

**Statement of
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before the

**Committee on Commerce, Science, and Transportation
United States Senate**

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear before you today to discuss NASA's views on the Risks, Opportunities and Oversight of Commercial Space and our specific efforts to support the development of commercial cargo and crew transportation systems. NASA has worked closely with commercial industry for our entire fifty-four year history. U.S. industry has been a part of every NASA program since our inception. As a government agency, we contract with industry to best utilize the unique attributes of the private sector for each particular activity. NASA investments have allowed U.S. industry to develop tremendous capabilities over the past five decades that have reduced costs to tax payers and expanded U.S. markets, creating billion dollar industries and hundreds of thousands of jobs. Space transportation has followed this well-worn path: government investment in space launch capability led to commercial ownership and operation of nearly all U.S. launch vehicles today.

NASA is pleased with the progress our industry partners have made in the development of commercial cargo transportation systems, as demonstrated on May 31, 2012, with the successful conclusion of the SpaceX demonstration flight to and from the International Space Station (ISS); this mission achieved all of the milestones originally intended to be met over two separate flights. Moreover, the mission was completed at significantly less cost to the American taxpayers than if we had pursued a traditional, cost-plus development contract approach. Data review and discussions – a required part of the milestone activity – are continuing so we can learn as much as possible from this mission. The success of our industry partners in these endeavors is critical to ensuring the effective utilization of the ISS. U.S. commercial cargo resupply capability will ensure the continued operation of the ISS and the utilization of its formidable research facilities as a U.S. National Laboratory. American commercial crew transportation and rescue services will enable the United States to fly its own astronauts to and from Station, end our sole reliance on foreign governments, and provide needed redundancy in the system. We are committed to launching our crew from U.S. soil on spacecraft built by American companies as soon as possible. This approach is good for our program, international commitments, the American taxpayer, and the U.S. economy. Commercial crew transportation will also allow us to increase the ISS complement to 7 from 6. This will allow for increased utilization on ISS. Partnering with the commercial space industry to provide access to low-Earth orbit (LEO) is enabling the Agency to increasingly focus on developing its own systems for sending astronauts on missions of exploration into deep space, and promote the development of an economy in LEO. However, achieving timely success in this critical endeavor will require that the industry partners receive robust funding from NASA.

International Space Station

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 and test of exploration technologies and systems. The ISS supports research across a diverse array of disciplines, and it is also a place to conduct technology development efforts. Research and Development (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 is a facility in which commercial companies can explore the benefits of space-based research as part of the ISS National Laboratory. Finally, the ISS will be critical to NASA's future missions of exploration beyond LEO.

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 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.

In the areas of human health, telemedicine, education, and Earth observations from space, there are already demonstrated benefits from ISS research. 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. Telemedicine and reduction in medical device size and complexity are needed on ISS. These same needs are present in terrestrial medicine today. ISS medical devices have tremendous synergy with hardware being developed for hospital and home use today. 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.

On August 31, 2011, NASA 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, an 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, developing and managing 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.

Through CASIS, users can utilize 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 envisioned demand for access to the ISS could increase the demand for 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.

Commercial Cargo 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 flights to the ISS that validate 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 2010, as part of the first SpaceX COTS demonstration flight, the SpaceX Falcon 9 rocket successfully launched, and the accompanying Dragon spacecraft successfully orbited the Earth and safely returned to the Pacific Ocean. In December 2011, NASA announced its decision to combine the flight objectives of SpaceX COTS demonstration flights 2 and 3 into a single mission. 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 and return of the cargo on board to NASA.
- Orbital Sciences Corporation has been using NASA assets at Stennis Space Center for engine acceptance testing and Wallops Flight Facility (WFF) for launch vehicle and spacecraft processing and integration as it prepares for its COTS demonstration flight. Launch Pad 0A at WFF is scheduled for completion and turnover to Orbital in June/July 2012. A short-duration hot-fire test of the first stage system is scheduled immediately after launch pad commissioning. Orbital's Antares launch vehicle maiden test flight is scheduled for late summer, and it will include a Cygnus spacecraft mass simulator. Orbital's COTS demonstration mission to ISS is scheduled by end of calendar year 2012.

Both companies are continuing to make sound progress in these activities, and NASA expects to see both the completion of the COTS effort and the beginning of operational cargo deliveries to ISS under CRS later this year. The SpaceX COTS activity will be complete in approximately 60 days after a detailed mission review.

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. We are planning, based on current commercial cargo schedules, for one commercial cargo service flight to be flown in 2012. This flight will be in addition to the COTS remaining demonstration flight which will carry some cargo.

