

**RISKS, OPPORTUNITIES, AND OVERSIGHT OF
COMMERCIAL SPACE**

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

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JUNE 20, 2012
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ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

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RISKS, OPPORTUNITIES, AND OVERSIGHT OF COMMERCIAL SPACE

WEDNESDAY, JUNE 20, 2012

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 10 a.m. in room SR-253, Russell Senate Office Building, Hon. Bill Nelson, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Good morning. We are starting promptly because the Senate will have a series of votes that will start shortly after 11 o'clock and this will be one vote right after another in what we call "vote-orama." Obviously, I would wait until our Ranking Member got here, but in view of the fact that we are so constrained and both Kay and John are on their way, let me just say good morning and thank you all for being here.

This hearing is timely in the risks, opportunities, and oversight in commercial space considering the fact that SpaceX has had the success that they have, and by the end of the year, we expect to see Orbital Sciences launching with cargo to the Space Station as well. And so it is a time to step back and take a look at what is going on in the whole venture of commercial space, what we have learned, what the current issues are.

John, I was saying I was killing time so that we can get right on in it. If it is OK with you, we will just dispense with the opening statements.

Now, what I would like you to do so we can get in everybody and that we can get in questions, I want each of you to confine your remarks to about 5 minutes, and then we will get into it and elaborate on your remarks with regard to our questions.

So let me just say, a star-studded panel. Bill Gerstenmaier, the Associate Administrator, is going to talk about NASA's perspective on commercial space. Dr. Dillingham from GAO is going to speak on some of the work GAO has done regarding commercial space and, in particular, a recent study that GAO has done. And then we have two Space Shuttle astronauts. It turns out that they actually flew together on STS-92. Colonel Pam Melroy and Captain Michael Lopez-Alegria. And Pam is here representing the FAA and Michael is here on his newly appointed being president of the Commercial Spaceflight Federation. If you can keep all that crowd together, you

are Merlin, the magician. And we have Michael Gold from Bigelow, and they are developing space habitats.

So thank you all for being here, and with that, we will start with you, Mr. Gerstenmaier.

**STATEMENT OF WILLIAM H. GERSTENMAIER, ASSOCIATE
ADMINISTRATOR, HUMAN EXPLORATION AND OPERATIONS,
NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION**

Mr. GERSTENMAIER. Thank you very much. Thanks for allowing me to represent the team that supports human spaceflight for NASA. I look forward to sharing my thoughts on the risks, opportunities, and oversight of commercial space.

First, in order to accept a risk, there must be an opportunity or the risk is not warranted. The opportunity associated with commercial space is that it allows NASA to obtain a critical service for the International Space Station with reduced cost and oversight. These two things, reduced cost and oversight, are allowing NASA to focus its talents on the bigger goals, utilization of the ISS and developing the next generation of hardware and skills that will allow us to extend human presence into the solar system beyond low-Earth orbit.

In the past, NASA needed to work hand in hand with our contractors not only ensuring the requirements were being met, but also helping to design and build the systems needed for low-Earth orbit. The hardware and systems needed for low-Earth orbit simply did not exist.

Today that story is very different. There are avionic systems, hardware systems, manufacturing tools and techniques readily available for use in low-Earth orbit. The ISS has developed the techniques needed for sustained human presence with reasonable risk in low-Earth orbit. However, the highly reliable and maintainable systems necessary for beyond low-Earth orbit do not yet exist, and NASA is focused on developing these systems. The ISS is being used to test and refine many of these systems needed for beyond low-Earth orbit. The new challenge for NASA is to develop these new techniques and systems for beyond low-Earth orbit. The challenge of operating days to months away from earth is dramatically more difficult than just being hours away in low-Earth orbit.

In addition to preparing for human journeys beyond low-Earth orbit, NASA must also use the ISS national laboratory activity to expose commercial industry to the advantages of space-based research for terrestrial applications. If industry can see the direct benefits of space-based research for gaining new insight and competitive advantage for products and services that these companies are developing for use on the Earth, then these commercial companies will want to utilize space without Government involvement. ISS is an avenue for companies to explore the benefits of space research at low risk and low cost. Commercial transportation will be critical to these companies using space for research. So NASA is embracing a new method of doing business for low-Earth orbit that will enable a bigger future for human space exploration and allow use of the ISS to its fullest extent.

Another risk associated with commercial spaceflight is assuming the transportation to and from low-Earth orbit is easy. The technical challenges will be larger than initially anticipated by the com-

panies. NASA will need to allow extra time for these services to materialize. NASA, with the support of the administration and Congress, correctly anticipated this risk by adding STS-135 to add extra margin for ISS cargo. We also need to be prepared for a failure or a problem during one of these missions. This is normal and we will need to protect with adequate margin. Further, we cannot afford a major stand-down for a problem. We need to anticipate and not overreact to these problems. We should learn from these problems and continue moving forward without extensive external investigations. These problems will occur and should not be viewed as a major failure.

Crew-related transportation, however, will require extra safety considerations beyond the safety requirements for cargo. Our NASA and industry teams have prepared for this handover to industry for years. Working with our international partners on ISS allowed NASA experience in working with equivalent standards. NASA needed to look at different ways of accomplishing tasks and protecting safety. The international partners also gave us experience in allowing the approach and berthing to ISS on the first flight of a new vehicle. The international partner experience gave us techniques that NASA is applying on the commercial cargo flights. The NASA team was fully ready for this transition to commercial cargo transportation.

NASA is all about doing seemingly impossible tasks. NASA does this through preparedness and innovation. We are constantly looking for new ways to accomplish our tasks. Commercial spaceflight is just one of the many ways we are opening up exploration to new partners or finding different ways of working with our established partners. We will apply lessons learned from the commercial crew and cargo to SLS and MPCV. We will continue to challenge our perception of what is possible by expanding human presence beyond low-Earth orbit while operating and expanding the benefits of space exploration to folks here on Earth.

I look forward to answering your questions. Thank you.
[The prepared statement of Mr. Gerstenmaier follows:]

PREPARED STATEMENT OF WILLIAM H. GERSTENMAIER, ASSOCIATE ADMINISTRATOR,
HUMAN EXPLORATION AND OPERATIONS, NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION

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 pur-

sued 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 facili-

tate 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 SpaceX, was brought to a successful conclusion on May 31, with the deorbiting and splash-down 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 micro-

gravity 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 develop-

ment 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.

Senator NELSON. Thank you, Mr. Gerstenmaier.

Kay, with your permission, we are going to dispense with the opening statements since we are racing the clock, and we will put everybody's opening statement in the record.

Senator HUTCHISON. Perfect. I want to hear from the witnesses and hope we have a chance also for questions. Thank you.

Senator NELSON. Thanks.

Colonel Melroy?

**STATEMENT OF PAMELA MELROY, (COLONEL, USAF (RET.)),
DIRECTOR OF FIELD OPERATIONS FOR FAA
COMMERCIAL SPACE TRANSPORTATION**

Col. MELROY. Chairman Nelson, Ranking Member Boozman, and Senator Hutchison, thank you for inviting me to speak with you today.

America recently witnessed a turning point in transportation to low-Earth orbit when a domestic commercial company, SpaceX, launched its Falcon 9 rocket from Cape Canaveral. The Dragon capsule successfully berthed with the International Space Station and later safely reentered the Earth's atmosphere, demonstrating the ability to deliver and return cargo for NASA.

Both the launch and the reentry of the SpaceX mission were licensed by the Federal Aviation Administration's Office of Commercial Space Transportation.

The Office was established in 1984 with a mission to ensure protection of the public during commercial launch and reentry activities. I have spent the lion's share of my career in space operations, and I can assure you that even with a rigorous framework of safety measures, space transportation is not without risk. Therefore, the FAA requires operators to purchase insurance to cover the maximum probable loss that a launch or reentry could cause to third parties and their property. By statute, claims by or against spaceflight participants are not covered by this insurance, since it is only for third-party damages.

In the case of a very low probability event with a likelihood of happening of less than 1 in 10 million, the second tier of the risk-sharing regime would result in the conditional U.S. Government payment of third-party claims in excess of maximum probable loss insurance. After hearing that mouthful, you can understand why it is commonly referred to as indemnification.

The Government's liability exposure is capped at \$1.5 billion, adjusted for inflation, with payments subject to congressional appropriation.

The U.S. Government has never been called on to make a payment since indemnification became law in 1988. Congress has maintained the regime's functionality and effectiveness over the past 24 years by enacting five extensions. The FAA supports extending the indemnification provision for an additional 5 years. A stable regulatory environment and predictable, risk-based financial responsibility requirements are critical to investor confidence and cost-effective business plans.

In addition to financial risk allocation, planning is in place for how to respond in the event of an accident. The FAA, the National Transportation Safety Board, and the Air Force have a joint memorandum of agreement that calls out our roles and responsibilities in the event of a mishap investigation. We value this partnership, respect each other's expertise, and are confident that our many joint exercises and discussions have prepared us to work together effectively in the future.

With regards to human spaceflight, by law, the FAA may not propose regulations for occupant safety until October of 2015. We anticipate that a comprehensive occupant safety regulatory framework will be a major undertaking and will involve significant public comment and input.

NASA is planning to contract with the private sector to transport NASA astronauts to the ISS, as you heard from Mr. Gerstenmaier. The FAA and NASA have signed an historic agreement addressing commercial space travel of astronauts to and from the ISS. We have agreed that FAA licensing for public safety will be required for operational flights to the ISS. Crew safety and mission assurance will remain NASA's responsibility. This approach allows us to integrate our areas of expertise, and share lessons learned as progress is made. We are grateful to NASA for paving the way for commercial crew transportation, and recognize that industry will benefit from our cooperation.

As the industry evolves, and the Government's reliance on commercial vehicle increases, it may be necessary to revisit some of the statutes and regulations that govern commercial space transportation. We look forward to working with the interagency community and with Congress to ensure the domestic commercial space transportation industry will continue to create jobs, fuel innovation, and drive economic growth.

Again, I am grateful for this opportunity to speak before you today, and I am happy to answer any questions you may have.

[The prepared statement of Ms. Melroy follows:]

PREPARED STATEMENT OF PAMELA MELROY (COLONEL, USAF, RET.), DIRECTOR OF
FIELD OPERATIONS FOR FAA COMMERCIAL SPACE TRANSPORTATION

Chairman Nelson, Ranking Member Boozman, and Members of the Subcommittee:

Good morning. Thank you for inviting me to speak with you today.

America recently witnessed a turning point in transportation to low-Earth orbit, when a domestic commercial company, SpaceX, launched its Falcon 9 rocket from Cape Canaveral, placing its Dragon capsule on a successful course to berth with the International Space Station (ISS). This flight successfully demonstrated SpaceX's ability to deliver cargo for NASA. Later, Dragon safely re-entered the atmosphere

and splashed down off the West Coast of the United States, demonstrating the domestic commercial ability to bring back scientific samples and other supplies. Both the launch and reentry for the SpaceX mission were licensed by the Federal Aviation Administration's (FAA) Office of Commercial Space Transportation.

The Office was established by statute in 1984, with a mission to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch and reentry activities—like those demonstrated by SpaceX. The Office also has a Congressional mandate to encourage, facilitate, and promote commercial space transportation. In carrying out our safety responsibilities, we develop and issue regulations; grant licenses, permits, and safety approvals; and conduct safety inspections during every licensed or permitted launch. We grant licenses for launch, reentry, and the operation of launch and reentry sites or “spaceports,” as they are popularly known. We issue permits for experimental reusable suborbital rockets launched or reentered for demonstrating compliance with license requirements, testing new design concepts, equipment, or operating technologies, and crew training. By law, permitted activities are not eligible for the government's conditional provision of payment of third-party claims exceeding a launch operator's required financial responsibility, also commonly referred to as “indemnification.”

Keeping Pace with Market Growth

The growing importance of the FAA's mission is evident, given recent expansion of commercial space transportation industry activity and the promise of more to come. In the suborbital domain, several new commercial providers expect to enter regular service within the next five years. We are funding a study, to be released this summer, to evaluate the potential growth in commercial suborbital activity. As for Earth-to-orbit commercial transportation, initiatives are on the verge of expanding well beyond traditional unmanned satellite launches. The most advanced of these new initiatives includes SpaceX cargo flights servicing the ISS and similar services by Orbital Sciences Corporation, through their contracts with NASA's Commercial Resupply Services (CRS) program. Like those of SpaceX, Orbital Sciences' flights will be licensed by the FAA. NASA estimates that commercial manned flights can be accomplished within the next five years. Beyond vehicle development and operations, several states are creating or expanding spaceports and the associated infrastructure to service evolving markets.

Typically, space operations require years for development. As a result, an accurate understanding of the full extent of the FAA's activities requires considering not only launches but also extensive pre-launch preparatory functions. For example, there were limited licensed launch operations in Fiscal Year (FY) 2011, involving three licensed launches and two permitted launches. However, intense preparation and testing also occurred, which we expect will result in increasing licensed and permitted launch operations in FY 2012 and FY 2013. In FY 2012, two licensed launches have already taken place. As for pre-launch licensing and permitting activity, in FY 2011 there were two new licenses, five license renewals, and one new permit. So far in FY 2012, we have already issued three new licenses, one license renewal, and one new permit. In addition, we are carrying out evaluations of three license applications and one permit application, as well as ten pre-application consultations for licenses and permits. This activity, coupled with informal inquiries from current and potential commercial launch developers, demonstrates a continued interest in commercial space operations.

Highlighting the increasing volume of the FAA's “behind-the-scenes” activities helps demonstrate not only market potential but also the growing workload of the Office of Commercial Space Transportation's dedicated professional staff. Field Offices are critical both to our understanding of transportation operations and to enhancing our key relationships with other U.S. Government entities, such as NASA and the Air Force. To address this need, we are moving headquarters staff to field assignments, recruiting new field personnel, and adding contractor support where appropriate to maximize efficiency. By increasing our field presence, FAA provides operational safety oversight, speeds up communications and efficiency, and strengthens partnerships with the many stakeholders in commercial space operations.

Further reinforcing the FAA's commitment to the commercial space transportation industry, the Office of Commercial Space Transportation funds research through the FAA's Center of Excellence in Commercial Space Transportation. This initiative is a dynamic research partnership comprised of government, academia, and industry that involves matching U.S. Government and private-sector funding to pursue a variety of projects relating to a broad spectrum of areas vital to industry safety and growth. The Office of Commercial Space Transportation also carries out a variety of education and outreach initiatives, designed to increase awareness of opportuni-

ties for companies, investors, potential transportation customers, and the general public.

Public Safety Protection

The FAA authorizes and oversees launch, reentry, and the operation of launch and reentry sites. Since 1989, we have licensed 207 launches with no loss of life, serious injuries, or significant property damage to the general public. Safety inspection is a core function of FAA oversight. Inspections involve the monitoring of all licensed and permitted commercial space transportation activities. Activities include those conducted by the licensee/permittee, its contractors and subcontractors. FAA inspectors use approved safety inspection plans, templates, and checklists to conduct and document inspections. A safety inspection encompasses more than flight activities alone. Inspectors also monitor and participate in mission dress rehearsals, safe and arm checks, flight termination system installation and checkout, accident investigation, and other activities related to public safety. Inspections are coordinated with other relevant agencies.

Liability Risk-Sharing Regime

Even with a rigorous framework of safety measures, space transportation is not without risk. As part of its licensing and permitting mission, the FAA administers financial responsibility and risk-sharing requirements for commercial launch and reentry operators. The Commercial Space Launch Act requires a licensee or permittee, any customer, contractors, and subcontractors, and the government to waive claims among themselves. In this “cross-waivers” arrangement, each party involved in a launch agrees not to bring claims against the other parties and is financially responsible for damage or loss it sustains to its own property. With the exception of the U.S. Government, each party is also responsible for claims associated with death or injury to its own employees, resulting from activities carried out under a license or permit.

Beyond first party losses, the risk-sharing regime places the first tier of risk of financial loss due to third-party damages squarely on the commercial company. The operator must cover the maximum probable loss that a launch or reentry could cause to third parties and their property. The FAA calculates a required amount of financial responsibility to ensure coverage of this maximum probable loss, or “MPL.” We assess the risk that a license applicant’s proposed launch or reentry activity might pose to “third parties”—in other words, the public on the ground not involved in the launch or reentry. The MPL methodology is based on a variety of carefully integrated factors, including historical experience with unmanned expendable launch vehicles and their payloads. Our office assesses the debris field resulting from a series of assumed failures along a launch or reentry trajectory, models the probability of failure of the activity, and ascertains the presence of property or potential casualties. The maximum financial responsibility requirement that the FAA could require of an operator is \$500 million for claims by third parties, and \$100 million for claims for U.S. Government property. Commercial launch companies generally demonstrate financial responsibility through the purchase of private liability insurance. By statute, the insurance policy must name all launch participants as additional insureds. This includes the U.S. Government and its contractors and subcontractors participating in launch. Also, by statute, claims by or against space flight participants are *not* covered by this insurance, which is only for third-party damages.

Only in the case of a very low probability event—one with a likelihood of happening of less than 1 in 10 million—would the second tier of the risk-sharing regime be activated. This second tier provides for the conditional U.S. Government payment of claims in excess of the amount of financial responsibility required of a commercial company. As mentioned above, this statutory risk balancing mechanism is commonly referred to as “indemnification.” Here, the government’s liability exposure is capped at \$1.5 billion, adjusted for inflation since 1988, and payments are subject to Congressional appropriation. This coverage is for third-party claims only; space flight participants, or the loss of the property of the launch operator, are not covered by this tier. Any claims above this amount would comprise a third tier of risk, which is the responsibility of the commercial company.

Since the financial responsibility and risk-sharing regime for launch activities became law in 1988, there has not been a need for any liability payments. Congress has maintained the regime’s functionality and effectiveness over the past twenty-four years by enacting five extensions of the regime. In 1998, Congress broadened the regime to include reentry in addition to launch. Ongoing support for extension of the regime is a testament to bipartisan efforts recognizing the need for developing a strong commercial launch industry to serve government and commercial interests.

Importance of Extending “Indemnification”

The FAA supports extending the “indemnification” provision for five years beyond its current statutory expiration date of December 31, 2012. This support is in line with the 2011 Commercial Space Transportation Advisory Committee (COMSTAC) finding that extension of indemnification past December of 2012 would be “critical to the viability of the commercial launch industry in the US.” COMSTAC issued a recommendation in May of 2012 reiterating its support for extension.

Should the indemnification provision expire, all other portions of the financial responsibility and risk-sharing framework would remain in force. Accordingly, the FAA would continue to be charged with licensing launches and reentries subject to minimum financial requirements. The remaining statutory requirements would only provide license applicants with an amount of financial responsibility that represents the maximum *probable* loss without regard to the maximum *possible* loss.

If the indemnification provision were to expire, increased demand for private insurance to address more than the maximum probable loss could lead to higher insurance costs. Companies with fewer resources could struggle to manage risk, and investors could be discouraged from providing capital to companies with catastrophic risk exposure, further restricting access to capital and suppressing growth. A stable regulatory environment, including predictable, risk-based financial responsibility requirements and certainty in allocating risk, is critical to securing investor confidence and willingness to place capital at risk.

The current financial responsibility and risk-sharing framework was created with Congress recognizing the emergence of foreign launch services made competitive through government subsidies and preferential foreign national laws. The emerging U.S. commercial launch industry requires a stable and predictable risk-sharing program, including government indemnification of claims in excess of maximum probable loss, in order to plan future operations and encourage investment. Maintaining the current risk-sharing regime through a five year extension of indemnification would contribute to meeting this need. Fostering growth of this vital industry will produce public benefit in the form of national security, technological capacity, and national pride, by enabling domestic access to space for government and commercial users and contributing to U.S. aerospace preeminence.

Accident Investigation

In addition to providing for appropriate government-industry risk sharing, planning is in place for the investigational procedures that will be necessary in the event of an accident. The FAA requires licensees to comply with their previously approved accident investigation plan, including immediate notification to the FAA Washington Operations Center in the event of a fatality or serious injury, or notification within 24 hours in the event of a mishap, which includes both accidents and incidents.

The FAA has also established a strong working relationship with the National Transportation Safety Board (NTSB) to familiarize the NTSB with commercial space flight. The NTSB has supported the FAA in developing plans for managing a mishap investigation as well as training and preparing the commercial space industry for a mishap. The FAA Office of Commercial Space Transportation Mishap Program Manager works directly with the NTSB on a frequent basis. Additionally, the FAA, NTSB and the Air Force have a joint Memorandum of Agreement (MOA) that calls out roles and responsibilities for mishap investigation. This MOA has been in place for several years. The FAA and NTSB, in coordination with NASA, the Air Force, and commercial space flight companies have reviewed mishap scenarios on a frequent basis at both the eastern and western launch ranges, in order to exercise roles and responsibilities in the event of a launch or reentry mishap. The NTSB will respond to a commercial space launch or reentry accident in a similar fashion to that in the commercial airline industry, if the FAA declares an accident has occurred in accordance with established FAA regulatory definitions in 14 C.F.R. Part 401. In the event of an accident, the FAA is prepared to carry out its investigatory responsibilities as outlined in the joint MOA. We value this partnership, respect each other’s expertise, and are certain that the many discussions and joint exercises have prepared us to work together effectively in the future.

Approaches to Human Space Flight

As human space flight begins to evolve, the current financial responsibility and risk-sharing regime is well suited to cover emerging activities such as commercial crew. Since MPL coverage only applies to third-party damage, the MPL estimate would not be impacted by whether the launch includes a commercial crew or space flight participants. The MPL is not an estimate of risk to crew or space flight participants, but rather, to third parties, including members of the public and non-fly-

ing U.S. Government employees. Space flight participants and crew are not third parties.

By law, the FAA may not propose regulations for occupant safety until October 2015, except under certain circumstances. We anticipate that occupant safety regulations will be a major undertaking, and will require a comprehensive regulatory framework to eventually be proposed through a suite of rulemaking activities. Implementing this framework will take time, and will involve significant public comment and input.

NASA is planning to contract with the private sector to transport NASA astronauts to the ISS within a few years. NASA and the FAA have agreed that FAA licensing will be required for operational flights to the ISS. Recently, the FAA and NASA signed a historic agreement to coordinate standards for commercial space travel of government and non-government astronauts to and from low-Earth orbit and the ISS. The two agencies will collaborate to expand efforts that provide a stable framework for the U.S. space industry, avoid conflicting requirements and multiple sets of standards, and advance both public and crew safety. The agreement establishes policy for operational missions to the ISS. Commercial providers will be required to obtain a license from the FAA for public safety. Crew safety and mission assurance will be NASA's responsibility. This approach allows both agencies to incorporate experience and lessons learned as progress is made. Beyond this, the FAA's role involving flights carrying NASA astronauts is still under consideration. We are grateful to NASA for paving the way for commercial crew transportation, and recognize that industry will benefit from our cooperation to ensure compatibility between operational requirements for NASA missions and regulations for commercial customers.

The FAA's top priority is public safety, and, when the time arrives, will extend to appropriately protect occupants from risks. However, we must also leverage our existing knowledge of human space flight safety in a way that does not restrict innovation. This is in accordance with the Congressional mandate that human space flight regulatory standards evolve as the industry matures so that regulations neither stifle technology development nor expose crew or space flight participants to avoidable risks.

Planning for the Future

As the industry evolves, and the Government's reliance on commercial vehicles changes, it may be necessary to revisit some of the statutes and regulations that govern commercial space transportation. Specifically, the FAA's statutory authority may require expansion and adjustments to definitions to ensure public safety. For example, there may be a need for greater regulatory authority in the areas of transportation on orbit as well as launch and reentry. We look forward to working with the interagency community and Congress as the industry matures and evolves.

The U.S. commercial space industry continues to achieve new milestones. Beyond servicing the ISS, companies may soon be transporting participants to commercial orbital facilities like those being developed by Bigelow Aerospace.

As the pace of change accelerates, the current launch liability risk-sharing regime remains good public policy and should be extended. As Congress has recognized, the development of the commercial space transportation industry enables the United States to retain its competitive position internationally, contributing to the national interest and U.S. economic well-being. Extending indemnification and the current risk-sharing regime will continue to enable industry to attract and maintain a growing customer base, in the face of international competitors offering robust protection against risk.

With the help and leadership of Congress, the domestic commercial space transportation industry will continue to move forward—fueling innovation, creating jobs, and driving economic growth.

Again, I am grateful for this opportunity to speak before you today, and I am happy to answer any questions you may have.

Senator NELSON. Thank you, Colonel.
Dr. Dillingham?

**STATEMENT OF GERALD L. DILLINGHAM, Ph.D.,
DIRECTOR, PHYSICAL INFRASTRUCTURE ISSUES,
U.S. GOVERNMENT ACCOUNTABILITY OFFICE**

Dr. DILLINGHAM. Thank you, Mr. Chairman, Ranking Member Boozman, Senator Hutchison, for inviting GAO to appear before you this morning.

My testimony focuses on four aspects of the U.S. commercial space launch industry: first, the trends and forecasts in the industry; second, the challenges that FAA faces in overseeing and promoting the industry; third, some of the factors that Congress may want to consider as it determines the future of commercial space launch indemnification for third parties; and fourth, some of the challenges to U.S. global competitiveness as the industry grows and matures.

With regard to the industry trends, as detailed in our written statement, the number of FAA-licensed launches has been generally lower since a peak of 22 launches in 1998. Our work shows that, despite the low number of launches in recent years, important commercial spaceflight research and development activities continue to take place. The number of commercial space launches is expected to increase in the years ahead as NASA begins procuring commercial cargo transportation services to the International Space Station and private industry continues developing vehicles for space tourism. Additionally, private companies and State governments have been developing spaceports to accommodate the anticipated space tourism flights and expand the Nation's launch capacity.

With regard to the second area of our testimony, we have identified several challenges that FAA will need to address as it carries out its oversight responsibilities for a changing and maturing space launch industry. These challenges include ensuring that it has the proper mix of skills and personnel in place to effectively handle industry growth. FAA must also ensure that its regulations on licensing and safety requirements at Federal launch sites for expendable launch vehicles will also be suitable for operations at commercial spaceports. The agency must also be mindful of potential conflicts of interest in overseeing the safety of commercial space launches while promoting the industry. And with the transformation of the Nation's air traffic control system to NextGen, FAA will need to accommodate spacecraft that are transitioning to and from space through the national airspace system.

With regard to the factors that Congress may want to consider with regard to indemnification, our written statement discusses: first, the potential increased cost for the Federal Government of this risk-sharing regime as a result of the expected increase in manned commercial launches; second, the Federal Government's potential exposure to liability as a result of FAA's process for calculating maximal probable loss; and third, the lack of Federal indemnification coverage for on-orbit activities.

We have also identified some factors that may have a negative impact on U.S. global competitiveness. These factors include relatively high U.S. launch prices when compared to other countries—such as China, Russia, and France—and the limitations on U.S.

technology exports, which could affect launch company abilities to sell their services abroad.

And finally, Mr. Chairman, there is also the fact that the commercial space launch industry operates without the benefit of a national strategy. The situation has resulted in multiple Federal agencies having responsibilities for space activities, and most have developed their own strategies for meeting their responsibilities. A national strategy could identify and fill any gaps in Federal policy.

Thank you, Mr. Chairman. This concludes my oral statement. I will be pleased to respond to any questions from you, the Ranking Member, or Senator Hutchison.

[The prepared statement of Dr. Dillingham follows:]

PREPARED STATEMENT OF GERALD L. DILLINGHAM, PH.D., DIRECTOR, PHYSICAL INFRASTRUCTURE ISSUES, U.S. GOVERNMENT ACCOUNTABILITY OFFICE

June 20, 2012

HIGHLIGHTS OF GAO-12-836T, A TESTIMONY BEFORE THE SUBCOMMITTEE ON SCIENCE AND SPACE, COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, U.S. SENATE

Commercial Space Transportation

Industry Trends, Government Challenges, and International Competitiveness Issues

Why GAO Did This Study

The commercial space launch industry is changing as NASA plans to begin procuring commercial cargo transportation services to the International Space Station later this year and companies are developing vehicles that could carry passengers for space tourism flights. FAA is responsible for overseeing the safety of commercial space launches and promoting the industry. A catastrophic commercial space launch accident could result in injuries or property damage to the public, or “third parties.” In anticipation of such an event, launch companies are required to purchase launch insurance, per calculations done by FAA and, under the Commercial Space Launch Act, the Federal Government is potentially liable for claims above that amount of purchased insurance. Unless reauthorized, the indemnification provision expires this year.

This testimony addresses (1) trends and forecasts in the commercial space launch industry and challenges FAA faces in overseeing and promoting the industry, (2) preliminary information on issues concerning Federal indemnification for third party losses, and (3) challenges to global competitiveness for the U.S. commercial space launch industry. This statement is based on a past GAO report and testimonies on commercial space launches, updated with information GAO gathered from FAA and NASA on industry trends and recent FAA and NASA actions, and on-going work on Federal indemnification. GAO is making no recommendations in this statement.

What GAO Found

Since a peak of 22 U.S. commercial space launches in Fiscal Year 1998, the annual number of launches generally ranged from 4 to 9 launches. The number of commercial space launches is expected to increase in the next 8 years as the National Aeronautics and Space Administration (NASA) plans to procure 51 launches from commercial cargo companies to resupply the International Space Station. FAA also expects space tourism to begin in the next several years, although no companies have applied for a FAA launch license and companies developing these services have experienced delays in the past. FAA faces several challenges overseeing the commercial space launch industry. For example, FAA expects its licensing and oversight responsibilities to expand in anticipation of an increased private sector role, suggesting that FAA and Congress must remain vigilant so that potential conflicts in FAA’s safety oversight and industry promotion roles do not occur. Also, as the commercial space launch industry grows and FAA continues to implement NextGen—FAA’s effort to develop a more automated, aircraft-centered, satellite-based air traffic management system—the agency will have to manage a mix of earth-based aircraft and space vehicles. FAA has begun to consider integrating spaceflight operations into NextGen. In past work, GAO recommended that FAA take several ac-

tions to improve its oversight of commercial space launches, including monitoring indicators of space tourism safety. FAA has taken some steps to address the recommendations.

Several factors have implications for Federal indemnification policy. For example, under the current policy, the potential increase in the number of commercial space launches increases the probability of a catastrophic accident and the possibility of a cost to the Federal Government. Also, GAO's preliminary work has raised questions about the soundness of the method currently used by FAA to calculate the amount of insurance that launch companies must purchase: FAA has not updated crucial components, such as the cost of a casualty, and its method is outdated, according to insurance industry officials and risk modeling experts. If the current indemnification policy is eliminated, the actual effects on the global competitiveness of the U.S. commercial space launch industry are unknown, in part, because it is not known whether launch customers might choose foreign launch companies over U.S. companies. However, launch companies said that the lack of government indemnification would decrease their global competitiveness by increasing launch costs.

The competitiveness of U.S. commercial space launch companies is affected by higher launch prices than those charged by companies in other countries and U.S. export controls, which affect U.S. companies' ability to sell services abroad. The U.S. Government has responded to foreign competition by providing the U.S. launch industry research and development funds, use of Federal launch facilities, and indemnification for a portion of third-party claims.

