

**U.S. House of Representatives  
Committee on Science, Space, and Technology  
Subcommittee on Space**

*The International Space Station: Addressing Operational Challenges*

**HEARING CHARTER**

**Friday, July 10, 2015  
9:00 a.m.  
2318 Rayburn House Office Building**

**Purpose**

At 9:00 a.m. on Friday, July 10, 2015, the Subcommittee on Space will hold a hearing titled *The International Space Station: Addressing Operational Challenges*. The purpose of this hearing is to examine the current status of the International Space Station (ISS). The Subcommittee will evaluate the National Aeronautics and Space Administration's (NASA) plans for dealing with operational and maintenance challenges, the status of the ISS partnership, how NASA is utilizing the ISS to enable future deep space exploration, and the Administration's request to extend ISS operations to 2024.

**Witnesses**

- **Mr. Bill Gerstenmaier**, Associate Administrator, Human Exploration and Operations Mission Directorate, NASA;
- **Mr. John Elbon**, Vice President and General Manager, Space Exploration, The Boeing Company;
- **The Honorable Paul K. Martin**, Inspector General, NASA;
- **Ms. Shelby Oakley**, Acting Director, Acquisition and Sourcing Management, Government Accountability Office.
- **Dr. James A. Pawelczyk**, Associate Professor of Physiology and Kinesiology, The Pennsylvania State University

**Background**

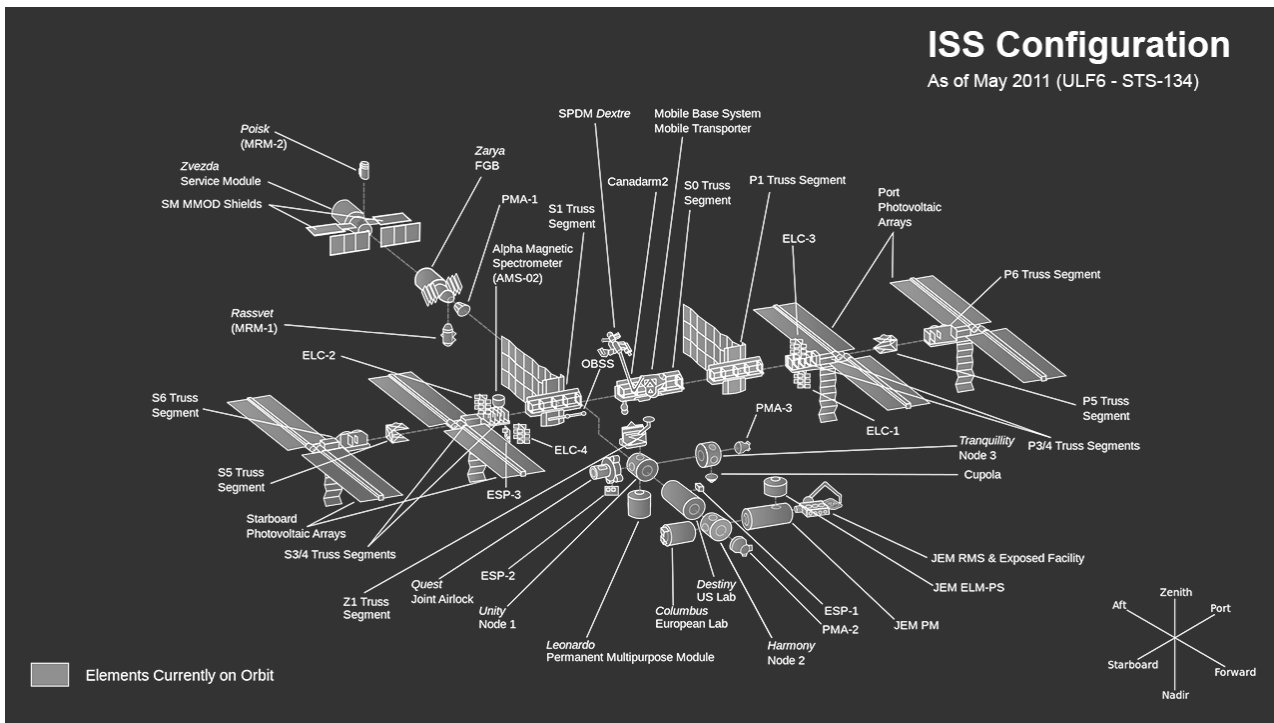
The ISS is one of the most complex and expensive man-made structures ever built.<sup>1</sup> The ISS is a joint project among five participating space agencies—NASA, Roscosmos (Russian Space Agency), the European Space Agency (ESA), Japanese Aerospace Exploration Agency (JAXA), and Canadian Space Agency (CSA). The ISS orbits approximately 250 miles above the Earth's surface once every 90 minutes at five miles per second. Weighing in at nearly one million pounds, it is the length of a football field (including end zones) and has the equivalent working

