

**STATEMENT OF
TIM HUGHES
SENIOR VICE PRESIDENT FOR GLOBAL BUSINESS & GOVERNMENT AFFAIRS
SPACE EXPLORATION TECHNOLOGIES CORP. (SPACE X)**

**BEFORE THE
SUBCOMMITTEE ON SPACE, SCIENCE & TECHNOLOGY
COMMITTEE ON COMMERCE, SCIENCE & TECHNOLOGY
UNITED STATES SENATE**

July 13, 2017

Mr. Chairman, Ranking Member Markey, and Members of the Committee,

Thank you for the opportunity to participate in this important hearing on “Reopening the American Frontier.” SpaceX is a firm believer that public-private partnerships between U.S. commercial space entities and the Government are the optimal vehicles to rapidly, safely, and cost-effectively advance space exploration and settlement of the solar system.

Under your leadership, the Committee recently has reviewed an array of matters, including regulatory reform to enable commercial space to thrive and revisions to the Outer Space Treaty, which are critical to ensuring the Nation’s continued leadership in space exploration. Today’s hearing provides a timely opportunity to discuss the nature of NASA’s recent successful partnerships with private industry and to review how the United States can leverage such innovative approaches in its deep space endeavors going forward. SpaceX’s direct and significant experience working under unique, innovative public-private partnerships with NASA should help to shape the contours of this dialogue. In addition to existing programs at NASA focused on deep space exploration transportation and architectures, NASA again should pursue a parallel track that leverages non-traditional, public-private partnership approaches to increase the likelihood of success for the Nation’s space exploration objectives.

From its beginning, SpaceX has leveraged American innovation, technical savvy, and an iterative culture to yield the most advanced space launch vehicle and spacecraft systems in history. We are grateful for NASA’s ongoing support, which has been critical to SpaceX’s success. We are proud to provide a dependable and affordable ride to space for NASA, the Department of Defense, and the world’s most sophisticated commercial satellite manufacturers and operators. Today, we regularly conduct critical un-crewed cargo resupply missions to and from the International Space Station (ISS) with our Dragon spacecraft—which was developed in partnership with NASA—and next year, we will begin launching American astronauts on American rockets for the first time since the Space Shuttle was retired in 2011. Commercially, SpaceX has restored the U.S. as a leader in global commercial satellite launch, taking back a market that had been wholly ceded to Russia and France for over a decade. As we look to the future, SpaceX is committed to continuing to support America’s space program and to contribute to our national exploration objectives through reliable, innovative, and affordable access to space.

To begin, it bears noting that the National Aeronautics and Space Act of 1958 identifies one of NASA’s core mission areas as follows: “[t]o seek and encourage, to the maximum extent possible, the fullest commercial use of space.”¹ Additionally, the National Space Transportation Policy expressly directs federal agencies to “[p]romote and maintain a dynamic, healthy, and efficient domestic space transportation industrial base,” and to do so, in part, by cultivating “increased technological innovation and

¹ Pub. L. 115–10, title III, §305(b), title IV, §443(b), Mar. 21, 2017, 131 Stat. 32, 47, added items 20148 and 20149.

entrepreneurship in the U.S. commercial space transportation sector through the use of incentives such as non-traditional acquisition arrangements, competition, and prizes.”² American policy-makers dating back to the formation of NASA have recognized that the commercial use of space represents one of the country’s greatest assets—private sector ingenuity and capital, rather than cost-plus contracts and open-ended requirements. This, coupled with unique Government capability, technical insight, experience, and resources, will sustain and grow American leadership in space, and more broadly, benefit all of humankind.

