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Industry Study

Final Report
Space Industry

The Industrial College of the Armed Forces
National Defense University
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SPACE 2011

ABSTRACT: For over fifty years our scientific innovation and exploration of space has been a critical aspect of our national security and technological contribution to globalization. In the future, commercial space will remain healthy in the short-term; national security and civil space require sustained government funding to remain healthy. The short-term impediments to the continued health of national security and civil space sectors include excessive government regulations, mission assurance, and budget cycles. In the long term, the space industry will likely be characterized by significant and dynamic transition as a result of static, if not decreasing budgets, programmatic uncertainty, supply chain fragility, as yet immature technologies, and new space entrants.

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NASA Goddard Space Flight Center, Greenbelt, MD
National Reconnaissance Office, Chantilly, VA
National Security Space (NSS) Office, Fairfax, VA
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INTRODUCTION

"The space age began as a race for security and prestige between two superpowers. The opportunities were boundless, and the decades that followed have seen a radical transformation in the way we live our daily lives, in large part due to our use of space. Space systems have taken us to other celestial bodies and extended humankind's horizons back in time to the very first moments of the universe and out to the galaxies at its far reaches. Satellites contribute to increased transparency and stability among nations and provide a vital communications path for avoiding potential conflicts. Space systems increase our knowledge in many scientific fields, and life on Earth is far better as a result."

- National Space Policy of the United States of America, June 2010

This year the global space community celebrates fifty years of manned spaceflight. When Yuri Gagarin, and then Alan Shepard, first ventured into space they touched off a half century of rapid technological development that engendered numerous applications for national security, industry, and consumer uses. However, the U.S. space industry is facing serious challenges ranging from the future of manned spaceflight to the fragility of the space industrial base. Solving these is critical to sustaining U.S. ability to exploit space to meet national security goals.

This report reflects the findings of the 2011 Industrial College of the Armed Forces (ICAF) Space Industry Study Seminar. Fifteen students, facilitated by their ICAF faculty team, analyzed the space industry over a five month period focusing on technology, business, economic, and government policy perspectives. The seminar group was comprised of senior U.S. military officers and federal government civilians representing the Army, Air Force, Marine Corps, Navy, Department of State, and the Intelligence Community (IC); participants had a range of space-related experience, from "space operations professional" to "DirecTV viewer."

Participants met with government and industry experts in the U.S. and Europe and developed assessments from these valuable exchanges. In an effort to bound the study within the given time constraints, the seminar concentrated on U.S. and European launch vehicle and propulsion segments, while gaining a broad understanding of the entire industry.

This Space Industry Study Report defines the industry under review and describes the current condition of the three major sectors of the space industry: National Security Space (NSS), Civil, and Commercial. We further identify major challenges within the space industry, project the future health of the industry, and recommend government policy changes. Finally, the study concludes with four essays on issues of particular interest and importance to the seminar students. These essays discuss the Evolved Expendable Launch Vehicle (EELV) program, Export Control, Rebalancing the National Security Space Architecture, and Science, Technology, Engineering, and Mathematics (STEM) Education Reform.

THE INDUSTRY DEFINED

Organizations define the space industry differently. For example, the North American Industry Classification System (NAICS) classifies the "space industry" within NAICS code 33641b, Guided Missile & Space Vehicle Manufacturing in the U.S. This grouping contains launch vehicle and satellite manufacturing, as well as guided missile sectors. The Satellite

Industry Association defines the space industry to include the launch industry, satellite manufacturing, and ground equipment.

This seminar defined the space industry to include launch, vehicles, and services segments. Launch includes rocket and rocket engine manufacturing, as well as launch range infrastructure. Vehicles include satellites, man-rated, exploratory and sub-orbital vehicles. Services include communications, imaging, and navigation.

There are three primary customers for the space industry. The NSS sector includes Department of Defense and IC applications critical to national security operations. The Civil Space sector includes the National Aeronautics and Space Administration (NASA) and other government agencies, such as the National Oceanic and Atmospheric Administration (NOAA) for manned and unmanned scientific and exploratory missions. Finally, the Commercial Space sector includes commercial companies with missions ranging from communications and imaging to the emerging market for space tourism to low-earth orbit scientific exploration.

Most government and industry experts supported one or more of the three primary customer sectors and focused on one of the segments of the industry (i.e., launch, vehicles, and services). Therefore, the seminar organized its analytic review by sector, using noted industry segments as evaluation benchmarks common to each sector.

CURRENT CONDITION

According to public and private source estimates of budgets and revenues, space is a $277 billion global market enabling launch, commerce, communication, collection of information and more.[1] More than 262,000 people are employed in the U.S. space industry with nearly 13,000 new jobs added between 2003 and 2007, all at wages outpacing U.S. national averages.[2] Although impressive, these statistics only scratch the surface of the scope and impact the U.S. space industry has on the economy. The technology and innovations derived from space industry activities are critical to daily life such as the Global Positioning System (GPS), television, radio and cellular telephone communication are taken for granted.[3] The following provides a brief assessment of the current condition of space industry sectors broken out by launch, vehicle, and service segments.

National Security Space (NSS)

NSS provides global communications, imaging, surveillance and environmental monitoring, missile warning and defense, positioning, navigation and timing, and space launch. Increasingly, U.S. national security is critically dependent on NSS. U.S. led space related technologies and industry are imperative to the U.S. role as a superpower.

The U.S. NSS launch segment is supported by the EELV program. In 1994, the U.S. Air Force started the EELV acquisition program. EELV was a result of years of studies on how to transition from the legacy launch systems (Delta II, Atlas IV, Titan IV) into an affordable, reliable and efficient launch program for the U.S. Today, the EELV program is a joint venture between Boeing and Lockheed Martin called United Launch Alliance (ULA) and consists of Boeing's Delta IV launch vehicle and Lockheed Martin's Atlas V launch vehicle. Both launch vehicles have proven exceptionally reliable, but extremely high launch costs have precluded them from becoming a viable commercial alternative to launch services outside of the U.S. government thus preventing ULA from capturing expected production efficiencies and supporting launch infrastructure overhead costs. Absent additional launch customers, the U.S. government faces an increasing financial burden to sustain the supply chain for this capability.

Regarding vehicles, the NSS community has preferred to develop limited numbers of larger, more complex, "exquisite" satellite systems that perform many payload missions. The U.S. remains dominant in NSS capabilities, but over the past two decades this approach has resulted in delays in the development of many satellite programs, costing billions of dollars and weakening the industrial base. Producing limited numbers of systems has forced the space industrial base to consolidate, leaving only a few satellite developers to compete for the low-volume business. Four major contractors have acquired over fifty companies within the last fifteen years.[4] In a 2010 report to Congress, the National Reconnaissance Office (NRO) noted production of "low-volume government satellites do not provide sufficient market stability."[5]

Throughout this study, government and industry executives identified the need to balance the NSS exquisite architecture with smaller, less expensive satellites and other options, such as hosted payloads.[6] The National Security Space Strategy (NSSS) opens the door to pursue a balanced architecture by stating, "We will continue to explore a mix of capabilities with shorter development cycles to minimize delays, cut cost growth, and enable more rapid technology maturation, innovation, and exploration."[7] The concept of smaller, less complex satellites and responsive launch is being pursued by the Operationally Responsive Space (ORS) office. While the ORS concept has laid the groundwork and continues to prove there is an important role for small satellites, a more concerted effort is needed to shake loose from the stalled space acquisition process to provide a balanced NSS architecture. The NSS community is pursuing opportunities to partner with international, civil, and commercial organizations and exploring acquisition strategies to lower the per-unit cost of a satellite.

