Tipping Point: Maintaining the Health of the National Security Space Industrial Base

September 2010

AEROSPACE INDUSTRIES ASSOCIATION

Crescent Moon
A last quarter crescent moon above Earth's horizon is featured in this image photographed by the Expedition 24 crew on the International Space Station.

Photo courtesy of NASA

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AIA released a report to the new administration and Congress in January 2009 on the important role America's space efforts play in the everyday lives of our citizens, our economy and national security. That report, *The Role of Space in Addressing America's National Priorities*, provided industry's perspective and recommendations for the path forward on a variety of the major space issues confronting our nation's policy makers.

In July 2009, AIA released a report, *The Unseen Cost: Industrial Base Consequences of Defense Strategy Choices,* that laid out the case for narrowing the gap between the Defense Department view of industry as an always ready supplier of military capabilities and how industry actually makes decisions on what capabilities it can offer.

In this new report, *Tipping Point: Maintaining the Health of the National Security Space Industrial Base*, AIA expands on the national security space sections in our earlier reports.

As discussed in *The Unseen Cost*, critical industrial base challenges already exist for the national security space sector. Moreover, *The Role of Space* highlights the increasing threats that today's national security space capabilities face and points out that space is relied upon by our economy, military, Intelligence Community and national leaders more today than at any point since the dawn of the space age.

The new National Space Policy and review of Defense Department Space Posture will help lay the groundwork for future government policy in national security space. However, changes in policy alone won't be sufficient to address the new challenges our nation faces. It's more critical than ever that new policy be backed by strong leadership, integrated strategy and the long-term funding and stability needed to maintain cutting-edge, cost-effective space programs.

As other nations make rapid advancements in acquiring or exploiting space capabilities, America's leadership in space is no longer guaranteed and the security of our space assets is no longer assured.

Given the growing U.S. dependence on these systems and their contribution to the global economy, our nation cannot afford to lose its preeminence in space. We must take the necessary steps to restore and maintain the vitality of our national security space programs to avoid a crisis beyond which irreparable harm occurs to our nation's defense and economic success.

Sincerely,

Marion C. Blakey
President and Chief Executive Officer

Looking Down on Earth
Clouds and sunlight over the Indian Ocean, as seen from Discovery during the STS-96 mission in 1999.

Photo courtesy of NASA

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EXECUTIVE SUMMARY:

I. Introduction

National security space systems provide missile warning and defense; global communications; environmental monitoring; global positioning, navigation and timing; launch capability, and intelligence, reconnaissance and surveillance. They are the bedrock of our 21st century military capabilities and part of our economy's critical infrastructure. Yet in light of an increasingly contested, congested and competitive space domain – and a national security space industrial base that is increasingly fragile – it is more important than ever to match policy goals with strong leadership, integrated strategy and the long-term funding and stability needed to maintain cutting-edge and cost-effective space programs.

II. Evolving Role of National Security Space Systems in U.S. Security

Since the dawn of the space age, military and intelligence space programs have been critical to our national defense. During the early years, national security space efforts were matched with clear goals and strong funding levels. However, in today's world national security space systems face an array of increased requirements and funding pressures.

III. National Security Space Today

While not widely understood by the general public, a look across today's national security space sector shows a variety of critical technologies and skills that are needed for robust national and homeland defense.

National Security Space provides:

- Global communications
- Imaging, surveillance and environmental monitoring from space
- Missile warning and defense
- Positioning, navigation and timing
- Space launch

IV. Key National Security Space Challenges

Export restrictions, unstable funding, the lack of a national security space strategy and strains in the U.S. workforce are placing pressure on U.S. space systems suppliers and manufacturers, which threatens U.S. space economic leadership.

Other priority areas:

- Space and cyberspace protection and space situational awareness
- Trade and international partnership
- Operationally Responsive Space
- Strategic systems and missile defense

V. AIA Recommendations

A coherent and long-range strategy for national security space systems must be matched with stable budgets and funding levels.

Recommendation #1 – Establish Leadership and Program Stability.

National level leadership is needed for the space sector that provides:

- A long-term national security space system investment strategy
- Multi-system procurement strategies important for space industrial base health
- Balanced and stable budgets and funding that are critical to maintaining cutting-edge national security space programs

Recommendation #2 – Modernize & Maintain Infrastructure.

National security space systems are a critical infrastructure and they must be sustained and modernized across areas such as:

- Liquid and solid rocket propulsion
- Military satellite communications
- Missile warning and defense
- Operationally Responsive Space
- Positioning, navigation and timing
- Selected space optics, overhead imaging and non-imaging sensors
- Supply chain and components

Recommendation #3 – Modernize Export Control Policies and Promote Industry's Ability to Compete.

AIA recommends that the U.S. government complete a careful review of space technologies – including commercial satellite technology – to reevaluate which technologies should be controlled at what level and to determine the most appropriate jurisdiction, while keeping our primary focus on national security concerns.

Recommendation #4 – Support Current and Future Workforce.

Make science, technology, engineering and mathematics education a national priority.

Recommendation #5 – Focus and Support Robust Funding for Research and Development and Science and Technology Efforts.

Recommendation #6 – Ensure the Protection and Responsiveness of U.S. Space and Cyberspace Capabilities.

Steps needed to protect U.S. space capabilities:

- Support robust funding for space and cyberspace protection, including funding for the Air Force Space Command and NRO joint Space Protection Program
- Develop and fund significant investments in space situational awareness (SSA) capability
- Collaboratively address the issue of orbital debris mitigation and remediation
- Implement a plan for leveraging commercial SSA and sharing appropriate capabilities with commercial space operators
- Maintain stable funding levels for Operationally Responsive Space that utilize industry capabilities to enable responsive, affordable, on-demand space support for national security operations and the U.S. warfighter

VI. Conclusion

Due to growing international competition, outdated export control policies and challenges facing our domestic workforce, the U.S. national security space industrial base is increasingly fragile. Adequate funding and a long-term strategy are more important than ever to ensure a healthy industrial sector that is able to meet government's mission needs.

We must restore the vitality of our national security space programs to prevent irreparable harm to our nation's defense and economic success.

Photo courtesy of U.S. Air Force

Unmanned Aerial Vehicle controlled via satellite communications link

I. Introduction

Tipping Point: Maintaining the Health of the National Security Space Industrial Base

Today's national security space assets have become critical components of the U.S. military, our national security and our economy. Once seen strictly as "strategic" assets for use by the Intelligence Community and national leadership, today's space systems are now enabling virtually every critical capability supporting the U.S. government and our warfighters: command and control of unmanned aerial vehicles (UAVs); weather and climate monitoring; improvised explosive device (IED) detection; global positioning, navigation and timing; global communications; precision strike and missile defense. In addition, national security space systems once relied upon solely by the U.S. government are now a vital part of our critical economic infrastructure.