PREPARED STATEMENT OF GERALD L. DILLINGHAM, PH.D., DIRECTOR, PHYSICAL
INFRASTRUCTURE ISSUES, U.S. GOVERNMENT ACCOUNTABILITY OFFICE

Chairman Nelson, Ranking Member Boozman, and Members of the Subcommittee:

Thank you for the opportunity to testify today on the commercial space industry. Historically, commercial space launches took place primarily at Federal launch sites and carried payloads (generally satellites) into orbit using unmanned vehicles that were only used once. The Federal Aviation Administration (FAA) is responsible for overseeing the safety of these launches and promoting the industry. Over the last several years the industry has begun to change. For instance, several companies are in the process of developing and testing manned, reusable launch vehicles for commercial space tourism. In addition, since the Space Shuttle fleet was retired in 2011, the National Aeronautics and Space Administration (NASA) plans to begin procuring commercial cargo transportation services to the International Space Station (ISS) later in 2012. With the successful mission of SpaceX's Dragon last month, the capability to do so has been demonstrated. NASA also intends to procure commercial manned launches to carry its astronauts to the ISS beginning in 2017.¹ Private companies and states are developing commercial spaceports—sites used for commercial (nongovernment) spacecraft launches to support the expected growth in commercial space launches. To foster a competitive environment for the U.S. space launch industry, the Federal Government provides, under the Commercial Space Launch Act Amendments of 1988 (CSLAA),² among other things, potential indemnification for a portion of third party liability claims that could arise from a catastrophic launch-related incident that results in injury or damage to uninvolved people or property.^{3,4} This legislation expires at the end of 2012, and Congress will

¹ Since NASA retired its Space Shuttle program in July 2011, it lacks a domestic capability to send crew and cargo to the ISS. To maintain the ISS through 2020, as required by the NASA Authorization Act of 2010, NASA is relying on international partners and commercial vehicles to transport cargo. Pub. L. No. 111-267, §501 All commercial cargo missions for NASA thus far have been demonstration missions conducted under Space Act agreements, which involve NASA providing significant funds to private industry partners to stimulate the development of large-scale commercial space transportation capabilities. Pub. L. 85-568, 72 Stat. In order to transport crew, NASA is currently purchasing seats on the Russian *Soyuz* vehicle. However, NASA has awarded a number of Space Act agreements to domestic private sector companies to stimulate development and demonstration of commercial human spaceflight capability, with an eventual goal of procuring crew transportation services in 2017. For more information on utilizing the ISS, see GAO, *NASA: Significant Challenges Remain for Access, Use, and Sustainment of the International Space Station*, GAO-12-587T (Washington, D.C.: Mar. 28, 2012). For more information on Space Act agreements, 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).

² Pub. L. No. 100-657, 102 Stat. 3903 (1988).

³ 51 USC § 50915.

⁴ The Federal Government, subject to appropriations, provides indemnification for losses that exceed the maximum probable loss up to a limit of \$1.5 billion adjusted for post-1988 inflation;

need to determine whether to end, reform, or continue current commercial space launch indemnification.

My testimony today focuses on: (1) trends and forecasts in the U.S. commercial space launch industry, (2) challenges FAA faces in overseeing and promoting the industry, (3) preliminary information on factors for Congress to consider as it determines the future of commercial space launch indemnification, and (4) challenges to U.S. global competitiveness as the commercial space industry grows and matures. This statement is based on our prior testimonies and report on commercial space issues and has been updated with information we gathered from FAA and NASA on industry trends and recent FAA and NASA activities.⁵ It is also based on ongoing work we are conducting for this committee and the U.S. House of Representatives' Committee on Science and Technology. Additional information on our scope and methodology is provided in each issued product. We conducted the work on which this is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

In 1984, the Commercial Space Launch Act required the Secretary of Transportation to “encourage, facilitate, and promote commercial space launches by the private sector.”⁶ Under the Act, FAA was charged with regulating the U.S. commercial space launch industry, which it does through licensing, compliance monitoring, and safety inspection activities. FAA licenses all commercial launches and reentries that take place in the United States and overseas by U.S. citizens or companies to ensure the safety of the public and property, to ensure compliance with international obligations of the United States, and to protect the national security and foreign policy interests of the United States.⁷ FAA is also responsible for licensing the operation of all U.S. spaceports from which commercial launches may occur. In addition to its safety oversight and regulatory responsibilities, FAA is tasked with facilitating the strengthening and expansion of the U.S. space launch infrastructure. In 2004, the Commercial Space Launch Amendments Act of 2004⁸ gave FAA the specific responsibility of overseeing the safety of space tourism. However, FAA is prohibited from regulating crew and passenger safety before October 2015, except in response to high risk incidents, serious injuries or fatalities, or an event that poses a high risk of causing a serious or fatal injury.

Other Federal agencies also support the commercial space launch industry. NASA supports the industry by providing infrastructure and operations support and encouraging private sector investment in its launches and other activities. The Department of Defense (DOD), through the Air Force, provides infrastructure, operations support, guidance, and safety oversight for government and commercial launches at its launch sites. The Department of Commerce (Commerce) is also responsible for promoting the commercial space industry.

In addition, similar to other countries such as China, France, and Russia, the U.S. Government provides indemnification for a portion of claims by third parties for injury, damage, or loss that result from FAA-licensed commercial launch-related inci-

in 2012, this amount was approximately \$2.7 billion. For each launch, FAA determines the maximum probable loss, which is the amount of third party losses against which a launch company must protect by buying third party liability insurance.

⁵ See GAO, *Commercial Space Launch Act: Preliminary Information on Issues to Consider for Reauthorization*, GAO-12-767T (Washington, D.C.: June 6, 2012); *Commercial Space Transportation: Industry Trends and Key Issues Affecting Federal Oversight and International Competitiveness*, GAO-11-629T (Washington, D.C.: May 5, 2011); *Commercial Space Transportation: Development of the Commercial Space Launch Industry Presents Safety Oversight Challenges for FAA and Raises Issues Affecting Federal Roles*, GAO-10-286T (Washington, D.C.: Dec. 2, 2009); and *Commercial Space Launches: FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry*, GAO-07-16 (Washington, D.C.: Oct. 20, 2006).

⁶ 51 U.S.C. 50903.

⁷ FAA issues four types of licenses: a launch license (for expendable launch vehicles), a reusable launch vehicle mission license, a reentry license, and a launch or reentry site operator license. The first three types of licenses are issued to the operator of a launch vehicle, and the fourth is issued to the operator of a spaceport. FAA also issues experimental permits for test flights of reusable launch vehicles.

⁸ Pub. L. No 108-492.

dents, provided Congress appropriates funds for this purpose.^{9,10} Prior to issuing a launch or reentry license, FAA determines the amount of third party losses against which a launch company must protect by buying third party liability insurance. FAA determines this by calculating the maximum probable loss, which is an estimate of the maximum third party losses likely to occur from a commercial space launch.¹¹ The Federal Government, subject to appropriations, provides indemnification for losses that exceed the maximum probable loss up to a limit of about \$2.7 billion.¹² Parties involved in launches—for example, passengers and crew—are not considered third parties, and thus damages to them would not be covered under the indemnification program.¹³ The commitments of the United States or other countries to pay third party claims have never been tested. Globally, there has never been a third party claim for damages from a commercial space launch failure that reached the level of government indemnification.

The Number of FAA-Licensed Space Launches Peaked in 1998, but an Increase Is Anticipated

Launch Trends

Since 1989, FAA has licensed 207 commercial space launches. Since a peak of 22 launches in Fiscal Year 1998, the annual number of launches generally ranged from 4 to 8 launches. (See fig. 1.) Space launches by private sector companies were relatively high in the late-1990s as U.S. commercial launch companies responded to the increase in global demand for commercial satellite launch services. Since then, the demand for commercial launches has generally declined, except for slight increases in Fiscal Years 2004 and 2008. The increase in Fiscal Year 2004 was due in part to the inclusion of 4 demonstration flights by SpaceShipOne and the increase in Fiscal Year 2008 was due, in part, to the return to service of one of the most common launch vehicles following a failure in the previous year.¹⁴ Since Fiscal Year 2009, FAA has licensed 13 commercial space launches, including the launch of the Falcon 9 rocket that carried the Dragon capsule that docked with the International Space Station last month.

⁹ 51 USC 50914(a)(1)(A).

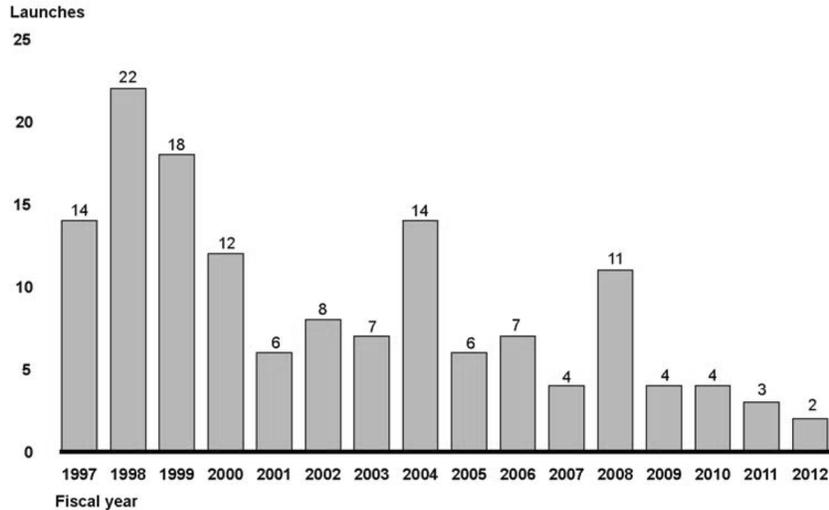
¹⁰ China, France, and Russia provide more indemnification coverage than the United States. These countries each have an indemnification regime in which the government states that it will assume a greater share of the risk compared to that of the United States because each country places no limit on the amount of government indemnification.

¹¹ More specifically, the maximum probable loss is based on estimates of losses from events having greater than a 1 in 10 million chance of occurring.

¹² The \$2.7 billion limit on the Federal Government's liability is for 2012; this amount is adjusted for inflation each year.

¹³ A crew includes any employee who performs activities directly relating to the launch, reentry, or other operation relating to the vehicle that carries human beings. 51 U.S.C § 50902(2). A passenger—also called a spaceflight participant—is an individual who is not crew, carried aboard a launch vehicle or reentry vehicle. 51 U.S.C § 50902(17).

¹⁴ SpaceShipOne, which resembles an airplane, was launched from an airplane into space, where it traveled nearly 70 miles above the earth, and returned to the original launch site.

Figure 1: FAA-Licensed Launches, Fiscal Year 1997 Through June 1, 2012


Source: GAO analysis of FAA data.

Note: These numbers include launches by Sea Launch—a multinational consortium that is licensed by FAA because one of its principals is a U.S. company. The numbers also include 5 launches by SpaceShipOne—4 in Fiscal Year 2004 and 1 in Fiscal Year 2005—which were not FAA-licensed as they were demonstration flights. All launches were orbital, except those of SpaceShipOne, which were suborbital.

Despite the low number of licensed launches in recent years, according to FAA, research and development activity in commercial spaceflight continues and the tests associated with this activity are not captured in launch numbers. According to industry experts that we spoke with, since 2006 the commercial space launch industry has experienced a steady buildup of research and development efforts, including ground tests and low-altitude flight tests of reusable rocket-powered vehicles that are capable of numerous takeoffs and landings. (See fig. 2 for examples of commercial spacecraft being developed.) These activities do not require licensing. In 2006, FAA began issuing experimental permits to companies seeking to conduct test launches of reusable space launch vehicles that could be used for manned commercial flights.

Figure 2: Examples of Commercial Spacecraft under Development


Sources: Virgin Galactic (left); Blue Origin (middle); and XCOR Aerospace (right).

The number of commercial space launches is anticipated to increase in the years ahead as NASA begins procuring commercial cargo transportation services to the ISS and private industry continues developing vehicles for space tourism flights. As previously noted, SpaceX recently completed the first commercial mission to deliver cargo to the ISS and bring back scientific samples and other supplies. (See fig. 3.) As a result of this success, SpaceX will begin to fly its 12 missions under NASA's Commercial Resupply Services contract for delivery of cargo to the ISS. Orbital Sciences Corporation has also been awarded a contract for cargo resupply missions

to the ISS through 2016, but has yet to conduct any demonstration missions. Together, the companies are scheduled to complete about 39 percent of NASA's planned launches to the ISS through 2020. (See table 1.)

Figure 3: SpaceX Dragon Docked with the ISS, May 2012



Source: NASA.

Table 1.—NASA's Planned Launches to Resupply the ISS from 2012 to 2020 (as of March 2012)

Vehicle	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
European Automated Transfer Vehicle (ATV) ^a	1	1	1	0	0	0	0	0	0	3
Japanese H-II Transfer Vehicle (HTV) ^a	1	1	1	1	1	1	1	1	1	9
SpaceX	2	2	2	3	3	0	0	0	0	12
Orbital	1	2	1	2	2	0	0	0	0	8
Follow-on commercial resupply ^b	0	0	0	0	0	5	5	5	4	19
Total	5	6	5	6	6	6	6	6	5	51

Source: GAO analysis of NASA data.

^aThe ATV and HTV are unmanned vehicles that have flown to the ISS.

^bNASA does not have contracts with commercial providers or negotiated agreements with international partners for flights from 2017 through 2020.

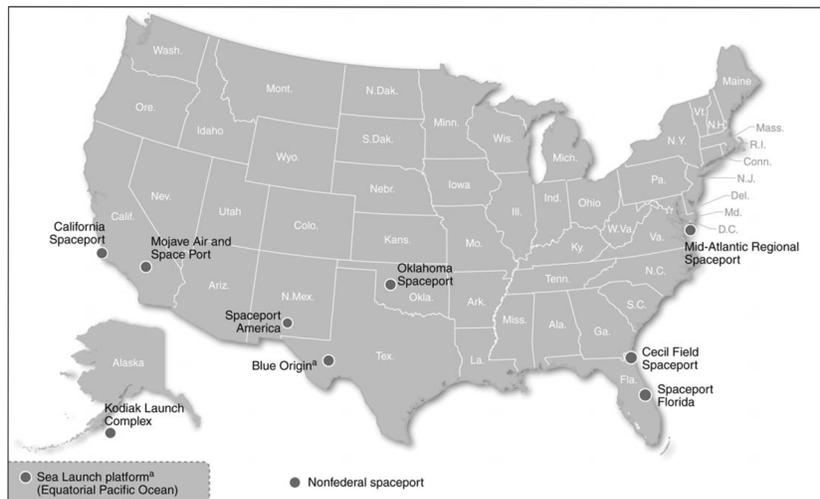
FAA expects space tourism activity to begin in the coming years and, while companies are developing vehicles to provide space tourism services, the industry has experienced delays in its development in the past. The prospect for commercial space tourism materialized in 2004 with the successful flights of SpaceShipOne, which have been the only manned commercial flights to date. Virgin Galactic, which formed a joint venture with Scaled Composites to develop SpaceShipTwo, is the farthest along among the space tourism companies and has taken deposits from more than 500 customers to reserve a place on a future flight. However, Virgin Galactic has not yet applied to FAA for a launch license and its planned schedule for flights has experienced delays in the past. The planned and anticipated increase in launches, from NASA and potentially from space tourism, has implications for FAA's oversight responsibilities and the Federal Government's potential liability in providing third party indemnification, as we discuss later in this statement.

Commercial Spaceports

In the United States, private companies and state governments have been developing additional spaceports to accommodate the anticipated space tourism flights and expand the Nation's launch capacity. There are currently eight nonfederal FAA-licensed spaceports as well as two private facilities each with one resident launch provider—Blue Origin and Sea Launch—which are termed sole-site operators. (See

fig. 4.) In addition, state governments and local communities have proposed establishing commercial spaceports in six additional locations.

Figure 4: Licensed Spaceports as of February 2012



Sources: FAA and GAO.

* Private facility with a sole site operator.

Both states and FAA have provided support for the development of commercial spaceports. States have provided economic incentives to developers to build spaceports to attract space tourism that could in turn provide economic benefits to localities. For example, New Mexico provided approximately \$209 million to construct Spaceport America¹⁵ and the Florida Space Authority, a state agency, invested over \$500 million in new space industry infrastructure development at Cecil Field Spaceport, including upgrades to the launch pad, a new space operations support complex, and a reusable launch vehicle support complex. In addition, Virginia recently enacted legislation to provide \$9.5 million annually to support the capital needs, maintenance, and operating costs of facilities owned and operated by the Virginia Commercial Space Flight Authority—including the Mid-Atlantic Regional Spaceport—and has provided state tax exemptions for companies launching payloads from the spaceport or doing space-related business activities in Virginia. However, according to a senior FAA official, continued state support for spaceports in the current fiscal environment has been mixed. The official added that although there are eight licensed spaceports, there has not been launch activity at all of them. Until there is a launch provider that begins operations and brings revenue to a spaceport, support is difficult to justify. In addition, Federal support for spaceports has been affected by the fiscal environment. In 2010, FAA distributed a total of \$500,000 in appropriated funds to four spaceports in the first Commercial Space Transportation Grants. Since then it has drawn from its operations budget to sustain the program.

FAA Faces Several Significant Challenges as It Oversees a Changing Commercial Space Launch Industry

As it oversees a changing commercial space launch industry, FAA faces various challenges. These include addressing a potential growth in its licensing and oversight workload, ensuring that its safety regulations are equally suitable for commercial spaceports and Federal launch sites, avoiding potential conflicts between its dual roles of safety oversight and industry promotion, and adequately accommodating space flight in its air traffic management system.

Potential Industry Growth and FAA's Workload

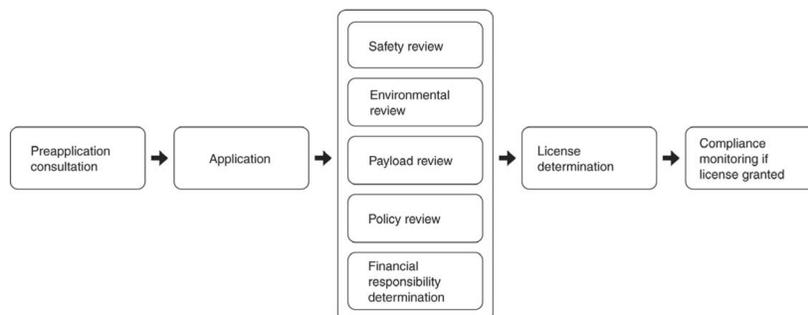
FAA expects its licensing and oversight responsibilities of commercial space launches to expand in the next few years with the licensing of NASA-contracted launches as NASA begins this year to use new commercially-developed and operated

¹⁵ Approximately \$133 million came from state appropriations. The remainder came from tax bonds collected from Dona Ana and Sierra counties in New Mexico.

vehicles to deliver cargo and later crew to the ISS. NASA plans to contract with commercial launch companies for these services. FAA and NASA announced on June 18, 2012, that FAA will license NASA-contracted vehicles and services. FAA expects the number of commercial launches to increase as private companies work toward providing flight services to paying passengers. FAA requires either a launch and a reentry license or a permit. As mentioned earlier in this statement, manned commercial launches have not occurred since 2004, and Virgin Galactic is the company closest to developing a vehicle for space tourism, but it has not filed for FAA licenses. Therefore, it is not clear when FAA's workload would be affected by space tourism.

As of November 2011, FAA's workload included 15 active launch licenses, 8 active launch site operator licenses, and 2 active experimental permits. FAA evaluates applications for launch licenses by reviewing the safety, environmental, payload, and policy implications of a launch and determining the launch company's insurance liability or financial responsibility. FAA's licensing process is described in fig. 4.

Figure 4: FAA's Launch Licensing Process



Source: GAO presentation of FAA information.

According to FAA officials, FAA's Office of Commercial Space Transportation has 72 full-time staff, as of June 2012, to oversee commercial space launches. FAA's Fiscal Year 2013 budget request includes resources to hire an additional 10 safety experts to evaluate license applications, conduct safety inspections, and provide oversight in its field offices.

FAA expects its workload to increase over the next several years as it begins to develop safety regulations for commercial human spaceflight. Although a moratorium on FAA regulations for passenger safety has been extended to October 2015, we have previously recommended that FAA identify and continually monitor indicators of space tourism industry safety.¹⁶ Although FAA was not able to address our recommendation directly because there have been no launches with passengers, it is taking other steps—e.g., reviewing NASA's certification of space launch vehicles as worthy of transporting humans (*i.e.*, human rating) and its own aircraft certification processes—that will help FAA be prepared to regulate passenger safety. We believe that these are reasonable preliminary steps to regulate crew and passenger safety.

Suitability of Safety Regulations for Spaceports

As noted earlier, spaceports are being developed to accommodate anticipated commercial space tourism flights. However, FAA faces challenges related to regulating commercial spaceports. Specifically, FAA must ensure that its regulations on licensing and safety requirements for launches and launch sites, which are based on safety requirements for expendable launch vehicles (*i.e.*, vehicles that are only used once and do not return to Earth) at Federal launch sites, will also be suitable for operations at commercial spaceports. We have reported that the safety regulations for expendable launch vehicles may not be suitable for space tourism flights because of differences in vehicle types and launch operations, according to experts we spoke with.¹⁷ Similarly, spaceport operators and experts we spoke with raised concerns

¹⁶ GAO-07-16.

¹⁷ We recommended that FAA develop a formal process for consultations between its Office of Commercial Space Transportation and Office of Aviation Safety about licensing reusable launch vehicles. In response, the two offices developed an agreement defining their roles and responsibilities regarding the review of hybrid aircraft/launch vehicles. See GAO-07-16.

about the suitability of FAA safety regulations for commercial spaceports. Experts told us that safety regulations should be customized for each spaceport to address the different safety issues raised by various types of operations, such as different orbital trajectories and differences in the way that vehicles launch and return to earth, whether vertically or horizontally. To address these concerns, we reported that it will be important to measure and track safety information and use it to determine if the regulations should be revised. We did not make recommendations to FAA concerning these issues because the Commercial Space Launch Amendments Act of 2004 required the Department of Transportation (DOT) to commission an independent report to analyze, among other things, whether expendable and reusable vehicles should be regulated differently from each other, and whether either of the vehicles should be regulated differently if carrying passengers. The report, issued in November 2008, concluded that the launch of expendable vehicles, when used to lift reusable rockets carrying crew and passengers, as well as launch and reentry of reusable launch vehicles with crew and passengers should be regulated differently from the launch of expendable vehicles without humans aboard. The report also noted that the development of a data system to monitor the development and actual performance of commercial launch systems and to better identify different launch risk factors and criteria would greatly assist the regulatory process.¹⁸

Dual Oversight and Promotion Roles

In 2006, we reported that FAA faced the potential challenge of overseeing the safety of commercial space launches while promoting the industry.¹⁹ While we found no evidence that FAA's promotional activities—such as sponsoring an annual industry conference and publishing studies of industry trends—conflicted with its safety regulatory role, we noted that potential conflicts may arise as the space tourism sector develops. We reported that as the commercial space launch industry evolves, it may be necessary to separate FAA's regulatory and promotional activities. Recognizing the potential conflict, Congress required the 2008 DOT-commissioned report to discuss whether the Federal Government should separate the promotion of commercial human spaceflight from the regulation of such activity. The 2008 commissioned report concluded there was no compelling reason to remove promotional responsibilities from FAA in the near term (through 2012) noting that FAA allocated approximately 16 percent of the commercial space budget in Fiscal Year 2008, which was significantly less than what was allocated for activities directly related to safety. FAA's requested allocation for promotional activities is 12 percent of the commercial space budget request for Fiscal Year 2013, according to an FAA official. The report further stated that periodic review of the issue was warranted as the commercial space launch industry changed. We continue to concur with the commissioned report's assessment and see no need for Congress to step in at this time to require a separation of regulatory and promotional activities since resource allocations for promotion remains at a relatively low level, and few commercial space launches are occurring. However, FAA and Congress must continue to remain vigilant that a situation in which FAA jeopardizes the public interest by subordinating it to that of the commercial space launch industry does not occur.

Spaceflight and NextGen

NextGen—FAA's efforts to transform the current radar-based air traffic management system into a more automated, aircraft-centered, satellite-based system—will need to accommodate spacecraft that are transitioning to and from space through the national airspace system. As the commercial space launch industry grows and spaceflight technology advances, FAA expects that the agency will need tools to manage a mix of diverse aircraft and space vehicles in the national airspace system. In addition, the agency will need to develop new policies, procedures, and standards for integrating spaceflight operations into NextGen. For example, FAA will have to define new upper limits to the national airspace system²⁰ to include corridors for flights transitioning to space; establish new air traffic procedures for flights of various types of space vehicles, such as aircraft-ferried spacecraft and gliders; develop air traffic standards for separating aircraft and spacecraft in shared airspace; and determine controller workload and crew rest requirements for space operations. FAA has begun to consider such issues and generally includes them in its concept of operations for NextGen.

¹⁸The Aerospace Corporation, *et al.*, *Analysis of Human Space Flight Safety, Report to Congress* (El Segundo, CA: Nov. 11, 2008).

¹⁹GAO-07-16.

²⁰The national airspace system currently extends to 60,000 feet above mean sea level.

Factors Congress Should Weigh Concerning Commercial Space Launch Indemnification

Several factors have implications for Federal indemnification policy. These include the potential for manned launches, the soundness of FAA's calculation of maximum probable loss, a gap in the indemnification policy, and the potential effects that ending Federal indemnification could have on the global competitiveness of the U.S. commercial space launch industry.

Potential Manned Launches

Our ongoing work indicates that the expected increase in manned commercial launches raises a number of issues that have implications for the Federal Government's indemnification policy for third party liability. First, the number of launches and landings covered by Federal indemnification could increase with NASA's planned manned launches, which will be FAA licensed. NASA expects to procure from private launch companies two manned launches per year to the ISS from 2017 to 2020.²¹ In addition, the development of a space tourism industry may also increase the number of launches and landings covered by Federal indemnification, but the timing of tourism launches and landings is uncertain.

According to insurance company officials with whom we spoke, the potential volume of manned launches for NASA and for space tourism could increase the overall amount of insurance coverage needed by launch companies, which could raise insurance costs, including those for third party liability.²² By increasing the number of launches, the probability of a catastrophic event is also increased, and any accident that occurs could also increase future insurance costs, according to insurance company officials. A catastrophic accident could also result in third party losses over the maximum probable loss, which would invoke Federal indemnification, provided Congress appropriates funds for this purpose.

Second, because newly developed manned launch vehicles have a limited launch history, they are viewed by the insurance industry as more risky than "legacy" launch vehicles. Insurance company officials told us that a launch vehicle such as United Launch Alliance's Atlas V, which launches satellites and may be used for future manned missions, is seen as less risky than new launch vehicles, such as SpaceX's Falcon 9, which could also be used for manned missions. According to insurance company officials with whom we spoke, they expect to charge higher insurance premiums for newly developed launch vehicles than legacy launch vehicles given their different risk profiles. Insurance company officials' opinions varied as to when a launch vehicle is deemed reliable—from 5 to 10 successful launches. They also told us that whether vehicles are manned is secondary to the launch vehicle's history and that the launch's trajectory—over water or land—is also considered in determining risk and, consequently, the price and amount of third-party liability coverage.

Third, having people on board a space vehicle raises issues of informed consent and cross waivers, which could affect third party liability and the potential cost to the Federal Government. CSLAA requires passengers and crew on spaceflights to be informed by the launch company of the risks involved and to sign a reciprocal waiver of claims (also called a cross waiver) with the Federal Government—meaning that the party agrees not to seek claims against the Federal Government if an accident occurs. CSLAA also requires cross waivers among all involved parties in a launch. Two key issues dealing with cross waivers include the estates of spaceflight passengers and crew and limits on liability for involved parties. One issue is the estates of spaceflight passengers and crew, which are considered third parties to a launch, are not covered by informed consent and cross waiver of claims, according to two insurance companies and one legal expert. Another issue, according to two insurance companies and two legal experts, requiring cross waivers among passengers, crew, the launch company, and other involved parties may not minimize potential third party claims as they would not place limitations on liability.

²¹ NASA-contracted launches for its science missions are not currently covered by CSLAA; rather, NASA requires its launch contractors to obtain insurance coverage for third party losses. The amount of the insurance required by NASA is the maximum amount available in the commercial marketplace at reasonable cost, but not to exceed \$500 million per launch. The facts and circumstances for claims in excess of this amount would be forwarded by NASA to the Congress for its consideration 51 U.S.C. § 20113 (m) (2). NASA-contracted launches for the Commercial Resupply Services to the ISS will be licensed by FAA under CSLAA, and will be covered by CSLAA indemnification.

²² Launch providers obtain insurance in addition to that for third party liability, including coverage of assets, such as the launch vehicle.

Maximum Probable Loss

The potential costs to the government under CSLAA—that is, the Federal Government’s exposure to liability—depends on FAA’s maximum probable loss calculation, which assesses a launch’s risk. If the calculation is understated, then the government’s exposure to liability is higher; conversely, if the calculation is overstated, then launch companies are required to purchase more insurance than intended. Therefore, it is important that FAA use an appropriate process for determining the maximum probable loss. Our preliminary work identified several issues that raise questions about the soundness of FAA’s maximum probable loss methodology:

- FAA uses a figure of \$3 million when estimating the cost of a single potential casualty—that includes either injury or death—which FAA officials said has not been updated since they began using it in 1988. Two insurers, as well as representatives of two risk modeling companies that specialize in estimating damages from catastrophic events, said that this figure is likely understated. Because this number has not been adjusted for inflation or updated in other ways, it may not adequately represent the potential current cost of injury or death caused by commercial space launch failures.
- FAA’s methodology for determining potential property damage from a commercial space launch starts with the total cost of casualties and adds a flat 50 percent to that cost as the estimate of property damage, rather than specifically analyzing the number and value of properties that could be affected in the event of a launch failure. One insurer and two risk modelers said that FAA’s approach is unusual and generally not used to estimate potential losses from catastrophic events. For example, officials from both modeling companies noted that the more common approach is to model the property losses first and derive the casualty estimates from the estimated property losses. One modeler stated that FAA’s method might significantly underestimate the number of potential casualties, noting that an event that has a less than 1 in 10 million chance of occurring is likely to involve significantly more casualties than predicted under FAA’s approach. Moreover, a 2007 FAA review conducted with outside consultants said that this approach is not recommended because of observed instances where casualties were low yet forecasted property losses were very large.
- More broadly, FAA’s method does not incorporate what is known in the insurance industry as “catastrophe modeling.” One modeler told us that catastrophe modeling has matured over the last 25 years—as a result of better data, more scientific research, and advances in computing—and has become standard practice in the insurance and reinsurance industries. Catastrophe models consist of two components: a computer program that mathematically simulates the type of event being insured against and a highly detailed database of properties that could potentially be exposed to loss. Tens of thousands or more computer simulations are generated to create a distribution of potential losses and the simulated probability of different levels of loss. In contrast, FAA’s method involves estimating a single loss scenario. FAA officials told us that they have considered the possibility of using a catastrophe model. However, they expressed concern about whether the more sophisticated approach would be more accurate, given the great uncertainty about the assumptions—such as the probability and size of potential damages—that must be made with any model. Also, both experts and FAA officials told us that developing a catastrophe modeling capability would entail significant costs.

