SECURING THE PROMISE OF THE INTERNATIONAL SPACE STATION: CHALLENGES AND OPPORTUNITIES

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

WEDNESDAY, MARCH 28, 2012

Serial No. 112–72

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PRINTING OFFICE
73–605PDF WASHINGTON : 2012

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HON. RALPH M. HALL, Texas, *Chair*

F. JAMES SENSENBRENNER, JR., Wisconsin
LAMAR S. SMITH, Texas
DANA ROHRABACHER, California
ROSCOE G. BARTLETT, Maryland
FRANK D. LUCAS, Oklahoma
JUDY BIGGERT, Illinois
W. TODD AKIN, Missouri
RANDY NEUGEBAUER, Texas
MICHAEL T. McCAUL, Texas
PAUL C. BROUN, Georgia
SANDY ADAMS, Florida
BENJAMIN QUAYLE, Arizona
CHARLES J. "CHUCK" FLEISCHMANN, Tennessee
E. SCOTT RIGELL, Virginia
STEVEN M. PALAZZO, Mississippi
MO BROOKS, Alabama
ANDY HARRIS, Maryland
RANDY HULTGREN, Illinois
CHIP CRAVAACK, Minnesota
LARRY BUCSHON, Indiana
DAN BENISHEK, Michigan
VACANCY

EDDIE BERNICE JOHNSON, Texas
JERRY F. COSTELLO, Illinois
LYNN C. WOOLSEY, California
ZOE LOFGREN, California
BRAD MILLER, North Carolina
DANIEL LIPINSKI, Illinois
DONNA F. EDWARDS, Maryland
BEN R. LUJAN, New Mexico
PAUL D. TONKO, New York
JERRY McNERNEY, California
TERRI A. SEWELL, Alabama
FREDERICA S. WILSON, Florida
HANSEN CLARKE, Michigan
SUZANNE BONAMICI, Oregon
VACANCY
VACANCY
VACANCY

CONTENTS

March 28, 2012

Page

Witness List 2
Hearing Charter 3

Opening Statements

Statement by Representative Ralph M. Hall, Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives 8
Written Statement 9
Statement by Representative Eddie Bernice Johnson, Ranking Minority Member, Committee on Science, Space, and Technology, U.S. House of Representatives 10
Written Statement 12
Prepared Statement by Representative Jerry Costello, Ranking Member, Subcommittee on Space and Aeronautics, Committee on Science, Space, and Technology, U.S. House of Representatives 13

Witnesses:

Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration
Oral Statement 14
Written Statement 17
Mrs. Cristina Chaplain, Director, Acquisition and Sourcing Management, U.S. Government Accountability Office
Oral Statement 27
Written Statement 29
Air Force Lieutenant General Thomas P. Stafford, Chairman, Nasa Advisory Council ISS Operational Readiness Task Force
Oral Statement 44
Written Statement 46
Discussion 49

Appendix 1: Answers to Post-Hearing Questions

Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration 66
Mrs. Cristina Chaplain, Director, Acquisition and Sourcing Management, U.S. Government Accountability Office 91

Appendix 2: Additional Material for the Record

GAO Contacts and Staff Acknowledgements 98

SECURING THE PROMISE OF THE INTERNATIONAL SPACE STATION: CHALLENGES AND OPPORTUNITIES

WEDNESDAY, MARCH 28, 2012

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Committee met, pursuant to call, at 9:36 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Ralph Hall [Chairman of the Committee] presiding.

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
www.science.house.gov

Full Committee Hearing

Securing the Promise of the International Space Station: Challenges and Opportunities

Wednesday, March 28, 2012
9:30 a.m. to 11:30 a.m.
2318 Rayburn House Office Building

Witnesses

Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration

Ms. Cristina Chaplain, Director, Acquisition & Sourcing Management, U.S. Government Accountability Office

Lt Gen Thomas P. Stafford, Chairman, NASA Advisory Council ISS Operational Readiness Task Force

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Securing the Promise of the International Space Station: Challenges and Opportunities

Wednesday, March 28, 2012
9:30 a.m. – 11:30 a.m.
2318 Rayburn House Office Building

Introduction

Assembly of the International Space Station (ISS) is complete, and NASA's focus is shifting from assembly and activation, to utilization and maintenance. The decision to extend the life of the ISS thru at least 2020 provides an unprecedented opportunity to perform promising scientific research. But will NASA be able to take full advantage of the research possibilities of the ISS? Currently, the U.S. laboratory section is about 50 percent utilized, and there are funding and access constraints that could affect the quantity and effectiveness of future research. Is NASA's funding for ISS research sufficient to allow a robust program? Has NASA adequately planned to enable effective research on the ISS? How much access will NASA have now that the Space Shuttle is no longer in service? What is the role of our international partners?

This hearing will review NASA's plans for conducting ISS research, and ensuring that essential spares, facilities, transportation and other resources are adequate to meet the research needs on the ISS thru 2020. This hearing is not intended to focus on NASA's commercial crew program or the Russian Soyuz system which all members of the international partnership are using for crew access for the next several years.

Witnesses

Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration

Ms. Cristina Chaplain, Director, Acquisition & Sourcing Management, U.S. Government Accountability Office

Lt. Gen. Thomas P. Stafford, Chairman, NASA Advisory Council ISS Operational Readiness Task Force

Background

The International Space Station partnership consists of Canada, Europe, Japan, Russia and United States. These entities have cooperated for two decades on design, development, operation and utilization of the ISS. The first element was launched in 1998, and the ISS has been permanently occupied since November 2000.

Now that the assembly of the ISS is complete, the focus has shifted from assembly and activation of the systems, to the maintenance and utilization of the facility. The majority of supplies and spare parts were traditionally delivered by the Space Shuttle. But since the Space Shuttle was discontinued in July of last year, NASA and the international partners must now rely on a combination of existing foreign and emerging domestic commercial launch systems to supply spares and other supplies to the ISS through at least 2020. NASA took advantage of the last two Shuttle missions to fully stock the ISS and deliver large spare parts and other components that could not be delivered on smaller vehicles. As a result, NASA believes that the sparing needs of the ISS are met for the remainder of this year. But NASA could face delivery shortfalls in the future.

Meeting ISS Requirements

Section 503 of the NASA Authorization Act of 2010 [P.L. 111-267] directed NASA to assess its plan to ensure that essential spare parts, equipment and systems were available to support ISS through 2020. The same Act directed the Government Accountability Office (GAO) to evaluate and report on the accuracy and level of confidence in NASA's assessments.

The reviews were to include "*the essential modules, operational systems and components, structural elements, and permanent scientific equipment on board or planned for delivery...required to ensure complete, effective and safe functioning and full scientific utilization of the ISS through September 30, 2020.*"[1] In January 2011 NASA reported to Congress that the ISS could be effectively maintained through 2020 with a combination of existing international, and planned domestic commercial re-supply vehicles.

Table 1 below shows NASA's assumptions as reported by GAO in December 2011.[2] Table 1 assumes two European ATV flights beyond 2014 (in 2016 and 2019) that are not currently agreed to by ESA. Table 1 also assumes three Japanese HTV flights beyond 2016 that are not currently agreed to by JAXA.

[1] Section 503, P.L. 111-267

[2] U.S. Government Accountability Office, GAO-12-162, International Space Station: Approaches for Ensuring Utilization through 2020 Are Reasonable but Should Be Revisited as NASA Gains More Knowledge of On-Orbit Performance, December 2011

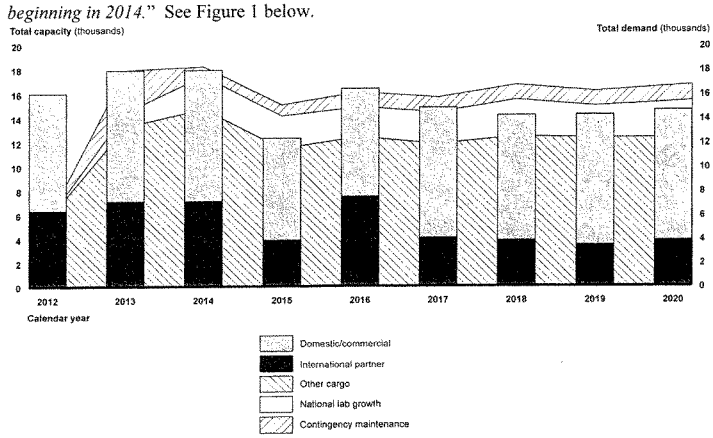
Table 1: NASA's Planned Vehicle Launches for 2012 to 2020 to Resupply the ISS

Vehicles	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
ATV	1	1	1		1			1		5
HTV	1	1	1	1	1	1	1		1	8
SpaceX	3	3	3	2						11
Orbital	2	2	2	2						8
SpaceX Follow On Vehicle A					3	3	2	3	3	14
Orbital Follow On Vehicle B					1	2	3	2	2	10
Total	**7**	**7**	**7**	**5**	**6**	**6**	**6**	**6**	**6**	**56**

Source: GAO analysis based on NASA documents.

Note: This table does not include flights by the Russian Soyuz or Progress vehicles.

Even though NASA's calculation of total launch capacity assumes the extra ATV and HTV flights shown above, a slight capacity shortfall remained. In December 2011 GAO noted, "*Although NASA expects domestic commercial launch vehicles to deliver the bulk of cargo required by the ISS through 2020, NASA strategic planning manifests indicate that NASA may not have sufficient capability to carry all the cargo that could be needed on the ISS. The manifests show that, when anticipated growth in national laboratory demands and margin for unforeseen maintenance needs are accounted for, the current number of flights NASA is planning for may not cover all of NASA's anticipated needs beginning in 2014.*" See Figure 1 below.



Source: GAO analysis of NASA data.

Figure 1: Cargo Capability of U.S. Commercial and International Partner Vehicles vs. NASA's ISS Sparing Needs from 2012 to 2020[3]

[3] U.S. Government Accountability Office, GAO-12-162, International Space Station: Approaches for Ensuring Utilization through 2020 Are Reasonable but Should Be Revisited as NASA Gains More Knowledge of On-Orbit Performance, December 2011

Based on NASA data provided to GAO, Figure 1 illustrates the shortfall in capacity needed to adequately service and utilize the ISS through 2020. As noted earlier, this chart contains assumptions about ATV flights in 2016 and 2019, and HTV flights beyond 2016, that artificially inflate the available launch capacity illustrated by the vertical bars. In the near term, the amount of launch capacity assumed in 2012 will likely be reduced due to schedule delays by the current domestic commercial providers. However, NASA believes the 2012 sparing needs have been met by the extra deliveries from the last two Space Shuttle missions. In the invitation to this hearing the Committee requested NASA to provide current estimates of the sparing requirements through 2020, and launch capacity based on current international commitments and realistic appraisals of the domestic/commercial providers.

Funding and Management of ISS Research

Amounts shown in millions of dollars	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
ISS Research	**225.5**	**229.3**	**227.4**	**231.3**	**238.3**	**241.7**
Biological & Physical Research	58.3	60.3	56.8	58.1	60.7	60.4
Non-Profit Organization	15.0	15.0	15.0	15.0	15.0	15.0
Multi-User System Support*	152.1	154.0	155.6	158.2	162.6	166.3

* MUSS is the infrastructure to support research

Figure 2: ISS Research Funding, NASA's FY2013 Budget Proposal[4]

Figure 2 shows NASA FY2013 budget request for ISS Research. Funding for NASA's Human Research Program is not shown because it is managed in the Exploration Research and Development account. The NASA FY2013 ISS Research budget is $229.3 million which includes $60.3 million for NASA-sponsored Biological and Physical Research, $154 million for the infrastructure to support the research, and $15 million to administer the new non-profit entity, the Center for the Advancement of Science in Space (CASIS). Given that the US section of the ISS is only about 50 percent utilized, is the FY2013 budget enough to support quality research? This topic will be discussed in more detail below.

The FY2008 Omnibus Appropriations Act (P.L. 110-161) directed NASA to engage the National Research Council (NRC) "*to conduct a "decadal survey" of life and physical sciences research in microgravity and partial gravity to establish priorities for research for the 2010-2020 decade.*" In April 2011 the NRC completed their report entitled, *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era.*

The National Academies report raised a number of concerns about the administrative and organizational oversight of life and physical sciences research, about the overall priority and declines in NASA funding for research, and about the need to rejuvenate the pipeline of graduate students,

[4] Does not include the Human Research Program funded by NASA's Exploration Research and Development

scientists, and engineers to improve the translation of fundamental and applied research to space exploration needs.

In the words of the report, "*...a vibrant and ultimately successful life and physical sciences space research program is a partnership between NASA and the scientific community at large. The present program, however, has contracted to below critical mass and is perceived from outside NASA as lacking the stature within the agency and the commitment of resources to attract researchers or to accomplish real advances.*"

The report noted that the scientific community has dwindled in the last decade due to declines in NASA's life and physical sciences research from approximately $500 million in FY2002 to less than $200 million in FY2010, with much of the latter going to the Human Research Program.

ISS National Laboratory

The NASA Authorization Act of 2005 designated the U.S. portion of the ISS as a National Laboratory. The Act also directed NASA to develop a plan to "*increase the utilization of the ISS by other Federal entities and the private sector...*," The National Laboratory designation was intended to stimulate ISS research and strengthen relationships among NASA, other Federal entities, academic and private institutions to pursue national advancement of science, technology, engineering, and mathematics.

In 2011 NASA formed a new division within the Human Exploration and Operations Directorate to coordinate and manage ISS research. NASA's Space Life and Physical Sciences Research and Applications Division (SLPSRA), "*oversees basic and mission driven scientific research in support of human space flight and crew health and safety, overseeing basic and applied scientific research in life and physical sciences and serves as agency liaison with the ISS National Laboratory management organization.*"

In 2011 SLPSRA sought proposals from qualified entities to manage the ISS National Lab and on July 13, 2011 selected the Center for Advancement of Science in Space (CASIS). Until this time, NASA had managed the ISS National Lab, and sought to facilitate utilization of the ISS to conduct basic and applied research, technology development and industrial processing by U.S. federal, state and local government entities, and U.S. commercial, academic and non-profit entities.

It is unclear when this new organization will be able to accomplish these objectives, while striking a balance between basic and applied research, technology development and industrial processing. Already there have been management changes at CASIS. On March 5th the Executive Director of CASIS resigned after less than six months on the job.

Over the coming months, NASA and CASIS will need to coordinate their efforts to ensure there is no disruption of current research activities. CASIS will need to engage with other non-NASA agencies, academic institutions and private industry to expand opportunities for research. This work is an important step in fulfilling the promise of the ISS, and the Committee will be monitoring this activity.

Chairman HALL. The Committee on Science, Space, and Technology will come to order. Good morning.

Before we get started, I would like to ask our witnesses to indulge us for just a few minutes to take care of some Committee business. It is my understanding that Ms. Johnson as the Ranking Member of the full Committee has some housekeeping that she wants the Committee to undertake regarding the Democratic Caucus Subcommittee Ranking Member assignments and rosters. It will just take a minute or so. The proposed modified roster is in front of each of you.

I now recognize Ranking Member Johnson to explain and make a motion regarding the change in the Democratic Caucus Subcommittee ranking Member assignments and rosters. Ms. Johnson.

Ms. JOHNSON. Thank you very much, Mr. Hall.

We have a couple of Subcommittee vacancies to fill on the Democratic side, and pursuant to direction from the Democratic Caucus of the Committee, I move that the following Subcommittee assignments be made: Mr. Costello of Illinois to serve as Ranking Member of the Subcommittee on Space and Aeronautics, and that Ms. Bonamici of Oregon to serve on the Subcommittees on Research and Science Education and Technology and Innovation.

Chairman HALL. Without objection, it is so ordered. Now I ask unanimous consent that the Committee adopt the revised roster in front of them reflecting these appointments as outlined by Ranking Member Johnson, and hearing no objection, the revised roster is adopted. Amen.

I would like to welcome everyone to today's hearing entitled "Securing the Promise of the International Space Station: Challenges and Opportunities." In front of all the members are packets containing the written testimony, biographies, and the Truth in Testimony disclosures for today's witnesses. I recognize myself now for five minutes for an opening statement.

I want to welcome everyone to today's hearing, and once again thank our witnesses for their time and their preparation and for sharing their experience and wisdom on the important topic of the International Space Station. The title of hearing describes what we hope NASA can accomplish, and that is "Securing the Promise of the International Space Station."

The ISS is an extraordinary engineering achievement, and it is a remarkably successful international collaboration that presents us an unprecedented opportunity to accomplish beneficial scientific research. I would like to see the ISS live up to its promising potential. I would like to see it enable scientists and researchers to do innovative research, the kind of lifesaving biomedical research that can only be done in space. Fulfilling the promise of the ISS would not only serve humanity, it would also strengthen America's leadership in science, technology, and education.

I am often painfully reminded that NASA will rely on our Russian partners for crew transportation to International Space Station for the next several years; however, for the purposes of today's hearing, we are not focusing on crew.

Fortunately there are a number of options for delivering the supplies and equipment necessary to conduct the research and utilize the International Space Station. Our international partners con-

tribute three different launch systems that are vital for maintaining and utilizing the International Space Station, and there are two domestic commercial cargo capabilities that will be tested later this year. In fact, the most recent European Automated Transfer Vehicle, the ATV, was launched Friday and should dock to the Space Station sometime around 6:30 p.m. today, this very day. We are reliant on the Russian Progress, the European Automated Transfer Vehicle and the Japanese H–2 Transfer Vehicle, but NASA does not have agreements with the European Space Agency to supply more Automated Transfer Vehicles after 2014, or with the Japanese Space Agency to supply H–2 Transfer Vehicles after 2016.

Now that NASA has finished International Space Station construction, I hope the incredible potential of the space station is not squandered because research funding is shortchanged, or because of poor coordination managing the U.S. National Lab, or because of reductions in launch capacity to support it, or because NASA just can't get the job done.

The President cancelled Constellation by running a line through it because of, so he said, someone else's failure to act, and he has become pretty adept at naming mistakes after other people other than himself. Sometimes he needs to look in the mirror and tell us why we are losing the pipeline and why we are going to get $5 gasoline.

I also want to reiterate again that the NASA Authorization Act of 2010 directed that the Space Launch System and the Orion crew capsule be designed to provide a backup capability for access to the space station. After spending tens of billions of dollars to build the space station, Congress wanted to ensure that a national capability to access it was not jeopardized by overreliance on untested commercial propositions.

Supplying and utilizing the International Space Station is simply too important to be left to others. Yet, NASA is pacing the development of Space Launch System and Orion to be operational around 2021, which could occur after the International Space Station's retirement. That is risky and borders on being outrageous. America's continued leadership in space, and our national security, depend in large part on developing and maintaining this critical capability. I can't stress enough the importance of accelerating this launch system to ensure we have an alternative method to transport people and cargo to the International Space Station as well as to launch future missions beyond low Earth orbit.

I look forward to today's hearing.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF CHAIRMAN RALPH M. HALL

I want to welcome everyone to today's hearing, and once again thank our witnesses for their time and preparation, and for sharing their experience and wisdom on the important topic of the International Space Station. The title of our hearing describes what we hope NASA can accomplish, "Securing the Promise of the International Space Station." The ISS is an extraordinary engineering achievement. And it is a remarkably successful international collaboration that presents us an unprecedented opportunity to accomplish beneficial scientific research. I would like to see the ISS live up to its promising potential. I would like to see it enable scientists and researchers to do innovative research—the kind of life-saving biomedical re-

search—that can only be done in space. Fulfilling the promise of the ISS would not only serve humanity, it would also strengthen America's leadership in science, technology and education.

I am often painfully reminded that NASA will rely on our Russian partners for crew transportation to ISS for the next several years; however, for the purposes of today's hearing, we're not focusing on crew. Fortunately there are a number of options for delivering the supplies and equipment necessary to conduct the research and utilize the ISS. Our international partners contribute three different launch systems that are vital for maintaining and utilizing the ISS, and there are two domestic commercial cargo capabilities that will be tested later this year. In fact, the most recent European Automated Transfer Vehicle (ATV) was launched Friday and should dock to the Space Station around 6:30 this evening. We are reliant on the Russian Progress, the European Automated Transfer Vehicle and the Japanese H–2 Transfer Vehicle (HTV), but NASA does not have agreements with the European Space Agency to supply more Automated Transfer Vehicles after 2014, or with the Japanese Space Agency to supply H–2 Transfer Vehicles after 2016.

Now that NASA has finished ISS construction, I hope the incredible potential of ISS is not squandered because research funding is shortchanged, or because of poor coordination managing the U.S. National Lab, or because of reductions in launch capacity to support it, or because NASA just can't get the job done.

I also want to reiterate that the NASA Authorization Act of 2010 directed that the Space Launch System and the Orion crew capsule be designed to provide a back-up capability for access to the ISS. After spending tens of billions of dollars to build the space station, Congress wanted to ensure that a national capability to access it was not jeopardized by overreliance on untested commercial propositions.

Supplying and utilizing the ISS is simply too important to be left to others. Yet, NASA is pacing the development of Space Launch System and Orion to be operational around 2021, which could occur after ISS retirement. America's continued leadership in space, and our national security, depend in large part on developing and maintaining this critical capability. I cannot stress enough the importance of accelerating this launch system to ensure we have an alternative method to transport people and cargo to ISS as well as to launch future missions beyond low Earth orbit.I look forward to today's hearing and I now recognize my good friend from Texas, Ranking Member Eddie Bernice Johnson.

Chairman HALL. I now recognize my good friend from Texas, Ranking Member Eddie Bernice Johnson.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and good morning. I want to join Chairman Hall in welcoming all of our witnesses to today's hearing, and in addition, I would like to express my appreciation in particular to one of the witnesses, Lieutenant General Thomas Stafford, for his decades of service to this country and his continuing effort to strengthen and promote the Nation's civil and military aerospace capabilities.

As this Committee attempts to better understand the needs of our civil space program in these times of fiscal pressures, it is important to take a close look at one of the most important elements of the Nation's human spaceflight program, namely, the International Space Station.

While the road to its completion has been a long one, with many twists and turns along the way, the Space Station stands as one of the engineering marvels of the modern age, and a testament to American ingenuity and perseverance. Now, there is a lot one could say about the International Space Station, but I think the citation that accompanied the award to the ISS team of the 2009 Collier Trophy, one of the aerospace profession's premier awards, sums up what has been accomplished. That is, "the design, development, and assembly in space of the world's largest spacecraft, an orbiting laboratory, promising new discoveries for mankind and setting new standards for international cooperation in space."

I would go further, and also note that it is an accomplishment that has had great inspirational value for our young people, as evi-

denced by the intense interest of our students in talking to the orbiting astronauts and in developing science projects that might fly on the Station.

However, while we can talk about the promise offered by the ISS in enabling future space exploration as well as carrying out basic and applied research that can benefit life here on Earth, its success in fulfilling that promise is not assured. We will only realize its promise if NASA and Congress ensure that the necessary steps are taken to make the ISS a productive research facility and technology test bed, and that is what we need to address at today's hearing.

I understand the importance of trying to maintain uninterrupted access to ISS, and I know that we will hear testimony today on some of the challenges in doing so. However, we should not forget that the purpose of cargo and crew transportation systems is to support the utilization of the Space Station, not as ends in themselves.

The reality is that the ISS is a perishable commodity, and "the future is really now" in terms of utilizing this unique facility. While some may hope to extend its agreed-upon service life past 2020, we need to make sure that the eight years that remain until the current end of the ISS program are used effectively to answer the research and engineering questions that can only be answered by on the ISS.

In short, we need clear, prioritized and integrated utilization plans from NASA, and we need to be assured that those plans are being carried out, both by NASA and by the independent International Space Station research management organization, CASIS, that was set up for that purpose. The former director of CASIS raised a number of serious concerns in her recent resignation letter, and this Committee will need to better understand what the situation at CASIS is, given its important role in International Space Station utilization.

As a result, Mr. Chairman, I hope that this Committee will convene another hearing before this session of Congress is over to examine all of the issues faced by the research community in trying to utilize the space station, as well as in carrying out related ground-based research and development. We need to hear from representatives of that community in addition to the testimony we will get from our distinguished panel testifying before us today.

Before I close, I would just like to make one more point. Namely, if we want to ensure that the space station carries out the needed research and technology activities in a timely and productive fashion, we have to be willing to make the needed investments. The ISS research budget is stagnating, and the agency's life and microgravity research budget has been cut deeply over the past decade. That does not seem to me to be a formula for success.

I am afraid that we get numb from the continued chipping away at NASA's accounts by both Congress and successive Administrations. However, those continued cuts have had a negative impact on NASA's ability to carry out its missions that we should not ignore. In spite of those negative impacts, the budget resolution that we will be voting on later this week would make additional cuts to the account that funds NASA and other R&D agencies. I hope that

this Congress thinks twice before we embrace such cuts to an agency that is so important as NASA.

In closing, I again want to welcome our witnesses and look forward to the testimony, and I yield back the balance of time that I don't have. Thank you.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF RANKING MEMBER EDDIE BERNICE JOHNSON

Good morning. I want to join Chairman Hall in welcoming all of our witnesses to today's hearing. In addition, I would like to express my appreciation in particular to one of those witnesses—Lt. Gen. Thomas P. Stafford—for his decades of service to this country and his *continuing* efforts to strengthen and promote the Nation's civil and military aerospace capabilities.