The NSS sector uses commercial services for some imagery requirements as well as communications. The Defense Information Systems Agency (DISA) reports explosive growth in the use of commercial satellite communications (SATCOM) for support of global military operations. Since 2007, expenditures have reportedly increased approximately 24% annually, while bandwidth usage increased 10% annually.[8] Approximately 80% of U.S. military communications to/from Iraq and Afghanistan rely on commercial SATCOM.[9] The United Kingdom's (UK) Ministry of Defence considers commercial SATCOM critical enough to enter into a long-term contract with Paradigm Communication Systems Limited. The contract assigns Paradigm as the sole-source provider of military satellite communications, hardened and protected X-band and UHF communications in accordance with NATO standards, for a nineteen year period. This innovative partnership includes incentives for managing cost while providing long term contract stability that allows Paradigm to invest in evolving technology.

The U.S. has recognized the need for increased international cooperation in the area of space situational awareness to improve the capabilities of all involved. One example of this is the expansion of the Space Fence program and the recent agreements signed with the Australian government to expand the capability to the southern hemisphere. This expansion will allow the Joint Space Operations Center (JSpOC) to track space debris and objects to a greater fidelity than currently available and will share this information with international partners.

Commercial Space

In the U.S. commercial space sector, the market is subject to the cyclic nature of government spending, competing national priorities, and stringent policy regulations. Barriers to entry are high and the industry average return on investment is ~5% with an ~1.9% anticipated growth rate for 2011-2016.[10] This rate of return is not attractive for a high risk industry. One of the biggest impediments to growth is export control restriction, specifically the International Traffic in Arms Regulations (ITAR), imposed by the government.

Currently, three U.S. companies have a demonstrated commercial launch service capability: United Launch Alliance (ULA), Orbital Sciences, and SpaceX. Sea Launch, a U.S.-based multinational entity, is re-entering the industry. The U.S. share of the global market appears to be in decline. Efforts to spur growth in the launch segment of the commercial sector appear inhibited by cost and logistics. Price points are too high to generate new demand for launch services and logistics limits launch capacity of existing providers; range availability impacts growth to a lesser degree. The result is an inability to generate sufficient cadence to stimulate innovation, increase demand, reduce cost, and generate a competitive market. Change is not imminent since U.S. launch tempo and satellite longevity is precluding a cadence increase. Other opportunities to increase demand, such as space-based solar power, require significant government investment in an era where budgets are under extreme pressure.

Commercial vehicles are primarily in demand for cargo and satellite delivery services to low earth orbit, with emerging markets for carrying astronauts to the International Space Station (ISS) and space tourism. NASA has changed their acquisition approach to astronaut transport and ISS resupply by acquiring these as services rather than acquiring the vehicles for transport. The vehicles are being developed, produced, operated and sustained by contractors, such as SpaceX, Orbital Sciences, Boeing, Sierra Nevada and Blue Origin.

There is also an emerging sub-orbital space industry segment, focusing on space tourism and scientific payloads, which is the predominant segment for innovation and entrepreneurship. Space tourism has captured investors and inventors at all levels. The effort closest to completion is a sub-orbital, air-launched spaceplane known as SpaceShipTwo, which is part of a joint venture between Scaled Composites and the Virgin Group of the UK. XCOR is a smaller company focusing on achieving sub-orbital altitude from a runway entirely under its own power using its Lynx rocketplane. Blue Origin has developed New Shepard, an unmanned spacecraft it intends to modify for human space flight as a tourism vehicle. Lastly, Masten Corporation is developing a scientific payload effort.

The use of commercial satellites for hosted payloads is an emerging commercial service whose greatest asset is reduced cost. In a fiscally constrained environment, the government could increase collaboration with industry and take advantage of shared expenses for satellite manufacturing, launch, and on-orbit maintenance. Geosynchronous satellites with communications equipment or scientific missions offer the most potential for this collaboration as there may be redundancies in the national security sector which would enable flexibility in priority allocation, operational employment, and end-of-life considerations. Another emerging space service is on-orbit satellite servicing. Recently, IntelSat and MacDonald, Dettwiler and Associates (MDA) announced the first contract for providing on orbit satellite and space vehicle servicing. Competition for this service is expected to emerge on the international market and possibly in the commercial sector. International competition for this service is expected to emerge, as the German Space Agency (DLR) is planned to demonstrate the Deutsche Orbitale Servicing Mission (DEOS) system within the next few years.[11]

Civil Space

The U.S. National Space Policy mandates a return to the Moon and manned missions to Mars; however, the President cancelled the Constellation manned space program as well as retiring the shuttle program. U.S. policy will have to rely on the commercial sector for manned and unmanned access to low earth orbit. SpaceX and Orbital Sciences Corporation are poised to begin re-supplying the ISS. NASA will rely on the Russian Soyuz rocket to transport U.S. astronauts to and from the ISS at a cost of $70M per seat. For inter-planetary missions, NASA will utilize medium and heavy-lift EELV rockets.

Over eighty separate exploratory vehicles are either in space or planned for launch in the near future; these are primarily funded and executed within the civil space sector. The missions encompass terrestrial, planetary, and interstellar scientific exploration with earth-based science comprising over 30% of the missions.[12]

Planetary exploration vehicles represent some of NASA's most expensive missions. Missions such as Cassini-Huygens (Saturn), MESSENGER (Mercury), New Horizons (Pluto) and several Mars exploration vehicles have dramatically increased knowledge of the planet and the solar system. Interstellar exploration vehicles, e.g., Hubble, Hershel, GLAST (Gamma-Ray Large Area Space Telescope) and the future James Webb space telescopes, extend humanity's knowledge of the galaxy and beyond but are also expensive. NASA is cooperating with ESA to maximize limited budgets through joint development, production and operation of both past (e.g. Mars exploration rovers Spirit and Opportunity) and future (e.g. ExoMars rover) Mars missions.

In the same spirit, the U.S. is increasing partnerships with other countries, notably Japan, Canada, and ESA members to facilitate shared costs and risks. About ten exploration vehicle programs involve bilateral or multinational collaboration, such as Astro-E2/Suzaku (NASA-Japan mission to discover more about x-rays in the universe), Cluster (ESA/NASA spacecraft to take 3D measurements of the Earth's Magnetosphere), SOHO (Solar Heliospheric Observatory, ESA/NASA program to study the Sun), and Terra (multinational partnership to better understand and protect Earth).

USG expenditures in research and development in Civil Space directly contribute to U.S. economic prosperity through advances in technology and innovation delivered through support services, including remote sensing capabilities for weather, agriculture, natural resources management and urban land use planning. The vehicles developed by NASA and NOAA provide these services to the scientific, public and commercial communities free of charge and include opportunities for "value added," second tier services. Additionally, other government organizations, such as the Departments of Agriculture, Interior and Energy, contract for remote sensing from commercial service providers in support of their public responsibilities.

CHALLENGES

ITAR

Legislation changes impacting export controls and ITAR have negatively impacted the space industry in the last decade. Controls meant to maintain space superiority and assured access provoked global competition, weakened the U.S. space industrial base, and contributed to an increase in the number of space-faring nations to approximately ten. The simple fact that over 60 nations possess space capabilities illustrates the contested, competitive, and congested nature of the space environment.[13] Larger companies appear to have established administrative procedures to handle export controls, but smaller companies, lacking resources and experience, struggle through export control processes. This challenges their ability to compete in the global market resulting in lost business opportunities. However, recent activity within Congress and the Executive branch is encouraging export control reform.

