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Space Industry

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ABSTRACT: Maintaining a robust and healthy space industrial base in the United States faces challenges from increased international competition, restrictive government regulations, business practices that inhibit global market expansion and now an austere fiscal environment. America's industrial dominance has eroded and it has lost ground to international competitors, but with entrepreneurial companies such as SpaceX, Scaled Composites, DigitalGlobe, and others. America's innovative spirit continues to push the domestic industry forward, providing the nation a global edge. In light of declining budgets and competing priorities, the government should address certain areas across all sectors of the space domain. These include more flexible and responsive acquisition policies and strategies coupled with stable funding streams; propagation of international standards to encourage interoperability and partnerships; increased international cooperation on policy and operations; and improved competitive opportunities to encourage more innovation.

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INTRODUCTION

"Space is a domain that no nation owns but on which all rely".[1] Whether for national security, civil or commercial purposes, space technology permeates all aspects of modern daily lives throughout the globe, and imagining a day without it is unfathomable. This reality has spurred governments to proactively and deliberately preserve the space environment, while ensuring freedom of exploration and maneuver.[2] The United States is no different in this regard. Maintaining a robust, healthy space industrial base is a critical priority for the nation and a key enabler to retaining American space superiority. Unfortunately, since the onset of the 21st century, the base has eroded due to increased international competition, restrictive governmental regulations and business practices that inhibit global market expansion. Now a constrictive, austere fiscal environment threatens to spur further contraction in the domestic space market. For the United States to remain a globally dominant and competitive leader in an increasingly congested and contested space environment, the nation needs to ensure its military capabilities, industrial capacities, and governmental policies aim towards that goal.

To understand and explore the various elements of space and the needed policy recommendations to strengthen its supporting industry, the 2012 Industrial College of the Armed Forces (ICAF) Space Industry Studies Program, comprised of 14 military and civilian government officials, conducted an intense, five month examination of the space industrial base across national security, civil, and commercial sectors. Along with ICAF faculty, participants met with a variety of domestic and international government and industry experts from each sector. The class visited several government organizations and industrial firms, covering most markets within the space industry including space capabilities and assets, launch, and space services.

This study provides insight from government professionals on: 1) the nature and condition of the current space industry environment with an emphasis on the domestic market; 2) the challenges facing the industry; and 3) the future outlook. Finally, the class offers an overview of government policy and program recommendations critical to the future sustainment and growth of the nation's space programs. In support of these recommendations, four detailed essays follow the review to provide amplifying information and insight into the major issues facing the space industrial base.

THE INDUSTRY DEFINED

The space industry encompasses three different segments: space capabilities, launch, and services. Each segment provides products to national security, civil, and commercial customers. National security customers use space for many purposes including intelligence, surveillance, reconnaissance, global navigation, and secure communications. Civil customers use space for space exploration and research endeavors. Commercial customers use space to offer telecommunications, entertainment, imaging, space tourism, and other products and services to the wider population.

The space capabilities segment includes the space assets and the associated ground systems and infrastructure required to derive data from space assets. This segment comprises development and production of satellite buses, satellite payloads, and other payloads which may include human-habitable spacecraft, space station components, or exploratory vehicles such as NASA's Mars rovers. This segment consists of a relatively small number of suppliers who integrate satellite buses and payloads, and a larger number of suppliers who provide smaller components, subsystems or payloads. In the space capabilities segment, one finds both highly innovative, one-of-a-kind space assets and less complex payloads that are produced in higher quantities. This segment also includes the ground services and infrastructure required to monitor and control spacecraft as well as the distribution of space-derived data to users on the ground. Generally, the supplier that develops and produces the satellite bus or the payload develops the ground segment and associated infrastructure.

The launch segment includes the development and production of launch vehicles to take the spacecraft into the desired orbit as well as the infrastructure and facilities to support launches. This segment can further be broken down by heavy, medium and light lift capabilities. The number of companies who launch large or "heavy" spacecraft is limited, and a larger number of suppliers concentrate exclusively on the "medium" or "light" lift market. This segment also includes propulsion which is represented by relatively few suppliers.

The services segment includes products that rely heavily on space assets including companies that sell digital imaging products, offer telecommunications services, and satellite television and radio. This segment also includes the many GPS-enabled applications and the emerging commercial space transportation companies which plan to carry space tourists. While the services segment primarily serves commercial customers, civil and national security customers increasingly demand commercially-provided services. For example, the U.S. government now obtains global imagery from commercial companies rather than relying exclusively on government systems.

The space industry is global. National, regional and local governments from both the U.S. and foreign countries are customers of space products, as are commercial firms from around the world. Similarly, suppliers originate from dozens of countries and increasingly suppliers representing multiple countries participate in major space programs and projects. Although the space industry is global, this study focuses primarily on the U.S. market.

CURRENT CONDITIONS

According to The Space Report 2012, the global space industry grew by 12.2% in 2011, the sixth straight year of expansion, to become a $289.77 billion market. Over the last five years, it has grown 41%. Commercial space products and services such as telecommunications and positioning services represented 38% of the market, totaling $110.53 billion in 2011, a 9% increase from 2010. The commercial infrastructure and support industries including spacecraft manufacturing, ground equipment, and launch services, represented 37% of the market totaling $106.46 billion in 2011, a 22% increase from 2010.[3] In contrast, space industry employment dropped by 7,500 jobs from 2009 to 2010 to a total of 252,000 marking the fourth straight year of reductions in the space workforce.[4] The ending of the Space Shuttle program caused some of these losses, but numerous industry representatives also reported downsizing in order to streamline processes and gain efficiencies.

National Security Space

National security space (NSS) includes global communications, imaging, intelligence, surveillance, reconnaissance, environmental monitoring, missile warning and defense, positioning, navigation and timing, and dedicated space launch. Increasingly, U.S. national security depends on space. U.S.-led space related technologies and industries are imperative to the U.S. role as a superpower. The Space Shuttle program completed 30 years of service on July 11, 2011 with the final landing of Atlantis at Kennedy Space Center in Florida. This left the U.S. with a sole-source launch provider United Launch Alliance (ULA), a consortium formed in 2006 with government permission by Boeing and Lockheed Martin. In October 2011, Space Explorations Technologies Corporation (SpaceX) agreed to complete Evolved Expendable Launch Vehicle (EELV) launch certification. If SpaceX can successfully compete for Air Force, National Reconnaissance Office (NRO), and NASA launch contracts, ULA will lose its monopoly in NSS space launch.