As this Committee attempts to better understand the needs of our civil space program in these times of fiscal pressures, it is important to tak a close look at one of the most important elements of the Nation's human spaceflight program, namely, the International Space Station.

While the road to its completion has been a long one, with many twists and turns along the way, the ISS stands as one of the engineering marvels of the modern age, and a testament to American ingenuity and perserverance. There is a lot one could say about the ISS, but I think the citation that accompanied the award to the ISS team of the 2009 Collier Trophy—one of the aerospace profession's premier awards—sums up what has been accomplished. That is, "*the design, development, and assembly in space of the world's largest spacecraft, an orbiting laboratory, promising new discoveries for mankind and setting new standards for international cooperation in space.*"

I would go further and also note that it is an accomplishment that has had great inspirational value for our young people, as evidenced by the intense interest of our students in talking to the orbiting astronauts and in developing science projects that might fly on the Station.

However, while we can talk about the promise offered by the ISS in enabling future space exploration as well as carrying out basic and applied research that can benefit life here on Earth, its success in fulfilling that promise is not assured. We will only realize its promise if NASA and Congress ensure that the necessary steps are taken to make the ISS a productive research facility and technology test bed, and that is what we need to address at today's hearing.

I understand the importance of trying to maintain uninterrupted access to the ISS, and I know that we will hear testimony today on some of the challenges in doing so. However, we should not forget that the purpose of cargo and crew transportation systems is to *support the utilization* of the ISS, not as ends in themselves.

The reality is that the ISS is a perishable commodity, and "the future is now" in terms of utilizing this unique facility. While some may hope to extend its agreed-upon service life past 2020, we need to make sure that the eight years that remain until the current end of the ISS program are used effectively to answer the research and engineering questions that can only be answered on the ISS.

In short, we need clear, prioritized, and integrated utilization plans from NASA, and we need to be assured that those plans are being carried out, both by NASA and by the independent ISS research managemenet organization, CASIS, that was set up for that purpose. The former director of CASIS raised a number of serious concerns in her recent resignation letter, and this Committee will need to better understand what the situation at CASIS is, given its important role in ISS utilization.

As a result, Mr. Chairman, I hope that this Committee will convene another hearing before this Session of Congress is over to examine all of the issues faced by the research community in trying to utilize the ISS, as well as in carrying out related ground-based R&D. We need to hear from representatives of that community in addition to the testimony we will get from the distinguished panel testifying before us today.

Before I close, I would just like to make one more point. Namely, if we want to ensure that the ISS carries out the needed research and technology activities in a timely and productive fashion, we have to be willing to make the needed investments. The ISS research budget is stagnating, and the agency's life and microgravity sciences budget has been cut deeply over the past decade. That does not seem to me to be a formula for success.

I am afraid that we get numb from the continued chipping away at NASA's accounts by both Congress and successive Administrations. However, those continued

cuts have had a negative impact on NASA's ability to carry out its missions that we should not ignore. In spite of those negative impacts, the budget resolution that we will be voting on later this week would make additional cuts to the account that funds NASA and other R&D agencies. I hope that this Congress thinks twice before we embrace such cuts to an agency as important as NASA.

In closing, I again want to welcome our witnesses, and I look forward to your testimony. I yield back the balance of my time.

Chairman HALL. Thank you, Ms. Johnson.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF RANKING SUBCOMMITTEE MEMBER JERRY COSTELLO

Mr. Chairman, thank you for holding today's hearing to review the International Space Station and what NASA is doing to make sure it can be used effectively through at least 2020.

Some have called the ISS the greatest engineering feat ever. After a dozen years of assembly in space, we now have a fully functioning orbital laboratory, and I commend the men and women of NASA and its contractors for making ISS asssembly look easy, because it was far from that.

The ISS Program was awarded the coveted Collier Trophy by the National Aeronautic Association in recognition of its singular achievement in designing, developing, and assembling in space this unique orbiting outpost.

With all that it took to get the ISS to where it is today, we must ensure it is fully utilized so U.S. taxpayers can see a return on their investment of over $50 billion.

Congress stressed the importance of ISS utilization in numerous authorization and appropriations Acts.

For example, the 2010 NASA Authorization Act directed NASA to "*take steps to maximize the productivity and use of the ISS with respect to scientific and technological research and development, advancement of space exploration, and international collaboration*."

Before we can make concrete plans for sending humans to explore far-away places like Mars, we need to better understand how to deal with such unknowns as radiation and bone loss and how human beings react to being in a closed environment in space for months, even years, at a time.

The ISS is a unique platform that will help us do the research necessary to gain such understanding.

Furthermore, the ISS will provide other federal agencies and industry with unparalleled microgravity facilities to do research on their own, and in September 2011, NASA awarded a cooperative agreement to an independent, non-profit entity to expand such non-NASA research as part of the U.S. National Laboratory.

That organization, however, is off to a rocky start, given the abrupt resignation of its Executive Director.

With the clock ticking on getting the ISS to a full and productive state, I hope to understand how NASA will ensure that this independent entity will enhance and augment ISS research, as directed in the 2010 Authorization Act.

I want to welcome this distinguished panel of experts and hope their insights can help shed further light on how we can better position the ISS to enable it to reach its full potential, including the possibility of it contributing to medical or other breakthroughs to make life better here on Earth.

Thank you, Mr. Chairman, and I yield back the balance of my time.

Chairman HALL. At this time, I would like to introduce our witnesses. Our first witness is Mr. William H. Gerstenmaier, Associate Administrator of the Human Exploration and Operations Mission Directorate at the National Aeronautics and Space Administration. As a supporter of human spaceflight, I am very grateful to Mr. Gerstenmaier's dedication and long-term service to the Nation. Mr. Gerstenmaier began his career with NASA in 1977 and has steadily advanced in the ranks. Over the past 20 years, he has been instrumental in the successful management of NASA's human space

exploration program, and welcome, Mr. Gerstenmaier. Welcome very much.

And our second witness is Mrs. Cristina Chaplain, the Director of Acquisition and Sourcing Management for the U.S. Government Accountability Office. Ms. Chaplain has a degree from Boston University and from Columbia University, and has been with GAO for over 20 years. She has conducted a number of assessments for NASA's major acquisition programs including a recent review on utilization and sustainment of the International Space Station. Ms. Chaplain, we thank you and your staff at GAO for your service and look forward to your testimony today.

As impressive as our first two witnesses are, I have saved what my speechwriter wrote here, the best for the last. I will let you all make that decision. It is as bad as judging a baby contest, and I know better than that. Our third and final witness is retired U.S. Air Force Lieutenant General Thomas P. Stafford, one of the most unusual men I know and one of the dearest friends I have. He is Chairman of the International Space Station Advisory Committee. Tom's many accomplishments are legendary, and his distinguished service was acknowledged again when we recently awarded the prestigious 2011 Wright Brothers Memorial Trophy for his "pioneering achievements that have led the way to the Moon, to greater international cooperation in space, and to a safer America." And just one person per year gets that recognition. General Stafford had played instrumental roles in many of America's successes in space, from the Gemini rendezvous and Apollo X missions with my other good friend, Gene Cernan, to the Apollo-Soyuz mission in 1975 that laid the groundwork of trust and mutual respect among former adversaries that has been so critical to the success of today's International Space Station. Tom, thank you for your service to America and for testifying before us today.

And as our witnesses should know, spoken testimony is limited to five minutes, after which Members of the Committee will have five minutes to ask their questions. We won't hold you to the five minutes. You are too valuable to us and your time is too valuable. You took your time to get ready to come here and give us this testimony, so we will be very lax on that.

I recognize our first witness, Mr. William Gerstenmaier of NASA.

STATEMENT OF MR. WILLIAM GERSTENMAIER, ASSOCIATE ADMINISTRATOR,
HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. GERSTENMAIER. Thank you. As you have already stated, the ISS represents an unparalleled capability for human space-based research that cannot be pursued on Earth as well as a platform for the development of exploration technologies. The ISS is the most sophisticated space research facility ever built. It contains state-of-the-art research laboratories from Russia, Europe, Japan, and the United States. It has amazing robotic capabilities from Canada. The facilities for research include a combustion rack, a fluid facility rack to investigate low-gravity fluid motion, external payload at-

tach capabilities for Earth and deep-space viewing, and a window observation facility, among many other unique facilities. ISS is truly a model for engineering development and international collaboration.

This facility was not easy to construct and faced huge challenges during its development. Approximately 37 shuttle flights and approximately 1,000 hours of space walks, or 162 EVAs, went into its construction. Every shuttle flight had to occur precisely as scripted. The teams had to deal with loss of Columbia in mid-assembly, and numerous in-flight challenges such as loss of the wrist joint on the Canadian arm early in assembly, loss of all onboard computers on board the space station, and a tear in the solar ray blanket.

The budget challenges were also huge. However, through it all, the amazing ISS team constructed this wonderful facility that we have on orbit today. The team showed an unbelievable ability to deal with unexpected problems and keep working together to complete construction. They did with behind-the-scenes detailed planning. The teams worked to keep open the option for extra shuttle flights beyond the original plan manifest. This work gave decision makers options later to add these flights. In space operations, knowing when to make decisions is often as important as the decision itself.

We are now facing a transition in ISS. We no longer need to focus on assembly, but we need to turn this dedicated team to using this amazing facility in space. The ingenuity, drive, and focus will now be applied to using the ISS for the benefit of all humankind. Through the conclusion of ISS expedition 28 in October of 2011, approximately 1,250 research investigations were performed that involved 1,309 principal investigators from 63 countries around the world. Of these, U.S. principal investigators under NASA's sponsorship conducted 475 investigations, 38 percent of that total. Expeditions 29 to 32, which covers the period from October of last year, 2011, to September of 2012, will include 259 investigations. In other words, approximately 20 percent as many investigations were performed in these two post-assembly expeditions as had been achieved in the prior 28 expeditions combined. We are starting to begin serious use of the International Space Station.

The ISS teams as well as the research community need to be ready for this next phase. However, this utilization will not be easy. There will be start-up transients with commercial cargo. The teams have planned ahead with ATV, HTV, and STS–135. We will have about a year for the commercial providers to come online.

Nothing in space is ever easy. The teams have the cargo ship to Japan for the HTV launch this summer. The cargo for the C2 mission is ready at KSC for launch on April 30th. The ATV will hopefully dock to the ISS tonight with critical supplies and research equipment. The teams have solid plans for the next year. We have always been dependent upon the Russians for crew rescue, but now we have a single method for crew transportation. This is a tremendous responsibility for the Russians.

We are working to bring commercial crew online as soon as possible. This utilization phase will not be easy for the International Space Station team. However, based on their performance in assembly, this team now focused on research and utilization will ac-

complish amazing things. They will build off of the techniques learned during assembly and place the necessary international agreements for cargo in place at the right time. The research community will also need to be prepared for this new phase. The priority will be on research and utilization and not on assembly and maintenance. ISS will bring tangible and intangible benefits to humankind.

The ISS will provide a facility for the human spaceflight team to prepare for voyages beyond low Earth orbit. ISS can be an economic engine and allow companies to use the unique properties of space-based research for competitive advantage. The International Space Station team will enable productive use of this amazing facility and will grow from the challenges ahead. ISS will be a bridge to the future. The teams are prepared. My written testimony expands on these thoughts and adds additional detail.

I thank this Committee for its support and the chance to respond to your questions.

[The prepared statement of Mr. Gerstenmaier follows:]

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
March 28, 2012

Statement of
William H. Gerstenmaier
Associate Administrator for Human Exploration and Operations
National Aeronautics and Space Administration

before the

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

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear before you today to discuss the status of the International Space Station (ISS) Program. The ISS represents an unparalleled capability for human space-based research that cannot be pursued on Earth, as well as a platform for the development of exploration technologies. ISS provides a research and development (R&D) environment that allows us to investigate physical processes in a very different environment than that obtainable on Earth. Observing from, and experimenting in, the environment of ISS gives us a chance to learn about our world and physical processes from a very different frame of reference. The three major science laboratories aboard the ISS -- the U.S. *Destiny*, European *Columbus*, and Japanese *Kibo* facilities -- as well as external testbeds and observatory sites, enable astronauts to conduct a wide variety of experiments in the unique, microgravity and ultra-vacuum environment of Low Earth Orbit (LEO). The ISS supports research across a diverse array of disciplines, including high-energy particle physics, Earth remote sensing and geophysics experiments, molecular and cellular biotechnology experiments, human physiology research (including bone and muscle research), radiation research, plant and cultivation experiments, combustion research, fluid research, materials science experiments, and biological investigations. It is also a place to conduct technology development efforts. R&D conducted aboard the ISS holds the promise of next-generation technologies, not only in areas directly related to NASA's exploration efforts, but in fields that have numerous terrestrial applications, as well. The ISS will provide these opportunities to scientists, engineers, and technologists through at least 2020. Beyond being a feat of unparalleled engineering and construction, as well as international collaboration, the ISS is a place to learn how to live and work in space over a long period of time and foster new markets for commercial products and services. The ISS will be critical to NASA's future missions of exploration beyond LEO. More importantly, ISS offers many unique benefits to the citizens of the United States and the world.

The ISS will continue to meet NASA's mission objective to prepare for the next steps in human space exploration. The ISS is NASA's only long-duration flight analog for future human deep space missions, and it provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep space missions. It is the only space-based multinational research and technology testbed available to identify and quantify risks to human health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration.

International Cargo and Crew Transportation Systems

In order to realize the full potential of the ISS' capabilities, the platform is serviced by a fleet of operational international vehicles. U.S. crew vehicles are beginning development and U.S. cargo vehicles are in the final stages of development to help ensure robust operations.

The Russian Soyuz spacecraft, an evolutionary development of a vehicle that has been flying since 1967, provides transportation to and from the ISS for the Expedition crews. Soyuz also has the capability to remain docked to the Space Station for the six-month periods required to support these crews, providing an on-orbit rescue capability in the event of a contingency aboard the ISS. The ISS can host six crewmembers on long-duration missions with the support of two Soyuz spacecraft. There are currently four Soyuz crew exchanges per year.

Recently, a Soyuz vehicle slated for an upcoming flight experienced a problem during pressure testing prior to its shipment to the launch site in Baikonur, Kazakhstan. While our Russian partners determine the cause of the over-pressurization, the vehicle has been suspended from flight, and a different Soyuz has been moved up in the launch sequence. This resulted in a six-week delay to the launch of mission 30S, which is now scheduled for launch on May 15. The crew of Soyuz 28S will remain on orbit another six weeks for a total of 168 days. Other Soyuz and Progress flights were re-planned for the remainder of 2012, with Soyuz 31S launching on July 15, Soyuz 32S launching on October 15, and Soyuz 33S launching on December 5, 2012.

The uncrewed Russian Progress cargo vehicle is used to resupply the ISS with dry cargo, propellant, water, and gas; it is also used to boost the orbit of the ISS and control the orientation of the Station. At the end of its mission, Progress is filled with trash, undocks from the ISS, and is incinerated in Earth's atmosphere in a controlled re-entry. There are generally four to five Progress resupply flights to ISS per year. These Progress vehicles primarily carry cargo for use in the Russian portion of the ISS. Progress 46P flew to the Station in January, and Progress 47P, 48P, and 49P are all scheduled to fly to ISS in 2012.

On August 24, 2011, the rocket used to launch Progress 44P experienced an anomaly that shut down its third stage engine. The vehicle did not reach orbit and landed in the Altai region of Russia. Since the Soyuz crew transport spacecraft uses essentially the same launch vehicle as Progress, when the Soyuz 26S crew undocked from ISS on September 15, 2011 at the end of their six-month stay on orbit, the launch of the Soyuz 28S crew was delayed, pending return to flight of the launch vehicle, and the ISS was left with a crew of three. A Russian Commission determined the problem was in the engine's gas generator, likely due to contamination. NASA conducted its own assessment of the Russian investigation, and agreed that the anomaly was not related to a design flaw, and that blockage by contamination was the most likely cause. The Russians flew a Progress mission (45P) to ISS without incident, before launching the next crew to ISS on Soyuz 28S. The period of reduced crew size was of sufficiently short duration that impacts to scientific research aboard ISS were modest. With the docking of Soyuz 28S to the ISS on November 16, 2011, the Soyuz crew exchange capability was restored, and the December 23, 2011 docking of Soyuz 29S restored the crew to a full complement to six for a nominal six-month duration.

As NASA has previously testified, some modification of the Iran, North Korea and Syria Non-proliferation Act (INKSNA) provisions will likely be required for the continued operation of ISS and other space programs after the current waiver expires. The Administration plans to propose appropriate provisions and looks forward to working with the Congress on their enactment. NASA is evaluating how this issue impacts the development of U.S. crew transportation systems and NASA's acquisition of services for the ISS and goods and services for other NASA human spaceflight activities, given the possibility that some U.S. domestic providers will need to use Russian goods and services. In addition to

the need driven by the ISS transportation requirements, NASA will require Russia-unique critical capabilities for the life of the ISS, such as sustaining engineering for the Russian built U.S. owned Functional Cargo Block, that are not available elsewhere.

ISS is also supported by the European Automated Transfer Vehicle (ATV), which has completed two successful missions. The ATV can carry dry cargo, atmospheric gas, water and propellant, and also provides trash removal at the end of its mission. As with the Progress, the ATV can boost the Space Station's orbit and control the orientation of the ISS. Between now and 2014 (ATV-5), ATV is a vehicle NASA and its partners could use to deorbit the ISS in the event of a contingency that would require the disposal of the Station (the vehicle for conducting such a contingency deorbit after 2014 is to be determined, but will likely involve the Russian Progress vehicle). The third ATV, *Edoardo Amaldi*, launched from the European Space Agency's (ESA) launch complex in French Guiana on March 23, 2012, and is scheduled to berth at ISS this evening just after 6:30, Eastern. Our current planning shows low utility for use of the ATV beyond ATV-5, scheduled to fly in 2014. At that point, propellant systems will be full and, from a NASA perspective, ATV would offer no cargo advantages above what can be provided by U.S. commercial providers.

The Japanese H-II Transfer Vehicle (HTV), which has also completed two successful missions, can carry dry cargo, gas and water to ISS, and notably, has both pressurized and unpressurized cargo carriage capability. Like the Progress, HTV can also provide trash removal at the end of its mission. The third HTV mission is scheduled for launch from the Japan Aerospace Exploration Agency's (JAXA) Tanegashima space center on July 21, 2012. The HTV has unique capabilities needed for ISS. The ability to carry large external cargo and transfer large internal racks will continue to make HTV a unique asset. Therefore, HTV will continue to be needed beyond 2015. NASA presently envisions that approximately four HTVs will be required beyond 2015.

Sustainability of ISS Operating Systems

The ISS continues to be a very healthy system operating well within prudent technical margins, and consistently demonstrating outstanding steady-state performance that meets or exceeds prior engineering estimates. While systems were originally specified to be both reliable and maintainable, the operational experience NASA and its Partners are gaining is providing invaluable information on reliability and maintainability standards for future application to spacecraft design and mission planning.

As in any complex system deployed in an extreme environment, occasional component outages or failures are to be expected. This inevitability is compensated through engineering estimates of the mean-time-between-failure (MTBFs) and mean-time-to-repair (MTTRs) for critical components. As in-space operational experience accrues, these engineering estimates are gradually replaced by actual operating histories of higher fidelity. Since sound engineering design is conservative in practice, operating experience often demonstrates that MTBFs and MTTRs are longer in duration than originally estimated, and this is proving generally true for most ISS systems. Therefore, we utilize industry-accepted techniques to update our reliability estimates yearly and likewise our sparing strategy becomes more closely aligned with actual performance.

The final flights of the Space Shuttle enabled pre-positioning of many critical system spares in accordance with lifetime predictions. We currently have on board two spare control moment gyroscopes; three spare pump packages for the external active cooling system; two main bus switching units; three direct current switching units; four battery charge discharge units; ammonia, nitrogen and high pressure gas tank assemblies; radiators; antennae; Canadarm2 pitch, roll and yaw joints, and a range of additional, but no less critical, components and assemblies. These prepositioned large critical spares as well as ATV

and HTV allow several years to almost 2020 before the new commercial providers would be required to carry this class of spare. Pressurized items, such as crew supplies, food, internal systems spares and consumables, and research equipment and samples, need to be regularly supplied. Current NASA projections show that the ISS can be operated with effective research and maintained by international partner assets through calendar year 2012, and perhaps longer, depending on specific component anomalies and research requirements, while the next generation of U.S. commercial resupply vehicles comes on line. The research needs both upmass and downmass, which will be carefully monitored in order to ensure productive use of the ISS as these new cargo providers begin to provide regular service.

U.S. Cargo and Crew Transportation Systems

As you know, NASA is developing and procuring cargo resupply services under two different approaches: Commercial Orbital Transportation Services (COTS) to develop and demonstrate commercial cargo transportation systems; and Commercial Resupply Services (CRS) to procure cargo resupply services to and from the ISS.

Commercial Orbital Transportation Services

As part of COTS, NASA has partnerships with Space Exploration Technologies, Inc. (SpaceX) and Orbital Sciences Corporation (Orbital) using funded Space Act Agreements (SAAs). These agreements include a schedule of fixed payment performance milestones culminating in demonstration missions to the ISS that includes vehicle launch, spacecraft rendezvous, ISS berthing, and re-entry for disposal or return safely to Earth.

Both COTS partners continue to make progress in developing and demonstrating their systems.

- In December 2011, NASA announced its decision to combine the flight objectives of SpaceX COTS demonstration flights 2 and 3 into a single mission, which is slated for launch no earlier than April 30. SpaceX will attempt to achieve the ISS fly-by mission objectives of the second demonstration flight before NASA approves the ISS final approach and berthing objectives originally planned on the third demonstration flight. It is important to note that each of the milestone objectives must be achieved before the associated payment is made, and if the mission is not able to achieve all milestone objectives, the remaining objectives would need to be demonstrated on another flight before payment will be made.

- Orbital has been using NASA assets at Stennis Space Center (SSC) for engine acceptance testing and Wallops Flight Facility (WFF) for launch vehicle and spacecraft processing and integration as it prepares for its COTS demonstration flights. The launch pad complex construction is the responsibility of the Mid Atlantic Regional Spaceport. A short-duration hot-fire test of the first stage system is scheduled immediately after launch pad commissioning. This hot-fire test could take place as early as late May 2012. The maiden flight of the Antares launch vehicle is planned for launch no earlier than June of 2012, and it will include a Cygnus spacecraft mass simulator. Orbital Sciences' COTS demonstration flight to the ISS is slated for no earlier than September of 2012.

Commercial Resupply Services

On December 23, 2008, NASA awarded CRS contracts to Orbital and SpaceX for the delivery of cargo to the ISS after the retirement of the Shuttle. NASA anticipates that both providers will have their first delivery flights to ISS in 2012. We are assuming, based on current commercial cargo schedules, that one

or two commercial cargo flights will be flown in 2012. These flights will be in addition to the demonstration flights which will carry some cargo.

- NASA ordered 12 CRS flights valued at $1.59B from SpaceX. The first SpaceX CRS flight is scheduled for Summer 2012, though this timeframe may be affected by the timing of the COTS demonstration flight milestones. There are five missions currently in the processing flow, and both cargo and external hardware manufacturing and integration activities are underway. There are two missions planned in FY 2013 and then three CRS missions each fiscal year beyond that through FY 2016.

- NASA ordered 8 CRS flights valued at $1.88B from Orbital. The first Orbital CRS flight is scheduled for December of 2012, though this may also be affected by the timing of the COTS demonstration flight milestones. There are four missions currently in the processing flow, and cargo integration activities and detailed planning have begun. The company is slated to fly two CRS missions each fiscal year from FY 2013 through FY 2016.

NASA is pleased with the steady progress both companies continue to make in their cargo vehicle and launch systems development efforts. NASA anticipated that our commercial cargo partners would experience inevitable start-up challenges associated with these technologically ambitious endeavors. Both the Agency and these partners have spent many years preparing for the full utilization phase of ISS. We are beginning to see the fruits of this planning and development this year.

NASA will also rely on commercial providers for crew transportation and rescue services. The Commercial Crew Program (CCP) is a partnership between the Agency and the private sector to incentivize companies to build and operate safe, reliable, and cost-effective commercial human space transportation systems. In the near term, NASA plans to be a partner with U.S. industry, providing technical and financial assistance during the development phase. In the longer term, the Agency plans to be a customer for these services, buying transportation services for U.S. and U.S.-designated astronauts to the ISS. NASA hopes these activities will stimulate the development of a new industry that will be available to all potential customers, including the U.S. Government.

In the early lifecycle stage of the CCP, referred to as Commercial Crew Development (CCDev), the activity was focused on stimulating industry efforts to successfully mature subsystems and elements of commercial crew spaceflight concepts, technologies, and capabilities. Subsequently, NASA continued this effort with CCDev Round 2 to address crew transportation system concepts to mature the design and development of elements of the system, such as launch vehicles or spacecraft. CCDev Round 2 is ongoing now, with four funded and three unfunded industry partners. Each partner is making good progress in meeting their milestones and these projects should be concluded later this year.