FAA officials said that they believe the maximum probable loss methodology is reasonable and produces conservative results. The same officials noted that they periodically evaluate their current maximum probable loss methodology, but acknowledged that they have not used outside experts or risk modelers for this purpose. They agreed that such a review could be beneficial, and that involvement of outside experts might be helpful for improving their maximum probable loss methodology. As we finalize our review of CSLAA indemnification policy, we will address any additional Federal actions needed in response to our analysis.

Gap in Federal Indemnification

Officials from the insurance industry and space launch companies, as well as an expert, characterized the lack of coverage of on-orbit activities—that is, activities not related to launch or reentry, such as relocating a satellite from one orbit to another orbit—as a gap in Federal indemnification, but they did not agree on the need to close this gap. FAA licenses commercial launches and reentries, but does not license on-orbit activities. Federal indemnification only applies to FAA-licensed space activities. One expert noted that Federal oversight of on-orbit activities may be

needed to provide consistency and coordination among agencies that have on-orbit jurisdiction. He pointed out that the Federal Communications Commission and the National Oceanic and Atmospheric Administration have jurisdiction over their satellites and NASA has jurisdiction over the ISS. Thus, according to the expert, there should be one Federal agency that coordinates regulatory authority over on-orbit activities. On the other hand, officials from two launch companies told us that they did not believe that on-orbit activities need to be regulated by FAA or that Federal indemnification coverage should be provided.

According to senior agency officials, FAA may seek statutory authority over on-orbit activities, although not for satellite or spectrum usage. An insurer told us that having FAA in charge from launch to landing would help ensure that there were no gaps in coverage. According to this insurer, this would help bring stability to the insurance market in the event of an accident as involved parties would be clear on which party is liable for which activities. Congress would decide whether FAA's on-orbit authority would include licensing on-orbit activities. If FAA were granted the authority to license on-orbit activities, this would increase the potential costs to the Federal Government for third party claims as its exposure to risk would increase.

Indemnification and U.S. Competitiveness

Our on-going work indicates it is difficult to predict how insurance premiums or other costs might change as well as the availability of coverage if indemnification were eliminated. In addition, we do not know whether or to what extent launch customers might choose foreign launch companies over U.S. companies. Furthermore, it is difficult to separate out the effects of withdrawing indemnification on the overall competitiveness of the U.S. commercial space launch industry. Many factors affect the industry's competitiveness, including other U.S. Government support, such as research and development funds, government launch contracts, and use of its launch facilities, in addition to the third party indemnification.

Our work to date suggests that while the actual effects on competition of eliminating CSLAA indemnification are unknown, several launch company representatives and customers with whom we spoke said that in the absence of CSLAA indemnification, higher costs and increased risk would directly affect launch companies and indirectly affect their customers and suppliers. The same participants said that two key factors—launch price and launch vehicle reliability—generally determine the competitiveness of launch companies. According to two launch customers, launch prices for similar missions can vary dramatically across countries. For example, two customers said that a similar launch might cost about \$40 million to \$60 million with a Chinese company, about \$80 million to \$100 million with a French company, and approximately \$120 million with a U.S. company. Other considerations also would be involved in selecting a launch company, according to launch customers with whom we spoke. For example, some said that export restrictions for U.S. customers could add to their costs or prevent them from using certain launch companies. One launch customer also said that it considers the costs of transporting the satellite to the launch site as well as other specific aspects of a given launch.

U.S. launch company representatives said that the lack of government indemnification would decrease their global competitiveness by increasing launch costs. Those officials said their costs would increase as a result of their likely purchase of greater levels of insurance to protect against third party losses, as the launch companies themselves would be responsible for all potential third party claims, not just those up to the maximum probable loss amount. Some launch companies told us that they would likely pass additional costs on to their customers by increasing launch prices. Two launch customers told us that in turn, they would pass on additional costs to their customers.

Launch company representatives and customers said that ending CSLAA indemnification would also decrease the competitiveness of U.S. launch companies because launch customers would be exposed to more risk than if they used launch companies in countries with government indemnification. For example, representatives from several launch companies and customers said that if some aspect of the launch payload is determined to have contributed to a launch failure, they could be exposed to claims for damages from third parties and therefore might be more likely to use a launch company in a country where the government provides third party indemnification. Some also noted that the increased potential for significant financial loss for third party claims could cause launch companies, customers, or suppliers to decide if it was no longer worthwhile to be involved in the launch business, resulting in lost jobs and industrial capacity. Lastly, one industry participant pointed out that some suppliers, such as those that build propulsion systems, have to maintain significant amounts of manufacturing capacity whether they build one product or many. If there are fewer launches, the cost of maintaining that capacity will be

spread among these fewer launches, resulting in a higher price for each launch. To the extent that the Federal Government is a customer that relies on private launch companies for its space launch needs, it too could face potentially higher launch costs.

Alternatives for Addressing Space Launch Risk

Because launch failures and changing market conditions could change the amounts of coverage available in the private market, you have expressed interest in other possible ways of managing catastrophic risk. While we have not conducted specific work to analyze the feasibility of alternative approaches for providing coverage currently available through CSLAA, FAA and others have looked at possible alternatives to CSLAA indemnification and we have examined different methods for addressing the risk of catastrophic losses associated with natural disasters and acts of terrorism.²³ These events, like space launch failures, have a low probability of occurrence but potentially high losses. Some methods involve the private sector, including going beyond the traditional insurance industry, in providing coverage, and include the use of catastrophe bonds or tax incentives to insurers to develop catastrophe surplus funds. Other methods aid those at risk in setting aside funds to cover their own and possibly others' losses, such as through self-insurance or risk pools.²⁴ Still other methods, such as those used for flood and terrorism insurance, involve the government in either providing subsidized coverage or acting as a backstop to private insurers.²⁵

Use of any such alternatives could be complex and would require a systematic consideration of their feasibility and appropriateness for third party liability insurance for commercial space launches. For example, according to a broker and a risk expert, a lack of loss experience complicates possible ways of addressing commercial space launch third party liability risk, and according to another risk expert, any alternative approaches for managing this risk would need to consider key factors, including the

- number of commercial space launch companies and insurers and annual launches among which to spread risk and other associated costs;
- lack of launch and loss experience and its impact on predicting and measuring risk, particularly for catastrophic losses; and
- potential cost to private insurers, launch companies and their customers, and the Federal Government.

As such, alternatives could potentially require a significant amount of time to implement.

Several Factors Hinder the Competitiveness of the U.S. Commercial Space Launch Industry

The competitiveness of the U.S. commercial space launch industry is affected by high launch prices and export controls, which affect its ability to sell its services abroad. Based on several measures of global competitiveness, the U.S. commercial space launch industry has generally trailed Russia and France in recent years. For example, in 8 of the last 10 years, U.S. commercial space launch companies generated less revenue than either Russia or France. U.S. companies generated no commercial launch revenue in 2011 because they conducted no launches.²⁶ (See fig. 5.)

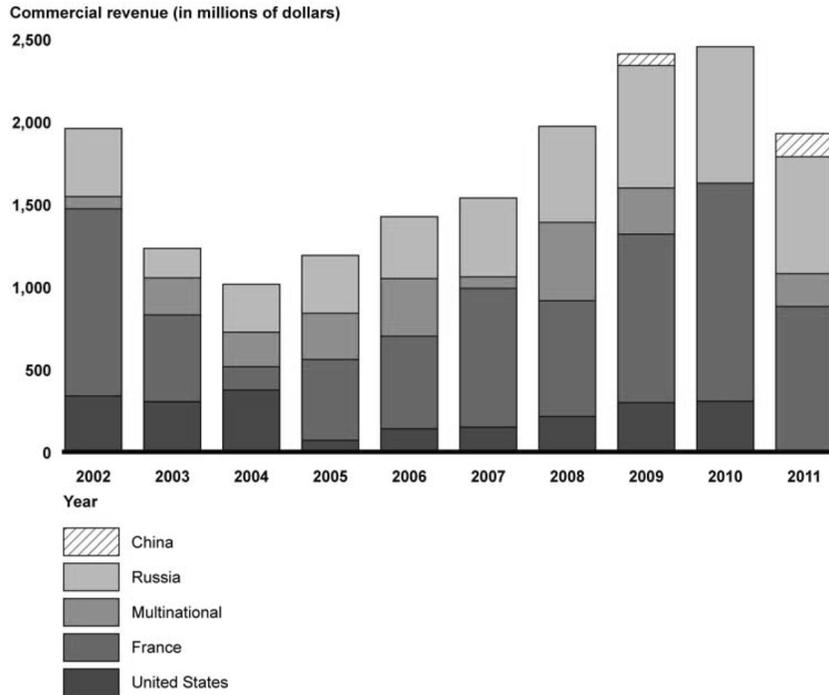
²³ See FAA, *Liability and Risk-Sharing Regime for U.S. Commercial Space Transportation: Study and Analysis* and Aerospace Corporation, *Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation*. See also GAO, *Catastrophe Insurance Risks: The Role of Risk-Linked Securities and Factors Affecting Their Use*, GAO-02-941 (Washington, D.C.: Sept. 24, 2002); *Catastrophe Insurance Risks: The Role of Risk-Linked Securities*, GAO-03-195T (Washington, D.C.: Oct. 8, 2002); and *Natural Disasters: Public Policy Options for Changing the Federal Role in Natural Catastrophe Insurance*, GAO-08-7 (Washington, D.C.: Nov. 26, 2007).

²⁴ See GAO, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk*, GAO-03-1033 (Washington, D.C.: Sept. 24, 2003). Self-insurance occurs when an entity assumes the risk for its losses and can involve the formation of an insurance company solely for that purpose. Risk pooling occurs when two or more entities agree to set aside funds to help pay for the others' losses.

²⁵ See GAO, *Flood Insurance: FEMA's Rate-Setting Process Warrants Attention*, GAO-09-12 (Washington, D.C.: Oct. 31, 2008) and *Terrorism Insurance: Status of Efforts by Policyholders to Obtain Coverage*, GAO-08-1057 (Washington, D.C.: Sept. 15, 2008).

²⁶ The one FAA-licensed launch that occurred in 2011 was by Sea Launch, which is a multinational company, not a U.S. company.

Figure 5: Worldwide Commercial Space Launch Revenues, 2002-2011



Source: GAO analysis of FAA data.
 Note: International revenue data for 2012 is not available.

We previously reported that as the U.S. commercial space launch industry expands, it will face key competitive issues, including high launch prices and export controls, that affect its ability to sell its services abroad.²⁷ Foreign competitors have historically offered lower launch prices than U.S. launch providers, as mentioned previously in this statement. The U.S. Government has responded to foreign competition by providing the commercial launch industry support, including research and development funds, government launch contracts, use of its launch facilities, and, as already discussed, indemnification for third-party losses that exceed the maximum probable loss.²⁸

Industry representatives that we interviewed told us that export licensing requirements affect the ability of the U.S. commercial space launch industry to sell launch vehicles abroad because they can deliver chemical, biological, and nuclear weapons. In previous work, a senior Commerce official told us that the U.S. commercial space launch industry had asked Congress to consider amending the statute that restricts space manufacturing items for export. A change in statute would allow for the Department of State (State) and DOD to review individual items for export, as they do for other industries.

Finally, the commercial space launch industry operates without the benefit of a national strategy. Numerous agencies—including FAA, NASA, State, and Commerce—are responsible for space activities and have developed their own strategies. A national space launch strategy could identify and fill gaps in Federal policy concerning the commercial space launch industry, according to senior FAA and Commerce officials. According to those officials, the need for an overall U.S. space launch policy, which includes commercial space launches, was being discussed within DOT and across other departments as part of the administration's review of national

²⁷ GAO-07-16.

²⁸ There have been no commercial space launch accidents that resulted in third-party losses that required government indemnification.

space activities, but developing a national policy had not yet begun. Guidance on launch acquisitions will, however, be included in the updated National Space Transportation Policy, which is currently under development and a date for issuance has not been publically announced.

Concluding Observations

In closing, despite the decrease in FAA-licensed commercial launches since Fiscal Year 1998, commercial space launch is a dynamic industry with newly developing vehicles and missions. As the realization of space tourism nears and NASA relies more heavily on commercial providers to deliver cargo and crew to the ISS, the number and types of flights may increase, which will have implications for FAA oversight and Federal indemnification support. As we previously recommended, FAA should continue to take steps to gather and review launch data that will enable it to be prepared to regulate human spaceflight when the regulation moratorium expires in 2015. In addition, as the industry changes and grows, continually assessing Federal liability indemnification policy to ensure that it protects both launch companies and the Federal Government will be important. As we complete our analysis of Federal indemnification, we will more fully address any additional Federal actions needed in response to these developments. Finally, the potential changes to the industry may present the conditions under which a subsequent review of FAA's dual role in promoting and overseeing commercial space launch safety is warranted.

Chairman Nelson, Ranking Member Boozman, and Members of the Subcommittee, this concludes my prepared statement. I would be pleased to answer any questions at this time.

Senator NELSON. Thank you, Doctor.
Mr. Gold?

**STATEMENT OF MICHAEL N. GOLD, DIRECTOR,
D.C. OPERATIONS AND BUSINESS GROWTH,
BIGELOW AEROSPACE**

Mr. GOLD. I would like to thank you, Chairman Nelson, Ranking Member Boozman, and Senator Hutchison, for this opportunity to testify.

Also, since I do not get to do this every day, I would like to take a moment to acknowledge my fellow witness, Bill Gerstenmaier, whose steady hand and tireless quiet leadership has made him one of the most respected and admired leaders in the space industry today.

Unlike Mr. Gerstenmaier, this is the first time a Bigelow Aerospace official has testified before Congress. I, therefore, would like to begin with some background on our company.

Bigelow Aerospace was founded in the spring of 1999 by Robert T. Bigelow with a mission to revolutionize space commerce via the development and deployment of inflatable or, as we prefer to call them, expandable space habitats. Expandable habitats provide greater volumes than traditional metallic structures, as well as enhanced protection from radiation and physical debris. When NASA ran out of funding for their own inflatable habitat program more than a decade ago, Bigelow Aerospace picked up the torch and rescued this promising technology which we will use to construct the world's first private sector space station.

In order to prove and demonstrate our designs and capabilities, Bigelow Aerospace deployed two sub-scale prototype habitats, Genesis I and Genesis III, a scale model of which is to my left, and they were launched in 2006 and 2007 respectively. And I still cannot believe I got the models through security.

[Laughter.]

Mr. GOLD. These launches were conducted in Russia aboard a converted Russian nuclear missile and launched from an active

Russian nuclear missile site. Having spent the better part of 3 years traveling back and forth to Siberia, I can assure you that we were not going there to enjoy the pleasant weather. Instead, Bigelow Aerospace was driven to Russia by one simple issue: price.

At the right price, we believe there is a substantial business case for commercial human spaceflight activities. Specifically, Bigelow Aerospace is focusing on what we term sovereign clients,” which are international space agencies, foreign governments or companies that wish to enjoy the benefits of orbital human spaceflight services. Bigelow Aerospace is actively courting these sovereign entities to lease space aboard our first station which will be comprised of a single or potentially several BA 330 habitats.

Bigelow Aerospace is also a strong supporter of microgravity research and development. We have conducted extensive discussions with numerous public and private officials both in the U.S. and abroad and we believe there are real and substantial benefits that companies and countries can enjoy, particularly in the pharmaceutical and biotech sectors, by gaining access to orbital microgravity R&D facilities.

However, to seize these opportunities, pricing must be kept under control, and in the aerospace world, prices are driven to a surprising degree by the laws and regulatory framework that hardware is developed and operates under.

I would like to take this opportunity now to address a few of these critical issues.

First and foremost, there has been a great deal of debate over the use of Space Act Agreements versus the Federal Acquisition Regulations. Recently, Congressman Wolf and Administrator Bolden reached an understanding that NASA would continue to use SAAs through CCIcap and that future commercial crew procurements would be implemented under the auspices of the FAR. Such a strategy directly parallels the successful cargo programs of COTS and CRS. This was not just a compromise, but was always the right thing to do and we applaud Congressman Wolf’s and Administrator Bolden’s efforts which have only made the commercial crew program stronger.

That being said, I would be remiss if I did not bring to the Committee’s attention what I believe to be a gross distortion of the law surrounding Space Act Agreements. Specifically, a review of relevant agency policy directives and GAO decisions demonstrate that NASA can mandate safety requirements under the auspices of a SAA. The current belief at NASA is that the Government cannot enjoy direct benefits of any kind from a Space Act Agreement and that to levy safety requirements would violate this inherent limitation. I believe that such an interpretation of the law is simply wrong. Per NASA’s own policy directives, funded SAAs are to be used—and I quote—to accomplish an agency mission. Moreover, in reviewing this very issue, the GAO stated that SAAs can be used so long as the principal purpose of the program is to stimulate the commercial market from which both the private sector and the Government can purchase services. These GAO decisions appear to actually encourage NASA to share requirements since, if the transportation systems are to eventually support Government acquisitions, this would be impossible to accomplish without companies

fully understanding and complying with the agency's mandatory safety needs. Because there are differing legal opinions on this topic I would strongly encourage the Committee to reach out to the ultimate arbiter of this issue, the GAO, for their advice and guidance.

Of equal importance to how a system is procured is who regulates it. We at Bigelow Aerospace have always been staunch advocates for strong, common sense safety practices. We believe that there is no better place for regulatory authority to reside than with the FAA-AST. Led by the very capable Dr. George Nield and supported by an exceptional staff, including my fellow witness and astronaut, Pam Melroy, the FAA-AST has experience in working with civil, commercial, and military launches and thereby has an unparalleled broad swath of knowledge to draw upon. In stark contrast to the FAA, NASA is not a regulatory agency. Administrator Bolden himself has made it publicly and explicitly clear that NASA should never become a regulatory agency. In order to enjoy the opportunity presented by commercial space, the risk of regulatory confusion must be eliminated as quickly as possible. Therefore, we hope that the Committee will work with the FAA, NASA, and commercial space companies to firmly ensconce regulatory authority over commercial space activities with the FAA since the AST is the only Federal entity with the staff, capabilities, and background to effectively play this role.

I hope this testimony has been helpful and look forward to answering any questions the Committee may have.

[The prepared statement of Mr. Gold follows:]

PREPARED STATEMENT OF MICHAEL N. GOLD, DIRECTOR, D.C. OPERATIONS AND BUSINESS GROWTH, BIGELOW AEROSPACE

I appreciate this opportunity to testify in regard to the oversight of commercial space activities, particularly because the pace of Bigelow Aerospace's development and our ability to attract customers are both inherently tied to the future success of the commercial crew program. However, before addressing the opportunities and risks that we see ahead I will begin by providing some brief background on our company. Bigelow Aerospace was founded in the spring of 1999 by Robert T. Bigelow. A Las Vegas native, Mr. Bigelow is dedicating his time and a significant amount of his personal fortune to Bigelow Aerospace's mission to revolutionize space commerce via the development and deployment of inflatable, or, as we prefer to call them, expandable space habitats. Expandable habitats provide greater volumes than traditional metallic structures, as well as enhanced protection from radiation and physical debris. Moreover, expandable habitats deliver these benefits while using less rocket fairing space, mass, and money. When NASA ran out of funding for expandable habitats more than a decade ago, Bigelow Aerospace picked up the torch and rescued this promising technology, which we will use to construct the world's first private sector space station.

In order to prove and demonstrate our designs and capabilities, Bigelow Aerospace deployed two sub-scale prototype habitats, Genesis I and Genesis II, which were launched in 2006 and 2007 respectively. To fly these spacecraft Bigelow Aerospace contracted with ISC Kosmotras, a joint Russian-Ukrainian company that takes decommissioned SS-18s (the old backbone of the Soviet nuclear arsenal and designated 'Satan' by NATO) replaces their nuclear warheads with commercial fairings, and subsequently uses this retrofitted rocket, called the "Dnepr", for global commercial space launch. In 2004, Bigelow Aerospace contracted with Kosmotras to launch the Dnepr with our unique expandable habitat prototypes from an active nuclear missile base in Siberia. Having spent the better part of three years traveling back and forth to this nuclear missile site, I can assure you that we were not going there to enjoy the good weather. Instead, Bigelow Aerospace was driven to Russia by one simple issue, price. While I cannot divulge the cost of our launches, I can tell the Committee that Kosmotras offered us a price that was a third of the closest

domestic competitor. A lack of competitive pricing is one of the greatest risks that the commercial crew and cargo programs will face.

If reasonable costs are maintained for crew transportation systems we believe there is a substantial business case for commercial human spaceflight. Specifically, Bigelow Aerospace is focusing on what we term 'sovereign clients', which are international space agencies or foreign governments that wish to enjoy the benefits of human spaceflight and orbital activities. Bigelow Aerospace is actively courting these sovereign clients to lease space aboard our first station which will be comprised of two or more BA 330 habitats (BA 330 habitats provide roughly 330 cubic meters of internal volume and can support a crew of up to six). Bigelow Aerospace is also a strong supporter of microgravity research and development. We have conducted numerous discussions with public and private officials, both in the U.S. and abroad, and we believe that there are real and substantial benefits that companies and countries can enjoy, particularly in the pharmaceutical and biotech sectors, by gaining the capability to conduct microgravity R&D.

However, as mentioned previously, pricing remains a principal programmatic risk, and this is certainly true for either the sovereign client or the microgravity market. Non-competitive domestic rocket pricing is what drove Bigelow Aerospace overseas previously, and is a real and present threat to prevent the next generation of commercial space activities from taking root here in America. Therefore, in its oversight of the commercial crew and cargo programs, we strongly urge this Committee to focus as much as possible on price, ensuring that both the commercial crew and cargo programs deliver services at costs that allow for the development of a truly commercial space industry.

In regard to the costs of space transportation systems, hardware expenses often have little to do with the actual pricing of services, which are driven to a surprising degree by the laws and regulatory framework that they are developed and operate under. I would like to take this opportunity to briefly address several of these issues.

First and foremost, there has been a great deal of debate over the use of Space Act Agreements versus the Federal Acquisition Regulations ("FAR"). Recently, Congressman Frank Wolf and Administrator Charles Bolden reached an understanding that NASA would continue to use Space Act Agreements ("SAAs") throughout the life of the Commercial Crew Integrated Capability ("CCiCap") program while future commercial crew procurements would be implemented under the auspices of the FAR. Congressman Wolf also asked that the FAR strategy be developed now in order to eliminate any gap between CCiCap and the actual procurement of services. Such a strategy directly parallels the successful cargo program comprised of the Commercial Orbital Transportation Services ("COTS") initiative and the Commercial Resupply Services contracts, wherein cargo delivery capabilities were developed and demonstrated via the SAA-driven COTS program, leading to the immediate implementation of a FAR-based procurement for services under CRS. What Congressman Wolf and the Administrator laid out wasn't just a compromise, but was always the right thing to do, and we applaud their efforts.

However, I would be remiss if I did not bring to the Committee's attention what I believe to be a gross distortion of the law surrounding Space Act Agreements. Specifically, a review of relevant GAO decisions and policy directives demonstrate that NASA can in fact conduct certifications and mandate safety requirements under a SAA. NASA's current understanding of the situation is that the government cannot directly benefit in any way from a SAA and that to levy safety requirements would therefore violate this inherent limitation. I believe that such an interpretation of the law is simply wrong. Per NASA's own policy directives, funded SAAs are meant to be used to "accomplish an Agency mission". Moreover, in reviewing this very issue the GAO stated that SAAs can be used so long as the principal purpose of the program is to stimulate a commercial market from which both the government and private sector can purchase services. To meet our needs, Bigelow Aerospace has certainly shared our requirements with potential crew transportation providers, and I see nothing in the relevant GAO decisions that would prevent NASA from doing the same. As a matter of fact, the GAO decisions appear to actually encourage NASA to integrate the Agency's requirements, since if these transportation systems are to meet not just private sector needs but support government acquisitions as well, this would be impossible to accomplish without receiving mandatory Agency safety requirements. Per his dialogue with Congressman Wolf, Administrator Bolden has stated that the primary purpose of the commercial crew program is to service the International Space Station. In other words, this program is being used to accomplish an Agency mission, and therefore no artificial limitations should be placed on what NASA can do relative to safety and certification regimes under SAA auspices. Since there are differing legal opinions on this topic, I would strongly encourage this

Committee to reach out to the ultimate arbiter of the issue, the GAO, for their advice and guidance.

Of equal importance to how a system is procured is who regulates it. We at Bigelow Aerospace have always been staunch advocates for strong, commonsense safety practices, and we believe that there is no better place for Federal regulatory authority to reside than with the Federal Aviation Administration's Office of Commercial Space Transportation ("FAA-AST"). Led by the very capable Dr. George Nield, and supported by an excellent staff including my fellow witness and astronaut Pamela Melroy, the FAA-AST has experience in working with civil, commercial, and military launches, and thereby has an unparalleled broad swath of knowledge to draw upon. In stark contrast to the FAA, NASA is not a regulatory agency, and Administrator Bolden himself has made it publicly and explicitly clear that NASA is not and should never become a regulatory agency. In order to enjoy the opportunity presented by commercial space the risk of regulatory confusion must be eliminated as quickly as possible. Therefore, we hope the Committee will work with the FAA, NASA, and commercial space companies to firmly ensconce regulatory authority over commercial space activities with the FAA-AST, since the AST is the only Federal entity with the staff, capabilities, and background to effectively play this role.

Yet another regulatory risk is America's obsolete and counterproductive export control regime. Second only to gravity, the International Traffic in Arms Regulations ("ITAR") had the greatest chance of preventing our spacecraft from leaving the Earth. With the recent release of the Section 1248 report, both the Department of Defense and the Department of State are now on the record that export control reform can be implemented without risking national security. As a matter of fact, I believe export control reform is unique in that it would bolster both national defense and commerce simultaneously. To address this problematic issue that has festered for over a decade, I urge the Members of this Committee to support including export control reform measures within the Fiscal Year 2013 National Defense Authorization Act. I would also like to enter into the Congressional record the attached law review article published in 2009 addressing the Constitutional shortcomings of the ITAR.

Finally, I would like to end my testimony by addressing the future opportunity that continuing a balanced approach for NASA's human spaceflight activities will provide. Expandable habitats were originally developed to take astronauts to Mars, and we would very much like to see this technology come full circle and again be used for beyond-Low Earth Orbit ("LEO") exploration activities. Our BA 330s could be stationed at L1 or L2, or serve as habitats on the surface of the Moon. Moreover, expandable habitat technology is eminently scalable, and we could leverage heavy-lift capacity to, in a single launch, place massive structures in space that could provide roughly 2,100 cubic meters of internal volume. Like NASA, Bigelow Aerospace desperately needs commercial crew capability to support our LEO operations, but we also could make great use of a heavy-lift system to support U.S. Government and international human exploration activities. Commercial crew and heavy-lift should not be viewed as competitors but instead as complimentary capabilities, with both playing a vital role in supporting America's future in space.

I hope this testimony has been helpful, and look forward to answering any questions the Committee may have.

Senator NELSON. Thank you, Mr. Gold.
Captain Lopez-Alegria?

**STATEMENT OF CAPTAIN MICHAEL LOPEZ-ALEGRIA, USN
(RET.), PRESIDENT, COMMERCIAL SPACEFLIGHT FEDERATION**

Mr. LOPEZ-ALEGRIA. Chairman Nelson, Ranking Member Boozman, and Senator Hutchison, thank you for the opportunity to testify today on the exciting future of commercial spaceflight.

Last month, Space Exploration Technologies launched the Dragon spacecraft atop its Falcon 9 rocket to the International Space Station, successfully completing the demonstration phase of its Commercial Orbital Transportation Services agreement with NASA. For the first time since the Space Shuttle retired, the world watched as Americans accomplished a new achievement in space. With the Shuttle Orbiters headed for their final homes, Dragon

showed us that America's leadership in space is alive and well and that by partnering with commercial spaceflight companies, NASA continues to do great things.

But recent success is not limited to SpaceX. While Dragon was berthed to the Space Station, the Sierra Nevada Corporation conducted a captive carry test of its winged Dream Chaser vehicle for the first time, and United Launch Alliance, Blue Origin, and others in NASA's commercial crew program are also making strong progress. We expect to see more exciting accomplishments in the months to come.

The Commercial Spaceflight Federation is the industry advocate for companies that are working to make commercial human spaceflight a reality. The CSF's members include spaceports, vehicle builders, service providers, robotic explorers, and suppliers that are building a web of commercial activity in space. The industry builds on two venerable American traditions: our entrepreneurial and inventive spirit and our half-century of leadership in human spaceflight.

In commercial spaceflight, as in any nascent high-tech industry, approaches to solve thorny problems vary greatly. Safety is paramount for all our members, and it is important to permit the industry to mature before allowing regulation to artificially limit technical approaches and, by extension, stifle innovation. To that end, we support the language in the Commercial Space Launch Amendments Act of 2004 that allows industry the space to rapidly innovate and adopt technical and safety improvements without the threat of regulation unless based on data from a serious safety incident, and we applaud the extension of this learning period to at least October 2015.

Further, we support the extension of the FAA regime that shares third party liability risk with launch providers required to purchase extensive insurance policies and the Government stepping in above that level. Termination of this regime would require American launch providers to purchase greater amounts of insurance. Simply put, that expense will either be passed on to the customers, putting the U.S. providers at significant market disadvantage vis-a-vis their Russian, French, and Chinese competitors, or be absorbed, causing likely unsustainable reductions in revenue. Either scenario could well lead to their exit from the market and result in the Federal Government paying the full cost of maintaining the national defense-related launch industry base, not to mention the significant loss of high-tech American jobs.

Having commanded the International Space Station, I share with this committee an understanding of its great value to America and indeed to the world, and I want to especially thank Senators Nelson and Hutchison for your tireless support over the many years. The ISS represents an unparalleled capability for space-based research and technology demonstration, but its full utilization potential is dependent on robust cargo and crew transportation. To this end, we support the highest possible funding for NASA's commercial crew program in the Fiscal Year 2013 and beyond to restore our national crew access, to bring NASA investment in high-tech jobs back to America, and to ensure that this gap in American human spaceflight capability ends soon and forever.

Space is no longer exclusively the domain of professional astronauts. I launched on a *Soyuz* in 2006 to the ISS with one spaceflight participant, and I landed 7 months later with another. In fact, every single available seat on the *Soyuz* has been sold with unfulfilled demand even as the price has increased over the years. According to Space Adventures, the CSF company that brokered these flights, the market demand for similar voyages on an American vehicle would be 5 to 10 times greater. As the CSF's members develop a U.S. commercial crew capability and plans for private on-orbit facilities progress, we expect this market to flourish.