Civil Space

The current National Space Policy of the United States of America replaced the previous goal of returning to the Moon with the goals of sending humans to an asteroid past the Moon by 2025 and sending humans to orbit Mars and returning them to Earth by the middle of the following decade.[5] However, while aspiring to these lofty goals, the U.S. faces an extremely difficult fiscal reality. With the ending of the Space Shuttle Program, the U.S. cannot presently conduct manned space flight and relies instead on the Russian Space Agency to transport astronauts to the International Space Station (ISS) at a cost of approximately $63 million per seat.[6] NASA provided Orbital Sciences Corporation and SpaceX opportunities to develop commercial space transportation capabilities under the Commercial Orbital Transportation Services (COTS) program and later awarded two Commercial Resupply Mission (CRS) contracts to these companies in support of the International Space Station.[7] While several commercial firms continue to develop spacecraft to carry people as space tourists, only SpaceX, currently seeks a “manned” rating, for their Dragon capsule, to compete with the Russians in manned transportation to space.

The German Aerospace Center (DLR) and Centre National d’Études Spatiales (CNES) maintain strong relationships with NASA but also actively reaches out to other non-European space organizations. DLR maintains a strong relationship with Russia, Brazil and India, while CNES cooperates with China in the research of certain space related technologies. This underscores how international cooperation between nations continues to be robust and will likely grow with or without U.S. participation.

Although partnering with international space capabilities providers is highly desirable, the U.S. government often acts counter to this philosophy. The most recent example of this is NASA's decision to withdraw from the European Space Agency's (ESA) ExoMars program. U.S. budgetary processes work on a shorter time scale than those of ESA and termination of the U.S. involvement in this joint venture requires ESA to seek additional partnerships to complete the project. Despite U.S. withdrawal from the ExoMars program, cooperation between NASA and ESA remains strong.

Commercial Space

Unlike national security and civil space, the commercial space market is highly competitive. Industry analysis of a representative group of firms identified the range of the return on investment to be between 9 to 15%. Satellite companies produce a diverse range of products making the market highly competitive with a range of launch solutions. Exceedingly high barriers to entry, particularly with regard to production and testing facilities, and substantial regulatory requirements discourage new firms from entering the market. Broadcasting and telecommunications continue to lead the commercial space market as the global demand for bandwidth and coverage increases. Satellite companies produce a diverse range of products making the market highly competitive with a range of launch solutions. ULA, SpaceX, Orbital, and Alliant Techsystems Inc. (ATK) provide rapidly evolving commercial space lift capabilities. These companies represent great diversity, ranging from a multi-billion dollar company (ULA) to smaller companies (Orbital) providing only small and medium space lift.[8] ATK and SpaceX on the other hand are pursuing human space flight business in addition to satellite launch.[9] A closer examination of these companies shows how differing business strategies drive launch providers into specific market segments. European commercial space companies, in particular Astrium, a subsidiary of the European Aerospace and Defence Company (EADS), apply similar strategies regarding satellite production and launch capabilities as their American counterparts.

The International Traffic in Arms Regulations (ITAR) continues to be a topic of intense discussion and overwhelmingly there is wide support for a revision of the regulatory requirements. However, the majority of firms identified they have developed internal procedures and processes allowing them to comply with the ITAR requirements without substantial loss of global market share.

In addition to the larger companies that supply the majority of space capabilities to the national, civil and commercial space markets, “boutique” companies provide specialized and valuable contributions to American space advances. Three such companies visited during the 2012 Space Industry Studies are Masten Space Systems, XCOR Aerospace, and Scaled Composites Incorporated.

Masten Space Systems, based in Mojave, California is an aerospace company with a total of 15 employees and has developed fully reusable vertical takeoff, vertical landing (VTVL) launch vehicles, technology and concept demonstration, technology acceleration, and engineering services.[10] In October 2009, Masten took first place and the $1 million dollar prize in the Northrop Grumman Lunar Lander Challenge. Their rocket Xoie (pronounced Zoey) successfully launched, flew for 180 seconds, and landed (with extreme accuracy) on a simulated lunar surface. Masten provides opportunities on Xoie for other scientists and principle investigators for experimentation and testing, while their engineers continue to innovate and advance their rocket technologies to prepare for future competitions.

XCOR Aerospace, also located in Mojave, is a slightly larger boutique company that focuses on the research, development, project management and production of safe, reliable, reusable launch vehicles (RLVs), rocket engines and rocket propulsion systems.[11] This small (presently 20 employees) firm is currently building the Lynx RLV for commercial space tourism. With over a decade of experience and experimentation behind them, engineers at XCOR have amassed thousands of hours on their rockets proving reliability and sustainability for reusable motors. They initially plan to build and sell, or in the case of foreign governments, lease their Lynx system to space tourism companies who will operate them.

Scaled Composites employs nearly 300 people and has emerged as a leader in "air vehicle design, tooling and manufacturing, specialty composite structure design, analysis and fabrication, and developmental flight tests of air and space vehicles.”[12] The Industry Study considers Scaled Composites a boutique company based on its relative size within the market, not what it provides to the space industry or its contributions to U.S. advancements in space. The company primarily focuses on experimental aircraft; its forte is "one off" designs. Scaled Composites entered the space business with its partnership with Virgin Galactic; designing and building a prototype air launched sub-orbital spacecraft, which Virgin will eventually manufacture and operate. Scaled Composites' most aggressive project is to create a new space launch system for Stratolaunch Systems. This will involve designing and building the largest aircraft in the world to carry SpaceX's Falcon 9 medium lift launch vehicle aloft in a flight profile similar to Orbital's Pegasus launch system. With a wingspan of 380 feet (more than 120 feet wider than the Airbus A380), six 747 engines, and a composite airframe, this new launch system requires an unheard of level of technological sophistication for a relatively new company the size of Scaled Composites. However, this kind of ambition and innovation is consistent with their past performance.[13] As Scaled Composites continues to gain experience in developing space technology, it is unclear whether they will remain a boutique innovator, or its parent company, Northrop Grumman, will further increase its participation. Scaled Composites' business plan resembles that of XCOR.