The next stage of the acquisition lifecycle will be a series of competitively awarded agreements with the intent of having multiple partners progress their integrated design and development efforts. This effort is referred to as Commercial Crew Integrated Capability (CCiCAP) and the specific content, scope, and duration of CCiCAP was communicated in an announcement for proposals, released on February 7, 2012. The announcement asks industry to propose a 21-month base period that will run from award through May, 2014. This base period will include completing major design efforts for an integrated transportation system, and also major risk reduction demonstrations and tests such as uncrewed flight tests, abort tests, and landing tests.

The announcement also calls for industry to propose optional milestones beyond the base period to achieve a crewed orbital demonstration flight. Goals for such a demonstration flight include achieving at least three days on-orbit with a system that could accommodate at least four crew members. NASA will

decide in the future whether to execute and fund any of the proposed optional milestones, and the decisions will be based on a number of factors including available budget and the partners' progress under the base period.

Successful commercial human space flight demands the highest commitment to safety. Therefore, in addition to the technical goals, the announcement specifies an overarching goal to ensure the safety of all hazardous activities involving humans. NASA is encouraging industry to propose risk reduction and safety processes such as strong inline checks and balances, healthy tension between responsible organizations, and value-added independent assessments.

Following the CCiCAP phase will be a "certification" phase, during which NASA will evaluate the technical progress of the commercial partners and accommodate changes if necessary to ensure compliance with Agency requirements. And finally, NASA plans to competitively award services contracts to obtain longer term crew transportation and emergency rescue services for the ISS.

NASA's acquisition strategy balances commercial partner design and schedule flexibility with government insight and oversight responsibilities throughout all program phases. Furthermore, it accommodates maturation of the commercial partner designs and vehicle programs at varying rates. Based on the availability of funding and industry performance, this strategy allows for adjustments in program scope, and enables a domestic capability to transport crewmembers to the ISS likely by 2017, based on a commercial partner's capability readiness to achieve NASA certification.

Growth in ISS Utilization

Completion of the ISS assembly and spares pre-positioning phase is now allowing the Program to focus directly on increasing the utilization of ISS laboratories, testbeds and observatory sites. Through the conclusion of ISS Expedition 28 in October 2011, approximately 1,250 research investigations were performed that involved 1,309 principal investigators (PIs) from 63 countries around the world. Of these, U.S. PIs under NASA sponsorship conducted 475 investigations (38 percent of the total). Expeditions 29 to 32, which cover the period from October 2011 – September 2012, will include 259 total investigations. In other words, approximately 20 percent as many investigations were performed in these two post-assembly Expeditions as had been achieved in the prior 28 Expeditions combined.

An impressive range of scientific research, technology demonstrations and educational outreach is underway. Recent highlights include:

- The Monitor of All-sky X-ray Image (MAXI) instrument, a highly sensitive X-ray slit camera externally-mounted for monitoring more than 1,000 X-ray sources in space, including black holes and neutron stars, made the first observation, along with the Swift spacecraft, of a relativistic x-ray burst from a super-massive black hole destroying a star and creating a jet of x-rays. The research teams co-published their results in *Nature*, 476: 421-424 August 2011.

- The Alpha Magnetic Spectrometer (AMS) cosmic-ray particle physics experiment was installed and began science operations on May 19, 2011. AMS has recorded to date the passage of over 13 billion cosmic ray particle events originating from elsewhere in our Milky Way galaxy. The U.S. Department-of-Energy-sponsored collaboration across the U.S., Europe, and Asia is actively analyzing these cosmic-ray particle data for potential new physics and astronomy discoveries. The AMS Payload Operations Control Center is located at the CERN, Switzerland, which conveniently allows coordination with the ground-based Large Hadron Collider high-energy particle accelerator research activity.

- Flame tests conducted by Principal Investigator Marshall B. Long, Ph.D. of Yale University in Connecticut during the Structure and Liftoff In Combustion Experiment (SLICE) yielded stable lifted flames that can be simpler to numerically model. SLICE investigates the nature of flames under microgravity conditions and the results could lead to improvements in technologies that aim to reduce pollution emissions and improve burning efficiency for a wide variety of industries.

- The same technology that went into building the Canadarm2 and Dextre (the Canadian robots that assembled, service and maintain the ISS) were adapted to produce the world's first robot capable of performing brain surgery -- neuroArm™ -- on a patient while the patient undergoes magnetic resonance imaging. This technology has since been licensed to a private, publicly traded medical device manufacturer who will produce a two-armed version that allows surgeons to see three-dimensional images, "feel" tissue, and apply pressure during neurosurgical operations.

- The Robotic Refueling Mission (RRM) began operations March 7-9, 2012, marking an important milestone in satellite-servicing technology. RRM is designed to demonstrate technologies, tools, and techniques needed to robotically service and refuel satellites in orbit. During the gas fittings removal task, robot tele-operators at Johnson Space Center directed Dextre to retrieve tools and go through the tasks required to remove representative fittings located on the RRM module on board ISS. These fittings are used on many spacecraft for filling fluids and gases prior to launch. Future RRM operations will practice robotic satellite refueling and servicing.

- Robonaut 2 (R2) was launched to ISS on February 24, 2011. This dexterous humanoid robot was developed in partnership with General Motors. It is designed to duplicate the manipulation capabilities of a human so that it can handle tools and assist astronauts in performing tasks in space, or help workers build cars on the assembly line. Like Dextre, R2 will be tele-operated from the ground, and it will test a different way to grip and manipulate objects with its human-like, five-fingered hands.

- Literally thousands of two-minute video submissions were received in areas of physics or biology from more than 80 countries for the first YouTube Space Lab global contest sponsored by YouTube, Lenovo Computers, and Space Adventures, Inc. in cooperation with NASA, ESA, and JAXA. This educational project challenges 14-18-year-olds to design a science experiment that can be performed in space, and the top two experiments will be conducted on ISS.

- Fluid physics experiments conducted by Portland State University in Oregon have led to a greater understanding of capillary flow phenomena and subsequent production of open-source code for modeling the behavior of fluids in space.

- Research on self-ordering systems (published in *Nature*, 478: 225-228 October 13, 2011) demonstrates mechanisms relevant to self-replication in primitive chemical environments. Colloidal systems for studying the behavior of self-assembling materials for photonic technologies are being used by Proctor and Gamble to develop more stable, concentrated products.

- Space Act Agreements were signed with the Arizona State University Bio-Design Institute to conduct experiments initially focusing on the development of vaccines, and with Surface Optics Corporation of San Diego, California to demonstrate proof-of-concept for the use of hyper-spectral imaging in agricultural applications.

NASA utilizes the ISS for exploration research and technology demonstrations, supporting the fields of environmental control, human health and performance, robotics, extravehicular activity, and propulsion. The Agency is committed to maximizing the crew time devoted to research and technology demonstrations. In addition, NASA makes available ISS attached payload accommodations for use in Earth and space science investigations. For example, NASA plans to fly, install, and begin operation of the Stratospheric Aerosol and Gas Experiment (SAGE III) in 2014. NASA's solicitations for science instruments of opportunity include ISS as a candidate host platform when applicable.

A National Laboratory in Orbit

In the NASA Authorization Act of 2005 (P.L. 109-155), Congress designated the U.S. segment of the ISS as a National Laboratory, and directed the Agency to seek to increase the utilization of the ISS by other Federal entities and the private sector. NASA has made solid strides in its effort to engage other organizations in the ISS program. Subsequently, in the NASA Authorization Act of 2010 (P.L. 111-267), Congress directed that the Agency enter into a cooperative agreement with a not-for-profit organization to manage the activities of the ISS National Laboratory. To this end, NASA issued a cooperative agreement notice on February 14, 2011, and on August 31, 2011, the Agency finalized a cooperative agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the ISS that operates as a U.S. National Laboratory. CASIS is located in the Space Life Sciences Laboratory at Kennedy Space Center in Florida. The independent, nonprofit research management organization will help ensure the Station's unique capabilities are available to the broadest possible cross-section of U.S. scientific, technological and industrial communities. NASA, with the help of the Office of Science and Technology Policy, put out a request for candidates for the permanent board that will guide CASIS' efforts in this groundbreaking enterprise. NASA is working with CASIS' interim Board of Directors to identify and evaluate a diverse group of outstanding individuals for that board.

CASIS will develop and manage a varied R&D portfolio based on U.S. national needs for basic and applied research; establish a marketplace to facilitate matching research pathways with qualified funding sources; and stimulate interest in using the national lab for research and technology demonstrations and as a platform for science, technology, engineering and mathematics education. The goal is to support, promote and accelerate innovations and new discoveries in science, engineering and technology that will improve life on Earth.

NASA's National Laboratory partners can use the unique microgravity environment of space and the advanced research facilities aboard Station to enable investigations that may give them the edge in the global competition to develop valuable, high technology products and services. Furthermore, the demand for access to the ISS will support the providers of commercial crew and cargo systems. Both of these aspects of the U.S. segment of ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

ISS – Benefits to Humanity

Almost as soon as the ISS was habitable, researchers began using it to study the impact of microgravity and other space effects. In the physical and biological sciences arena, the ISS is using microgravity conditions to understand the effect of the microgravity environment on microbial systems, fluid physics, combustion science and materials processing, as well as environmental control and fire safety technologies. The ISS also provides a test-bed for studying, developing, and testing new technologies for use in future exploration missions. Although each space station partner has distinct agency goals for station research, each partner collectively shares a unified goal to extend the resulting knowledge for the

betterment of humanity. In the areas of human health, telemedicine, education and Earth observations from space, there are already demonstrated benefits. Vaccine development research, station-generated images that assist with disaster relief and farming, and education programs that inspire future scientists, engineers and space explorers highlight just some of the many examples of research that can benefit humanity.

ISS crews are conducting human medical research to develop knowledge in the areas of: clinical medicine, human physiology, cardiovascular research, bone and muscle health, neurovestibular medicine, diagnostic instruments and sensors, advanced ultrasound, exercise and pharmacological countermeasures, food and nutrition, immunology and infection, exercise systems, and human behavior and performance. Many investigations conducted aboard ISS will have direct application to terrestrial medicine. For example, the growing senior population may benefit from experiments in the areas of bone and muscle health, immunology, and from the development of advanced diagnostic systems.

The ISS also plays an important role in promoting education in the science, technology, engineering, and mathematics (STEM) fields, inspiring students to pursue scientific and technical careers. Astronauts aboard ISS participate in educational downlinks with schools, and engage in communicating with people around the world using "ham" radio. The Program also conducts experiments that involve student participation. One example is the Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) facility. SPHERES are three bowling-ball sized spherical satellites that are used inside the Station to test telerobotics operations in addition to spacecraft formation flight, autonomous rendezvous and docking maneuvers. NASA, along with the Defense Advanced Research Projects Agency with implementation by the Massachusetts Institute of Technology, have co-sponsored three "Zero Robotics SPHERES Challenge" competitions for high school and middle students from the U.S. and abroad. The competitions challenge students to write software code, which is uploaded to the robots on ISS, and the SPHERES satellites then execute the instructions, such as formation flight and close proximity operations. Student finalists were able to watch their flight program live on NASA-TV.

International Partnership Progress

The ISS Multilateral Coordination Board (MCB) and Heads-of-Agency (HOA) met in Quebec City, Canada, February 28 and March 1, 2012, to discuss future plans for the ISS, progress on utilization, and potential contributions to future human exploration missions. The International Partners reported progress on identifying potential technology demonstrations that could be conducted on the ISS. These demonstrations correlate closely with the recent report issued by the National Research Council, Aeronautics and Space Engineering Board on NASA Space Technologies and Priorities.

In addition, the MCB and HOA released two documents related to ISS utilization:

- *"ISS Utilization Statistics,"* Fall 2011 (inaugural issue), which documents the number and thematic areas of research being conducted by each partner.
- *"ISS Benefits for Humanity,"* which launches a new international web portal describing achievements of the ISS partnership in the areas of human health, Earth observation and disaster response, and education.

Copies of both documents are available at:

http://www.nasa.gov/mission_pages/station/research/index.html

Conclusion

We have many challenges and opportunities ahead as we continue to sustain and productively utilize the ISS. These include training the next generation of scientists, engineers, and technologists for greater challenges as human presence is extended further into the solar system. This mission pull drives us to develop innovative solutions that benefit humans on the Earth today. We have two extraordinary assets that have never before existed in the history of human space exploration – an experienced international partnership encompassing Canada, Europe, Japan, Russia, and the U.S., and a permanently crewed, full-service space station in low-Earth orbit. Our ability to continue working together as a global team, while making the best applied use of our assets, will pace the future progress of space exploration and expansion of benefits on Earth.

Great nations explore in order to advance. Throughout history, nations have progressed and benefited from exploration. Exploration drives technological breakthroughs and scientific discoveries that benefit society; without exploration, the cycle of innovation and advancement is broken. The ISS Partnership has transformed exploration from an effort for the advancement of individual nations, to an endeavor committed to the advancement of humankind.

The ISS has now entered its intensive research phase, and this phase will continue through at least 2020. Station will continue to meet NASA's mission objective to prepare for the next steps in human space exploration – steps which will take astronauts beyond LEO to destinations such as the asteroids, the Moon, and eventually, Mars. The ISS is NASA's only long-duration flight analog for future human deep space missions, and it provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep space missions. It is the only space-based multinational research and technology test-bed available to identify and quantify risks to human health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration.

Closer to home, NASA's National Laboratory partners can use the unique microgravity environment of space and the advanced research facilities aboard Station to enable investigations that may give them the edge in the global competition to develop valuable, high technology products and services. Furthermore, the demand for access to the ISS will support the providers of commercial crew and cargo systems. Both of these aspects of the U.S. segment of ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

NASA appreciates this Committee's ongoing support of the ISS as we work together to support this amazing facility that yields remarkable results and benefits for the world.

Mr. Chairman, I would be happy to respond to any question you or the other Members of the Committee may have.

Chairman HALL. I thank you.

I now recognize Mrs. Chaplain of the GAO to present her testimony.

STATEMENT OF MRS. CRISTINA CHAPLAIN, DIRECTOR, ACQUISITION AND SOURCING MANAGEMENT, U.S. GOVERNMENT ACCOUNTABILITY OFFICE

Ms. CHAPLAIN. Mr. Chairman, Ranking Member Johnson and Members of the Committee, thank you for inviting us to talk about the International Space Station and the challenges associated with maximizing its very unique capabilities.

Our work touches on a range of challenges facing the space station, and I will go over the major categories of those challenges and what we have said in recent years.

The first area is whether ISS can safely operate for years to come. As you know, we recently reported that NASA is doing a very credible job in assessing the structural health and safety of the International Space Station, and that this is no easy task, given the uniqueness of the station and the limitations to making these assessments. They are still in the process of conducting structural assessments, however, and there may be issues that get pointed out in these assessments in the next few years that need mitigation that could affect things like cargo flights in the future.

The second area we have looked at in recent years is the utilization of the station after its construction. When we did so, we compared the ISS to some national labs. We knew there was no direct analog to the ISS, but we looked to see what comparisons were relevant to how the space station and its research was managed. We recommended that there be a central management organization established to represent users of the ISS, oversee selections of research, conduct peer reviews, and ensure research is not duplicative. Other labs have used such an approach, and the National Research Council had recommended something similar. NASA is in the early stages of implementing this recommendation, and its effectiveness remains to be seen.

The third area we have looked at in recent years is the development of commercial vehicles under both the COTS program and now the crew program. For COTS, we found that NASA had established reasonable controls for their Space Act agreements and they tailored them when appropriate. For the crew acquisition strategy, we recommended that NASA rethink its strategy in light of receiving about half the funding requested. NASA has restructured its strategy. We have not evaluated that revised effort. But throughout all this work and following the commercial crew development and commercial cargo development, we have recognized that these efforts are inherently risky, and in the latest report we did stress optimistic schedules in the commercial crew providers.

Because of this, we have always emphasized the importance of followed discipline practices and knowledge-based practices for these efforts. These include things like not moving programs forward with a lot of unknown about costs, requirements, and technology. As the commercial efforts are entering their most difficult

phases of development, it is more important that these practices be adhered to.

That concludes my statement. I will be happy to answer any questions you have.

[The prepared statement of Ms. Chaplain follows:]

United States Government Accountability Office

GAO

Testimony

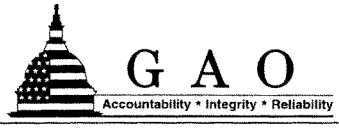
Before the Committee on Science, Space, and Technology, House of Representatives

For Release on Delivery
Expected at 9:30 a.m. EDT
Wednesday, March 28, 2012

NASA

Significant Challenges Remain for Access, Use, and Sustainment of the International Space Station

Statement of Cristina T. Chaplain, Director
Acquisition and Sourcing Management



March 28, 2012

GAO
Accountability * Integrity * Reliability
Highlights

Highlights of GAO-12-587T, a testimony before the Committee on Science, Space, and Technology, House of Representatives

NASA

Significant Challenges Remain for Access, Use, and Sustainment of the International Space Station

Why GAO Did This Study

Construction of the International Space Station (ISS) required dedication and effort on the part of many nations to be successful. Further, the funding necessary to accomplish this task was significant, with the United States alone directly investing nearly $50 billion in its development. As construction of the on-orbit laboratory is complete, now is the time for the United States and its partners to make use of this investment and recently, Congress took steps to extend the life of the ISS until at least 2020.

GAO has cautioned for years that NASA should ensure it has a capability to access and utilize the space station following retirement of the space shuttle in 2011. We have highlighted the challenges associated with transporting cargo and crew to and from the ISS, as well as the difficulties NASA faces in ensuring the ISS supports its purpose of scientific research and in safely operating the station. Some risks have been realized. For example, commercial vehicles are significantly behind schedule—with the first launch to the space station planned for 2012.

GAO's statement today will focus on the progress NASA has made and the challenges the agency faces in accessing, ensuring full utilization of, and sustaining the ISS. To prepare this statement, GAO relied on prior relevant work on the ISS and NASA's commercial cargo and crew efforts and conducted a limited amount of additional work to update planned flight information.

View GAO-12-587T. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

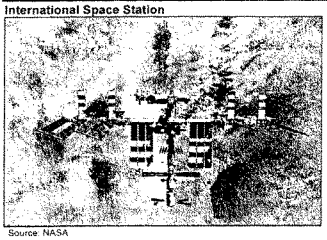
What GAO Found

NASA plans to use international partner and new domestic commercial launch vehicles to access, utilize, and sustain the International Space Station from 2012 through 2020. However, the agency faces challenges in transporting cargo and crew to the ISS as well as ensuring the station is fully utilized. NASA's decision to rely on the new commercial vehicles to transport cargo starting in 2012 and to transport crew starting in 2017 is inherently risky because the vehicles are not yet proven and are experiencing delays in development. Further, NASA does not have agreements in place for international partners to provide cargo services to the ISS beyond 2016. The agency will also face a decision regarding the need to purchase additional seats on the Russian Soyuz vehicle beyond 2016, likely before commercial vehicles have made significant progress in development, given the three-year lead time necessary for acquiring a seat. This decision is further complicated because restrictions prohibit NASA from making certain payments to Russia in connection with the ISS unless the President makes a determination. Further, NASA currently expects to transport all cargo needed by the ISS in 51 flights through 2020, but if international partner agreements and commercial service contracts do not materialize as the agency plans for the years beyond 2016, the situation could lead to a potential cargo shortfall.

If NASA can access the station, it will next be challenged with fully utilizing the ISS national laboratory for its intended purpose—scientific research. To take steps to meet this challenge and consistent with a 2009 GAO recommendation, in 2011 NASA selected an organization to centrally oversee ISS national laboratory research decision-making. It is too soon, however, to determine whether this organization is ensuring full scientific utilization of the ISS. Regardless of the efforts of the management body, as GAO noted in a 2009 report, constraints on crew time for conducting science could also impact full utilization.

If NASA can overcome its challenges related to accessing the station, it has reasonable approaches in place for estimating spare parts and assessing the structural health of the space station. These approaches provide NASA with increased assurance that the agency will have sufficient spares and will put mitigations in place to effectively and safely utilize the space station.

International Space Station



Source: NASA

Chairman Hall, Ranking Member Johnson, and Members of the Committee:

Thank you for inviting me here today to discuss utilization of the International Space Station (ISS). The construction of the ISS is a significant technical achievement. In essence, the National Aeronautics and Space Administration (NASA) and its international partners have assembled and constructed a skyscraper-sized laboratory in low-earth orbit. This achievement involved dedication and effort on the part of all participating nations and individuals. With construction completed and a full crew of six astronauts on-board, the ISS stands poised to deliver scientific breakthroughs enabled by its unique capabilities. The potential of the ISS program to deliver on the promise of scientific discovery, however, is inextricably linked to NASA's ability to safely access, sustain, and fully utilize the laboratory in orbit.

Now that ISS construction is finished, NASA and the ISS program face three major challenges, which will be the focus of my testimony. First and foremost, NASA must be able to transport cargo and crew to and from the ISS. Second, NASA must ensure that the management of the ISS national laboratory results in effective utilization of the station for its primary purpose—scientific research. Finally, NASA must ensure that replaceable spares are available and that the ISS is structurally sound and can safely continue operations.

We have been reporting on the difficulties associated with sustaining the ISS in the post-space shuttle era since May 2005 when we first recommended that NASA take actions to determine the best available options for supporting the station after shuttle retirement.[1] In July 2006, we expressed our initial concerns regarding NASA's acquisition strategy for the shuttle's replacement, the human spaceflight system known as Constellation, because of lack of a sound business case based on resources that are matched to requirements, a stable design, and well-defined cost estimates.[2] Since 2008, we have cautioned that the use of international launch vehicles is only a back-up and a less-capable means

[1] GAO, *NASA: More Knowledge Needed to Determine Best Alternatives to Provide Space Station Logistics Support*, GAO-05-488 (Washington, D.C.: May 18, 2005).

[2] GAO, *NASA: Long-Term Commitment to and Investment in Space Exploration Program Requires More Knowledge*, GAO-06-817R (Washington D.C.: July 17, 2006).

of supporting the station, as well as raised concerns about the ambitious schedules for the vehicles being developed under NASA's Commercial Crew and Cargo Program.[3] In a November 2009 report, we iterated our concerns that limited international partner vehicle capacity and potential delays in planned commercial vehicle development could impede efforts to maximize utilization of all ISS research facilities.[4] In 2011 reports and testimony, we observed that commercial cargo launch development remained behind schedule and, even when coupled with international partner launch capacity, may not cover all of the ISS anticipated needs beginning in 2014.[5] Further, we reported that the funding provided for NASA's commercial crew efforts was significantly less than expected, as other priorities such as the Space Launch System received increased funding.

In preparing this statement, we relied on our prior reports and testimonies, including those related to NASA's management of commercial launch vehicle development, the agency's acquisition approach for commercial crew transportation, and ISS sustainment and utilization.[6] We also conducted a limited amount of additional audit work in March 2012 to update information on planned commercial cargo and international partner flights. Our prior work in these areas, as well as the work conducted to support this statement, was performed in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient and appropriate evidence to provide a reasonable basis for our findings and

[3] GAO, *NASA: Challenges in Completing and Sustaining the International Space Station*, GAO-08-581T (Washington, D.C.: Apr. 24, 2008) and *NASA: Commercial Partners Are Making Progress, but Face Aggressive Schedules to Demonstrate Critical Space Station Cargo Transport Capabilities*, GAO-09-618 (Washington, D.C.: June 16, 2009).

[4] GAO, *International Space Station: Significant Challenges May Limit Onboard Research*, GAO-10-9, (Washington D.C.: Nov. 25, 2009).

[5] GAO, *Commercial Launch Vehicles: NASA Taking Measures to Manage Delays and Risks*, GAO-11-692T, (Washington, D.C.: May 26, 2011); *International Space Station: Approaches for Ensuring Utilization through 2020 Are Reasonable but Should Be Revisited as NASA Gains More Knowledge of On-Orbit Performance*, GAO-12-162, (Washington, D.C.: Dec. 15, 2011); and *National Aeronautics and Space Administration: Acquisition Approach for Commercial Crew Transportation Includes Good Practices, but Faces Significant Challenges*, GAO-12-282, (Washington, D.C.: Dec. 15, 2011).

[6] GAO-05-488; GAO-06-817R; GAO-08-581T; GAO-09-618; GAO-10-9; GAO-11-692T, GAO-12-162; and GAO-12-282.

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.