With the increasing importance of space to our economy, warfighters and national security, the space domain faces very serious challenges. According to government leaders and the Defense Department's preliminary Space Posture Review, other countries are making significant advances and today's space environment is more "contested, congested and competitive" than ever.[1]

More than 60 nations today are engaged in space efforts. Both China and India are investing in launch systems whose costs rival U.S.-manufactured systems. From 2005 to 2008 China conducted 26 space launches that achieved Earth orbit or beyond, according to AIA's *2009 Aerospace Facts and Figures*. In that same period India conducted seven launches, with significant increases planned by the Indian Space Research Organization for the future. Russia and the European Space Agency conducted 94 and 23 launches respectively during that period. U.S. space launches during that timeframe stood at 72, well behind Russia.[2]

Current U.S. export control policies for space systems often harm U.S. industry. Outdated policies for commercial satellites and related items have decreased America's worldwide share of the global satellite market. This poses challenges to the U.S.'s ability to lead space partnerships with our allies abroad, weakens our ability to compete and ultimately wreaks havoc on our domestic space industrial base and security.

In addition, program cancellations and changes at NASA and the Defense Department are further exacerbating workforce deficiencies that will impact future U.S. space efforts. The number of national security space suppliers is dwindling. Loss of U.S. suppliers and their robust pool of space professionals endangers our nation's lead in producing the world's preeminent space technologies, especially as other nations graduate thousands more engineers than the United States.[3]

With competitors making rapid advancements in acquiring or exploiting space capabilities, American leadership in space is no longer guaranteed and the security of its space assets is no longer assured. Given the growing U.S. dependence on space systems and their contribution to the global economy, our nation cannot afford to lose its preeminence in space. We need to maintain – and in some cases restore – the vitality of our space programs to prevent irreparable harm to our national economic and security interests.

II. Evolving Role of National Security Space Systems in U.S. Security

Most Americans are familiar with the role fighter aircraft, submarines and tanks play in national security. However, because satellites are not readily visible, the importance of space infrastructure is not always recognized. Yet military and intelligence space efforts have grown from the dawn of the space age to become absolutely critical to our national defense and economy.

Industry has played a key role in developing space systems for the U.S. government since the beginning of the space age. In author Neil Sheehan's *A Fiery Peace in a Cold War*, the story of legacy aerospace companies like Convair and TRW and the race in the 1940s and 50s to build national security space launch and reconnaissance technology for the U.S. military and Intelligence Community is an important chapter in space history.[4]

The early years of national security space were characterized by our national needs during the Cold War. U.S. national security space efforts were distinguished by clear national priorities, stable funding levels, a growing and diverse industrial base and a good degree of risk tolerance. For instance, the National Reconnaissance Office's (NRO) acclaimed Corona program endured despite twelve successive launch failures.[5] The national drive to achieve and maintain U.S. leadership in space helped achieve many of the truly amazing space capabilities upon which our troops, national leaders and economy rely today.

III. National Security Space Today

The Persian Gulf War of 1990-1991 marked a significant milestone in the evolution of national security space. Deemed by some as the nation's first "space war," it was the first time that the U.S. military relied on space systems and their capabilities for much of its operations. Space systems supported soldiers in the field, Patriot anti-missile systems and air and sea operations. According to the Defense Department, more than "90 percent of communication into and out of this theater went over communications satellites."[6]

By the new millennium, space systems were not only fully integrated into military operations, but became more and more interwoven into the fabric of the modern information-based U.S. economy. However, organization of U.S. national security space operations did not keep pace with these changes. A Space Commission was established by Congress in 2000 to examine the organization and management of national security space activities. And in 2008, another group of national leaders highlighted the importance of national security space as part of the National Security Space Independent Assessment Panel. One significant concern in the report was that at a time when national security space is relied upon more than ever, no single agency or leader was in charge.


Photo courtesy of U.S. Air Force

Advanced Extremely High Frequency joint service satellite communications system

Today's national security space systems are now integrated into virtually all aspects of our economy. Space systems provide modern business communications, commercial remote sensing and digital television and music for millions of consumers. Space system industry sales in 2009 topped $40 billion, bolstering thousands of American jobs.[7]

Federal funding remains a driver for the industry, and for national security space systems it accounted for more than half the $42.6 billion the U.S. government spent for space capabilities in 2008.[8] Industry continues to develop and build the government and commercial systems that are vital to our defense and economic health, contributing billions of dollars to our GDP.[9] Without U.S. industry and its workforce, we would lack a resource capable of developing, building and operating the critical space systems.

A review of today's key space capabilities shows their importance to the warfighter, U.S. defense and economic success.

Global communications

In today's challenging battlefield environment, our warfighters must be able to communicate rapidly in remote, hard-to-reach regions of the world. As demand for technology that carries intelligence and information to our deployed forces increases, global military satellite communications play an essential role in keeping our warfighters in contact with their fellow soldiers and providing them support. Satellite communications help power UAVs and also help keep troops in contact with their families – a key element in maintaining morale during lengthy deployments.

During the Cold War, national security space satellite communications largely consisted of systems designed to provide communications for the president and secretary of defense in time of nuclear war. Today, these types of survivable systems are still needed, but have other missions as well. Commercial communications satellites are also increasingly integrated into the broader global economy, providing satellite phone service, satellite television, satellite radio and other services to the public.

Imaging and surveillance from space

There are a variety of systems currently in orbit that provide imaging, geospatial, weather monitoring and other sensing capabilities to the U.S. military and everyday citizens. According to an April 2010 commentary in *Space News* by Alden Munson, former deputy director of National Intelligence for Acquisition and Technology, the need for climate monitoring satellites for military and intelligence purposes is critical.[10] Climate monitoring satellites help us better understand climate change and forecast weather to ensure safe transportation of our troops worldwide.