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<sup>1</sup> The NASA Inspector General estimates that the United States has invested almost \$75 billion which includes "\$43.7 billion for construction and program costs through 2013, plus \$30.7 billion for 37 supporting Space Shuttle flights, the last of which took place in July 2011." Extending the Operational Life of the International Space Station Until 2024 (IG-14-031). Retrieved at: <https://oig.nasa.gov/audits/reports/FY14/IG-14-031.pdf>.

and living space of a six bedroom home. The pressurized living space is approximately equal to a Boeing 747. The solar arrays used to power the Station would cover nearly an acre and eight miles of electrical wiring powers various sections of the facility. Out of the global space launch market, launches to the ISS accounts for approximately 15 percent of the total. For 2013-2014, this was 25 out of 168 total launches worldwide.<sup>2</sup>

Among other benefits, the ISS provides a proving ground for NASA’s human exploration technologies and other NASA mission directorates and various federal agencies as well as a microgravity laboratory for private companies. The ISS generally operates with a rotating crew of six astronauts from the U.S. and international partner space agencies, though at times this drops to three crewmembers as is the case at present.



Graphic Courtesy of NASA

The United States currently launches cargo resupply missions to the ISS through the Commercial Resupply Services (CRS) contract. The Russian *Progress* and Japanese *HTV* also provide cargo resupply to the ISS.

The two U.S. providers under this contract, Orbital ATK and Space Exploration Technologies Corporation (SpaceX), provide cargo delivery services on a firm fixed-price contract. The two providers carry supplies for the astronauts as well as science and research equipment to the ISS in conjunction with international partners.

<sup>2</sup> Launch history is based on data compiled by the FAA’s Office of Commercial Space Transportation (AST) Annual Commercial Space Transportation Compendium found at: [https://www.faa.gov/about/office\\_org/headquarters\\_offices/ast/media/FAA\\_Annual\\_Compndium\\_2014.pdf](https://www.faa.gov/about/office_org/headquarters_offices/ast/media/FAA_Annual_Compndium_2014.pdf)

NASA currently lacks a domestic capability to ferry astronauts to and from the ISS. American astronauts (and international partners) are reliant on the Russian Soyuz which launches from the Baikonur Cosmodrome in Kazakhstan. NASA’s existing contract for Russian Soyuz runs through 2017 and costs roughly \$75 million a seat.<sup>3</sup> NASA recently announced that it is negotiating a new contract with Russia for services from 2017 to 2018.<sup>4</sup> Last fall, NASA signed contracts with Space Exploration Technologies (SpaceX) and the Boeing Company to develop and provide transportation to and from the ISS through the Commercial Crew Program (CCP).

Once the Commercial Crew program begins ferrying astronauts to the ISS, NASA may be able to add a seventh crew member. This has the potential of increasing research and utilization time on the station equivalent to approximately 35 hours a week.<sup>5</sup> In fiscal year 2014 (FY14), the Station hosted 368 experiments (a 28 percent increase from FY13). These included 64 in biology and biotechnology, 91 in Earth and space science, 50 educational activities, 36 in human research, 43 in physical science, and 84 in technology.<sup>6</sup> The utilization of the unique microgravity environment on the ISS is augmented by the Center for Advancement of Science in Space (CASIS). This non-profit organization was chosen in 2011 in accordance with the NASA Authorization Act of 2010.<sup>7</sup>

## Budget

Budget Authority (\$ in millions)	Actual	Enacted	Request	FY15 vs	Notional			
	2014	2015	2016	FY16	2017	2018	2019	2020
Space Operations	3,774.0	3,827.8	4,003.7	175.9	4,191.2	4,504.9	4,670.8	4,864.3
International Space Station	2,964.1	-	3,105.6	-	3,273.9	3,641.0	3,826.0	4,038.3
Space and Flight Support (SFS)	809.9	-	898.1	-	917.3	863.8	844.8	826.1