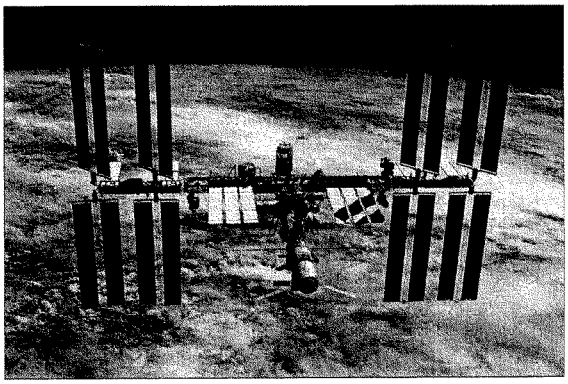
Background

The ISS program began in 1993 with several partner countries: Canada, the 11 member nations of the European Space Agency, Japan, and Russia. From 1994 through 2010, NASA estimates that it directly invested over $48 billion in development and construction of the on-orbit scientific laboratory, the ISS. NASA intended ISS assembly to be complete much sooner than it was. For example, in 1995, NASA expected to ISS assembly to be finished by June 2002, whereas the agency actually completed assembly in 2010. With ISS expected to be in use only through 2015, this slower pace shortened the amount of time NASA had available to take advantage of the significant monetary investment and to fully utilize the station. As a result, the NASA Authorization Act of 2010 required the NASA Administrator to take all actions necessary to ensure the safe and effective operation of the ISS through at least September 30, 2020. [7]

The ISS is the largest orbiting man-made object. (See fig. 1) It is composed of about 1 million pounds of hardware, brought to orbit over the course of a decade. The ISS includes (1) primary structures, that is, the external trusses which serve as the backbone of the station and the pressurized modules that are occupied by the ISS crew, and (2) functional systems made up of replaceable units, that is, systems that provide basic functionality such as life support and electrical power that are made of modular components that are replaceable by astronauts on orbit.

[7] National Aeronautics and Space Administration Authorization Act of 2010, Pub. L. No. 111-267 § 503.

Figure 1: International Space Station



Source: NASA.

The ISS was constructed to support three activities: scientific research, technology development, and development of industrial applications. The facilities aboard the ISS allow for ongoing research in microgravity, studies of other aspects of the space environment, tests of new technology, and long-term space operations. The facilities also enable a permanent crew of up to six astronauts to maintain their physical health standards while conducting many different types of research, including experiments in biotechnology, combustion science, fluid physics, and materials science, on behalf of ground-based researchers. Furthermore, the ISS has the capability to support research on materials and other technologies to see how they react in the space environment.

NASA planned for the space shuttle to serve as the means of transporting crew, hardware, and supplies to the ISS through the end of the station's life. However, in 2004, President George W. Bush announced his Vision for Space Exploration (Vision) that included direction for NASA to develop new spaceflight systems under the Constellation program to replace the space shuttle as NASA's primary spaceflight system. The Vision also included provisions for NASA to pursue commercial alternatives or

providing transportation and other services to support the ISS after 2010.[8] NASA established the Commercial Crew and Cargo Program in 2005 to facilitate the private demonstration of safe, reliable, and cost-effective transportation services and purchase these services commercially. When the Constellation program was cancelled in 2010, the commercial vehicles became NASA's primary focus for providing cargo and crew transportation to the ISS. The success of commercial efforts became even more important in 2010 when Congress authorized the extension of space station operations until at least 2020 from 2015, and the President directed that NASA transition the role of human transportation to low-earth orbit to commercial space companies.

NASA Faces Challenges Transporting Cargo and Crew to and from the ISS

The greatest challenge facing NASA is transporting cargo and crew to and from the ISS to make effective use of the ISS. NASA plans to rely on ISS international partner and new commercial launch vehicles to transport cargo and crew to and from the ISS until at least 2020. NASA hopes to begin using new commercial cargo vehicles in 2012 and crew vehicles to transport astronauts to and from the ISS beginning in 2017. NASA's decision to rely on the new commercial vehicles is inherently risky because the vehicles are still in development and not yet proven or fully operational.

NASA Plans to Use International Partner and Commercial Flights but International Agreements Are Not in Place and Commercial Vehicles Remain Unproven

NASA is relying on 51 flights of international partner and commercial vehicles to transport cargo to the ISS from 2012 through 2020, but agreements for international flights after 2016 are not in place and the commercial vehicles are unproven. NASA has agreements in place with the European and Japanese space consortiums for their respective vehicles—the European Automated Transfer Vehicle (ATV), and the Japanese H-II Transfer Vehicle (HTV)—to conduct cargo resupply missions beginning in 2012 through 2016. The ATV and HTV are unmanned vehicles that have flown to the ISS, and carry such items as

[8] In 2004, President George W. Bush established a new space exploration policy—*A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration* (Vision)—which called for the retirement of the space shuttle and development of a new family of exploration systems to facilitate a return of humans to the moon and eventual human spaceflight to Mars.

hardware and water.[9] NASA's current plans anticipate employing a total of 12 international partner launches—8 from 2012 to 2016 and 4 from 2017 through 2020. NASA does not have agreements in place for international partners to provide cargo services to the ISS beyond 2016. NASA plans to use the ATV for a number of cargo flights through 2014, but no longer anticipates its use after that time. NASA plans to use HTV for a number of cargo flights through 2016, but its negotiations with the Japanese partners for flights beyond 2016 are in their infancy.

NASA also plans to use two types of domestic commercial launch vehicles to maintain ISS from 2012 through 2020. Development of these vehicles—the Falcon 9 and Antares[10]—was fostered under a NASA-initiated effort known as Commercial Orbital Transportation Services. These vehicles are being developed by private industry corporations—Falcon 9 by SpaceX and Antares by Orbital Sciences Corporation. In late 2008, NASA awarded contracts to both companies to provide cargo transport services to the ISS. Only SpaceX will be able to safely return significant amounts of cargo to earth, such as the results of scientific experiments. NASA anticipates that SpaceX will begin providing that capability in 2012.

Commercial vehicles are essential to sustaining and utilizing the ISS. As table 1 indicates, SpaceX and Orbital are scheduled to fly 20 (71 percent) of the 28 launches NASA plans through 2016 and follow-on commercial resupply vehicles are expected to fly 19 (83 percent) of the 23 launches from 2017 through 2020.[11]

[9] In 2008 and 2009, the ATV and HTV vehicles respectively flew to the ISS and docked at the station to demonstrate their capabilities. In 2011, both vehicles again launched. These flights were the second for both systems.

[10] The Antares was previously known as the Taurus II.

[11] NASA has awarded contacts to SpaceX and Orbital for cargo resupply services to the ISS through 2016. Planned follow-on commercial resupply vehicles are the vehicles NASA will use for flights beyond those currently under contract.

Table 1: NASA's Planned Vehicle Launches for 2012 to 2020 to Resupply the ISS as of March 2012

	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Vehicles										
ATV	1	1	1							3
HTV	1	1	1	1	1	1	1	1	1	9
SpaceX	2	2	2	3	3					12
Orbital	1	2	1	2	2					8
Follow-on commercial resupply						5	5	5	4	19
Total	**5**	**6**	**5**	**6**	**6**	**6**	**6**	**6**	**5**	**51**

Source: GAO analysis of NASA data.

Note: NASA does not have contracts with commercial providers or negotiated agreements with international partners for flights from 2017 through 2020.

This plan relies on commercial vehicles meeting anticipated—not proven—flight rates. As we have previously reported, both SpaceX and Orbital are working under aggressive schedules and have experienced delays in completing demonstrations.[12] SpaceX flew its first demonstration mission in December 2010, some 18 months late, because of such factors as design issues and software development. Currently, SpaceX's next demonstration launch to the ISS has been delayed from November 2011 to late April 2012 because of additional testing and resolution of some technical issues such as electromagnetic interference. Likewise, Orbital experienced programmatic changes and developmental difficulties that led to multiple delays of several months' duration. In May 2011 testimony,[13] we noted that Orbital's inaugural demonstration mission had been delayed to December 2011. Currently, this flight has been delayed further to August or September 2012, primarily because of issues related to construction and testing of the launch pad at Wallops Island, Virginia. NASA has made efforts to accommodate delays in commercial vehicle development, including use of the final shuttle flight in July 2011 to pre-position additional ISS spares. However, if the commercial vehicle launches do not occur as planned in 2012, the ISS could lose some ability to function and sustain research efforts due to a lack of alternative launch vehicles to support the ISS and return scientific experiments back to earth.

[12] GAO-09-618.

[13] GAO-11-692T.

If the international partner agreements and commercial service provider contracts do not materialize as NASA plans for the years beyond 2016, this could lead to a potential cargo shortfall. As we reported in 2011,[14] NASA's strategic planning manifests showed that, when anticipated growth in national laboratory demands and margin for unforeseen maintenance needs are accounted for, the 56 flights NASA was planning for at the time of our review might not cover all of NASA's anticipated needs. These shortfalls amounted to a total of 2.3 metric tons—approximately the cargo that one SpaceX commercial vehicle will be able to transport to the ISS. As of March 2012, NASA has cut its planned number of flights from 2012 through 2020 from the 56 flights we reported to 51 flights. However, its current ongoing analysis is no longer projecting a cargo shortfall even with the decreased number of flights. According to an ISS program official, cargo estimates, particularly beyond 2013, are for planning purposes and could change as they are updated frequently based on launch vehicle availability and the ISS's need for spares.

NASA Lacks a Domestic Ability to Transport Crew to the ISS until at Least 2017

NASA faces two major challenges in transporting crew to the ISS—adjusting its acquisition strategy for crew vehicles to match available funding and deciding if and when to purchase crew seats on the Russian Soyuz in case domestic commercial crew vehicles are not available as planned in 2017. In 2010, President Obama directed NASA to transition the role of transporting humans to low-Earth orbit to commercial space companies. Consequently, in 2010 and 2011 NASA entered into funded and unfunded Space Act agreements[15] with several companies to develop and test key technologies and subsystems to further commercial

[14] GAO-12-262.

[15] Space Act agreements are transactions other than contracts, leases, and cooperative agreements. Congress granted NASA the authority to enter into these types of transactions in the National Aeronautics and Space Act of 1958 to give the agency greater flexibility in achieving its mission. Pub. L. No. 85-568, § 203(b)(5). Under a funded Space Act agreement, appropriated funds are transferred to a domestic partner, such as a private company or a university, to accomplish an agency mission. These agreements differ from Federal Acquisition Regulation (FAR) contracts in that they do not include requirements that generally apply to government contracts entered into under the authority of the FAR. Unfunded agreements accomplish the same goals but no appropriated funds are transferred. Under such agreements, the company can benefit from NASA's experience, guidance, and advice and NASA can gain insight into the company's system. For more information see GAO, *Key Controls NASA Employs to Guide Use and Management of Funded Space Act Agreements Are Generally Sufficient, but Some Could Be Strengthened and Clarified*, GAO-12-230R (Washington, D.C.: Nov. 17, 2011).

development of crew transportation services. NASA's intent was to encourage private sector innovation and to procure safe, reliable transportation services to the space station at a reasonable price. Under this acquisition approach, NASA plans to procure seats for crew transportation to the ISS from the private sector through at least 2020.

In 2011, we reviewed NASA's plans for contracting for additional commercial crew development efforts and found that the agency's approach employed several good acquisition practices including competitive contracting that—if implemented effectively—limit the government's risk. As we also noted in that report, NASA's funding level for fiscal year 2012 is almost 50 percent less than it anticipated when it developed its approach for procuring commercial crew services. Given this funding level, NASA indicated it could not award contracts to multiple providers, which weakened prospects for competition in subsequent phases of the program.[16] The main premise of its procurement approach to control costs—full and open competition for future phases of the program—therefore was likely no longer viable. Without competition, NASA could become dependent on one contractor for developing and providing launch services to the space station. Reliance on a sole source for any product or service increases the risk that the government will pay more than expected, since no competitors exist to help control market prices. As a result of this funding decrease, NASA adjusted its acquisition strategy. The agency now plans to enter into another round of Space Act agreements to further the development of commercial crew vehicles and has delayed the projected purchase of commercial crew transportation until 2017.

Additionally, the agency faces another looming challenge—a decision about if and when to purchase crew space on the Russian Soyuz vehicle. NASA will likely need to decide by the end of 2013 whether to purchase additional seats that might be needed beyond 2016 because the lead time for acquiring additional seats on the Soyuz is 3 years. However, in the 2013 time frame, NASA cannot be fully confident that domestic crew efforts will succeed because the vehicles will not yet have entered the test and integration phase of development. Furthermore, the decision to

[16] We reported in GAO-12-282 that, although private investment was anticipated from the commercial companies, without government investment, the commercial market for launch vehicles alone may not continue to grow and provide more than one contractor that would be able to compete for subsequent phases.

purchase crew seats on the Russian Soyuz is complicated by restrictions found in the Iran, North Korea, and Syria Nonproliferation Act.[17] These restrictions prohibit NASA from making certain payments to Russia in connection with the ISS unless the President makes a determination. NASA currently has a statutory exemption from this restriction that allows certain types of payments, but that exemption expires in 2016. According to NASA officials, the agency has begun working toward resolution of this problem, but the issue is not yet resolved.

NASA Faces Challenges Maximizing ISS Research Utilization

NASA's greatest challenge to utilizing the ISS for its intended purpose—scientific research—is inextricably linked with the agency's ability to carry scientific experiments and payloads to and from the ISS. International partner vehicles have much less cargo capacity than the space shuttle did to carry supplies to the ISS and no ability to return research payloads back to earth. The Russian Soyuz vehicle has some ability to transport research payloads back to earth, but the capability is minimal at only 132 pounds. As mentioned previously, SpaceX, however, will provide NASA with the capability to transport research payloads back to earth. Consequently, if the new commercial launch vehicles are not available as planned, the impact on ISS utilization could be dramatic. In the past, NASA officials have told us that the impact of failures or significant delays in developing the commercial cargo capability would be similar to the post-Columbia shuttle disaster scenario,[18] where NASA operated the ISS in a "survival mode" and moved to a two-person crew, paused assembly activities, and operated the ISS at a lower altitude to relieve propellant burden. NASA officials stated that if the commercial cargo vehicles are delayed, they would pursue a course of "graceful degradation" of the ISS until conditions improve. In such conditions, the ISS would only conduct minimal science experiments.

Nonetheless, NASA expects scientific utilization to increase since construction of the ISS is complete. The ISS has been continuously staffed since 2000 and now has a six-member crew. The primary objective for the ISS through 2011 was construction, so research utilization was not the priority. Some research was conducted as time and

[17] Pub. L. No. 106-178 (2000) (as amended), *codified at* 50 U.S.C. §1701 (note).

[18] This refers to the 2003 loss of the Space Shuttle Columbia, which resulted in NASA suspending shuttle flights until 2005 while investigations were under way.

resources permitted while the crew on board performed assembly tasks. NASA projects that it will utilize approximately 50 percent of the U.S. ISS research facilities for its own research. As we reported in 2009, however, NASA's scientific utilization of the ISS is constrained by limited crew time. Limiting factors include the size of the crew on board the station; the necessary division of crew work among many activities that include maintenance, operations, and research; and the need to share research facilities with international partners.

Per statutory direction, NASA has opened the remaining facilities to other federal government entities and private industry and is operating the ISS as a national laboratory. As we reported in 2009, NASA may face challenges in the management and operation of ISS National Laboratory research.[19] There is currently no direct analogue to the ISS National Laboratory, and though NASA currently manages research programs at the Jet Propulsion Laboratory and its other centers that it believes possess similar characteristics to other national laboratories, NASA has limited experience managing the type of diverse scientific research and technology demonstration portfolio that the ISS could eventually represent.

To manage ISS National Laboratory research, as we recommended in 2009,[20] NASA selected a body in 2011 to centrally oversee ISS research decision-making. This body, the Center for the Advancement of Science in Space (CASIS), is charged with developing and managing a varied research and development portfolio based on U.S. national needs for basic and applied research; establishing a marketplace to facilitate matching research pathways with qualified funding sources; and stimulating interest in using the national lab for research and technology demonstrations and as a platform for science, technology, engineering, and mathematics education. CASIS has begun outreach efforts and has issued a Request for Information due back in March 2012 that seeks to identify and gather information from entities capable of serving as implementation partners. CASIS plans to develop an internal database from the information collected via this Request for Information, which will enable identification of entities that can support payload development needs according to their requisite areas of expertise. CASIS will refer to

[19] GAO-10-9.

[20] GAO-10-9.

this database when issuing solicitations for funded opportunities to support research payload activities. Since the establishment of CASIS as the management body of ISS research is relatively recent, we have not examined its effectiveness; therefore, it is too early for us to say whether it will be successful in ensuring full scientific utilization of the station as a national laboratory.

NASA Has a Reasonable Approach to Meeting the Challenge of Estimating ISS Spares and Assessing Structural Health and Safety

We recently reported[21] that NASA has an appropriate and reasonable approach in place to determine the spares needed for the ISS as well as to assess ISS structural health and safety. Estimating ISS spares and gauging the structural health and safety of the ISS are not simple challenges. Among the many factors to be assessed are the reliability of key components, NASA's ability to deliver spares to the ISS, the projected life of structures that cannot be replaced, and in-depth analysis of those components and systems that affect safety. While some empirical data exist, because the ISS is a unique facility in space, assessing its extended life necessarily requires the use of sophisticated analytical techniques and judgments.

NASA's approach to determining necessary spare parts for the ISS relies on a statistical process. The statistical process and methodology being used to determine the expected lifetimes of replacement units is a sound and commonly accepted approach within the risk assessment community that considers both manufacturers' predictions and the systems' actual performance. NASA also has a reasonable process for establishing performance goals for various functions necessary for utilization and determining through modeling whether available spares are sufficient to meet goals through 2020, but the rationale for establishing performance goals has not been systematically documented.

NASA is also using reasonable analytical tools to assess structural health and determine whether ISS hardware can operate safely through 2020. NASA currently anticipates that—with some mitigation—the ISS will remain structurally sound for continued operations through 2020. NASA also is using reasonable methodologies to identify replacement units and other hardware that could cause serious damage to the ISS if they were to fail. Through 2015, NASA plans to develop methods to mitigate issues

[21] GAO-12-162.

identified and expects to begin implementing corrective actions as plans are put in place.

Concluding Observations

In summary, although NASA has done a credible job of ensuring that the ISS can last for years to come, the question that remains is whether NASA will be able to service the station and productively use it for science. Routine launch support is essential to both, but the road ahead depends on successfully overcoming several complex challenges, such as technical success, funding, international agreements, and management and oversight of the national laboratory. Finally, if any of these challenges cannot be overcome, it will be contingent upon NASA to ensure that all alternatives are explored—in a timely manner—to make full use of the nation's significant investment in ISS.

Chairman Hall, Ranking Member Johnson, and Members of the Committee, this concludes my prepared statement. I would be pleased to respond to any questions that you may have at this time.

Chairman HALL. I thank you very much. Both were under five minutes. That is unusual, disciplined.

General, I recognize you, sir. Turn your mic on, General, not that I could order a General around. A JG in the Navy wouldn't have much to say in your presence, sir.

STATEMENT OF LIEUTENANT GENERAL THOMAS P. STAFFORD, CHAIRMAN, NASA ADVISORY COUNCIL ISS OPERATIONAL READINESS TASK FORCE

Lieutenant General STAFFORD. Thank you, Mr. Chairman, Ranking Member Johnson and distinguished Members of the Committee, it is a pleasure to be here and testify before you and express my views and concerns of my committee. I will answer the questions provided in your letter of invitation, Mr. Chairman, from the standpoint of expertise as a former astronaut, former Deputy Chief of Staff for Research, Development and Acquisition, and serving in many committees and chairman of those committees, both for the DOD and NASA, over a period of years. I have submitted a written statement for the record, and so in the essence of time, I will go right away to the questions.

Question number one: Are NASA's current plans adequate to ensure that requirements for the ISS maintenance, growth and crew supplies and expendables, B, NASA's scientific research utilization, National Laboratory growth and utilization and other contingency maintenance, can they be met through the year 2020?

In response to your first question, for the near term, NASA's current plans are adequate to ensure that requirements for the ISS maintenance, growth, crew supply and expendables and the scientific research and the national lab utilization, contingency maintenance can be met for the immediate future for one to two years. This is in large part thanks to the supply of STS–134 and 135, and I want to acknowledge Mr. Gerstenmaier's leadership in pushing to have those last two shuttle missions launch and provide those supplies. Without those two shuttle missions, right now we would be in a serious situation and probably be considering how we would de-crew the space station to a certain number of people. So, Mr. Gerstenmaier, the country owes you a lot of thanks for that, sir.

Beyond this time frame, say, beyond the mid-part of 2013, NASA becomes increasingly dependent on its projected flow of resupply needs and on the planned fleet of cargo vehicles which includes the ATV, the HTV, the Progress and the commercial resupply services.

In joint assessment with the Aerospace Safety Advisory Panel headed by Admiral Joe Dyer, my ISS Advisory Committee concluded that the commercial vehicle launch schedule was overly optimistic, and we have not received sufficient data to conclude with confidence that the schedule could be met. This was the unanimous conclusion of both groups. Both commercial contractors, Orbital Science Corporation and Space Exploration Corporation, continue to experience significant delays in their development, testing, and their launch dates.

With the present schedule beyond 2016, ISS resupply is almost totally dependent upon the CRS vehicles. However, I did notice

that there were now proposed some HTV flights out there, which will help. And recently NASA has updated and revised the launch manifest, making the schedule more realistic, but this still may have some potential optimistic assumptions. The real-time updates of the use of consumables and spares requirements are fed into the schedule. I think it is significant that NASA has been conservative in their requirements and their forecasts for spares and the orbital replacement units. These have gone longer than forecast, and this gives us some pad that can take some of the delays of the commercial resupply services.

And with that, I will stand by to answer questions from the Committee. Thank you, Mr. Chairman.

[The prepared statement of Lieutenant General Stafford follows:]

Written Testimony of

Lieutenant General Thomas P. Stafford, USAF (ret.)

Chairman, International Space Station Advisory Committee

Before the

Committee on Science, Space and Technology

United States House of Representatives

March 28, 2012

Thank you, Mr. Chairman, for that warm introduction. I appreciate the opportunity to come before the Members to once again express my views and concerns, and those of my Committee members at this hearing. I will attempt to answer the questions provided in your letter of invitation from the standpoint of my expertise as a former astronaut, Air Force Deputy Chief of Staff for Research and Development and Acquisition, having served on and chaired many committees overseeing NASA in human spaceflight programs, and my current position as the ISS Advisory Committee Chairman. In this most recent position, I lead the committee to review NASA's current plans, and the underlying assumptions, for supplying the necessary upmass and downmass capacity to ensure the continued health and maintenance of the International Space station, and enable scientific research utilization through at least 2020. All members of my Committee have extensive experience in the development, testing and flight operations of the NASA Human Spaceflight program. I also had the unique experience of working with the Soviet-era Russians as the Commander of Apollo during the Apollo-Soyuz Test Project. Through that effort, I was afforded an opportunity to view their space program up close alongside their best engineers and technicians. As a result of that successful joint program, NASA and ROSCOSMOS were able to again cooperate in space with the Shuttle-MIR program, culminating in our successful partnership on ISS. I have had the privilege of serving as Chairman of the ISS Advisory Committee for over 10 years, and in that capacity, I became familiar with the Shuttle-Mir operations and have since been fortunate to have assessed the assembly, maintenance and day-to-day operations of the ISS since its inception. Throughout our long collaboration, I have continued to observe and assess the Russian space program.

Question 1

Are NASA's current plans adequate to ensure that requirements for a) ISS maintenance, growth, crew supplies, and expendables, b) NASA's scientific research utilization, c) National Laboratory growth and utilization, and d) other contingency maintenance, can be met through at least 2020?

In response to your first question, NASA's current plans are adequate to ensure that requirements for ISS maintenance, growth, crew supplies, and expendables, NASA's scientific research utilization, National Laboratory growth and utilization, and other contingency maintenance, can be met for the immediate future (at least 1 – 2 years). This is in large part thanks to the fortuitous delivery of consumables and spares delivered to the ISS by STS-134 and STS-135. Beyond that timeframe, NASA becomes increasingly dependent on its projected flow of sparing and re-supply needs, on the planned fleet of cargo vehicles which includes the ATV, HTV, Progress, and Commercial Resupply Service (CRS) Vehicles. In joint assessment with the Aerospace Safety Advisory Panel (ASAP), my ISS Advisory Committee concluded that the commercial vehicle launch schedule was overly optimistic and we have not received sufficient data to conclude with confidence that the schedule could be met. This was the unanimous conclusion of both groups. Both commercial cargo contractors (Orbital Science Corporation and Space Exploration Corporation) continue to experience significant delays in their development, testing and launch dates. Beyond the year 2016, ISS resupply is almost totally dependent on these CRS vehicles.

NASA has updated and revised the launch manifest, making the schedule more realistic, but this may still have potentially optimistic assumptions. Real time updates of the use of consumables and spares, the changing mission requirements, and the development of alternative operational procedures and techniques will continually alter the schedule, the changing logistics needs and the required vehicle launches in the out years. The increased dependence on the Follow-On Commercial Cargo Vehicles still gives us concern until they have demonstrated reliability and repeatability. For the near term, NASA has done a credible job in adjusting the schedule to meet the changing consumables and propellent required.

Question 2

Highlight any areas of concern, or assumptions, that could materially affect NASA's ability to ensure complete, effective and safe functioning, and full scientific utilization of the International Space Station through at least 2020.