These three companies represent only a sample of the smaller businesses that contribute to our national space capabilities. Their "grass roots" innovation and experimentation will lay the foundation for America's future space endeavors. These small boutique companies distinguish the American space sector from that of Europe which is dominated by larger companies many of which are partially owned by the government. The processes these companies demonstrate may be more beneficial to the space industry than the products themselves. Young engineers, interns, and technicians at these companies receive hands on experience designing, building, and testing new technologies. Their successes and failures continue to advance our collective knowledge base in the areas of propulsion, composites, and navigation.

CHALLENGES

Currently, the U.S. faces decreasing budgets and an era of austerity following ten years of war in Afghanistan and Iraq. The budget decreases affect not only the government but also the commercial and private sectors that provide the personnel expertise and material required to maintain and grow a national space program. From the government side, decreasing budgets force government leaders to prioritize and make tough decisions about which programs to continue or cut. Furthermore, as government budgets decrease, less funding reaches commercial companies forcing some companies out of business and reducing much needed competition. Finally, yearly budget cycles, as opposed to multi-year budgets, prevent the government from realizing savings inherent in economy of scale.

The space industry also faces the challenge of an aging space workforce. At several of the sites the class visited, industry experts remarked the average age of their employees was between 45-48 years old. To remain a global power, the U.S. needs to address the aging demographic of the defense industrial base. Congressional action reducing the number of temporary worker visas (H-1B) limited opportunities for foreign students, including those earning valuable engineering and science degrees to obtain legal permanent residence in the U.S. This resulted in a significant loss of potential engineering talent as more than half of engineering graduates come from overseas.[14]

National security and the space industrial base are also hindered by acquisition challenges. Many NSS programs incorporate state-of-the-art technologies and so require extensive development and testing resulting in long and costly acquisition processes. The incorporation of state-of-the-art technologies also increases program risk and drives the use of cost-reimbursable contract types which can further increase costs to the government. Extensive development timelines mean that spacecraft completion schedules are uncertain so the launch schedules cannot be well coordinated. This can cause further cost and schedule delays to a program. Due to the budgeting process, the government cannot commit to a long-term program. This introduces demand uncertainty which threatens the stability of the space industrial base and leads to economy of scale issues which contribute to higher costs for the government. Since costs to develop an NSS program are so high, and the acquisition process is so long, the consequences of a launch failure can be devastating. As such, launch is extremely costly as rigorous testing and mission assurance activities are required.

In addition to budget, acquisition, and workforce issues, the U.S. space industry faces many challenges in the competitive environment. First, the electromagnetic spectrum is increasingly congested leading to the possibility of interference, as illustrated by the conflict between Light Squared's proposed Fourth Generation wireless network and GPS.[15] Second, current ITAR restrictions hinder U.S. companies from being competitive internationally, especially smaller companies. On April 18, 2012, a joint report from the Departments of Defense and State recommended the easing of export restrictions on commercial satellites and related components. These changes should help commercial companies become more competitive internationally, but require Congressional legislation to enact.[16] Another challenge is the ambiguity of international space law, which states that nuclear weapons or weapons of mass destruction may not be used in space. The ambiguity lies in that it does not explicitly prohibit all weapons in space and could lead to an arms race in space.[17] Further challenges of particular interest to the industry study are discussed in detail below.

National Security Satellite Architecture

As technology continues to advance, the exquisite satellites built and launched are increasingly expensive and heavy. As the cost of launch becomes prohibitively expensive, the U.S. needs to explore more resilient satellite architecture through greater variety of satellites to include expanded use of hosted payloads and smaller, less individually-capable satellites. These options provide the opportunity to reduce launch costs and increase the frequency of launch. One of the challenges to this architecture is convincing national security customers of the benefits of hosted payloads and the value of smaller but more distributed capabilities. Another challenge, especially with regard to hosted payloads, is developing an acquisition strategy and a process for matching the hosted payloads with a host satellite.

Space Debris

An increasing amount of orbital debris threatens the access to space of all nations. Approximately 500,000 pieces of space debris ranging in size from large spacecraft parts to objects with a diameter of half an inch lie in Low-Earth Orbit (LEO).[18] The Department of Defense's (DoD) Space Surveillance Network tracks about 22,000 objects, four inches in diameter or larger.[19] A collision with even a small piece of debris can cause severe or catastrophic damage to a spacecraft.

The DoD routinely conducts collision avoidance analysis and provides situational awareness warnings to U.S. government agencies. Due to sensitivities regarding technical capabilities of some satellites (e.g. intelligence, surveillance, and reconnaissance missions), the DoD does not share all of this information with commercial satellite companies. Furthermore, very few countries have the capability to track orbital debris, and no centralized international body tracks and mitigates potential hazards.

ESA, DLR and CNES maintain a very strong positive relationship and dependence on information coming from the DoD Space Surveillance Network. In addition, ESA has recently established an office of space debris with the goal of forming a European consortium to address this problem. Due to the national security issues associated with sensitive satellites the various Ministries of Defense would represent their respective nations in forming this group. This effort, however, is in its infant stage.

Commercial Imagery

The U.S. has a long history of developing remote sensing satellites, beginning with the Corona program in 1960. While Corona satellites employed film based photography requiring the film to be de-orbited, [20] today's imaging satellites utilize electro-optical imaging and transmit the data digitally. Two U.S. commercial companies provide the lion's share of digital imagery, DigitalGlobe and GeoEye. The U.S. government funds both companies to develop commercial satellite imagery systems and provide imagery. In addition, both companies operate the satellites and provide commercial imagery to foreign governments and international organizations.

With defense budgets declining, both DigitalGlobe and GeoEye face possible cuts to their contracts with National Geospatial Intelligence Agency (NGA) in 2013. Although the funding for FY12 has been authorized, the two companies stand to lose as much as $290M (54% of the total contract) in FY13.[21] One or both companies may not survive, thus eliminating competition in the domestic commercial imagery market.[22] In an effort to pre-empt bankruptcy, GeoEye made an unsolicited bid for DigitalGlobe in February 2012. This was quickly followed by a counter take-over of GeoEye by DigitalGlobe and then a repeat offer by GeoEye in May 2012.[23] The stalemate will likely continue until NGA announces its FY13 budget plans at the end of the year.

Launch

The U.S. leads in overall competitiveness in the space industry; however, its competitive advantage continues to decrease as developing nations begin building their own space programs.[24] In 2011, 84 rocket launches reached orbit. Of those, Russia launched 31, China launched 19, and the U.S. launched 18.[25] The year 2011 marked the final mission of the Space Shuttle. Several commercial companies continue to develop launch vehicles with the goal of becoming human rated; however, they must go through a stringent certification process.

