

Testimony of Captain Michael Lopez-Alegria, USN (Ret.)
President, Commercial Spaceflight Federation
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Chairman Nelson, Ranking Member Cruz, and Members of the Subcommittee, thank you for holding this hearing and for the opportunity to testify as President of the Commercial Spaceflight Federation.

The Federal government has worked with the American space industry in innumerable capacities since the dawn of the space program. Companies like Boeing, Aerojet and the David Clark Company have worked with the Department of Defense (DoD), NASA and NASA's predecessor NACA since the 1940s to develop many of the spaceflight systems that took our astronauts to orbit and then to the Moon. In the 1980s, the first wave of space privatization occurred, giving birth to a number of new companies and a fast-growing commercial satellite industry that reached almost \$180 billion in revenue by 2011. The Commercial Space Transportation office, now at the Federal Aviation Administration, was also established in the 1980s, to regulate and promote the commercial space launch industry. Many of the advancements that followed privatization have been in turn deployed for government purposes, proving the value of enlisting industry as an active partner in government space endeavors.

In the last few years, the industry has undergone significant growth in revenue, employees and capability. Much of its success has been based on the tremendous support that NASA has provided in developing and providing technologies, supporting development of space systems and buying services from commercial providers. This partnership between the private sector and NASA has helped create an industry that can provide services to both NASA and private customers, while creating jobs all over America.

Under the old paradigm for public-private partnership, NASA engineers would design space systems and then offer portions under cost-plus contracts for competitive bidding. This has been a successful method for building one-of-a-kind systems at the cutting edge of technology that can accomplish missions never before attempted. However, as our presence in space has expanded, it has become clear that there are wide variety of necessary systems and services that do not fit that template.

The new paradigm, which has emerged to complement but not replace the old, has been referred to as commercial procurement. It changes the role of government, so that it is a customer and involved participant in developing space systems, but not the designer, builder, operator or sole customer. This approach has proven highly successful in reducing the cost of maintaining critical space infrastructure in the pioneering Commercial Orbital Transportation System (COTS) and Commercial Resupply Services (CRS) programs, while promoting the development of systems that can also be used for commercial purposes. The model is a refinement of one that NASA and the DoD used in the 1990s to develop launch vehicles still in use today.

Meanwhile, completely commercial space activities are thriving as well. American orbital launch providers have become more competitive on the world market, bringing high-tech jobs back to America. Suborbital providers are building and testing vehicles that will tap a worldwide market

for space tourism and fulfill scientists' need for more frequent and inexpensive access to space. Other companies are developing technologies to mine asteroids for valuable resources, visit the Moon, and disaggregate large satellites into small satellite constellations.

Orbital

A year ago, SpaceX launched its first mission to the International Space Station (ISS). Coming less than a year after the retirement of the Space Shuttle, the launch captured the imagination of the American people, strengthened the ISS program, and ushered in a new era of spaceflight cooperation. Of course, one competitor is not enough for a competitive marketplace, and just last month, Orbital Sciences Corporation completed a test flight that took the company one step closer to ISS. These companies are replacing some of the capabilities lost with the retirement of the Space Shuttle and ensuring that the investment and jobs involved in resupplying the ISS are staying in America.

Unlike most other government programs, which tend to increase in cost over time, NASA's Commercial Cargo Program (CCP) has the potential for cost reductions. The vehicles and rockets providing cargo services can also be available for commercial satellite launches, NASA crew launches and other commercial markets. In this way the fixed costs of development and manufacturing infrastructure will be spread over multiple customers, lowering the cost of the flights for NASA.

Meanwhile, NASA has been working with the companies competing to fly astronauts to the ISS. The Boeing Corporation recently performed force and moment wind tunnel testing of an integrated test article including both the CST-100 capsule and the launch vehicle adapter. Sierra Nevada Corporation has recently completed its integrated system safety analysis review, demonstrating the safety and reliability plans for the major components of its Dream Chaser crew transportation system. SpaceX conducted its Ground and Ascent Preliminary Design Review and continues to do qualification testing of its Falcon 9 "version 1.1" launch vehicle.