In the suborbital arena, many companies are competing to be the first to launch a reusable vehicle to space since SpaceShipOne. Space flight has the unique ability to inspire students and sub-orbital commercial spaceflight will open space to a large population of young people as prices for small experimental payloads to suborbit will be within reach for foundations and even school districts. With frequent, regular flights to space, citizen-astronauts will be teachers and mentors to countless pupils inspiring the next generation of science, technology, engineering, and mathematics students.

I greatly appreciate the opportunity to provide testimony for this hearing and I look forward to working with all of you, and your staff, as the Commercial Spaceflight Federation promotes the development of this promising American industry, pursues ever-higher levels of safety, and shares best practices and expertise throughout the industry.

[The prepared statement of Mr. Lopez-Alegria follows:]

PREPARED STATEMENT OF CAPTAIN MICHAEL LOPEZ-ALEGRIA, USN (RET.),
PRESIDENT, COMMERCIAL SPACEFLIGHT FEDERATION

Introduction

Chairman Nelson, Ranking Member Boozman, and Members of the Subcommittee, thank you for inviting me to testify on behalf of the commercial spaceflight industry.

Last month, SpaceX launched a Dragon spacecraft atop its Falcon 9 rocket to the International Space Station (ISS), successfully completing the demonstration phase of its Commercial Orbital Transportation Services (COTS) agreement with NASA. For the first time since the Space Shuttle retired last year, the world watched as Americans accomplished a new achievement in space. People across the country cheered when Dragon launched, berthed and landed safely, and all of us here joined them. With the Shuttle orbiters headed for their final homes, Dragon showed the American people that America's leadership in space is alive. By partnering with commercial spaceflight companies for cargo and crew companies in addition to its other great work, NASA continues to do great things.

At the same time, many other companies are making progress here on Earth and in the skies, using similar, innovative partnerships with NASA. Two days before Dragon was unberthed from the Space Station to return home, Sierra Nevada Corporation flew its winged Dream Chaser vehicle for the first time in a captive carry test. Not long before, another commercial aerospace company, Boeing, tested its CST-100 capsule by dropping and landing it with parachutes and airbags. The Commercial Crew Program is moving forward rapidly, and we expect to see more exciting accomplishments in the months to come.

In the suborbital arena, many companies are competing to be the first to launch a reusable vehicle to space since SpaceShipOne, including Armadillo Aerospace, Blue Origin, Masten Space Systems, Virgin Galactic and XCOR Aerospace. The reusability and quick turnaround of these vehicles will offer frequent opportunities for scientists and the interested public to launch to space on a regular schedule, on safe and reliable vehicles, for a relatively affordable price. This will improve the value of research conducted on other platforms while transforming STEM education. In addition, these suborbital vehicles will speed learning and likely form the basis

for fully reusable orbital systems that hold the promise to fundamentally transform the space industry.

The Commercial Spaceflight Federation is the industry organization for the companies that are competing in these new space races, companies that are working to make commercial human spaceflight a reality. The Federation's members are spaceports, vehicle builders, launch services providers, robotic explorers, suppliers and many others that are building a web of commercial activity in space. The industry is concentrated in the United States, and builds on two venerable American traditions: our entrepreneurial and inventive spirit, epitomized by heroes like Benjamin Franklin, Orville and Wilbur Wright, and the many creators of the modern Internet; and our half-century of leadership in human spaceflight, from Mercury, Gemini and Apollo to the Space Shuttle and the International Space Station.

These companies are made up of people who are passionate about space, who were inspired by NASA to reach for the stars, and who are living their dream: To open up space to the American people, and help NASA explore the solar system. Across the nation, we have seen how our excitement engages young people, giving them pride in their country and encouraging them to enter Science, Technology, Engineering and Mathematics disciplines.

On behalf the members of the Commercial Spaceflight Federation, I would like to provide this subcommittee with our observations and recommendations on the following issues: commercial partnership in NASA programs; the importance of extending the current risk-sharing regime; and overall commercial space regulation as it relates to the safe, efficient growth and promotion of the industry. Finally, I will discuss several market sectors that will benefit from safe, reliable U.S. space transportation capabilities and provide the basis for future market growth.

NASA Programs

When Dragon was berthed to the Space Station last month, the media declared the dawn of a new commercial space age. Those who have been paying attention know that this is not the true beginning, but perhaps the end of the beginning. SpaceShipOne flew in 2004, winning the X Prize and sounded the starting gun for a new suborbital space race. NASA started the COTS program in 2006 to develop a reliable and affordable American capability to resupply the Space Station through public-private partnerships codified in Space Act Agreements. Congress supported and funded the program, displaying faith in America's tradition of ingenuity, invention and competition.

Those who work on complicated NASA programs often must overcome tough technical and organizational challenges to achieve their goal. The COTS program has proven that complex tasks can be accomplished with Space Act Agreements, offering NASA a new tool that it can deploy in other areas. NASA's projects are generally big—big ideas, big vehicles, big teams and big costs. Because Space Act Agreements are milestone-based, companies are only paid when they perform and NASA is able to remove a company for not progressing according to those milestones. Because they are fixed-price, the cost of schedule delays is borne by the companies, rather than the taxpayers. The success of the COTS program shows that a lean team can accomplish a big mission, and has set the stage for commercial companies to move beyond hauling cargo to carrying crew.

NASA's Commercial Crew Program is also a public-private partnership with commercial space companies that utilizes competition to develop safe, affordable, and reliable systems to carry astronauts to and from the ISS and relieve our reliance on our Russian partners. As the program has progressed, NASA has worked with Congress to plan its full arc, culminating in an outline for the program that preserves competition while ensuring that NASA has the insight it needs to certify the vehicles to carry NASA astronauts. The companies in this competition believe that with appropriate funding and management, they can fly crew to the ISS by as early as 2015. We hope that with a shared agreement on the program plan, Congress will see fit to fund the Commercial Crew Program as close to the President's request as possible. Every year that the Commercial Crew Program is delayed or its milestones prolonged due to funding, NASA sends approximately \$400 million to Moscow. Keeping this domestic program strong will reduce our dependence on aging Russian infrastructure, protect our investment in the ISS, fully realize the its potential, and create jobs here at home.

At the same time, NASA is working hard with another sector of the industry—the suborbital vehicle builders. Companies like XCOR Aerospace, Virgin Galactic, Masten Space Systems, Blue Origin, and Armadillo Aerospace are racing to safely and efficiently launch scientists and citizens on reusable vehicles that can reach the edge of space. These vehicles will provide high-quality microgravity and access to

the upper atmosphere at a reasonable price for scientists across the country, and a life-changing view of the Earth and weightless experience for participants.

NASA's Flight Opportunities Program has agreed to purchase flights on these vehicles for scientists and engineers who have experiments that require microgravity or access to space. Because suborbital launches will be flexible, safe, affordable and frequent, they offer an opportunity to perform scientific experiments that otherwise wouldn't fly and test instruments in real environments, supplanting ineffective ground or expensive flight testing, and developing new technologies faster.

By making a small commitment through the Flight Opportunities Program, NASA has provided certainty to the market and demonstrated that suborbital vehicles are exciting new tools for science and engineering. There has been one rocket flight under this program already, and in the next two years we expect to see many more, out of spaceports across the country.

Finally, NASA works with many innovative companies on specific projects that bear great fruit for the Nation. NASA's Innovative Lunar Demonstrations Data (ILDD) program is leveraging and incentivizing private sector investment in exploration beyond Earth orbit, extending a COTS-like model to lunar exploration, so that risk remains with the private sector and fixed-price payment is made only for successful completion of pre-determined milestones. One of our members, Moon Express, and five other U.S. companies were selected by NASA for the ILDD program in 2010, with the first private lunar robotic landings anticipated in 2014 or 2015. The data from this program will contribute to NASA's efforts to create a sustainable and affordable space exploration program beyond low-Earth Orbit.

FAA Risk-sharing Regime

Under the Commercial Space Launch Amendments Act (CSLAA), the industry is regulated by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST). FAA played an important role in the recent SpaceX mission to the space station, licensing both the launch and the re-entry of the Dragon spacecraft.

The CSLAA designates the FAA AST as the licensing agency for commercial space launch and reentry. As described in greater detail below, in order to obtain a launch license, a provider is required to purchase insurance against possible damage to third parties that could result from a launch or reentry. It also provides for risk sharing by the U.S. Government should third-party damages exceed the required insurance amount. To date, third-party claims have never surpassed the required insurance amount; therefore, this provision has had zero cost on the taxpayers since it was instituted in 1988.

The FAA AST's insurance requirements are based on their calculation of the Maximum Probable Loss (MPL), which is the maximum amount of damage to the uninjured public that could possibly be done in any launch or entry of the vehicle in 99.99999 percent of cases. The company must purchase insurance up to the MPL. Above this figure, which averages around \$100 million and has a maximum of \$500 million, the Federal Government may provide additional coverage for the next \$2.7 billion, dependent on expedited Congressional appropriation. If there were to be any damage above this level, the liability would be the responsibility of the parties involved with the launch, such as the launcher and payload provider. The coverage provided by the CSLAA's risk-sharing regime only applies to damage to uninvolved third parties. It does not cover damage suffered by the launch provider, payload provider, crew, or spaceflight participants.

This regime has been in place since 1988 and it is important to provide certainty to the marketplace. The launch industry's primary foreign competitors in Russia, Europe, and China receive even stronger liability protections from their governments (see Table 1). In fact, none of the other large spacefaring nations has a limit on the total amount of government risk sharing. The law expires at the end of the 2012 calendar year, and in order to protect and enhance American competitiveness in the launch market, it is important that it be extended.

Table 1.—Liability Risk-Sharing Regimes for Various Countries

Country	Third Party Liability Insurance Requirements	Number of Tiers of Risk-Sharing	Launch Licensee's Required Third-Party Liability Insurance (\$US)	Limit on Government Risk Assumption
United States	Yes	3	MPL, not exceeding \$500 million	Up to \$2.7 billion
France	Yes	2	\$72 million	No limit
China	Yes	2	\$100 million	No limit
Russia	Yes	2	\$80–\$300 million (vehicle dependent)	No limit
Japan	Yes	2	\$42–\$168 million (vehicle dependent)	No limit

¹Vedda, J.A. "The Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation." *The Aerospace Corporation*, August 2006.

If the risk-sharing provision expires, American launch providers may have to purchase additional insurance from risk-averse insurers, or if that is not available, exit the market. In addition, this would act as a deterrent for any new entrants into the marketplace. If these companies become uncompetitive on the world market, high-tech American jobs will be lost. America's share of the commercial launch market is currently not large, but companies with competitive pricing and reliable services are demonstrating that America can recapture commercial launch market share that it has ceded over the last three decades.

Because of the safety measures taken by industry, the regulations issued by the FAA AST and the very small probability of significant damage (1 in 10 million), the Federal Government has never had to pay one cent in the 24 years the regime has been in place. Highly unlikely, but damaging, risks are the hardest to insure in any insurance market, and the space insurance market is relatively small. This creates a potential market failure that the government can solve with minimal risk and virtually no cost, and we encourage you to extend the risk-sharing regime for as long as possible to provide certainty to launch companies and customers whose plans are often made years in advance.

The Government Accountability Office (GAO) has suggested certain changes to the calculation of the MPL. We have no objection to making modifications to that calculation, and look forward to working with FAA AST and Congress to accomplish that, as long as the benefit outweighs the cost. It should be noted that there are many endemic uncertainties in the calculation of any loss of this type, and an exceptionally detailed analysis could be an unwise use of taxpayer funds if it leads to no more precision in calculating the MPL.

Regulation

Over its two decades of existence, the FAA AST has appropriately focused its efforts on promoting the commercial space industry, protecting the uninjured public from harm and encouraging continuous safety improvement throughout the industry. CSF has worked closely with the agency to make certain that vehicles are safe for participants and the uninjured public. AST has issued several regulations to improve safety, and we are developing industry consensus standards to ensure that best safety practices are shared throughout the trade.

Congress passed the Commercial Space Launch Amendments Act in 2004, which directed the FAA AST to issue regulations to protect third parties and the crew of any manned vehicle, and established an informed consent regime for spaceflight participants. In the absence of specific data indicating a safety risk, the FAA AST was constrained from regulating for passenger safety "in the dark," until an eight year learning period had passed. That learning period was broadly supported by the Congress for good reason—to enable a new industry to mature, and to provide the regulator with real-world data on which to base sound regulatory policy.

Many observers expected there would be many commercial human spaceflights by the time the learning period expired in 2012, which would allow FAA to regulate with a robust set of data about safety. Unfortunately, the industry did not develop as quickly as expected, largely due to industry behaving with extreme caution and developing safe systems prior to any flight. Consequently, no commercial human spaceflights have occurred since 2004, providing no data on which to develop sound regulatory policy. For this reason, we thank Congress for acting in January to extend the learning period through October 1, 2015, with an eye toward restoring the original intent of the learning period provision.

Despite the passage of time, the concerns that led to the establishment of the learning period are still valid. There are no hard data from commercial human spaceflights on which to base regulations. Spacecraft designs are in flux, and regulations would be very difficult to draft in a way that would not eliminate some potential designs, most of which are impossible to evaluate at this point. In addition, in a nascent industry like commercial spaceflight, safety lessons are learned and applied rapidly, and regulation could easily fall behind. These factors mean that regulation should be data-driven and careful, a conclusion that has been implemented in the establishment of the learning period.

We share a concern with FAA AST that the end of the learning period, whenever it may come, represents a drastic change in regulatory environment. Recently, based on continued requests from CSF and in compliance with Congressional report language, FAA AST has started to provide industry with information on the general approach that it is planning to take toward regulating for spaceflight participant safety when the learning period expires. We support those efforts wholeheartedly and look forward to ongoing conversations with FAA AST and Congress about our common goal of protecting spaceflight participants, crew and the public. We also encourage FAA AST to work with us to share data that they have gathered on safety issues with the industry, in a form that does not compromise confidential or proprietary information, so that best practices can be quickly and effectively spread throughout the industry.

There are other existing regulations that have a detrimental impact on American aerospace companies and our national security. The International Traffic in Arms Regulations (ITAR) have been ripe for reform for many years, and the House recently took the first step in that direction by including a provision in the National Defense Authorization Act of 2012 that would allow the President to remove communications satellites and other related technologies from the U.S. Munitions List so that they could be more appropriately regulated through the Department of Commerce.

Over the last decade, much of the commercial space launch business has moved overseas. There are many reasons for this, including subsidies from foreign governments, but ITAR has also played a major role. The U.S. market share of satellite exports has decreased from 75 percent in 1995 to 40 percent in the last decade since the regulations went into effect. Returning some of that business would not only strengthen our defense industrial base but restore the U.S. market share and ultimately result in the creation of high-tech jobs here in America.

Therefore, we strongly support efforts to reform ITAR by returning to the President the ability to move satellites and related items from the U.S. Munitions List to the Commerce Control List, where they can be more appropriately regulated as dual use items. We particularly support the immediate removal of commercial space items, such as manned suborbital vehicles, from the Munitions List, and we look forward to working with Congress and the Executive branch to create an export control regime that better protects our national security and keeps high-tech jobs here in America.

Federal Government Demand for Commercial Services

The International Space Station is an invaluable resource to the science and research community if it is fully utilized. It will also be an important market for both commercial launch service providers and researchers. Current NASA plans involve the purchase of six seats per year aboard *Soyuz* flights to the ISS at a cost of about \$400 million per year. The result is that at any one time there are three United States Orbital Segment astronauts available to perform utilization tasks in addition to their other duties.

Due to the necessity of performing spacecraft operations, maintenance and other tasks, these three crewmembers are having a difficult time achieving the NASA target of 35 research hours per week. Indeed, a November 2009 GAO report cited "limited crew time as a significant constraint for science on board the ISS." The ISS is outfitted and will be provisioned to increase its full time crew complement from six to seven. The fourth USOS crewmember will dramatically increase the research capacity of the ISS.

All of the vehicles being proposed in the Commercial Crew Program have the capacity to carry seven crewmembers. While four would remain aboard as long duration astronauts, there are many options under consideration for the remaining three seats: They could be used for short duration sortie missions by NASA or other international partner astronauts; they could be likewise filled by highly specialized researchers in a program akin to the use of payload specialist aboard the Space Shuttle; they could be filled with science-related up-mass that is critical to onboard research; or they could be sold to non-professional space flight participants to offset

the costs to NASA. The realization of cost-effective and reliable commercial service to the ISS will provide NASA with myriad flexible options to optimize the utilization of our national orbital asset.

NASA Administrator General Charlie Bolden testified in March that he expects ISS to operate past 2020 and that conversations were already under way with international partners on this topic. Equipment reliability aboard the ISS has surpassed engineering expectations, and there are no immediate maintenance concerns that could require deorbiting. NASA and our international partners have yet to identify any technical reason the ISS would need to close down before 2028. Given the large investment the American taxpayers have made, we support measures to preserve and extend the ISS and believe that there will continue to be an ISS commercial crew market beyond 2020.

In addition, regardless of the long-term fate of the ISS, we believe that NASA and other government agencies will have a long-term need for cost-effective, reliable and safe crew and cargo access to low-Earth orbit. Two hundred years after Lewis and Clark set off to find the Northwest Passage, the Federal Government continues to require the services of geologists, naturalists and other scientists in the Western states. We expect that NASA and the rest of the Federal Government will similarly continue to have a need, and as prices drop and volume increases, those markets will grow.

Finally, suborbital spaceflight companies will also provide services to the Federal Government, from testing of components that will later fly on high-value missions for NASA or DoD, to science experiments that test microgravity regimes that are otherwise much more expensive to achieve. And these examples are just the start—as the capability arises, many more may arise. As one example, in 2007 NASA Administrator Michael Griffin said, “If I was still at the helm of NASA when [suborbital spaceflight] became available, I would guarantee you that we would use it to begin entry-level training of astronauts.”

Other Demand for Commercial Services

Historically, space has been the domain of science, defense and communications. Scientists have been studying the Earth, the solar system and the universe, through spacecraft for decades, but in many ways that study has only just begun. Scientists at universities and research centers across the country are interested in flying experiments, interplanetary probes and satellites to space. Scientists in countries that do not have active space programs have wanted to fly missions to space for years, but have had little opportunity.

Furthermore, a 2010 Avascent study found that astronauts from only 50 of the world’s 195 nations have gone to space, and very few of those nations have had continued access. But many nations and companies see astronauts and space research as valuable commodities, and they represent a largely untapped market for commercial space. These customers are interested in access to space for scientific and industrial research, but also for public relations, advertisement and other purposes.

Over the last decade, private astronaut access to space has become a reality. Space Adventures, a member of the Commercial Spaceflight Federation has sold several trips to the ISS on Russia’s *Soyuz* rocket to private individuals. In fact, every additional seat available on the *Soyuz* has been sold, with unfulfilled demand, even as the price has increased over the years. As our members develop an American commercial crew capability, and plans for private on-orbit facilities progress, we expect that market to flourish. According to a market analysis performed by Futron in 2010, 60 percent of surveyed individuals are more likely to fly on a more convenient American vehicle than the *Soyuz* alternative.

On the suborbital front, the Southwest Research Institute, another CSF member, has purchased six seats on suborbital vehicles, with options for more, to allow researchers to perform experiments that would otherwise be unattainable. Other researchers have expressed great interest as well, with more than 400 people attending the Next-Generation Suborbital Researchers Conference in February. Competitors in the Google Lunar XPRIZE competition, who are planning to return data from rovers on the Moon, are also looking for rides to space. As capabilities increase, flight rates rise and prices fall, we expect a great deal more interest.

The commercial satellite market is an international market with many billions of dollars in revenue each year. Historically, satellite providers have only been able to choose from a limited set of commercial space capabilities, primarily launch and on-orbit maneuvers. However, as new techniques emerge from the commercial space sector, we expect the commercial satellite industry to become a customer for a wider set of services.

Spaceflight has a unique ability to inspire students, and commercial spaceflight offers the opportunity to open space to a large population of young people as prices

for small experimental payloads to suborbit may be just a few thousand dollars, well within reach for foundations and even school districts. With frequent, recurring flights to space, citizen-astronauts could be teachers and mentors to countless pupils and more students could have a role in an experimental payload that flies to space. Many education programs could be birthed from safe, reliable flights to space, stimulating the next generation of STEM students.

The first airplane companies could not conceive of the many uses that their vehicle would one day be put to, uses that now include rapid package delivery and commuting to work. An early computer pioneer named Howard Aiken said in 1952, “[o]riginally one thought that if there were a half dozen large computers in this country, hidden away in research laboratories, this would take care of all requirements we had throughout the country.” Clearly, we do not have certain knowledge in any detail of the markets that will emerge for the commercial space industry. What we can say is that the currently available markets for government and private access to space are large enough for a successful industry and that there are many possible avenues for growth.

Many of our member companies were founded by experienced business leaders who have led highly successful companies involved in many sectors of the economy. They have invested a large amount of their capital into these businesses. If they did not believe there would be a market outside of the government, that level of investment would be unlikely. It is difficult to predict several years ahead what the most important sector of an emerging market will be, and it is likely that our members have somewhat different opinions on each sector. However, we believe that markets have been demonstrated to exist and that they will grow rapidly as capabilities increase, volume increases and prices are reduced.

Conclusion

The last month has been an important one for commercial space, with successes and exciting new announcements across the industry. I greatly appreciate the opportunity to provide testimony for this hearing and I look forward to working closely with all of you and your staff as the Commercial Spaceflight Federation promotes the development of this promising American industry, pursues ever higher levels of safety, and shares best practices and expertise throughout the industry.

Senator NELSON. Thank you all. This is very good.

This is an important time for us to have this hearing because we are in the state of change from a reliable system of the Space Shuttle now bringing in commercial but, in parallel, continuing NASA’s mission of exploring the heavens, of getting outside of low-Earth orbit. And it is all coming into the consciousness of the American people. The success of SpaceX, as we already mentioned, and on July 2, the first piece of flight hardware for the big rocket arrives, and it will be arriving at the Kennedy Space Center and will be assembled. And its first test flight will occur in 2014. And of course, this is NASA’s program that they refer to as the space launch system with the capsule being dubbed Orion. So this is a very important time that we get it right and that the success that we have had thus far is quite promising.

I am going to ask just a couple of questions and turn it over to my colleagues and I will wrap up.

But, Mr. Gerstenmaier, since you all rotate three astronauts to and from the station every 6 months—most of these commercial vehicles are designed to hold seven people. So how many commercial crew flights per year is NASA planning to buy, and how many seats will NASA make use of on each flight? And then I want to talk to you about how much cost savings that you are looking for that we are going to achieve per seat over and above what we currently pay to the Russians on *Soyuz*.

Mr. GERSTENMAIER. In terms of flights to ISS, we are anticipating staying with the rotation period of about 180 days as we have had. So that would be about two flights per year. We would

definitely increase the crew size on ISS to seven crew members. We currently have six crew members on ISS. We would add one more. The Space Station was designed to operate at a full complement crew of seven. We think that will increase the research capability on board station, allow us to do more national lab research and be more effective in utilizing the Space Station. So we will definitely use four seats from the commercial providers.

In terms of the other seats, we are still off investigating what makes sense. Would it be better to carry some cargo in those seats? Would it be better to carry crew, other participants? Could we do other things with those? We are still off investigating what the right mix is.

We are also exploring a little bit what the right duration is. We may do some extended missions on board Space Station on the order of a year or so, and that is to gain some experience with the kind of durations we may need in space for Mars-type missions.

So we are still off looking at those exact numbers, but I would say we are on the order of about two flights per year with a confirmed four seats on those flights. And then we are looking at how we could use those other seats effectively.

In terms of prices, we are still working that through the commercial crew program. We will see what the commercial providers come in at. We have budgeted the seat price at roughly what we pay for the *Soyuz* activity. That is just a budgeting number. That is not what we expect the seats to cost. We expect there to be a cost reduction, but I think it is a little too early for us to pick a particular value for that cost reduction.

Senator NELSON. In light of Mr. Gold's experience of going and finding a much cheaper rocket, do you expect those costs to come down considerably? In his case it was cargo. In your case we are asking the question about crew.

Mr. GERSTENMAIER. Again, I believe the prices will be cheaper than what we will have to pay for the *Soyuz* vehicle in terms of seat price. Exactly how much that is a function of the design, the ops concept, and all of the work that comes in front of us. So, you know, we have got a lot of work in front of us. We put our safety requirements out for the commercial providers to go look at. We are in the middle of this commercial crew capabilities activity where we are going to go on to the next phase of SpaceX with some providers to move forward. And until we really get a chance to see what those numbers are, it is tough to speculate exactly what that delta will be, but I expect it to be less expensive than *Soyuz*.

Senator NELSON. Under what appears to be going to be the number coming out of the NASA appropriations bill for commercial crew, \$525 million, with a down select to two and a half competitors, when do you think that with \$525 million —what is the realistic time that we will first launch crew? Is it 2016?

Mr. GERSTENMAIER. What we have done is in the President's budget, which we have submitted to you where we show essentially a higher number in 2013, but say, if we just had the \$525 million in 2013 and then we had an increase in the following years, in 2014, 2015, 2016, and 2017, if we get that increase similar to what the President had requested and what we have requested in our submit to you, if we get those kind of levels, we think we would

have crew available in the 2017 timeframe. Some of our providers think they can deliver crew earlier than 2017. We have heard estimates as early as potentially 2015. But from a NASA perspective, we kind of have to protect for the worst case. So we want to make sure that we have looked at the outer bounds of that so if there are schedule delays or problems that have occurred, which are routine in our business—as you can see, even with cargo some of the flights are a little later than the commercial companies had projected. But we are protecting for that 2017 date with the hopes that the commercial providers can do better than that and deliver earlier than the 2017. But we will need funding on the level of what we have asked for in the President's request.

Senator NELSON. It is true that some of the competitors are saying that they could go earlier. Whether it is 2015 or 2017 and being able to deliver seven crew members, then I think the obvious thing is that you get around to 2020 and the Space Station is not going to be deactivated.

Before I turn it over to Senator Hutchison, would you just reaffirm for everyone that they understand some of the magnitude of the experiments that are going on on the Space Station such as a vaccine for salmonella that is in its final FDA trials here on Earth that was developed on board the properties of near 0 G on the station and a vaccine for MRSA that is in its first stages of FDA trials here on Earth? Would you confirm or expand on that?

Mr. GERSTENMAIER. One of the unique properties we see in space is that viruses and bacteria mutate into a variety of forms in space. And we are not exactly sure why that occurs. We have some researchers that are looking at the phenomenon, why it occurs. But the industry is potentially able to take advantage of that because you get a variety of salmonella that can then be returned to the Earth. They can then look at that, determine which genes get turned on, and then essentially modify that salmonella such that it is strong enough to cause an immune reaction in a human system but not actually give you the disease. So, therefore, you are able to create a vaccine in a much shorter amount of time than you could ever in ground-based research because you take advantage of the fact that you end up with a whole variety of virus and bacteria.

As you discussed earlier, it also can apply to MRSA, to other things, to influenza viruses, et cetera. So this offers a potential avenue of a way to get better pharmaceutical or better drug productions for us in general. So it is much like when we went to Africa to look for new plant species and things to create new drugs. We are now using the unique properties that these viruses and bacteria do in space to essentially create a new industry.

There are also areas in materials, combustion, other areas that will have the same promise, and our intent is to try to expose commercial industry to these properties, let them understand for their individual industries what the benefits of space-based research are. Then this essentially creates potentially a new economy based on space-based research which could have dramatic impacts. And that is the ultimate goal of what we are trying to do at station over these next several years.

Senator NELSON. And I bring that attention to that subject because many people have missed that very good piece of news of

what is happening on board the Space Station where six humans are right now. And it is timely that you spoke of that, Mr. Gerstenmaier, because when we adjourn this hearing to go vote at 11:30, this very same topic is the topic of discussion with two astronauts that have been on the Space Station and this will occur in the Rayburn foyer at 11:30 this morning.

Senator Hutchison, I want to turn to you.

**STATEMENT OF HON. KAY BAILEY HUTCHISON,
U.S. SENATOR FROM TEXAS**

Senator HUTCHISON. Thank you very much, Mr. Chairman. I certainly appreciate your continued interest.

Senator Boozman, I have to say you have stepped up to the plate and done your homework, and I appreciate so much the good job you are doing as ranking member.

Senator NELSON. And I just want to say so that everybody understands how much we are going to miss Senator Hutchison. She is the reason that there is a designated national laboratory on the Space Station, and she has been consistently the promoter of the International Space Station, and the next hearing that we have in this subcommittee will be on that subject. Thank you.

Senator HUTCHISON. Well, thank you.

Let me say that I was very excited, as I know everyone was, with the SpaceX, the Dragon success. That just is a wonderful milestone. To get equipment and payload to the Space Station and dock is wonderful.

And what I would have said in my opening statement, which I will put in the record—but we are paying a heavy price for the Russian *Soyuz* spacecraft. And the reason that we are paying hundreds of millions of dollars—and it will be in the billions before we are finished—is because we were not able to fund adequately to close the gap for a commercial crew vehicle following on to the shuttle retirement. We knew it was coming. Senator Nelson and I worked in every way possible. We have worked with three administrations, and we have never had the adequate support to plan ahead and not have the gap that is here.

I do not want that to happen again as we are looking forward, which NASA, as our space exploration agency, should be doing. We know what the next mission is going to be. We do not know what we are going to be finding, just like we did not know when we went to the Moon what we would find exactly and what we would gain from it. And the gains have been enormous, which we know.

But now we know that we have got to utilize the Space Station. We believe that commercial is the way to do it in an efficient way to put people there to do the experiments, and the Space Station will be our major focus until at least the year 2020.

But we know that after that, the next horizon is beyond low-Earth orbit. And what Senator Nelson and I have tried to do—and Senator Boozman has been so helpful—is to assure that we are not shortchanging the future by only focusing on the present and having the same thing happen where kids start saying, well, gosh, why are we giving up space exploration in 2020 because everything is shut down because we did not look to the future?

So here is my question, Mr. Gerstenmaier. You are the one that, I think, does have a vision for what we can and must do for the future beyond low-Earth orbit. Can we be assured going forward that the allocations for NASA will adequately fund the crew vehicles to use the Space Station and hopefully—I cannot wait to find out what the alphaspectrometer might bring us, having seen the hits myself at Johnson Space Center. Can we, though, be assured that NASA will fully fund the commercial crew vehicle and the commercial efforts up to that time and also continue the progress so that in 2020—well, before 2020, but in 2020 when the Space Station will possibly go away that we will have a fully ready-to-go, heavy launch vehicle with a capsule on it for astronauts, that we will have a mission ready so that we are not going to see what happened frankly this year, when they took the exact amount out of heavy launch and put it into commercial.

Now, we rebalanced that. We are going to fully fund commercial, and with the down select to two, we will do that. And I know Congress, with the leadership of Senator Boozman and Senator Nelson going forward and the other people who are going to be coming into Congress, are going to want to do the same thing. Will NASA do that kind of balanced budgeting going forward rather than this constant pull as if there is a competition between the present and the future? Mr. Gerstenmaier?