The Space Operations Account funds activities for the International Space Station, cargo delivery, and space flight and support. These activities fall under NASA’s Human Exploration and Operations Mission Directorate. The President’s Space Operations budget request for FY16 is \$4.003 billion, which represents an increase of \$175.9 million (4.6 percent). Of this, operations, crew and cargo transportation, and research aboard the ISS accounts for \$3.105 billion. For these same activities, the House Appropriations bill includes \$3.075 billion<sup>8</sup> (3.2 percent increase over FY15)<sup>9</sup> and the Senate Appropriations bill includes \$3.051 billion<sup>10</sup> (2.5 percent increase over FY15).<sup>11</sup>

<sup>3</sup> *Ibid.* 1, p. 21.

<sup>4</sup> NASA Sole-source Procurement Announcement of Crew Transportation and Rescue Services from Roscosmos <https://prod.nais.nasa.gov/cgi-bin/eps/synopsis.cgi?acqid=163919>

<sup>5</sup> ISS utilization projections are courtesy of NASA delivered via staff briefings in February and March of 2015 in support of the President’s Budget Request.

<sup>6</sup> President’s Budget Request for Fiscal Year 2016 for the National Aeronautics and Space Administration, Congressional Justification. P. SO-14. Retrieved at [http://www.nasa.gov/sites/default/files/files/FY2016\\_Budget\\_Book\\_508\\_TAGGED.pdf](http://www.nasa.gov/sites/default/files/files/FY2016_Budget_Book_508_TAGGED.pdf)

<sup>7</sup> Section 504 of the National Aeronautics and Space Administration Authorization Act of 2010. Retrieved at <https://www.congress.gov/111/plaws/publ267/PLAW-111publ267.pdf>

<sup>8</sup> Title 3, H.R. 2578, Commerce, Justice, Science and related agencies Appropriations Act of 2016. Retrieved at <https://www.congress.gov/bill/114th-congress/house-bill/2578/text/rh?q={%22search%22:%2222hr2578%22%22}>

<sup>9</sup> Based on estimates from NASA’s FY15 spending plan submitted to Congress

<sup>10</sup> Title 3, H.R. 2578, S. Rep. 114-66. Retrieved at <https://www.congress.gov/114/crpt/srpt66/CRPT-114srpt66.pdf>

<sup>11</sup> *Ibid.* 9.

The prime contractor for operations and maintenance of the ISS is the Boeing Company. This accounts for \$1.106 billion of the overall Space Operations account in the FY16 budget request. Operations and maintenance includes managing resources, logistics, systems, and operational procedures. Additionally, the operations and maintenance project manages resource requirements and changes, including vehicle traffic, cargo logistics, stowage, and crew time. The project is also responsible for providing anomaly resolution and failure investigations as needed.

## Commercial Cargo

The Commercial Spaceflight program at NASA began in 2006 by funding multiple companies to develop systems for transporting cargo to the ISS with an eye towards eventually having multiple carriers compete for the resupply contract. This was accomplished through the Commercial Orbital Transportation Services (COTS) and Cargo Resupply Services (CRS) programs. At this point, both of the companies involved, Orbital ATK and SpaceX, have successfully delivered cargo to the ISS. While the SpaceX contract includes a down-mass capability (returns cargo to Earth), Orbital ATK's *Cygnus* spacecraft (like the Russian Progress, European Space Agency's ATV or the Japanese Space Agency's HTV) has no down-mass capability. In 2008, NASA signed two CRS contracts. The SpaceX contract is valued at \$1.6 billion for 12 missions and Orbital ATK contract is valued at \$1.9 billion for eight missions.<sup>12</sup> Regardless of anomalies or accidents, the cost associated with these launches is set and paid out in increments as various milestones are met through the manufacturing process. The final payment is not made unless the payload docks with the ISS and delivers the cargo. In some cases, substantial portions of the contract may be paid out prior to delivery of the cargo.<sup>13</sup>

On October 28, 2014, Orbital ATK attempted to launch its *Cygnus* cargo ship to the ISS carrying 5,000lbs. of supplies and science experiments. Approximately 15 seconds after launch the Antares rocket suffered a catastrophic failure and the rocket as well as the *Cygnus* were lost. The investigation into the exact cause is ongoing. In the meantime, Orbital ATK procured the services of United Launch Alliance (ULA) to launch its next *Cygnus* payload to the ISS. This flight is required under the company's CRS contract and it is tentatively scheduled for launch in October. As the CRS contract is firm-fixed price, the use of a different rocket and altered launch conditions will not financially impact the government.