Other companies are also working with NASA to develop orbital launch systems, including Blue Origin, who, under the Commercial Crew Development program, performed a successful pad abort test and tested components of a new 100,000-pound American rocket engine at NASA's Stennis Space Center. That engine is now undergoing evaluation at Blue Origin's West Texas facility.

Suborbital

While many companies are developing and flying orbital launch vehicles, we have seen a steady stream of progress in the suborbital arena, where reusable vehicles offer the possibility of high flight volume. Companies such as Armadillo Aerospace, Blue Origin, Masten Space Systems, Virgin Galactic and XCOR Aerospace are competing to offer flights for private individuals, researchers and experimental equipment to altitudes above 100 kilometers.

Virgin Galactic has performed many glide tests over the last year, and in April accomplished the first powered flight of its SpaceShipTwo vehicle, breaking the sound barrier and kicking off a busy year of flight-testing. XCOR is building a liquid rocket-powered vehicle that will be capable of aircraft-like operations. In March, the company performed a 67 second test firing of an engine mated to the vehicle fuselage, the first firing of a fully piston-pump-powered rocket engine. Also in March, Masten Space Systems completed the latest in a series of unmanned vertical-takeoff vertical-landing flights for Draper Labs to test autonomous control systems for use on vehicles

that will land on the Moon or Mars. Finally, late last year, Armadillo Aerospace conducted a series of flights, including the first FAA-licensed flight from Spaceport America in New Mexico by an unmanned liquid propellant sounding rocket with a steerable parachute recovery system.

Each month brings new accomplishments among a set of companies competing for a robust market for research, space tourism and other applications. A recent study by analysts at the Tauri Group showed a demand for hundreds of suborbital flights a year for a broad array of purposes. In fact, because of the operational benefits of reusable vehicles, suborbital reusable capabilities could be a disruptive technology that creates entirely new markets. The personal computer, although less powerful than a room-sized mainframe, was infinitely more useful simply because of its easier operation and came to dominate the market not by replacing supercomputers, but rather by demonstrating the market was much larger than anyone had anticipated.

The development of reusable suborbital vehicles is a truly American phenomenon, and one that is creating high-tech jobs in Florida, Texas, California, New Mexico, Colorado, Washington and many other states across the country. Many states and local communities are modifying existing airports to accommodate horizontal and vertical launch suborbital vehicles or building new spaceports to bring home the benefits of the suborbital revolution.

NASA has been admirably forward-looking in creating the Flight Opportunities Program to purchase commercial reusable suborbital flights for technology demonstration and development and for other purposes. By being an anchor customer for services, the program provides significant incentives for private investment while only paying for services rendered. The program issues calls for proposals to fly technology payloads and has seen impressive interest from the research and technology development communities, indicating a pent-up demand for inexpensive, regular access to the space environment.

Other Commercial Space Activities

Over the last few years, as the suborbital and orbital arenas have become competitive industries in search of near-term markets, new businesses have arisen to support and take advantage of new developments and push the envelope of space economic activity farther. A web of suppliers and service providers, some traditional aerospace firms and some from other sectors that have only recently become involved in space activities, support each of the companies developing orbital or suborbital vehicles.

Many states have developed or are developing commercial spaceports, including New Mexico, Florida, Texas, Oklahoma, Virginia, Alaska, Colorado and California. Testing and training facilities are providing venues to test equipment and train crew and spaceflight participants in the types of environments they will experience. Companies around the country are supplying spacecraft parts and subsystems, ranging from screws and fasteners to environmental control systems, engines and spacesuits.

Meanwhile, new companies have arisen that are pursuing business plans using new ways to access space to build novel businesses. Several companies are building and launching small communications and remote sensing satellites that promise to make existing and new satellite applications more available and more robust. Other companies are building platforms that can host scientists and individuals in orbit. Finally, commercial space has targeted asteroids and the Moon through the efforts of companies like Planetary Resources, Moon Express and Golden Spike. All in all, it is an exciting time for commercial space as early investments bear fruit and a second generation of companies builds on the accomplishments of the first.