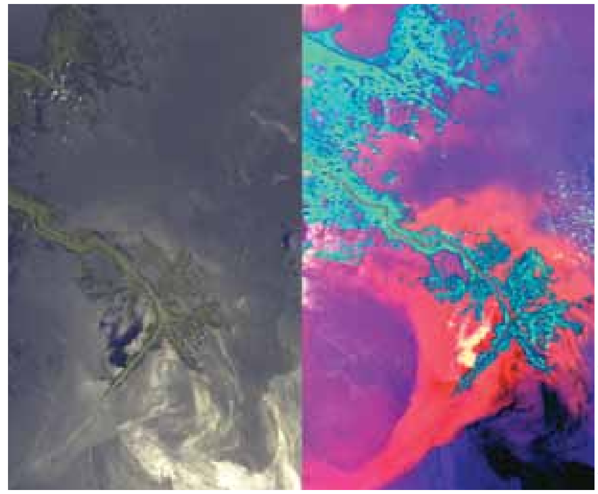


Photo courtesy of NASA

Satellite imagery of oil moving into Louisiana's coastal wetlands

With support from the National Geospatial-Intelligence Agency, imaging satellites provide critical intelligence to protect our troops. Today commercial satellite imagery is also commonplace – just look at the wealth of information available publicly over such programs as Google Earth. Imagery satellites helped our nation respond to Hurricane Katrina in 2005 and to the 2007 California wildfires.[11] Imagery satellites have also been used in 2010 to monitor the oil spill threatening the environment and economies of the Gulf Coast.[12]

Another key space surveillance capability is missile warning. When missiles are launched anywhere around the world, missile warning systems allow the United States to quickly detect and track those missiles and determine whether they are a threat.

Missile Defense

Today, the U.S. Missile Defense Agency employs a missile defense architecture designed to intercept missiles launched against our troops, homeland, friends and allies. With nations such as North Korea and Iran developing increasingly sophisticated long-range missiles, missile defense has become a must-have for protection.

Photo courtesy of Missile Defense Agency

Space Tracking and Surveillance System monitoring missile launch

Today's missile defense is an integrated, layered architecture that helps provide multiple opportunities to intercept enemy missiles. In addition, international cooperation with friends and allies such as Japan, the U.K., Australia, Israel and others helps ensure wide coverage of missile defense capability.[13]

Positioning, Navigation and Timing

The Global Positioning System, originally designed for military use, is now relied on for many commercial applications including online banking transactions, ATMs, agriculture, air traffic and ground transportation systems and by emergency responders.

As of March 19, 2010, there were 35 satellites in the GPS constellation according to the National Executive Committee for Space-Based Positioning, Navigation and Timing.[14] Today the civilian market for GPS is worth nearly $5 billion. Maker of GPS hardware and software Garmin Ltd., saw total 2008 sales of $3.5 billion, more than doubling 2006 sales, according to *Space News*.[15]

Photo courtesy of NOAA

One of over 20 GPS satellites that transmit radio signals to Earth

GPS helps farmers make more effective use of their land, directly contributing to lower maintenance costs and increased crop yields by allowing them to more efficiently sow seeds, till, water, fertilize, apply pesticide and map field boundaries. Personal smart phones are also increasingly connected to the GPS network. Overnight delivery services are integrating GPS into their transportation vehicles to move goods faster for delivery and commercial aircraft increasingly rely on GPS for navigation. The Federal Aviation Administration is pursuing a major effort to modernize air traffic control and flight navigation by upgrading outdated radar systems to satellite-based systems.[16]

Space Launch

Of course, none of the key space capabilities would be possible without the means to get spacecraft into orbit such as the Defense Department's Evolved Expendable Launch Vehicle (EELV). Delta IV and Atlas V rockets are designed for a high degree of reliability and are able to launch large amounts of payload into orbit, including large satellites and smaller secondary payloads.

According to a 2006 RAND Corporation report, the Atlas V and Delta IV were developed with significant amounts of private investment to serve commercial customers. When commercial customers did not materialize, the U.S. government became the sole user of EELVs. The RAND report concludes that the technology embedded in the EELV rocket families has a high degree of reliability and "should be able to meet national security space needs through 2020 and beyond."[17] The EELV family has had more than 70 successful launches in the past ten years.[18]

Summary

In essence, virtually all military operations – and even many critical civilian economic functions – rely on national security space. The services require national security space for warfare planning, environmental monitoring, missile warning, situational awareness, secure communications, disaster relief and humanitarian assistance. The nation relies on space systems and the industry that provides them for missions that are increasingly complex and important to U.S. global preeminence.

IV. Key National Security Space Challenges

The industrial base that underpins national security space systems is increasingly fragile. The chart below, cited in AIA's report *The Unseen Cost*, provides a perspective on overall consolidation in the defense industrial base. Consolidation is particularly apparent in the national security space sector, with only one new entrant in the liquid-fueled launch sector in recent years.

Increased consolidation has placed limitations on industry competition, leaving some companies as the only providers of core U.S. national security space capabilities. As a result, when government makes decisions to cut or cancel programs, these decisions can have a dramatic impact on the remaining companies and workforce. In addition to industrial base challenges, other issues such as international partnership, space protection and missile defense must be grappled with in order to maintain our security and space capabilities.

Industrial Base Challenges: Export Barriers

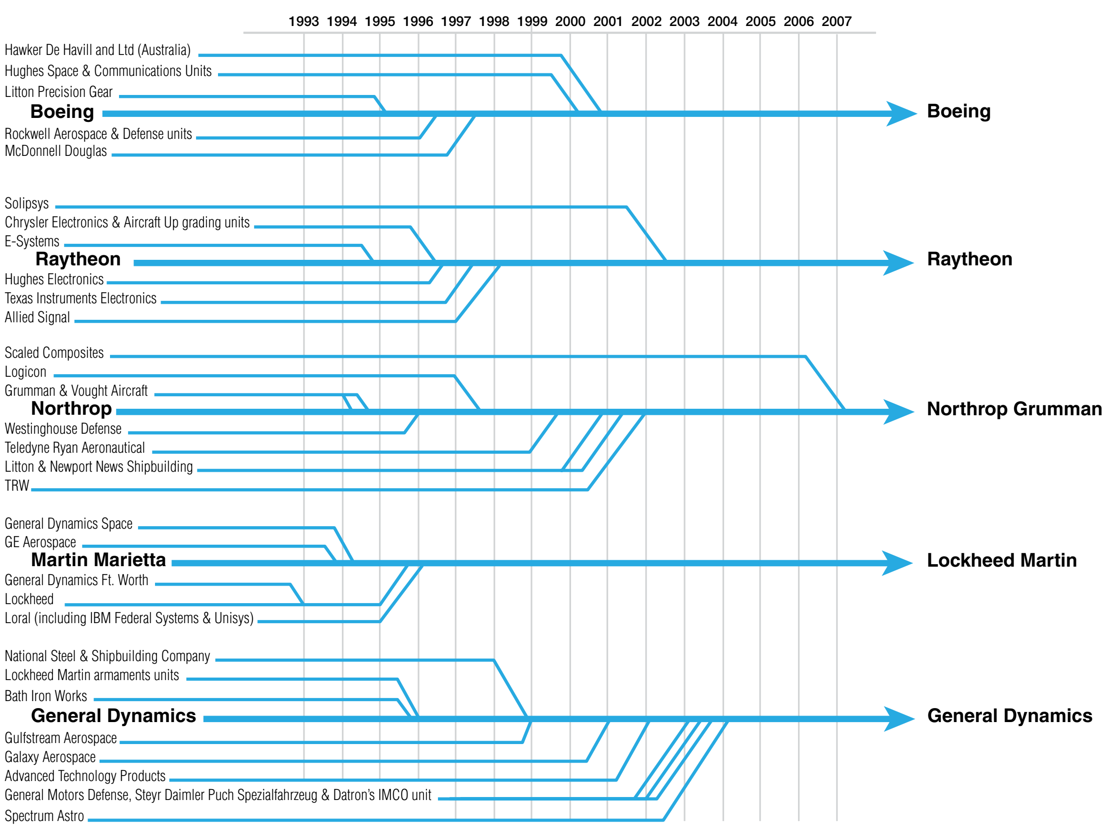
A variety of very serious challenges are negatively impacting the health of our national security space industrial base. At the forefront of these challenges are the strains created by our nation's export control policies for space technology.