- NASA ordered 12 CRS flights valued at \$1.6B from SpaceX. With the successful completion of all of its COTS milestones, SpaceX is scheduled to fly its first CRS flight in the fall of 2012. There are five missions currently in the processing flow, and both cargo and external hardware manufacturing and integration activities are underway. There are three SpaceX cargo missions planned each fiscal year from FY 2013 through FY 2016. The recently completed COTS demonstration flight included CRS upmass and downmass, delivering to ISS 1,014 pounds of supplies including experiments, food, clothing and technology. On its return trip to Earth, the 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 ordered 8 CRS flights valued at \$1.9B from Orbital. The timing of Orbital's first cargo service flight is dependent on successful completion of their COTS demonstration flight milestones by the end of 2012. There are five missions currently in the processing flow, and cargo integration activities and detailed planning have begun. The company is slated to fly one CRS mission in FY 2013, two CRS missions each fiscal year from FY 2014 through FY 2016, and one CRS mission in FY 2017.

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 these transportation planning and development efforts this year.

Commercial Crew Program

The Commercial Crew Program (CCP) will 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., Canadian, European, and Japanese astronauts to the ISS.

Commercial Crew Development

To date, NASA's investments have been aimed at stimulating efforts within the private sector to develop and demonstrate human spaceflight capabilities through the Commercial Crew Development (CCDev) initiative. Since 2009, NASA has conducted two CCDev solicitations, requesting proposals from U.S. industry participants to further advance commercial crew space transportation system concepts and mature the design and development of elements of the system, such as launch vehicles and spacecraft. In the first round of CCDev, NASA awarded five funded SAAs in February 2010, which concluded in the first quarter of 2011. Awardees and the amounts of the awards were: Blue Origin, \$3.7 million; the Boeing Company, \$18 million; Paragon Space Development Corporation, \$1.44 million; Sierra Nevada Corporation, \$20 million; and United Launch Alliance, \$6.7 million. Under these SAAs, companies received funding contingent upon completion of specified development milestones. All milestones were successfully accomplished by the CCDev industry partners.

During the second CCDev competition, known as CCDev2, NASA awarded four funded SAAs that are currently being executed with the following industry partners:

- Blue Origin's work involves risk-reduction activities related to development of a crew transportation system comprised of a reusable biconic shaped Space Vehicle launched first on an Atlas V launch vehicle and then on Blue Origin's own Reusable Booster System. The company is working to mature its Space Vehicle design through Systems Requirements Review (SRR), maturing the pusher escape system, and accelerating engine development for the Reusable Booster System. As of May 31, 2012, Blue Origin had successfully completed seven of ten milestones and NASA had paid \$11.2 million of the \$22 million planned for this effort.
- The Boeing Company is maturing its commercial crew transportation system through Preliminary Design Review (PDR) and performing development tests. Boeing's system concept is a capsule-based spacecraft reusable for up to ten missions that is compatible with multiple launch vehicles. Boeing's testing milestones include launch abort engine and orbital maneuvering engine static test firings, landing air bag and parachute drop demonstrations, wind tunnel testing, service module propellant tank and system testing, and launch vehicle Emergency Detection System interface testing. As of May 31, 2012, Boeing had successfully completed ten of sixteen milestones and NASA had paid \$85.0 million of the \$112.9 million planned for this effort milestones.
- Sierra Nevada Corporation (SNC) is maturing its commercial crew transportation system, the Dream Chaser, through PDR. The Dream Chaser is a reusable, piloted lifting body, derived from NASA's HL-20 concept that will be launched on an Atlas V launch vehicle. SNC's effort also includes fabrication of an atmospheric flight test vehicle, conducting analysis and risk mitigation, and conducting hardware testing. As of May 31, 2012, SNC had successfully completed eleven of fifteen milestones and NASA had paid \$68.8 million of the \$105.6 million planned for this effort.
- SpaceX is maturing its flight-proven Falcon 9/Dragon transportation system focusing on developing an integrated, side-mounted Launch Abort System and other crew systems. The uncrewed version of Dragon is already being demonstrated as part of the Commercial Cargo project, and will be used operationally as part of the ISS cargo resupply services effort. As of May 31, 2012, SpaceX had successfully completed seven of eleven milestones and NASA had paid \$55.0 million of the \$75 million planned for this effort.

In addition to the four funded agreements mentioned above, NASA has also signed SAAs without funding with three companies: Alliant Techsystems, Inc. (ATK); United Launch Alliance (ULA); and Excalibur Almaz, Incorporated (EAI). The ATK agreement is to advance the company's Liberty launch vehicle concept. The ULA agreement is to accelerate the potential use of the Atlas V as part of a commercial crew transportation system. The EAI agreement is to further develop the company's concept for LEO crew transportation. As of May 31, 2012, ATK, ULA, and EAI had all successfully completed four of five milestones.

Commercial Crew Integrated Capability

The next stage of the acquisition lifecycle will be a series of competitively awarded agreements with the intent of having no more than two and a half (2.5) partners further advance 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 base period that will run from award through May 2014. This base period will include completing major design efforts

through critical design review 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.