NASA Programs

While purely commercial activities are a vital and rapidly growing part of the demand for launch services, NASA has expanded that demand to include delivery of cargo and crew to the ISS. The success of NASA's commercial cargo and crew programs has been encouraging. Unfortunately, use of the term "commercial" has become the subject of some disagreement. All programs have some commercial aspects; the companies that built vehicles in the Apollo and Space Shuttle programs were selling goods or services, and were therefore commercial enterprises. Rather than being "commercial" or not, all programs fall somewhere on a continuum of development and procurement practices. It is our view that those that display the following characteristics are closer to the "commercial" end of the spectrum:

Full and open competition. Fair and open competition is a fundamental principle that has driven the economic engines of the free world that now dominate the global economy. This concept is eminently applicable to the acquisition of space systems and services to limit cost, incentivize efficiency, and promote innovation. Too often in the past, NASA programs have ended the competition with a prime contract award near the beginning of the program. Maintaining competition through all major procurements in a program is essential, and the DoD has thusly used competition in many of its major aircraft procurements. So far, NASA's commercial cargo and crew programs have used multi-stage competition to preserve the competition throughout the life of the program, while still providing enough business to the industry partners to justify their investment. It is clear from independent analyses that the COTS program saved money as compared to the traditional development cost of a single system, even though NASA's investment was split between two companies. In addition to desired cost containment effects, competition provides critical redundancy—both technical and programmatic—that allows the program to remain robust much later in the programmatic cycle than is afforded by an early down-select to one provider. In planning any program, we suggest that the Congress and NASA put a high premium on preserving competition.

Milestone-based fixed-price payments. The COTS program has shown how much NASA can accomplish when using its Other Transaction Authority to put in place milestone-based Space Act Agreements. In the absence of a firm-fixed-price contract or agreement, the objectives of the contractor and agency can be misaligned. Without performance incentives, the contractor has little motivation to create efficiencies and lower the project cost, and absent fixed-price milestones, the agency is free to add requirements or change its mind midway through the program, raising the price of the program for the taxpayer. While not all systems can be developed on fixed-price contracts or agreements, in general, the more freedom to change the price, the more expensive the product will be in the end. Selecting the right firm, fixed-price instrument is also critical to achieving cost effectiveness. Where NASA is actually acquiring goods or services, a Federal Acquisition Regulations (FAR) contract should likely be used. However, FAR contracts, even firm, fixed-price, limit flexibility and are subject to cost increases when the government directs changes. NASA has been very innovative in using funded Space Act Agreements in the crew and cargo programs to take advantage of their low overhead and flexibility to achieve cost effectiveness. Since NASA is only "buying" the certification of these transportation systems, using a FAR contract only for the certification data keep costs to a minimum while ensuring NASA oversight and verification of performance and safety.

Well-defined and well-communicated requirements and standards. Proper program design is required to keep any program on schedule and on budget. The Government Accountability Office (GAO) has analyzed failing programs and provided appropriate guidelines to many agencies to help them manage programs more effectively. Unfortunately, one of the most damaging forms of

mismanagement—requirements creep—is still a problem. In one example discussed by the GAO, the addition of new requirements late in the development cycle helped double the cost of a GPS-related DoD program.

The degree to which a customer can be specific about its requirements, and that it can define those requirements sooner rather than later, is of great benefit to the cost effectiveness of a program. Defining program requirements, standards and milestones early is difficult, and some flexibility is always required as engineering developments may necessitate a modified or alternative requirement or standard. In its Commercial Crew Program, NASA is seeking to strike the right balance through an iterative process with industry partners in the first phase of the Certification Products Contracts. This process must continue apace to avoid costly, late changes to requirements. By facing these issues early, NASA is following the best practices outlined by the GAO and other experts. The processes pioneered by the commercial crew and cargo programs show great promise and should be practiced more widely at NASA.

