U.S. Government Oversight of

Commercial Space Enterprises

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About the Editor

Michael Erbschloe has worked for over 30 years performing analysis of the economics of information technology, public policy relating to technology, and utilizing technology in reengineering organization processes. He has authored several books on social and management issues of information technology that were published by McGraw Hill and other major publishers. He has also taught at several universities and developed technology-related curriculum. His career has focused on several interrelated areas:

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Books by Michael Erbschloe
Social Engineering: Hacking Systems, Nations, and Societies
Extremist Propaganda in Social Media: A Threat to Homeland Security (CRC Press)
Threat Level Red: Cybersecurity Research Programs of the U.S. Government (CRC Press)
Social Media Warfare: Equal Weapons for All (CRC Press)
Walling Out the Insiders: Controlling Access to Improve Organizational Security (CRC Press)
Physical Security for IT (Elsevier Science)
Trojans, Worms, and Spyware (Butterworth-Heinemann)
Implementing Homeland Security in Enterprise IT (Digital Press)
Guide to Disaster Recovery (Course Technology)
Socially Responsible IT Management (Digital Press)
Information Warfare: How to Survive Cyber Attacks (McGraw Hill)
The Executive's Guide to Privacy Management (McGraw Hill)
Net Privacy: A Guide to Developing & Implementing an e-business Privacy Plan (McGraw Hill)

Introduction

How is it that we are able to enjoy live national or worldwide television and radio broadcasts? Make international telephone calls? Use high-speed Internet and nationwide paging services? Receive weather forecasts? Manage natural resource use? Respond to emergencies and disasters? Pay by credit card at a retail store? Satellite technology is the short answer. But how do those satellites make it into space? This is the function of commercial space transportation.

Thirty years ago there was no commercial space transportation industry. By 2009, U.S. commercial space transportation and the services and industries it enables accounted for more than $208 billion in economic activity. Over one million people were employed as a result of these activities. This level is likely to grow in the future as new applications dependent on commercial space transportation emerge.

The FAA is responsible for ensuring protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and encouraging, facilitating, and promoting U.S. commercial space transportation. To date, (August 2019) the FAA Office of Commercial Space Transportation has licensed or permitted more than 370 launches, reentries, and launch sites.

The U.S. commercial space transportation industry had its most productive year ever in fiscal year 2018, with 32 FAA-licensed launches, three reentries, and two new launch sites, bringing the total number of U.S. launch sites to 12. The FAA is forecasting as many as 40 FAA-licensed commercial space transportation activities in fiscal year 2019.

Between 1963 and 1982, U.S. expendable launch vehicle (ELV) manufacturers produced vehicles only under contract to the National Aeronautics and Space Administration (NASA) or the Department of Defense (DOD). In the early 1970s, when private companies and foreign governments purchased communications satellites, they had to contract with NASA to launch their payloads. Through NASA, launches could be procured on any one of four ELVs: Titan, built by Martin Marietta; Atlas, built by General Dynamics; Delta, built by McDonnell Douglas; and Scout, built by LTV Aerospace Corporation. NASA would purchase a launch vehicle through traditional government procurement practices, and the launch would be conducted by a private-sector contractor under NASA supervision.

For a long time the U.S. government essentially served as the only provider of space launch services to the Western world. Seeing an opportunity to provide launch services, the European Space Agency developed its own ELV, Ariane, which became the first competitor to NASA for commercial launches. The first Ariane launch occurred in 1979, and in 1984, a private company, Arianespace, took over commercial operation of the vehicle.

In the late 1970s, the U.S. government decided to phase out all ELVs, except Scout, in favor of the U.S. space shuttle. The shuttle would take all U.S. government satellites, as well as commercial satellites, into orbit. NASA declared the shuttle, which made its first flight in 1981, operational in 1982, and government funding of ELV production ceased in 1983. It quickly became evident, however, that the flight schedule of the shuttle could not meet all of the U.S. security, civil and commercial launch requirements. As the need grew for more launches than

NASA could handle, some launch vehicle manufacturers expressed interest in offering commercial launch services.