On April 28, 2015, the Russian *Progress* resupply vehicle, M-27M launched from Kazakhstan carrying 5,196lbs of cargo to the ISS. After achieving orbit, the *Progress* vehicle suffered several anomalies that resulted in the loss of the vehicle. The Progress-60 launched on July 3, 2015 carrying 6,100lbs of cargo and docked with the ISS on July 5, 2015.

On June 10, 2015, while performing various software testing procedures there was an inadvertent firing of thrusters used to control the orbit of the ISS. The Russian and American engineering teams are the process of identifying the root cause, but as of yet have not released any public findings.

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<sup>12</sup> NASA Awards Space Station Commercial Resupply Services Contracts. Retrieved at [http://www.nasa.gov/home/hqnews/2008/dec/HQ\\_C08-069\\_ISS\\_Resupply.html](http://www.nasa.gov/home/hqnews/2008/dec/HQ_C08-069_ISS_Resupply.html)

<sup>13</sup> Commercial Cargo: NASA Management of Commercial Orbital Transportation Services and ISS Commercial Resupply Contracts. NASA Office of Inspector General released on June 13, 2013. Retrieved at <https://oig.nasa.gov/audits/reports/FY13/IG-13-016.pdf>

On June 28, 2015, SpaceX attempted to launch its seventh cargo resupply mission to the ISS. At approximately 139 seconds after lift-off, the rocket suffered a catastrophic failure that resulted in the loss of the vehicle. The unmanned *Dragon* capsule was carrying approximately 5,000 pounds of pressurized cargo, including research experiments, food, crew provisions and exercise equipment. Additionally, the vehicle was carrying a replacement spacesuit for EVA activity, this suit was necessary after water started seeping into the helmet of one of the spacesuits in December 2013. The cause of the SpaceX launch failure is still under investigation. As with the Orbital ATK launch failure, the contractor will be responsible for the investigation with participation and oversight from NASA, Federal Aviation Administration (FAA), and the National Transportation Safety Board (NTSB) in accordance with FAA regulations for licensed commercial launches.

The extent to which these three failures over the course of eight months will affect the ISS program is unclear. NASA announced that the astronauts aboard the Station are in no immediate danger and that they have enough food, water, and oxygen to last until September. The next resupply mission of a Japanese HTV is scheduled to be launched in August.<sup>14</sup>

## Commercial Crew

NASA awarded fixed-price contracts to Boeing and SpaceX in September 2014 for the Commercial Crew program. The total potential values of these contracts are \$2.6 billion for SpaceX and \$4.2 billion for Boeing for a total of \$6.8 billion over the life of the contracts. These two companies will proceed through the final design, development, testing, evaluation and human rating certifications under a fixed-price contract.

The President's budget request for FY16 includes \$1.24 billion for the Commercial Crew Program. This would be an increase of 54 percent over the appropriated funding for FY2015 (\$805 million). In testimony before this Committee earlier this year, a NASA official stated that

*"[i]f NASA does not receive the full requested funding for CCtCap in FY 2016 and beyond, NASA will have to adjust (delay) milestones for both partners proportionally and extend sole reliance on Russia for crew access to the ISS. The partners may request contract cost adjustments and the certification dates will be delayed."*

Federal Acquisition Regulations (FAR)<sup>15</sup> and the commercial crew contracts<sup>16</sup> do allow NASA to adapt their acquisition strategy for one or two contractors to accommodate varying appropriation levels. Despite the \$6.8 billion projected value of the contracts, NASA has never completed an independent cost estimate of the Commercial Crew Development Program or the

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<sup>14</sup> Statement by NASA Administrator Charles F. Bolden, Jr. June 29, 2015. Retrieved at <https://www.nasa.gov/press-release/nasa-administrator-statement-on-the-loss-of-spacex-crs-7>

<sup>15</sup> Federal Acquisition Regulations 52.249-2, Termination for Convenience of the Government (Fixed-Price). Retrieved at [http://www.ecfr.gov/cgi-bin/text-idx?SID=d3e3b99553af16abc0188213eee065c3&mc=true&node=se48.2.52\\_1249\\_62&rgn=div8](http://www.ecfr.gov/cgi-bin/text-idx?SID=d3e3b99553af16abc0188213eee065c3&mc=true&node=se48.2.52_1249_62&rgn=div8)