It is important that the ISS investment provide high-value return with more time allocated to research. Clearly the major drivers to increasing utilization margins are crew size and availability of utilization hardware, that is, up mass and down mass. The ability to maintain a 6-person crew together with ISS utilization is critically dependent on the success and continued

viability of both commercial resupply service providers and continued viability of current logistics vehicles. The ISS is in a safe and logistically- sustained configuration through the rest of this year, so there is margin for it to absorb delays in the launch schedule of the commercial providers. Given that, and the extra help that my Advisory Committee has seen the ISSPO provide to the commercial cargo suppliers, my Committee is confident that they could safely deliver cargo to the ISS within the next year to 18 months. However, experience has shown that with many developmental program, delays are inevitable. The concern is that these providers become operational in order that major adjustments to the current launch schedules are avoided. Mean Time Between Failures (MTBF) calculations for Orbital Replacement Units (ORUs) by NASA have historically been done conservatively, using the best practices and industry standards. Operational experience shows that many components are operating well past calculated life and the ISS Program Office has used that data to forecast sustainability plans that support the station through 2020 with the possible potential to go beyond that with continued support. Ensuring the technical rigor of testing and analysis of critical ISS components to function through 2020 is another area that needs to remain at the forefront of the ISS Program Office's priorities. The Advisory Committee has not seen any indications of that being overlooked. This is a complex vehicle and extending its use will present challenges to the program, however they are challenges that NASA can overcome with appropriate resources and support.

Mr. Chairman, I thank you and the committee for giving me this opportunity, and thank you for all you do to advance American human space flight.

Chairman HALL. I thank you, General, and I thank all of you for your testimony. I remind the Members that the rules limit questions to five minutes, and the Chair will at this point open the round of questions, and I recognize myself for five minutes.

I am concerned about dates that have been assigned back through the years to launches. The initial date of the proposed flight of the second rocket or demo 2. I go with the first date I see, June 2009, when the initial proposal when the Commercial Orbital Transportation Service, or COTS, contract was signed I think in 2006 and gave us three years. It started in 2009, and there has been just time after time after time after time where now we are promised the date of April of 2012, and that schedule was changed in February, I think. This is April. I don't know what to think. I guess I will just go to asking questions for it.

Mr. Gerstenmaier, we spent two decades and tens of billions of dollars to build the International Space Station with our international friends and people that trusted us. Now that it is finished, I hope NASA doesn't squander the incredible potential for life-saving research and other important science because President Obama cancelled the shuttle's replacement. I am beyond frustration to know that our space station program is now dependent on a launch system of other countries to do the job that NASA ought to be doing. Congress has been pretty clear that NASA is not to rely totally on these commercial proposals, and I hear excuses and delay after delay for the supposedly simple act of delivering cargo to the space station.

Mr. Gerstenmaier, NASA has spent $1.6 billion on this effort so far, and the Nation doesn't have very much to show for it. What does NASA get back when companies continue to delay, and what is the penalty when they don't perform? What do you need? And if they have a successful test flight, can we be assured it can meet the demands of the space station? I guess that is my question to you, sir. And are there any penalties if they don't meet it?

Mr. GERSTENMAIER. Yes, sir. When they misschedule and have delays, they owe us an equitable adjustment under the contract. This is under the contract phase for cargo delivery. So if they miss a launch date, they owe us either some financial consideration or additional analysis.

Chairman HALL. What kind of financial consideration?

Mr. GERSTENMAIER. The things we have been able to do is, we wanted to add more refrigerator-freezer capability to their vehicles. We didn't have those in the initial contracts. That allows us to carry refrigerated samples to space station and also return them. That wasn't in the original contract, so for one of the delays we got as part of the compensation for that a redesign and new equipment to be added into their capsule to carry these precious biological cargo to station and return them. So for every slip that occurs beyond a 1-month period, we get some benefit back to us and we have to show how that provides equitable benefit to us equal to the amount of slip.

And to your first point, they have spent quite a bit of time developing their launch pads. Their launch pads are now fully up and operational. Wallops still needs a little bit more work to get that done. That was done by the State of Virginia but Orbital will use

that facility. The SpaceX launch pad was built by them. That was part of their investment that you discussed.

Chairman HALL. Is that launch pad finished?

Mr. GERSTENMAIER. The one in Florida is finished and ready. They have already flown one demonstration flight off of that launch pad, or several, one for us and then one is another use. And then they have this next flight that is getting ready to launch off the pad but it is fully operational. They just did a wet dress several months ago and they are ready to go do the launch at the end of April. In the case of Orbital, the launch pad at Wallops is still behind schedule a little bit. That launch pad is being built by the Mid-Atlantic Regional Space Port. They are providing that to the Orbital Corporation to launch off of. They still have some more activation work to do at the launch pad, and that is what is holding up the cargo flights from Orbital. But they got started a little bit later in cargo delivery than the SpaceX team.

Chairman HALL. All right. I think the people that you are dealing with have delivered before, have deep pockets, and ought to be able to produce. What do you need from Congress to stop the delays. Of course, we need more recognition of the needs of NASA rather than limiting us to less than one percent of the budget. We have asked the last three Presidents for those and not received them. So I guess that has to be part of your answer for our inability to keep the dates that have been set.

I will ask General Stafford, from your experience, sir, what are some of the problems that are causing these delays and how can the government ensure that they get performed? Use your microphone, General.

Lieutenant General STAFFORD. Here we go again.

Chairman HALL. Don't let that happen anymore. Go ahead.

Lieutenant General STAFFORD. From my experience as the Air Force Deputy Chief of Staff for Research, Development and Acquisition, and at that time I had acquisition. My budget was far more than the total NASA budget. Under that, you have some categories of the good, the bad and the ugly, and to be sure that they end up in the good, you need good, experienced program managers, people that have experience. You need insight and you need direction on how they do it. You have to look out for unrealistic lowball bids and unrealistic schedule by contractors and also by the government to lay on unrealistic requirements. In other words, they request technology that is not going to come on time.

As I brought out at the Wright Brothers Memorial Trophy dinner, probably the record was set when I started the 117A. It was completely secret. It was very black, as they say. But we flew that airplane in less than two years and eight months, and it was operational in a little over three years, which is a modern record. And we pushed, and we had insight to it. It met all the FARs. We did bypass Air Force regulations but it met all the FARs and so we knew exactly where we were. We had the insight to it. I don't know that we have the insight.

I have not been involved with the management in these delays. My committee looks at the safety and the operational part of it. When you go down to the good, the bad, the ugly, you review what has happened in the past just from reading open literature like the

turbo pump on the space station main engine. It was bid in low at $150 million, $160 million. It ended up ten years later about $1.2 billion or $1.3 billion. And the same way with the Webb telescope this Committee knows about, when I read in open literature. It was way underbid and probably the technology was not there.

So again, you have to have good program managers and you have to have good program structures. Now, the way these programs are structured, as I have observed from the outside—I have not been involved in management—under these Space Act agreements, which is other transactional authority, I don't know that it can really have the insight in the management that you would have if you have a good program manager, and we had some of the best in Apollo with General Sam Phillips, Dr. von Braun, probably some of the best, but they were right there on top of things.

Chairman HALL. I have gone over my time. I thank you. Others will have other questions, I think.

Now I recognize Ms. Johnson for seven minutes.

Ms. JOHNSON. Thank you very much.

Chairman HALL. Fair is fair.

Ms. JOHNSON. Mr. Gerstenmaier, we are all aware that the first few years in International Space Station, time was spent assembling it and long before we could begin the research, but once the research was initiated and is ongoing, where is the focus now in research?

Mr. GERSTENMAIER. ISS is a very diverse research facility. There is an alpha magnetic spectrometer that is on the outside of space station that actually looks for antimatter and dark matter from the universe looking at potentially how the universe was formed. There is also some Earth observation equipment on board, the HICO–RAIDS instrument. It is a hyperspectral instrument that is looking at the ocean, looking at waves. There are some experiments being done now on combustion onboard space station. We recently did some things looking at combustion stability in space. The advantage of looking at it in space is, without gravity, the researchers can actually model the phenomena so then when look at more efficient gas turbine engines or more efficient automobile engines, they can take the knowledge that they gained on how the combustion actually works in low gravity, apply that here to the Earth. There is a lot of medical investigations going on aboard space station that deal with activities that can help us here on the Earth, things that help the elderly with bone loss. Stability issues that astronauts face can also be investigated on space station. So it is a wide variety of research. There is probably five to six or so investigations every day being done uniquely onboard the space station each and every day as we are in this next phase.

Ms. JOHNSON. What areas do you think will bring the major breakthroughs between now and 2020?

Mr. GERSTENMAIER. Again, I think the advantage of the space station is the fact that the crews have a long period of time to work on the investigations. In other words, they are not scripted that they have to complete an investigation immediately in a certain amount of time. They can do research much like we would do on a recent lab here on the Earth. So if the astronauts see a unique phenomenon that occurs in space that the researchers didn't expect

to see, they have time to now investigate that research and they may discover new phenomena or new things that never really existed. We are learning a lot about how biological samples behave in space, how bacteria become stronger, how viruses become stronger. We can use that information to essentially build vaccines potentially for us here on the Earth.

So I think the advantage of space station is the uniqueness of being able to take time to really do research and be creative in the way you do research and not be on a structured timeline that limits the amount of knowledge that you can gain.

Ms. JOHNSON. Thank you. But there is kind of a timeline that we are working against, and I have some real concerns in the vaccines as well as viruses. Do you feel you are closer to any kind of breakthroughs?

Mr. GERSTENMAIER. We have done research on salmonella and we have been able to develop essentially a strain of salmonella that is strong enough to cause the immune system to react but not strong enough to give you the disease, so that is essentially a vaccine. That is about ready to go into FDA trials. There has been a lot of work working with the FDA to get it into trials, but we were able to use a small organism to get through the first phases of the FDA process and then potentially it could go into FDA trials fairly soon. So the unique property that occurs with salmonella vaccine occurs with viruses and other things as well, so we could potentially explore developing new vaccines for viruses and other things as well onboard space station. So it gives a whole new research avenue for companies and pharmaceutical companies to pursue in space.

Ms. JOHNSON. Thank you.

Ms. Chaplain, how can Congress determine whether NASA is on track to meet the objectives by 2020?

Ms. CHAPLAIN. Major projects at NASA regularly report data to the committees on cost schedule performance and status. These projects I don't believe are among those, and that is one key way you could be asking for data to follow progress in addition to these hearings. That data comes in semi-yearly cycles and yearly cycles, so it might not be as timely as needed. We have ourselves an ongoing assessment of all major projects within NASA, and we do plan to include these efforts next year to help the Congress have more insight and oversight as well.

Ms. JOHNSON. Feeling the pressure of 2020 approaching, does that add anxiety or add any more effort to reaching some conclusions? How do you internalize that date for research time?

Ms. CHAPLAIN. In terms of overseeing the commercial development efforts or in terms of research for the station? We have not revisited our previous work in terms of assessing how the station is being used for research. We made a recommendation when we did our review that they establish an organization to manage the research and prioritize it and ensure it is not duplicative. That is just getting underway, so the next year or so is really going to be critical to see how effective that mechanism is and is it going to be the best to optimize the space station's research.

Ms. JOHNSON. This could be unfair, but with the direction of this Administration where it appears to be headed with less and less

and less and less financial support, does that affect performance or direction or planning?

Ms. CHAPLAIN. It could possibly. I have seen in several agency budgets that money for S&T types of activities, research activities are being cut and it could affect plans that some agencies have had to use the ISS for their own research activities.

Ms. JOHNSON. Thank you very much.

Thank you, Mr. Chairman.

Chairman HALL. Thank you.

The Chair now recognizes the gentleman from Mississippi, Mr. Palazzo, for five minutes.

Mr. PALAZZO. Thank you, Mr. Chairman.

Mr. Gerstenmaier, according to the GAO's testimony in 2011, NASA anticipated 56 flights to the ISS between 2012 and 2020 and would likely be at risk of a shortfall to cover all the National Laboratory demands and margin for unseen maintenance. However, this month NASA told GAO that in spite of decrease in the anticipated flights to 51, NASA is no longer projecting a cargo shortfall. What changes have occurred to cause you to reduce the number of flights without having any impact on estimated needs for cargo?

Mr. GERSTENMAIER. Well, what has occurred is the failure rate of the onboard spares and equipment onboard space station has been less than what we originally predicted. We are seeing the hardware is performing better than we thought. It is lasting longer without maintenance and need for repair, so that gives us some of the margin that you described. We still have not taken fully into account what we actually observed for those failure rates. We still are biasing it more towards the conservative side, so we think there may be even some more margin if the hardware performs as good as it has been performing in the past several years.

Mr. PALAZZO. Ms. Chaplain, are you satisfied with NASA's justification and what information would you need to make sure they have conducted sound analysis?

Ms. CHAPLAIN. Yes. What was being said about the spares lasting longer does agree with what we were finding in our latest research. We had also heard that the space station was using fewer supplies now than before. They must have found ways to use things more effectively. We would probably like to see more information along those lines, and we haven't analyzed the latest data in great detail, so those are the kinds of things we would probably want to see behind it.

Mr. PALAZZO. Mr. Gerstenmaier, Ms. Chaplain in her testimony cited crew availability as a major constraint on the productivity of the ISS National Lab. How does NASA plan to address this constraint and how significant will it be going forward?

Mr. GERSTENMAIER. Crew time is clearly a precious commodity onboard space station. What we have been trying to do is reduce the amount of activities that the crew needs to do to take care of themselves. In some cases, we have looked at ways that we can do less medical investigations directly on the crews, so there is a little more time available for them. Some of the maintenance activities, we have been able to cut back and defer. Some of the testing we do on components, we have cut back, and what that is allowing is

some more research time for the researchers to use the crews for those research activities.

If we get commercial crew at some point, we would like to increase the number of crew members on the flights from three to four, and that would allow us to have additional crew member on orbit, which would also increase the crew time available for research.

Mr. PALAZZO. Thank you.

Ms. Chaplain, do you care to comment?

Ms. CHAPLAIN. Crew time availability was a concern in our review. That was two years ago, so I do recognize that actions have probably been taken to kind of make that time smarter.

Mr. PALAZZO. I will kind of change it a little bit. Let us talk about the Soyuz.

Mr. Gerstenmaier, do the Russians have the industrial capacity to produce additional launch systems after 2016 to satisfy crew transportation demand if commercial crew systems or the Space Launch System are not ready?

Mr. GERSTENMAIER. They have the industrial capability to manufacture the vehicles. Our typical lead time is roughly three years to maybe 2–1/2 years that we have to make known that we need a vehicle for our purposes, so we will have to order those vehicles in the 2013 time frame for flights in the later half of 2016 and early 2017.

Mr. PALAZZO. When would NASA—this is for you, Mr. Gerstenmaier. When would NASA and the international partners need to decide on extending the life of the ISS?

Mr. GERSTENMAIER. And by extending the life, you mean beyond 2020?

Mr. PALAZZO. Yes.

Mr. GERSTENMAIER. Probably in the 2015 time frame. We are estimating around December 2015. Again, that is based on us having to procure items about three years in advance, so then you could take 2021, subtract three years, and that is 2018 or so ordering time and then it takes us a little bit of time to work through the contracting activities. So we think sometime in 2015 we should be making decisions about whether we are going to extend beyond 2020. And we would have to do that also internationally, get approval from our international partners, etc. So that is a pretty lengthy process, but we would start that activity in 2015.

Mr. PALAZZO. Well, thank you all.

Mr. Chairman, I yield back.

Chairman HALL. Thank you. The gentleman yields back.

I recognize Ms. Bonamici of Oregon for five minutes.

Ms. BONAMICI. Thank you, Mr. Chairman.

I would like to thank all of you for your testimony today on this important hearing that is focused, I believe, appropriately on the challenges and opportunities of the International Space Station, and I wanted to ask you to discuss some educational issues and the value of the work being done on the ISS for educational purposes, and I recall, for example, Oregonian astronaut Susan Helms, who actually spent 163 days on the ISS, coming into Oregon schools and inspiring hundreds, if not thousands, of students about space and about science and especially the young girls. So that is just one ex-

ample, and I wondered if you could please discuss how the ISS is being used currently to inspire and educate young people in science and technology and engineering and mathematics, the STEM disciplines. Do you have specific examples? And also, is there potential that is not being met?

Mr. GERSTENMAIER. One good example is, last week we concluded a science fair project with students onboard space station. We teamed with YouTube, Google and Space Adventures, and they sponsored a global international competition for students to present science fair projects to be performed in space. The age categories were 13-year-olds through 18-year-olds. We received 9,000 videos throughout the world, three-minute videos of science projects that students would like to perform on space station. We down-selected out of those to two finalists, whose experiments will actually fly to space station on HTV this summer and they will be performed by Suni Williams onboard space station in the fall. One winner was from Egypt, and two girls in the 13- and 14-year-old category were from the State of Michigan. It was pretty exciting to see the videos and the creativity the kids put together. The girls from Michigan, they focused on this bacteria and virus discussion I had. They were intrigued by that, so there is 13-year-old students trying to pick up the state-of-the-art research at the age of 13 and actually proposing an extremely wonderful experiment to be done on station.

The Egyptian experiment dealt with a spider that jumps to catch its prey, so the question or hypothesis was, would this spider, how would it do in space when it jumps and, you know, it floats instead of uses gravity, would it be able to adapt and learn. So again, the students were pretty inquisitive of how they understood what the microgravity properties were and submitted pretty special investigations.

The discussion you had with Susan Helms was the ham radio activities. We still do lots of ham radio activities in schools, and the response from kids is phenomenal.

Ms. BONAMICI. Thank you. Can you identify constraints that might—other than budget, of course, that might affect the ISS utilization for STEM education and outreach?

Mr. GERSTENMAIER. Again, I think crew time becomes a consideration, how much time the crew has available. As you stated, budget is always a constraint for us. We have made available some additional upmass like we have this summer to carry the students' experiments to space, so there is upmass available in the cargo manifest. So we have tried to accommodate it within our resources to make sure that kids get a chance to virtually participate in the space station and get a chance to see what the astronauts are doing.

Ms. BONAMICI. Terrific. Thank you.

And Ms. Chaplain, in the past NASA has told the GAO that failures or significant delays in developing the commercial cargo transportation would be NASA to operate the ISS in a survival mode including going to a two-person crew, and under that scenario, the ISS would only conduct minimal science experiments. Is this still the anticipated scenario if the commercial cargo providers are significantly delayed or experiencing a failure?

Ms. CHAPLAIN. I believe what has already been said here is very on point, that if you have delays that extend beyond 2013, or into 2013 and beyond, you will see a lot of impacts on space station and a lot of scaling back of research. Whether it would actually take them to the survival mode is more for Mr. Gerstenmaier to answer.

Ms. BONAMICI. Mr. Gerstenmaier.

Mr. GERSTENMAIER. I think ultimately if we don't get the cargo in the time frame we need, we will have to cut back on research first and then eventually go to the survival mode. But we have diversity in cargo vehicles. We have the HTV, the ATV. We can use some limited upmass on Progress, and then we have the two commercial providers, so out of those five different entities, we think we have a broad enough variety of cargo providers that we can meet this challenge of utilizing the space station in the future.

Ms. BONAMICI. Thank you very much. I yield back.

Chairman HALL. I thank the lady.

I recognized Mr. Hultgren for five minutes.

Mr. HULTGREN. Thank you, Chairman, and thank you all for being here today. I appreciate your time and the information.

A couple questions, specifically more timeline and plans with NASA. Mr. Gerstenmaier, I wonder if I could address these to you? The NASA Authorization Act of 2010 requires that NASA design the Multipurpose Crew Vehicle, Orion, to provide backup capabilities for cargo and crew transport to the space station in the event commercial or partner supply vehicles are unable to do so. I wonder if you could tell me specifically how NASA is doing, what they are doing now to ensure that Orion Multipurpose Crew Vehicle will be operational and ready in time to comply with the law?

Mr. GERSTENMAIER. We are proceeding as fast as we can with both the Multipurpose Crew Vehicle and the Space Launch System. We have planned a schedule uncrewed flight in 2017 and then our first crewed flight is in 2021. And 2017 is driven more by the hardware manufacturing ability and additional funding really doesn't move the 2017 date very much. That is where it sits. We have a pretty exciting test flight coming up here in 2014 that will give us key information on how well the Orion capsule performs. The 2021 date is driven a little bit more by budget. We would have the option of potentially moving that date forward as we refine our budgets to help if we need to, to try to get it in front of the end of space station. But it looks like with the MPCV and SLS, the earliest we could be potentially there to help out with station would be probably in the 2018 time frame.

Mr. HULTGREN. Okay. Following up a little bit, or just refining, I guess. NASA's fiscal year 2013 budget request I know just reduced Orion's funding by $200 million. Even though you have stated that these Orion and SLS are top priorities, again, wondering with that 2014 test flight of Orion, I know that is an uncrewed flight that is coming up but wondered what specific human spaceflight or life support work is being funded by NASA now to ensure that Orion will in fact be ready to jump in and act as backup to service space station if needed?

Mr. GERSTENMAIER. We are doing some limited life support development. It has ramped down a little bit. We also have quite a bit of life support equipment that we are actually using onboard

the space station. It provides CO_2 removal and oxygen generation for the crew onboard station. That has direct application to the systems that would fly in Orion in the future. So we are doing some work along those lines to keep things moving forward as much as we can.

You know, we have to make hard decisions and trade things across our budget. When we look at it, commercial crew had the potential of being there a little bit earlier than we can with the government systems, so we are pushing or aiming our direction towards the commercial crew activity to provide that service.

Mr. HULTGREN. The chairman had talked a little bit earlier of our reliance on the Russians right now, and I wonder, what is NASA's plan if a catastrophe, and again, we all hope and pray that never happens, but if a catastrophe occurs during the returning Soyuz capsule, what is NASA's plan to respond to that and how would the United States retrieve remaining astronauts on the station if something were to happen?

Mr. GERSTENMAIER. At this point, as I stated in my opening remarks, we are dependent totally upon the Russians for crew transportation. We have always been dependent upon the Russians for rescue capability from the space station, so that risk is still there. If we had some event that occurred where the Soyuz was not available for us, we would be in the situation where we would have to look at decrewing the space station. We would try to accelerate both commercial crew and the Orion SLS MPCV systems as much as we could to reestablish a crew presence as soon as we could on orbit from those events.

Mr. HULTGREN. Okay. And if you can comment on this but then I will open it up to the other witnesses as well, just wondering if you could talk about what you see as applications of value to the U.S. economy that we might be able to expect to see from the ISS over the next several years.

Mr. GERSTENMAIER. I think one of the biggest advantages is, there is unique properties in microgravity that exemplify themselves in microgravity such as the bacteria discussion I had with you, materials properties, crystal growth, etc. Our hope is that commercial companies, we can expose to them what these unique properties are, what NASA's research has shown in the past. These commercial companies can see these processes and then decide to try and experiment, take it to space station and see if they can develop one of these commercial processes that will help them gain an economic advantage globally. So things like vapor deposition, combustion research, fluid motion, all those things we think if we can expose to the commercial companies what the unique research can be done in space in those areas, we think the commercial companies can then exploit that to their economic advantage and gain a competitive advantage over other companies that don't take advantage of space-based research.

Mr. HULTGREN. Okay. I don't know if any of the other witnesses have any thoughts on economic benefits or benefits for our Nation over the next several years from the International Space Station.

Ms. CHAPLAIN. I would just comment that the nonprofit organizations set up for the station, it is one of their goals to bring in commercial companies into the research and increase that, and that

could be beneficial, and I do recall earlier hearings here a few years ago where you had some commercial representatives talking about how they would count on the station more and more if they could get research up there, and they thought it would be beneficial to the economy.

Mr. HULTGREN. Thank you all very much. I yield back, Chairman.

Chairman HALL. The gentleman yields back.

Ms. Edwards of Maryland, five minutes.

Ms. EDWARDS. Thank you, Mr. Chairman, and thank you to our witnesses.

Mr. Gerstenmaier, I want to actually focus on an issue related to the 2013 budget request for ISS. It appears that NASA plans—the plans for utilization and research or the ISS funding in the outyears will depend in part on assumed reductions to the operations and maintenance costs for the ISS. It looks as though NASA projects those O&M costs will drop more than $400 million over the five-year 2013 budget horizon. Is that correct?

Mr. GERSTENMAIER. I would have to look specifically at the budget numbers that you are looking at, but I think that general trend is there, and it is caused by when we retired the shuttle program, we had to redesign a lot of our spares and components. That shows up in the maintenance and operations budget. Once that redesign is complete, than that budget is no longer needed. Those spares are designed and they are ready to go fly.

Ms. EDWARDS. Is that at all dependent also on the projected meeting of milestones by the—in the commercial cargo area?

Mr. GERSTENMAIER. That reduction is separate. This is development of the hardware that those vehicles would carry, the commercial cargo providers carry that cargo to orbit. So the actual ability to get the cargo and spares to orbit will be dependent upon the providers, but the budget reduction comes from the fact that we are no longer doing non-recurring engineering or redesigning components again here on the ground.

Ms. EDWARDS. Okay. So let me just ask you, and we have focused a lot in other things about the commercial cargo crew and all of that, but I look over the next several months actually and there are a number of milestones that have to be met by the commercial providers. What will be the impact on the ISS if those milestones aren't met? One coming up, I think April 30th, right?