In 2008, AIA participated in the working group that produced a Center for Strategic and International Studies (CSIS) study titled, *The Health of the U.S. Space Industrial Base and the Impact of Export Controls*. This important study was commissioned to address rising concern within the national security space community.

The findings showed that export restrictions have hit our nation's space companies, especially the space supplier base, particularly hard. According to CSIS, the United States dominated the global satellite export market at more than 70 percent of worldwide share in 1995. Three years later, Congress passed a law that moved the export classification of commercial communications satellites to the International Traffic in Arms Regulations (ITAR) regime, which was intended to protect sensitive space technologies and preserve U.S. preeminence in space. While intentions may have been good, the results were disastrous. According to the CSIS report, contract awards to U.S. companies for commercial communications satellite manufacturing dropped more than 20 percent by 2000, and by 2005 the United States' worldwide share of the global satellite export market stood at a mere 25 percent.[19]

ITAR hasn't slowed down the spread of space technology as more than 60 nations are engaged in space activities today. Since the U.S. law was changed, many companies in Europe and elsewhere

Significant Industry Consolidations



Consolidation of the aerospace and defense industry over time actually tout their satellites and components as "ITAR-free."[20] Commercial satellites are now the poster child for the need to modernize the U.S. export control system. U.S. firms are forced to navigate an extremely challenging pathway to gain export approval under ITAR. Even more troublesome, all parts of a commercial satellite – no matter how innocuous – are restricted and considered munitions list items. This poses challenges to the United States' ability to lead space partnerships with our allies abroad and is wreaking havoc on our domestic space industrial base.

With outdated and unduly restrictive export control policies, our nation has in effect forced the space industry to rely on the U.S. government for its survival and prevented the development of a robust commercial base for the U.S. space industry. According to CSIS, 60 percent of the industry's revenues are tied to national security, and when civil government space is included, nearly 95 percent of the industry's revenues are tied to the U.S. government.[21]

A 2008 survey by the National Security Space Office of nearly 200 small U.S. space companies found that 70 percent of those companies surveyed stated that ITAR restrictions inhibited their ability to compete for foreign business. More than 40 percent of companies cited ITAR restrictions for hiring difficulties. Many of the survey's findings show that our nation's small space businesses are the most vulnerable to fluctuations in government funding and compliance burdens.[22] Small businesses are the foundation of any strong and innovative industry, but export restrictions pose real challenges to sustaining and growing the supply chain.

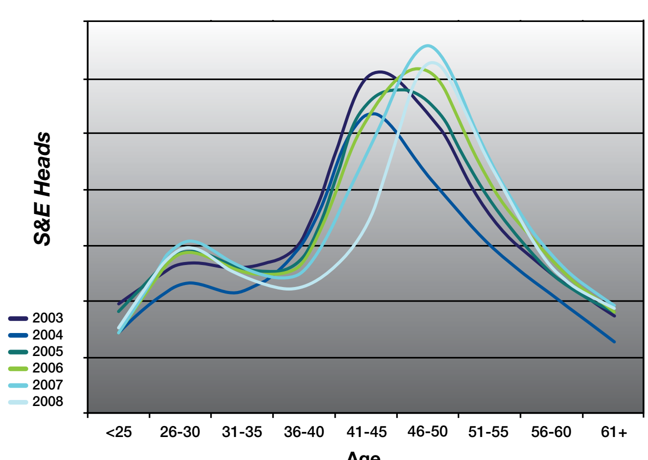
At a time when the U.S. government should be encouraging growth across all sectors of the economy, export controls are limiting growth in the space sector, especially among component suppliers. In the absence of a healthy, cutting-edge U.S. space industrial base our government may be forced into reliance on foreign suppliers for key components, accelerating the loss of U.S. leadership in space.

Industrial Base Challenges: Shrinking Workforce and Budget Instability

The health of the U.S. space industry faces significant challenges as many employees approach retirement. America's workers, scientists and engineers represent the core of our nation's space industrial base, but we are not producing the workforce currently needed to keep America on the cutting edge of technology development.

According to a 2005 study by the Defense Department's Cost Analysis Improvement Group (CAIG) – now known as the Cost Assessment and Program Evaluation (CAPE) – there is a "significant shortfall in the [numbers of] 30-40 year-old engineers and scientists supporting the space industry." Seasoned employees in the 30-40 year-old range are not present in sufficient numbers to take the reins when older employees retire.