In April 2009, the Subcommittee on Terrorism, Nonproliferation and Trade to the House Foreign Affairs Committee held hearings on "Export Controls on Satellite Technology." The results of those hearings were included in a bill entitled "Defense Trade Controls Performance Improvement Act of 2009" (H.R. 2410). In August 2010, the President announced a joint National Economic Council and National Security Council review of the export control regime. When the joint review was completed, the President announced a three phase plan to implement four major changes. "The goal of the reform effort is 'to build high walls around a smaller yard' by focusing enforcement efforts on U.S. [national security technologies] or 'crown jewels.'"[14]

In any new export control system, a balance must be struck between controlling and protecting advanced technologies not available in other markets while allowing exports of everything else to stimulate trade. The House bill and the President's three phase plan represent progress toward improving the U.S. export control system. Steps to make the process timely and less complicated will enable industry participants to compete internationally and enhance the industrial base (especially for second and third tier subcontractors) and national security.

The Space Industrial Base

The U.S. space industrial base's (SIB) health is dependent primarily on USG resources. Today some 90% of all sales and production are the result of USG contracts, a marked increase from 2006.[15] The industry in the last two decades has consolidated into a near-oligopoly, with four large prime vendors (Lockheed Martin, Boeing, Northrop Grumman and Raytheon) securing 60% of the market. New entrants into this market are discouraged by formidable barriers, including complex government contracting requirements for space systems, a changing yearly program budget, large capital investments in infrastructure, and a skewed playing field which favors established companies with proven systems. The chaotic budget flows have led to industry's inability to build the appropriate sized, sustainable infrastructure and workforce and results in a greatly varied work flow from year to year, negating the ability of the companies to accurately forecast future requirements.

Several companies visited had identified excess capacity. Although some were implementing consolidation measures, maintaining this excess overhead reduces the space industry's commercial and international competitiveness. Also, an uncertain future demand prevents the USG from taking advantage of economies of scale and the associated learning curve in a steady production environment. The result is large dollar programs with multiple schedule delays and cost overruns. Much of this was addressed in the 2003 Young Report. U.S. NSS organizations are implementing recommended changes. A second concern is the effect government budget fluctuations have on the stability and sustainability of second and third tier vendors. The majority of innovation occurs in smaller businesses, yet their revenue streams lack diversity and are not resilient enough to weather the boom and bust volatility of USG acquisition programs. Given that prime vendors typically outsource approximately 70-80% of the work to subcontractors and vendors, the long-term health of the SIB is a concern.

Loss of Shuttle

Following the last space shuttle launch in June, the U.S. will experience a gap in manned space capability and heavy cargo transport for at least seven years. The U.S. will rely on Russia to transport U.S. astronauts to and from the ISS. Economically, the severity of the impact has been exacerbated by cancellation of the Constellation program, which both NASA and the space industry at large had depended on for sustainability. From solid rocket boosters, to reusable main engines, to services and other components of space industry, the viability of the shuttle prime contractors with their associated technologies and human capital face the increasing likelihood of atrophy, if not elimination. Second tier suppliers face a grimmer future. Domestic suppliers of critical technologies may be forced to end production, resulting in qualification lapses. Startup and re-qualification costs may preclude reentry into the market, thereby increasing dependence on foreign sources and reduced assured access to space for the U.S.

Budget, Resource, and Acquisition

Given the current U.S. fiscal environment (unsustainable deficit spending and rising national debt), government funding for all activities, including space, will most likely remain constant or may even decline in the foreseeable future. Since the U.S. space industry is primarily driven by U.S. government spending, the overall state of the industry will remain, at best, stagnant. Less funding will put pressure on both government and industry, and as the overall funding base declines, per unit costs will rise, limiting government purchasing power for systems critical to national security and civil space requirements.

Concern about the sustainability of the U.S. space industry led the Department of Defense (DoD) and Intelligence Community (IC) to propose multiple-item procurements in the FY12 President's budget. The DoD/IC requested authority to purchase five EELV rockets from ULA in FY12 and FY13. The DoD/IC also committed to buying five per year in FY14-16 for the Air Force, plus an unspecified number for the NRO. This plan commits the government to long-term deliveries, instead of buying rockets individually, which should stabilize the launch vehicle industrial base and achieve cost savings. The Air Force is extending the multiple-item procurement strategy to satellites, including the Advanced Extremely-High Frequency Satellite and the Space-Based Infrared System, through the Evolutionary Acquisition for Space Efficiency (EASE) program. EASE is based on four main concepts: block buys of satellites, stable research and development investment, fixed price contracting, and full funding through advance appropriations. With this revised strategy, the Air Force expects to lower overall costs, support the SIB, and promote future innovation.[16]

Education

The U.S. must maintain a competitive advantage in Science, Technology, Engineering, and Mathematics (STEM) as these skills are considered the underpinnings of a self-sustaining society and assure a leading edge in technical proficiency. The U.S. education system is the core foundation to developing these skills. In 2008, the Government Accountability Office (GAO) issued a report on STEM citing a growing concern that the U.S. is not preparing a sufficient number of students, teachers, and professionals in STEM and notes a mismatch between U.S. student achievement and our nation's role as a world leader in science innovation.[17]

In the space industry NASA has developed a rigorous STEM effort through their education directorate, with specific initiatives tied to metrics for programs ranging from K-12 through the graduate-level. The federal government has implemented a program for re-training and re-utilizing its existing space workforce as the nation retools its approach to space. A range of private entities and state-run programs are also promoting space-related STEM education. At this juncture, space industry leaders indicate they have a sufficient pool of talent to fill the demand. However, in the long-term, the space industry will face challenges as a result of systemic STEM education failure beginning in K-5, limited government marketing of space education initiatives, and a declining space industry job market.

OUTLOOK

Short-Term Outlook (2011-2016)

The future health of the space industry can be divided into national security, civil and commercial sectors. Commercial space will remain healthy in the short-term; national security and civil space require sustained government funding to remain healthy. The short-term impediments to the continued health of national security and civil space sectors include excessive government regulations, mission assurance, and budget cycles.

The U.S. focus on national security has resulted in severe restrictions on the export of space technologies and the vehicles and spacecraft that contain them. ITAR is the prime example. As previously discussed, the goal of ITAR is to avoid giving potential adversaries access to U.S. technologies which could eliminate the advantages in U.S. national security programs. However, the result is the U.S. satellite industry cannot export U.S. products. This has reduced the global market share for U.S. satellites while engendering nascent foreign satellite companies to meet international demand. How the government is able to revise export regulations will have a significant impact on the future viability of the domestic space industry.

The goal of mission assurance is to minimize the risk of failure. With some national security satellites costing billions of dollars, the USG takes every measure to ensure launch and deployment of the satellite is successful. This very expensive endeavor not only increases costs exponentially but also stifles innovation given the propensity to stick with proven technologies. The question that policy makers and program managers must answer is whether reducing the risk of failure by a few percentage points is worth the increased cost of the mission.