Mr. GERSTENMAIER. That is correct. The SpaceX demonstration flight would be on April 30th. We have margin on orbit in terms of spares and consumables and research along with our ATV and HTV flights that are flying, and to last essentially about a year, so we can stay in the current configuration doing the number of research investigations I described earlier for roughly about a year. Then beyond that, we are going to have to take some action if these providers have not delivered any cargo during that period. So we have been assuming that we will get maybe one or two commercial cargo flights this year. The demonstration flights carry a reduced amount of cargo but they will also help, even the demonstration flights will. So if those are successful, we will be able to push that date out further and continue with normal operations. So we need something to occur within about the next year.

Ms. EDWARDS. So let me just ask this then, because I think that it is important to assure the committee. What is your confidence level in the commercial providers being able to meet those milestones including the important one in September of this year?

Mr. GERSTENMAIER. Again, I think within a year time frame, we will see the cargo providers start to make their first flights and then there will be some ramp-up time required for them to get operational and get into a pace, you know, a cadence of regular flights, and we have allocated some margin to go do that. You know, it is not a large margin but I think it is a reasonable plan to get that done.

Ms. EDWARDS. So do you have a high level of confidence that they are going to meet those milestones this year?

Mr. GERSTENMAIER. They will meet the minimum milestones that I just described to you.

Ms. EDWARDS. Let me just ask you about the reliability of the Soyuz because we have already seen, you know, at least some problems that caused delay. There is another launch that is planned for May 15th. Is that on target? And if it is not, what would that mean then to continued on-schedule operations and crew operations on the ISS?

Mr. GERSTENMAIER. That launch is on target. It is on schedule for the May 15th time frame. The Russians have talked to us about building another vehicle, both a cargo vehicle on their side, a Progress vehicle, and also Soyuz vehicle and having it in reserve so if a problem comes up, they would have another vehicle essentially ready to go fly in its stead if something occurred. The problem you described was in manufacturing of a Soyuz vehicle that was getting ready to go fly.

Ms. EDWARDS. And so presuming that we meet that May 15th target for crew operations, we are fine, but if we don't meet the May 15th, what would be the impact on ISS operations and research?

Mr. GERSTENMAIER. Again, we probably have several weeks margin to that date, and we would end up having to return the crew and the Soyuz vehicle at roughly the 180-day, 200-day on-orbit limit. When we do that, we would drop the crew size from six down to three and then that would result in a reduction in research when we make that crew size reduction.

Ms. EDWARDS. Mr. Chairman, I think that my clock started late, so I am not going to take that whole five minutes that is still on there, but I do have one last question. I am curious as to with respect to the resignation of the center's Executive Director and particularly some of the very strong language that she used in criticizing both the political and other aspects of standing up the center as a nonprofit reaching out to agencies and to the private sector to fully utilize the ISS, whether it is really appropriate that this is a role for a nonprofit and how it is that that is going to be stood up so that we get more than 50 percent capacity in ISS usage for the United States.

Mr. GERSTENMAIER. It is a cooperative agreement we have with the nonprofit. They gave to us an annual performance plan of objectives and milestones that they were to accomplish during this year. I have sent them a letter and asked them to respond to us

by today or tomorrow, we will see, on what their plan is to achieve those milestones that we have established with them, things such as they are supposed to reach out and bring some investigations in, they are supposed to do an evaluation model, etc., that sits in there. So we have objective milestones that we have asked them to give us an extra assurance that they can actually meet those in light of the uncertainties and the problems that they have had during startup.

Ms. EDWARDS. And has the GAO, Ms. Chaplain, taken a look at the center and whether it has the capacity, really looked deeply at the criticisms that were leveled on the center's operations and its ability to meet those milestones?

Ms. CHAPLAIN. No, we have not been asked to look at the center and how effective it is yet. I would note that the organizations that operate research for the other labs that we visited, they are a bit different than this one. They tend to be consortiums of universities or contractors, so it is a little different situation, probably worth looking at.

Ms. EDWARDS. Maybe, Mr. Chairman, as I yield, it would be a great idea for us to request a look at the center's operations because for me, the resignation of the Executive Director and the problems that she highlighted are really troubling with respect to trying to figure out a way that we make the maximum use of the space station and its research capacity. Thank you, and I yield.

Chairman HALL. I agree with you, but what do you mean, take a look?

Ms. EDWARDS. I mean perhaps we could ask for GAO to review the center, the nonprofit, the relationship that it has and the agreement with NASA and whether it is appropriate and prepared to meet the goals that have been set out so that we get more than 50 percent utilization capacity in the ISS.

Chairman HALL. Yeah, I want somebody to go, don't you, to the station?

Ms. EDWARDS. Yeah, I do. I want someone to go and I want experiments there, and I want more than 50 percent of——

Chairman HALL. I went out to the West Coast with Mr. Rohrabacher, walked through SpaceX's place. I was impressed. I found a young man there with an impressive operation and high hopes. I came here in 1980 and I think it seemed like 1982 or 1983, something like that, Orbital was here, a company with deep pockets and a history of success, and now we have one going to get ready by September 2012 or late April of 2012. To be continued, I guess. And we are very hopeful that somebody is going to get there to the space station, and I know you are, aren't you? Do you have any penalties or anything for failure of going past those times or do you have some expectation of that?

Mr. GERSTENMAIER. As I described earlier, I talked——

Chairman HALL. One doesn't have a launch in place and the other does. I don't know what that adds into it.

Mr. GERSTENMAIER. The contract we have with them for an indefinite delivery, indefinite quantity contract so we could potentially add additional flights to one that is successful if one is achieving and making more milestones and has the ability to deliver earlier than the other.

Chairman HALL. I recognize Mr. Rohrabacher for five minutes.

Mr. ROHRABACHER. Thank you, Mr. Chairman. I think that last suggestion that the Committee received, we ask for a GAO report on this. I think it is a request that we could all support and would be supportive of your leadership in that, Mr. Chairman.

First and perhaps the most important question on my mind right now, Mr. Gerstenmaier, is, what happened to the spider?

Mr. GERSTENMAIER. We will find out this fall.

Mr. ROHRABACHER. All right. About the same time we find out about whether or not the commercial space crew is working or not. There has to be a relationship there somewhere.

Let us see. So let me ask you this. In terms of, if we were not trying to go down the commercial path at all, if this commercial alternative had not been before us, would it—as compared to if it is successful, would it cost more for NASA to do this on its own, just within NASA and the Orion, etc., or would it cost less if we would have not gone the commercial route because of duplication that the chairman has mentioned?

Mr. GERSTENMAIER. For commercial cargo, we were able to bring on the two commercial providers and so far I think it has been discussed, we spent about $1.6, $1.8 billion on that. That is significantly less than we would have spent on a typical NASA full-up development of that activity. So we have the potential to really get this cargo capability at dramatically less cost than we would have paid under our traditional contracting.

Mr. ROHRABACHER. Even with the factor of, when you have competition, that means there are two different groups going and you are having to finance both, but even that, when you have competition in play and you have private sector cost savings in mind, that still gives us—if it works, and that is a big if, if it does work, that still means it was the right decision financially to go in that direction if it works. Okay. Because there is a lot of—Mr. Chairman, there is a great concern that we have more than one company involved, and I understand that, and just at first glance, it would look like that that is duplicative and thus it is a waste of money. In the private sector, we have this all the time where you have competition with different companies and it ends up in the long run if successful cost-effective for the taxpayer, and that would be the same way perhaps with airplane development, et cetera, et cetera.

Let me ask this. So later on this year we are going to find out whether or not the commercial end of this strategy in terms of the commercial strategy of cargo is actually meeting its goal. Is that correct?

Mr. GERSTENMAIER. That is correct.

Mr. ROHRABACHER. Okay. And then the crew would be five years from now, we will find that out. Is that correct?

Mr. GERSTENMAIER. Yes. Our current projections are 2017 for crew.

Mr. ROHRABACHER. Okay. So if we will know within about—would we know within two years whether or not the crew, the progress towards actually fulfilling the contract and meeting the deadline for crew, will we know that within two years whether they are on track?

Mr. GERSTENMAIER. Yes. We are about ready to issue a Space Act or award a Space Act. We received proposals for a commercial crew integration capability activity. That will kick off with awards potentially in July and run for a 21-month period. So by the end of that, we expect to have the designs at the critical design level and we should know whether they are making good progress or not.

Mr. ROHRABACHER. Because we need a three-year notice to give the Russians in order for them to build a vehicle that will make up if the commercials fail. So we will be watching with you and we would appreciate you keeping us informed as to the minute as these things progress.

One last thought while I have 11 seconds, or maybe I am already over, I am not sure, but just to note, I noticed that the European Space Agency, the director of the European Space Agency was talking to the Chinese about the possibility of using the Chinese spacecraft and permitting it to dock at the ISS. Mr. Chairman, for the record, I would like to state my strong opposition to any cooperation with the Chinese dealing with the International Space Station. We should not be permitting their rockets to dock. We should not be depending on them. We should not be in cooperation with them. Their rockets, after all, are the product of the greatest theft of technology in the history of mankind and they are a belligerent power to the safety and security and prosperity of the people of the United States.

So I just want to make sure that is on the record, and I would hope that our folks at NASA would deeply consider that at a time when I know they are being pressured to try to cooperate with the world's worst human rights abuser, and that is China. Thank you very much, Mr. Chairman.

Chairman HALL. I will mark that down, Rohrabacher one, China, nothing.

All right. I believe everyone has had an opportunity, but I would open it for two minutes to anybody else that wanted to make a statement or had some follow-up statement here. There are just one, two, three of you left.

Ms. JOHNSON. Thank you, Mr. Chairman. I hope it won't take two minutes, but I would like to request that both NASA's letters to CASIS and their response be given to the Committee for the record. Thank you.

Chairman HALL. The gentlelady yields back. Ms. Edwards, do either of you all have questions? Okay.

I may take a couple of minutes here to ask Mr. Gerstenmaier, what is the current state of negotiations with the European Space Agency for future Automated Transfer Vehicle, or ATV, missions beyond the three remaining and does NASA assume any of ATVs, that they are going to be available beyond 2014?

Mr. GERSTENMAIER. In our latest assessment, we don't plan on using ATV vehicles beyond 2014. What we have been able to do is, we found a more efficient way to use propellant onboard the space station. We were able to feather the solar ray string drag periods. It reduces the propellant usage. We are also able to do maneuvers now with space station that require no propellant usage when we do the maneuvers. We use control gyros to make those maneuvers. So that has allowed us to essentially fill up the propellant tanks

onboard space station so at this point the unique capability of the Automated Transfer vehicle to carry propellant is not needed. It also—the vehicle doesn't have any capability to carry external cargo, which is important to us. So when we project forward and we look at it, the ATV provides us really no unique capability beyond what we can get from commercial providers so we would like to provide that capability through commercial providers beyond 2015 time frame.

We have not had any formal discussions with the Europeans. We have talked to them conceptually about what we just described to you. We need to also work that with the Russians because we are required to provide propellant to them. We will work that out internationally over the next year or so. We plan to have probably an agreement with the Europeans maybe at the end of this year.

Chairman HALL. What is the current state of negotiations with the Japanese Space Agency for the future HTV missions beyond the five remaining? Does NASA assume any HTV capability will be available beyond 2016?

Mr. GERSTENMAIER. Again, when we look at HTV, it provides you a unique capability. It can carry external cargo, which is important to us. It also can carry batteries for us, which need to be replaced onboard space station. It is a much more effective vehicle to carry those than any of our other providers. It also has a large hatch where you can actually carry full research racks across the space station. So HTV has a lot of unique capabilities. We would like to have potentially approximately four HTVs from the Japanese in that period beyond 2015. Again, we have not had those discussions with the Japanese. We have told them that we would like to have their vehicle and continue to use it. We will have those discussions probably in the next year but we would be looking for somewhere on the order of three to four HTVs to fill out that time frame between 2015 and 2020.

Chairman HALL. Well, thank you.

Ms. Chaplain or General Stafford, do either of you have any concerns or statements about these statements or assumption? I will recognize either of you. General.

Lieutenant General STAFFORD. Mr. Chairman, I think it is a positive move that Mr. Gerstenmaier described as far as starting talks with the Japanese for the HTV because of the large volume it can carry and the payload it can carry up there because if we are only dependent upon the commercial and we have issues there that the HTV could certainly fill that in and help us there. That could then result in adequate research.

Chairman HALL. Ms. Chaplain, do you have any suggestions or to close? Ladies always get the last——

Ms. CHAPLAIN. The last word? I like that.

Chairman HALL. Yes, summation.

Ms. CHAPLAIN. I like having the last word. I think it is great if we could get more of them. The questions for me would be, with the production lines, can they be sustained that long? Are we going to face issues like obsolescence, things like that that you typically face, but the longer you can keep something you know that works going, the better in this case.

Chairman HALL. All right. I thank you, and I thank the witnesses for their very valuable testimony and the Members for their questions. Members of the Committee will have some additional questions for you. If we do, we will respond to you in writing and ask you to respond back to us in writing. The record will remain open for two weeks for additional comments from Members.

The witnesses are first thanked very much for your time it took to get you here and the time to prepare and the time you have given us and the time it will take you to get back to your work station. The witnesses are excused and this hearing is adjourned.

[Whereupon, at 10:58 a.m., the Committee was adjourned.]

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. William Gerstenmaier

Questions for William Gerstenmaier
From Chairman Ralph Hall
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Since one of NASA's COTS providers- Orbital Sciences Corporation (OSC)- uses modified Russian hardware on its launch vehicles, when will NASA need to seek a waiver to the Iran, North Korea, Syria Non-proliferation Act (INKSNA) to buy their launch services?**

ANSWER: We are already on contract with OSC for cargo support to the International Space Station (ISS) through the current exception period. (ending June 30, 2016). Some modification of the Iran, North Korea, Syria Nonproliferation Act (INKSNA) provisions will likely be required to continue using those services after 2016.

2. **Other than the Soyuz purchases what other aspects of the International Space Station partnership will require an INKSNA waiver?**

ANSWER: Modification may be needed for Russia-unique ISS goods and services including, among other things, Russian space suits and extravehicular activity tools, sustaining hardware support for the Functional Cargo Block (FGB) and docking adapters.

It should also be noted that some entities that have expressed an interest in pursuing commercial opportunities are contemplating teaming plans that could include Russian goods or services. In order to justify the expense of final development, long lead procurements, production, and flight testing, industry needs certainty as soon as possible as to the status of the present INKSNA human space flight prohibition as they make future business and teaming plans that could include Russian goods or services for future procurements.

3. **When does the Administration plan to begin to work with Congress on the necessary INKSNA provisions?**

ANSWER: As Dr. Holdren said to Congressman Palazzo during his June 20, 2012, hearing before this committee, "I agree with the importance of getting a modification to the Iran, North Korea and Syria Nonproliferation Act for the purpose you indicate. And it's clear that it's going to be required. It's clear that sooner is better than later." NASA looks forward to working with Congress on an appropriate INKSNA modification.

4. **One of the goals in establishing a National Laboratory was to broaden the range of research that could be done on the ISS to include more applied research, technology development and industrial processing. Given that the Center for the Advancement of Science in Space (CASIS) organization is managed under the same NASA division that provides grants for other basic research, how will NASA ensure that it can accomplish this wider range of**

applied research objectives?

ANSWER: While NASA's Space Life and Physical Sciences Research and Applications (SLPSRA) division acts as the liaison between the Agency and the Center for the Advancement of Science in Space (CASIS), SLPSRA does not manage CASIS or determine the research priorities for use of the International Space Station (ISS) as a National Laboratory; CASIS will have the responsibility for determining those priorities. NASA believes this will help ensure that research from a wide range of disciplines is carried out aboard ISS.

5. **Given NASA inability to enforce requirements on COTS participants through Space Act Agreements, and given that NASA has spent over $835M on CRS milestone payments without successful COTS demonstrations, what recourse does NASA have if the initial COTS test flights are not fully successful?**

   ANSWER: The COTS and Commercial Resupply Services (CRS) efforts are separate activities. The Commercial Orbital Transportation Services (COTS) effort is a demonstration program based on milestone payments. If a vendor does not meet a milestone, NASA will not pay for that milestone. It should be noted that on May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for Space X, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule.

   The payments NASA has made on the CRS contracts are for long-lead items and milestone payments, which are typical for launch vehicle contracts. Launch vehicle contracts typically provide for payments incrementally prior to launch.

   a. **If any of the COTS demonstrations are unsuccessful, with NASA re-compete the commercial cargo program?**

   ANSWER: Regarding COTS, if a partner misses a milestone, then NASA assesses whether the partner has in place a reasonable plan for successfully completing the milestone in the future. No payments are made until successful completion. Given the progress made by both partners to date, including the completion of COTS flight demonstration milestones by SpaceX, NASA does not plan to recompete the COTS agreements if the remaining demonstration is unsuccessful.

6. **Much of our discussion has focused on the capacity to get supplies and equipment to the ISS, but the ability to bring scientific payloads back to Earth is currently limited to 132 pounds on the Soyuz. Is this sufficient to meet the needs of the research community?**

   ANSWER: On the return trip to Earth from the recent COTS demonstration mission, the SpaceX Dragon capsule carried science experiments that will be

returned to researchers hoping to gain new insights provided by the unique microgravity environment in the station's laboratories. In addition to the experiments, Dragon returned a total of 1,367 pounds of hardware and cargo no longer needed aboard the Station. NASA anticipates that SpaceX Dragon spacecraft will continue to provide the downmass required to meet the needs of the research community through the terms of the current contract. Follow-on CRS contracts will also include downmass services to meet the needs of the U.S. Operating Segment (USOS). The USOS is currently staging return research on ISS until Dragon is available to return the cargo.

a. How much mass is the Dragon capsule expected to bring back and will this provide enough down-mass to serve the intended community?

ANSWER: The Dragon capsule is expected to return approximately 1,400 kilograms (3086 lbs) of downmass. At a projected 3 flights per year, the expected return capability is sufficient to meet all ISS projected return requirements.

b. Please provide the anticipated downmass requirements for the 2012-2020 timeframe.

ANSWER: The anticipated recoverable downmass requirement for ISS is an average of 2,200 kilograms (4850 lbs) per year for the years 2012-2020.

7. The GAO report from last year suggests a shortfall of launch capacity to meet the requirements of the ISS. If launch capacity is diminished for any reason, or contingency maintenance increases, where do the offsets come from?

ANSWER: ISS utilization is a high priority for NASA and its partners. However, if launch capacity is diminished or contingency maintenance increases, NASA and its partners would have to reduce upmass dedicated to research in order to ensure continued Station operations.

a. How does NASA prioritize the supply and maintenance needs with the research needs?

ANSWER: NASA and its International Partners would coordinate to ensure that critical maintenance and operations needs are met. Each Partner would determine its own research priorities based on its share of the remaining upmass, and CASIS would determine the priorities of National Laboratory research based on its own allocation.

8. What steps is NASA taking to reduce the sparing and utilization demand of the ISS between now and 2020?

ANSWER: Thanks to Space Shuttle missions STS-134 and -135, the ISS has

been well provisioned in terms of spares and supplies, and as the CRS providers' vehicles become available, ISS sparing and utilization demands will be met. At the same time, NASA and its partners are working to reduce these demands by conserving resources on orbit. One example is the increased use of the Station's Control Moment Gyros to change the attitude of the vehicle, reducing the consumption of propellant by the ISS.

9. **How is NASA's expertise being shared and used by the National Lab researchers?**

ANSWER: Several technical interchange meetings have been held between CASIS management and NASA field center personnel to provide CASIS with information on NASA capabilities that may be of use to National Lab researchers. CASIS is also identifying "implementation partners," organizations offering services in research payload design and development to National Lab researchers. These organizations have typically acquired their expertise through experience as NASA contractors and participation in the NASA SBIR program.

a. **Please provide some examples of the ways NASA is working to make experiments more autonomous to require less up mass and downmass.**

ANSWER: A number of experiments on ISS are already autonomous or ground-controlled (the Alpha Magnetic Spectrometer is an example of the former). NASA is working on ways to downlink highly detailed information about research results to ground-based scientists to minimize the need to return actual experimental samples to Earth, thus reducing downmass requirements. Laboratory analysis techniques are being developed that can be used to perform tests on biological specimens on the ISS and thus reduce the number of samples that have to be returned to Earth for analysis. The Agency is also taking advantage of smaller, lighter experiments in order to decrease upmass requirements and increase the amount of research that can be done on ISS.

10. **What is the current state of negotiations with the European Space Agency for future ATV missions beyond the three remaining, and does NASA assume any ATV s will be available beyond 2014?**

ANSWER: NASA does not require Automated Transfer Vehicles (ATVs) beyond #5, which will be flown in 2014, and is in early discussions with ESA to provide an alternative barter acceptable to NASA and ESA.

a. **What is the current state of negotiations with the Japanese Space Agency for future HTV (H-II Transfer Vehicle) missions beyond the five remaining, and does NASA assume any HTVs capabilities will be available beyond 2016?**

ANSWER: NASA is planning to discuss its needs for future HTV missions with the Japan Aerospace Exploration Agency (JAXA) as part of its barter arrangement negotiations.

b. What amount of domestic commercial capacity does NASA assume with be available in each year from 2012 thru 2016?

ANSWER: NASA anticipates 1-2 commercial cargo flights in FY 2012, and 4-5 per year from FY 2013 through FY 2016, with delivery of a minimum of 20 metric tons of cargo to the ISS, as well as the return or disposal of 3 metric tons of cargo, during that time period. The Agency will have to negotiate for commercial cargo resupply after FY 2016.

11. According to GAO's testimony, in 2011 NASA anticipated 56 flights to the ISS between 2012 and 2020 and would likely be at risk of a shortfall to cover all of the national laboratory demands and margin for unforeseen maintenance. However, in March NASA told GAO that in spite of decreasing the anticipated flights to 51, NASA is no longer projecting a cargo shortfall. What changes have occurred to cause NASA to reduce the number of flights without having any impact on estimated cargo needs?

ANSWER: The main factors influencing NASA's cargo requirements projection are: 1) equipment on board ISS is lasting longer than originally anticipated; and 2) the Agency's conservation efforts have enabled a reduction in the projected fuel requirements for ISS.

12. How is NASA coordinating with the new National Lab management entity, and are there management issues or NASA funding constraints that could limit or restrict the ability to fully utilize the ISS National Lab?

ANSWER: NASA coordinates with CASIS, the ISS National Laboratory management organization, through the ISS Program Office and the Human Exploration and Operations Mission Directorate. CASIS coordinates its flight planning, payload development, and research operations with the ISS Program Office, and its strategic guidance, management policies, and program planning with HEOMD. NASA is not aware of any management issues or funding constraints that could limit or restrict the ability to fully utilize the ISS National Lab.

13. Who pays for the launch costs for experiments that are flown by the academic institutions and other non-NASA researchers?

ANSWER: NASA will pay for the launch costs of experiments flown by academic institutions and other non-NASA researchers involved in the ISS National Laboratory.

a. If CASIS is successful in increasing the research demand on the ISS, what impact if any would that have on NASA's budget?

ANSWER: NASA's budget already assumes that the Agency will pay for launch and on-orbit utilities costs for the users of the ISS research capacity

allocated to the National Laboratory, as managed by CASIS. NASA will take into account the demand for access to ISS in determining future budgets for research.

14. GAO's written testimony noted that NASA has developed a method and statistical process to determine the expected lifetimes of replacement parts. Are ISS critical spare parts already in inventory so they could be available on short notice (assuming there is rocket to carry them), or are there critical spares that do not exist yet that will be funded in future budgets? If so, what are those?

ANSWER: NASA has spare Orbital Replacement Units (ORU's) either on-orbit, in inventory on the ground, or in the procurement process for all systems to meet safe operations to 2020 based on the current models for life expectancy, except for one. NASA is in the process of evaluating the cause of the ammonia pump failure that occurred in August 2010. If the cause of the failure is determined to be systematic, the 3 replacement ORU's currently on-orbit are likely to be insufficient to meet safe operations to 2020. If the cause is determined to be a unique event, the current ORU's on-orbit would be sufficient. If the cause is systematic, NASA would evaluate if it would be cost-effective to build and manifest the same design, or if it would be more cost-effective to design and build a new configuration. In either case NASA is evaluating whether or not the current pump package or a new configuration could be accommodated on currently available cargo vehicles.

15. To what extent do NASA's research requirements impact or constrain the operations and management of the ISS National Laboratory?

ANSWER: At present, there are no resource conflicts between NASA research resource requirements and ISS National Laboratory utilization.

a. How will NASA allocate the capacity on cargo flights to prioritize between NASA's own research needs and those of the ISS National Lab?

ANSWER: NASA develops and integrates the cargo manifest across the partnership and across the multiple partner cargo vehicles including Progress, ATV and HTV. NASA is also beginning to develop and integrate the manifest for the upcoming SpaceX and Orbital CRS missions. NASA takes into consideration actual on-orbit needs and performance as well as increment science priorities as established by the COUP (Consolidated Operations and Utilization Plan). These needs and requirements are then balanced against the flight readiness and capabilities of the individual flight vehicles. NASA works across the partnership and science stakeholders, including National Lab users, to ensure that their needs and priorities are being met.

16. NASA's testimony reveals that the agency no longer assumes the availability of the European Automated Transfer Vehicle (ATV) after 2014. Since the A TV has been used to carry propellants how does NASA plan to do without

this capability?

