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Statement of
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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.

<u>Commercial Orbital Transportation Services</u>

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.

<u>Commercial Resupply Services</u>

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.