Space program cycles do not match budget cycles. Budgets are passed annually, while space programs span years to decades. Too often programs are initiated with the promise of steady budget allocations only to see annual budgets change or disappear from one year to the next. Two, four, and six year electoral cycles exacerbate the problem. New administrations can change the direction of the U.S. space policy and rotations within the legislative branch encourage a short-term focus to yield tangible results for re-election, rather than maintaining consistent space policy and direction. The Administration and Congress will need to work together to provide space program vision, direction, and stability.

Launch, for many years controlled solely by governments, is the weakest and least vibrant of the space industry segments. A new entrant into the launch industry, SpaceX is poised to change this. Using a business model focused on streamlined processes, low-risk development, and vertical integration, it has demonstrated potential for dramatically reducing the cost and production time of launching spacecraft into both low earth and geosynchronous orbits. Within five years, it will be clear whether SpaceX has indeed provided an affordable and reliable means to achieve orbit, the first step towards changing the balance of the launch cost equation.

Long-term outlook (2017-2030)

The space industry will likely be characterized by significant and dynamic transition as a result of static, if not decreasing budgets, programmatic uncertainty, supply chain fragility, as yet immature technologies, and new space entrants.

During this period, several questions should be resolved that will set the course for the space industry for decades to come. These include: (1) What is the course for manned spaceflight and human exploration beyond the life extension of the ISS? (2) What level of government investment can be sustained post-financial crisis recovery? (3) Will price competition for launch services and satellite manufacturing create new business opportunities to expand the industry as a whole (e.g., on-orbit servicing, robotic manufacture or solar power)? (4) Will viable sub-orbital markets (e.g., science payloads and tourism) truly emerge as anticipated by several "new space" entrants? and (5) Will governments or international organizations significantly invest to prevent or "clean-up" orbital debris?

The space industry, domestically and internationally, will continue to depend largely on government expenditures and subsidies. USG expenditures are not expected to increase over the next fifteen years, and probably will decline due to increasing competition for finite federal resources. A return to full employment and the return of a vibrant manned program may lead to increased civil space program spending. However, this is predicated on the U.S. developing and implementing a coherent exploration program that is effectively marketed to the American public. This could provide a positive impact on the entire industry due to increased demands. The domestic commercial demand for space related services is expected to continue growing at a sustained rate and the emergence of new services could result in a higher growth rate.

If government investment in space continues to decline, especially in the absence of a significant, long-term human exploration program at a reasonable funding level, continued technological atrophy will occur with commensurate loss of critical suppliers. In this environment, the survivors will be those who specialize in unmanned and robotic systems which have a much narrower industrial base. However, even without increased government investment, should the space cost equation change by the mid-term, the industry should be able to at least stabilize, if not begin to re-grow. In either case, during this period, there will likely be a shake-out of the new entrants as well as continued consolidation among more established players. If neither increased government investment nor significant change in the cost equation occurs, the viability of the space industry in the long run will be in jeopardy.

Internationally, ESA expects to triple their programs over the next twenty years. Decisions regarding the future of U.S. programs impacts international programs such as extension of the ISS and its associated impact on ESA's Automated Transfer Vehicle. International demand should experience the largest growth as developing countries seek to join space-faring nations, purchasing organic satellite capabilities and services.

GOVERNMENT ROLE

As discussed throughout this paper, the U.S. is challenged by a slumping space industry that impacts national security, civil, and commercial space capabilities. However, the industry can be rejuvenated with swift and creative government intervention. The government can take measures such as publishing a clear long term space strategy and vision to guide industry decisions and investments, implementing conducive procurement methods, stimulating demand, leveraging commercial innovations more heavily, and implementing efficient policy reform. Along these lines, this paper provides several recommendations for government consideration. Pursuing these recommendations can potentially resolve several of the challenging issues and enable the U.S. to maintain its preeminence in space.

POLICY RECOMMENDATIONS

Support for Commercial Space

The U.S. made a major shift in its space policy by deciding to support ISS operations with commercial launch services. During our commercial industry visits, we observed the seedlings of positive change from this policy shift. Companies that are supporting the NASA re-supply contracts are thriving, innovative and have a positive outlook for the future. The U.S. must stay the course with the new policy and not revert back to the previous civil-focused paradigm. Commercial companies will soon be able to leverage NASA-funded infrastructure and innovation improvements into gaining increased global market share. Further support of the commercial launch industry can be attained through streamlining regulations for launch ranges.

Expand USG use of Commercial Capabilities

The government needs to consider different ways of accomplishing space missions such that we buy services rather than systems. Examples of this approach include NGA's contract for commercial imagery and NASA's contract for commercial re-supply of the ISS. Additional efforts will require a cultural shift from being "owner/operator" to being "user," and should be part of the analysis of alternatives in acquisition strategies. For example, NOAA has always owned and operated weather satellites, but this mission could be performed commercially. Drawing on an international example, the UK MOD has a long-term contract with Paradigm for military SATCOM; the US could consider a similar arrangement. Overall, this approach could stimulate new demand in the space industry while providing lower cost capabilities and more frequent technology refresh to warfighters.

NASA's Future

The false start and subsequent cancellation of the Constellation program has been detrimental. Industry appears reluctant to invest resources until they perceive the USG has an established long-term strategy backed by resources. NASA's mission should remain focused on basic research and technology development, manned space exploration, and unmanned scientific space exploration. Further, the USG should consider commercial alternatives to maintaining heavy-launch system development within NASA to spur growth in the commercial sector.

ITAR reform

As previously mentioned, ITAR is an on-going challenge for the competitiveness of the market and national security; however, there is room for reform. Recommendations include rapid implementation of the President's ITAR reform plans and establishing an annually approved technology list or authorized vendor status for ally countries and their companies that do not require review for each transaction.

New Acquisition Strategy Considerations

NSS program offices should rebalance towards small-to-medium satellites and hosted payloads with less technological stretch to reduce cost, accelerate development cycle times, reduce risk, and disperse satellites as potential targets. The ORS concept should be part of each NSS program offices' architectural strategy, utilizing a mix of capabilities, such as smaller satellites and hosted payloads. To accomplish this, the government will need to accept commercial specifications and reduce government oversight. Additionally, they must commit to a disciplined requirements process that rejects requirements creep and limits the technology stretch to smaller, incremental steps to reduce cost/schedule risk. This last practice requires the USG to launch more satellites and payloads more quickly, evaluate their performance, redesign, and then repeat. Increasing launch cadence will help drive down launch costs, reduce overhead, and revitalize the space industrial base with more production volume. A revision of the acquisition culture is necessary to balance funding between smaller satellites, hosted payloads, and larger, exquisite systems. Program offices should be required to incorporate hosted payloads and/or smaller satellites into their current architectures.

Additionally, in this challenging fiscal environment, the U.S. will need to seek cost effective and efficient business solutions for space acquisition. Some options to consider include: (1) Leverage international partnerships for national security space programs to spread costs, similar to NASA; (2) Increase opportunities for multi-year procurement strategies, split funding, and advanced procurement to stabilize programs; (3) Invest in innovative solutions, such as nano and cube satellites or acquiring only the services to support the mission rather than the infrastructure; (4) Alert primary contractors and government on opportunities for quantity buys; and (5) Allow flexibility of funding for cross component purchases.