In 1982, the first successful private launch in the United States took place – a test launch of the Space Services' prototype Conestoga rocket. The procedures required to gain approval for that launch, however, proved time-consuming and led to the introduction of legislation to make it easier for companies to pursue commercial launch activities. A bill (HR 1011) introduced in the House by Congressman Daniel Akaka (D-HI) would have designated the Department of Commerce as lead agency, while the Senate bill (S 560), introduced by Earnest "Fritz" Hollings (D-SC), intended to give the lead role to the Federal Aviation Administration (FAA). Others suggested the lead go to the Department of State or NASA. While Congress debated the efficacy of its legislation, on July 4, 1982, President Ronald Reagan issued national security decision directive (NSDD) 42, "National Space Policy," stating that expansion of U.S. private sector involvement in civil space activities was a national goal.

The President's Senior Interagency Group on Space subsequently reviewed the policy and concluded a commercial ELV capability would offer substantial benefits to the nation by:
• Maintaining a high-technology industrial base;
• Providing jobs for thousands of workers, thus adding to the federal tax base;
• Spawning numerous spinoff and supporting activities;
• Strengthening the U.S. global position;
• Providing a potential market for excess flight hardware, special-purpose tooling, test equipment, and propellants; and
• Creating a market for U.S. government and facilities.

On May 16, 1983, the President issued NSDD 94, "Commercialization of Expendable Launch Vehicles." This stated the "U.S. Government fully endorses and will facilitate the commercialization of U.S. Expendable Launch Vehicles. The U.S. Government will license, supervise, and/or regulate U.S. commercial ELV operations only to the extent required to meet its national and international obligations and to ensure public safety."

The directive created an interim space working group on commercial launch operation co-chaired by the Department of State and NASA. FAA and the Federal Communications Commission also had representatives in the group. Among other things, the President mandated the group develop and coordinate the requirements and processes for the licensing, supervision, and/or regulations applicable to commercial launch operations and recommend the appropriate agency with the U.S. government responsible for commercial launch activities.

The group submitted its report on September 15, 1983. It did not recommend a lead agency, but, instead, deferred to the Cabinet Council for Commerce and Trade. At a meeting of the Council on November 16, 1983, President Reagan announced his intention to designate the Department of Transportation (DOT) as the agency with principal responsibility for fostering the private commercial ELV business. His rationale centered on the fact that DOT, as a department that understood the regulatory process and with experience as a deregulator (airline, railroad, etc.), was uniquely suited to remove regulatory barriers and to streamline regulations necessary to create a commercial space industry.

In a January 1984 speech, Secretary of Transportation Elizabeth Dole explained the President wanted to stimulate interest in commercial space ventures by removing regulatory barriers. She said that companies trying to operate in space must go through as many as 17 agencies to get appropriate permits and licenses. DOT would give companies one-stop service to help them "cut through the thicket of clearances, licenses, and regulations that keep industrial space vehicles tethered to their pads."

On February 24, 1984, Executive Order 12465 formally designated DOT as the lead agency for encouraging, facilitating, and licensing commercial ELV activities. DOT entrusted these duties to a new Office of Commercial Space Transportation. Dole appointed Jennifer "Jenna" Dorn as the first director of the new office. Prior to her appointment, she had served as Elizabeth Dole's special assistant.

Congress affirmed and expanded these actions through the Commercial Space Launch Act, enacted on October 30, 1984. This legislation addressed three substantive areas: licensing and regulation; liability insurance requirements; and access of private launch companies to government facilities. Despite the legislation, U.S. launch firms remained largely uninterested in offering commercial launch services, finding it difficult to compete against the government subsidized space shuttle. U.S. policy changed in the wake of the January 28, 1986, space shuttle Challenger tragedy. The government reversed its policy of phasing out ELVs and instead adopted a mixed-fleet approach where both ELVs and the shuttle were available for commercial users.

On August 15, 1986, Reagan issued NSDD 254, "United States Space Launch Strategy," which limited NASA's role in providing commercial launches to only those satellites that required the unique capabilities of the shuttle or for which there were unusual foreign policy considerations. The resulting unavailability of NASA as a domestic civilian launch service, coupled with the already enacted legislation, led to the emergence of the U.S. commercial launch services industry. On February 11, 1988, President Reagan issued the "Presidential Directive on National Space Policy," which required U.S. government agencies to purchases launch services from commercial companies.

The U.S.-licensed commercial space industry made its first launch in March 1989 when Space Service, Inc., sent a scientific payload on a suborbital trip aboard a Starfire rocket. Later in 1989, McDonnell Douglas made the first U.S.-licensed commercial orbital launch on August 27, using a Delta I launch vehicle.