My testimony today will focus on the following areas:

- 1) The NASA Commercial Orbital Transportation Services (COTS) program should serve as an object lesson in successful, high-value public-private partnership approaches. The COTS program resulted in significant new capability for the U.S. Government, saved hundreds of millions in taxpayer money, and helped restore U.S. competitiveness in commercial space launch. The lessons learned through COTS—a program to support cargo transportation to low Earth orbit (LEO)—could easily be transposed on innovative partnership arrangements for deep space exploration going forward.
- 2) Public-private partnerships and commercial-type contract approaches under the Federal Acquisition Regulations (FAR) can provide cost-effective, accelerated development and deployment of new space capabilities, if properly constructed and tailored. Here, my testimony will focus on how the unique features of such approaches can and should be applied to deep space exploration initiatives to keep America at the cutting edge of space technology within reasonable budgets and timetables.
- 3) Specific commercial partnership concepts for deep space exploration can complement and enhance the space exploration efforts NASA is currently undertaking through more traditional contract and development approaches. Here, my testimony sets forth some possibilities that are additive, and emphasizes that no single approach is perfect. That is, it is evident that the country will benefit by applying multiple different approaches and enabling multiple different, redundant pathways to space exploration.

I. SpaceX Today

Founded in 2002, SpaceX employs approximately 6,000 people dedicated to designing, manufacturing, and launching rockets and spacecraft in and from the United States. To this end, SpaceX was created with the express goal of dramatically improving the reliability, safety, and affordability of space transportation. We have made that goal a reality. And, of course, our ultimate goal is to help to establish a permanent human presence in the stars, with an initial focus on Mars as a destination.

To date, the SpaceX Falcon 9 launch vehicle has successfully launched 37 times, all while achieving important evolutionary reductions in the cost of space launch. Among other things, SpaceX has focused on making our rockets reusable. After several years of self-funded research and development on reusability, beginning with critical work at our McGregor, Texas Rocket Development Facility, SpaceX has now recovered a total of 13 Falcon 9 first stage boosters since December 2015—5 at Landing Zone 1 at Cape Canaveral Air Force Station and 8 aboard our autonomous spaceport droneships at sea. After a four-month qualification program, SpaceX successfully launched and landed a previously-flown Falcon 9 booster in March of this year, placing a high-value telecommunications satellite into orbit for SES, a global satellite operator. This was an historic first for an orbital-class booster. In June 2017, SpaceX repeated this success

² National Space Transportation Policy. November 1, 2013. Available at: https://www.nasa.gov/sites/default/files/files/national_space_transportation_policy_11212013.pdf

with the launch of the BulgariaSat-1 satellite using a flight-proven booster, which itself had previously launched in January of 2017.

Currently, SpaceX has approximately 70 missions on manifest, representing more than \$10 billion in signed contracts for a diverse and growing set of customers, including NASA, the Department of Defense, commercial satellite operators, and allied international governments. As our business continues to grow, SpaceX, as technology companies should, invests heavily in the company's manufacturing and launch infrastructure and advanced research and development projects, including spacecraft development.

We remain laser-focused on reliability and safety as we prepare to launch U.S. astronauts next year. This is a sacred responsibility that we approach with the utmost dedication and diligence. Additionally, we continue efforts to reach a cadence of a launch every two weeks or less for 2017, with an even higher rate planned for 2018; to move toward rapid and complete reusability of our boosters; to launch our Falcon Heavy launch vehicle later this year, which will be the most powerful rocket to launch since the Saturn V Moon rocket; to develop and produce the initial prototypes for our broadband satellite system; and to continue design and development work of a Mars launch vehicle architecture. Critically, all of this innovation is occurring in the United States, creating high-paying jobs, advancing technology, and generating substantial economic activity.

To update the Committee on SpaceX's major milestones for 2017:

- We have completed 10 missions in the past 7 months, for a total 37 successful Falcon 9 launches overall. Recently, SpaceX launched 4 successful missions in 32 days (3 of those in just 12 days);
- We have already successfully completed two cargo resupply missions to the ISS for NASA, CRS-10 and CRS-11, which was the first re-flight of a Dragon spacecraft;
- We successfully launched two flight-proven Falcon 9 rockets for commercial satellite customers;
- We successfully delivered the NROL-76 national security payload to orbit for the National Reconnaissance Office (NRO) on May 1, 2017, the first dedicated national security mission flown by SpaceX, under an innovative, commercial services contract;
- We were awarded a second GPS III missions under a competitive procurement in the Evolved Expendable Launch Vehicle (EELV) Program, yielding a significant cost savings to the Air Force;
- We have launched missions from both active East and West Coast launch sites; and,
- We are completing final upgrades to the Falcon 9 (Block 5), after which we'll focus much of our launch vehicle engineering talent on SpaceX's Mars vehicle.