One of these companies, United Launch Alliance (ULA), has a monopoly on U.S. national security space launch through the EELV program. Without competition, the price of these launches is projected to rise. In addition, all U.S. launch companies currently rely on substantial government contracts to remain in business. Finally, the requirement for such a high level of mission assurance and testing has greatly increased costs, but remains a top priority of the U.S. government.

INDUSTRY OUTLOOK

Despite the challenges that the space industry faces, the outlook for this sector of the industrial base is largely positive. Government spending on space is no longer the sole metric for the health of this industry. This is particularly true in the U.S. and Europe where economies have slowed and government space priorities must compete with other national priorities. Space programs face increasing uncertainty as policymakers choose between competing programs. This will likely place more emphasis on effective international partnerships, stimulate innovative approaches in government-industry relations and impact industry plans and profits as budgets constrict.[26]

Government use of commercial space capabilities and increased use of hosted payloads have emerged in response to declining budgets. The U.S. Air Force's Space and Missile Systems Center (SMC) has issued contracts for studies to determine the feasibility of using commercial satellites for its secure communications requirements. SMC has also formed a Hosted Payload Office (HPO) similar to that of the Hosted Payload Alliance formed by seven U.S. satellite companies.[27] Several of the companies visited discussed the benefits of standardizing configuration of bus/payload systems for greater interoperability to facilitate launch from a variety of providers. Private sector organizations will also likely increase their use of hosted payloads. For example, Johns Hopkins Applied Research Lab has applied for a NASA grant to place a network of scientific instruments on the commercial constellation of Iridium satellites.[28]

Commercial applications for space are increasing. Space-based technology creates a dependency in our daily lives on tools such as cell phones, GPS, digital TV, and credit card transactions. As such, a vibrant commercial satellite industry has evolved to meet this demand. Companies such as Boeing, Orbital Sciences Corporation, Hughes, Sirius XM, and others have stepped in to take advantage of these emerging markets.

However, these companies are limited by their ability to get their products into space and have turned to the international market for launch. The largest single cost for getting capabilities to space is the cost of launch. Although ULA dominates the medium and heavy lift market for NSS launches, the high cost of these launch vehicles leaves fertile ground for entrepreneurial firms like SpaceX to enter these markets with innovative rocket designs creating the potential for more affordable space launch vehicles. SpaceX's projection for cheaper launch enables them to compete for contracts with the U.S. government. USAF launch facilities at Vandenberg and Cape Canaveral are currently being or have been converted to accommodate commercial launch; however, until SpaceX establishes a longer record of successful launches, commercial manufacturers will continue to use international launch providers such as Arianespace, Sea Launch, or Russian providers Starsem and International Launch Services which provide commercial launch at a significantly lower cost than can be found in the U.S.

RECOMMENDATIONS

Government roles and responsibilities with regard to space include developing a balanced set of oversight strategies and policies for space programs and acquisition of space products and services. These should support the space industrial base and remove barriers to achieve a more resilient and affordable space program.

Based on discussion with key government and industry participants, the Space Industry Study of 2012 proposes the following recommendations. Detailed essays on satellite architecture, space debris, commercial imagery, and launch capabilities are provided to further explain the reasoning for the recommendations.

Space Acquisition Policy and Strategy:

- Rely on proven commercial practices when possible and reduce testing requirements to lower program costs and enable the use of firm-fixed price contracts.
- Identify candidate payloads that are suitable for hosted payloads.
- Nurture, by way of prizes and set-aside contract awards, small boutique firms that develop innovative technologies and grow seasoned technicians and engineers.

Launch:

- Continue to provide competitive opportunities to new entrants in the launch industry to compete for contracts once they achieve certification.
- Continue to set aside a small number of launches for new entrants under full and open competition if certified capabilities develop.
- Consider using international launch providers when U.S. launch companies cannot provide timely launch capabilities for crucial assets.
- Study the feasibility of recovery and reutilization of EELV first stage components.

Workforce Renewal:

- Enable foreign students studying science and technology to apply for residency upon graduation.

National Security Satellite Architecture:

- Establish a more resilient satellite architecture in Low Earth Orbit through greater use of hosted payloads and smaller, distributed capability satellites.
- Partner with industry to create standard interfaces between buses and payloads, enabling more "plug and play" integration for satellite telecommunications, software, and hardware components.

Frequency Spectrum:

- Conduct a review of FCC regulating procedures to ensure regulatory stability for the U.S. space industry.
- Promote interference solutions and industry standards for more robust GPS receivers.

Commercial Imagery:

- Support the sustainment of at least two satellite imagery companies in the U.S. by continuing the EnhancedView, or a similar contract.

- Pursue multi-year service agreements with commercial firms to provide a stable revenue stream.
- Expand international sharing of commercial imagery and imagery analysis.
- Encourage the adoption of international restrictions on imagery distribution by leading a coalition to develop worldwide standards for sales.
- Consider allowing U.S. commercial imagery companies to sell higher resolution imagery to customers to maintain competitive advantage.

International Space Policy:

- Issue "blanket" ITAR licenses for appropriate programs.[29]
- Restructure the ITAR process as a "two-dimensional structure that would consider both the sensitivity of the technology and the level of trust in the partner nation." [30]
- Incentivize industry to develop standard interfaces between the systems of major space faring nations. [31]
- Encourage the United Nations to establish an International Orbital Conjunction Analysis Space Center (IOCASC) to provide timely and usable information to mitigate the risk of space collisions and provide a common space picture.
- Seek advisory/observer status within the new ESA-sponsored European consortium on space debris.

CONCLUSION

Space remains the domain of an exclusive club of technologically savvy and resource rich nations who use it to advance their national security and economic interests. The world historically looked to the United States for guidance and direction on the uses of space and exploration. Its imagination, innovation, and wealth gave the U.S. military, industrial, and political advantages and wrought forth technologies that undergird modern life; however, America's industrial dominance has eroded and it has lost ground to international competitors. The number of nations engaged in space operations has increased dramatically increasing commercialization and competition across the international industry, challenging America's space preeminence.