Anticipation of other customers. The nation's recent economic difficulties mean NASA's budget has been smaller than the funding profile laid out in the NASA Authorization Act of 2010. Meanwhile, NASA's missions have stayed fixed or grown. In order for NASA to accomplish the remarkable things we all expect of it, the agency must be able to reduce the fixed costs associated with maintaining the nation's current space capabilities. Unfortunately, some capabilities required for NASA's mission are unique, and for those NASA bears all the fixed costs of development and maintenance. Whenever possible, NASA should avoid this situation by developing and using services that also have other customers, allowing NASA to insist that commercial partners invest their own funds as well.

In the case of crew and cargo transportation to ISS, the capabilities developed by industry in partnership with NASA will also provide services to a diverse set of markets, including commercial satellite launch, space tourism, sovereign space exploration and utilization, future NASA missions and others.

By implementing lessons learned from past and ongoing commercial programs, NASA can ensure that its investment is used in the most efficient way possible. NASA's Commercial Crew Program is currently the most high-profile commercial space program in development. Its success is important to the commercial space industry, but even more important to our nation. In difficult economic times, extending the period that American jobs are taken by Russian rocket companies is a mistake. The success of the Commercial Crew Program will mean that we are no longer dependent on Russian vehicles to transport our astronauts to the ISS. Meanwhile, it has already helped create thousands of jobs in the American space industry and will create many more as it comes to maturity.

The success of the program to date is due to the highly innovative teams at the competing companies, the skilled technical team at NASA and the commitment by NASA to commercial agreements and a minimum of unnecessary overhead. In the current phase of development, the Commercial Crew Integrated Capacity (CCiCap) program, NASA has undertaken an inventive two-pronged approach that reflects the two related, but different, goals of the program: Help industry create a competitive marketplace for crew delivery services to low Earth orbit, and secure crew delivery services for NASA that satisfy its demanding requirements. Under this approach, the development of the systems is primarily performed under milestone-based Space Act Agreements that keep costs to a minimum while still providing NASA the insight needed to ensure the vehicles are safe for crew transport. Meanwhile, NASA is pursuing a parallel certification process under a traditional, fixed-price Federal Acquisition Regulation-based

contract that will make certain that any other information NASA needs to ensure the safety of its astronauts is provided. In this way, the two transaction authorities are used for precisely the reasons they were created: Space Act Agreements to partner with industry to develop new capabilities that are relevant to both the government's needs and existing and emerging commercial markets, and FAR-based contracts to secure a service for NASA to use.

Despite seeking and receiving proposals—called optional milestones under CCIcap—from the participating companies that would allow them to proceed all the way to first crewed flight, NASA has indicated that it is planning to move the entire program to FAR-based contracts at the end of the current phase, just over a year from now. The transition away from the two-pronged approach may impose an increase in complexity and red tape on industry partners, which could result in growth in cost and schedule. Another approach would be to exercise the optional milestones under existing or revised Space Act Agreements while modifying the current FAR-based certification contracts. In this way, NASA maintains oversight, controls risk, verifies safety and will get the safe, reliable and cost-effective ISS crew transport it needs in a timely and affordable manner.

The ISS is the crown jewel of our human space enterprise. To quote Astronaut Chris Hadfield, who just returned from commanding ISS, “We are leaving Earth permanently. It is a huge historic step and we are trying to do it right and it takes time, it takes patience and it takes tenacity—and we're going to do it.” ISS touches all aspects of why we go into space—exploration, science, inspiration and commerce. NASA will soon have astronauts flying on ISS for over a year, providing critical information about the long-term effects of weightlessness for astronauts going to Mars. Science experiments like the Alpha Magnetic Spectrometer are peering into the mysteries of dark matter. And, equally exciting, ISS is creating a marketplace of space users—whether it’s small scale projects, like NanoRack’s MixStix, a small test-tube experiment platform, or very large projects like Bigelow Aerospace’s BEAM module, ISS is the proving ground for orbital space commerce. These activities will drive the demand for space access and perhaps new installations in Earth orbit. We strongly urge the Congress to extend utilization of the ISS to its design-life limit of 2028.