SpaceX maintains its manufacturing and engineering headquarters in Hawthorne, CA; a satellite system design and development office in Redmond, WA; a Rocket Development and Test Facility in McGregor, TX; and launch pads at Cape Canaveral Air Force Station, NASA Kennedy Space Center, Vandenberg Air Force Base, and, soon, a commercial launch site near Brownsville, TX. SpaceX also relies upon a network of more than 4,400 American suppliers and partners—an investment in the American industrial base when others are spending heavily abroad.

II. COTS: A Successful Model for Public Private Partnerships

The Commercial Orbital Transportation System (COTS) program has been widely and correctly hailed as a major success for NASA and its commercial partners, delivering significant new capability to the

Government at incredible value to the taxpayer.³ After the Space Shuttle *Columbia* disaster in 2003, all Space Shuttle flight operations were suspended for more than two years, and the United States became reliant upon foreign governments to carry both American cargo and crew to the International Space Station (ISS). In 2006, NASA established the COTS program to develop new U.S. cargo capability to serve as a follow-on to the Space Shuttle Program for missions to ISS. COTS was an innovative, commercially competitive program that successfully leveraged private sector dollars and ingenuity through public-private partnerships.

The COTS program was the first of its kind for NASA: a pay-for-performance partnership between the U.S. Government and private businesses to rapidly design and prototype critical technologies. NASA structured the COTS program as a collaborative partnership with the commercial space industry, sharing the risks, costs, and rewards of developing new space transportation capabilities. Under the program, NASA provided seed money for the development of private spaceflight capabilities, but issued payment only after a company met technical and financial performance milestones. The participating COTS contractors, likewise, invested in the program and put their own financial skin in the game. The contractual mechanism utilized was a “Space Act Agreement” (SAA), which allows the agency to rapidly design and prototype technologies, and allows contractual flexibility such that private parties can contribute financially to what would otherwise be a Government effort. The SAA has its genesis in “other transactions authority,” which exists in federal statute for NASA, as well as the Department of Defense and many other Federal agencies.

NASA competitively awarded a COTS Space Act Agreement to SpaceX and another entity in 2006. For SpaceX, the SAA ultimately represented a total of \$396 million of NASA investment, primarily focused on development of the Dragon cargo capsule and two demonstration flights of the Falcon 9 launch vehicle and Dragon spacecraft. SpaceX in turn invested more than \$500M (at that time) in the development of the Falcon 9, including launch sites, production, and test facilities.⁴ In only four years, SpaceX went from a clean sheet design to launch of the Falcon 9 and the first orbit and reentry of Dragon—an unprecedented reduction in development time for a complex space system that was realized under the SAA approach.

In May 2012, Falcon 9 successfully launched Dragon to orbit and the spacecraft then successfully berthed with the Space Station, a mere six years after contract award. Shortly thereafter in October 2012, the first operational mission under the follow-on Commercial Resupply Services (CRS) contract lifted off, resulting in mission success and kicking off a new area of U.S. resupply to the space station.

This level of output and speed relative to expenditures is unprecedented in the aerospace community and marked a major success for NASA and its innovative approach to restore a critical capability. In short, this was a major win for the U.S. taxpayer, for U.S. manufacturing, for NASA specifically, and for the U.S. commercial space industry. It was perhaps the greatest “bang for the buck” that NASA has ever achieved.