Having conducted a five-month, comprehensive assessment on the state of America's space industrial base, the 2012 Space Industry Studies Program concludes the industry remains healthy despite increasing international competition. With SpaceX, Scaled Composites, DigitalGlobe, and other entrepreneurial companies, America's innovative spirit continues to push the domestic industry forward, providing the nation a global edge. Nevertheless, in light of declining budgets and competing priorities, the government should address certain areas across all sectors of the space domain. These include more flexible and responsive acquisition policies and strategies coupled with stable funding streams; propagation of international standards to encourage interoperability and partnerships; increased international cooperation on policy and operations; and improved competitive opportunities to encourage more innovation. Government focus in these areas will ensure the industry continues to grow through business and technology innovations, yielding long-term national security, economic, and scientific benefits for the nation and ensuring America's space superiority.

ESSAYS ON MAJOR ISSUES

ESSAY 1: Building Strategic and Industrial Resilience in Low Earth Orbit

For over half a century, the United States has held uncontested dominance in space. Now, the worst global financial crisis since the Great Depression, the cost of two lengthy counterinsurgency operations in Iraq and Afghanistan, and the rise of China as a potential peer competitor in orbit threaten American preeminence. Low Earth Orbit (LEO) has become a global commons. The world relies upon LEO spacecraft for a variety of services including global telecommunications, remote sensing for national security and weather prediction. While the United States struggles against economic and military retrenchment, the 2010 National Security Space Policy clearly states that space today is more congested, contested, and competitive than ever before.[32]

Yet, the U.S. can remain the most important nation in space. As the protector of many global commons for over sixty-five years, the leading technological innovator in spacecraft, and allied with most of the leading space-using nations of the world, the U.S. can exercise its leadership to create a satellite architecture for LEO that builds strategic resiliency in space, strengthens our international alliances, and improves the strength of our space defense industrial base for a reasonable cost. Exquisite national reconnaissance spacecraft, hosted payloads, and inexpensive, smaller satellites offer the opportunity to provide greater order and resiliency to the global commons of LEO under the aegis of the United States. This architecture would tie together a variety of satellite types into a more coherent, resilient, and affordable system.

Hosted payloads offer the most immediate opportunity to make the U.S. LEO architecture more resilient. The U.S. can build more national security space payloads into planned commercial and civil satellites built by allied states and their satellite operators. Examples include national security remote sensing payloads and communications payloads riding aboard commercial satellites. This process requires considerable coordination with the commercial vendors, but provides a significantly faster ride to orbit, as commercial satellites are built on a two to three year timeline rather than taking a decade or more as do many conventional national security satellites. The payloads themselves are smaller than more exquisite purpose-built national security satellites and, while less capable individually, still capable as a network and far less expensive.

Recent examples of hosted payloads aboard commercial satellites include the Commercially Hosted Infra-Red Payload (CHIRP) program for the USAF and the Wide Area Augmentation System (WAAS) for the Federal Aviation Administration.[33] Australia has bought hosted payloads as well.[34] In an era of smaller budgets and greater congestion, expanded distribution of assets across allied satellites provides greater resiliency at a lesser cost. The U.S. should make greater use of hosted payloads and establish commercial and international agreements to make this process more routine.

This proposed LEO architecture would meet the concerns articulated in the national security space strategy and benefit the U.S. strategically. The architecture would also benefit the national space industrial base economically. It addresses the challenges articulated in the National Security Space Strategy. Hosted payloads would help address the “contested” element of space’s global commons by distributing U.S. space capabilities across a greater number of satellites. Small national security satellites also offer greater responsiveness through shorter construction cycles and greater flexibility for launch opportunities. Hosted payloads would also help address the “competitive” challenge by providing government contracts to a greater number of satellite industry firms.

The U.S. would benefit strategically from greater satellite variety in multiple ways. By placing hosted payload-based national security capabilities on satellites owned by allied nations, the architecture would create targeting problems for an opponent by potentially widening any conflict in orbit. Also, the satellite architecture would be both less expensive and more responsive due to the smaller size of many satellites. Greater affordability also leads to greater redundancy and resilience as more of the capability is purchased. The network’s increased size and dispersion would create difficulties for an adversary seeking to degrade our capability in LEO.

This proposed satellite architecture would also have significant economic benefits for the space defense industrial base. With hosted payloads, our national security launch requirements would be smaller, but more frequent due to their more limited capabilities, shorter construction time, and lesser cost. The more varied components would provide increased revenue for a greater number of commercial satellite providers, including those building satellites and payloads and those hosting payloads. This would provide a significant boost to launch providers, while also reducing the cost of launch itself. Even with these benefits however, there remain challenges that must be addressed to build this proposed architecture.

For the U.S. to build a managed LEO architecture consisting of large national security satellites, an expanded network of hosted payloads, and more numerous smaller satellites, it must overcome a number of challenges. Large, exquisite satellites are hugely expensive and take a long time to develop. They also have unrivalled capabilities and thus remain necessary in small numbers. Expanding the use of hosted payloads faces the challenge of convincing our national security space organizations that the network would add value while drawing funding for less individually capable observation and communications platforms. Operationally responsive smaller satellites face challenges similar to those of hosted payloads.

The U.S. government has made notable advances across the range of these satellites. The several hosted payload systems either operational or soon to be have proven the validity of the capability for national security space. The contracting and funding processes greatly impedes the development of a standardized process for using hosted payloads. As a speaker from the U.S. Navy recently commented at the International Satellite Conference in Washington: “Hopefully... the Navy will think about different ways to fund and different ways to contract," he said. "That's the biggest challenge.”[35]

The commercial satellite industry continues to strive to expand the use of hosted payloads in LEO. Companies including Intelsat have established hosted payload offices. A number of large satellite providers (including Boeing, Loral, and SES, among numerous others) have joined together to form the Hosted Payload Alliance.[36] This industry group has established a working relationship with the Air Force Space and Missile Command's Hosted Payload Office. Government and industry clearly desire to expand this piece of the LEO architecture, but there equally clearly needs to be an established contracting and funding process to streamline the use of hosted payloads.

This satellite architecture is within our reach. With moderate regulatory action, some dynamic diplomacy, and the willingness to use smaller satellites more frequently, the U.S. can fulfil the guidance issued in the National Security Space Policy published in 2010. Even though LEO is now congested, contested, and competitive, the U.S. can remain the leading nation in space and can maintain its superiority through wiser use of exquisite satellites.