NASA is currently in a procurement "black out" period for CCiCAP, during which the Agency is evaluating proposals. After careful analysis of the proposals is completed, NASA expects to announce awards in the late-July/August timeframe.

Commercial Crew Certification and Services

Before a provider can deliver ISS services to NASA, it must be certified to ensure that it meets NASA's technical and safety requirements. Finally, NASA plans to competitively award services contracts to obtain crew transportation and emergency return services for the ISS. The details of this acquisition approach are still being developed and finalized; due to the nature of the certification requirements, NASA anticipates using FAR-based contracts for this effort. We intend to have this procurement strategy substantially complete by the award of CCiCAP. Current agreements have the FAA certifying the launch and entry portions of these missions for public safety.

NASA's acquisition strategy is taking into consideration the need to balance commercial design and schedule flexibility with government insight and oversight responsibilities throughout all program phases. The Agency is using Space Act Agreements to support the development of commercial crew transportation capabilities that NASA could eventually buy, and will use competitively-awarded FAR-based contracts for the certification of available capabilities and to procure crew transportation services to and from the ISS. This approach will accommodate maturation of the commercial 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 the readiness of U.S. commercial providers to achieve NASA certification.

Human Rating/Safety

The CCP represents a shift in near Earth space transportation operations to the private sector, freeing NASA (and NASA's limited resources) to pursue other human spaceflight goals, including developing the hardware, and concepts necessary to set out on human missions of exploration beyond LEO. The Space launch system and Orion vehicle are two of the first systems being developed to explore deep space.

Within this new paradigm, NASA will maintain its stringent safety requirements and standards. The Agency has always used contractors to build our space systems; however, as we transition to a commercially-driven marketplace for these services, our partners will take a greater responsibility for systems safety. In these programs, NASA is using an approach that allows the commercial providers more freedom to pursue cost-effective and innovative development approaches, but still allows the Agency the appropriate level of insight and oversight to ensure that the systems will be safe. Developing crew transportation systems to achieve LEO does not require any significant technological breakthroughs, but rather only evolutionary development, which is a key factor in enabling a unique insight/oversight

approach. NASA will maintain crew safety by way of a crew transportation system certification, and no system will receive this certification until the Agency has confidence that our personnel and those of our International Partners will be safe.

NASA is committed to managing the requirements, standards, and processes for certification to ensure that commercial missions are held to the same safety standards as Government missions. NASA will be responsible for defining, managing, reviewing, and approving certification plans and verification closure of requirements related to CCP missions.

As an additional “check and balance” in the area of safety, all CCP activities will be subject to evaluation by organizations independent of and funded separately from CCP, including the NASA Safety and Mission Assurance independent technical authority, the NASA Space Flight Safety Panel which is chaired by a member of the Astronaut Office, the NASA Office of the Chief Engineer, the NASA Office of the Chief Health and Medical Officer, and the NASA Aerospace Safety Advisory Panel. The FAA will protect for public safety.

Challenges

There are many challenges confronting the development of a viable commercial crew transportation system. These include securing stable and adequate financial resources, overcoming specific technical issues, and finding the optimal level of NASA involvement. The challenge of securing stable and adequate funding has been consistently cited as the top risk to commercial crew development and NASA’s stable support and financial commitment is critical to mitigating this risk. For example, in the fall of 2009, the Augustine Report concluded, “...unless NASA creates significant incentives for the development of the [commercial crew] capsule, the service is unlikely to be developed on a purely commercial basis.”

NASA’s CCP is designed to reduce the risk for private industry by providing a stable market demand, plus adequate financial and technical assistance for the development of these systems. NASA believes that by providing assistance in both the system development and demand for the service, the “business case” for commercial human spaceflight providers can close for one or more U.S. aerospace companies in a manner that also yields a safe and cost-effective capability for meeting NASA’s crew transportation needs. For these reasons and the timing issues discussed earlier, it is important that the Congress provide the requested funding level for NASA’s commercial crew initiative. This Congressional support will incentivize industry in obtaining investment capital above the amounts appropriated by Congress to NASA.

In addition to financial challenges, each of the commercial crew developers has unique technical challenges associated with its system. Given NASA’s current understanding of the state of the commercial crew development efforts, the Agency is confident that the commercial crew developers can overcome these challenges. In order to mitigate the risk associated with technical challenges, NASA plans to support multiple (but no more than 2.5) commercial providers, thereby obtaining the benefits of competition and insulating the Agency in the event a commercial provider cannot complete its development effort. In addition, NASA plans to be fully supportive of the commercial development activities, providing technical assistance, lessons learned, and past experience and knowledge in the area of human spaceflight development and operations.