On August 7, 1995, DOT announced that the Office of Commercial Space Transportation would move from the Office of the Secretary to FAA, effective October 1, 1995, as part of a larger DOT reorganization. The transfer of the office was delayed, however, until sanctioned by legislation. The fiscal year 1996 DOT appropriations bill, signed by President Bill Clinton on November 15, 1995, cleared the way for the transfer of the Office of Commercial Space Transportation from DOT's Office of the Secretary to FAA. The transfer became effective on November 16 of that year.

The Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST) is the U.S. government organization responsible for regulating the safe operations of the U.S. commercial space transportation industry and facilitating its international competitiveness. It accomplishes its task by licensing and permitting these activities, which include expendable and reusable orbital launch vehicles, and suborbital launch vehicles. The AST innovative experimental launch permitting process is designed for the testing, development, and reentry of reusable suborbital launch vehicles. As private industry comes closer to testing vehicles that will be capable of taking passengers and tourists on suborbital flights, companies and organizations are proposing to offer training in human spaceflight training and several organizations have already begun to provide this service.

Space transportation is the movement of, or means of moving objects, such as satellites and vehicles carrying cargo, scientific payloads, or passengers, to, from, or in space. Commercial space transportation is carried out using orbital and suborbital vehicles owned and operated by private companies or organizations for profit, procured through a competitive bidding process. The U.S. space transportation industry operates in almost half the states in the United States.

Today, there are several companies around the world that offer orbital commercial launch services. Additionally, some companies are being established to offer suborbital services for paying passengers. In recent years, commercial launches have comprised about one-third of all launches conducted worldwide.

Another, growing part of the commercial space transportation industry in the United States is the development of private or state-operated launch, re-entry, and processing sites known as commercial spaceports (PDF). These spaceports can provide alternatives to government launch sites operated by the U.S. Air Force or NASA. AST licenses the operation of commercial spaceports in the U.S. By 2018, AST had issued ten licenses in eight states.

Commercial Space Transportation Advisory Committee (COMSTAC) was established in 1984 to provide information, advice, and recommendations to the Administrator of the Federal Aviation Administration (FAA) on critical matters concerning the U.S. commercial space transportation industry.

The economic, technical, and institutional expertise provided by COMSTAC members has been invaluable to our work in developing effective regulations that ensure safety during commercial launch operations and policies that support international competitiveness for the industry.

COMSTAC membership consists of senior executives from the commercial space transportation industry; representatives from the satellite industry, both manufacturers and users; state and local government officials; representatives from firms providing insurance, financial investment and legal services for commercial space activities; and representatives from academia, space advocacy organizations, and industry associations.

NASA's role in fostering the Emerging Commercial Space sector is shared with the FAA Office of Commercial Space Transportation and the Office of Space Commercialization of the Department of Commerce. At the first Commercial Space workshop in June 2010, NASA established 5 working groups that focus on mapping the barriers for Commercial Space and identify potential solutions to these barriers. During a follow on workshop in July, the working groups have addressed these issues and are working on mapping the barriers and possible solutions. This will ultimately drive the prioritization of where NASA technology development and investment will be steered towards.

On June 28, 2010, President Obama issued a National Space Policy directive providing comprehensive guidance for all government activities in space, including the commercial, civil, and national security space sectors. The new policy leaned farther forward in support of U.S. business interests than any previous space policy. The principles section of the policy states, “The United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship.”

The first of the six stated policy goals is to “Energize competitive domestic industries to participate in global markets and advance the development of: satellite manufacturing; satellite-based services; space launch; terrestrial applications; and increased entrepreneurship.”

The policy includes a set of Commercial Space Guidelines directing the U.S. Government to:

Purchase and use commercial space capabilities and services to the maximum practical extent when such capabilities and services are available in the marketplace and meet United States Government requirements;

Modify commercial space capabilities and services to meet government requirements when existing commercial capabilities and services do not fully meet these requirements and the potential modification represents a more cost-effective and timely acquisition approach for the government;

Actively explore the use of inventive, nontraditional arrangements for acquiring commercial space goods and services to meet United States Government requirements, including measures such as public-private partnerships, hosting government capabilities on commercial spacecraft, and purchasing scientific or operational data products from commercial satellite operators in support of government missions;

Develop governmental space systems only when it is in the national interest and there is no suitable, cost-effective U.S. commercial or, as appropriate, foreign commercial service or system that is or will be available;