Author: LtCol Scott Lacy, USMC

ESSAY 2: Pursuing an International Solution for Addressing Space Debris Challenges

Space has increasingly become more congested with both active spacecraft and debris from many generations of orbiting spacecraft. An epidemic of space junk threatens utilization of space on a global scale. Half a million objects ranging in size from large spacecraft parts down to half an inch diameter orbit the Earth.[37] The Department of Defense Space Surveillance Network currently tracks about 21,000 objects larger than 4 inches in diameter.[38] These dangerous objects can travel at speeds up to 17,500 mph and can render significant damage to an orbiting satellite or manned spacecraft.[39] Orbital debris continually collides creating even more debris further raising the risk to active spacecraft. The global space community should address this growing problem and decide how to best mitigate the negative effects of space debris.

A review of the space policies of several nations suggests concerns and shows a great desire to minimize space debris. The U.S. Space Policy specifically identifies the necessary collaboration required to address this issue:

The Secretary of Defense, in consultation with the Director of National Intelligence, the Administrator of NASA, and other departments and agencies, may collaborate with industry and foreign nations to: maintain and improve space object databases; pursue common international data standards and data integrity measures; and provide services and disseminate orbital tracking information to commercial and international entities, including predictions of space object conjunction.[40]

With the release of the European Space Policy, the European Commission assumed a leading role in the areas of debris collision mitigation. In February, the European Space Council identified space debris mitigation as a priority, "In the field of security, the Resolution underlined the need for Europe to equip itself with a capability to monitor and survey its space infrastructure and space debris, with the European Union - in conjunction with the European Space Agency (ESA) and member states - taking an active role in order to define the governance of this capability."[41] The Council advocated the creation of an international organization to draw a single picture of space debris and issue real time information to space faring nations to enhance debris collision mitigation.

The U.S. should take a leading role in encouraging the United Nations to create such an international organization to provide space debris avoidance information and policies. Such an organization might be called the International Orbital Conjunction Analysis Space Center (IOCASC). IOCASC would demonstrate an international commitment to standardize and share data, to provide Space Situational Awareness (SSA) to reduce potential risk to spacecraft.

To provide enhanced data, a commitment to share data is paramount to the overall success of an IOCASC. Currently only the U.S. and Russia integrate data on space debris and SSA. The ESA has similar systems, but there is no link to share information. Interestingly, the U.S. and Russia have a Joint Data Exchange Center (JDEC) used for early missile warning and could be used as a model of cooperation. The JDEC evaluates data promptly and disseminates analysis to both countries. This could be done on a larger scale that resides in the IOCASC. All cooperative countries provide analysis that bring to the forefront their countries SSA capabilities and merge with partner nations to provide integrated information. In the case where a country refuses to provide high fidelity location data on classified spacecraft, then it should provide low fidelity data. Nations that do not provide precise data on their spacecraft must be vigilant in self-analysis of potential collisions and take evasive measures. To this end, all nations must provide information on all space craft in orbit, regardless of classification mission.

Data production and delivery must be structured to internationally recognized standards. The integration of data across multiple nations, systems, metrics, and languages could be problematic. There are currently large amounts of data from various SSA systems and the challenge would be to merge and translate data into one common space picture. It is obvious that investments need to be made in hardware and software to address the multiple formats of data. An upfront investment in a robust data processing system could substantially reduce centrally located analysis in the IOCASC. Many countries already have collision avoidance (COLA) and SSA data in their operations centers and will only have to push data to the IOCASC for processing and distribution.

A compatible end-to-end information technology architecture and viable distribution process are fundamentally linked and would serve as the backbone of the IOCASC. The IOCASC will be responsible for prevention and resolution of systems disruptions, governance, and maintaining user confidence. Due to the nature and expediency of data, the IOCACS must maintain the ability to provide warning detection of anomalies, which is vital to mission success. This will provide minimal system distributions, failures, and quicker problem resolution. Providing the proper governance will ensure the proper protocols are in place at both spectrums to account and verify compliance to prevent cyber attacks, viruses, and network disruptions. Designing and maintaining a well managed network will garner increased trust from the international space community. Providing all of these important elements will sustain an efficient and user-friendly IT structure.

Providing the services of the IOCASC as an international organization will bring much angst to some space faring nations. For some, the mere cost may not equate to a valid return on investment and such an organization may entail levels of bureaucracy that will prove to be fatal to its existence. Others may fear insurmountable restrictions, loss of sovereignty, or possible corruption amongst larger nations. Unfortunately, the legal and treaty aspects of such an organization would be problematic and could not be fully captured in this context. All of these concerns are valid and should be considered. It should be the desire of the international community to establish the size of this organization as to ensure goals and missions are achieved. The IOCASC should be only chartered to integrate, process, analyze, and distribute data, not be a governing committee.

Establishing policy to leverage current SSA and COLA technologies on the international level has many challenges, to include a consensus among all nations. The U.S., Russia, and the EU have taken proactive measures to protect space assets and assist other nations in limited debris avoidance. The international reliance on larger space faring nations should be addressed in a cohesive policy that delineates responsibilities to the broad space community. Building partnerships and sharing data across the full international spectrum not only reduces threats to spacecraft, but also provides depth and redundancy driven by policy goals.

Author: CAPT Keith Hoskins, USN

ESSAY 3: Addressing the Long-Term Impact of Military Support of Commercial Satellite Imagery

Satellite imagery provides immeasurable benefits. Since the U.S. government first captured space images in 1959[42], the technology has improved and proliferated to almost every government agency, private company and household in America. The government has pledged to foster commercial space capabilities to the maximum extent practicable raising several provocative and critical questions. To what degree can the military use less-expensive commercial imagery? How does increased dependence on commercial imagery by the military impact national security in the long-term?

The DoD originally developed satellite imagery to assess the military capabilities of the Soviet Bloc.[43] More recently satellite imagery has enabled observation of Iranian military movements, Chinese submarine bases, and Syrian riots as well as target identification and damage verification in Afghanistan. Which of these capabilities can be commercialized and which must, or can, be protected?

Capabilities

Space imagery systems accomplish ever better results by increasing the resolution of the image, defined as "the minimum separation between two similar objects needed for an imaging system to distinguish the objects as two rather than one."[44] The industry standard worldwide presently stands between one and 20 meters. France has capability to 0.7 meters while the GeoEye-1 satellite can reportedly image to an accuracy of 0.41 meters and the upcoming GeoEye-2 will achieve a resolution of 0.33 meters. International firms are projected to reach competitive resolutions in just a few years.