Notably, in August 2011 NASA, using the NASA-Air Force Cost Model (NAFCOM), determined that had Falcon 9 been developed under a traditional NASA approach, the cost would have been approximately \$4 billion. The analysis also showed development of the Falcon 9 would have been approximately \$1.7 billion based on the traditional commercial models and assumed factors. However, NASA independently verified SpaceX’s development costs of both the Falcon 1 (our early “pathfinder” vehicle) and Falcon 9 at approximately \$390 million in the aggregate (\$300 million for Falcon 9; \$90 million for Falcon 1).⁵

³ “The development of commercial cargo vehicles is considered by many as one of the major success stories at NASA in the last decade.” Jeff Foust, “For commercial cargo, ideas old and new,” *The Space Review*, March 23, 2015. Available at: <http://www.thespacereview.com/article/2717/1>.

⁴ SpaceX has continued to invest in reliability, performance, and reusability enhancements for Falcon 9.

⁵ NASA Deputy Associate Administrator for Policy, “Falcon 9 Launch Vehicle: NAFCOM Cost Estimates,” August 2011. Available at: https://www.nasa.gov/pdf/586023main_8-3-11_NAFCOM.pdf

Beyond COTS, NASA has had other successes utilizing the innovative and flexible framework enabled by Space Act Agreements.⁶ For example, NASA successfully worked with Bigelow Aerospace, which makes expandable modules and habitats for use in space. Here, once again NASA used an SAA applying a firm-fixed-price structure and leveraging significant private investment by Bigelow, to launch the Bigelow Expandable Activity Module (BEAM) to the ISS. SpaceX launched BEAM to the Space Station on April 8, 2016 during a cargo resupply mission. Once Dragon berthed with the Space Station, NASA astronauts extracted the BEAM module from Dragon’s unpressurized trunk and attached it as a new module to the ISS. When activated, BEAM expanded to ten times its size at launch to provide more than 565 cubic feet of new volume to the Station and became the first human-rated expandable module in space. With this success, Bigelow and others will now develop technologies for habitats in low Earth orbit and beyond, which will likely later be utilized by space agencies and commercial customers for in-orbit research labs, habitats in LEO, lunar orbits, on Mars or elsewhere.⁷

III. Value of Partnerships and Commercial-Type Partnerships

By any accounting, the COTS program has been an historic success. According to NASA, “[b]ecause these were partnerships, not traditional contracts, NASA leveraged its \$800M COTS program budget [less than a single Space Shuttle mission] with partner funds. This resulted in two new U.S. medium-class launch vehicles and two automated cargo spacecraft and demonstrated the efficiency of such partnerships.”⁸ We encourage the Committee to consider ways to take the lessons learned from the COTS program and more broadly utilize of the basic features of this approach in future public-private partnerships that extend to deep space exploration initiatives.

The basic features of the COTS program include:

- (1) Establishing high-level requirements and encouraging contractors to execute against them with creative, innovate, and cost-effective solutions, reducing “requirements creep” and encouraging new thinking. The COTS program required contractors to meet a clear set of established safety and interface ISS requirements and high-level milestone requirements, rather than implementing overly-specified and ever-changing detailed Government requirements. This requires the Government customer to tell contractors what they need to be done, rather than prescribing how to do it. Coupled with firm, fixed-price arrangements, the Government Accountability Office (GAO) has found that “the use of firm-fixed-price contracts—along with *well-defined requirements* and a sufficient level of knowledge about critical technologies—presents the least risk to the government.”⁹
- (2) Using firm, fixed price, pay-for-performance, milestone based agreements or contracts, creating proper incentives on the contractor to execute toward successful conclusion, and discouraging continuous Government requirement changes that add costs and delay schedules. Pay-for-

⁶ See: NASA, “Public-Private Partnerships for Space Capability Development: Driving Economic Growth and NASA’s Mission,” April 2014. Available at:

https://www.nasa.gov/sites/default/files/files/NASA_Partnership_Report_LR_20140429.pdf

⁷ NASA, “Bigelow Expandable Activity Module (BEAM),” May 31, 2017. Available at:

https://www.nasa.gov/mission_pages/station/research/experiments/1804.html

⁸ NASA, “Commercial Orbital Transportation Services: A New Era in Spaceflight,” February 2014. Available at:

<https://www.nasa.gov/sites/default/files/files/SP-2014-617.pdf>

⁹ Government Accountability Office, “NASA: Acquisition Approach for Commercial Crew Transportation Includes Good Practices, but Faces Significant Challenges,” December 2011, (GAO-12-282). Available at:

<http://www.gao.gov/assets/590/587021.pdf>. (Emphasis added).

performance creates proper incentives on both sides of the Government/contractor relationship. Here, the GAO has reported: “[f]irm-fixed-price contracts place the onus on the contractor to provide the deliverable at the time, place, and price negotiated by the contractor and the government. In addition, firm-fixed-price contracts place the maximum risk on the contractor as well as full responsibility for all costs and any resulting profit or loss.”¹⁰

- (3) Maximizing competition, which is critical to drive value and performance, and improve quality of service to the customer. Again, GAO has reported that “promoting competition can help save the taxpayer money, improve contractor performance, and promote accountability for results.”¹¹
- (4) Requiring a significant private capital contribution to the overall program. The COTS agreements required commercial partners to share costs and provide a significant percentage of the overall total investment, resulting in lower costs to the Government and high incentives for commercial firms to drive toward operational success to generate revenue and recoup their investment.
- (5) Tolerating programmatic risk, and easy termination for failure. One of the major early lessons learned under the COTS model was borne of the failure of Rocketplane-Kistler, one of the original winners of the first competitive down-select, alongside SpaceX. Ultimately, Rocketplane-Kistler was unable to execute against one of the financial milestones in its agreement with NASA. As a result, NASA was able to early terminate the agreement without significant lost investment or time, and pivot to OrbitalATK (then Orbital Sciences) to serve as the second provider under the program. This flexibility to terminate contracts and rapidly “stop the bleeding” on non-functional programs is one that is largely lost when applied to traditional FAR-based contracts.
- (6) Encouraging new, non-traditional companies to work with NASA. Due to the complexity and cost associated with conforming to traditional FAR-based contract requirements, start-up companies with small teams and no expertise interfacing with the complex regulatory and contractual environment associated with U.S. Government are often deterred from participating at all. As a result, the Government is often not at the cutting edge of new commercial technology offerings. The use of Space Act Agreements—as with COTS—can help enable such firms to do business with the Government.
- (7) Facilitating the development of new markets, and leveraging market-driven pricing to support U.S. Government requirements and missions. Today, SpaceX is the world’s leading commercial launch services provider measured by manifested launches. A substantial majority of our more than 70 missions under contract are commercial. This year, we are on track to launch more than half of the world’s accessible¹² commercial missions to geostationary transfer orbit (GTO). Next year, we expect to launch a majority of the world’s missions to GTO with our Falcon 9 and Falcon Heavy launch vehicles.

Prior to SpaceX entering the commercial space launch market with the Falcon 9 launch vehicle, the U.S. had effectively ceded this market to France and to Russia, and no U.S. company had launched a single commercial mission to GTO since 2009. SpaceX has brought this multi-billion dollar market back to the United States. The benefit to NASA, and to the entire U.S. Government when buying launch services, is that commercial competitiveness drives launch prices lower for the Government customer (since costs are widely distributed instead of borne entirely by the Government), increases the robustness of the launch company’s business, and increases reliability

¹⁰ Ibid.

¹¹ Ibid.

¹² Not all of the world’s commercial satellite launches are open to competition.

and launch heritage through higher flight rates. As a result of COTS—at least with respect to SpaceX—NASA and the Department of Defense are paying lower prices for launch with higher performance than in the past.