Refrain from conducting United States Government space activities that preclude, discourage, or compete with U.S. commercial space activities, unless required by national security or public safety;

Pursue potential opportunities for transferring routine, operational space functions to the commercial space sector where beneficial and cost-effective, except where the government has legal, security, or safety needs that would preclude commercialization;

Cultivate increased technological innovation and entrepreneurship in the commercial space sector through the use of incentives such as prizes and competitions;

Ensure that United States Government space technology and infrastructure are made available for commercial use on a reimbursable, noninterference, and equitable basis to the maximum practical extent;

Minimize, as much as possible, the regulatory burden for commercial space activities and ensure that the regulatory

environment for licensing space activities is timely and responsive;

Foster fair and open global trade and commerce through the promotion of suitable standards and regulations that have been

developed with input from U.S. industry;

Encourage the purchase and use of U.S. commercial space services and capabilities in international cooperative arrangements; and

Actively promote the export of U.S. commercially developed and available space goods and services, including those developed by small- and medium-sized enterprises, for use in foreign markets, consistent with U.S. technology transfer and nonproliferation objectives.

The guidelines define “commercial” space as referring to goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for

controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers.

The Office of Space Commerce is the lead federal agency for the advancement of commercial space activities. It acts as an industry advocate within government, promoting commercial space opportunities, and coordinating space commerce policy issues within the Department of Commerce (DoC) while maintaining close cooperation with the National Space Council. DC will elevate the Office of Space Commerce to have direct line of reporting to the Secretary, giving it a stronger voice to advocate for the U.S. commercial space industry. Through close coordination with the commercial space sector, we will learn what government actions and policies are needed for the industry to flourish. DoC will promote a robust and responsive U.S. industry that is the world leader in space commerce and will focus on regulatory reform needed for the U.S. commercial space industry to lead human creativity and advancement in space, and remain the preferred destination for commercial space business activity.

NASA's Commercial Crew Program has worked with several American aerospace industry companies to facilitate the development of U.S. human spaceflight systems since 2010. The goal is to have safe, reliable and cost-effective access to and from the International Space Station and foster commercial access to other potential low-Earth orbit destinations. NASA selected Boeing and SpaceX in September 2014 to transport crew to the International Space Station from the United States. These integrated spacecraft, rockets and associated systems can carry up to four astronauts on NASA missions, maintaining a space station crew of seven to maximize time dedicated to scientific research on the orbiting laboratory.

The size of the global space industry, which combines satellite services and ground equipment, government space budgets, and global navigation satellite services (GNSS) equipment, is estimated to be about $335 billion. At $98 billion in revenues, or about 29 percent, satellite television represents the largest segment of activity. Following satellite television are services enabled by global navigation satellite systems (GNSS), which represent about $81 billion in revenues, or 24 percent. Government space budgets represent $77 billion, or 23 percent. Other satellite services (fixed and mobile satellite services, broadband, and remote sensing) generated about $30 billion in revenues, and ground equipment represents $28 billion in revenues. Satellite manufacturing generated nearly $17 billion.

All of this activity would not be possible without orbital launch services. Global launch services is estimated to account for $5.4 billion of the $335 billion total, or only about 2 percent. Most of this launch activity is captive; that is, the majority of payload operators have existing agreements with launch service providers or do not otherwise “shop around” for a launch. About a third of the $5.4 billion represents internationally competed, or commercial, transactions.

In 2016, service providers conducted a total of 85 orbital launches in seven countries. Since 2014, U.S. providers have begun to cut into the existing share of commercial launches occupied by Russian providers. This U.S. gain is the result of a combination of factors. First, the entrance of Space Exploration Technologies (SpaceX), which has been offering its Falcon 9 and Falcon Heavy vehicles to the global market at low prices, is attracting significant business. In addition, launch failures, quality control problems, and supply chain issues have plagued the Russian

space industry, leading some customers to seek alternatives like SpaceX. Meanwhile, Europe's Arianespace remains a steadfast provider, offering reliable services via the Ariane 5 ECA, Soyuz 2, and Vega. Sea Launch, for a time a key player but never a dominant one, has essentially ceased operations. Finally, Japan's Mitsubishi Heavy Industries (MHI) Launch Services and India's Antrix have become more aggressive at marketing their H-IIA/B and PSLV vehicles, respectively.