Mr. GERSTENMAIER. I am responsible for human spaceflight, and what I mean by human spaceflight is it is both. It is the commercial aspect and it is also the vehicles that go beyond low-Earth orbit, the Orion and the heavy lift launch vehicle. And within the tight budget constraints, it is my job to balance those, that we deliver programs in a timely manner that best serve what we need as a Nation. And we are working really hard to go do that.

As Senator Nelson talked about earlier, the final weld is occurring today on the Orion test capsule that will be used in 2014 to go be the first vehicle to return at 80 percent of the lunar velocity into the atmosphere to make sure that works. That is going to get delivered to Florida on July 2, as he talked about. That final weld is actually occurring in New Orleans today and the teams are being careful with that weld, and if they need to take a little extra time, they may. And we may have to do something with July 2, but we will do the right thing overall. But the teams are really focused and moving forward.

We just completed a systems design review for the heavy lift launch vehicle. We are starting to lay out the plans to get that work done. We are going to test that vehicle down at Stennis in December 2016 in support of its first flight in 2017. We now, for the first time, have detailed schedules laid out. We know when the first drawings for that heavy lift launch vehicle need to be delivered, and those drawings start being released in August of this year.

So we have real concrete plans to keep moving the Orion forward, move the SLS forward, and with your help for funding, we will keep all these programs moving forward as well as commercial crew.

And it is not about one or the other, as you very accurately described. Human spaceflight is about all of these, and we need to

work as a team to pull this off to make this happen so we can continue to be a leader in space and continue to be where we are. So we treat it just as you describe. This is a package. There is a role for commercial spaceflight in low-Earth orbit. There is a role for us beyond low-Earth orbit. We need to find that balance to move those forward to keep human spaceflight in this Nation strong.

Senator HUTCHISON. Well, thank you. That is a wonderful answer. And I just hope that there will no longer be budget proposals from the President, whoever that will be next year, that will appear to cut back on the future and fund the present because we have an authorization bill that assures both. We support both. I am going to see the SpaceX operation in Texas in July. I am very excited about it. I do not want to see next year another instance of what we saw this year, Mr. Gerstenmaier, and I just hope that we can see that commitment on the part of NASA and the President's OMB. And believe me, I did not like what OMB did in the last administration or the one before that either. So I am balanced in my disappointment in this commitment, but since you are here now, I do hope that you will assure that the budget that comes from the President's office will reflect what you and I have both said is our goal. And I know that the two Senators here agree.

Thank you very much.

Senator NELSON. Well, thanks to you and Senator Mikulski and Congressman Wolf and Congressman Fatah, you all have basically kept NASA's appropriations level while every other agency is feeling the effects of the increased austerity that we have been facing as a result of the budgetary problems. So again, we thank you, Senator Hutchison.

Senator Boozman.

**STATEMENT OF HON. JOHN BOOZMAN,
U.S. SENATOR FROM ARKANSAS**

Senator BOOZMAN. Thank you. And again, I just want to echo that is such good advice—and it is just difficult in these tough fiscal times—of the statement about do not shortchange the future, you know, as you focus on the present. And again, you two have worked so hard to make sure in this particular case that that is not being done. And that has been a real challenge.

Let me ask something that I would like to get your all's opinion on real quick, and I think this is important. While the U.S. cooperative programs with Russia were expanding in the 1990s, including Russia joining the Space Station International Partnership in 1993, it also became clear that Russia was a source of sensitive technology to Iran. The Iran Nonproliferation Act of 2000 was enacted to help stop foreign transfers to Iran of weapons of mass destruction, missile technology, and advanced conventional weapons technology particularly from Russia.

One of the things that that Act did was to ban payments by any agency of the U.S. Government to Russian Government agencies for work on the International Space Station. This provision has raised difficulties regarding U.S. access to the Space Station. In 2005, Congress amended the act to exempt *Soyuz* flights to the Space Station from the ban through 2011, and in 2008 the exception was further extended through June 2016.

It has been said that without further extension of this exception the current restrictions will severely limit the U.S. from sustaining and fully utilizing the Space Station. The United States would have no means of transporting our astronauts to and from the Space Station, and equally important, relief is needed to clearly enable NASA partnerships with some U.S. commercial partners for Space Station crew and cargo services that utilize Russian space technologies.

So with the planned extension of the Space Station operations to at least 2020, it seems that an extension beyond 2016 is needed.

So can you comment on that and just kind of clarify your thoughts and where you think we need to go in that regard? I will start with you, Mr. Gerstenmaier.

Mr. GERSTENMAIER. As I have previously testified here, I think we will likely require some exceptions to the Iran, North Korea, Syria Nonproliferation Act as you described. We need that for a variety of activities. We do basic engineering with the Space Station and other activities of which we have to pay for or we even barter for services, and we will likely need some relief for that restriction that sits in front of us.

Senator BOOZMAN. And what would be the consequence if we did not get the relief?

Mr. GERSTENMAIER. We would still have to work with our partners. The way we understand the restriction is it also does not allow us to barter. I think it says for goods as well as funding. So we barter for a lot of engineering analysis and other things. We would not be able to have the support that we need to operate the Space Station without some relief to that Act. And we will still continue to work with our Russian partners. Maybe they would donate that engineering service and that research service without bartering for it. I do not know if that is the case or not.

It goes back to, I think, some earlier testimony that was given down here. The commercial folks really need some certainty of where they are going and to be forward, and to sit there with this uncertain thing going forward I think potentially impacts the ability for use ISS in the most effective manner.

Senator BOOZMAN. So the uncertainty is as much a problem as anything.

Mr. GERSTENMAIER. Yes, because I think we could debate whether we could work around this in some way. There may be a way legally to get through it. It will take us a significant amount of time to do that, and while we are going through that period, there is a fair amount of uncertainty with that. But they might be better able to address it from their perspective.

Senator BOOZMAN. Ms. Melroy?

Col. MELROY. Thank you, Senator. We have been informed of the same things that Mr. Gerstenmaier has said. Industry has also told us the same things, and we support our NASA colleagues in this.

Senator BOOZMAN. Dr. Dillingham?

Dr. DILLINGHAM. That issue is something that we have not looked at at this point in time.

Senator BOOZMAN. Mr. Gold?

Mr. GOLD. Our company has, of course, conducted extensive operations in Russia, and if I could just add some fuel to the fire of

your concerns, I think we also have a broken export control regime. Mr. Gerstenmaier correctly points out uncertainties. We never knew what to expect relative to technology that we could share or could not share. Our export control system is obsolete and counter-productive. Second only to gravity, the ITAR had the greatest potential to keep us from launching, and we need to get reform language into the National Defense Authorization Act to take care of this issue so we can protect our technology in a better fashion.

Senator BOOZMAN. Yes, sir?

Mr. LOPEZ-ALEGRIA. Senator, it is clear that we are quite interested in providing Commercial Crew services to the ISS and, therefore, we sort of need the ISS to be there for us. So it appears that the current legal thinking is that some relief will be required for NASA to be able to pursue that. Excluding perhaps the Russian *Soyuz*, or even not thinking about the *Soyuz* situation, there are some other things that are important for the survival of the ISS. So even leaving that part out of the equation, we support whatever is necessary to ensure future use of the Space Station.

Senator BOOZMAN. Very good.

Dr. DILLINGHAM, I think Mr. Gold referred to you as kind of the final authority on some of these things. Tell us about—can you update us on the status? You know, we have been talking about indemnification. I think everybody on the panel has mentioned that. You have had some recommendations to the FAA regarding the process. Can you give me a further update on what is happening with your recommendations?

Dr. DILLINGHAM. Yes, Senator. We looked at the insurance regime, and as we talked to many people in the industry—the launchers, the launch providers, and FAA, and it was clear that third-party indemnification is very important for the industry to mature and move on in that area.

One of the things that we had discussions with FAA about was the maximum probable loss calculations and the way that is currently done by FAA because it has an effect on the potential liability for the Federal Government. If it is done one way, there could be more liability for the Federal Government. If it is done another way or done incorrectly, in any case, it could cost more for launch companies.

And FAA agrees that their maximum probable loss calculation is rather dated, and they also agree that it is something that they would like to update to more modern techniques so that they could be more definitive in the insurance and the risks that the Government would be exposed to. And they also, of course, indicate that it is not going to be free to do that. So the indemnification regime is important. However, that part of it, we think, is something that needs to be relooked at after all of these years.

Senator BOOZMAN. Should we extend it before your recommendations are put into effect?

Dr. DILLINGHAM. I think so. You know, we did not talk to anyone in the industry who said that this is something that should not be extended. Indemnification is present in all of our competitors around the world. You have heard the captain say this morning—and we heard it several times in our work—that in terms of competition, without that, it could have a potentially negative impact

on our ability in a competitive way, raise the cost of launches, send business across the water, and impact our national defense as well and our industrial base. So, yes, it is very important. We did not get any strong sense that it should not be extended.

Senator BOOZMAN. So we should extend, but this would be a good time to clean it up a little bit.

Dr. DILLINGHAM. Exactly, sir.

Senator BOOZMAN. Thank you, Mr. Chairman.

Senator NELSON. Thank you, Senator.

Just a passing comment on that indemnification. For the commercial companies—and this started way back in the 1980s when we were first trying to get some commercial activity—companies have to know what they can buy insurance for. And if they know that, given the fact that there is always a possibility, albeit remote, that you could have a catastrophic event on an urban population, extremely remote with all the safety that is put into the launching, but if they know that they have to buy insurance to protect them for catastrophic insurance up to a billion and a half and that the Government is going to indemnify them on any catastrophic thing above a billion and a half, then that is a cost of doing business that commercial companies can figure into their overall cost. And that is why we have simply got to continue this.

I want to get back to you, Mr. Gerstenmaier. NASA did a contract for cargo resupply way back in 2008, long before anyone had demonstrated the capability. This is in a previous administration. So it has nothing to do with the orientation of any particular administration. And now, having spent \$800 million in the demonstration flights for cargo, NASA has paid almost \$1 billion under the ISS cargo resupply contract even though we have not actually had the official start of the contract. And that would come later, presumably this year, with another SpaceX launch successfully delivering cargo. And Orbital Sciences does not even yet have a working launch pad. So why is the Government making these payments and what is the services that NASA has received?

Mr. GERSTENMAIER. This is pretty typical of most of our launch contracts, even for our expendable launch vehicles. If you look at the payment schedule, after we give authority to proceed to a contractor, generally the payments occur with certain milestones, for example, when hardware is ready at some state to move forward, et cetera. So our commercial resupply services contracts are the same way. There are certain milestones, certain design reviews, certain activities that occur for preparation of which they are paid. And it turns out the majority of the funding is actually paid before the actual launch occurs. And then when the launch occurs, the final payment typically occurs. That is typical throughout our industry, and that is the way we have done things. That is the way the CRS contracts are started and the way they are structured.

So we have gotten positive work on these. If you go look at Orbital, for example, you can see what work is actually down there. They have several launch vehicles ready. They have a fleet of engines ready to go supply and support. They have their Cygnus capsule on board or down in Wallops ready to get launched. It has been through thermal vacuum testing. They have done a significant amount of work building a control center in Reston to monitor

that activity. So they have spent those funds and are essentially preparing for this activity to deliver cargo.

The unfortunate thing in our business is it takes a long time for us to get ready. So we really have to start with these kind of lead times, typically 3 to 4 years, to do earnest work before we are ready to actually go deliver the activity or the service we want out the other side.

We started the CRS contracts when we did because we knew the shuttle was going to retire in the 2010 timeframe at that point. And if we were going to be able to keep Space Station resupplied and realize the vision of Space Station of doing this research, we had to get moving. Even though it was an uncertain environment, we had to take some risk and move forward with these providers and lay out a reasonable plan to go forward. And that is what we did in 2008.

And I think if you look at their state of readiness, it is a little bit later than we had anticipated, but they have delivered the hardware. They have delivered the services. They are poised to deliver the cargo just like we had anticipated when we issued those contracts back in 2008.

Senator NELSON. That is a very complete answer. And congratulations on your progress to this point.

Mr. Gold, I wanted to ask you about your business plan. Do you have a business plan going forward that the launch services are going to be what the Russians have charged you on the basis of what you already have in orbit? And of course, what we have seen is the delivery of different crew going up. We have seen it from \$20 million per passenger several years ago to over \$60 million per passenger now. So what is your business plan to put crew on your larger vehicle of getting them up there?

Mr. GOLD. Senator, just like NASA, we are extraordinarily dependent on the success of the commercial crew program. It is why we are here today. It is why we care about commercial crew.

I can assure you that if we are forced to abide by the pricing that currently exists for *Soyuz*, our business plan and frankly any business plan would be unsustainable. Those prices must come down from the \$60 million-plus range. They must come down dramatically for there to be a business case from the private sector.

However, if you do not mind, Senator, I would also like to mention that the Committee should not limit its view to pricing alone. Per my opening testimony, there are substantial regulatory issues that are as important as pricing. As Ranking Member Boozman pointed out, we are facing serious export control issues, and if I may, I would like to share a quick anecdote with you on that front.

When I first traveled to Moscow, it was myself and a handful of our engineers. Across the aisle from us were a dozen former card carrying members of the Communist Party. Yet, it was not them but me as an American citizen who traveled with not one but two Government monitors breathing down my neck, listening intently and prepared to tell me what I could or could not say. Worse yet, I was paying for this monitoring to the tune of roughly \$140 per hour per monitor plus room and board and all of their travel expenses. We paid around \$300,000 to \$400,000 in direct costs to the Government for monitoring and probably about \$1 million in ITAR

compliance overall. I would joke with the Russians that the KGB may have spied on them back in the day, but at least they had the good courtesy to do it for free.

[Laughter.]

Mr. GOLD. And I would not be so upset if we were actually contributing to national security. Per, again, Ranking Member Boozman's comments, there are definitely some technologies that we have to be very careful with. But again, to give you an example, we had a stand, and the purpose of the stand was to keep our spacecraft off of the ground. It was round and had four legs coming out. If you put some silverware on top of it, maybe a nice tablecloth, the stand would be indistinguishable from a metal coffee table. Despite its benign nature, we had to have two security guards watching that coffee table full-time plus we had to pay two Government monitors to watch our guards watching the coffee table. Now, I can only imagine the national security implications of this table technology leaking out to the Russians, which they could then share with the Iranians or the Chinese, who could subsequently serve coffee or even tea on it. Therefore, beyond pricing, there are some significant regulatory issues that have to be dealt with in order for a true commercial business case to come to fruition.

Senator NELSON. Of course, but I can tell you that because we were not minding the store back in the 1980s and we started allowing American satellites to be launched on the Chinese launch vehicle, the Long March, significant American technology was transferred, and it was not supposed to be. And so clearly, when you come to the national security interests, you do have interests and you got to pay attention to them. And the Chinese are successful today in part because they got a lot of our technology that was supposed to be kept from them, even though a number of those aerospace companies insisted that they be able to sell their very sophisticated satellites for a Chinese launch vehicle. So there is a balance that you have to achieve here.

Well, if you get yourself around the regulatory—and by the way, this INKSNA—we do not have any choice. We have to pass that because we simply cannot let that get in the way of us moving ahead with the space program.

Not counting NASA, how many people in the private sector are willing to pay how much to fly up to your vehicle?

Mr. GOLD. Well, let me first say when it comes to people—and if I could dispose of some misperceptions relative to Bigelow Aerospace. I have been told that we are building a space hotel. I have even been told that we are building a space casino. I can assure you that neither is the case. This is what happens when you come from Las Vegas.

Our business case is based upon a model that is not overly different than the ISS where you will have countries on one end of the spectrum—take Japan, for example, that has a robust human spaceflight program but with all of the budget problems they are facing would like to get more astronaut seats and more capability for less money. Then on the other hand, take a country like Singapore, which has never had a human spaceflight program before and

would like to do so for the first time, particularly if they could get through it without breaking the bank.

That is really where we are going, plus the excellent point that you raised previously relative to microgravity research and development. I really believe we are grossly underestimating the impact of that on our overall economy and particularly on the pharma and biotech sectors. You mentioned some of the good vaccine research that is going on. That is just scratching the surface. We have had conversations with Johns Hopkins about cancer research that could eventually have dramatic results. But we have to develop regular, robust, and reliable access to space to bring that to fruition. The microgravity revolution will happen in pharma and in other sectors. The question is will it happen in America or will it happen in China.

Senator NELSON. Would you give the Committee just a glimpse of some of that additional microgravity research that you think is very promising?

Mr. GOLD. Certainly, sir. I am a lawyer not a biologist, so please forgive any inaccuracies.

For example—and this is the conversation we were recently having with Johns Hopkins, when you are developing a cancer drug in a 2-D terrestrial environment, you can spend hundreds of millions of dollars and years on a therapeutic only to find out that the drug does not work. It makes your hair fall out. You grow a third arm. It's bad. There will also be drugs that could have created significant benefits to human health and in terms of the economy that were dropped because of false negatives.

When you get into the microgravity environment, it basically simulates the human body, which is a 3-D, suspended set of matrices, in a fashion that cannot be done terrestrially. By properly simulating the human body in microgravity you can get real results in terms of what drugs will work and what drugs will not work. This capability could save pharmaceutical companies hundreds of millions of dollars, if not billions, just by giving the industry data as to what drug to bet on moving forward.

I think we have already seen some examples of this on the ISS with Amgen that did studies relative to osteoporosis. They were able to determine what the right drug was to invest their money in. You know, forget Las Vegas, pharmaceuticals are a big gamble, and if you can provide that extra information, that is something that every pharmaceutical company is going to need.

Senator NELSON. I think the American people are suddenly going to fixate on that once we see come out of the FDA trials the first major vaccine that is going to have a profound effect here on Earth as a result of the research that occurred in the properties of near 0 G on the station.

Anybody else want to comment on any of this?

[No response.]

Senator NELSON. OK. Then let me ask. Colonel, how does the—let us pick up on this regulatory thing. And the FAA is going to be involved in that. How does the prohibition on regulation hamper your ability to discuss, plan, and propose future safety regulations for spaceflight passengers and crew?

Col. MELROY. Well, Senator, protection of humans in space, especially when you are not specifically looking at a single mission, but are instead covering a broad array of vehicle types and uses, will be a major undertaking. Therefore, we would like to have an extended discussion that is very specific with industry about making sure that we are not stifling innovation, and, at the same time, we are trying to avoid risks that we know about.

Under the Administrative Procedure Act, we have some restrictions on the way that we can discuss potential regulations until we are in a rulemaking, and at this time, we cannot propose regulations. Therefore, we have to keep our conversation very general and on overarching topics. But, we will work with that. We are working with our industry advisory group, COMSTAC, and plan to work within the constraints of the law.

Senator NELSON. Do you want to pick up on regulations?

Senator BOOZMAN. Yes, sir, just for a second. Thank you, Mr. Chairman.

Let me ask you, Mr. Gerstenmaier. Under the new agreement for a limited number of commercial partners under the Space Act Agreements, how will NASA ensure that its safety standards and human readiness requirements will be met by the vehicles being developed?

Mr. GERSTENMAIER. We have approached that several ways. We have published all our safety requirements now, which are available to industry to take a look at. They are in a series of documents that sit out there. So this is different than we have done before. We have actually got all those requirements out there so industry can see those and can start implementing and designing to those requirements.

We are starting to think about now what our right strategy is, how we move forward. We are going to do Space Act for this next phase, and then we want to go into a commercial contract, a FAR-based contract activity, for the actual certification and demonstration phase. We are in the process now of discussing internal to the agency exactly how we do that flow and how we do that movement into that larger certification contract. In there, there will be some phase-in period or some kind of phase-in contract where we will be able to actually work and ensure that we have the right insight and the right oversight to work directly for these unique safety requirements. But we are going to again try to limit our interface and interaction to really just the safety requirements, the things that we determined throughout the years are really critical to protecting crew safety.

So we are still in the process of that, and in the next several weeks or so, we will be able to discuss with you in more detail exactly some more specifics of how that strategy lays out. But we definitely are thinking about that, but the big advantage now is the contractors can see our requirements. They know exactly what we expect from a human safety standpoint, and that is a big plus for them as they move forward.

Senator BOOZMAN. That really does seem to be a key in the sense that it has got to be done right. I mean, there are no ifs, ands, or buts. And yet, hopefully we can figure out a way to ensure safety

and do it where it is as cost efficient as possible because that is going to be a real key to whether or not it is viable going forward. I do want to congratulate SpaceX for their very successful mission.

And with that, Mr. Chairman, I yield back.

Senator NELSON. And Mr. Gold and Captain Lopez, having some assurance of the safety by NASA with their regulations I assume is going to be extremely important to you for your customers. Do you want to make a comment?

Mr. GOLD. It is extremely important. Again, we need the commercial crew program to go well and produce an affordable, safe product. Frankly, we shared many of the concerns of Congressman Wolf in regard to ensuring that we have a FAR-based procurement that is being developed in parallel to the SAA-driven activity so that when that SAA activity finishes, there can be a clean handoff from the SAA development to the procurement phase, just like we have done with COTS and CRS.

Additionally, per my opening testimony, we believe that Mr. Gerstenmaier's hands should be untied relative to providing mandatory safety requirements even under the context of a Space Act Agreement, particularly if the future crewed options are to be triggered under the current CCiCap regime. We disagree with NASA legal's assessment that this cannot be done. Again, I would urge the Committee to go to the GAO for additional insight into this issue.

Senator NELSON. Captain?

Mr. LOPEZ-ALEGRIA. Senator, I would say that I think the approach that Mr. Gerstenmaier outlined is an appropriate one in that NASA is hands off during the design and development of tests of these vehicles to assure the most rapid decisionmaking and basically get to a critical design stage as soon as possible, but that they should have oversight when it comes to safety.

Now, which form that oversight takes place, if it has to be a FAR-type contract or if it can be a Space Act Agreement, that is sort of beyond my purview as I am not an attorney like Mr. Gold. But I think the principle that NASA has the final say-so on safety is key.

Senator NELSON. The final question. Mr. Gerstenmaier, since NASA science launches are not licensed by the FAA, does that mean there is no Government indemnification for these launches?

Mr. GERSTENMAIER. Well, I will have to take that for the record and go look at that. I believe that under our NLS contract, those are FAA-licensed. Pam, can you help me?

Col. MELROY. I believe there is one that has been licensed and falls under the CSLA indemnification regime. I am not an expert, but I do understand that there is a separate indemnification process for missions that are executed by and for NASA.

Senator NELSON. OK. If you all will check that and let us know. [The information requested follows:]

NASA-contracted launches for NASA's science missions are not generically covered by an indemnification authority. For these missions, liability coverage for third-party claims is formed in three-tiers: (1) NASA contractually requires its launch providers to obtain insurance coverage for third party losses. The amount of the insurance required by NASA is the maximum amount available in the commercial marketplace at reasonable cost, but does not exceed \$500 million for each launch.

(2) To the extent claims are not fully compensated by the liability insurance, the NASA administrator has the ability to consider third party claims under the meritorious claims authority, Statute 51 USC 20113(m)(1)¹, up to \$25,000. (3) To the extent meritorious claims exceed the first two tiers of coverage, the facts and circumstances for such claims would be forwarded by NASA under Statute 51 U.S.C. § 20113 (m)(2)¹ to the Congress for its consideration.

In order for an agency to indemnify a contractor under the broad coverage of Public Law 85-804, the contractor must provide evidence and the agency must make case-by-case determinations that the contract activity will require the contractor to undertake “unusually hazardous or nuclear risks” and will “facilitate the national defense.” If a science payload includes a nuclear power source, a different indemnification mechanism could apply for liability resulting from the contract work involving that nuclear power source. Indemnification provided under the Price Anderson Amendments Act (PAAA) is only relevant to NASA launches that carry a nuclear power source provided by the Department of Energy (DOE) as only DOE has authority to provide PAAA coverage to its contractors and subcontractors. Such indemnification covers a contractor’s “public liability,” meaning legal liability arising out of a nuclear incident or precautionary evacuation involving injury or damage to persons or property related to a radioactive release, up to \$12 billion in the case of nuclear incidents occurring within the United States and up to \$500 million for incidents occurring outside the United States.

For SLS/MPCV, it may be possible to indemnify under Public Law 85-804 as we did with Shuttle, but the specific circumstances of the activity, the risk, and the available commercial insurance would need to be evaluated at the time a contractor requested such relief.

Senator NELSON. And then are we to assume that there is the normal indemnification when you all get into the big rocket, the SLS and Orion?

Mr. GERSTENMAIER. Yes. That will be the standard thing we have done in the past for the shuttle program, et cetera. We will work out the details associated with that, but it will be similar to what we have done with previous manned programs like the shuttle and other aspects.

Senator NELSON. I want to thank the witnesses for being especially very much to the point and mindful of the time. And we have even made it to the finish line with 10 minutes to spare when the votes are being called. Thank you all. Have a good day.

The meeting is adjourned.

[Whereupon, at 11:20 a.m., the hearing was adjourned.]

¹51 USC 20113

(m) Claims Against the United States.—In the performance of its functions, the Administration is authorized—

(1) to consider, ascertain, adjust, determine, settle, and pay, on behalf of the United States, in full satisfaction thereof, any claim for \$25,000 or less against the United States for bodily injury, death, or damage to or loss of real or personal property resulting from the conduct of the Administration’s functions as specified in section 20112(a) of this title, where such claim is presented to the Administration in writing within 2 years after the accident or incident out of which the claim arises; and

(2) if the Administration considers that a claim in excess of \$25,000 is meritorious and would otherwise be covered by this subsection, to report the facts and circumstances to Congress for its consideration.

A P P E N D I X

PREPARED STATEMENT OF HON. JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

Washington, D.C.—The United States has long been a world leader in using space for societal and commercial benefits. Satellites, for example, provide us with instant communication, the indispensable Global Positioning System—or GPS—for navigation, and weather data to inform forecasts that prevent loss of life and property. While the original investment for each of these examples came from the Federal Government, the commercial sector went on to make them profitable industries.

The commercial sector is now looking at space transportation and the market that may emerge as the next big business opportunity, and that's what this hearing will consider here today. NASA's purpose in the development of domestic commercial space flight capabilities is to lower the cost of getting crew and cargo back and forth to the International Space Station.

Lowering the cost of access to space is not just important to NASA, but to the defense and intelligence communities, as well as satellite broadcasting and communications providers, just to name a few. But if NASA's investment is to pay off in seeding this "commercial" industry, there are tough questions that need to be asked regarding the taxpayers' investment. What have these programs cost NASA so far; how are the funded companies performing; and, above all, how cost effective will these service providers be once NASA has invested in their development?

It is important to remember that as soon as there is a domestic capability, NASA is required by law to stop purchasing Russian *Soyuz* seats to get to the International Space Station. What is to stop a company from turning around and charging the Government a fortune to access our space station? Much has been said about not wanting the government to pick winners and losers, which is why we should not lock in a dominant player at this stage of the game. Key to the premise of competition, however, is whether or not a viable market for commercial space emerges beyond the Federal Government.

As these companies work to attract private investment, we hear repeatedly that they need certainty and stability both for investors and the emerging market; however, "certainty" and "stability" only seem to apply in certain situations. Many companies have advocated that extending the government's indemnification of third party liability adds certainty and stability; however, some of these same companies argue that FAA regulation at this time does not. Many advocated and were successful in obtaining a continued moratorium on FAA's regulation of crew and passenger safety until October 2015 in the FAA Reauthorization. I didn't like this provision then, and I don't like this provision now, as it increases the chances that regulation will be decided in reaction to an accident. Space flight is inherently risky and we know accidents happen.

With these questions in mind, I welcome our witnesses here today to help the Committee with its policy deliberations and oversight responsibilities in this area.

PREPARED STATEMENT OF THE AEROSPACE INDUSTRIES ASSOCIATION

Chairman Rockefeller, Ranking Member Hutchison, Subcommittee Chairman Nelson and Ranking Member Boozman and distinguished members of the Subcommittee, I appreciate the opportunity to submit testimony to the Committee regarding the commercial space industry and its role in the Nation's space program. On behalf the Aerospace Industries Association, I would like to emphasize the importance of renewing the Commercial Space Launch Act risk management provision, eliminating the sunset provision of the Act, and removing the indemnification cap for space launch activities. In addition, another important concern is the expansion of the excess intercontinental ballistic missile (ICBM) assets and the effect on the U.S. industrial base.

The Aerospace Industries Association (AIA) represents over 350 aerospace manufacturing companies and their highly-skilled employees. These companies make the spacecraft, launch vehicles, sensors, and ground support systems employed by NASA, NOAA, the Department of Defense, the National Reconnaissance Office (NRO), other civil, military and intelligence space organizations throughout the globe, and many of the commercial communication satellites. This industry sustains nearly 3.5 million jobs, including much of the high-technology work that keeps this Nation on the cutting edge of science and innovation. The U.S. aerospace manufacturing industry remains the single largest contributor to the Nation's balance of trade, exporting \$89.6 billion and importing \$47.5 billion in relevant products, for a net surplus of \$42.1 billion.

U.S. space launch capabilities are essential to our Nation's security and its ability to lead in space exploration. To sustain this capability, a healthy U.S. space launch industrial base is needed; as with aviation, to mitigate cyclical impacts, this industrial base would ideally serve military, civil government and commercial customers. Unfortunately, in recent years, our Nation's space launch industrial base has been struggling to adapt to reduced demand by government—especially due to the end of the Space Shuttle program—and downward pressures on DOD, NASA and NOAA budgets that threaten to exacerbate the risk to the industrial base. Furthermore, international launch providers have been aggressively bidding and winning commercial opportunities, often with the help of their governments in the form of either financial assistance or low cost financing. The sad reality is that the U.S. launch services industry has had a minimal share of the commercial worldwide market for launches; indeed, in 2011, there were NO commercial orbital launches from a U.S. space port.

Nonetheless, recent private sector investments by U.S. industry—including AIA member companies ATK, Aerojet, Boeing, Lockheed Martin, Northrop Grumman, Sierra Nevada, SpaceX and Virgin Galactic as well as others—and supportive policies by government agencies are enabling the emergence of new domestic space launch capabilities. These new systems have the potential to increase the U.S. share of the commercial launch market while also opening up exciting new markets. These companies have made their investments within the existing domestic launch business climate and domestic policy framework, but they face a challenging international competitive environment.

Many foreign launch providers competing against U.S. companies already benefit from generous indemnification rules. For example, the European company Arianespace is required to purchase insurance up to just 60 million Euros (roughly \$75 million). Any damages above this cap are the guaranteed responsibility of the French government.¹

Mr. Chairman, the U.S. space launch industry is not seeking any subsidy. Instead, the U.S. commercial space launch industry requires a stable and predictable business environment enabled by maintaining the existing launch risk mitigation framework for the foreseeable future. FAA's launch indemnification program has been in place for over twenty years—providing critical risk management enabling the emergence of a U.S. commercial launch market, benefiting the broader U.S. space industry, U.S. technological leadership, and ultimately, the U.S. consumer through the launch of U.S. communications satellites—without ever costing U.S. taxpayers a dime.