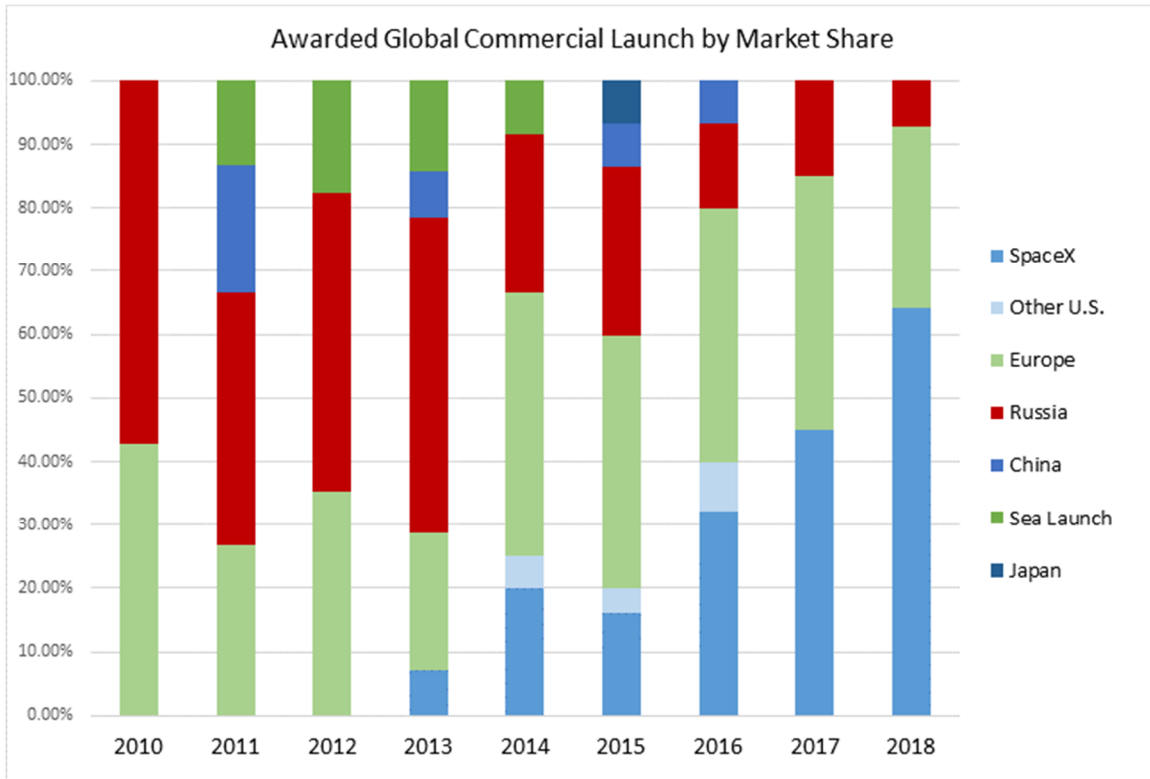


Figure 1: Global Commercial Market Share

IV. Recommendations for Increasing Use of Public-Private Partnerships for Deep Space Exploration

SpaceX applauds this Committee for examining ways in which public-private partnerships and commercial arrangements can contribute to the Nation’s space exploration objectives, just as they have done to enhance America’s capabilities in low Earth orbit. To this day, America’s achievement of landing men on the Moon and returning them safely to Earth likely represents humankind’s greatest and most inspirational technological achievement. This was accomplished in eight years using slide rules and pencils, with engineers literally inventing rocket science as they progressed. Now, other nations like China seek to replicate an achievement America first accomplished *48 years ago*.

With the technology advancements and increased knowledge through decades of work by NASA in deep space, including Mars, the United States is now well-positioned to build upon past achievements in space and surpass them. Coupled with the NASA resources and unique expertise, American ingenuity, the principles of free enterprise, and the benefits of competition, the United States can do more in space than has ever been accomplished previously.

SpaceX recommends that, in parallel with existing programs at NASA focused on deep space exploration transportation and architectures, NASA again leverages non-traditional, public-private partnerships to improve the likelihood of success for its space exploration objectives. By leveraging flexible, innovative contracting approaches as well as private capital, NASA and the space program could generate efficiency

gains and accelerate progress, while expanding the potential pool of technology companies contributing to the overall effort to expand humanity's presence in the solar system and ultimately establish settlements on other planets.