Since about 2004, the annual number of orbital launches conducted worldwide has steadily increased. This increase has primarily been due to government activity outside the U.S., as U.S. government launches remain relatively steady. For example, retirement of the Space Shuttle in 2011 decreased the number of U.S. launches per year relative to the previous three decades. However, commercial cargo missions to the International Space Station (ISS) have helped to fill the resulting gap, along with anticipated commercial crew missions beginning in 2018.

Perhaps the most notable in terms of government launch activity is China. The number of orbital launches conducted by China has steadily increased each year since 2010, with a peak of 22 launches in 2016. The China Great Wall Industry Corporation (CGWIC) has also been aggressively pursuing international clients via package deals that include satellite manufacturing and launch. These launches are not considered commercial since the launch contract is not internationally competed. In 2015, China introduced two new small-class launch vehicles, the Long March 6 and the Long March 11. In 2016, China successfully launched the Long March 5 and Long March 7, both of which were launched from a new launch site on Hainan Island. Finally, China's human spaceflight program continues in a deliberate fashion, with the 2016 launch of its Tiangong 2 space station. The Chinese National Space Agency (CNSA) is also continuing to develop its robotic investigations of the Moon with plans for venturing further. These signs point to a robust future in Chinese spaceflight, expanding the Chinese slice of the pie.

Testimony of Mike French Vice President, Space Systems Aerospace Industries Association

Before the Subcommittee on Space and Aeronautics
Committee on Science, Space, and Technology
U.S. House of Representatives
July 25, 2019

Chairwoman Horn, Ranking Member Babin, and distinguished members of the Subcommittee, thank you for the opportunity to provide testimony today on the commercial space sector. The Aerospace Industries Association (AIA) represents an aerospace and defense (A&D) industry that is at the heart of the American economy, generating $929 billion in economic output and a trade surplus of nearly $90 billion in 2018 – the largest of any U.S. exporting sector. Our industry is supported by more than 2.5 million dedicated employees – representing 20 percent of the nation's manufacturing workforce – who are responsible for the continuous stream of innovations that improve American lives.

Moreover, our members helped create the foundation of America's space efforts, starting with the Mercury Program. They enabled NASA's exploration of our solar system, put the first humans on the Moon, and supported countless missions since.

We are proud that our innovations have shaped history and have been particularly gratified to recognize these contributions as the world celebrates the 50th anniversary of Apollo 11. But our eyes are also focused firmly on the future.

Earlier this year, AIA released a report called "What's Next for Aerospace and Defense: A Vision for 2050." Based on in-depth interviews with Chief Technology and Chief Strategy Officers across the industry, the report paints a picture of the innovations that will drive the way we move, connect, explore, and defend our interests thirty years from now. And it should not surprise you to know that many of these technologies rely on space and will depend on an effective partnership between government and the commercial space industry.

Our companies, of course, are not waiting for 2050. They are living these partnerships every day. Northrop Grumman Corporation's Antares and Cygnus and Sierra Nevada Corporation's Dream Chaser are partnered with NASA to resupply the International Space Station (ISS).

Virgin Galactic's SpaceShipTwo will soon transport passengers to space, while The Boeing Company's Starliner will soon launch U.S. astronauts to the International Space Station from U.S. soil. They set the stage for taking the next Americans to the Moon and beyond on Boeing's Space Launch System and Lockheed Martin Corporation's Orion spacecraft. These examples are only a glimpse into the role of commercial space companies – from small to midsize to large – in ensuring America's space leadership.

Long-standing Government and Commercial Space Link

The commercial space industry is not a new phenomenon. It is part of a $360 billion space economy that has existed for decades. It supports commercial activities, like satellite communications, and has supported government space activities since the beginning of the space age. Just look to the Apollo 11 landing, a historic moment made possible by the contribution of more than 370,000 contractors from industry and academia. The Space Shuttle, International Space Station, NASA's missions to explore our solar system, and now NASA's commercial cargo and crew programs are all connected to the contributions and leadership of commercial space companies.

In recent years, there has been much discussion about "commercial space," but that discussion has lacked consistency on what constitutes "commercial." The definition of commercial is often inconsistently applied across companies, programs, and contracting mechanisms. While a common perception is that commercial space companies are small start-ups with private financing, government's commercial space partners have, in fact, spanned a range of corporate types – including established, publicly traded companies; recent startups funded by private capital; and private firms supported by both private and public investment.

