aeronautics and Space Administration

Acting Administrator
Deputy Associate Administrator
Associate Administrator for Strategy and Plans
Associate Administrator for Human Exploration and Operations
Associate Administrator for Mission Support

Non-NASA Organizations and Individuals

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    Deputy Associate Director, Energy and Space Programs Division

Government Accountability Office
    Director, Office of Acquisition and Sourcing Management

Center for the Advancement of Science in Space
    President and Executive Director, Center for the Advancement of Science in Space

Congressional Committees and Subcommittees, Chairman and Ranking Member

Senate Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

Senate Committee on Commerce, Science, and Transportation
    Subcommittee on Space, Science, and Competitiveness

Senate Committee on Homeland Security and Governmental Affairs

House Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies

House Committee on Oversight and Government Reform
    Subcommittee on Government Operations

House Committee on Science, Space, and Technology
    Subcommittee on Oversight
    Subcommittee on Space

(Assignment No. A-17-003-00)