National Security Space Headcounts



Source: Department of Defense

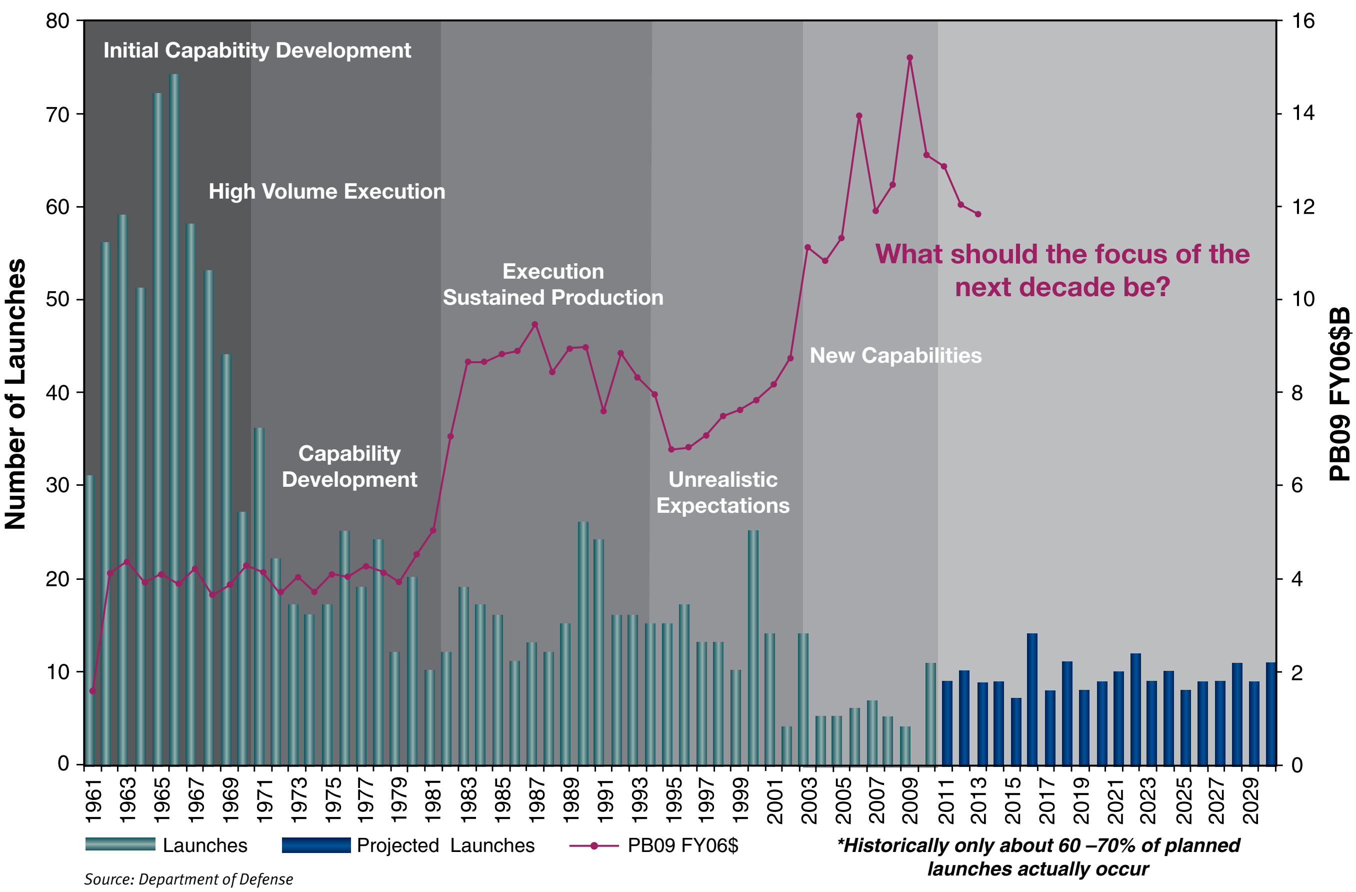
A 2009 national security space study by CAIG provided detailed data on national security space budgets and their correlation to workforce levels. During the 1990s, flattening of national security space budgets hampered industry in attracting the best and brightest to its programs. CAIG data for 2008 showed a national security space workforce largely made up of individuals in the 50 year old range, with the remainder falling mainly in the under-30 range. This development points to potential retention issues, as well as a looming retirement crisis. When placed on a graph, CAIG data on the age of the current workforce displays a distinctive "U" shape, with pronounced spikes in the under-30 and over-50 age ranges and an equally pronounced trough in the age ranges between 30 and 50.

Elsewhere, workforce levels are also less than robust. It is estimated that from 2006 through 2010 the average total NASA workforce was around 172,014.[23] This is down significantly from the peak NASA workforce average of 222,012 from 1991 through 1995. Employment in the aerospace industry, specifically workers who develop missiles and space vehicles averaged 75,000 from 2004 through 2008, down from an average of 81,000 during the prior decade.[24]

Budget instability can often exacerbate workforce shortages. An updated version of CAIG's 2009 national security space analysis shows significant budget instability in the national security space sector writ large. CAIG's 2009 analysis shows that individual programs with stable budgets have executed well and retain healthy workforce levels. Conversely, programs with unstable budgets have executed poorly and did not retain a stable workforce. Budget instability not only causes challenges for prime contractors, but also harms subcontractors and contributes to cost increases in parts and components.

Adding program terminations to the mix intensifies workforce challenges. For example, with the end of the Air Force's Transformational Satellite Communications System – which was intended to be the military's next generation satellite communications program – it will be important to ensure our nation does not lose the critical skilled workforce and suppliers associated with that effort. Without a robust pool of space professionals, we risk losing our nation's edge in producing the world's preeminent space technologies, especially as nations like China and India annually graduate thousands more engineers than U.S. universities.

NSS's Changing Focus – 2010 Update



Source: Department of Defense

Alarmingly, almost 70 percent of our eighth graders currently score below proficient in math and science, and our fifteen year olds are consistently outperformed by students from other nations. The percentage of U.S. post-secondary students earning degrees in science, technology, engineering and mathematics (STEM) fields fell from 32 percent in 1995 to 27 percent in 2004 according to the GAO.[25]

The Defense Department, NASA and industry actively support a number of STEM programs to attract more young people to the space industry and STEM career fields. The Team America Rocketry Challenge (TARC), organized by AIA and the National Association of Rocketry is one such program that has touched some 50,000 youth since its inception in 2003. TARC, along with other industry-supported programs such as MathMovesU and FIRST Robotics are important programs to help U.S. students become more competitive.

Industrial Base Challenges: Acquisition Process

Space system procurement is characterized by low production rates, small quantities and long lead times between major programs and program upgrades. This unique situation has contributed to a "win or die" environment for contractors and suppliers, which forces many space industry suppliers to refocus on non-space markets to ensure their survival. Complex and costly production and testing facilities are kept idle by low levels of development and production instead of setting the groundwork for future programs.

Challenges specific to our acquisition system also hamper industry's ability to provide the necessary space systems our warfighters expect. Although many defense programs deliver products and services on schedule and on budget, studies and reports indicate that cost growth, schedule delays and performance challenges that impact major programs emphasize the need for meaningful reforms to the acquisition system. Space systems are often the target of these discussions.

The ability of the defense acquisition process to produce the best military equipment at the best value for the taxpayers is dependent on several important factors: a strong industrial base, a rational and flexible acquisition process, well-defined requirements, stable budgets, stable procurement plans and a well-trained and experienced acquisition workforce.