What accuracy critically impacts national security? With a ten meter resolution image, an enemy can potentially identify bridges or the deployment of military hardware. With a two meter resolution, an enemy can identify individual aircraft and roads, and, with a one meter resolution, the enemy can precisely locate individual troops.

The military benefits from supplementing its own imagery with commercial imagery. Military satellites cannot cover all areas at all times, thus commercial coverage can reduce the gaps in coverage. The U.S. shares classified imagery with a few close allies only after a careful review, but can quickly share commercial imagery with a broad range of coalition partners. Commercial imagery costs less because commercial satellites contain less redundancy and less hardening reducing payload size. Launching a commercial satellite costs less than a spy satellite because of the NRO's schedule, the need for secrecy, and the higher overall risk associated with losing exquisite capabilities. In addition, commercial firms and governments can quickly and more easily develop, share and maintain unclassified databases and software.

Arguments against military use of commercial imagery focus on government control and money. When the U.S. finances commercial industries through service agreements and research and development projects, improved capabilities are eventually transitioned to the rest of the world via the commercial market. While export controls restrict imagery distribution, Russia and China regularly purchase commercial imagery from U.S. suppliers.[45] Additionally, NGA doesn't have the capacity to review or analyze the majority of the pictures collected and funded. Although the imagery is data based for future reference (comparisons of areas over time are often useful), it is politically difficult to justify spending billions of dollars on unused data.

Today's Issues

Today two U.S. commercial companies design, launch, and operate imagery satellites: DigitalGlobe and GeoEye. Each provides imagery to customers worldwide, but under the Enhanced View contract, the U.S. military provides most of their revenue. The contract is for 10 years but each year is optional. In 2011, Congress cut DoD's budget over ten years by $500B for FY13 and sequestration may lead to an additional $500B reduction. Although the FY12 EnhancedView contract has been fully funded,[46] substantial cuts may occur in 2013 and beyond. NGA has not determined the impact to each company, but cuts to GeoEye may cause the company to go bankrupt. Even though DigitalGlobe's main customer is the DoD, it is assessed to survive potential cuts because it is a more established company with more operational satellites and a broader range of services than GeoEye. GeoEye has twice attempted to acquire DigitalGlobe, while DigitalGlobe has offered its own buy-out proposal. Both companies will stoically wait for the NGA future budget plans expected at the end of the year.

In a perfect free market, weak businesses fail and strong businesses grow. Satellite imaging, however, is not an open free market. Congress has restricted the sale of certain imagery products, and DoD provided the majority of the investment to develop the capability. As stated in the National Space Policy, "The United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector..."[47] Ensuring a long-term competitive market remains in the U.S., regardless of budget cuts, in order to facilitate the growth of the space sector and the strength of national security. If GeoEye dissolves and DigitalGlobe becomes a monopoly, then DigitalGlobe will be able to significantly raise the cost of commercial images to the government and will have less incentive to reduce cost and improve capabilities. If a foreign company is allowed to purchase either GeoEye or DigitalGlobe, the U.S. military may have to accept increased risk of unreliability, lesser quality of products, or price fluctuations. Such a result would serve to undercut the U.S. industrial base contrary to the National Space Policy.

Recommendations

Long-term benefits outweigh the disadvantages of continued commercial support. To ensure innovative growth, it is recommended that the U.S. Government support at least two domestic satellite imagery companies continue to ensure the technical innovation and cost restraints required for strong national security. Cost for imagery can be reduced by allowing multi-year service agreements that provide the commercial firms reliable income and the resulting confidence to invest in research and development of innovative next-generation satellites. The U.S. should continue to promote international sharing of commercial imagery and imagery analysis. Collaborative intelligence analysis provides significant added value to coalition strategy developments and evaluations.

Expanded satellite imagery capabilities will benefit the U.S. military in the long-term by providing more data for less cost. Although foreign countries and individuals gain increasingly easy access on-line and by subscription to some of these capabilities, the military must accept these risks to benefit from the inevitable increase in affordable innovation and efficiency. The U.S. must lead the development to ensure they are involved in each of the potential benefits.

Author: Ms. Sandra Brown, DN

ESSAY 4: Improving U.S. Space Launch Capabilities

The commercial space launch industry continues to evolve, and can satisfy most U.S. space launch needs today. United Launch Alliance (ULA), Orbital Sciences Corporation (Orbital), Alliant Techsystems Inc (ATK), and Space Exploration Technologies (SpaceX) contend for or provide crucial launch vehicle components for government-funded civil and national security launches as well as compete in the international market for commercial launch. These American companies must overcome many challenges, including an overreliance on the U.S. government, to effectively compete with Arianespace, Russian companies International Launch Services (ILS) and Starsem and other international launch providers with proven lift capabilities. Arianespace in particular has the potential to augment U.S. space launch capabilities should U.S. commercial launch providers fail.

ULA, the largest U.S. launch provider, has unparalleled heavy lift capabilities, and a 100% success rate for the EELV program. NASA continues to explore the possibility of using EELVs as a human-rated launch system. Although ULA is well positioned to provide ultra reliable launch capabilities, its relatively high cost has created an opening for new launch providers like SpaceX. SpaceX successfully delivering the Falcon Heavy in 2013, will challenge ULA's last remaining monopoly, the Delta IV Heavy. ULA does not possess a small lift capability following the retirement of their Delta II launch vehicle. Their choice not to compete in this market leaves room for other commercial launch providers like Orbital.

Orbital's family of launch vehicles provide small to medium space lift to commercial and government customers. Orbital has flown the Pegasus, Minotaur, and Taurus space launch systems, and will soon fly the Antares. Orbital's business strategy for commercial space launch relies on the small to medium space lift market, with some diversity between commercial, civil, and government payloads.[48] Orbital's advanced space program also includes a Commercial Resupply Service (CRS) for the ISS using their new Antares launch vehicle. Orbital's heavy reliance on U.S. government contracts, R&D efforts, and surplus ICBM rocket engines are vulnerabilities, which could threaten future success. It also faces additional challenges including the failure of the payload fairing of its two most recent Taurus launches and construction delays at the Wallops Island launch site.