<sup>16</sup> Clause B.4 Post Certification Missions, Clause H.4 NFS 1852.232-77 Limitation of Funds (fixed-price contract), Clause H.8 Post Certification Mission Task Ordering Procedures (Applicable to CLIN 002), Commercial Crew Transportation Capability (CCtCAP) Contract with Boeing (NNK14MA75C), Commercial Crew Transportation Capability (CCtCAP) Contract with SpaceX (NNK14MA74C). Retrieved at [http://www.nasa.gov/centers/kennedy/about/foia/reading\\_room.html#.VZKzV\\_IvBc](http://www.nasa.gov/centers/kennedy/about/foia/reading_room.html#.VZKzV_IvBc)

program estimates that the companies provided for their funding requirements;<sup>17</sup> however, the contracts are fixed-price, meaning they are capped at the agreed upon levels. This does not guarantee that the contractors will not need to be bailed-out in the event that they are unable to complete the contractual work.

The NASA Authorization Act of 2010 authorized \$312 million, \$500 million, and \$500 million for the Commercial Crew Program for fiscal years 2011, 2012 and 2013 respectively. NASA has consistently requested more funding for Commercial Crew than the program has been authorized or previously appropriated.<sup>18</sup> Three years ago, the NASA Administrator testified before the Committee that the FY13 request would put NASA “on track” for a commercial crew capability by 2017.<sup>19</sup> The actual appropriation for FY13 was \$305 million less than the request. Two years ago, the Administrator testified to the Committee that NASA was still on track for a 2017 launch date, but full funding of the FY14 request was “essential” to enabling Commercial Crew access to the International Space Station by 2017.<sup>20</sup> The actual appropriation for FY14 was \$125 million less than the request. The FY16 NASA budget justification states that 2017 is still the target date for a Commercial Crew capability. The Committee-passed NASA Authorization Act for FY16 and FY17 included full funding for the Commercial Crew program. Funding history for the program is included below.

Funding History <i>\$ in millions</i>	Program Phase						
	Partner	CCDev1	CCDev2	CCiCap	CPC1	CCtCap	Total
Paragon		1.40	-	-	-	-	1.40
United Launch Alliance		6.70	-	-	-	-	6.70
Blue Origin		3.70	22.00	-	-	-	25.70
Sierra Nevada		20.00	105.60	227.50	10.00	-	363.10
SpaceX		-	75.00	460.00	9.60	2,600.00*	3,144.60
Boeing		18.00	112.90	480.00	9.90	4,200.00*	4,820.80
Total Funding		49.80	315.50	1,167.50	29.50	6,800.00	8,362.30

Source - <http://www.nasa.gov/sites/default/files/files/CCtCapFactSheet.pdf>

\*Represents total potential value of the contract.

<sup>17</sup> NASA contracted with Booz|Allen|Hamilton to complete an independent cost assessment of the program which was released on March 1, 2013 and can be found here [http://www.nasa.gov/pdf/741617main\\_CCP-ICA-DRD-2e-Public-Releaseable-Final-Report-3-5-13-508.pdf](http://www.nasa.gov/pdf/741617main_CCP-ICA-DRD-2e-Public-Releaseable-Final-Report-3-5-13-508.pdf). However, as noted by the NASA Inspector General, “the assessment found that the estimates were optimistic, and that the Program was likely to experience cost growth. In addition, Booz Allen noted that without costs projected over the life of the Program, NASA officials will not be able to independently evaluate each partner’s progress.”

<sup>18</sup> FY2011 request: \$500 million. FY2011 actual: \$307 million. FY2012 request: \$850 million. FY2012 actual: \$392 million. FY2013 request: \$830 million. FY2013 actual: \$525 million. FY2014 request: \$821 million. FY2014 actual: \$696 million.

<sup>19</sup> Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Space, and Technology, March 7, 2012.

<sup>20</sup> Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Technology, and Space, Subcommittee on Space, April 24, 2013.