STEM

The space industry is challenged by systemic STEM education failure beginning in grades K-12. Reversing this decline requires a national mandate for education reform that specifically addresses STEM with clear, measurable goals and a sense of urgency for tomorrow's "space race." Specifically, policy implementation directives must delineate expectations for DoD and the IC regarding existing STEM metrics and a future strategy. The initial responsible party for this should be the DoD STEM office. Additionally, President Obama must tie funding for 100,000 new STEM educators to national directives for curriculum; states requesting funding for STEM programs or for STEM educator development must agree to these curriculum standards rather than retaining state authority. Further, NASA's education budget should be doubled; this additional funding should be accompanied by a directive to collate existing NASA education initiatives by state and a requirement for NASA educational offerings to be provided to state education administrators within one year. Finally, the National Science Foundation (NSF) must provide return on investment statistics for its sixty STEM education programs as well as receive guidance to review programs and double K-12 opportunities.

Orbital Debris

With over a half century of human space activities, the amount of debris in space is now reaching a point of significant concern. Assessing current measures in light of potential risks is required to determine responsible long-term courses of action. The first step is to improve current space situational awareness capabilities. The U.S. should continue proactively seeking agreements in sharing active satellite ephemeris data with commercial and foreign partners. The U.S. should continue seeking military-to-military relationships to collaborate on capabilities which track space debris. The U.S. has implemented strong policy language to mitigate debris resulting from launches; however, the cost of this mitigation is high and will ultimately be passed on to the customer, reducing U.S. competitiveness in other markets. Short-term consideration should focus on enhancing space situational awareness instead of funding excess capacity on launch vehicles to de-orbit down-stages of rockets. The USG should begin developing a long-term affordable international solution for orbital debris.

ESSAYS ON MAJOR ISSUES

The seminar selected four essays of interest to further evaluate challenges faced within the space industry and elaborate on recommendations for change.

ESSAY 1: PUSHING FORWARD WITH EELV

The EELV program is currently the sole means of ensuring the U.S. has reliable and guaranteed access to space for its NSS satellites. Per the U.S. Space Transportation Policy, "access to space by U.S. space transportation capabilities is essential to USG space endeavors and the U.S. must maintain robust, responsive, and resilient space transportation capabilities to assure access to space".[18] The U.S. has committed to maintaining two separate launch vehicles (Atlas V & Delta IV) to ensure guaranteed access. Following the 1986 Space Shuttle Challenger disaster, the U.S. policy makers realized the vulnerability in having a single launch vehicle for accessing space. Knowing the U.S. is committed to guaranteed access, and accepting the decision to maintain two vehicles, it is now incumbent upon the USG to implement policies that support the development of the industrial base and to focus on reducing costs due to the government's current constrained financial situation.

Policy Recommendations

- The USG should consolidate medium to heavy-lift launch orders and purchase in bulk from ULA. The U.S. should stop purchasing medium and heavy-lift launches in a piecemeal fashion. The USAF, NRO and NASA should develop a joint team to develop a consolidated future launch schedule and to coordinate bulk rocket purchases. Sub-optimizing purchases within each USG organization currently provides the opportunity for relative cost savings within each organization, depending upon size of launch contracts, but holistically the total costs of U.S. launches is greater. Bulk purchases will allow ULA to negotiate less costly prices from its suppliers.[19] Additionally, a consolidated schedule should be optimized to evenly distribute the timing of launches wherever possible. By creating an even distribution, ULA and its sub-contractors are able to streamline their workforces, and optimize their production lines.
- Shift to a three year re-compete period for the EELV contract. A five-year contract will lock out competition for too long. An increased rate of competition will allow the USG to capture cost savings between each contract. Increased rate of competition supports the potential for a competitor to emerge and will push ULA to pursue cost-savings measures. In addition, a five-year contract will encourage second and third tier suppliers to build in bulk to quickly fulfill the order and then shut down their production lines, resulting in higher costs for future purchases when the production lines have to be restarted.[20]
- Evaluate ULA's cost production curve. Until the EELV contract is re-competed, the U.S. government should not shift any USAF, NRO, or NASA medium to heavy-lift missions to emerging competitors. To maintain assured access, the U.S. is committed to covering ULA's overhead costs whether it purchases zero or ten launches per year. By evaluating ULA's cost

production curve and determining the minimal value of marginal costs per launch, the U.S. government will know at which point additional medium and heavy-lift missions can be re-directed to competitor companies while taking into consideration ULA's sunk costs. Diverting funds to purchase competitor launch services prior to reaching the minimal marginal cost point ultimately raises the total combined launch costs to the USG.

- ULA is focused on equivalent unit costs, not reducing total costs. Under the current EELV acquisition strategy, ULA is not incentivized to become competitive for commercial launch business. Their focus is on lowering unit costs, which positions them for future EELV lot buys. The EELV contract should be tailored to drive reducing total costs.

- Reduce government regulations. The number of requirements in government regulations required to fly from a federal range needs reviewing. While most were born from lessons learned and previous issues and incidents, a renewed look is warranted based upon the maturation of the launch industry. New entrants are required to develop large staffs to meet the existing requirements of USAF AFSPC Manual 91-710 and the FAA Code of Federal Regulations, which ultimately requires significant investment and stifles innovation.[21] To develop leanness within new entrants, bureaucratic processes need to be scrutinized for unnecessary requirements to help foster a renewed focus on innovation.

- Oversight or insight. The current government launch business is characterized by stringent oversight. Data is reviewed down to the piece part level and there are independent reviews of all major system designs and qualification efforts.[22] The EELV contract incorporates the costs associated with this increased oversight; however, if there is a transition to fixed price launch services it will be difficult for new entrants to develop commercially competitive pricing while absorbing the overhead required by stringent oversight.[23] The USG needs to be flexible enough to operate simultaneously in both oversight roles for high mission assurance required launches, as well as insight roles in the more routine launch missions.

- Focus Space Test Program (STP) and NASA light to medium-lift missions to emerging competitors. Creating opportunities for emerging competitors to develop a foothold in the launch industry and mature their technologies is beneficial for future competition. Providing opportunities for funded flight tests will allow them to mature technology beyond the "infant mortality" period of rocket development. Providing emerging companies opportunities to prove their reliability will encourage commercial launch contracts, which in turn will help offset launch range overhead costs. The recent NASA Commercial Orbital Transportation Services (COTS) program awarded to SpaceX and Orbital Sciences Corporation is a perfect example of USG supporting emerging companies by awarding milestone funding incentives.

- Focus on reducing ULA's supply chain costs. ULA's supply chain cost is the key remaining variable to cost control. Due to low production cadence, second and third tier suppliers are passing on their increased costs to ULA. Because these costs are absorbed within the EELV cost reimbursable contract, the USG needs to focus its policies and procedures to contain them. For example, with the discontinuation of the shuttle program, Pratt & Whitney Rocketdyne (PWR) overhead costs are now being absorbed within the EELV program. Previously, those costs were being partially supported from NASA.

- Reduce time required to re-manifest payloads between EELV launch vehicles. One of the original requirements of the EELV Operational Requirements Document was a standardized payload interface between EELV launch vehicles.[24] According to ULA, this requirement has been met.[25] However, the time required to change a payload from an Atlas vehicle to a Delta vehicle (or vice versa) is measured in months to a year.[26] This is significant because one of the big factors in launch costs is delays in the launch schedule due to satellites not being ready for launch on the previously scheduled manifest. Reducing the time required to switch payloads (even within the same launch family) would allow rapid re-manifesting with satellites that are ready to launch and prevent launch pads from remaining locked down and the resulting associated infrastructure costs. An analysis of alternatives should be completed to determine feasibility to de-couple payloads with specific tail numbers.