Under the existing program, the risk exposure of the Federal Government is managed; FAA controls the level of company insurance required by establishing the Maximum Probable Loss coverage required for each license and Congress ultimately controls the government's assessment of loss legitimacy since a specific Appropriation is required to pay any claims. Moreover, given that the current U.S. risk approach has been in place for so long, it is not clear how much additional underwriting capability is available in the space insurance market; adding new uncertainty will harm U.S. industry.

For the United States to adopt a purely laissez-faire approach to the U.S. commercial launch business, which competes in an international launch market where its Chinese, Japanese, European, and Indian competitors all operate under comparable risk management frameworks would amount to unilateral disarmament: Even if commercial companies could insure for the additional risk exposure commercially, it would add costs their competitors do not include, thus making commercial U.S. launch sales more difficult.

¹ Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation by J. A. VEDDA, Center for Space Policy and Strategy, National Space Systems Engineering, The Aerospace Corporation. 1 August 2006, Page 58.

But our rationale for continuing indemnification support is not narrowly focused on its benefits for industry—it also provides benefits for the U.S. Government. When U.S. launch rates were relatively high, the costs for all users—including the U.S. Government—were more affordable as the fixed costs of launch infrastructure and investments were spread out over a wider base of customers.

To better understand the importance of providing space launch risk mitigation legislation, understanding the history of U.S. commercial space launch is essential. Two decades ago, American space launch capabilities were a major player in the market—with a high percentage of worldwide commercial launches leaving from our spaceports.

Figure 1 shows how large the U.S. share of commercial space launch was from 1990—to 2001. The benefits to the U.S. economy were also significant; in 1999, according to a study by the FAA's Office of Commercial Space Transportation, commercial space transportation and enabling industries were responsible for \$3.5B in economic activity and over 28,000 jobs—by 2009, those numbers had shrunk to \$827M and just under 4,000 jobs.

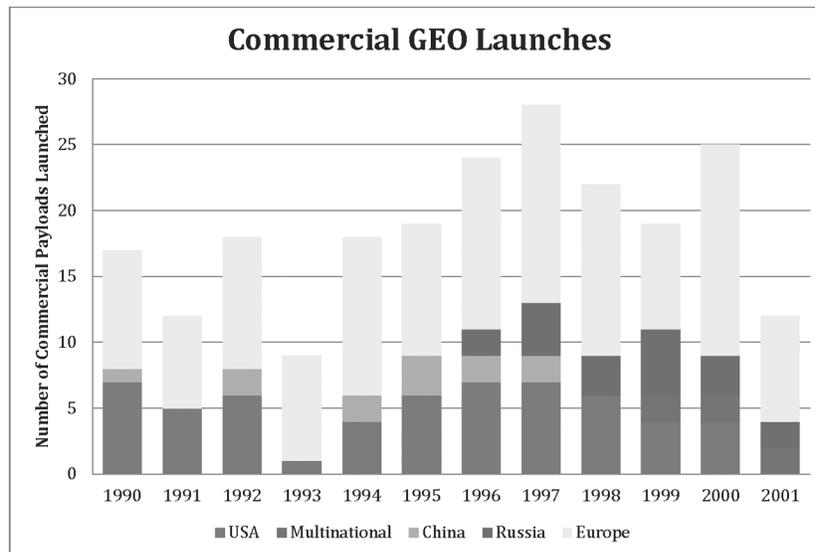


FIGURE 1—Commercial GEO Payloads Launched by Country from 1990–2001.
Source of data: FAA Office of Commercial Space Transportation.

The U.S. launch market share began a precipitous decline (see FIGURE 2) as a result of the collapse of the Soviet Union—which brought large numbers of Soviet developed Russian and Ukrainian launch capabilities into the market with a cost structure far below U.S. prices. Additionally, in this same timeframe, there was the advent of the more capable Ariane 5 launch vehicle, developed by the European Space Agency.

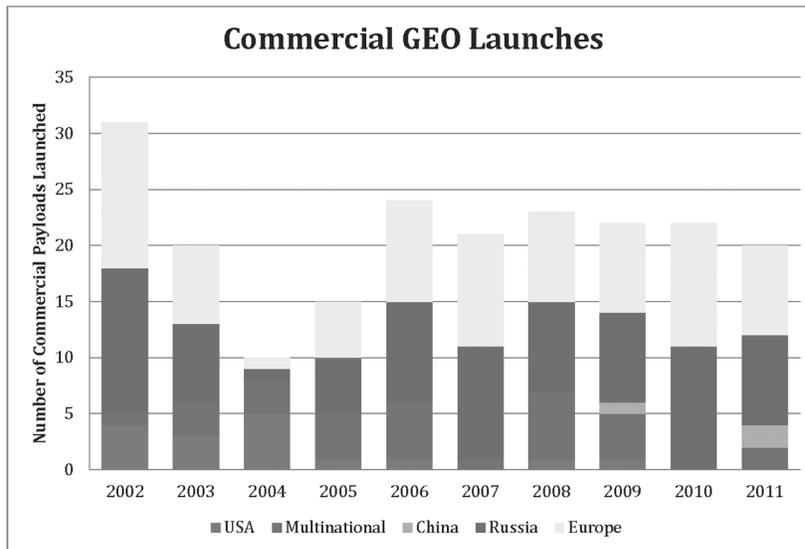


FIGURE 2—Commercial GEO Payloads Launched by Country from 2001–2011.
Source of data: FAA Office of Commercial Space Transportation.

In subsequent years, U.S. Government launch costs have risen substantially—partially due to the shift of commercial satellite launches to much lower cost foreign systems. This has also adversely impacted the space industrial base—an industry base significantly impacted already by the wind down of the Space Shuttle program. The success of the new launch ventures is also important to the Federal Government since they offer the real potential to reverse this trend.

Recent Space Launch Developments

Fortunately, American industry has been making investments to capture new space launch business opportunities utilizing innovative new systems—from launching commercial communications satellites more cheaply to supporting the International Space Station and creating new opportunities for private citizens to experience space flight. These investments—and the willingness of the private sector to commit their own resources to create new U.S. launch capabilities is a uniquely American development; no other nation in the world has a significant private sector effort underway—yet, in the U.S., a number of new systems, with a mix of private and government contract funding are in operation or under development. With good insight from the FAA's Office of Commercial Space Transportation and the workforce and design expertise developed by over fifty years of space launch investments by NASA and DOD, these new systems should soon enable our Nation to regain its space launch leadership while creating new markets and thousands of new U.S. jobs.

Figure 3 shows the projections by the FAA COMSTAC (Commercial Space Transportation Advisory Committee) of the potential for 300 commercial space payloads that will require 128 commercial launches through 2021. It should be stressed that this market forecast is a conservative estimate based only on existing markets; future markets for suborbital or orbital launch systems are not included but could potentially greatly increase the number of missions. These space launch investments have also been made in a business environment where, for over two decades, the U.S. Government has understood the need for a statutory risk management framework, enabling industry to pro-actively manage the potential liability in the event of a catastrophic accident. This space launch indemnification program is modeled after similar liability provisions for other industries that the government has sought to nurture, including nuclear power (*e.g.*, the Price-Anderson Act) and homeland security related safety technology.

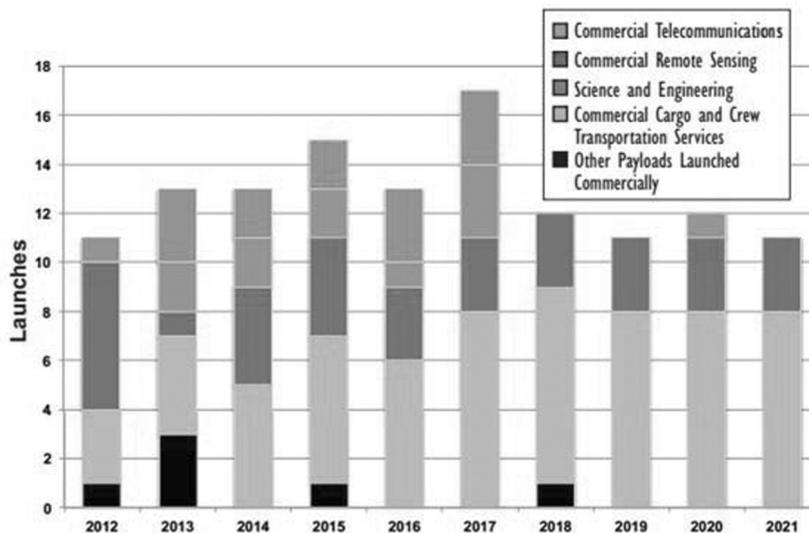


FIGURE 3—Commercial Space Launch Market Forecast 2012–2021.
Source of graph: 2012 Commercial Space Transportation Forecasts, FAA Commercial Space Transportation and the Commercial Space Transportation Advisory Committee

Mitigating Space Launch Risks

The current FAA approach to risk management has three tiers with substantial industry responsibility:

Tier 1: The FAA calculates the maximum probable loss (MPL) that could result from the licensed launch—that is the damage that could result to uninvolved third parties from the most likely worst case scenario. The launch provider, as the licensee, is required to purchase private insurance for the MPL covering all parties involved with the launch, including the U.S. Government. The MPL is capped at \$500 million, though rarely is that full amount required by the FAA's calculations.

Tier 2: Subject to Congressional appropriations following a Presidential request, the U.S. Government is authorized to pay up to a \$2.7 billion cap for third-party claims that exceed the insurance coverage and therefore the FAA calculated maximum probable loss. It should be noted that payments of claims are not automatic and no funds are committed to this regime. Congress can approve such payment and appropriate funding to implement it only if and when a claim is made. To date, no loss has ever occurred that would have triggered this regime, and Congress has never been asked to appropriate funding for the CSLA.

Tier 3: Any third-party claims above the Tier 2 cap are the responsibility of the licensee or the liable party.

The CSLA's risk management regime assures adequate liability coverage in case of catastrophic launch-related events, minimizes government risk exposure, avoids any need for annual outlays while also supporting the U.S. space and national security industrial base. It also strengthens U.S. international competitiveness in a global space launch market characterized by foreign providers offering government indemnification as a standard and discriminating feature of their services.

By maintaining continuity in the business environment, CSLA supports existing launch service providers and encourages new U.S. entrants into the launch business, ultimately enabling the development of new commercial innovative space markets—both for suborbital and orbital vehicles. In the end then, CSLA helps to keep vital space launch jobs in the United States.

Based on the 2004 Congressionally-mandated FAA Study of the Liability Risk-Sharing Regime in the United States for Commercial Space Transportation conducted by The Aerospace Corporation, the FAA Commercial Space Transportation Advisory Committee (better known as COMSTAC) has strongly endorsed and rec-

ommended to the Secretary of Transportation continuation of the commercial space launch risk management regime in the CSLA. The Congressional Budget Office (CBO) has also previously estimated that extending the agency's indemnification authority would have no significant budgetary effect for 5 years following its proposed extension in 1999. The current risk management regime is exactly the same regime assessed by the CBO in 1999.²

Risks of Non-Renewal

The CSLA regime enables U.S. launch providers, like their foreign competitors, to operate without "betting the company" with every single launch. In a competitive market with narrow returns, the loss of the risk management regime would cause U.S. companies to reconsider the risks and benefits of staying in the commercial launch business, suspend activity, and even exit the market.

Failure to renew CSLA would unnecessarily hamstring U.S. companies' ability to compete in the international launch services market. Without the risk management regime, U.S. launch providers appear riskier and more costly to prospective launch customers in a market with numerous foreign launch providers whose governments indemnify launches. As if harming U.S. commercial market competitiveness would not be bad enough, the U.S. civil and national security space communities could also experience increased launch costs for essential government payloads for communications, weather observation, remote sensing, GPS, and other satellite systems that are an integral part of our Nation's infrastructure and economy. Without a renewal of the regime, our Nation's space industrial base could be foregoing business that would share the fixed cost of space launch from government programs with the commercial market—savings that could be passed on to the taxpayer.

Non-renewal of the risk management regime could also mean an outright exit from the commercial launch market by U.S. providers, making it much harder to sustain high technology space launch jobs in the United States. We cannot afford to drive away highly skilled technical jobs to foreign countries, where the regulatory frameworks provide better critical risk management tools. Lastly, a non-renewal could impede new U.S. entrants to the commercial launch market, discourage future space launch innovation and entrepreneurial investment. Without a level playing field for competition, new U.S. entrants could find it highly undesirable to begin their business ventures in the United States, reversing recent trends.

Updating Space Launch Risk Management for the 21st Century

FAA's space launch indemnification approach began in 1988 when the Congress enacted amendments to the Commercial Space Launch Act (CSLA) of 1984, establishing a regulatory regime for FAA-licensed commercial space launches that included a risk management regime for third-party losses resulting from launch-related activities. Today, this risk management regime factors into all U.S. commercial space launch business decisions and provides a more level playing field for U.S. competitors. The FAA's launch risk indemnification backstop has been renewed 5 times since 1988—creating the reasonable expectation that it will be renewed in the future without completely eliminating the business uncertainty. But developing space launch systems is a long term effort—not uncommonly five years or more—and launch contracts are typically signed at least two years prior to launch. AIA believes the sunset provision of this law should be eliminated thereby increasing business confidence and promoting additional new investment.

FAA's three tier approach has never been utilized; losses to date have been relatively minor and have never exceeded the commercially-insured Maximum Probable Loss threshold let alone the cap on the Federal Tier 2 limit. Given that any Tier 2 payout would require a specific Appropriation anyway, AIA recommends that the Tier 2 cap should be dropped and that Tier 3 should be eliminated entirely.

In conclusion, the Aerospace Industries Association sees the continuation of U.S. space launch indemnification as an exceedingly low risk means to support to our Nation's vital space launch industrial base that provides substantial upside potential to enable new markets, create new jobs, and assure U.S. space technology leadership for the 21st century. U.S. industry is investing capital and innovative ideas to support this new future and U.S. Government agencies and the Congress have also taken important steps that have helped foster these new initiatives. It would

²The CBO's assessment of H.R. 2607, The Commercial Space Transportation Competitiveness Act of 1999 stated that "Based on information from DOT, we estimate that extending the agency's indemnification authority would have no significant budgetary effect over the next five years. DOT has never had to pay claims to third parties for incidents involving commercial space vehicles or services. Thus far, the costs associated with incidents have been small and have been covered by private insurance." H.R. 2607 became Public Law No. 106-405 in 2000, extending the risk management regime to 2004, which was extended again in 2009.

be a shame if these nascent capabilities were to be limited in its potential or even founder due to the lack of a level playing field with foreign competitors.

In order to allow U.S. companies to compete on a more level playing field for hundreds of new payload opportunities and creating thousands of new jobs:

- AIA recommends the Congress renew the Commercial Space Launch Act risk management provision (Section 70113(f) of title 49 of Public Law 111–125) well in advance of its expiration on December 31, 2012.
- Given the long lead times for space launch development and operations, the need for stable policies to promote investment and to maximize our industry's ability to be competitive, Congress should eliminate the sunset provision of the Act or at least extend them for a much longer time than in the prior renewals.
- To be consistent with our international competitors, AIA recommends the Congress remove the indemnification caps beyond Tier 1 for space launch activities.

Excess Intercontinental Ballistic Missile (ICBM) assets

The U.S. Government makes use of excess Minuteman and Peacekeeper ICBM assets for orbital launches of small satellites and suborbital launches of missile defense targets. According to section six of the 2005 U.S. Space Transportation Policy, excess U.S. ICBM assets shall be retained for government use only under certain conditions, including certification that their use has very limited impact on the U.S. space transportation industry. Unfortunately, limited use of these excess assets has not been the case and will pose increasing risks to future investment in civil, commercial, and military small space transportation options.

From 2000 through 2011, twenty three excess ICBM asset missions were conducted. This number is equal to the 23 combined launches of Pegasus, Taurus, Falcon 1, and Athena over the same timeframe. In AIA's view, using excess assets at a level equal to industry's sales adversely impacts the space transportation industrial base. Indeed, for smaller payloads, excess ICBM assets are nearing monopoly status. In 2010–2011 eight of nine small launches were excess ICBMs.

Increased reliance on excess missile assets converted to space transportation uses may seem convenient and cost-effective in the short term. Over the longer term, this short-sighted practice could negatively impact broader industry investment in small launch capabilities. AIA believes that these excess assets are jeopardizing industry's ability to support future mission requirements and may necessitate significant future investment to re-establish U.S. production capabilities.

AIA recommends that current law (the Commercial Space Act of 1998, P.L. 105–303) that allows for the conversion of ballistic missiles into space transportation vehicles be amended. In order to provide access to space for small-and medium-class government payloads, while sustaining and promoting growth in the U.S. space launch services industry, the use of excess ballistic missile assets as launch vehicles should be limited to only the launch of Federal Government technology demonstration satellites. In addition, improving the method of calculating the true cost of excess ICBM storage, transport, and conversion to a space launch vehicle should be addressed in the updated policy.

Thank you for the opportunity to submit testimony on behalf of the U.S. space industry.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO
WILLIAM H. GERSTENMAIER

Commercial Orbital Transportation System—COTS

Question 1. Please provide details of the steps required to transition SpaceX to performance under its Commercial Resupply Services contract. Please include information regarding the review and analysis of data from what appears to have been a very successful COTS 2+3 combined demonstration flight.

Answer. It is important to note that Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) are separate activities; the work under CRS is not a transition from COTS. SpaceX has been working under contract to NASA to provide cargo delivery services since SpaceX was awarded a CRS contract in December 2008. SpaceX delivered cargo under CRS during its COTS demonstration and has already completed milestones under the CRS contract for the five missions currently in process. This work has been focused in three main areas—(a) cargo processing, (b) mission planning and overall vehicle performance, and (c) completion of the visiting vehicle safety requirements. All three of these key areas were demonstrated during the COTS demonstration mission.

SpaceX and NASA have completed several post flight reviews and lessons learned sessions reviewing the COTS demonstration mission and improvements in each of the key areas have been identified. Examples of the improvements include an updated process for review and testing of software upgrades, updates to cargo packing both on the ground and on orbit, changes in how quickly flight data will be accessible after the spacecraft has returned, and updates in telemetry and tracking. These improvements have been included into the standard verification work and mission planning that supported the first CRS mission in October 2012 and will continue to be performed prior to every CRS mission.

With the successful completion of the COTS C2+ flight, SpaceX has accomplished all objectives necessary to demonstrate they can transport cargo to the ISS and return cargo to Earth. NASA is currently reviewing post flight data with SpaceX, as has been the standard practice with all demonstration flights. Two formal reviews have taken place to date. The final review was held in August 2012 and coincided with the transmittal of the mission final report to NASA. The next flight flown in October 2012 was the first operational mission under the CRS contract.

Additionally the ISS technical and safety integration teams have been working with SpaceX since August 2006 when the COTS Space Act Agreements (SAA) began. The interactions and the information and products provided by SpaceX have been of high quality and have enabled the ISS program to safely integrate SpaceX capabilities and operations into the program.

Question 2. What is your confidence level regarding that the ability of the Orbital Sciences Corporation to launch its demonstration mission this year? Are there any technical concerns with the launch vehicle and/or the Cygnus system?

Answer. Orbital Sciences continues to make progress in preparing their ground and flight systems for their upcoming test and demonstration flights. Critical vehicle testing on the pad is required prior to the test mission. Orbital is planning to complete the wet dress rehearsal and hot fire pad tests by the end of January. The launch of the Antares test flight will occur soon after the tests are complete. Orbital's demonstration mission to the ISS could be flown approximately 2–3 months after the Antares test flight, pending nominal pad refurbishment activities. Currently, Orbital Sciences is processing the test and demonstration flight launch vehicles and spacecraft with no major anomalies being identified. Orbital is conducting Joint Integrated simulations with the ISS program in preparation for the COTS demonstration flight as well as progressing through the ISS visiting vehicle verification process. As with the development of all complex space systems, there is always a chance of uncovering technical issues during this period but NASA and its partners will work to mitigate any issues that may arise.

Question 3. Can you summarize, to the extent possible, the technical issues that have impeded the launch pad development at the Wallops Island launch complex?

Answer. The state of Virginia's Mid-Atlantic Regional Spaceport (MARS) is responsible for construction and operation of the launch pad that Orbital Sciences will use for their COTS demonstration as well as ISS operational flights. Pad construction has been a clean sheet effort versus refurbishing an existing facility. As pad construction progressed, technical issues arose that are not atypical with construction of extremely complex infrastructure intended to distribute fuel and super-cold oxidizer at the precise flow rates and pressures needed to support launch vehicle loading and launch. Technical challenges were discovered when these super-cold fluids were introduced into transport lines for the first time. Additionally, as pad systems were activated, problems arose that required rework and increased the time-frame needed to complete the pad. Pad turnover has now been completed.

Question 4. While there have been slips to Commercial Cargo demonstration flights, what is the production status for the hardware needed for follow-on cargo resupply flights, which are needed to supply ISS. Are they slipping as well or are these contractors ready to fly, once they have demonstrated their capabilities in the upcoming demonstration flights?

Answer. The current ISS Flight Program includes three SpaceX and two Orbital CRS missions to ISS by the end of calendar year 2013. Production status is as follows.

- *SpX-1:* The Dragon launched atop a SpaceX Falcon 9 rocket from Cape Canaveral Air Force Station in Florida, on October 7, 2012. It carried 882 pounds of cargo to the complex, including 260 pounds of crew supplies, 390 pounds of scientific research, 225 pounds of hardware and several pounds of other supplies. This included critical materials to support 166 scientific investigations, of which 63 were new. Returning with the Dragon capsule was 1,673 pounds of cargo, including 163 pounds of crew supplies, 866 pounds of scientific research, and 518 pounds of hardware. Dragon splashed down in the Pacific Ocean October

28, 2012. The splashdown successfully ended the first contracted cargo delivery flight contracted by NASA to resupply the International Space Station.

- *SpX-2 (FY13 Q2)*: The interstage, the first stage and second stage have been shipped to the Cape. The Dragon capsule and trunk are in final assembly and are planned to be shipped to the Cape in December.
- *SpaceX-3*: This is the first CRS mission with upgraded Falcon Version 1.1. Production schedule for the new launch vehicles are being developed. The thrusters are scheduled to be complete in February 2013. The service section is planned to be mated in January with final closeout scheduled in April 2013. The dragon module has a planned completion date of May 2013. The current schedule has the Dragon capsule and trunk ready to ship to the Cape in June 2013.
- *Orb-1*: The first stage core of the Antares launch vehicle has been delivered to the Wallops Flight Facility (WFF). The first stage engines are scheduled for shipment to Stennis Space Center (SSC) for testing and shipment back to WFF in January 2013. The upper stack avionics cylinder is in system testing through March 2013. The Castor 30B (upper stack engine) final assembly is complete and stored awaiting a shipment due to WFF. The pressurized cargo module of Cygnus is also complete with planned delivery to WFF in April. The service module is currently undergoing Final Integrated Systems Test with shipment to WFF planned for March 2013.
- *Orb-2*: The current plan for the Orb-2 launch vehicle is to use the refurbished core from the 7K-test article. One first stage engine is integrated into the test article and will be refurbished and used for Orb-2 after the hot fire test. The second first stage engine is scheduled for delivery to WFF in February 2013. The upper stack avionics cylinder and payload cone are complete. The avionics system is being assembled and testing will occur from November through January 2013. The Castor 30B is in production and will ship to WFF in April. The pressurized cargo module of Cygnus is complete and integration testing is in progress. The planned delivery date to WFF is June 2013. The service module is undergoing spacecraft assembly, with the Initial Integrated System Test completed. Component testing is underway with Final Integrated System Test planned for completion in March 2013.

Question 5. How much cargo was transported to ISS and back to Earth during the SpaceX demonstration flight? How does that payload capability compare with the payload transport requirements for the full-up operational SpaceX system? What additional effort, NASA support, and resulting government funding is required to meet the payload requirements under the SpaceX Cargo Resupply Services contract?

Answer. During the May SpaceX COTS demonstration mission, the Dragon capsule delivered about 525 kilograms to the ISS as upmass under the CRS contract. On the return trip, Dragon carried science experiments to be returned to researchers. Including the experiments, Dragon returned a total of about 665 kilograms of hardware and cargo no longer needed aboard the Station as downmass under the CRS contract. The Dragon has the capacity to carry 3,200 kg of upmass internally or externally. As a practical matter, the internal carrying capacity will likely be limited by the volume available and will be about 1,600 kg. The capsule can return approximately 1,400 kg of downmass, which, at the projected 3 flights per year, should be sufficient to meet all ISS projected return requirements.

In terms of NASA support to SpaceX under the CRS contract, on December 23, 2008, the Agency ordered 12 CRS flights valued at \$1.6B from SpaceX. These funds are paid to SpaceX under a milestone structure based on progress for each flight.

Question 6. Now that SpaceX has completed their cargo demonstration flights, can you tell us how much government funding, including the cost for the use of government facilities and NASA personnel expertise, was required to complete the SpaceX cargo vehicle development effort?

Answer. Commercial Orbital Transportation Services (COTS) is the only NASA effort that directly funds the cargo vehicle development effort and NASA has provided \$396M to SpaceX under the COTS Space Act Agreement. NASA also budgeted and spent approximately \$40.1M through October 31, 2012, for NASA's efforts to manage and support the commercial cargo development effort. This includes the cost of government facilities and NASA personnel expertise provided through the program office. However, the NASA does not track the cost to support the individual providers, SpaceX and Orbital. Also, NASA does not track additional, indirect support provided for the cargo development effort by other Programs such as ISS.

Question 7. I understand that there were a large number of issues to resolve prior to this last flight by the SpaceX team. How was NASA involved in the resolution

of those issues, and what level of NASA resources were required to resolve those issues? Please include figures regarding the civil servant time applied to support commercial activities?

Answer. NASA's primary role is to monitor the progress of its commercial partners through an assessment of the milestones and to make payment for successfully completed milestones. NASA provides expert technical assistance; as requested or where considered necessary, via the NASA COTS Advisory Team (CAT) discipline experts drawn from across the Agency. CATs selectively support commercial partner reviews and consult on technical issues as requested. More extensive NASA support requires reimbursement for services or facility use via Reimbursable Space Act Agreements. Commercial Partners also receive ISS integration and certification support for their visiting vehicles. NASA has spent \$40.1M of the funds appropriated for the COTS program since 2006 managing and supporting the COTS effort of both commercial partners, and approximately \$16.8M of that cost (through October 31, 2012) is NASA civil servant labor. See Answer to question 6 for more details.

Question 8. According to the schedule associated with the CCDev Space Act Agreement between NASA and SpaceX, the recent SpaceX flight was almost 2½ years late. Now that the demonstration phase is complete, along with government funding that went with it, will NASA hold SpaceX to its contractually mandated delivery schedules and other terms under the CRS firm fixed price contract they have signed?

Answer. It is important to note that the Commercial Orbital Transportation Services (COTS) Space Act Agreement (SAA) with SpaceX is distinct from both the Commercial Crew Development (CCDev) SAA and the Commercial Resupply Services (CRS) cargo contract. In the case of the latter, the contract calls for the 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 from the orbiting complex. The contract is a firm-fixed price, Indefinite Delivery Indefinite Quantity procurement with a period of performance from January 1, 2009, through December 30, 2015, and NASA pays SpaceX for only those milestones that are successfully met.

When awarding the CRS contracts, NASA understood that the management of these contracts would be challenging for both NASA and the contractors. The contractors have the difficult job of producing the launch and cargo vehicles. NASA has the difficult job of orchestrating multiple missions to the ISS along with managing all of the on orbit activities. Under these conditions it is expected that schedules will be changed and both NASA and the CRS contractors have requested changes in the mission dates and consideration for the mission moves have been negotiated.

Launch windows for CRS flights to the ISS are baselined at the Vehicle Baseline Review (VBR) as provided for by the CRS contract. If SpaceX is not able to meet the contractual launch window, NASA negotiates with SpaceX an equitable adjustment to the value of the contract depending on the length and nature of the delay.

Question 9. NASA has committed to transitioning to firm fixed price contracts for the purchase of ISS resupply services. Fixed price contracts allocate risk of delay to the contractor, so any schedule delay should result in consideration paid to NASA. Will this in fact be the case as NASA and the ISS service providers transition to firm fixed price contracts?

Answer. Please see the response to question #8, above. NASA will only pay its CRS contractors when they meet milestones. At the Vehicle Baseline Review (VBR), NASA and the contractor jointly reach agreement on a 90 day launch window. After VBR, either NASA or the contractor can request a launch delay of up to 30 days without penalty. Any delays beyond 30 days need to be negotiated and could result in an equitable adjustment, change in delivery schedule or change in the period of performance.

Question 10. Administrator Bolden has stated that the procurement of actual ISS cargo services will be conducted under FAR-based fixed price contracts. Can you provide assurance that any future competition for either crew or cargo servicing will be under FAR-based contracts open to all bidders?

Answer. The procurement of actual ISS cargo services for the direct benefit of NASA were awarded as FAR-based fixed price contracts. Future competitions for both crew and cargo servicing will be awarded using competitive FAR-based contracts.

Question 11. NASA officials and the Director of OSTP continue to state that the use of commercial services for crew and cargo transport to low Earth orbit will free up more resources for exploration beyond LEO. However, NASA continues to press for additional funding for commercial crew development, while reducing funding for SLS and Orion. Can you explain this contradiction between NASA officials' public statements and their funding requests?

Answer. NASA is committed to operating and utilizing the International Space Station (ISS) and preparing for the next crewed missions of exploration beyond low Earth orbit (LEO). Now that the Space Shuttle has been retired, it is important to provide funding for the development of commercial crew systems that will enable the U.S. to resume flying its astronauts to the ISS on American-made vehicles as soon as possible. Once developed, these vehicles will allow NASA to spend less on LEO crew transportation through the purchase of domestic services than would be the case if the Agency had to build, operate, and maintain its own spacecraft for this purpose. This in turn enables NASA to focus more of its resources on the development and operation of launch vehicles and spacecraft for beyond LEO missions. If commercial crew or cargo were acquired in a typical cost-plus procurement manner, the cost would likely be higher than the current program. This new approach is providing cost avoidance.

Commercial Crew Development Program

Question 12. Under the new agreement for a limited number of commercial partners under Space Act Agreements, how will NASA ensure that its safety standards and human rating requirements will be met by the vehicles being developed?

Answer. NASA cannot impose requirements or standards on commercial companies via Space Act Agreements. However, NASA can terminate a Space Act Agreement if it determines that a commercial company's planned performance of an activity under that Agreement presents an unacceptable risk to human life. A clause to this effect is included in the CCIcap Space Act Agreements (SAAs).

In the case of the future Commercial Crew contracts for missions to the ISS, separate from the CCIcap activities, crew safety standards and human rating requirements will be applied and verified via FAR-based certification contracts. Thus, providers who wish to provide ISS crew transportation services in the future are incentivized to take NASA's human rating standards into account as they develop their vehicles.

Question 13. What is NASA's authority to oversee crew safety under NASA's use of Space Act Agreements (SAAs)?

Answer. Please see response to question 12, above.

Question 14. Please explain how NASA can ensure crew safety without contractual requirements.

Answer. Please see the response to 12. Furthermore, NASA intends to use FAR-based contracts for system certification and for flights involving NASA crew, so NASA's requirements and standards will be imposed.