## ***Orion as a Backup***

In addition to the use of commercial crew contractors, NASA is required under federal law to ensure that the *Orion* crew vehicle has the capability to dock to the ISS in an emergency.<sup>21</sup> The law,<sup>22</sup> which was passed by Congress and signed by the President, was very specific in describing this as a “minimum capability requirement”<sup>23</sup> for the capsule. It is important to note that the law does not require *Orion* to be launched by the Space Launch System (SLS). While *Orion* may not be an efficient vehicle to conduct ISS transportation missions, the ability to conduct a mission to the ISS would provide redundancy and additional options for access. At present, NASA is not building the *Orion* with the capability to service the ISS. In an interview with *Space News* in June 2014, Administrator Bolden expressed his view of the legal requirement for *Orion* to serve as a backup capability:

*“It’s a bad, bad day when you have to send Orion to the international space station because it means either we’ve lost each of the [commercial] vehicles that was designed to do that through some accident, or they failed or something. So we don’t want to have to rely on Orion to do that.”*

*“We made a commitment to industry we would not compete with them.”*

*“If we had said, ‘We’re going to keep Orion as a backup,’ there were serious doubts as to whether industry would have made the investment at all in a commercial crew vehicle because their assumption was, ‘OK, if NASA is going to build a vehicle to go to low Earth orbit, what is NASA going to want to use?’ Naturally, they’re going to want to use their own vehicle.”*

*“So Orion, while it probably can — or will — be capable of going to the international space station, is not designed to do that, is not intended to do that.”<sup>24</sup>*

Given the subsequent launch failures with the Orbital ATK and SpaceX cargo vehicles as well as the loss of the Russian *Progress* vehicle over the course of the past year, the potential loss of commercial crew capabilities seem to have a higher likelihood of possibly occurring.

It is unclear how NASA would handle such a situation given the current state of the development efforts of *Orion*. The Administration has consistently requested less than has been previously appropriated for the program. In the FY13, FY14, and FY15 budget requests, the Administration asked for reductions of \$175.1 million, \$87 million, and \$144.2 million from previous year funding.<sup>25</sup> It is difficult to assess the ability of NASA to press the *Orion* into service for emergency crew transfer capabilities while simultaneously requesting reductions to the budget for the program.

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<sup>21</sup> Title 42, §18323(b)(3), United States Code

<sup>22</sup> National Aeronautics and Space Administration Authorization Act of 2010 (P.L. 111-267). Retrieved at <http://www.gpo.gov/fdsys/pkg/PLAW-111publ267/pdf/PLAW-111publ267.pdf>

<sup>23</sup> Title 42, §18323(b), United States Code

<sup>24</sup> Klotz, Irene, “Orion No Backup for Commercial Crew, Says Bolden,” SpaceNews, June 18, 2014. Accessed at <http://www.spacenews.com/article/civil-space/40957orion-no-backup-for-commercial-crew-says-bolden>

<sup>25</sup> President’s Budget Requests for Fiscal Year 2013, Fiscal Year 2014, and Fiscal Year 2015.

## ISS Utilization

Since inception of the ISS, utilization of the facility has been an ongoing concern of Congress. There are several factors that limit the amount of research that can be conducted on the ISS at any given time; the most limiting of these is crew time to perform the experiments. Additionally, NASA's Inspector General reported last year that only about 41 percent of crew time was used on utilization and research.<sup>26</sup> NASA claims that, once the Commercial Crew contractors are providing consistent service, the addition of a seventh crew member could nearly double research time.

The NASA Authorization Act of 2010 required NASA to procure the services of a non-profit entity to run the National Laboratory portion of the ISS. NASA awarded this cooperative agreement to the Center for the Advancement of Science in Space (CASIS). The GAO recently reviewed the progress CASIS has made towards satisfying the requirements of their agreement. Generally speaking, the organization is making good progress, but there are still questions about the efficacy of the National Lab. According to GAO it is difficult to assess the progress made by CASIS in fulfilling its requirements under the cooperative agreement because NASA has not established a formal process for doing so:

*“Using the established metrics, NASA is required by the cooperative agreement to perform an annual program review of CASIS’s performance. This review is informal and not documented as ISS program officials provide the results to CASIS orally. This approach is inconsistent with federal internal control standards, which call for information to be recorded and communicated to those who need it to manage programs, including monitoring performance and supporting future decision making. Although NASA officials reported that they were generally satisfied with CASIS’s performance, CASIS officials said a formal summary of the results would make the information more actionable.”<sup>27</sup>*

In addition to CASIS activities, NASA is required to maximize use of the ISS. The NASA Authorization Act of 2010 requires NASA to “sustain the capability for long-duration presence in low-Earth orbit, initially through continuation of the ISS and full utilization of the United States segment of the ISS as a National Laboratory, and through assisting and enabling an expanded commercial presence in, and access to, low-Earth orbit, as elements of a low-Earth orbit infrastructure.”<sup>28</sup> Additionally, NASA is required to utilize the ISS as a “testbed” for technologies developed for future human exploration in deep space.<sup>29</sup> Finally, NASA must “maximize the productivity and use of the ISS with respect to scientific and technological research and development, advancement of space exploration, and international collaboration.”<sup>30</sup>

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<sup>26</sup> *Ibid.* 1, p. 7.