As NASA plans for exploration beyond earth orbit, we should also keep the lessons of the commercial programs in mind. Where NASA’s purposes overlap with those of commercial entities, non-profits, other government agencies, and other governments, it should pursue approaches that take maximum advantage of those resources by engaging early and on multiple levels. NASA should include the private sector in planning exercises to ensure that overlapping purposes are recognized and pursued. As partners, NASA and industry can ensure a sustained American human presence beyond low Earth orbit, and expand commercial, scientific and exploration opportunities throughout the Solar System.

The commercial spaceflight industry has competencies that can augment and complement NASA’s for spaceflight beyond low Earth orbit. For example, commercial spaceflight companies are working to identify, track, analyze, and eventually interact with near-Earth asteroids, complementing NASA's own efforts. Congress has an opportunity to leverage this innovative private-sector activity; the same skills and technology that enable asteroid mining, for example, enable defense from potentially hazardous asteroids and a NASA asteroid retrieval mission. The same technologies that allow Google Lunar X PRIZE companies to develop robotic spacecraft on the Moon will help NASA to accomplish its goals for lunar exploration. Congress should consider inexpensive ways to promote commercial activity in deep space, so that these companies and their investors can help accomplish national objectives and maintain U.S. leadership in a new industry. In the meantime, Congress should make it clear to the State Department that

international negotiations about space resources must take U.S. private-sector activities into account.

Other companies like those that have been involved in NASA's commercial crew and cargo programs could modify their vehicles to provide cargo supply to a mission beyond low Earth orbit. We urge NASA to adopt the highly successful COTS/CRS model, particularly the use of Space Act Agreements, wherever possible in the development of exploration capabilities that could have synergy with commercial activities, thereby reducing the cost and enhancing the safety of these systems. In other parts of NASA's mission, such as the dedicated or secondary launch of small satellites, commercial terms should also be the rule. We welcome further conversation on how the commercial space industry can enable NASA to reach farther and do more.

Federal Regulations

With the Commercial Space Launch Act of 1984, Congress established an office within the Department of Transportation to license and promote commercial launch activities. In the 1990s, the Office of Commercial Space Transportation was moved into the Federal Aviation Administration and was also given the authority to license reentry operations. From the beginning, the office's mandate was to ensure the safety of the uninvolved public (often called third parties), and since 1988 part of that task has been to ensure that an appropriate level of financial responsibility was established for licensed companies so that there would be funds available to pay any claims in the event of damage to the uninvolved public or the Federal government.

Since it has been several years since the last full reauthorization of this agency, there are a number of course corrections that we feel are warranted to streamline the regulatory process and ensure the safe and beneficial development of the industry.

In 1988 Congress set up a "risk sharing regime" to deal with potential harm to uninvolved third parties. This regime requires that license applicants meet a stringent financial responsibility requirement by compelling them to purchase insurance or demonstrate sufficient financial resources to cover third-party damage claims up to the amount that could be caused by a 1-in-10 million probability launch accident. Importantly, the Federal government is in fact protected from claims up to this Maximum Probable Loss (MPL) by the company's insurance or assets. In the extremely unlikely event of an accident that caused damage above the MPL, the Federal government agreed to seek an expedited appropriation to cover damage above the insured amount.

In fact, because of the tiny chance of an accident costing more than the MPL, the risk-sharing regime is scored as having no significant cost by the Congressional Budget Office and has been renewed many times by Congress since 1988. According to our calculations, the regime has an actuarial cost of less than \$10 per launch. The insurance policy that a launch company purchases to protect the public and the government typically costs many orders of magnitude more.

Last year, Congress only renewed the regime for one year at the end of the previous Congress, and it will expire again at the end of 2013. In view of the powerful protection that the risk-sharing regime provides to the Federal government as well as industry, we strongly urge Congress to extend it indefinitely.