A final challenge is balancing the need for NASA involvement in order to obtain a safe and reliable system and allowing the providers the freedom to seek innovative and cost effective solutions. Striking the right balance will be key to successful and timely delivery of the crew transportation systems. NASA insight is critical to ultimately certifying the systems as safe crew transportation missions; however, we

must be careful to avoid excessive oversight which would hinder industry's innovative approaches at achieving substantial cost savings relative to traditional government development programs.

Coordination with the Federal Aviation Administration

Both NASA and the Federal Aviation Administration (FAA) envision a state where the FAA licenses commercial human spaceflights provided by a robust industry, from which NASA and the private sector can purchase transportation services. The requirements and processes of these separate agencies must be carefully coordinated and aligned to assure that both Agencies' roles are accomplished with thoroughness and rigor. At the same time, it will be critical to the success of the industry ventures to minimize the burden of Government requirements and regulations imposed by multiple agencies.

The nature of the FAA involvement in NASA's commercial crew activities will vary through the development and operation of each potential flight system. NASA will establish initial certification and operations requirements for the services it wishes to acquire from commercial providers. NASA will partner with the FAA for the purposes of determining common standards and uniform processes to ensure both public safety and protection of crews and spaceflight participants for the NASA-sponsored missions. NASA and the FAA will work towards minimizing the duplication of requirements, developing a streamlined process and addressing indemnification issues.

This will be accomplished by clearly defining roles and responsibilities of each Agency, sharing relevant data, and jointly performing assessments to enable the commercial partner to be successful in support of NASA-sponsored missions and non-NASA commercial human spaceflight missions. In support of this, NASA and the FAA recently signed a Memorandum of Understanding (MOU) that harmonizes standards for commercial space travel of government and non-government astronauts to LEO and the ISS. The two agencies will expand collaborative efforts to provide a stable framework for the U.S. space launch industry, avoid conflicting requirements and multiple sets of standards, and advance both public and crew safety.

Indemnification under the Commercial Space Launch Act

The Administration supports extending the Commercial Space Launch Act, as amended, (CSLSA) "indemnification" provision, 51 U.S.C. § 50915, for commercial launch and reentry operators for five years beyond its current statutory expiration date of December 31, 2012. This support is in line with the Commercial Space Transportation Advisory Committee (COMSTAC) finding that extension of indemnification past December of this year is "critical to the viability of the commercial launch industry in the U.S." COMSTAC recently issued a recommendation reiterating its support.

Conclusion

Following the example of many successful industries in past, the United States is now entering a new era in spaceflight that harnesses the innovation and ingenuity of the private sector. This capability will provide cargo and crew access to LEO, while NASA once again pushes the boundaries of human exploration. The ISS has now entered its intensive research phase, and this phase will continue through at least 2020. In order to realize the promise of this facility, NASA will be relying on U.S. industry to provide cargo resupply and disposal services, as well as crew transportation and rescue services. And while there are still challenges ahead, the recent success of the SpaceX C2+ mission is a harbinger of the enormous potential of procuring cargo services from private entities. Commercial cargo services will

enable the delivery and recovery of research equipment and scientific samples that will make possible ISS R&D efforts critical to long-duration spaceflight, as well as the utilization of the Station as a National Laboratory by other U.S. Government and nongovernmental organizations. Establishing routine cargo services will be a challenge, but the teams are ready for this challenge. ISS has benefits to NASA research as well as benefits to the terrestrial population. The international team that assembled this tremendous facility can serve as a model for real international cooperation.

The area of commercial crew transportation also faces challenges. Human spaceflight is a very difficult endeavor, and NASA's industry partners will have the responsibility for the full end-to-end system. The Agency cannot guarantee their success; however, NASA is structuring an enabling approach that provides the highest probability of success. NASA's current path is a solid approach for developing and acquiring crew transportation services in a manner that is cost effective, and provides for crew safety. We need the support of this Committee to authorize the funding required for this effort with appropriate oversight that enables full and effective implementation of the program. Procuring commercial crew transportation services from U.S. industry will allow NASA to focus its resources on the development of vehicles that will take our astronauts beyond LEO for the first time since 1972. This new deep space exploration era will start with increasingly challenging test missions beyond LEO to cis-lunar space, which will be used to test systems and retire risks associated with longer-duration human missions to multiple destinations, first to near-Earth asteroids (NEAs), and ultimately to Mars as a part of a sustained journey of exploration in the inner solar system.

Successful U.S. private enterprise and affordable commercial operations in LEO will enable expanded markets, increased U.S. jobs, lower costs, increased reliability, and a sustainable step in America's expansion into space. Exploring space challenges our researchers, scientists, students, and engineers to solve problems that are beyond our current technical capability. No one nation or individual alone can meet these challenges. We must work as a team. Solving these challenges bring new benefits to all citizens of the Earth and changes the way we think.

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