What are the goals and near-term outcomes of such an approach?

- **American Aspiration and Inspiration.** The last astronaut left the surface of the Moon in 1972, and no one has returned since. Despite being an historic achievement for America and humankind, the Apollo program did not create a lasting, sustained presence in deep space for humanity. A permanent human presence on the Moon presents humanity's next obvious foothold outside of Earth. However, rather than look back to the Moon alone, the United States should also lead the world to the next great destination: Mars. Moving beyond the Earth-Moon system will open the broader solar system to human exploration, a potentially generations-long enterprise. Both missions would enable settlement and tap into America's spirit of exploration.
- **U.S. Leadership.** A realistic and sustainable human exploration program will demonstrate American leadership in space exploration, technology innovation, and scientific discovery for many years to come. This leadership will enhance the American economy, extend America's technological edge, and project American power. The technologies and applications developed invariably will have beneficial impacts to America's national security goals and space superiority.
- **American Jobs and Industrial Growth.** Every dollar spent on effective public-private partnerships and commercial-type contracts to establish an American presence on the Moon or Mars represents an investment in our economy, our technological infrastructure, and our ability to achieve accelerated advancements in space exploration and settlement. A viable Moon or Mars program will create tens of thousands of high-tech, high-paying American jobs and revitalize the U.S. manufacturing sector in order to develop and produce large scale systems for deep space transportation and capability (e.g., propulsion systems, launch vehicles, spaceships, orbiting reconnaissance systems, and communications satellites), as well as systems to enable a permanent human presence on celestial bodies other than Earth (e.g., life support systems, habitats, surface power, surface exploration, and resource extraction). A Moon-Mars initiative that leverages the strengths of the U.S. government and the strengths of the private sector and invests in America's workforce will create *new, high-paying* American jobs in dozens of states—but most importantly, it will move the Nation's space exploration goals meaningfully forward.

To run in parallel with existing programs and increase the probability of success of establishing initial human presence on the Moon or Mars within the next in eight years to ten years, NASA could build upon the already demonstrated successful COTS model and create a similar COTS-like program for deep space exploration initiatives based on the following proven elements:

- **Competition.** NASA should hold an outcome-oriented, open competition, and award initial contracts to at least four companies. Later, NASA should down-select to at least two contractors to maintain competition and, critically, to have back up capability. Companies (or teams of companies) can compete with existing or novel designs and technologies.
- **Focus on Performance Goals Not Requirements.** Like the COTS program, NASA should set overall goals and establish clear milestones for the program and enforce only the necessary level of requirements and conduct continuous insight to ensure contractors are meeting milestones. NASA should let private companies determine how to achieve high-level requirements, rather dictate detailed specifications that suffocate innovation and ingenuity.

- **Fixed-Price, Milestone-Based Payments.** NASA should pay for performance achieved along the way, on a firm, fixed-price basis that encourages rapid prototyping and development, rather than only use traditional cost-plus Government contracts that historically have resulted in cost overruns and led to schedule delays.
- **Contractor Investment / Public-Private Partnership.** The benefits and burdens of funding such a program should be shared by the Government and awardees, with commercial space partners making commitments of at least one-third of the funding for any bid made. This will buy-down risk for the Government, incentivize performance, and demonstrate commitment. Corporations should view this as an investment in technology and potential follow-on business.

Mr. Chairman, I appreciate your invitation to testify before the Committee today. Commercial-type contracts and public-private partnerships have resulted in significant successful outcomes for NASA and the nation with respect to space capability. The principles applied in past programs for low Earth orbit capability can and should be applied to deep space exploration. The United States can achieve incredible advancements in technology by coupling NASA's established capabilities, technical skills, and resources with those of the private sector and American entrepreneurship.

Again, we appreciate and support the work this Committee has undertaken to address policy matters before the commercial space industry, and we look forward to continuing the dialogue.