<sup>27</sup> Government Accountability Office report #GAO-15-397, “Measurable Performance Targets and Documentation Needed to Better Assess Management of National Laboratory.” Retrieved at <http://www.gao.gov/assets/670/669851.pdf>

<sup>28</sup> Section 202, National Aeronautics and Space Administration Authorization Act of 2010 (P.L. 111-267). Retrieved at <http://www.gpo.gov/fdsys/pkg/PLAW-111publ267/pdf/PLAW-111publ267.pdf>

<sup>29</sup> Section 308(c), National Aeronautics and Space Administration Authorization Act of 2010 (P.L. 111-267). Retrieved at <http://www.gpo.gov/fdsys/pkg/PLAW-111publ267/pdf/PLAW-111publ267.pdf>

<sup>30</sup> Section 502(a) National Aeronautics and Space Administration Authorization Act of 2010 (P.L. 111-267). Retrieved at <http://www.gpo.gov/fdsys/pkg/PLAW-111publ267/pdf/PLAW-111publ267.pdf>



For fiscal year 2016, NASA requested \$394 million for the purpose of microgravity research aboard the ISS. This represents approximately 9.8 percent of the total budget for the Space Operations account or about 35 percent of what it costs for the operations and maintenance of the program. The ISS currently supports activities for the Science Mission Directorate space and Earth science payloads, Space Technology Mission Directorate, Human Research Program (HRP), and Advanced Exploration Systems (AES). In addition to the ISS research program, NASA utilizes the ISS as a testbed for technology development in the Space Technology Mission Directorate and the Science Mission Directorate. The NASA Authorization Act of 2015 passed by the House by unanimous consent explicitly authorized the use of the ISS for this purpose.<sup>31</sup>

The ongoing experiments, future experiments, and ISS utilization efforts can be reviewed in detail at [http://www.nasa.gov/mission\\_pages/station/main/index.html](http://www.nasa.gov/mission_pages/station/main/index.html). The most notable of these experiments include:<sup>32</sup>

- Study on the effects of long-term spaceflight on astronaut Scott Kelly and cosmonaut Mikhail Kornienko. Both astronauts will spend almost a full year in space.
- Leveraging microgravity environment for protein crystal grown and disease models to aid study of human diseases such as Huntington's, cystic fibrosis, ALS, and others.
- Creation of a searchable publicly accessible database on biological flight data for use by academia, industry, and other federal agencies to retrieve and analyze science conducted on organisms flown in space.
- Multi-generational, long duration fruit fly laboratory research to aid in human research. As fruit flies share 77% of human disease genes, this provides for a unique study scenario.
- Development of Cold Atom Laboratory with research teams that includes three Nobel Laureates.
- Demonstrate 3D in-space printing as a first step in the "machine shop" capability for long-duration deep space human exploration.
- Conduct Bigelow Expandable Activity Module (BEAM) demonstration. This activity supports the AES program in understanding inflatable habitat use in deep space.
- Continuing operation of the Alpha Magnetic Spectrometer (AMS), a state of the art particle physics detector with a primary mission to find evidence of dark matter. The initial positron science results have been referenced in 279 astrophysics/physics publications.

While NASA's use of the ISS has improved in recent years, there are still areas of concern with regards to utilization. There is a lack of a unified federal government strategy for utilization of the facility. The NASA Authorization Act of 2015 requires the Administration to develop a federal government-wide utilization plan.<sup>33</sup> Additionally, the recent launch accidents resulted in the loss of research equipment and technology assets that may limit the utilization of the Station for at least the immediate future.

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<sup>31</sup> Section 213 and Section 503, H.R. 810, National Aeronautics and Space Administration Authorization Act of 2015, retrieved at <http://www.gpo.gov/fdsys/pkg/BILLS-114hr810rfs/pdf/BILLS-114hr810rfs.pdf>

<sup>32</sup> Examples of ISS experiments and utilization are courtesy of NASA via staff briefings delivered in February and March of 2015 in support of the President's Budget Request.