Question 15. Who within NASA will certify that the commercial crew launches are "go for launch"?

Answer. For commercial crew launches, the commercial company, in coordination with the FAA, will be responsible for determining that they are "go for launch." NASA will not be certifying such flights for launch. NASA crew flights will only be performed under contracts, not Space Act agreements. The contracts will include terms to ensure crew safety. NASA intends that the FAA will license those flights for public safety.

NASA has not yet determined the details of how the flight readiness and mission management processes will be performed. At a minimum, NASA will have responsibility to certify that the NASA crew members are "go for flight." Furthermore, NASA will be responsible for verifying that a commercial company's transportation system fully meets NASA's human rating requirements prior to any launch involving NASA crew.

Question 16. Are you considering the use of additional activities to ensure these vehicles can be certified for operational use, and to avoid the possibility of additional time and money being needed to bring them into compliance after this current development phase is finished?

Answer. Yes, NASA is developing a comprehensive strategy for certifying commercial crew transportation systems to NASA requirements, which will include methods of mitigating the risks that companies' designs will require costly modifications down the road to receive operational certification. NASA communicated this strategy to Congress before the CCIcap agreements were awarded.

Question 17. The track record for Commercial Cargo development is poor regarding proposed vs. actual schedules. For example, SpaceX's original Demo 1 flight date was in September, 2008, but the actual flight was in December 2010; SpaceX's original Demo 2 flight date was June 2009, and as we all know now they flew just last month; and finally Orbital's original Demo 1 flight date was in December 2010, but the Current Plan is later this year. And Commercial Cargo is much simpler than

Commercial Crew. What is your level of confidence in the Commercial Crew offerors making the promised readiness dates?

Answer. NASA is confident that if Congress funds the program to the level requested in the FY 2013 President's Budget that commercial crew transportation will be available by the end of calendar year 2017. The commercial participants have stated that they could make services available before 2017.

Question 18. NASA has said that both commercial crew and exploration launches will use the same safety and human rating requirements, in particular "emergency egress" among those that will drive significant costs. Were these particular (and overall) requirements used and accounted for in all cost analyses to date?

Answer. Yes, NASA's cost estimates incorporate certification costs associated with meeting NASA's crew transportation certification requirements. NASA's understanding of these costs continues to mature as better data becomes available.

Question 19. Is it true that the requirements for emergency crew return would preclude any vehicle from delivering crew members to the space station and then departing for a secondary destination?

Answer. NASA's requirements for ISS Crew transportation services, which are reference for CCI Cap and will be mandated on future commercial crew contracts, include a capability for the CTS to remain docked to the ISS for up to 210 days to provide assured crew return for four NASA crew members. The ISS requires continuous presence of crew return spacecraft. However, these requirements do not preclude a vehicle from delivering crew members to the ISS and then departing, as long as there were sufficient crew return spacecraft at the ISS to enable full crew return.

INKSNA –Iran, North Korea and Syria Non-proliferation Act

Question 20. Can you tell us the key reasons why the exception in the Iran, North Korea, Syria Non-Proliferation Act should be extended to enable us to purchase Russian goods and services for spaceflight?

Answer. Without further modification, INKSNA would have severely limited the U.S. from sustaining and fully utilizing the ISS and from pursuing a robust human exploration strategy that includes Russian capabilities. The Congress provided NASA with relief from INKSNA in the recently passed Space Exploration Sustainability Act.

Question 21. What are the risks to the International Space Station if the ISS INKSNA exception is not extended?

Answer. See answer to question 20 above.

Question 22. NASA has testified that INKSNA waiver language is needed whether we continue to buy Soyuz seats or not. Do you know what the current plan and status is for bringing proposed INKSNA language to the Congress from the Administration?

Answer. NASA is very grateful that Congress has passed H.R. 6586, the Space Exploration Sustainability Act, which extends the INKSNA exemption by 4 years and removes restrictions on non-ISS, human space flight-related activities. The relief provided in this legislation meets the Agency's need, and was the product of very hard work in both the House and the Senate, for which NASA is profoundly thankful.

ITAR Reform

Question 23. There appears to be some movement recently in discussions regarding the ITAR reform process. Do you know if there is a plan for bringing a package of reforms to the Congress that would allow our aerospace industry to be truly competitive in the world market?

Answer. NASA has been supporting the Administration's efforts to reform the U.S. export control program and to revise the export control lists. Thus far, the Departments of State and Commerce have published proposed rules for nine of 19 categories of the United States Munitions List (USML) administered by the State Department. The State Department-proposed rules set forth what would remain in a given USML category, while the companion Commerce Department-proposed rules map out what would be moved from the USML. The Departments of Commerce, Defense, and State can provide more information on this effort.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO
WILLIAM H. GERSTENMAIER

Question 1. NASA's budget documents indicate that in the transition from the Space Act Agreement phase to a certification phase, NASA will have to "accommodate redesign as necessary to ensure compliance with agency requirements." What

is NASA doing to minimize the need to significantly redesign commercial partners' crew systems to ensure they meet agency requirements?

Answer. NASA baselined and released the future certification requirements for industry to begin using as reference to mature their designs. All partners have access to the requirements and standards NASA will use for the future contracts for ISS.

For commercial crew services, crew safety standards and human rating requirements will be applied and verified via FAR-based certification contracts. Thus, providers who wish to provide ISS crew transportation services in the future are incentivized to take NASA's requirements into account as they develop their vehicles reducing the likelihood of significant redesign.

Question 2. Does NASA have an estimate as to how much it might cost to ensure compliance?

Answer. Please see response to #1, above. Costs associated with redesign due to non-compliance will be partner-specific and NASA's understanding of these costs continues to mature as better data becomes available.

Question 3. Do the savings presented by using a Space Act Agreement outweigh the lack of insight and oversight provided by a Space Act Agreement?

Answer. Collaboration with industry in the early stages via Space Act Agreements allowed the Government and industry to mutually leverage each others' investments. As the program moves further into the development phase, NASA plans to use a Federal Acquisition Regulation (FAR)-based contract for certification of commercial systems prior to flying crew on these systems. The Agency intends to structure the certification effort to permit the Agency to fully evaluate the proposed systems and accommodate any necessary redesign to ensure compliance with NASA safety, performance, and mission success requirements. The provider(s) awarded a certification contract will not only be required to meet the NASA requirements in order to fly NASA personnel, but they will also have to show verified compliance of how the design and hardware will meet these requirements. The use of Space Act Agreements to support commercial development does not change the need to fully review and certify any system selected to transport NASA crew. NASA believes the combination of both FAR-based contracts and SAAs throughout various elements of the programs strikes an appropriate balance of cost effectiveness and insight and oversight.

Question 4. Is NASA comfortable that the level of insight and oversight during this critical phase of development is sufficient to provide the government with sufficient information to eventually certify a vehicle and ensure obtaining the best price possible when buying commercial crew services?

Answer. Please see response to #1, above, regarding vehicle certification. NASA has made awards to three companies in the latest phase of SAAs (CCiCap). The Agency believes the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases. Having multiple companies competing against each other will help ensure the best price possible for the Government and will help enable voluntary adherence to safety requirements.

Question 5. Recently, the FAA and NASA signed an agreement to coordinate standards for commercial space travel of government and non-government astronauts to and from low-Earth orbit and the ISS. Can you please describe this agreement and responsibilities from the NASA point of view? Can you assure me that NASA will retain the ability to ensure that commercial crew carriers meet the same safety requirements that our other human spacecraft meet?

Answer. The nature of the Federal Aviation Administration's (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 and impose its requirements by contract. NASA will partner with the FAA to advance 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 and developing a streamlined process.

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) to support the transition to commercial transport of government and non-government persons to LEO in a manner that avoids conflicting requirements and multiple sets of standards. In developing these standards, the parties will exchange knowledge and best practices in the various disciplines of space flight, including safety.

Question 6. As you know, the long term goal of U.S. human space flight and exploration efforts is to expand permanent human presence beyond low-Earth orbit. But in order to do so, the United States must have assured access to the ISS for our astronauts and must design and build the new rockets to take us beyond low-Earth orbit: the Space Launch System and Orion crew capsule. The government must work in cooperation with the U.S. commercial sector in order to accomplish these objectives. Space, however, is an unforgiving environment, resulting in unusually hazardous risks, which can be a deterrent to commercial sector participation. It has been the U.S. policy since at least 1958 to provide its private sector contractors some assurance that engaging with the government in such unusually hazardous activities will not put their business at total risk should there be a catastrophic failure resulting in damages to third parties through use of an indemnification regime.

The Commercial Space Launch Act authorizes the FAA to license launch and reentry activities other than those activities the Government carries out for the Government. Who has the responsibility to determine when activities under NASA contracts are Government activities carried out for the Government?

Answer. NASA has the responsibility to determine when activities under NASA contracts are Government activities carried out for the Government. NASA decides whether any particular launch is a government launch (where it substantially directs or controls the launch) or a commercial launch depending on the needs of the program. As part of the program formulation and acquisition processes, the roles for NASA and the contractor, including the roles related to the conduct of launch are established based on the best interests of the Government and the public, consistent with law and policy. As an example of this decisionmaking process, NASA recently determined that all launches supporting ISS crew transportation services will be commercial, thus licensed by the FAA. NASA and FAA entered into an MOU for Achievement of Mutual Goals in Human Space Transportation on June 4, 2012, to among other things, work together to reach a common understanding and approach for meeting that objective.

As noted, the Commercial Space Launch Act, provides the Secretary of Transportation (acting by delegation through the FAA Office of Commercial Space Transportation) authority to license and permit commercial launches and reentries. The Secretary's authority does not apply to "(1) a launch, reentry, operation of a launch vehicle or reentry vehicle, operation of a launch site or reentry site, or other space activity the Government carries out for the Government . . ." 51 U.S.C. 50919(g). Therefore, launch and reentry activities that are not commercial (carried out by NASA for the Government) are not licensed by the FAA.

NASA has the responsibility as part of its program formulation and acquisition processes to determine whether activities under NASA contracts retain for the Government NASA direction and control, and are thus Government activities carried out for the Government or are commercial launches.

Question 7. NASA had used authority under Public Law 85-804 to provide third-party indemnification assurances for Shuttle launches. What authority does NASA intend to use for SLS and Orion launches? Or for future science payload launches under the Launch Services Program, for example?

Answer. NASA was able to provide indemnification to its Shuttle contractors under P.L. 85-804 (50 U.S.C. §§ 1431-1435) for claims for unusually hazardous risks because NASA was able to make the determination that doing so facilitated the national defense. Recall that the DoD was a user of the Shuttle.

Similarly, in order for NASA to be able to utilize the authority of P.L. 85-804 for other launch programs such as NASA Launch Services (NLS), Space Launch System (SLS), and the Multipurpose Crew Vehicle, (MPCV or Orion), the Agency would have to demonstrate a nexus between the commercial contract requirements and facilitating the national defense. Otherwise, NASA has no authority to provide P.L. 85-804 indemnification to its contractors even for activities that are unusually hazardous.

Under the NLS contract, NASA utilizes its meritorious tort claim authority (51 U.S.C. § 20113(m)). It is not an indemnification authority. It covers third-party claims against the contractor arising from performance of the contract, but NASA may only pay claims up to \$25,000 (above any claims covered by insurance). Claims in excess of \$25,000 would be forwarded by NASA to the Treasury for consideration of payment from the judgment fund under 31 U.S.C. § 1304. NASA may certify such claims to facilitate payment from the judgment fund.

At this time, NASA has not determined whether any indemnification protection would be available to the SLS and Orion contractors. However, the Agency's meritorious tort claim authority may be provided to them. Likewise, future science payloads under the NLS contract may be protected through the Agency's meritorious tort

claim authority, as is currently available under NASA's NLS contract with its launch service providers.

Question 8. In the past, budget estimates were requested for the life cycle costs to develop the commercial crew vehicle. Can you share this information now, based on the risk/cost/safety trades NASA is currently making? What are the key risks for the safety of commercial crew?

Answer. NASA has recently collected detailed technical information from our CCiCAP partners for projected cost/schedule requirement to complete development and achieve a crewed flight demonstration. NASA will use this information as input to cost and schedule models to support an independent cost assessment, develop a more rigorous project plan, and inform updates of NASA's budget estimates for the certification phase 2 as part of the FY 2014 budget request. Each partner concept has its own unique risks and they are tracked by the companies, with NASA insight.

Question 9. While U.S. cooperative programs with Russia were expanding in the 1990s, including Russia joining the space station international partnership in 1993, it also became clear that Russia was a source of sensitive technology to Iran. The Iran Nonproliferation Act of 2000 was enacted to help stop foreign transfers to Iran of weapons of mass destruction, missile technology, and advanced conventional weapons technology, particularly from Russia.

Among other things, that Act banned cash or "in kind" payments by any agency of the U.S. Government to Russian Government agencies or to any entity under their jurisdiction or control for work on the International Space Station or for obtaining goods and services relating to human spaceflight. This provision has raised difficulties regarding U.S. access to the International Space Station. When the President in 2004 announced that the Space Shuttle would be retired in 2010, the Russian *Soyuz* became the only vehicle available after that date to transport astronauts to and from the ISS. In 2005 Congress amended INA to exempt *Soyuz* flights to the ISS from the ban through 2011 and in 2008 the exception was further extended through June 30, 2016. Is a further extension necessary? If so, why?

Answer. Without further modification, INKSNA would have severely limited the U.S. from sustaining and fully utilizing the ISS and from pursuing a robust human exploration strategy that includes Russian capabilities. The Congress provided NASA with relief from INKSNA in the recently passed Space Exploration Sustainability Act.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO
COLONEL PAMELA MELROY

FAA Regulatory Authority

Question 1. If the moratorium on regulation expired today—what would be the FAA's process and time-frame for developing and implementing regulations? Do you see benefits in starting this process as soon as possible?

Answer. Rulemakings on complex technical subjects often involve substantial preparation that includes studying an issue and consulting with stakeholders before proposed regulations can be drafted. The FAA is currently in this period. The impact of the moratorium on this phase is that draft regulations may not be issued for public review and discussion, only general issues. The benefit of starting the rulemaking process as soon as possible would be that more substantive discussions could be made in the near term. This would provide stakeholders the opportunity to comment and provide feedback on the most relevant issues that require the FAA's fullest consideration up until the appropriate time to issue regulations arrives. If the moratorium expired today, our "best case" estimate is that a final rule could be issued in mid-2016. This would include submitting the project to the FAA Office of Rulemaking for review at the end of 2012, following the standard process timeline, and publishing proposed rules for comment in late summer 2014. This is the normal timeline; complex rules generally take more time, and the FAA believes that 4 to 5 years is more realistic.

Under current law, with the moratorium set to expire on October 1, 2015, we estimate that following the standard rulemaking process, a final rule could potentially be in place March 2019. Realistically, we expect that it is most likely the final rule would be published in 2020.

Question 2. Would you agree that regulations necessarily inhibit innovation, or could they provide a more certain environment in which commercial companies can innovate?

Answer. I disagree that regulations always inhibit innovation. When the appropriate time comes to regulate, I believe well-written, performance-based regulations would provide a valuable “checklist” to industry regarding what *safety* precautions to consider, assure investors and insurers that safety is being addressed, and allow great flexibility in technology solutions. Thoughtful, quality regulations can elevate the safety of an industry while still allowing innovation.

Question 3. The FAA has no authority to regulate on-orbit activities, including commercial satellites, and in the future, crewed spacecraft. In fact, the FCC has more authority to regulate on-orbit activities than the FAA.

Ms. Melroy, what are some of the risks and consequences of not having any regulations, besides those of the FCC, for on-orbit activities of commercial spacecraft?

Answer. As the industry evolves, and the government’s reliance on commercial vehicles changes, private U.S. operators of transport spacecraft could operate outside international orbital debris mitigation norms, and thereby unnecessarily threaten the long term sustainability of space. The orbital debris environment continues to worsen and there is much international activity directed at ensuring the long term sustainability of space. It is essential that all government and private operators of spacecraft follow common sense debris mitigation measures. The government only oversees a portion of private spacecraft operators with regard to collision avoidance and orbital debris mitigation—the FCC and NOAA regulate communications and remote sensing spacecraft, respectively. The operation in orbit of transport spacecraft is not regulated.

For manned vehicles, many hazards exist for occupants of spacecraft on-orbit. Having no regulatory authority over the on-orbit phase of flight could increase the risk of those occupants for a significant portion of the mission.

Question 3a. Are there some clear areas—perhaps orbital debris mitigation—where an appropriate level of regulation could be helpful to your industry?

Answer. Yes. Some members of industry and the insurance community have told us that single, clear regulatory oversight of collision avoidance, orbital debris mitigation, and the protection of humans on board spacecraft are areas where balanced, well-crafted regulations and safety oversight could provide business certainty and reassure investors and insurers who do not have expertise in the area of space transportation that adequate safety oversight exists.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO
COLONEL PAMELA MELROY

Regulation of Commercial Spaceflight

Question 1. As you indicate in your statement, an important part of your and the FAA’s responsibility is observing and accumulating data on the various vehicle development and testing activities. What is FAA able to do to prepare for eventual regulation of on-orbit activities during the “moratorium” ending in 2015?

Answer. The FAA is making good progress in preparing for the challenge of regulating occupant safety of commercial human space transportation after the moratorium ends in 2015. We have assembled a team to define the approach and do the groundwork for this regulatory framework. The team’s activities include:

- Studying other human safety requirements such as the NASA Commercial Crew Program requirements, aviation safety regulations, and various human rating studies.
- Identifying and documenting ground rules and assumptions to ensure we are focusing on known, reasonably avoidable risks and realistic operations in the near term.
- Soliciting industry input on a variety of technical topics through our Commercial Space Transportation Advisory Committee, COMSTAC.
- Studying the current industry designs of human spacecraft to understand the different ways current commercial providers are thinking about addressing occupant safety.
- Identifying best practices and lessons learned for the use of standards and guidance documents from other regulatory organizations and NASA.

With regards to any eventual private commercial human space transportation that would occur in Earth’s orbit, neither the FAA, nor any other Federal agency, has the authority to issue regulations that I believe may eventually be necessary to fully protect these occupants against known hazards. We are, and will continue to be focused on understanding orbital transportation safety issues and other issues

such as orbital debris caused by launch and reentry. We will also collaborate with our colleagues at NASA, NOAA, the Department of Defense, and other agencies as appropriate.

Question 2. Can you suggest any needed legislative language to enable your ability to carry out those activities in anticipation of your eventual authority to develop a regulatory regime for commercial spaceflight?

Answer. The FAA will continue to work within its regulatory authority in anticipation of a regulatory regime for commercial spaceflight. At this time, we are engaging in general conversations with stakeholders. However, absent certain circumstances, the FAA may not issue draft regulations for public review and discussion before October 1, 2015. Our ability to propose rules will impact stakeholders' ability to provide comment and input for the consideration of the FAA on issues more relevant to what might exist down the road as regulations.

With regard to orbital activities, as the industry evolves, and the government's reliance on commercial vehicles changes, it may be necessary to revisit some of the statutes and regulations that govern commercial space transportation. Specifically, the FAA's statutory authority may require expansion and adjustments to definitions to ensure public safety. For example, there may be a need for greater regulatory authority in the areas of transportation on orbit as well as launch and reentry.

Question 3. Currently there is no regulatory authority for the on-orbit activities of commercial space vehicles. What are your views as to when the appropriate time would be to consider legislation that would enable that kind of authority? Do you have an opinion as to who should or shouldn't regulate this regime?

Answer. In 1984, Executive Order 12465 designated the Department of Transportation as the lead Federal agency for encouraging and facilitating the commercial space transportation activities occurring at that time. Since then, the Department's role has been supported by Congressional action with Congress giving the Secretary of Transportation, acting by and through the FAA Office of Commercial Space Transportation, authority over launch and reentry. The regulation of launch and reentry includes transportation issues that may occur in Earth's orbit at the end of launch and at the beginning of reentry. At this time, the operation in orbit of commercial transport spacecraft is not regulated.

Earlier this year, prior to the FAA reauthorization, the Administration endorsed the concept of giving the FAA safety oversight of commercial on-orbit transportation. As mentioned in my previous response, as the industry evolves, and the government's reliance on commercial vehicles changes, it may be necessary to revisit some of the statutes and regulations that govern commercial space transportation. I believe the U.S. commercial space industry will continue to achieve new milestones. In addition to the SpaceX's Dragon servicing of the ISS last June, companies may soon be transporting participants to commercial orbital facilities like those being developed by Bigelow Aerospace. On behalf of the FAA Office of Commercial Space Transportation, we look forward to working with the interagency community and Congress as the industry matures and evolves.

Question 4. As a former shuttle commander—and the second woman to command a space shuttle—what can you share from your personal vantage point about the current commercial crew development efforts? Do you have a sense they are being undertaken in a way that will ensure the maximum safety and efficiency of operations?

Answer. Personally, I am pleased to see many of my colleagues who have joined the commercial providers to advise them regarding safety requirements and I believe they are keeping the lessons learned from human space flight firmly in mind. I believe that the commercial providers are attempting to find the best balance between mission capability, cost-efficiency, and safety. The FAA and NASA have been working for the past several years in a partnership arrangement toward ensuring commercially-developed human-rated systems for low-Earth orbit are safe and effective. Leveraging the previous launch and mission experience from these two agencies ensures the maximum safety and efficiency of operations for these commercial human space flight missions.

Question 5. Does FAA have the resources and tools it needs to regulate and license commercial space launches and re-entries? On orbit activities?

Answer. The FY 2013 President's Budget Request represents the best prioritization and allocation of U.S. Government resources, given the challenges and opportunities facing our Nation. The FAA team is working with intensity and efficiency to manage a growing level of activity, much of which is expected to result in a significant increase in the number of commercial launches. FAA's dedicated professional staff must have the time and tools necessary to carry out vital functions. Particularly significant is our finding that Field Offices are critical both to our

understanding of transportation operations and to enhancing our key relationships with other U.S. Government entities, such as NASA and the Air Force. The field is where it's happening, and the FAA must be there to provide operational safety oversight, speed up communications and efficiency, and strengthen partnerships with the many stakeholders in commercial space operations. To address this urgent need, we are moving headquarters staff to field assignments, recruiting new field personnel, and adding contractor support where appropriate to maximize efficiency.

While the FAA has authority over launch and reentry, the FAA does not have authority to regulate the operation in orbit of commercial transport spacecraft. As mentioned previously, as the industry evolves, there may be a need to consider expanding or modifying the FAA's statutory authority to ensure safety in the areas of transportation on-orbit as well as launch and reentry.

We look to the continued support of the public and of Congress as we move forward in carrying out our mission to encourage, facilitate, and promote commercial space launches by the private sector while protecting the public safety, national security, and foreign policy interests of the United States.

Question 6. Are you concerned about conflict of interest at FAA between safety and promotion and if so what should be done about it?

Answer. We respect the wisdom of Congress in directing the Secretary of Transportation, and through subsequent delegation, the FAA Office of Commercial Space Transportation (AST), to have regulatory oversight of the public safety for commercial launch and reentry and to "encourage, facilitate, and promote" the commercial space transportation industry. To simplify, we will refer to these latter roles as "promotion." The safety and promotional roles of the FAA are essential, and reinforce each other. One of the most important means of promoting the growth of any industry is to provide assurance of safety, at levels appropriate for that particular industry's phase of development. Furthermore, the FAA's promotional role is needed to encourage economic growth in an industry sector facing unique technical, policy, and economic challenges. As Congress has recognized, promoting the U.S. commercial space launch industry contributes to U.S. aerospace preeminence. Further, a U.S. commercial space launch industry is essential to assure access to space for Government and commercial users.

At this time, access to and activity in the space environment are physically difficult, and opportunities involving space are still not well understood in the business community. Promotional activities include education, technical research, market studies, facilitation of industry dialogue, and outreach to enhance public awareness. The FAA Center of Excellence for Commercial Space Transportation (COE-CST) is an excellent example of the FAA's vital promotional role. The COE-CST represents an expansion of a highly successful FAA network of COEs in non-space fields, focused on key aviation technology and safety issues. Each COE involves a partnership between the FAA and major universities to carry on research vital to improvement and growth of transportation services. There is a one-to-one match of Federal and university-team resources to fund the COEs. University-led teams arrange the participation of industry as well as non-Federal Government entities. Both financial and in-kind contributions help university teams satisfy their requirement for matching funds. For the COE-CST specifically, research initiatives are divided into four categories: (1) space traffic management and operations, (2) space transportation operations, technologies, and payloads, (3) human spaceflight, and (4) space transportation industry viability.

The investment community, insurance firms, legal establishment—and most of all, potential customers—are reassured when Government provides promotional initiatives to highlight unfamiliar opportunities, coupled with appropriate safety regulations to reduce risk. When the United States desperately needs new job creation, we should not deprive the marketplace of vital promotional and regulatory support.

Although the FAA's promotional and regulatory roles are mutually supportive, we do recognize the need for these functions to be kept independent of specific promotional activities. Accordingly, AST's licensing and inspection teams operate separately from the other units of AST. By maintaining a sound safety decisionmaking process, embracing a strong safety culture, and remaining vigilant to potential safety concerns, the FAA effectively satisfies both the public's need for safety and our Nation's need for a growing commercial space transportation industry.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO
COLONEL PAMELA MELROY

Federal Aviation Administration

Question 1. By law, the FAA may not propose regulations for occupant safety until October 2015. In your testimony you state that you anticipate that occupant safety regulations will be a major undertaking, and will require a comprehensive regulatory framework to eventually be proposed through a suite of rulemaking activities. Can you describe your efforts in this regard? And how you see the roles of FAA and NASA regarding public safety and mission assurance?

Answer. The FAA is making good progress in preparing ourselves for the challenge of regulating occupant safety of commercial human space transportation after the moratorium ends in 2015. We have assembled a team to define the approach and do the groundwork for this regulatory framework. The team's activities include:

- Studying other human safety requirements such as the NASA Commercial Crew Program requirements, aviation safety regulations, and various human rating studies.
- Identifying and documenting ground rules and assumptions to ensure we are focusing on known, reasonably avoidable risks and realistic operations in the near term.
- Soliciting industry input on a variety of technical topics through our Commercial Space Transportation Advisory Committee, COMSTAC.
- Studying the current industry designs of human spacecraft to understand the different ways current commercial providers are thinking about addressing occupant safety.
- Identifying best practices and lessons learned for the use of standards and guidance documents from other regulatory organizations and NASA.

Regarding our roles, the FAA is currently responsible for public safety for commercial launches and reentries. NASA is responsible for all aspects of safety—public and crew—and mission assurance for its government-owned and operated space vehicles such as the International Space Station (ISS) and Orion Multi-Purpose Crew Vehicle. For commercial crew services to and from the ISS, NASA and the FAA have agreed that the FAA will oversee public safety through its regulations and NASA will oversee mission assurance and crew safety through its contracts.

Question 2. You also state that the FAA is funding a study, to be released this summer, to evaluate the potential growth in commercial suborbital activity. What prompted this study?

Answer. The commercial suborbital reusable vehicle (SRV) industry represents an important new economic sector in its own right, as well as a potential source of near-term revenue helping developers pursue longer-term orbital system design. Given the relative novelty of commercial SRVs, and the widespread uncertainty regarding potential customer demand for such services, the FAA Office of Commercial Space Transportation (AST) commissioned a market demand study to be carried out by a highly respected market research firm, The Tauri Group. AST collaborated with Space Florida to fund this effort and the study was released on July 31, 2012.

One of the hallmarks of this market research initiative was open and continuing communication with stakeholder groups, both within and outside the suborbital vehicle development community. Extensive contact with potential customer groups yielded valuable information concerning the course that market expansion might take. And, although human spaceflight services were considered a very important source of market demand, it was important to have the study address several other market areas as well (*e.g.*, test/demonstration, scientific research). By appropriately characterizing market scope, as well as intensively interacting with both prospective providers and potential customers, the study promises to make a significant contribution to better understanding space-related business opportunities.

Question 3. Recently, the FAA and NASA signed an agreement to coordinate standards for commercial space travel of government and non-government astronauts to and from low-Earth orbit and the ISS. Can you please describe this agreement and responsibilities from the FAA point of view? Can you assure me that FAA will insist that commercial crew carriers meet the same safety requirements that our other human spacecraft meet?

Answer. The FAA and NASA have complementary and interdependent interests in ensuring commercially-developed human-rated systems for low-Earth orbit are safe and effective. Our agencies have been working in a partnership arrangement in achieving our common interests for the past several years and recently signed

a Memorandum of Understanding for the Achievement of Mutual Goals in Human Space Transportation. Through this agreement our agencies commit to support the transition to commercial transport of Government and non-Government participants to low-Earth orbit in a manner that precludes conflicting requirements and multiple sets of standards. This agreement further states NASA intends that all launches supporting ISS crew transportation services will be licensed by the FAA for public safety. More specifically, the FAA will license for public safety on launch and re-entry consistent with our authority, and crew safety and mission assurance will remain the responsibility of NASA for all phases of flight (launch, on-orbit, and re-entry).

The FAA will ensure the commercial crew carriers meet the same launch and re-entry public safety requirements that other orbital missions have previously as the licensing process, applicable regulations, and application reviews and assessments are the same. Given the moratorium on regulating occupant safety, the FAA may not exercise its authority to ensure commercial crew missions meet the same occupant safety requirements of other past human space flight missions absent certain circumstances including a death, serious injury, or an unplanned event that posed a high risk of death or serious injury. To date the only U.S. orbital human space flight missions have been carried out by NASA. We are, and will continue to be focused, and will collaborate with NASA, on understanding orbital transportation safety issues. When the time comes to regulate occupant safety, the FAA will do so ever mindful of what we have learned from NASA's experience and will also draw from our own expertise to best ensure that commercial human space flight is safe for occupants and the public alike.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO
GERALD L. DILLINGHAM, PH.D.

Indemnification

Question 1. Dr. Dillingham, would you please compare the impact of allowing the current indemnification policy to expire against the risk to the government of extending the policy?

Answer. If the current indemnification policy is extended, the Federal Government risks having to pay third-party claims in the event of an accident; if the policy is ended, the risk becomes potentially damaging the competitiveness of the U.S. commercial space launch industry. However, comparing the impact of allowing the current indemnification policy to expire against the risk to the government of extending the policy is difficult as there are many unknowns regarding the actual effects of ending indemnification. Specifically, we do not know how ending indemnification would affect commercial space launch companies. For example, launch companies' insurance premiums or other costs and the availability of coverage might change. In addition, we do not know whether or to what extent launch customers might choose foreign launch companies over U.S. companies. Furthermore, it is difficult to separate out the effects of withdrawing indemnification on the overall price competitiveness of the U.S. commercial space launch industry as the cost of third party liability insurance for launch companies is small—about 1 percent of the dollar amount of coverage they purchase. In addition, launch companies with whom we spoke said that ending indemnification would increase their potential for significant financial losses for third party claims, which could cause them to reassess whether the benefits of staying in the launch business outweigh the risks.