While the chance of damage to uninvolved people on the ground is small, spaceflight is an inherently dangerous business for those of us who fly. No one should board a launch vehicle believing that it is perfectly safe. In 2004, as commercial human spaceflight moved from the

drawing board to the skies above Mojave, Congress passed a law declaring that customers of commercial human spaceflight launches were not passengers, but rather active “spaceflight participants.” Along with this declaration came a requirement that any company launching a participant into space must fully inform them that the Federal government does not certify spaceflight vehicles to be safe, of the risks of spaceflight in general, and of the specific safety record of their vehicle type. I am pleased to report that the Commercial Spaceflight Federation is currently developing an industry consensus standard practice for informing participants of these risks so that they are fully aware of the hazards.

Because of the risks of spaceflight, Congress understood that litigation could arise in the event of an accident, and because of the many different companies and individuals involved in any spaceflight, that litigation could be extended and complicated, imposing large costs on all parties involved. In order to avoid this situation, the Commercial Space Launch Act includes a requirement that the parties involved in a spaceflight (including customers) sign reciprocal waivers of claims with each other. All parties were included in this requirement except spaceflight participants, which raises the specter of protracted and complicated litigation. We therefore ask that Congress include spaceflight participants in the waiver of claims structure, knowing that the waivers do not excuse gross negligence or intentional action. We also ask that Congress clarify that Federal law controls any space launch activity, including the enforceability of waivers granted by spaceflight participants, and that these questions be under the sole jurisdiction of the Federal Courts, to avoid having conflicting law in different jurisdictions on matters that are fundamentally Federal in nature.

In the Commercial Space Launch Amendments Act of 2004 Congress recognized that human commercial spaceflight was a new and innovative business and that improvident regulation could easily stifle it. In that act, Congress established the principle that the Office of Commercial Space Transportation could continue to issue regulations to protect the uninvolved public without restriction, but should initially only issue regulations aimed at the safety of crew and spaceflight participants based on specific flight incidents that led or could have led to injury or death. This regime has provided regulatory stability, while enabling the industry to find inventive solutions to challenging technical problems. Though a sunset date was inserted in the 2004 bill, that date was extended in 2012 to the end of 2015. We ask that this extension be continued, as the general principle of flight-data-based regulation is important to allow the types of innovation that will improve safety in the long run.

Another correction would ensure that vehicles could continue to be tested after they are licensed, in appropriate circumstances. Current law forbids issuing an experimental permit for an individual reusable spacecraft after a launch license has been issued for a launch or reentry of a rocket of that design, meaning that further testing of the vehicle class could be limited. A technical fix would allow companies more flexibility to improve safety and increase performance. It would also enable flight-testing of new vehicles as they enter service, something required as the industry matures into operating fleets of vehicles.

Finally, air-launched or hybrid vehicles are currently regulated by two branches of the FAA depending on the particular activity taking place, a situation that the Commercial Space Launch Act tried very hard to prevent. FAA's Office of Commercial Space Transportation regulates an entire hybrid system on launch day, but FAA's Office of Aviation Safety regulates the launch platform and spaceship separately if other activities, such as repositioning and testing are pursued. Having two separate regulators thwarts congressional intent, adds to the cost and time burden of compliance, and creates the potential for regulatory gaps and conflicts that could

potentially have a negative impact on safety. We are currently pursuing a solution within the FAA, but a legislative solution may be necessary.

Conclusion

It is said that some of the greatest companies in American history were formed during recessions. Adversity can sometimes bring the best out of government programs as well as people, breeding innovation that seeds the next great round of exploration. I hope that as you consider legislation later this year, you think of the commercial space industry as a resource that can help NASA achieve its ever-more-difficult missions and bring a new energy to the scientists, engineers, dreamers and policy-makers who see space as a vital component of our next economic boom. Please let me know of any way in which the Commercial Spaceflight Federation can help.