Conclusion

In the mid-1990's the U.S. was burdened by government launch services based on heritage launch vehicles that were costly, had numerous configurations, disparate launch facilities and questionable reliability. Forecasted launch predictions showed exponential growth both in predicted demand for government launches as well as commercial launches. The EELV program was seen as an opportunity to consolidate the number of launch vehicles, evolve launch vehicle technology, and position the government to share infrastructure overhead costs with a booming commercial segment. Unfortunately, the rosy predictions turned into a bubble that busted. Acquisition professionals worked hard to preserve the U.S. launch industry to preserve national security while trying to maintain fiscal responsibility within the EELV program. It is time again to look for additional changes within the EELV program to position the U.S. for future success within the launch industry. The recommendations identified within this paper can position the U.S. for increased competition within the domestic launch industry and ultimately lower launch costs that will help preserve the nation's national security.

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ESSAY 2: REBALANCING THE NATIONAL SECURITY SPACE ARCHITECTURE

The U.S. NSS community has preferred to develop limited numbers of larger, more complex, or exquisite, satellite systems that perform many payload missions. Over the past two decades, this approach has produced delays in the development process of multiple satellite programs, costing the government billions of dollars.

Last year, the Director of the NRO, retired General Bruce Carlson, hinted at a plan to get space acquisition back on track. He referred to acquiring systems that are less costly, standardized, and modular, allowing the NRO to rapidly incorporate state-of-the-art technology for warfighter use.[27] Exquisite satellite systems have lengthy development cycles, are expensive and vulnerable, and are withering away the space industrial base. The NSSS calls for energizing the space industrial base in support of national security.[28] Energizing the space industrial base is another way of saying; *provide the space industrial base more business*. The government's space acquisition process takes so long that the innovation in the end products becomes diminished. More business, leading to more production volume, is needed to spark innovation and energize the space industrial base. Large, exquisite satellite systems do not afford the government this opportunity. Retired Major General James Armor, former director of the National Security Space Office, recognized the enduring need for the exquisite, national security satellite systems to maintain every "asymmetric advantage they provide for our competitive edge,"[29] but suggested there may be a more balanced way to "fill the rest of the requirement space."[30] In 2010 testimony to Congress, Cristina Chaplain, the Director of the Government

Accountability Office, stated, "DoD has preferred to make fewer but heavier, larger, and more complex satellites that perform a multitude of missions rather than larger constellations of smaller, less complex satellites that gradually increase in sophistication."[31]

In the current fiscally constrained environment, an effort to balance the U.S. exquisite space architecture with smaller, less expensive satellites is needed. The 2011 NSSS, which opens the door to pursue a balanced architecture, states, "We will continue to explore a mix of capabilities with shorter development cycles to minimize delays, cut cost growth, and enable more rapid technology maturation, innovation, and exploration."[32] A strategic approach to balance U.S. space architecture between small satellites and large, exquisite satellites is needed to strengthen the industrial base, improve warfighter capability, and reduce acquisition costs.

Strengthening the Space Industrial Base

> *"A resilient, flexible and healthy space industrial base must underpin all of our space activities."*[33]
>
> \- National Security Space Strategy, January 2011

More business opportunities for the space industrial base will strengthen it through increased innovation, competition, and sheer volume. Producing limited numbers of systems has forced the space industrial base to consolidate, leaving only a few satellite developers to compete for the low-volume business. Developing more small satellites versus fewer large satellites will provide a steadier pipeline for industry, energizing them and allowing them to maintain expertise. In a 2010 report to Congress, the NRO described how production of "low-volume government satellites do not provide sufficient market stability."[34]

In the last 10-15 years, the space industrial base has consolidated from over 50 companies to just four major contractors today.[35] Instead of four satellite builders capable of competing for contracts, a variety of companies can afford to get into the small-satellite business and invent new ideas and concepts. More contracts available for satellite payload and component development will most certainly boost competition, which has a doubling effect of reducing costs and increasing innovation. Long development cycles, typical of exquisite systems, hamper innovation by locking in designs and technologies years ahead of going operational. Innovation will create concepts where constellations of smaller satellites provide opportunities to operate cooperatively to perform a single mission, enhancing existing capabilities limited by traditional, single-satellite thinking.[36]

Improved Warfighter Capability

As the space environment becomes more contested, the traditional, stationary, national security satellites offer a big target for anti-satellite systems. The simple fact that over 60 nations possess space capabilities illustrates the contested, competitive, and congested nature of the space environment.[37] As more nations fly space assets, more space debris is being produced.

A more balanced architecture would improve warfighter capability through increased survivability and responsiveness. Developing smaller satellites will not only make them harder to shoot down, but it will increase their agility, making them more difficult to find after a possible change in orbit, and more easily able to maneuver and avoid space debris. Survivability can also take the form of replenishing damaged satellites in a rapid manner. If a constellation of small satellites were to be deployed, more assets increase the survivability of the warfighter capability by sheer numbers. Responsiveness to the warfighter is another advantage of a more balanced architecture. Combatant Commanders or the actual troops in the field request intelligence, surveillance, and reconnaissance (ISR) information, but may not have first priority to receive the collected data. A small-satellite concept may be able to provide dedicated ISR or communications capabilities to the troops in the field.[38] Recent successes of TacSat-3 in the area of responsiveness are encouraging. Within ten minutes of being tasked from troops in the field, TacSat-3, a small satellite technology demonstration, downlinked the requested data to them. Responsiveness can also be enhanced by taking advantage of the latest technology. Although, small satellites are not designed to last long on orbit, mainly due to fuel weight, the rapid refresh rate of new technology will provide the warfighter with the most up-to-date technologies. While small satellites are currently limited in power, resolution, and persistence, greater technology refresh and miniaturization of circuitry and components will inevitably bring traditional, big-space capabilities to smaller satellites.

Decreased Costs

In 2009, the Chief of Staff of the Air Force, General Schwartz, told a defense writers' group that the Air Force might be in a better situation if it designed space platforms that were smaller and less complex.[39] General Schwartz's comments support the concept of evolving into a balanced architecture involving smaller, less expensive satellites. A balanced architecture allows space acquisition costs to decrease due to increased competition, shortened development cycles, standardization, and launch costs.

The dramatic and growing gap between funding and the number of space launches seen over the years highlights the growing costs and fewer systems. The gap is an indication of problems in space acquisition. In the 1960s, the U.S. launched about 55 systems a year for approximately $4 billion per year. In the 2000s, the U.S. launched about 6 systems a year for approximately $11 billion per year.[40,41] Less complex, small satellite systems would reduce the per-unit cost of satellite systems, increasing competition and rejuvenating the space industrial base. The Advanced Extremely High Frequency satellite costs ended up over $2 billion per satellite.[42] For $88 million, TacSat-3 demonstrated an inexpensive approach that enabled state-of-the-art hyperspectral imaging technology to be exploited by the warfighter.[43] If funding for exquisite and small satellites was allocated more equitably, the U.S. could have a whole arsenal of small communication satellites, potentially providing better support to the warfighter and greatly increasing survivability. More satellites would generate a regular production flow and launch volume, surely driving efficiencies, standardization, and technological innovation along the way, shortening the development cycle.

Smaller satellites can also be launched by less expensive launch vehicles. The smaller satellites become, the easier, more responsive, and less expensive launches will become. SpaceX and Orbital Sciences are striving to make launching satellites more affordable.