AIA believes that there is room for significant improvement in the federal government's acquisition process, which many experts believe is too large, too bureaucratic, too cumbersome, too expensive and too slow in getting goods and services to our warfighters. Up-front planning and knowledge of industrial base capabilities are critical to enable informed and meaningful trade-offs between less ambitious capabilities that can be made available more quickly at lower cost and capabilities that rely on greater leaps in technology but that are also harder to define, involve greater risk, take longer to deploy and are more costly.

There have been a number of efforts by Congress to improve the acquisition system. Over the last decade, the number of legislative provisions has increased three-to-four-fold, approaching 100 over the past two years. While some of these provisions address serious problems, the continuously changing set of acquisition rules causes instability in the system, which contributes to schedule delays and increased costs.

As highlighted by the GAO, more realistic cost estimating is critical to improving space system acquisition. In July 2006, AIA helped form a Cost Estimating Forum Working Group of industry and key government representatives from the Air Force, DOD, NRO and DNI. This effort developed into what is known today as the Joint Space Cost Council, chaired by the Air Force deputy assistant secretary for Cost and Economics. On January 9, 2009, then Under Secretary of Defense for Acquisition, Technology & Logistics, John J. Young Jr., announced that the Defense Department would require the standard work breakdown structure pioneered by the Joint Space Cost Council – an important step to improve national security space program management.

Government and industry agree that there are major disconnects in the defense acquisition process among government requirements, programs and budgeting functions. Successful and sustained reform must also take into consideration the factors that drive industry decision-making and the impact of the change on the ability of the space industrial base to support our national space policy. A renewed partnership among the Defense Department, Congress and industry is needed for a world-class acquisition system that uses tax dollars wisely to purchase goods and services efficiently for our warfighters.

In addition to the workforce, export control and acquisition challenges discussed above, AIA also recommends that the following priority areas be addressed by government and industry:

Space and Cyberspace Protection and Space Situational Awareness

Space systems are woven into the fabric of everyday American life. As pointed out by the director of the National Reconnaissance Office, "one of the great engines of this world is the combination of space and cyberspace."[26]

Dozens of nations are engaged in space efforts, and according to the U.S. Strategic Command, the U.S. military tracks more than 21,000 pieces of debris traveling in low Earth orbit at speeds in excess of 17,000 miles per hour (27,200 kilometers per hour). Estimates project that there are more than 600,000 smaller pieces or particles measuring one centimeter or more that are large enough to jeopardize astronauts, spacecraft and orbiting telescopes but are too small to be seen by today's sensors.[27]

Space debris is caused by many events. In January 2007, the Chinese used a ballistic missile to

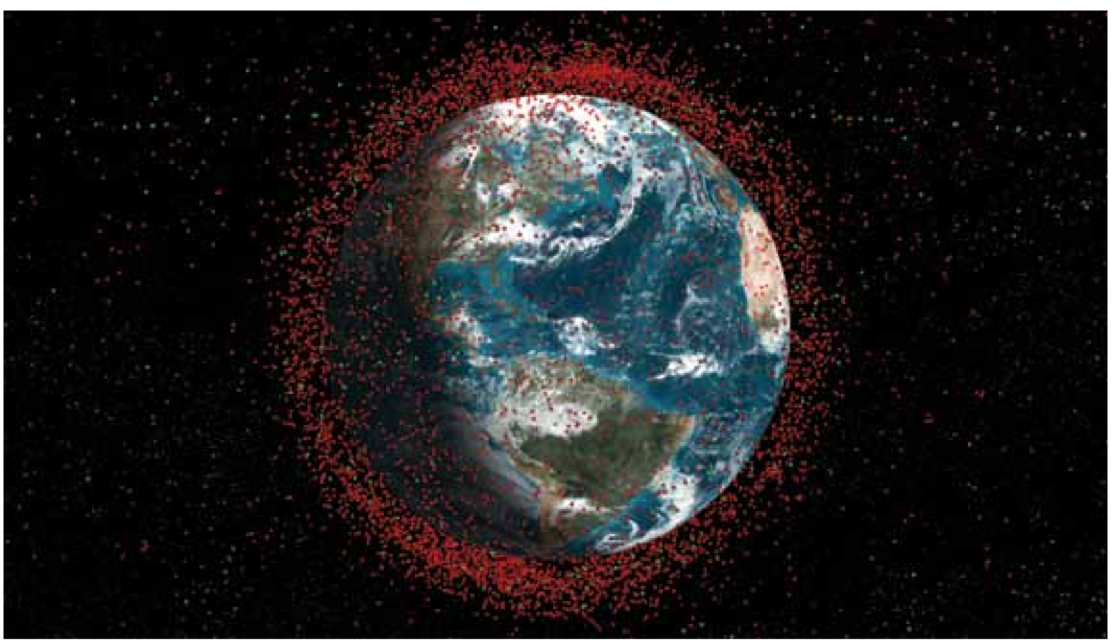


Image courtesy Analytical Graphics, Inc.