<sup>33</sup> Section 211(g), H.R. 810, National Aeronautics and Space Administration Authorization Act of 2015, retrieved at <http://www.gpo.gov/fdsys/pkg/BILLS-114hr810rfs/pdf/BILLS-114hr810rfs.pdf>

## ISS Extension to 2024

Last year, the Administration proposed extending the life of the ISS from 2020 to 2024, but has not provided its plan to get commitments from the international partner space agencies or budget requirements for the extension.<sup>34</sup> NASA is currently authorized to operate the ISS until 2020 under current law.<sup>35</sup> The extension of the program requires legislative action. As the Administration works to get the international partner nations to agree to extend the ISS, the House-passed NASA Authorization Act of 2015 includes a requirement that NASA provide an extension criteria report to Congress. This report would provide Congress with a baseline and notional plan to evaluate the merits of extending the program.<sup>36</sup>

The NASA Inspector General (IG) released a report on ISS extension in September 2014. The IG found several areas of concern with regards to extension. First, that NASA had not identified major structural obstacles to extension but that several risk areas required mitigation. According to the report,

*“First, the ISS faces a risk of insufficient power generation due in part to faster than expected degradation of its solar arrays. Second, although most replacement parts have proven more reliable than expected, sudden failures of key hardware have occurred requiring unplanned space walks to repair or replace hardware. Third, although NASA has a robust cargo transportation system, it has a limited capacity to transport large replacement parts – such as solar arrays and radiators – to the Station.”<sup>37</sup>*

The IG also found that cost projections for extension appeared overly optimistic. According to NASA officials, the budget for the ISS will remain between \$3 billion and \$4 billion annually through 2024. In the judgment of the IG, “this estimate is based on overly optimistic assumptions and the cost to NASA will likely be higher.”<sup>38</sup> NASA does not have a public estimate on the costs associated with extension. However, a recent Congressional Budget Office (CBO) cost estimate on the ISS extension provision in S. 1297, The U.S. Commercial Space Launch Competitiveness Act,<sup>39</sup> estimates that, should appropriations be allocated under the extension, it would cost the government approximately \$14.3 billion over the next ten years to extend the ISS operating life to 2024.<sup>40</sup>

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<sup>34</sup> Statement by NASA Administrator Charles F. Bolden, Jr. January 8, 2014 <http://blogs.nasa.gov/bolden/2014/01/08/obama-administration-extends-international-space-station-until-at-least-2024/>

<sup>35</sup> Title 51, §70907, United States Code.

<sup>36</sup> Section 211(f) National Aeronautics and Space Administration Authorization Act of 2015, retrieved at <http://www.gpo.gov/fdsys/pkg/BILLS-114hr810rfs/pdf/BILLS-114hr810rfs.pdf>

<sup>37</sup> *Ibid.* 1, p. ii.

<sup>38</sup> *Ibid.* 1, p. iii.

<sup>39</sup> Section 13, S. 1297, U.S. Commercial Space Launch Competitiveness Act. Retrieved at <http://www.gpo.gov/fdsys/pkg/BILLS-114s1297is/pdf/BILLS-114s1297is.pdf>

<sup>40</sup> Congressional Budget Office Cost Estimate of S. 1297. Retrieved at <http://www.cbo.gov/sites/default/files/114th-congress-2015-2016/costestimate/s1297.pdf>

## **Key Questions**

1. What are the costs associated with extension of the ISS and how are those costs measured against the benefits of extension?
2. How can Congress assess whether the ISS program is meeting its goals and objectives and how can those metrics inform the costs and benefits of extension?
3. If Congress does not extend ISS operations beyond 2020, what impact would that have on the U.S. Space Program?
4. What can NASA expect to gain by extending the ISS beyond 2024?
5. Is there an optimal date for extension beyond 2020?
6. Are there any technical concerns that would limit extension beyond a certain date?
7. How does NASA plan to mitigate the extension concerns expressed by the Inspector General?
8. What are the impacts on utilization of the ISS associated with the three cargo flight failures and how will those impacts be mitigated by NASA and the international partners?
9. Will ISS crew be limited as a result of the cargo failures, and if so, how will that impact utilization?
10. What steps have been taken to mitigate risks associated with reliance on private contractors for crew and cargo transportation?
11. Has NASA taken the appropriate steps to ensure that the *Orion* can serve as a backup to the commercial crew contractors in an emergency situation?