Conclusion

A swift strategic move to balance the U.S. NSS architecture with small satellites is essential to rejuvenate and strengthen the space industrial base, ensure the U.S. warfighter advantage, and save costs on space acquisition. As more countries have space assets and anti-satellite capabilities, traditionally large, exquisite systems are more vulnerable. As presented, small satellites offer the opportunity to energize the space industrial base through increased competition, innovation, and production volume. Small satellites will improve warfighter capabilities through increased survivability, responsiveness, and innovative technologies.

Additionally, the increasing cost of space acquisition could potentially be reduced by pursuing small satellite constellations. Without new strategic direction, the U.S. will continue to shrink the space industrial base, pay exorbitant amounts of money for space capabilities, and lose the technological warfighter's edge gained through innovation. Every NSS program office should investigate incorporating small satellites into their mission architecture. Recent leadership remarks and national policy support a shift in these space strategies. A balanced architecture of small and exquisite satellites is the cure for acquisition woes and space industrial base issues.

Author: Mr. Kevin Gooder, Department of the Air Force

ESSAY 3: EXPORT CONTROL – HELP OR HINDRANCE TO NSS?

In the last decade there has been a dramatic shift in the U.S.'s ability to compete in the world market as evident in the growing number of worldwide successful launches which have not been provided by a U.S. company. One of the primary issues considered to be constraining U.S. access to the world space market is the current export control regime. The export control regulations were put into place to assure U.S. national security and maintain a technological edge. The problem for the U.S. is the global space market continues to grow and technologically advance in spite of the U.S. tightly holding onto pace technology. Therefore, all the export regulations do is act as a competitive barrier to U.S. space companies creating a potentially bigger national security issue – a dwindling U.S. space industry.

Export Control Act and the International Trafficking in Arms Regulations

The Arms Export Control Act (AECA) was enacted in 1976 and authorized the president "to control the import and the export of defense articles and defense services and to provide foreign policy guidance to persons of the U.S. involved in the export and import of such articles and services."[44] It further authorized the president to establish a list of those defense articles and services to which the law applies, known as the U.S. Munitions List (USML) and to establish regulations licensing the import and export of these items. The regulation controlling items listed on the USML is known as the International Trafficking in Arms Regulations (ITAR) and is managed by the Department of State (DoS) under the Directorate of Defense Trade Controls.

With a globalized world, any limitations put on a business's ability to compete in the world market can have devastating and unrecoverable effects. Barriers could be catastrophic for the industry and the country. In the 1990's during the "peace time dividend drawdown" the global economy exploded, and so did the commercial satellite market. Unfortunately, several contractors also "exploded" by sharing "sensitive U.S. technologies as they pursued commercial relations with China"[45] and Congress reacted, ultimately with devastating results for the U.S. satellite market and cascading effects for the rocket/launch market.

The Fall and the Consequences

Prior to 1996, communications satellites (COMSATs) were monitored and licensed for export by the DoS under ITAR. In 1996 during the Clinton administration, due to pressure from the Department of Commerce (DoC) and several satellite and space industry groups, comsats were removed from the USML and transferred to the Commerce Control List (CCL) for dual-use technologies under the auspices of the DoC. [46] Around this same time there were two incidences stemming from rocket failures in 1995 and 1996 that created an international stir.

By 1998 when these issues came to light, a special Congressional bi-partisan panel was commissioned to investigate whether the two companies had shared sensitive U.S. space technology information with China. It was determined by the panel, and later corroborated by a separate Department of Justice investigation, that sensitive information had been shared with the Chinese. Congress reacted with the FY1999 Strom Thurmond National Defense Authorization Act (NDAA) which removed any authority of the president to decide whether comsats should be on the CCL or the USML by stating specifically not only communication satellites but "all satellites and related items" will be included on the USML.[47] Therefore, to provide relief to the industry would require an act of Congress rather than a mere policy change by the president.

Effects on Domestic Space Business

So what effect has this strict language, and cumbersome and lengthy processes had on the space industrial base? The Center for Strategic International Studies (CSIS) did an assessment of the U.S. space industrial base and the effect of export controls. There were several findings, but those of note include: (1) The current export control policy has not prevented the rise of foreign space capabilities and in some cases has encouraged it (ITAR-free space products); (2) The U.S. share of the global space market is steadily declining, and U.S. companies are finding it increasingly difficult to participate in foreign space markets (particularly the 2nd and 3rd tier contractors); and (3) There is unanimous agreement that the export control process can be improved without adversely affecting national security.[48]

The latest Defense Industrial Base (DIB) Assessment on the U.S. space industry corroborates CSIS findings. The overall worldwide satellite industry revenue over the previous five years has increased an average of 11% per year due to commercial communications satellites,[49] yet the U.S. share of satellites sold has decreased. The U.S. share of the market over that same approximate time period has dropped to around 60-65% of the world market, whereas before 1999 and the addition of satellites to the USML, the share was around 80-85%.[50] The U.S. share of worldwide launch revenues has also decreased from approximately two-thirds of the market to one-third.[51]

The additional question to explore besides the decreasing share of the global market is - what is the cost associated with compliance with the export control rules? The latest DIB Assessment report determined average compliance costs totaled $49 million per year with the largest share (64%) stemming from salaries of people hired to process the compliance packages for export licenses and support from outside council.[52] The trend in who carries the burden of those costs falls primarily to second tier and third tier contractors who bear an average 29% and 57% of the total yearly export licensing costs, respectively.[53] Unfortunately, second and third tier contractors are more likely to be smaller firms with less diverse product or service lines. Also, with the length of time necessary to gain approval for export control licenses, there has to be some associated cost and lost business that international competitors do not have to bear.

Plans to Correct the Situation

There are some definitive actions being taken elsewhere within the government to try to solve this complicated problem. In April 2009 Congressman Brad Sherman, Chairman of the Subcommittee on Terrorism, Nonproliferation and Trade to the House Foreign Affairs Committee held hearings on "Export Controls on Satellite Technology".[54] The results of those hearings ended up in a bill titled "Defense Trade Controls Performance Improvement Act of 2009" (H.R. 2410). Unfortunately, it stalled in the Senate and never went any further.

In August 2010, the President announced a joint National Economic Council and National Security Council review of the export control regime. When the joint review was completed, the President announced a three phase plan to implement four major changes. The first phase will be to "harmonize definitions to end jurisdiction confusion between the two lists"[55] and streamline and standardize the licensing processes. Phase II will be about restructuring both lists into the same structured approach and start to "transition toward a single electronic licensing system."[56] Finally, Phase III will "merge the two lists into a single list, and implement systematic process[es] to keep [the lists] current,"[57] and "implement a single licensing agency."[58] "The goal of the reform effort is 'to build high walls around a smaller yard' by focusing our enforcement efforts on our 'crown jewels.'"[59]

Despite the President's intentions, it is not clear that the steps go far enough. The combined list needs to be broken down to specific component of even subcomponent levels of restriction. Also, for many items the U.S. needs to be more open with allies and establish say an annual authorized technology list or annual authorized vendor status for each of our allies that will not require a review for each and every transaction before they take place, but only for those components or subcomponents on the combined list. The U.S. must make these changes in a timely manner so as to not jeopardize the 2nd and 3rd tier contractor industrial base. Finally it should be noted in discussing a possible solution to the issue with industry reveals that they have talked with Congressional representatives on the issue, but they believe Congress will not act without hearing from the government departments as to the economic and national security implications of a potentially failing space industrial base.