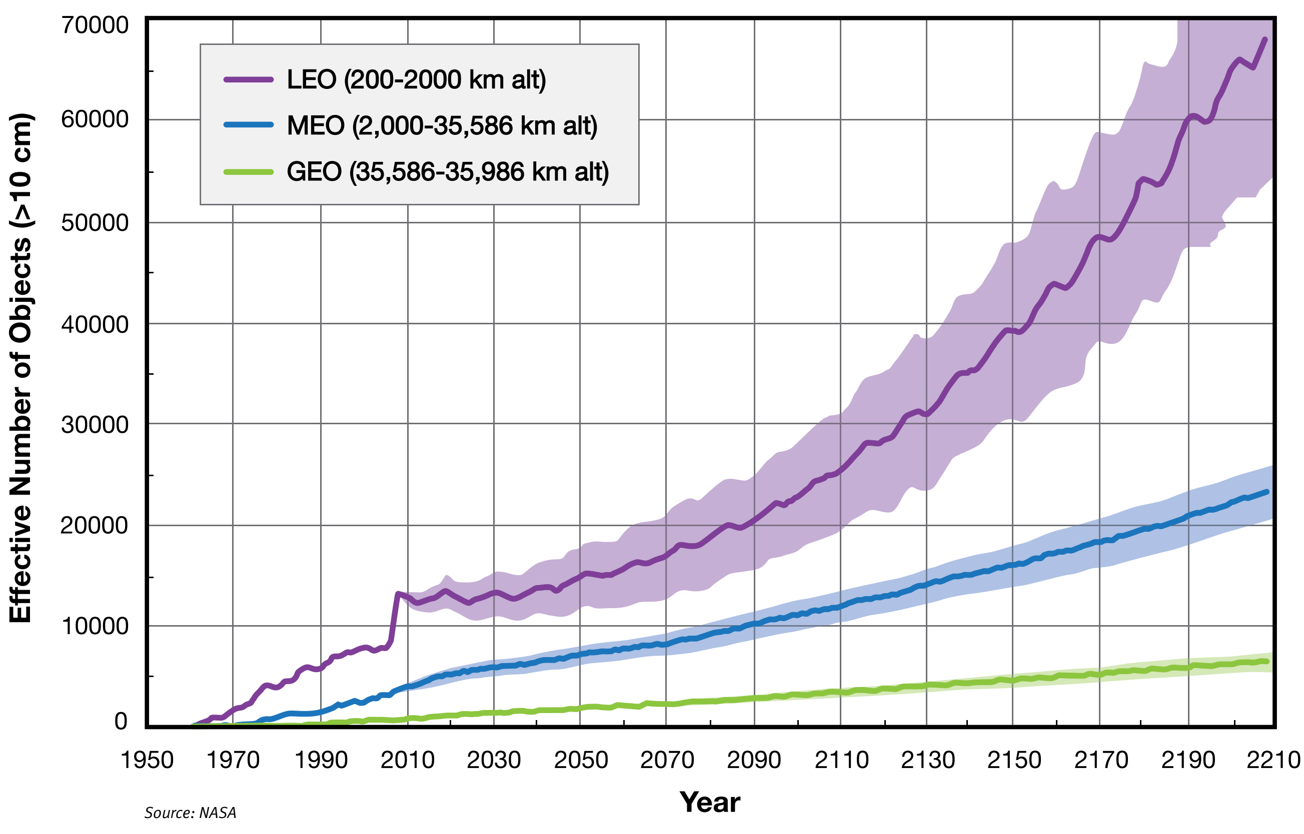
Thousands of pieces of space debris in orbit around Earth destroy an aging weather satellite. This anti-satellite test demonstrated the very real ability of a foreign power to attack and destroy space assets and resulted in a dangerous debris cloud. In addition, the February 2009 collision of a commercial U.S. satellite and Russian satellite showed that space systems not only face disruption from intentional attack but are also at risk from unintentional events in an increasingly crowded environment. In early 2009, crews aboard the International Space Station and the docked Space Shuttle Discovery undertook emergency maneuvers to avoid a small piece of debris that put their lives and craft in danger. More recently, NASA's safety chief said that space junk was one of the chief perils for the Space Shuttle Atlantis and its crew during their mission to repair the Hubble Space Telescope.

Although a number of U.S. aerospace companies are investing in the development of technologies to clean up space, the growing number of major debris fields presents a real impediment to the safety of future missions. The 2010 National Space Policy makes repeated references to the growing problem of orbital debris. It also takes the important step of calling for joint NASA and Defense Department research into technologies that could mitigate or remove on-orbit debris.[28]

Work on this front is already occurring through the Defense Advanced Research Projects Agency (DARPA) and NASA effort known as "Catcher's Mitt," which is analyzing ways to remediate space debris.[29] Charts by NASA show an alarming increase in orbital debris in recent years, and there is a real threat that debris could dramatically increase in years to come without the development of effective removal methods. Space debris absolutely must be addressed in order to protect and maintain U.S. space capabilities.

Currently, all space systems face diverse and evolving threats, not just from debris, but from unintentional or intentional satellite collision, cyber attack, radio-frequency jamming, spoofing,

Non-Mitigation Projection



Source: NASA

lasing, co-orbital ASAT and nuclear detonation. In April 2010, a satellite services provider lost control of a Galaxy 15 satellite in geostationary orbit – demonstrating the potential for disabled satellites to threaten other operational U.S. satellites in orbit.[30] In addition, a 2008 Report to Congress by the Defense Department, new threats to our GPS infrastructure continue to emerge:

> ***"New and improved jammers and jamming employment concepts are expected to emerge as potential adversaries come to recognize and appreciate the asymmetric advantage U.S. and coalition forces now enjoy through the use of GPS. Several countries have openly concluded that GPS jamming is an effective means of disrupting U.S./allied operations. Some manufacturers are even marketing GPS jammers on the Internet and in trade magazines."***[31]

According to General C. Robert Kehler, commander of Air Force Space Command, future conflicts could very well begin in cyberspace and extend to space. In a 2009 edition of the Air Force Space Command's *High Frontier Journal*, Lt. Gen. Larry James, commander of the 14th Air Force, writes that as identified in the military's Schriever V wargame, "most of the elements of the space infrastructure are tied in some fashion to the cyber domain." Cyber attacks on command and control, ground stations and satellites themselves could have serious repercussions for military efforts as well as the broader U.S. economy.[32] As a July 2010 article in *The Economist* puts it, "Computer bugs bring down military e-mail systems; oil refineries and pipelines explode; air-traffic control systems collapse; freight and metro trains derail; financial data are scrambled; the electrical grid goes down in the eastern United States; orbiting satellites spin out of control."[33]

One important step forward has been the creation of the joint Air Force and NRO Space Protection Program in 2008. This effort has developed a Space Protection Strategy and is helping consolidate stakeholder protection initiatives and requirements in order to maximize our nation's security interests.[34] Space technologies and their associated cyberspace networks are a critical infrastructure that needs safeguarding through efforts like the Space Protection Program, ample funding for space situational awareness and protection, and better data sharing with our international allies and improved government-industry partnerships.

Trade and International Partnership

As highlighted by the 2010 National Space Policy, as the space environment becomes increasingly congested and dangerous for U.S. space assets, it is more important than ever that the United States work cooperatively with other nations.[35] Cooperation can take the form of joint U.S. industry and allied nation industry work on space system development or cooperation between the U.S. and foreign governments on ways to manage space traffic and debris. U.S. security interests can be more effectively addressed through close cooperation with our allies, friends and partners in space, yielding benefits for both U.S. industry and the protection of U.S. space capabilities.

In addition, according to the White House's *2010 National Security Strategy*, the United States should "deepen cooperation" with our international allies and friends and work with all nations on the responsible and peaceful use of space.[36] Working with our allies and partners in the space domain can result in preserving the flow of commerce and global communications.

Countries like India with growing space sectors hold a wealth of potential new opportunities for U.S. companies seeking to diversify their business. Yet to fully maximize the recommendations for international cooperation in the National Space Policy, the United States needs a modern export control system that keeps sensitive technologies out of the wrong hands, while facilitating technology trade and cooperation with our friends and allies in a timely manner that supports U.S. interests.