There is not just one model for a commercial space business. NASA's high-profile commercial cargo and crew programs provide a perfect example, as the primary partners are companies with diverse portfolios that include significant government contracting activity from three publicly traded companies and one private company.

While commercial space has existed for decades, in recent years, several hundred private investment-backed firms have entered the sector. These firms are not monolithic, and how they fit within the existing commercial space economy is important to understanding their role in current and future government space activities.

These newer companies fall into two general categories. The first is a handful of more fully-capitalized companies actively engaged as direct government contractors or suppliers. The second and much larger group of these companies remain in a pre-revenue phase and are still developing their planned space offerings.

This latter group of companies is more likely to be active in "data-buy" programs (e.g., NASA and NOAA's purchase of commercial remote sensing data), the government's early stage funding programs (e.g., the Small Business Innovation Research and the Small Business Technology Transfer), and more recent programs intended to engage with these types of firms, such as NASA's Jet Propulsion Laboratory's space accelerator. In addition to private funding, many of these newer firms have also received significant government investments. A recent

report found that, of the companies that received private capital from 2000 to 2018, they also received $7.2 billion in U.S. public funding during this period. Of firms that received both private and public funding, cumulative total investment from both public and private funding areas was about equal.

Overall, the commercial space industry is one that is diverse, including small and large companies and companies that receive private and public investment, and has been growing. This presents both new opportunities and risks for the government as it continues to look to the commercial sector to meet its requirements.

Shifting Procurements Strategies

The government has a series of tools available to meet these requirements in the space arena. In NASA's case, these tools include:

- Off-the-Shelf / Low-Dollar Items: simplified acquisition methods run by the Government Services Administration, other agencies, or NASA itself;
- Federal Acquisition Regulation (FAR): fixed-price and cost-plus contracts to both buy services and develop new capabilities; and,
- Space Act Agreements: a statutorily provided transaction authority that allows NASA to partner with industry in an either cost reimbursable, no exchange of funds, or funded arrangement.4

In deciding which of these frameworks to use, the government typically considers the requirements it needs from a product or service and what the commercial market currently provides. In the case of a widely available commercial product, like printer paper for example, the government is well served to buy the off-the-shelf product.

Conversely, as the government seeks to build a next generation stealth bomber, meeting its requirements will involve significant new developments that are not commercially available. The government will also desire a significant level of control in both the development and ultimate use of a stealth bomber, given its function and capabilities. In this case, the government would be best served to use a cost-plus FAR framework.

In some cases, the market may have an available product, but the government may also desire a level of control or enhanced capabilities that cannot be met commercially. Satellite communications are a market example of where the government takes multiple approaches. The government procures commercially available satellite bandwidth for its use from satellites operated by companies (essentially, buying an off-the-shelf service). The government also contracts with commercial space companies in a fixed-price or cost-plus model to build specialized communications satellites the government itself will use and control.

In the space context, the government has shifted its procurement strategies in some areas based on an assessment of where the commercial space industry's capabilities and market fall along the printer paper to stealth fighter spectrum. This is most visibly seen in NASA's commercial cargo and crew programs. In these programs, NASA used a "public investment/private service" model, which is when government subsidizes the creation of a commercial service as the primary

customer, while also requiring companies to invest varying levels of private funds into the development of that service.

Under this model, NASA funded the majority of the development of new launch vehicles and spacecraft by purchasing the future "service" of companies transporting NASA cargo and astronauts to the International Space Station. The prime companies in these two programs are The Boeing Company, Northrop Grumman Corporation, Sierra Nevada Corporation, and SpaceX.

This is in contrast to a model where NASA would fund the development of a launch vehicle or spacecraft that NASA *itself* would operate to transport cargo and astronauts. Further, NASA crafted the procurement to require industry to commit some level of internal investment to the effort. This was again based on an assessment of the market and a determination that industry would be willing to make this commitment based on the opportunity to gain commercial business from the ensuing capabilities.

Market Maturity Important to Procurement Choices

NASA recently announced its intent to use this newer "public investment/private service" model for the procurement of a human lunar lander for the Artemis Program. The extension of the public investment/private service model to new areas requires a nuanced understanding of the commercial space market today and a realistic assessment of its direction to ensure overall risks and opportunities are being considered. A partnership in an area with a robust, competitive market will allow different opportunities and risk postures than partnerships in areas that are considered nascent markets.