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ESSAY 4: SPACE RACE TO SNAIL'S PACE? A REVIEW OF STEM EDUCATION

Introduction

The 2010 National Security Strategy identifies strengthening education and human capital as a top priority for the future prosperity of this nation. Specifically, the strategy enunciates the need for us to invest in STEM to regain lost ground in these skill areas so we retain our competitive advantage in an increasingly connected and mobile global economy.[60] The NSSS further emphasizes STEM, recognizing it is the foundation for space-related career fields. The strategy suggests the Department of Defense and the Intelligence Community will synchronize education initiatives and investments with other departments and agencies to ensure an ample supply of space professionals with appropriate skills and capabilities and even discusses structured personnel development programs.[61]

As strategies, both the National Security Strategy and the NSSS use the right words and prioritize STEM education properly, but they lack clear, measurable goals. STEM education is more than training tomorrow's workforce. It is training tomorrow's generation to survive, to make the right decisions for the nation, to understand allies, enemies, and developing nations.

It Starts with Education

The State Educational Technology Directors Association (SETDA) is trying to avoid STEM education failure. In a 2008 report, they assessed STEM education, identified barriers to implementing STEM education, and recommended options for policymakers and stakeholders to support STEM education.[62] Barriers to implementing STEM are, simply put, the constraints of the education system. Curriculum development and approval is challenging because STEM does not bucket neatly into existing standard curricula. Teachers are not qualified and it is a challenge to get qualified teachers because of the system. Statistics cited by SETDA include: few graduates major in STEM-related fields and then choose a teaching career; only 60% of public school grade 7-12 math teachers majored in math in college; two-thirds of students taking physical science classes do not have teachers who majored in physical sciences in college or are certified to teach physical sciences; certification requirements make it difficult for STEM trained professionals to transfer to teaching; and there are inadequate policies to recruit.[63]

These statistics are focused on K-12, where STEM inspiration begins. The facts are compounded by increased emphasis on reading rather than science and math in underperforming schools, low pay for teachers compared to STEM industry pay, and lack of quality education for those teachers who emphasize education as their focus area and teach STEM.[64]

SETDA recommends fixing the problem through initiatives that begin with Kindergarten and end with recruiting, training, and retaining a STEM education workforce. Their initiatives, developed largely by education professionals, seek to inspire the nation, state-by-state, to create the same sense of urgency our nation had after World War II. SETDA argues STEM education is more than developing the next generation of innovators; it is ensuring the next generation can understand how STEM impacts their lives and make informed decisions.[65] In the end, SETDA concludes STEM stakeholders must bear the responsibility of ensuring all students have access to high quality STEM education so they may thrive in a 21st century global economy.[66]

Existing National STEM Initiatives Lack a Mandate for Change

In their FY2006-2011 Strategic Plan, the National Science Foundation (NSF) identified initiatives to support transformational research and promote excellence in science and engineering education to fuel innovation, stimulate the economy, and improve quality of life.[67] Additionally, metrics were developed with the Office of Management and Budget Program Assessment Tool to ensure accountability.[68] NSF advertises sixty grant programs promoting STEM education from K-12 through the post-doctorate level. NSF does not post achievements made with grant money, including areas of education most competitive for grants and areas achieving greatest results. This is disconcerting. However, the NSF interprets its legislative mandate to develop methods which will bridge the gap between K-12 and undergraduate STEM programs, to broaden participation in STEM programs, and to integrate research and education.[69] The strategy provides the means to further STEM education, not a plan for change.

In 2009, President Obama made STEM education a national priority. His mandate was to re-define and right-size the federal role in education, by replacing No Child Left Behind with a new law that raises expectations, challenges failure, rewards success, and provides greater flexibility for schools to innovate and improve results for their students.[70] However, his specific strategy is to prepare an additional 100,000 STEM teachers by the end of the decade, emphasizing improving teacher preparation and education to ensure a talent pool of qualified science and math teachers is available to educate the next generation.[71] President Obama did not tread into areas of what those teachers would impart on students, suggesting his rationale is that more teachers will fix the problem rather than a change in curriculum emphasis.

STEM Education Initiatives in the Space Industry

NASA has the lead for the government in space education. All of NASA's mission directorates have an education compendium. NASA's perspective is that you need to do more than offer a grant or provide materials to students and they emphasize this approach through a consistent effort to build relationships with 500+ colleges and universities, hundreds of K-12 schools/districts, and 350+ museums and science centers.[72]

NASA's Office of Education manages funding, including nine higher education programs and 12 K-12 programs. Each program is assessed by an independent review to ensure it is meeting goals. All programs fully support national STEM priorities focusing on state-based education and student performance; the intent is to provide hands-on, practical experience which inspires a future workforce in STEM, ideally in a field that aligns with NASA's missions.[73] For FY11, the President's Budget Request included $145M for education initiatives, which is 22% more than the FY10 request but nearly 40% less than what was authorized in FY10.[74] In FY11, the budget request includes an increase for K-12 initiatives, with nearly $20M more requested for this emphasis area.[75] It is largely directed toward the Summer of Innovation program that provides intensive STEM education targeted to middle-school students.[76]

Further, NASA's website has focused areas for students and educators. Each section is filled with information regarding upcoming programs, teaching tools, games, and other ideas to inspire interest in STEM, though the emphasis is on space and space-related topics. Additionally, each NASA entity engages in an active mentoring program and focused engagement with schools. NASA's efforts are outstanding but remain hard to learn about unless you are researching STEM education opportunities because of lack of marketing.

In California, one organization is tackling the challenge of marketing space education and careers. The California Space Authority (CSA) is a non-profit corporation, representing commercial, civil, and national defense/homeland security interests of California's diverse space enterprise community in all four domains: industry, government, academia, and workforce.[77] CSA established a subsidiary non-profit, the California Space Education and Workforce Institute (CSEWI) whose goal is to inspire engagement in California-based space-related education and to attract and retain a healthy California space workforce.[78] CSEWI has established an online STEM inventory of informal and formal education opportunities; implemented a method to connect California universities with the California aerospace industry to facilitate cross-cutting research and development; and begun a project to target mid-career changers in STEM fields to become public school teachers and vocational instructors.[79] CSEWI is lashed up with NASA.

Google is using an informal method to influence STEM education through its Google X PRIZE Foundation, which has as a goal to get children excited about math and science through a series of web offerings and youth contests. The Foundation also sponsors the Lunar X PRIZE contest, which offers $30M in prizes to the first privately funded teams to safely land a robot on the moon, have the robot travel 500m over the lunar surface, and send pictures and data back.[80](There is a subtle STEM education initiative within the rules and regulations of the Lunar X PRIZE competition. Each team had to agree to specific public relations requirements, including extensive social media outreach using specific methods.[81] This method of advertising the competition may prove the most effective of existing space industry STEM education inspirational initiatives since it targets children where they live – in a world of social media.

Conclusion

Space is increasingly congested, contested, and competitive. Our nation must be poised to respond to the challenges and threats this evolving environment presents. Space is no longer manned missions for exploration. Our very ability to communicate relies on space. We need a generation of Americans skilled in everything from environment to communications to finance and how space intersects and interacts with these. We do not need just STEM education; rather, we need a letter from Roosevelt. We need a national mandate for education reform and a sense of urgency for tomorrow's "space race."

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ENDNOTES

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