ATK's past focus on providing solid rocket motors to other space lift providers is evolving into fielding complete launch systems. ATK recently unveiled a joint venture with Astrium to build the Liberty Launch System by combining the Ariane 5 first stage with a modified solid rocket booster derived from the space shuttle program.[49] The 46 straight successful launches of the Ariane 5, combined with the 107 straight successes of the Space Shuttle's redesigned solid rocket motors, promises to provide extreme reliability comparable to the EELV program.[50] ATK is on a path to deliver a human rated launch system. ATK's reliance on U.S. government support is vulnerability, and the Liberty Launch System threatens to shift ATK's status from a U.S. to an international launch company. ATK is not the only company pursuing human rated space lift.

SpaceX is the only privately held commercial space launch company in the U.S. and promises to deliver dramatic increases in reliability, reductions in cost, and new launch capabilities.[51] SpaceX provides small and medium space lift using the Falcon 9 launch vehicle. Planned developments include the much anticipated Falcon Heavy rocket, with a promised capability to lift more than twice the payload of any existing launch system. SpaceX is under contract by NASA to provide CRS missions to the ISS commencing with a 30 April 2012 launch. SpaceX also relies on launch facilities at both Cape Canaveral and Vandenberg AFB. They have received significant assistance from NASA in development of the Dragon spacecraft, and launch vehicles. SpaceX has designed their Dragon spacecraft from the very beginning for human space flight. If the May 19, 2012 CRS mission is successful, SpaceX will be well on their way to providing a human rated launch system in the near future. With an extensive launch manifest, SpaceX is poised to become the first truly commercial space launch company in the very near future. Space launch companies must overcome a variety of challenges, not the least of which is establishing a record of reliability worth risking a multi-million dollar payload on. Another challenge is to overcome the dependence on government contracts, infrastructure, and expertise, which is highly vulnerable to economic and political fluctuations. A third challenge is the large number of launch providers competing for an uncertain, worldwide demand of less than 100 space launches per year.[52] Another challenge is the associated risk, where a single launch failure can be disastrous in an expensive, fiercely competitive market. Finally, the recent concept of "bulk buys" of rocket cores from ULA to achieve economies of scale could create a barrier to entry for up and coming space launch companies.[53] These challenges create a competitive, complex and expensive marketplace for U.S. commercial space launch providers.

The four companies discussed above all depend on support from the U.S. government in the form of lucrative contracts, infrastructure, and collaborative R&D efforts. "Commercial" in this case is only a thin veneer hiding various forms of government subsidized launch capability. Given the extreme barriers to entry into the space launch market, landing large government contracts may be a necessary first step for any commercial launch provider. However, it remains to be seen whether a space launch company can actually "cut the cord," and exist as a truly commercial entity. SpaceX and Orbital seem to be on a path to possibly achieve some form of independence from the U.S. government. The likelihood that one or more will succeed is very high, especially with the assistance of seed contracts from NASA. Commercial space launch companies are also the only answer for a U.S. human-rated launch capability. International launch companies face similar challenges, but provide much needed space lift options to the U.S.

International space launch providers offer viable alternatives to U.S. launch companies. Arianespace in partnership with the European Space Agency flies the Ariane 5, Vega, and Soyuz launch vehicles. The Ariane 5 has become the workhorse for placing commercial satellites in geosynchronous orbit (GEO). The extreme reliability and lift capability of the Ariane 5 certainly influenced NASA's decision to accept the ESA offer of an Ariane 5 to launch the James Webb Space Telescope in 2018. The maiden flight of the Vega, combined with the addition of a Soyuz launch vehicle, provide reliable small and medium lift for international customers. Other international launch providers include International Launch Services (ILS), which markets the Proton and Starsem which markets the Soyuz launch systems. Sea Launch has also recently emerged from bankruptcy to continue delivering medium lift capabilities using their Zenit launch vehicle. China is also eager to provide launch services using their Long March series of launch vehicles. The availability of reliable space lift capabilities outside U.S. borders is but one area where the U.S. government should focus its attention in the immediate future.

The U.S. government should focus on several areas to improve U.S. space launch capabilities, drive down costs, and encourage competition. To begin with, pathways must be kept open to allow new entrants like SpaceX to compete for launch contracts once they achieve certification. Recent steps by the Air Force to set aside a small number of launches for non-ULA providers is a positive step forward, but this should be allowed to evolve quickly to full and open competition if certified capabilities develop. Bulk buys of rocket cores, rocket engines, or similar launch components are a threat to that competition, and should be considered very carefully. Secondly, international launch providers should not be ruled out purely to support the U.S. space industry. Doing so not only encourages cost growth from the current launch monopoly held by ULA, but also denies our war fighters much needed space capabilities. A good example of this is the Wideband Global SATCOM (WGS) constellation, where WGS-5 has sat in storage for a year, with WGS-6 to soon joint it. DoD needs both satellites now, but ULA will not have launch vehicles ready until at least December of 2012 to take them to orbit. The U.S. should therefore resort to using Arianespace if forecasted U.S. capabilities are not available to provide crucial space capabilities in a timely fashion. This would required the U.S. to finally pursue with industry a common payload interface to a set of predetermined launch vehicles, providing greater space launch flexibility. Increased competition would also go a long way towards driving down costs for space launch. Thirdly, attempts should be made to recover and if possible, reutilize first stage components from EELVs. This may include mounting black boxes on the rocket bodies to assist in recovery, or even employing a more powerful 2nd stage to jettison the first stage earlier in flight. Regardless of the means used to recover these assets, the opportunity to recover a $30M rocket engine is sufficient to warrant the effort. Finally, the U.S. government should consider additional "should cost" estimates for the entire supply chain of launch components to ensure cost growth is justified. To keep costs under control in a time of budget austerity, the government should challenge recent dramatic cost growth in significant areas of the launch business that contribute to the overall costs of space lift such as the 360% rise in solid rocket fuel prices over the past three years.

The rapidly evolving commercial space launch industry can satisfy the space lift needs of the U.S. today, and provide even greater capabilities in the near future including human space flight from U.S. soil. ULA, SpaceX, Orbital, and ATK provide rapidly evolving commercial space lift capabilities in the U.S., but international providers are also available to fulfill our space lift requirements if necessary. All commercial space launch companies have overcome many challenges, but still rely on government support both in the U.S. and abroad. Dramatic increases in the cost of space lift require the U.S. government to consider additional means to drive down costs and encourage competition in the space launch industry. Emerging American launch providers Orbital, SpaceX, and ATK have an opportunity to both compete with international companies for commercial launches and to compete with ULA in meeting U.S. government civil and national security needs.

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