ANSWER: NASA does not require the capabilities of the ATV after 2014, and the remaining ATVs to be flown to ISS will supply the Station's propellant needs. After that, the ISS partnership will use Russian Progress cargo vehicles to deliver propellant to the ISS and to conduct ISS reboosts.

a. The European contribution to ISS amounts to 8.3 percent, so if ESA doesn't provide ATV after 2014 what type of contribution will ESA make?

ANSWER: NASA is in early discussion with ESA to provide an alternative barter acceptable to NASA and ESA.

17. Since crew availability as a significant constraint to the productivity of the ISS National Laboratory, how does NASA plan to address this constraint, and how significant will it be going forward?

ANSWER: Even with six crewmembers aboard ISS, crew availability is a constraint on research. NASA and its partners are working to decrease the amount of crew time required to conduct experiments by using crewtime more efficiently, by increasing the autonomy of the experiments, and by enabling ground-based scientists to conduct their research through improved downlinks and uplinks with ISS. The ISS Program Manger has made using crew time for research the highest priority, and now requires justifications for operations and maintenance activities that would impact crew time for research. To the maximum extent practical, "housekeeping" systems involving redundant tasks are being automated to reduce crew time requirements and free up additional crew time for research. Finally, the ISS Program is examining options for evolving to a seven-person crew in the future so the additional crew time can be made available to support research.

18. Are there critical spares or other components that are too big and heavy for the capabilities being contemplated by the CRS (Commercial Resupply Service) providers?

a. If so, please list them, and describe the contingency plans NASA has to ensure the overall health of the ISS thru 2020?

ANSWER: With the exception of a replacement radiator and batteries, all other critical spares that might be required by ISS can be launched with the CRS vehicles, and the heavy batteries that might be required for Station can be launched externally on Japanese HTVs. Even in the case of the radiator, NASA is reviewing the prospects for breaking the radiator into component pieces that can be launched on separate vehicles.

b. If necessary, could the ATV (Automated Transfer Vehicle) or HTV (H-

11 Transfer Vehicle) or Progress vehicles carry the largest and heaviest components?

ANSWER: Please see response above.

19. **Do the Russians have the industrial capacity to produce additional launch systems after 2016 to satisfy crew transportation demand if commercial crew systems or the Space Launch System (SLS) and Orion are not ready?**

ANSWER: The Russians have the industrial capacity to produce additional launch systems after 2016 to satisfy crew transportation demand if U.S. systems are not ready, though NASA would have to provide notice well in advance of the intended launch timeframe in order to ensure the availability of the Soyuz spacecraft.

20. **When would NASA and the international partners need to decide on extending the life of the ISS?**

ANSWER: The decision to extend ISS Operations beyond 2020 will need to be made well before 2020 to enable a smooth continuation of the program.

a. **Please describe the actions that would be necessary in the next few years to enable NASA to extend the ISS beyond 2020.**

ANSWER: NASA is currently looking at the technical feasibility of extending the life of the ISS beyond 2020; this effort is aided as the commercial partners continue to gain on-orbit experience with the Station's structure and systems. In addition to certifying ISS' systems to operate beyond 2020, the decision to extend the life of the vehicle would require multilateral agreement among the Station partners. If the ISS is extended, NASA would prefer to have procurements in place by the end of FY 2017.

Questions for William Gerstenmaier
From Ranking Member Eddie Bernice Johnson
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Given the limited resources we have available, we need to better understand our national objectives in using the ISS.**
   a. **What are NASA's three highest priority objectives for utilizing the ISS before 2020 and what is the status of your progress on meeting those objectives?**

ANSWER: NASA's highest priorities for utilizing the ISS are (1) meeting international commitments so that all International Partners succeed in advancing research that benefits humanity, (2) NASA's exploration mission driven research in biophysical sciences and spacecraft technology, and (3) applied research in the U.S. national interest that demonstrates the practical benefits of orbital space stations.

The recent "International Space Station Benefits for Humanity" publication (http://www.nasa.gov/mission_pages/station/research/benefits/index.html) highlights the partnership's progress in using the ISS to improve life on Earth in the areas of human health, Earth observation and global education. NASA's exploration driven research encompasses both the human research program, which is steadily addressing the risks associated with future human exploration (see question 3), and the technology development program, which is utilizing the ISS to demonstrate enhanced communications, environmental control and life support, power and propulsion, advanced materials and visiting vehicle technologies. Finally, the ISS as a National Laboratory provides space-based opportunities for advancing the nation's basic and applied science and technology interests to other U.S. government agencies, university-based researchers and private firms.

   b. **How is NASA managing ISS constraints and resources to meet those objectives?**

ANSWER: NASA integrates the utilization requirements across the ISS partnership and works with science stakeholders, including National Lab users, to ensure that their needs and priorities are being met within the available resources. Even with six crewmembers aboard ISS, crew availability is a constraint on research. NASA and its partners are working to decrease the amount of crew time required to conduct experiments by using crewtime more efficiently, by increasing the autonomy of the experiments, and by enabling ground-based scientists to conduct their research through improved downlinks and uplinks with ISS. Biomedical research on human health and performance in space uses the majority of the available crew time, not only because it is the highest priority research on the ISS, but also because in biomedical research, the crew is both the investigator and the subject. Recent agreements with our ISS partners to share access to

crewmembers, as subjects for biomedical research, and data from biomedical investigations will enable increased efficiency in the use of on orbit crewtime.

In addition, the ISS Program Manger has made using crew time for research the highest priority, and now requires justifications for operations and maintenance activities that would impact crew time for research. To the maximum extent practical, "housekeeping" systems involving redundant tasks are being automated to reduce crew time requirements and free up additional crew time for research. Finally, the ISS Program is examining options for evolving to a seven-person crew in the future so the additional crew time can be made available to support research.

c. Is there an overarching strategy that maps the experiments to human exploration mission requirements or priority scientific objectives?

ANSWER: The Human Research Program has developed an overarching space human health risk architecture that focuses its research on the highest risks associated with future human exploration missions. Crew health and performance is critical to successful human exploration beyond low Earth orbit. The Human Research Program (HRP) investigates and mitigates the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from radiation, hypogravity, and terrestrial environments, as well as unique challenges in medical support, human factors, and behavioral health support. The HRP utilizes an Integrated Research Plan (IRP) to identify the approach and research activities planned to address these risks, which are assigned to specific Elements within the program. The Human Research Roadmap is the web-based tool for communicating the IRP content (http://humanresearchroadmap.nasa.gov/).

2. **What the government pays for commercial crew and any additional cargo services in the latter part of the decade will also have a bearing on funds available for research, assuming total ISS costs continue at about the same funding level. What funding level is NASA assuming in the FY 2013 budget plan for commercial crew and cargo costs in FY 2016 and beyond?**

ANSWER: In the President's FY 2013 Budget Request, the ISS Crew and Cargo Transportation is notionally budgeted in the ISS Program, under the Space Operations account, at $1.8B in FY 2016 and $1.9B in FY 2017 (the final year of the 5-year budget runout). In addition, the Commercial Crew Program, under the Exploration account, is notionally budgeted at $829.7M per year from FY 2013 through FY 2017.

What analysis are the commercial crew and cargo costs beyond FY 2016 based upon, given none of the commercial systems have yet flown?

ANSWER: In order to reduce program risk, NASA has budgeted for commercial crew seats using the current Soyuz contract as a basis of estimate. There continues to be a lot of uncertainty regarding the ultimate commercial crew seat cost since this program is in the early stages of development and there are a wide variety of potential providers with different approaches. This approach to budgeting for commercial crew seats protects NASA should commercial crew be delayed and provides flexibility to address the uncertainty in costs. The current Commercial Resupply Services (CRS) contract was used as a basis of estimate for cargo transportation in FY 2016 and beyond.

3. **In 2007, NASA prepared a Human Research Plan for the ISS that identified key risks and the anticipated timeframe required from the ISS to address the risk and validate countermeasures.**
    a. **What is the status of retiring the risks identified in that 2007 plan? Have you updated it?**

ANSWER: NASA has implemented the ISS flight studies identified in the 2007 plan and made significant progress understanding and mitigating the health risks associated human space flight. Significantly, NASA has made progress in the following areas: 1) understanding how to manage space-induced bone and muscle loss by using new exercise protocols and pharmaceutical and nutritional countermeasures; 2) behavioral and performance risks associated with sleep disruptions and monitoring of crewmember alertness; 3) demonstrating exploration medical capability including in-flight IV fluids production; 4) management of crewmember orthostatic intolerance; 5) added new ISS biomedical capabilities including the second-generation ultrasound for medical imaging, the urine monitoring system, the jointly developed ESA/NASA muscle atrophy research and exercise system, and Portable Pulmonary Function System; and 6) identified a significant health risk visual impairment/intracranial press (VIIP) that has been already incorporated into future ISS flight plans.

Since the 2007 Human Research Plan, HRP has completed and started the following ISS flight experiments:

Completed

- ISS Urine Monitoring System (UMS)
- ISS Ultrasound 2 to provide high-resolution biomedical images
- Evaluation of Commercial Compression Garments to Prevent Post-Spaceflight
- Orthostatic Intolerance
- Sleep-Wake Actigraphy and Light Exposure During Spaceflight
- Behavioral Issues Associated with Long Duration Space Expeditions: Review and Analysis of Astronaut Journals
- Spinal Elongation and Its Effects on Seated Height in a Microgravity

Environment
- Surface, Water, and Air Biocharacterization- A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment
- Cardiovascular and Cerebrovascular Control on Return from ISS (NASA managed and implementation in agreement with CSA)
- Intravenous Fluid Generation for Exploration Missions

Started and On-going
- Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration
- Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise
- Capacity, and Risk of Cardiac Arrhythmias
- Maximal Oxygen Uptake During Long Duration International Space Station Missions
- Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss
- Validation of Procedures for Monitoring Crewmember Immune Function
- Nutritional Status Assessment
- Physiological Factors Contributing to Changes in Post-Flight Functional Performance
- An Integrated Resistance and Aerobic Training Study for the Validation of an
- Exercise Countermeasures Regimens Aboard the International Space Station
- Biomechanical Analysis of Treadmill Exercise on the International Space Station
- Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism During Spaceflight and Recovery

Currently, HRP is conducting 14-16 studies per increment with an additional 5-6 experiments in definition phase being prepared for flight. Results are made available as soon as practical, given the investigator's right to publish. Results are published in technical journals, NASA technical publications, and the HRP Evidence Books. In FY 2011, NASA flew 11 major medical experiments to optimize exercise, nutrition and sleep to evaluate the immune system and other human health areas to make exploration missions healthier, safer, and more productive. NASA completed two of these ISS research studies and initiated three new studies.

NASA is continually updating both its strategic and tactical ISS flight plans to optimize ISS experiment throughput and maximize crew participation in biomedical flight experiments. The HRP strategic flight plans associated with each risk area are contained in the Integrated Research Plan (IRP). The IRP is available via the Human Research Roadmap (http://humanresearchroadmap.nasa.gov/) and is updated on a yearly basis.

The tactical ISS flight plans list the current and planned human research experiments that will be undertaken in each ISS increment and is updated continually throughout the year. The tactical ISS flight plans, or ISS Fly-Off plan, is available at the ISS Medical Project website (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-issmp.html).

b. Do you have similar plans and timelines for technology development and scientific research? If not, why not?

ANSWER: NASA's HRP maintains a comprehensive research plan, called the Integrated Research Plan (IRP), which includes both flight and ground experiments and facilities. The IRP is available via the Human Research Roadmap (http://humanresearchroadmap.nasa.gov/). The Integrated Research Plan lays out for the scientific community the expected progression of research and technology tasks intended to address critical questions that must be answered to quantify the risks or develop mitigation strategies for the risks as they relates to the overall exploration mission campaign plans. The HRP research and technology activities are performed on ISS either because there are no effective ground-based analog environments to conduct the work on Earth, or the research activity needs the complete operational environment of space flight to validate the countermeasure or technology. The ISS is necessary to mitigate 22 of the 31 human health risks in the HRP portfolio.

4. **I understand that NASA is encouraging prospective researchers using the Station to develop experiments that can be performed autonomously and do not require crew intervention and participation. Since these researchers are likely to be more knowledgeable in their own field than on automated support technology, what is NASA doing to assist in transferring its knowledge of automated support mechanisms to the research community?**

ANSWER: Extensive automation of flight experiments does require more complex designs and more expensive experiment systems. To date, NASA has accommodated ISS investigators primarily in NASA-built experiment systems. As the ISS National Laboratory concept matures, the capabilities of the payload development contractors who plan to support on-orbit research will need to evolve to build more complex experiments. NASA and the ISS National Laboratory management organization, the Center for the Advancement of Science in Space, are holding information exchange meetings to identify resources and establish interfaces that will enable National Laboratory participants to access the expertise available at NASA field centers.

5. **GAO reported last December that NASA had not attempted to develop techniques or equipment to conduct x-ray or sonographic inspection of the ISS because doing so would be expensive, impractical, or both. Can you elaborate on the size of those costs and what makes them**

impractical?

ANSWER: During NASA's investigation into methods for evaluating the ISS structural components, it became clear that methods such as x-ray or sonographic inspection would entail removal of ISS ORU's and other equipment from the base structure in order to accommodate inspection devices. This was deemed impractical and cost prohibitive, as the ISS was not designed to be stripped of its equipment on-orbit and inspected by such means. As a result, NASA has employed thorough analytical methods to assess structural life.

Questions for William Gerstenmaier
From Congressman Dana Rohrabacher
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Given that grants to U.S. universities are the primary mechanism for funding peer-reviewed biological and physical science research, why out of $3B operations budget for FY 2012 is only $9.6M being used for grants and principal investigator support?**

   ANSWER: The total FY 2013 budget request for ISS is $3.0B, full cost. Less than half of the FY 2013 ISS budget, $1,493.5M, is for ISS Systems Operations and Maintenance. The ISS Crew and Cargo Transportation budget is $1,284.8M. The remaining budget of $229.3M is for ISS Research and includes three major categories: Multi-User System Support (MUSS), the Non-Profit Organization (NPO), and biological and physical research.

   The MUSS budget, $154.0M, provides strategic, tactical, and operational support to all the NASA sponsored payloads and non-NASA sponsored payloads, including international partner research payloads. This budget incorporates maintenance and operation of the ISS research infrastructure, including research integration, payload engineering, payload integration, payload operations payload systems support etc. The $15M NPO budget supports the Center for the Advancement of Science in Space (CASIS) and will likely also fund some grant activity. The biological and physical research budget, $60.3M, is comprised of grants, principal investigator funding and grant support such as hardware development, civil servant and contractor labor, and other activities required of the grantees in order to conduct their research on ISS. Of the $60.3M for biological and physical research, approximately $15M is being applied to grants and principal investigator support in FY 2013.

   There are several other budgets outside of ISS which also contribute to research and technology demonstrations on ISS. For example, NASA's Human Research Program is providing approximately $30M in ISS research support. The Office of Chief Technologist (OCT), Advanced Exploration Systems (AES), and Space Communications and Navigation (SCaN) are also funding technology activities which will ultimately be demonstrated on ISS. It should also be noted that the experience of maintaining and operating a system such as ISS is, in and of itself, providing valuable research for future exploration missions.

2. **In NASA's FY 2013 ISS budget, how much is allocated for biological and physical research university grants, and how does that compare with FY 2012?**

   ANSWER: The biological and physical research budget in FY 2012 is $58.3M (excluding MUSS and NPO), and approximately $12M will be

awarded directly for grants. The planned biological and physical research budget for FY 2013 is $60.3M, of which ~$15M will be awarded in grants.

3. **What is the rationale for managing Biological and Physical Research as part of the ISS operations budget?**

ANSWER: The near term strategic goal of ISS Research is to conduct a program of scientific research endorsed by the research community and focused on the accomplishment of outstanding scientific objectives. ISS biological and physical research is dependent on ISS operations for success. The Space Life and Physical Sciences, Research and Applications (SLPSRA) Division has management of biological and physical research and the ISS program has the responsibility for operating the vehicle and managing ISS utilization for NASA and its partners. Retaining the ISS biological and physical research budget within the overall ISS budget is reflective of this symbiotic relationship and supports collaboration between the two offices.

Questions for William Gerstenmaier
From Congressman Randy Neugebauer
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **If current projections and timelines for commercial crew and Orion do not pan out, will we still be relying on Russian Soyuz after 2016? Do we have a guarantee that the Soyuz will be operational at that time?**

   ANSWER: If U.S. commercial vehicles and Orion MPCV are unavailable beyond 2016, then NASA would continue to purchase Soyuz seats for crew transportation and rescue purposes, as the agency has been doing for several years, assuming appropriate INKSNA modification and pending sufficient contracting lead time. NASA anticipates that Soyuz vehicles will still be operational at that time; they continue to be the Russians' only crew-carrying spacecraft.

   a. **What consideration has NASA taken in the potential for a change in agreements with the Russians based on geopolitical tension or frayed international relations?**

   ANSWER: The Russians have proven to be very reliable partners in the ISS Program; their efforts to provide additional Soyuz transportation in the aftermath of the 2003 Columbia Shuttle accident enabled the partnership to continue operating the Station. However, the continuing reliance of the U.S. on an international partner for crew transportation and rescue services underscores the importance of developing domestic commercial crew services as soon as possible.

2. **What are your projections, assessments, and predictions for the future of the ISS past its current timeframe of 2020?**

   ANSWER: NASA is currently looking at the technical feasibility of extending the life of the ISS beyond 2020 – possibly to 2028. This effort is aided as the partners continue to gain on-orbit experience with the Station's structure and systems. In addition to certifying ISS' systems to operate beyond 2020, the decision to extend the life of the vehicle would require multilateral agreement among the Station partners.

Questions for William Gerstenmaier
From Congressman Brad Miller
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. In February, the executive director of CASIS (Dr. Jeanne L. Becker) resigned from her position citing serious concerns regarding the relationship of ProOrbis, a for profit consulting firm, with CASIS. She cited pressure from some NASA officials, an unnamed congressional staffer and Space Florida board members for CASIS to pursue engagements with ProOrbis. This was despite a legal opinion from CASIS's attorneys stating that CASIS's continued involvement with ProOrbis could jeopardize CASIS's non-profit status. These are very serious allegations.

a. What NASA has done to look into these allegations?

ANSWER: NASA's Office of the Inspector General is reviewing this matter.

b. Has NASA contacted the NASA IG about this?

ANSWER: NASA is aware that the NASA IG is reviewing aspects of the CASIS cooperative agreement and is providing all requested information to the IG.

c. CASIS was hired by NASA to manage the U.S. National Laboratory on the ISS. Can you provide us with any insight into why NASA or other interested parties would interfere with CASIS's ability to carry out its duties to manage the ISS Laboratory or attempt to interfere with the organization's ability to carry out its mission?

ANSWER: NASA fully supports CASIS' management of the National Laboratory aspects of the ISS and looks forward to transitioning the existing National Lab Memoranda of Understanding and Space Act Agreements over to CASIS.

d. What is NASA's legal opinion as to whether having Pro Orbis involved with CASIS is a conflict-of-interest?

ANSWER: Based on the known facts, NASA is not aware of any organizational conflicts of interest. Civil servants prepared the Cooperative Agreement Notice. Although ProOrbis prepared the reference model, this information was publicly available and proposers could elect to adopt portions of the reference model and/or include ProOrbis as a team member in their proposal.

e. Is there anything else you can add about how NASA is handling this situation, ensuring that these allegations are investigated thoroughly and helping CASIS gets back on track quickly?

ANSWER: NASA is working to ensure that CASIS continues to move forward

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

March 21, 2012

Reply to Attn of: Human Exploration and Operations Mission Directorate

Mr. Frank DiBello
President and CEO
Space Florida
P. O. Box 656
Cape Canaveral, FL 32920

Re: Response to Mr. Frank DiBello regarding Notification of Actions Following Dr. Becker's Resignation

Mr. DiBello:

Thank you for the explanation of the actions the interim board anticipates taking as a result of Dr. Becker's resignation as the Executive Director of Center for the Advancement of Science in Space (CASIS). According to your plan, the Board had established an Executive Office of the Chairman within CASIS, and has asked Mr. Jim Royston to serve as the Interim Executive Director. Nevertheless, the National Aeronautics and Space Administration (NASA) has several concerns that must be mutually addressed. Continuation of the cooperative agreement is dependent upon demonstrated performance under the agreement.

Section 4.1 of the Cooperative Agreement defines the Executive Director of CASIS as the Principal Investigator (PI) for this agreement. Section 4.7 of the Cooperative Agreement provides that "significantly reduced availability of the services of the PI named in the grant could be ground for termination, unless alternative arrangements are made and approved in writing by the Grant Officer." In addition to approving a change in the PI, the NASA Grants Officer must approve the alternative arrangements made by the CASIS interim board during this transition period. The specific clauses of the cooperative agreement are copied below.

Moreover,.the functions identified in the Cooperative Agreement and the milestones in the Annual Program Plan (APP) are critical given the limited amount of time remaining to do research on the International Space Station (ISS). NASA would like assurances from the Board that CASIS will be able to meet the milestones in the APP. The agency also requests the interim board explain in writing how these milestones will be met.

Additionally, per the NASA Authorization Act of 2010, "the cooperative agreement shall require the organization entering into the agreement to engage exclusively in activities relating to the management of the ISS National Laboratory..., without any other organizational objectives or responsibilities on behalf of the organization or any parent organization or other Entity." Your interim plan appears to involve the efforts of a member of

the interim CASIS Board of Directors in the daily operations of CASIS. Depending on the authority of this position, this may create a conflict of interest with the fiduciary responsibilities of the Board to oversee CASIS. You have explained verbally how this apparent conflict of interest can be resolved. This needs to be documented in writing and sent to the grants officer for evaluation.

NASA's primary focus for CASIS is to increase value to the nation by utilization of the ISS for other than NASA sponsored research. I appreciate the recent discussions and interactions, and request that you follow up those discussions with Bradley Carpenter and the Grant Officer by written formal response to the topics raised in this letter by March 28, 2012.

Sincerely,

William H. Gerstenmaier
Associate Administrator
for Human Exploration and Operations

Enclosure

From NASA Cooperative Agreement NNH11CD70A dated August 31, 2011.

4.1 General Definitions

4.1.1 "Principal Investigator" shall be deemed to mean "Executive Director" for purposes of this Cooperative Agreement.

4.7 CHANGE IN PRINCIPAL INVESTIGATOR OR SCOPE (OCTOBER 2000) [1260.25]

(a) The Recipient shall obtain the approval of the NASA Grant Officer for a change of the Principal Investigator, or for a significant absence of the Principal Investigator from the project, defined as a three month absence from the program or a 25 percent reduction in time devoted to the project. Significantly reduced availability of the services of the Principal Investigator(s) named in the grant instrument could be grounds for termination, unless alternative arrangements are made and approved in writing by the Grant Officer.

(b) Prior written approval is required from NASA if there is to be a significant change in the objective or scope.

CASIS℠

Center for the Advancement of
SCIENCE IN SPACE

March 28, 2012

Mr. Bradley Carpenter
Grant Officer – CASIS Cooperative Agreement
Human Exploration and Operations Mission Directorate
National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

Re: Formal Response to the topics raised in your Response to Mr. Frank DiBello regarding Notification of Actions Following Dr. Becker's Resignation, dated March 21, 2012.

Mr. Carpenter:

Thank you for your quick and concise response to our explanation of the actions taken and proposed by the Interim Board following Dr. Becker's resignation as the Executive Director of the Center for the Advancement of Science in Space (CASIS). With this formal response, the interim board addresses the several concerns raised by NASA in the referenced letter, and to which we concur, must be mutually addressed.

The Interim Board understands that continuation of the Cooperative Agreement is dependent upon demonstrated performance under the agreement. We, also, understand that the Cooperative Agreement defines the Executive Director of CASIS as the Principal Investigator (PI) for this agreement and that in addition to approving a change in the PI, the NASA Grants Officer must approve the alternative arrangements made by the CASIS Interim Board during this transition period. This approval must be in writing by the Grant Officer.

Respective to the preceding paragraph we request formal approval from you of our action to have Mr. Jim Royston assume duties as the Interim Executive Director for a limited period, during which a nationwide search is being conducted to select a permanent Executive Director. Mr. Royston will fulfill these duties as a full time employee of CASIS reporting to the Board. Once a permanent Executive Director is selected, Mr. Royston will return to his former duties as the Director of Strategy & Planning.

We do wish to modify our proposed action of creating an Executive Office of the Chairman within CASIS. Given the benefit of further discussions and evaluation of the need to provide additional capacity within CASIS management, we no longer see the benefit to create such an office given that in-place management has organized to make up for their recent loss of personnel and has added sufficient additional resources with appropriate management and scientific credentials. We therefore withdraw the proposal of assigning a member of the Interim Board with daily advisory operational duties within CASIS.

In addition, we believe it is a benefit to the management of CASIS both in appearance and in fact, that we seek to transition the CASIS Interim Board to a more independent membership profile in the spirit of the Reference Model as soon as is practical, while the formal selection process for the initial Permanent Board is in process. Specifically, we propose that, in consultation with you, we would replace current members Ms. Denise Swanson and Mr. Howard Haug with new qualified individuals with strong experience and backgrounds that would match the profiles of a managing member and a scientific member. If you concur, we will communicate with you and keep you informed of our progress with this action.