Our work also identified other ways of managing catastrophic risk in lieu of extending or eliminating indemnification. Although we did not conduct specific work to analyze the feasibility of alternative approaches for providing coverage currently available through indemnification, some of these approaches have been used in areas that can result in catastrophic losses such as natural disasters. Some of these methods involve the private sector, including going beyond the traditional insurance industry, in providing coverage, and include the use of catastrophe bonds or tax incentives to insurers to develop catastrophe surplus funds. Other methods aid those at risk in setting aside funds to cover their own and possibly others' losses, such as through self-insurance or risk pools. Still other methods, such as those used for flood and terrorism insurance, involve the government in either providing subsidized coverage or acting as a backstop to private insurers.

Question 2. If we decide to extend the indemnification policy, what future industry conditions would indicate that we can phase it out?

Answer. The amount of third party liability coverage the insurance industry is willing to provide for a single launch would be a key factor indicating whether Federal indemnification could be phased out because it would determine the extent to

which the industry might be able to potentially replace coverage available from the Federal Government. While the maximum coverage available is currently around \$500 million, which is above the average FAA insurance requirement of around \$99 million per launch and the highest requirement for any individual launch (around \$260 million), this might not always be the case. According to some insurers we spoke to, a space launch accident with large third-party losses could significantly reduce the amount of coverage insurers are willing to provide. Other factors that affect the amount of coverage insurers are willing to provide include the number of insurers in the space launch market, the size of the premiums insurers are able to charge compared to the size of the potential losses, and the affordability to launch companies of the higher premiums insurers would need to charge for higher coverage amounts.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO
GERALD L. DILLINGHAM, PH.D.

FAA Regulatory Activity

Question 1. In GAO's opinion, does FAA have the resources and tools it needs to oversee commercial space launches and reentries? Eventual on-orbit activity?

Answer. Yes, we believe that FAA currently has the resources and tools it needs to oversee commercial space launches and reentries. In 2006, we raised concerns that FAA's experience in human spaceflight was limited because its launch safety oversight had focused primarily on unmanned launches of satellites into orbit using expendable launch vehicles. Thus, we recommended that FAA assess the levels of expertise and resources that will be needed to oversee the safety of the space tourism industry and the new spaceports under various scenarios and timetables. In response to our recommendations, FAA's Office of Commercial Space Transportation hired 12 aerospace engineers. In addition, since our report, FAA has established field offices at Edwards Air Force Base and NASA's Johnson Space Center in anticipation of increased commercial space launches including NASA-procured launches to the International Space Station and space tourism flights. Nonetheless, it will be important that FAA continue to monitor its resources and tools as NASA-procured launches and space tourism flights begin. FAA does not have statutory authority to regulate on-orbit activities. Decisions the Congress makes about FAA's authority in the future, such as whether FAA will license on-orbit activities, could affect FAA's workload and need for expertise.

Question 2. Has GAO found any inherent conflict between FAA's dual roles of both promoting and regulating commercial space activity? What, if anything, should be done to monitor and evaluate this potential conflict?

Answer. Yes, an inherent conflict exists between FAA's dual roles to promote and regulate commercial space activity. However, we found no evidence that FAA's promotional activities—such as sponsoring an annual industry conference and publishing industry studies—have negatively affected its regulatory role. We continue to stand by our 2010 assessment of the issue and see no need for Congress to step in at this time to require a separation of regulatory and promotional activities. However, FAA and Congress must remain vigilant that any inappropriate relationship between FAA and the industry—which is periodically asserted regarding FAA and the airline industry—does not occur with the commercial space launch industry. The situation should be monitored because potential conflicts may arise as the space tourism sector develops.

Risk Indemnification

Question 3. How important is Federal third-party liability indemnification to the growth of the commercial space launch industry?

Answer. The growth of the U.S. commercial space launch industry will, in great part, depend on customer demand for launches carried out by U.S. launch companies. Several launch company representatives and customers told us that two key factors—launch price and launch vehicle reliability—generally determine the competitiveness of launch companies. To the extent that potential third-party liability coverage provided by the Federal Government helps control or reduce the costs of U.S. launch companies, it will be important for the competitiveness and growth of the U.S. commercial space launch industry. While the actual effects on competition of eliminating indemnification are unknown, several launch company representatives said that the lack of government indemnification would decrease their global competitiveness by increasing launch costs.

Question 4. What do you believe would be an appropriate period of time for an extension of FAA's indemnification authority?

Answer. While evaluating an appropriate period for an extension of the U.S. indemnification program was not part of our work, Congress may wish to consider at least two factors in determining a period of time for a potential extension. First, a planned increase in the number of manned commercial launches—expected to begin in 2017—could have implications for the Federal indemnification program that are not yet known. Second, if the commercial launch industry found it needs to consider private, third-party liability insurance to replace coverage currently provided by the government, this change could require a significant amount of time to implement.

Question 5. What did your review find with regards to the need for third-party insurance if on-orbit operations are regulated by FAA?

Answer. Our study found mixed views on the need for third-party indemnification for on-orbit activities. FAA licenses commercial launches and reentries but does not license on-orbit activities. Federal indemnification only applies to FAA-licensed space activities. Two launch companies with which we spoke do not believe that FAA needs to regulate on-orbit activities or provide Federal indemnification as activities between the launch company and the International Space Station will be covered by NASA launch contracts. However, one insurance company noted that other proposed manned launches—such as an on-orbit “hotel” that is in development—will not be covered in NASA-related contracts and will not be covered by any regulatory regime. If FAA is granted authority to license on-orbit activities, then Federal indemnification would be provided. If this were to occur, the Federal Government’s potential costs to cover third party claims may increase as its exposure to risk increases.

Question 6. The capacity of the space launch insurance industry was cited as a reason for the shared-risk third-party liability provisions enacted into law in 1988. Has the insurance industry developed that capacity to sustain third-party losses?

Answer. Some insurers and brokers suggested that the maximum amount of private sector third party liability coverage the industry is currently willing to provide is generally around \$500 million per launch. One broker said that no launch company thus far has pursued private sector insurance protection above \$500 million. Two insurers said that there might be slightly more coverage available beyond \$500 million, and one said that up to \$1 billion per launch in liability coverage might be possible in the private insurance market. According to FAA data on commercial launches, the average maximum probable loss is about \$99 million. As a result, in the absence of Commercial Space Launch Act Amendment (CSLAA) of 1988 indemnification, insurers could still provide some of the coverage currently available through the government under CSLAA. For example, if the maximum probable loss for a launch is \$100 million and the insurance industry is willing to offer up to \$500 million in coverage, the private market could potentially provide \$400 million in additional coverage.

Question 7. How can Congress determine if the insurance industry’s capacity for third-party liability can accommodate the anticipated changes in and types of commercial space launches?

Answer. Whether the insurance industry has capacity to provide third party liability coverage for future commercial space launches, given the anticipated changes in the types of launches, would depend on the amount of insurance coverage FAA required for those launches. It is not yet clear how such changes might affect FAA’s determination of the required insurance coverage. However, the amount of such coverage the insurance industry is currently willing to provide—around \$500 million—is above the average amount of insurance required by FAA for a launch license (around \$99 million) and the highest amount currently required for a single launch (around \$260 million). As a result, even if FAA were to double the highest amount of insurance required, the insurance industry would currently have the capacity to provide that coverage.

Other Questions for GAO

Question 8. What are some of the key factors that the Congress should consider as it deliberates on the reauthorization of the Commercial Space Launch Act?

Answer. The Federal Government’s provision of third party liability insurance is the only element of the Commercial Space Launch Act Amendment (CSLAA) of 1988 indemnification policy that expires this year. As Congress deliberates on its reauthorization, there are two key factors raised by the planned increase in manned commercial launches. First, we have recommended that FAA update how it assesses Federal liability. FAA’s methodology for determining the maximum probable loss for a commercial space launch and reentry, which determines the amount of insurance coverage launch companies must buy and the amount above which government indemnification begins, is outdated and should be reassessed.

Second, having people on board a space vehicle raises issues of informed consent and cross waivers, which could affect third party liability and the potential cost to the Federal Government. The CSLAA requires passengers and crew on spaceflights to be informed by the launch company of the risks involved and to sign a reciprocal waiver of claims (also called a cross waiver) with the Federal Government—which means that if an accident occurs the party agrees not to seek claims against the Federal Government, which would have licensed the launch. The CSLAA also requires cross waivers among involved parties in a launch except for spaceflight passengers. However, according to insurance companies and legal experts that we spoke with, requiring cross waivers among crew, the launch company, and other involved parties may not minimize potential third party claims as they would not place limitations on liability. Without a limitation on liability, insurance premiums for third party and other launch insurance coverage could increase as the same small number of insurance companies insures passengers, crew, launch vehicles, and third parties to a launch. Launch and insurance companies believe that a limit or cap on passenger liability could decrease uncertainty and, consequently, decrease the price of insurance. As a result, according to the Federal Aviation Administration, putting a limitation on spaceflight passenger liability could foster the development of the commercial space launch industry through lower costs for insurance and liability exposure.

Question 9. How does U.S. involvement in the commercial space launch industry differ from foreign government involvement?

Answer. Our most recent work compared third party liability coverage among countries. We found that the United States provides less total third party liability coverage than China, France, and Russia, according to published reports. Like the United States, each of these countries requires launch companies to be responsible for third party claims up to a certain amount (called first tier coverage) with government coverage provided for claims above that amount. These countries each have an indemnification regime in which the government states that it will assume a greater share of the risk compared to that of the United States because each country has no limit on the amount of government indemnification. By comparison, the United States caps government indemnification at \$1.5 billion, adjusted for inflation, beyond the first-tier insurance amount. However, U.S. Government coverage, in some cases, begins at a lower level than that of the other countries because U.S. coverage begins above the estimated maximum probable loss, which averaged about \$99 million for active FAA launch and reentry licenses as of January 2012 and ranged from about \$23 million to \$267 million. The level at which government coverage begins for the other three countries ranged from \$79 million to \$300 million. However, for all these governments, including the United States', commitments to pay third party claims have never been tested because there has not been a third party claim that exceeded a private launch company's insurance. In addition, like other countries, the United States provides other forms of support for the commercial space launch industry, including funds to develop launch vehicles, access to Federal launch sites, and launch contracts.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO
GERALD L. DILLINGHAM, PH.D.

Question 1. Please provide an update on the status of your recommendations to the FAA regarding their indemnification processes.

Answer. We recommended in our July 2012 report on commercial space launch indemnification that FAA review and periodically reassess its maximum probable loss methodology.¹ DOT responded that it will consider our recommendation.

Question 2. Should the Congress extend the indemnification authority before GAO's recommendations are implemented?

Answer. The answer would depend on the importance Congress places on the accuracy of FAA's determination of the amount of third party liability insurance coverage that launch companies must obtain to receive a launch license, as compared to the potential effect of waiting to reauthorize the program. A more accurate determination could better ensure that the Federal Government's exposure from the program is neither overstated nor understated, but several launch companies and customers we spoke with said that ending Federal indemnification could potentially decrease the competitiveness of U.S. launch companies. Congress may also want to consider that it is not yet clear whether an improved methodology will increase or

¹ GAO, *Commercial Space Launches: FAA Should Update How It Assesses Federal Liability Risk* (Washington, D.C.: July 30, 2012).

decrease FAA's estimates of the maximum probable losses associated with FAA licensed launches.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO
MICHAEL N. GOLD

Bigelow Inflatable Modules

Question 1. Can you provide any detail, or at least a general description, of the microgravity research capabilities of your inflatable modules?

Answer. As the name indicates, our BA 330 habitats will offer an unprecedented 330 cubic meters of internal volume per module to support microgravity research, development, and manufacturing. Although a single BA 330 can operate as an independent space station, our habitats allow for a modular approach, and with several habitats ganged together, individual modules could be entirely dedicated to micrograv R&D if NASA or any other client (or combination of clients) wishes to lease the habitats for such activities. Moreover, as opposed to the International Space Station ("ISS") client astronauts aboard a Bigelow station will be able to dedicate all of their time to microgravity research and development (or whatever activity they so choose) without the burden of station operations and maintenance which will be addressed entirely by Bigelow Aerospace ("BA") personnel. We believe that this ability for client astronauts to focus exclusively on microgravity R&D will dramatically enhance the quality and utility of their work and help to ensure that public and private customers receive substantial benefits from their orbital operations.

In regard to hardware, the BA 330 will offer customers unparalleled flexibility in terms of the micrograv R&D environment. Our spacecraft have been designed to allow for Bigelow Aerospace to tailor the internal architecture to meet clients' needs in ways that might not be possible aboard the ISS. We believe that this inherent flexibility will be another contributing factor to ensure that clients receive substantial value from their micrograv R&D activities.

Question 2. What are the key differences between the environment provided there and that provided by the International Space Station, from a scientific research perspective? (*e.g.*, active rack isolation capability.)

Answer. Volume is a key benefit of an expandable habitat architecture versus a traditional rigidized metallic structure such as the ISS. As mentioned above, with several BA 330s ganged together, entire habitats could be exclusively dedicated to microgravity R&D and/or manufacturing. Additionally, unlike the ISS which is an inherently open environment, Bigelow Aerospace will provide sovereign clients with the ability to conduct proprietary scientific research. Particularly in the extremely competitive pharmaceutical and biotech world, this ability to conduct work in a confidential manner will be critical in enhancing the value of orbital activities for both countries and companies.

Safety is also a vital issue both for conducting scientific research and for overall space station operations. Bigelow Aerospace expandable habitats will offer better protection than the ISS from both physical debris and radiation. As a matter of fact, the ability of expandable habitats to provide enhanced protection from radiation during a long duration human mission to Mars is one of the primary reasons that NASA initiated the 'TransHab' program over 20 years ago.

Flight frequency and repeatability are also critical needs that the micrograv R&D community requires. Particularly for scientific research in the pharma/biotech industry, researchers must have the opportunity to iterate experiments, just like in a terrestrial laboratory. Of course, a key aspect of giving scientists this capability is ensuring that costs are sufficiently low to allow for repeated, frequent flights, and this is another difference between the ISS and BA micrograv capabilities. Assuming safe, reliable, and affordable commercial crew transportation comes to fruition, BA expects to be able to offer its clients robust access to the microgravity environment at costs that are substantially lower than those of the ISS, which will in turn support more frequent launches and thereby dramatically improve the ability to rapidly iterate experiments bolstering the quality and utility of the microgravity R&D conducted aboard BA habitats.

Additionally, leasing volume and flying astronauts with Bigelow Aerospace will be a relatively simple and straightforward process, allowing researchers to focus on their work instead of on coping with the substantial domestic and international bureaucracy that has grown up around the ISS. Finally, the ability to fly a country's or company's own personnel to conduct research rather than relying on others will be a fundamental difference for scientists between working with Bigelow Aerospace and the ISS.

Question 3. From an orbital mechanics point of view, would it even be possible for a commercial crew or cargo vehicle to conduct a mission in which it could make two separate “stops” in one flight—one to the space station and one to a Bigelow module?

Answer. If a Bigelow station shared a similar orbit, inclination, and altitude as the ISS, making separate stops at each space station would be theoretically possible and potentially beneficial. Per my prepared testimony, the key issue for this or any other crew/cargo delivery is cost. If a model is adopted that provides an opportunity along the lines of what we see happening with secondary payloads today, wherein the launch cost paid by the secondary payload provider is relatively minimal, then a spacecraft making more than one stop could be attractive. However, if the price paid by the equivalent of a secondary payload provider under this scenario becomes too high, then the transaction costs and other inherent difficulties of such operations lose their value.

Commercial Market

Question 4. You represent one of the potential customers for commercial services, as well as a destination for such services. What are your thoughts about the potential growth of a market for these systems once they are operational?

Answer. The potential for growth is limitless. Bigelow Aerospace envisions eventually operating not just one, but numerous stations in LEO to support burgeoning commercial activities. Per my previous testimony, we believe that there will be strong global demand for astronautics opportunities and that microgravity research, development, and manufacturing has great future potential. However, for this market to develop commercial crew systems must not just be operational but must be able to offer safe, reliable, and affordable services. If per-seat prices remain at the current levels that NASA is paying for *Soyuz* it would be extremely difficult if not impossible to close a private sector driven business case.

Question 5. How important is Federal third-party liability indemnification to the growth of the commercial space launch industry?

Answer. Extension of third party liability indemnification is absolutely critical to the growth of the commercial space launch industry. Without Federal third-party indemnification costs will rise and some companies may even drop out of the field entirely. Per testimony from the GAO before the House in June, the U.S. already provides less third-party liability indemnification coverage for commercial space launches than other nations such as France, Russia, and China. Even discussing the possibility of abandoning the U.S.’s already weak third-party indemnification has negative repercussions and allowing the current indemnification regime to expire would represent a substantial failure by Congress that could cripple America’s commercial space launch industry.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO MICHAEL N. GOLD

Question 1. As a representative of a potential user of commercial launch services, what is your view of the indemnification authority provided to FAA by the CSLA?

Answer. Extending third-party indemnification is critical to the future of the American commercial space launch industry. Per testimony from the GAO before the House in June, the U.S. already provides less third-party liability indemnification coverage for commercial space launches than other nations such as France, Russia, and China. Even discussing the possibility of abandoning the U.S.’s already weak third-party indemnification has negative repercussions and allowing the current indemnification regime to expire would represent a substantial failure by Congress that could cripple America’s commercial space launch industry.

Moreover, in our view, such an extension could and should be combined with lifting the FAA–AST’s regulatory moratorium. Per my testimony, the FAA–AST is the only organization with the proper staff, structure and experience to play this regulatory role, and ensconcing this authority with the FAA–AST will allow insurers, commercial crew providers, and NASA to eliminate potential areas of confusion, as well as bolstering Congress’s ability to extend the third-party indemnification regime with a high degree of confidence.

Question 2. Indemnification authority expires at the end of this year. Should Congress extend it, and if so, how long?

Answer. Ideally, indemnification should be extended indefinitely. Making the indemnification permanent would send a strong message to companies, insurers, and global competitors that America is serious about regaining its position as the world’s commercial space launch leader.

Question 3. What would be the impact if indemnification authority was NOT extended?

Answer. Failure to extend indemnification authority would unquestionably result in higher prices and could even force some companies out of the crewed commercial space launch field entirely. In addition to a broken export control system, failing to extend indemnification authority would further aggravate a domestic regulatory environment that provides significant advantages to America's European, Chinese, and Russian competitors.

Question 4. In your prepared statement you mention that ISC Kosmotras, the joint Russian/Ukrainian launch provider, was able to offer a launch for one third the cost of U.S. domestic providers. You recommend that this Committee focus on price, so as to deliver at costs that allow for development of truly competitive services. Can you provide some insight on how we should do that?

Answer. First and foremost, the Committee should request that the GAO confirm NASA's ability to provide mandatory safety requirements under a Space Act Agreement ("SAA"). Confirming that such requirements may be developed and implemented under the auspices of a SAA will help to avoid problems that could result in significant future programmatic cost increases. Additionally, hearings should be held on a regular basis with the Commercial Crew Integrated Capability ("CCiCap") participants and relevant NASA officials to establish what the various spacecraft expenses will be. If astronaut seat costs remains in the range of current *Soyuz* pricing then the Committee should investigate why no progress has been made on costs and work with NASA and the CCiCap participants to address any issues that would prevent the commercial crew program from living up to its promise of providing safe, reliable, and affordable transportation to Low Earth Orbit ("LEO").

Question 5. NASA has expressed a strong desire to keep as many competitors in the process as long as possible. It is felt that this will continue to drive the ultimate cost down. This is somewhat true as long as there are multiple entities working in parallel on this development. But the companies have to cover their costs. They have to make some profit. In the end, final decisions will have to be made to down-select, as NASA has now agreed to do during the CCiCap phase of commercial crew development. Eventually, prices for crew transportation will depend to some degree on how many competing companies survive. That will depend on the market. In your view, will the market support more than one commercial provider of crew transportation services?

Answer. As background, we fully support the agreement that was struck between Congressman Wolf and Administrator Bolden to proceed with no more than 2.5 CCiCap participants. While NASA may have a strong desire to keep as many competitors in the process as long as possible, this desire must be subordinated to harsh fiscal realities. In these austere financial times, Federal funding has been and will continue to be limited. Therefore, NASA must proceed cautiously and husband its resources as carefully as possible by only providing CCiCap funding to companies that have the greatest chance of successfully fielding safe, affordable, and reliable commercial crew transportation systems.

Ultimately, we believe the market will support more than a single commercial crew provider. Our hope is that at least two companies will produce operational spacecraft avoiding U.S. public and private reliance on a single system. Monopolies result in high prices and little to no innovation, and with some of the recent problems experienced by the *Soyuz*, NASA has already become all too familiar with the financial and substantive dangers of complete dependence on a single spacecraft.

Combined demand from Bigelow Aerospace and NASA will create sufficient demand to support two providers. Moreover, Bigelow Aerospace's future plans include launching multiple stations each serving distinct customers and orbital market segments. With a growing number of destinations in LEO, market opportunities for commercial crew systems will increase providing sufficient demand for multiple entrants and engendering robust and beneficial competition among such providers.

Question 6. While U.S. cooperative programs with Russia were expanding in the 1990s, including Russia joining the space station international partnership in 1993, it also became clear that Russia was a source of sensitive technology to Iran. The Iran Nonproliferation Act of 2000 was enacted to help stop foreign transfers to Iran of weapons of mass destruction, missile technology, and advanced conventional weapons technology, particularly from Russia.

Among other things, that Act banned cash or "in kind" payments by any agency of the U.S. Government to Russian Government agencies or to any entity under their jurisdiction or control for work on the International Space Station or for obtaining goods and services relating to human spaceflight. This provision has raised difficulties regarding U.S. access to the International Space Station. When the

President in 2004 announced that the Space Shuttle would be retired in 2010, the Russian *Soyuz* became the only vehicle available after that date to transport astronauts to and from the ISS. In 2005 Congress amended INA to exempt Soyuz flights to the ISS from the ban through 2011 and in 2008 the exception was further extended through June 30, 2016. In your view, is a further extension necessary?

Answer. No, a further extension is neither necessary nor desirable. While international cooperation in space is commendable, foreign dependence is deplorable. Sending American taxpayer dollars and astronauts to Russia as our only means of human spaceflight is an embarrassment to NASA, the domestic space industry, and the Nation as a whole. Over the course of the past twenty years NASA, reacting to the leadership (or lack thereof) of past Congresses and Presidential Administrations has initiated and subsequently canceled the National Aero-Space Plane (X-30), the X-33, VentureStar, the X-34, the X-38, the Space Launch Initiative, the Orbital Space Plane, the Crew Exploration Vehicle, and the Orion (which has now been revived as the Orion Multi-Purpose Crew Vehicle). Clearly, the traditional model that is being followed via these programs is not working and has resulted in American dependence on the Soyuz along with the loss of billions of dollars and decades of time. Soyuz represents a crutch that would allow this pernicious pattern to continue without serious repercussions. Our recommendation is that this crutch be removed in order for the American human spaceflight industry to regain the ability to stand on its own two feet.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO
CAPTAIN MICHAEL LOPEZ-ALEGRIA, USN (RET.)

Commercial Spaceflight Market

Question 1. You have made a point in your statement and elsewhere that there does not need to be a “choice” between the development of a commercial space launch capability and the development of the heavy-lift and Orion crew exploration capability. Can you elaborate on that point and about how that perspective can be more broadly shared by advocates of both capabilities?

Answer. The NASA programs that utilize and support the commercial spaceflight industry are non-competitive partners to SLS and Orion, working toward a common goal of expanding the United States space exploration capability. The programs have two different mission objectives: NASA’s goal when initiating the Commercial Orbital Transportation Services (COTS) and Commercial Crew programs was to make use of efficient commercial competitions for transportation to low-Earth orbit and the International Space Station, so that NASA could direct its resources and expertise towards exploration beyond. The advancement of the commercial spaceflight industry helps reduce the cost of access to space, therefore freeing up funds that NASA needs for SLS, Orion and the rest of the deep space exploration architecture that will use them.

Question 2. NASA is required by law to use commercial vehicles for ISS transportation needs if they are available. Thus, for ISS transportation, the Russian *Soyuz* would not represent a source of competition. Do you see any other way in which U.S. commercial transportation entities might be in competition with *Soyuz*? How do you view the potential for that kind of competition and its impact on the broader commercial market?

Answer. ISS transportation is not the sole market for commercial launch providers. Satellites, scientific research payloads and space tourism are all growing markets for commercial companies and are markets in which the *Soyuz* could represent a source of competition. The U.S. commercial providers project significant cost savings over the *Soyuz* vehicle for crew transport to ISS, and we believe that commercial companies will be extremely competitive on price, quality and safety in several markets, with the *Soyuz* and other international vehicles.

Question 3. How important is Federal third-party liability indemnification to the growth of the commercial space launch industry?

Answer. The commercial space launch industry is growing quickly and many of the companies are still small and would have difficulty carrying the financial burden of insuring launches without indemnification. Without the third-party risk-sharing regime, these companies would be forced to purchase more insurance, and that expense would be passed on to the customer or absorbed by the company. Either outcome would hurt the competitiveness of the American launch industrial base, and discourage new companies looking to enter the industry. Several overseas spaceflight companies receiving unlimited indemnification from their governments,

so it is vital for the U.S. commercial space launch industry to have the regime in place to stay competitive in the global marketplace.

Question 4. What are the main obstacles to Space Tourism?

Answer. The primary obstacles are availability of flights and destinations, followed by expense and an uncertain regulatory environment. Dennis Tito, the first “space tourist,” reportedly paid \$20 million to Space Adventures for his flight to the International Space Station, and since that time seven additional flights have occurred. In no cases have flights come available that were not filled, even as the reported prices rose, suggesting that demand has outstripped supply. Commercial orbital suppliers have been making significant progress, and as those capabilities come online, supply will increase. As in-space habitats and other destinations are developed, demand will increase as well.

Meanwhile, several companies are rapidly developing suborbital vehicles and accumulating flight reservations, with over 800 announced so far. These flights, which have been quoted at price points of \$95,000-\$200,000 per passenger, open the door to a much larger customer base.

However, an unstable regulatory environment would threaten this emerging industry. Human spaceflight is not easy, and these companies are working through difficult design problems through rapid prototyping and testing. Early human spaceflight regulations would short-circuit that process and create serious problems for the industry.

Question 5. How does U.S. involvement in the commercial space launch industry differ from foreign government involvement?

Answer. NASA is the undisputed leader among space agencies in facilitating the development of commercial space launch, continuing America’s long tradition of independence and free enterprise. In many other countries, spaceflight is solely the province of government. One exception is the United Kingdom, which created the UK Space Agency in 2010 and promulgated a strategy to increase its development of commercial space services. At this time, there are some commercial space firms situated around the world, but few comparable to the commercial industry in America. However, the success of American commercial firms has begun to affect foreign space agencies that see competitors to their government-supported companies, which could trigger a broadening of the commercial space industry across the world.

When it comes to regulation, the picture is more complicated. All of the largest foreign space faring nations completely indemnify launches of their commercial space companies, above a relatively small amount, for which the company generally buys insurance. This means that their risk-sharing regime is only two-tiered, with no limit to the government’s indemnification. The U.S. on the other hand, has a three-tiered system, with the government only covering up to \$2.7 billion past the Maximum Probable Loss (MPL).

Many other countries also feature much less restrictive export restrictions on space hardware. America’s ITAR regime is hurting our space industrial base and raising prices for government purchases of space equipment and services. As outlined in April’s 1248 Report from the Department of Defense, loosening some export controls would engender a more vibrant industry while protecting our most advanced technologies, and would in fact be a net benefit for national security.

Few countries have needed to contemplate the possibility of commercial human spaceflight. The United Kingdom has begun to consider policies on commercial human spaceflight regulation, and we are optimistic that they will follow the licensing model that has been pioneered here.

Question 6. The term “commercial” implies that a product or service provider has other customers in addition to the U.S. Government. Please provide any information you are able to share regarding what customers other than NASA have been identified by the commercial ISS service providers.

Answer. The current commercial ISS service providers are SpaceX and Orbital, both of whom also sell their services to commercial customers. Both companies have launched commercial payloads and have announced future commercial payloads. Of the competing commercial crew companies, all the winners of the latest round have announced that they are launching on a ULA Atlas V or a SpaceX Falcon 9, vehicles with known commercial customers.

But we anticipate that the prospect of human commercial spaceflight, the advent of smaller micro-and nano-satellites and the availability of regular flights will bring a broad array of new commercial and non-NASA government customers, including those interested in scientific research, earth observation, space experiences, product sponsorship and media tie-in, and other applications. As one example, only 50 of the world’s 195 nations have sent people to space, most through cooperative agreement

with the other governments. The advent of orbital commercial human spaceflight offers some of the rest of those nations that opportunity.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO
CAPTAIN MICHAEL LOPEZ-ALEGRIA, USN (RET.)

Question 1. NASA has expressed a strong desire to keep as many competitors in the process as long as possible. It is felt that this will continue to drive the ultimate cost down. This is somewhat true as long as there are multiple entities working in parallel on this development. But the companies have to cover their costs. They have to make some profit. In the end, final decisions will have to be made to down-select, as NASA has now agreed to do during the CCIcap phase of commercial crew development. Eventually, prices for crew transportation will depend to some degree on how many competing companies survive. That will depend on the market. In your view, will the market support more than one commercial provider of crew transportation services?

Answer. The competition and assured capability that NASA gains from having multiple vehicles in the competition is extremely valuable. I believe that each of our member companies interested in competing for the eventual Commercial Crew services contract has performed in-depth proprietary research on the market for human spaceflight services. I have not, and that makes it difficult to answer with certainty. However, it is important to keep in mind that the market is dependent on the price, and every Commercial Crew competitor has indicated that they anticipate being able to offer NASA a price per seat below that of the *Soyuz*. The men and women who run these companies are highly successful businesspeople, and they would not be making that claim without a deep understanding of their own market competitiveness.

Question 2. While U.S. cooperative programs with Russia were expanding in the 1990s, including Russia joining the space station international partnership in 1993, it also became clear that Russia was a source of sensitive technology to Iran. The Iran Nonproliferation Act of 2000 was enacted to help stop foreign transfers to Iran of weapons of mass destruction, missile technology, and advanced conventional weapons technology, particularly from Russia.

Among other things, that Act banned cash or “in kind” payments by any agency of the U.S. Government to Russian Government agencies or to any entity under their jurisdiction or control for work on the International Space Station or for obtaining goods and services relating to human spaceflight. This provision has raised difficulties regarding U.S. access to the International Space Station. When the President in 2004 announced that the Space Shuttle would be retired in 2010, the Russian *Soyuz* became the only vehicle available after that date to transport astronauts to and from the ISS. In 2005 Congress amended INA to exempt *Soyuz* flights to the ISS from the ban through 2011 and in 2008 the exception was further extended through June 30, 2016. Has your organization taken a position on whether or not a further extension is necessary?

Answer. We support policies to ensure that the International Space Station is safely maintained and utilized to the fullest extent possible. If modifications to INKNSA are necessary to achieve that, than they should be supported. We also believe that promptly creating an American capability to supply crew to the International Space Station is necessary to ensure safe maintenance and full utilization.