The existence of a multi-billion-dollar commercial satellite launch market was critical to NASA's procurement decision regarding the commercial cargo and crew programs. Given the existence of this market, NASA weighed the present capabilities of U.S. industry with the status of the market and determined this was an area where the "public investment/private service" model procurement strategy was viable.

At the time, NASA understood this presented a risk. Although the market was established and launch solutions existed, NASA would not be buying an "off-the-shelf" capability. Launch vehicles and spacecraft would still have to be developed by industry to provide the procured services. Further, NASA assessed industry would be willing to put in some level of internal investment, with the rationale that the ensuing launch vehicles could be used by the companies to gain commercial business apart from NASA.

As NASA considers using the "public investment/private service" procurement model more widely, it is important to assess the market in emerging areas and whether they are presently or expected to be revenue generating. From a NASA procurement perspective, using a "public investment/private service" model framework creates a different risk posture if used in areas that lack a current or near future market.

Looking at the global space economy, there is not an active commercial lunar market. The lack of a current market in deep space activity presents three primary risks in using a "public investment/private service" model procurement strategy.

First, given there is no current commercial market in deep space, there are not established commercial services for NASA to buy today. Therefore, the service of landing humans on the Moon will require a great deal of development before it can be provided to NASA. These services today are far from "off the shelf"

Second, requiring commercial companies to invest internal funds in an area with limited market prospects may prevent firms that are otherwise highly capable from competing to provide the service. As the future market is more speculative, the risk of investment and the potential time to see a return increases. Depending on the level of required investment by NASA, this could especially impact medium and smaller companies that are unable to take these risks, even if they have leading capabilities.

Third, purchasing these capabilities as services will require a detailed assessment and clear, predefined determination of government versus industry responsibilities to ensure the overall program is integrated successfully. Determining these responsibilities required significant cooperation between government and industry in the commercial cargo and crew programs, and there is the risk this will be increasingly complex in a deep space program.

From NASA's perspective, these risks will require the agency to make a robust assessment of whether the technical, schedule, and price proposed by industry will close present capability gaps to meet NASA's technical and schedule requirements. Further, NASA will have to consider whether any proposed industry investment is supported by a realistic assessment of future business. Having reviewed the market and considered these factors, there may be areas where NASA determines a different procurement path is necessary.

Finally, no matter the procurement model, NASA will require clear human safety requirements as well as a level of insight, oversight, and transparency into the development of human-rated systems. Currently, it will be NASA astronauts flying on these systems and the government serving as primary funder and customer. To the extent the "public investment/private service" model is extended to lunar activity, NASA is likely to be held responsible for safety at the end of the day. In this regard, Congress can learn from what worked well and where NASA ran into roadblocks during the commercial crew development process.

Congress as a Space Ally

Congress' review of the commercial space landscape and its policy decisions will shape both government action and the commercial space market.

As you consider NASA's next authorization and appropriations bills, Congress should provide direction about the motivation and objectives of our deep space exploration investments and the role of NASA and its commercial partners in these arrangements. In some cases, Congress may find a set of space activities are core national capabilities, similar to assets owned and operated

by the Department of Defense, while in others, it may find industry-ownership and control beneficial.

Of course, Congress' actions are not limited to procurement policy, but have impacts across the space policy domain. An often forgotten and essential component to commercial space growth is the need for reliable, interference free, radio frequency spectrum for everything from launch and re-entry to accurate, timely, and reliable weather forecasting data. Spectrum is space's invisible nervous system, allowing critical data to be transmitted to and from Earth. Without access to this spectrum, our nation's space assets and capabilities cannot communicate. Building a viable commercial space landscape requires a comprehensive approach to our nation's future spectrum policy that ensures adequate and globally-harmonized spectrum for a full range of space uses: commercial, civil, and national security.

These are just a few examples of the many roles – from passing a multi-year NASA reauthorization to investing investment in STEM education and ensuring we have the most talented workforce – where Congress should be an active ally in ensuring a thriving space enterprise.

The commercial space industry has been a partner with government since the earliest days of the U.S. space program and will continue to be while government looks to meet its future space requirements and consider various procurement models. Whatever approaches the government chooses, commercial industry is primed to meet the next set of space challenges, from the continued support of U.S. national security to returning to the Moon and going beyond.