Lastly, we agree that the functions identified in the Cooperative Agreement and the milestones in the Annual Program Plan (APP) are critical and, based on our review of performance to date, we believe that CASIS will be able to meet the milestones defined in the APP for this reporting period.

CASIS℠
Center for the Advancement of
SCIENCE IN SPACE

The following are key elements of performance that we will report on at the end of the initial first two quarters of operation. In general, they represent progress on the key goals of facing the market, finding new customers for the ISS, and standing up the organization to service existing and new markets:

Technical /Operational ... ... Engaging and Servicing New Customers:

- A Selection process for the full Initial Board has been approved and is underway.
- A plan for selection of the permanent Science Collegium has been developed and is ready for implementation by the Initial Board once selected.
- An Interim Chief Scientist has been appointed.
- An Interim Scientific Collegium (ISC) has been created and is in operation.
- ISC analyzed 132 ISS experiments, identified pathways that are most promising and facilitate a shorter cycle to practical use.
- Three major pathways identified, with sub-pathways defined, based on market place analysis.
- Outreach has been initiated to marketplace customers with near-term potential for flight programs in the pathways of interest.

Performance Metrics ... ... CASIS Implementation:

- Organizational policies, procedures and protocols are defined and implemented.
- Organizational staffing currently at 20, representing approximately 60 percent of plan.
- A Valuation and Prioritization methodology is developed and is being tested with both theoretical and actual experiments.
- An initial capital marketplace has been established to provide an access point for potential research funding and investment.
- Member structure is defined and member software is being implemented.
- Marketplace validation is underway.
- A Program for marketplace messaging has been developed.
- Branding, communications, marketing and public relations campaigns are developed and being implemented.
- Existing ISS National Lab user's agreements are being transitioned and are being finalized.
- Customer Service offerings and procedures have been developed and servicing of existing User Agreements has begun.
- A "new user" agreement has been developed and is being negotiated with a "new" first flight payload customer.
- Website is in beta testing. Should be fully functional by mid-April.

I thank you again for your consideration and response to our request. If you have any questions or wish us to address additional matters please don't hesitate to contact me directly.

Sincerely,

Frank A. DiBello
Chairman, CASIS Interim Board

Cc: William Gerstenmaier, NASA HQ

CASIS 032812-jk-hh-fd

888.641.7797 • www.iss-casis.org
Headquarters: **Space Life Sciences Laboratory • Kennedy Space Center, FL 32899**
7000 Fannin Street, Suite 1950A • Houston, TX 77030

Manager of the International Space Station U.S. National Laboratory

March 28, 2012 hearing. *Securing the Promise of the International Space Station: challenges and Opportunities.*

Here is the answer on Rep. Miller's question. Best regards,
Tom

Question:
(The) Procurement Integrity Act prohibits former federal officials who oversaw certain procurements from going to work for the contractor that they awarded contracts to. NASA is using Space Act agreements extensively in the acquisition of commercial crew capabilities. Is it correct that the post-employment restrictions of the (Procurement) Integrity Act do not apply to Space Act Agreements? If the post-employment restrictions of the (Procurement) Integrity Act do not apply to Space Act Agreements, do you think Congress should make them apply?

NASA Response:
The post-employment restrictions of the Procurement Integrity Act (41 USC § 423, as amended), which prohibit former Federal employees who perform certain duties related to Federal contracting from accepting a position with a contractor benefiting from particular agency decisions for a year, only apply to government contracts to obtain goods or services under Title 41 of the U.S. Code. Accordingly, they do not apply to grants, cooperative agreements, and other instruments to which the U.S. Government is a party such as Space Act agreements. We note additionally that NASA is not using Space Act agreements to acquire commercial crew capabilities, but to support the development of commercial services that could eventually provide access to low-Earth orbit. However, the broad restrictions on post-employment representational activities contained in 18 U.S.C. § 207 apply with equal force to contracts and Space Act agreements, and in NASA's experience are more likely to result in restrictions affecting an employee's post-employment options than the restrictions in the Procurement Integrity Act. Accordingly, NASA believes that the post-employment restrictions contained in 18 U.S.C. § 207 provide appropriate protection for the U.S. Government for non-procurement matters, such as Space Act agreements.

to fulfill its responsibilities to stimulate, develop, and manage the national use of the ISS, and is fully cooperating with the review by the NASA IG. NASA is assessing the progress made by CASIS in standing up their organization and establishing an initial research portfolio, and will be working with CASIS management to correct any shortcomings that may be identified.

f. How do you believe these recent events may impact the management of the scientific projects anticipated for the International Space Station?

ANSWER: At present, no long-term impact to the management of the ISS National Laboratory is anticipated. Planned work like the review of biological and biomedical research opportunities has been completed on schedule, and other planned activities, such as the 2012 research solicitation, are on schedule. Working with a nationally known executive search firm, the interim CASIS Board of Directors has identified candidates for the new Board, and the new Executive Director. The new Board is expected to be in place this summer, and will be responsible for selecting the new Executive Director.

Responses by Mrs. Cristina Chaplain

Questions for Cristina Chaplain
From Chairman Ralph M. Hall

March 28, 2012 Hearing on
Securing the Promise of the ISS—Challenges and Opportunities

1. **What do you think are the most important aspects for NASA to consider as it tries to balance its own research priorities against those of the ISS National Lab?**

   In our 2009 report, we expressed concern that the ISS lacked one central body that oversees the selection and prioritization of all U.S. research and that could strategically decide what research should be conducted and at what time. NASA has since awarded a cooperative agreement with the Center for the Advancement of Science in Space (CASIS) to serve as the not-for-profit entity for management of the ISS National Laboratory. According to this agreement, CASIS will prioritize National Laboratory research using a fair, transparent, and impartial selection process that maximizes the value of the ISS investment.

   While the responsibilities assigned to CASIS are important, this body will not be responsible for managing research on the entire U.S. portion of the ISS. As such, while CASIS may identify valid, meritorious research projects and match those projects with funding opportunities, the Center will only be responsible for National Lab payloads. NASA, however, may opt to prioritize different research or to prioritize different payloads. In order to support the user community managed by CASIS, NASA should ensure that the method for prioritizing research on the U.S. portion of the ISS is transparent. Additionally, NASA should minimize deferment of vetted and funded National Laboratory research in order to carry out the agency's own priorities.

2. **According to GAO's testimony, in 2011 NASA anticipated 56 flights to the ISS between 2012 and 2020 and would likely be at risk of a shortfall to cover all of the national laboratory demands and margin for unforeseen maintenance. However, NASA recently told GAO that in spite of decreasing the anticipated flights to 51, NASA is no longer projecting a cargo shortfall. How did NASA justify a reduction in the number of flights without having any impact on estimated needs of the ISS for cargo?**
   a. What, if any, additional information is needed to ensure they have conducted sound analysis?

   According to NASA, several factors played a part in its justification that fewer flights would be needed through 2020:

   - The ISS program does not require as much overall cargo capacity in 2012 as originally anticipated because the ISS and its crew are not using as many supplies and consumables as NASA anticipated.

- NASA built overlap into the 2012 commercial launch. For example, the agency is planning for both Orbital and SpaceX flights in December 2012. However, NASA anticipates only one of the two vehicles will launch. NASA purposefully built in this schedule margin so the agency could use one or the other if the competitor was not yet ready to fly or choose just one if both were ready to fly. NASA is highly unlikely to need both flights so close together, as the flights are actually scheduled only 1 day apart. Consequently, the vehicle that does not fly will be launched in the following year, 2013. In turn, the other 2013 launches will be pushed to later dates because the agency will have more cargo capacity than initially planned. NASA anticipates this domino effect will impact launches and associated cargo capacity through 2016.
- NASA needs less cargo space for National Lab cargo than anticipated. When we discussed cargo demand with NASA in 2011, the agency had not yet planned for the National Lab's dedicated cargo space on individual flights. Once NASA planned for the National Lab cargo space by individual flight and spread that capacity over several launches, the agency found it needed less cargo space than originally expected.

Updated information, consisting of NASA's regularly updated cargo analyses, is necessary to verify information about the number of flights NASA anticipates and the amounts and types of cargo they will carry. NASA plans vehicle flights and associated cargo in a tactical time frame (about 18 months in advance) and a strategic time frame (currently beyond 2013). The agency updates those cargo analyses, at minimum, every 3 months, based on launch vehicle availability and ISS needs for consumables, supplies, and hardware spares. Therefore, the most recent analyses are the best sources of accurate information.

Questions for Cristina Chaplain
From Ranking Member Eddie Bernice Johnson

March 28, 2012 Hearing on
Securing the Promise of the ISS—Challenges and Opportunities

1. **GAO reported last December that it was satisfied that NASA had reasonable approaches for ensuring ISS utilization through 2020. Does GAO know of any comparable situations in other federal agencies that would provide confidence in NASA's approach? Are you concerned about the current level of utilization?**

   Ensuring that the ISS can be effectively maintained through 2020 within the normal range of human spaceflight risk presents NASA with unique challenges that are not directly comparable to situations in other federal agencies. However, as discussed in our December 2011 report, the statistical process and methodology used by NASA to estimate the expected lifetimes of replacement units is a sound and commonly accepted approach within the risk assessment community that considers both manufacturers' predictions and the systems' actual performance. We found that this process has been widely used by NASA to update failure rates for components on numerous programs, including the Space Shuttle, the Hubble Space Telescope, and the TDRSS family of satellites.

   Similar methodologies are also used by other government agencies and industry.

   - The Nuclear Regulatory Commission employs the Bayesian estimation process to update the failure rates of components in nuclear power plants.
   - The oil and gas industry employs the Bayesian estimation process to update the failure rates of pressure vessels and other types of equipment at industrial oil and gas facilities.
   - The Food and Drug Administration has developed guidance for the assessment of medical device effectiveness based on the Bayesian estimation process.

   At the time of our 2009 review of ISS utilization, NASA projected that it would use about half of the ISS research facilities for its own experiments. Limiting factors to research on the ISS include the availability of transport vehicles and the cost of transporting research cargo to the ISS in orbit. Until affordable transport vehicles are available, the scientific research capabilities of the ISS are unlikely to be fully utilized.

2. **GAO's 2009 report on ISS utilization concluded that *"A viable user base will not develop without sufficient launch opportunities to permit recurring access, consistent funding opportunities, sufficient crew time to conduct research, and longevity of the ISS."* From your perspective, does NASA have today sufficient launch opportunities, consistent funding opportunities, and sufficient crew time to develop a viable user base?**

Overall, our perspective is that without the successful development of new affordable crew and cargo transport vehicles, the ISS is unlikely to ever be fully utilized.

Launch:
Due to the retirement of the Space Shuttle and the current absence of an alternate commercial launch capability, NASA's ability to support launches to and from the ISS are further reduced from what we reported in 2009. In an active NASA Research Announcement (NRA) funding announcement to potential ISS researchers that is up for selection on May 21, 2012, NASA states "with the end of the Space Shuttle Program, the timing of definite flight opportunities cannot be assured at this time. This NRA is therefore constructed to be dependent upon those flight opportunities to ISS that present themselves (ATV, HTV, Progress, Soyuz, Dragon, and Cygnus)." Another active NRA states that "alternative access to space may include spacecraft or payload accommodations on a U.S. - or foreign-manufactured spacecraft launching on a U.S. - or foreign-manufactured launch vehicle." Until the commercial launch vehicles come on-line, launch will continue to be an issue for ISS researchers. Further, as we reported in 2009, none of the commercial launch vehicles nor Soyuz have the upmass and downmass capabilities of the Space Shuttle, so researchers will continue to be constrained to the available space on these other vehicles, which will have competing NASA demands.

Funding:
We have not conducted any new audit work specifically in this area since our 2009 report. However, according to NASA, funding for the agency's research goals is provided via NRAs, while funding for researchers who wish to utilize the National Laboratory portion of ISS is sought from other government agencies, academia, and the private and non-profit sectors. NASA lists NRA opportunities for researchers on its website, and there are currently four announcements (one for human research, one for life and physical sciences, and two for earth and space science). There are currently no open funding opportunities for Technology Development and Demonstration. We do not know what the availability is of non-NASA funding for ISS research.

Crew Time:
We have not conducted any additional audit work specifically on the issue of crew demands since our 2009 report. However, the size of the crew on board the ISS is constrained at six based on safety constraints, and demands on the crew's time are split amongst many activities beyond research that will likely remain unchanged (e.g., eating, sleeping, training, etc.). Additionally, crew will continue to have demands placed on their time by international partners and NASA-sponsored research. As such, crew time will likely continue to be a constraining factor for all ISS research. Additionally, if more maintenance is required as the ISS continues to age, crew time available for research could reduce further.

3. **What concerns, if any, do you have with respect to NASA's ability to obtain insight and to exercise sufficient oversight of commercial cargo and crew providers? What are the implications of projected insight/oversight processes on the ultimate goal of supporting ISS utilization?**

   Our primary concern relative to NASA's ability to obtain insight and to exercise sufficient oversight of commercial cargo and crew providers is the agency's ability to manage contracts and maintain a balanced approach to insight and oversight. Our previous work indicates that NASA has often struggled with contract management. For example, the agency's past efforts to develop new spacecraft through traditional and non-traditional contracting arrangements have often experienced cost and schedule increases and resulted in program cancellations. These past failures have been attributable to many issues, from immature requirements on NASA's part to contractors' inability to deliver on cost and schedule. The bottom line, however, is that NASA has been unsuccessful in several attempts to contract for a replacement for the Space Shuttle. NASA is currently attempting to procure crew and cargo transportation systems commercially. It remains to be seen if NASA's current approach can offer sufficient insight into contractor activities and progress to, at a minimum, ensure compliance with NASA requirements without being overly prescriptive. Without sufficient insight, NASA could lack assurance that the contractors are making the progress necessary to meet performance and safety goals, as well as the ambitious schedules they are pursuing. On the other hand, if the agency employs overly prescriptive design and reporting requirements, NASA could lose the cost and schedule benefits they are seeking via commercial procurement.

   The implications of insight and oversight are far-ranging. In the long run, having insight into cost and technology will help to minimize future costs, especially if competition is reduced. Further, appropriate levels of insight and oversight will help ensure the ambitious schedules for commercial crew and cargo transportation systems are met as the window of opportunity diminishes for utilizing these systems to support the ISS. With appropriate balance, NASA has the opportunity to foster competition and guide the development of a new generation of safe, affordable human spaceflight transportation systems. If NASA errs in its new approach, we are likely to end up with systems that are either unsafe or unaffordable, or perhaps both.

4. **NASA seems to have implemented a number of your recommendations related to utilization of ISS, namely the establishment of an entity to manage the research of the national lab. Does the establishment of this body allay your concerns about full utilization of the station? If not, why not?**

   NASA's decision to grant CASIS the authority to manage research on the National Laboratory seems to be a step in the right direction, though we have not conducted any analysis on how CASIS is set-up or how it will manage and

prioritize research. Further, as we stated in response to Question 1, NASA will still be responsible for prioritizing its own research and for prioritizing the payloads that will fly on flights to and from ISS. If limited flight opportunities result in National Laboratory research being grounded as a result of NASA prioritization, greater station utilization may be difficult to achieve.

5. **Your December 2011 report indicates that NASA has in place good practices to understand what it needs to maintain and safely operate the ISS. While I understand that NASA's processes are good, does that mean that there are no concerns/questions about the operational life of the ISS from a safety perspective?**

Human spaceflight, including operations at the ISS, will always involve risk. To assess and mitigate those risks, NASA is conducting ISS structural health assessments and in 2011 was updating ISS-related safety reviews. At the time of our report in 2011, NASA had assessed the structural health of about 40 percent, by weight, of the ISS. NASA does not expect to complete ISS structural assessments until early 2016 because most of the ISS structures have not been on orbit long enough to accumulate the data needed for analysis. Additionally, the agency was updating information on potential safety hazards and hardware component issues that could impact safe operations onboard the ISS. NASA originally documented safety hazards to both crew and station in 92 safety hazard reports applicable to ISS operations through 2015. In 2011, NASA was reassessing these reports to determine if the hazards required additional mitigation as a result of extending ISS life through 2020 and potentially beyond. According to an official working on this effort, preliminary results indicated that 58 hazard reports were affected by extending ISS life beyond 2015 and required further study. Similarly, NASA was identifying ISS hardware components, such as hoses and tubing, which must be replaced before failure because the hardware's failure could lead to loss of crew or station. According to NASA officials, preliminary results of this study indicated that some hardware components will likely require replacement or mitigation before failure, while other hardware can be used until failure because that failure would result only in degradation of functions rather than catastrophic loss of crew or the station itself.

Appendix 2

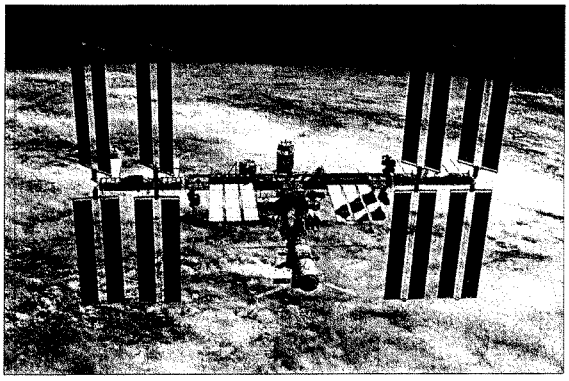
Additional Material for the Record

Appendix I: GAO Contacts and Staff Acknowledgements

GAO Contacts	For questions about this statement, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this testimony.
Staff Acknowledgements	Individuals making key contributions to this statement include Shelby S. Oakley, Assistant Director; John Warren, Tana Davis, and Alyssa Weir.

GAO's Mission	The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.
Obtaining Copies of GAO Reports and Testimony	The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's website (www.gao.gov). Each weekday afternoon, GAO posts on its website newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to www.gao.gov and select "E-mail Updates."
Order by Phone	The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's website, http://www.gao.gov/ordering.htm. Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537. Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.
Connect with GAO	Connect with GAO on Facebook, Flickr, Twitter, and YouTube. Subscribe to our RSS Feeds or E-mail Updates. Listen to our Podcasts. Visit GAO on the web at www.gao.gov.
To Report Fraud, Waste, and Abuse in Federal Programs	Contact: Website: www.gao.gov/fraudnet/fraudnet.htm E-mail: fraudnet@gao.gov Automated answering system: (800) 424-5454 or (202) 512-7470
Congressional Relations	Katherine Siggerud, Managing Director, siggerudk@gao.gov, (202) 512-4400, U.S. Government Accountability Office, 441 G Street NW, Room 7125, Washington, DC 20548
Public Affairs	Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800 U.S. Government Accountability Office, 441 G Street NW, Room 7149 Washington, DC 20548

Figure 1: International Space Station



Source: NASA.

The ISS was constructed to support three activities: scientific research, technology development, and development of industrial applications. The facilities aboard the ISS allow for ongoing research in microgravity, studies of other aspects of the space environment, tests of new technology, and long-term space operations. The facilities also enable a permanent crew of up to six astronauts to maintain their physical health standards while conducting many different types of research, including experiments in biotechnology, combustion science, fluid physics, and materials science, on behalf of ground-based researchers. Furthermore, the ISS has the capability to support research on materials and other technologies to see how they react in the space environment.

NASA planned for the space shuttle to serve as the means of transporting crew, hardware, and supplies to the ISS through the end of the station's life. However, in 2004, President George W. Bush announced his Vision for Space Exploration (Vision) that included direction for NASA to develop new spaceflight systems under the Constellation program to replace the space shuttle as NASA's primary spaceflight system. The Vision also included provisions for NASA to pursue commercial alternatives or

providing transportation and other services to support the ISS after 2010.[8] NASA established the Commercial Crew and Cargo Program in 2005 to facilitate the private demonstration of safe, reliable, and cost-effective transportation services and purchase these services commercially. When the Constellation program was cancelled in 2010, the commercial vehicles became NASA's primary focus for providing cargo and crew transportation to the ISS. The success of commercial efforts became even more important in 2010 when Congress authorized the extension of space station operations until at least 2020 from 2015, and the President directed that NASA transition the role of human transportation to low-earth orbit to commercial space companies.

NASA Faces Challenges Transporting Cargo and Crew to and from the ISS

The greatest challenge facing NASA is transporting cargo and crew to and from the ISS to make effective use of the ISS. NASA plans to rely on ISS international partner and new commercial launch vehicles to transport cargo and crew to and from the ISS until at least 2020. NASA hopes to begin using new commercial cargo vehicles in 2012 and crew vehicles to transport astronauts to and from the ISS beginning in 2017. NASA's decision to rely on the new commercial vehicles is inherently risky because the vehicles are still in development and not yet proven or fully operational.

NASA Plans to Use International Partner and Commercial Flights but International Agreements Are Not in Place and Commercial Vehicles Remain Unproven

NASA is relying on 51 flights of international partner and commercial vehicles to transport cargo to the ISS from 2012 through 2020, but agreements for international flights after 2016 are not in place and the commercial vehicles are unproven. NASA has agreements in place with the European and Japanese space consortiums for their respective vehicles—the European Automated Transfer Vehicle (ATV), and the Japanese H-II Transfer Vehicle (HTV)—to conduct cargo resupply missions beginning in 2012 through 2016. The ATV and HTV are unmanned vehicles that have flown to the ISS, and carry such items as

[8] In 2004, President George W. Bush established a new space exploration policy—*A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration* (Vision)—which called for the retirement of the space shuttle and development of a new family of exploration systems to facilitate a return of humans to the moon and eventual human spaceflight to Mars.

hardware and water.[9] NASA's current plans anticipate employing a total of 12 international partner launches—8 from 2012 to 2016 and 4 from 2017 through 2020. NASA does not have agreements in place for international partners to provide cargo services to the ISS beyond 2016. NASA plans to use the ATV for a number of cargo flights through 2014, but no longer anticipates its use after that time. NASA plans to use HTV for a number of cargo flights through 2016, but its negotiations with the Japanese partners for flights beyond 2016 are in their infancy.

NASA also plans to use two types of domestic commercial launch vehicles to maintain ISS from 2012 through 2020. Development of these vehicles—the Falcon 9 and Antares[10]—was fostered under a NASA-initiated effort known as Commercial Orbital Transportation Services. These vehicles are being developed by private industry corporations—Falcon 9 by SpaceX and Antares by Orbital Sciences Corporation. In late 2008, NASA awarded contracts to both companies to provide cargo transport services to the ISS. Only SpaceX will be able to safely return significant amounts of cargo to earth, such as the results of scientific experiments. NASA anticipates that SpaceX will begin providing that capability in 2012.

Commercial vehicles are essential to sustaining and utilizing the ISS. As table 1 indicates, SpaceX and Orbital are scheduled to fly 20 (71 percent) of the 28 launches NASA plans through 2016 and follow-on commercial resupply vehicles are expected to fly 19 (83 percent) of the 23 launches from 2017 through 2020.[11]

[9] In 2008 and 2009, the ATV and HTV vehicles respectively flew to the ISS and docked at the station to demonstrate their capabilities. In 2011, both vehicles again launched. These flights were the second for both systems.

[10] The Antares was previously known as the Taurus II.

[11] NASA has awarded contacts to SpaceX and Orbital for cargo resupply services to the ISS through 2016. Planned follow-on commercial resupply vehicles are the vehicles NASA will use for flights beyond those currently under contract.

Table 1: NASA's Planned Vehicle Launches for 2012 to 2020 to Resupply the ISS as of March 2012

	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Vehicles										
ATV	1	1	1							3
HTV	1	1	1	1	1	1	1	1	1	9
SpaceX	2	2	2	3	3					12
Orbital	1	2	1	2	2					8
Follow-on commercial resupply						5	5	5	4	19
Total	**5**	**6**	**5**	**6**	**6**	**6**	**6**	**6**	**5**	**51**

Source: GAO analysis of NASA data.

Note: NASA does not have contracts with commercial providers or negotiated agreements with international partners for flights from 2017 through 2020.

This plan relies on commercial vehicles meeting anticipated—not proven—flight rates. As we have previously reported, both SpaceX and Orbital are working under aggressive schedules and have experienced delays in completing demonstrations.[12] SpaceX flew its first demonstration mission in December 2010, some 18 months late, because of such factors as design issues and software development. Currently, SpaceX's next demonstration launch to the ISS has been delayed from November 2011 to late April 2012 because of additional testing and resolution of some technical issues such as electromagnetic interference. Likewise, Orbital experienced programmatic changes and developmental difficulties that led to multiple delays of several months' duration. In May 2011 testimony,[13] we noted that Orbital's inaugural demonstration mission had been delayed to December 2011. Currently, this flight has been delayed further to August or September 2012, primarily because of issues related to construction and testing of the launch pad at Wallops Island, Virginia. NASA has made efforts to accommodate delays in commercial vehicle development, including use of the final shuttle flight in July 2011 to pre-position additional ISS spares. However, if the commercial vehicle launches do not occur as planned in 2012, the ISS could lose some ability to function and sustain research efforts due to a lack of alternative launch vehicles to support the ISS and return scientific experiments back to earth.

[12] GAO-09-618.

[13] GAO-11-692T.