It is also important that world governments address the growing threat of space debris.[37] Careful and collective thought is needed to produce effective solutions for debris mitigation and remediation. In addition, the United States will need to work more closely with other nations to share information on space situational awareness and promote sustainability in the space domain.

Partnership with international allies also helps to create interdependencies that may provide incentives to maintain a safe space environment and long-term investments in space systems. While international cooperation in space is and should be a national priority, increased international competition requires measures to maintain U.S. global leadership and to counter the indigenous space capabilities being developed by some countries.[38] As the U.S. government considers partnering with other nations on space systems, the importance of maintaining a healthy U.S. space industrial base remains a priority.

Operationally Responsive Space

A declassified U.S. Space Command assessment of Operations Desert Shield and Desert Storm completed in 1992 expressed concern about the lack of on-demand launch capability for the U.S. military and argued that development of reactive launch systems should be a priority.[39]

Then in 2007, the Chinese anti-satellite test dramatically demonstrated our nation's lack of responsive space capability and prompted our nation's policy makers to address some of the concerns raised by the military's 1992 report.

The Operationally Responsive Space (ORS) initiative was born of congressionally directed action in the fiscal 2007 National Defense Authorization Act. The ORS effort calls for the deployment of small spacecraft rapidly to augment or replenish space capability where and when required. The concept of ORS has the potential to become an important model for fulfilling affordable, on-demand space support for military operations and supporting a more robust national security space architecture.

Specifically, ORS provides space power to the warfighter and national security community through a three-tiered strategy that calls for rapid exploitation of existing capabilities; use of existing technologies and capabilities to replenish, augment and reconstitute space assets, and development of new technologies and capabilities to replenish, augment and reconstitute space assets.

The ability to quickly reconstitute lost space capabilities ultimately enhances space survivability and deterrence. Commander of U.S. Strategic Command General Kevin Chilton stated at a 2009 conference that he would like to focus on swelling the number of satellites the military could launch as needs arise to prevent future capability gaps.[40]

Policymakers in the executive branch and Congress strongly support the aggressive development of ORS capabilities. Adequate funding to develop the three-tiered strategy is crucial if our nation is going to have the near-term ability to quickly and cost-effectively augment or replenish national security space systems. Already, ORS-led satellites like the industry developed Tactical Satellite-3 are demonstrating new plug-and-play technologies and sensors that benefit our soldiers, sailors, airmen and marines around the world.[41]

AIA believes industry is a critical partner in the ORS initiative and should continue to be utilized in ORS efforts. Strategies to expand the ORS model – to move it outside Defense Department laboratories and into industry as well as other civil and commercial space efforts – should be pursued to create an environment that enables industry participation, ensures additional support to the U.S. warfighter and helps strengthen the U.S. space industrial base.

Image courtesy of U.S. Air Force

Tactical Satellite-3 spacecraft mission badge

Regarding the launch side of ORS, the U.S. government currently uses excess Minuteman and Peacekeeper ICBM assets for orbital launches of small satellites and suborbital launches of missile defense targets and hypersonic test vehicles. To date, these launches have primarily supported a limited number of test and demonstration missions; however, that number is expected to increase and include operational missions. While increased reliance on these excess missile assets may appear convenient and cost-effective, the practice negatively impacts broader industry investment in future small launch capabilities and potentially jeopardize operational missions. AIA is concerned about any moves to restrict launch vehicle options for ORS and believes it is necessary that industry-produced small launch systems are utilized for the ORS initiative to ensure continued investment in the propulsion and solid rocket motor base industrial base.[42]

Strategic Systems & Missile Defense

The United States established strategic nuclear weapons capabilities during the Cold War to deter direct aggression by the Soviet Union against our nation and its vital interests. Since the Cold War began, a growing number of nations have become nuclear powers. China, which went nuclear in 1964, has expanded and modernized its strategic arsenal. India and Pakistan also have demonstrated their nuclear capabilities, while rogue states such as Iran and North Korea are proceeding with the development and acquisition of their own nuclear material and delivery means. The U.S. strategic nuclear posture stands at a crossroads. Without sustainment of a credible U.S. strategic force and industry, key alliances will weaken and decrease U.S. ability to deter adversaries and hinder proliferation, potentially exacerbating regional instability.

Today, U.S. strategic infrastructure and skills stand largely as they were at the end of the Cold War 20 years ago. According to government reports, recommendations from the congressionally mandated Nuclear Posture Review in 2001 were inadequately funded. The United States is the only nuclear power that does not have on-going programs to modernize its Cold War-era strategic systems. As a result, the United States faces the prospects of slow, unilateral nuclear disarmament due to the lack of a coherent and adequately funded sustainment strategy.

Maintaining a credible nuclear deterrent and effective industrial base is absolutely necessary for the near-term needs of the United States and our allies. In addition, a multi-layered and integrated ballistic missile defense (BMD) system is critical to protecting U.S. national security to counter the growing threat from nations like Iran and North Korea. Currently fielded ground- and sea-based BMD capabilities have demonstrated tangible results that have significantly improved U.S. national security and serve to protect citizens and our allies from harm. However, as rogue nations continue to pursue increasingly sophisticated nuclear and missile technologies, the need to develop a global BMD response capability is indisputable.

Launch of an SM-3 anti-ballistic missile

Ballistic missile defense is one of the most technologically complex and challenging defense missions our nation has ever pursued. The operational timelines and technological complexity of detection, tracking and discrimination, communication, interception and negation are not trivial problems. Yet today, the United States is ready to provide a limited operational defense against an attack against any one of our 50 states. The United States has also deployed systems to defend against short-range ballistic missiles and has a range of mid- and long-term programs to defend against threats across the spectrum of a ballistic missile's flight. Great strides have been made in leveraging limited resources by partnering with international allies, as evidenced by the agreements with Japan, Israel and NATO countries.

While the United States has made substantial progress, much remains to be done. Ballistic missile systems to protect the U.S. homeland and provide forward defense of U.S. global interests can and should be strengthened to protect against increasingly sophisticated threats. An integrated and multi-layered missile defense system that addresses near-term threats and prepares for the long term is an essential investment in U.S. security.

Also noteworthy is that missile defense missiles are powered by solid rocket motors (SRMs) that can propel them either into space or near-space environments. Solid rocket motors are utilized for launch of large defense and scientific satellites and the Space Shuttle, as well as for small satellites. According to the 2009 Defense Department Solid Rocket Motor Industrial Capabilities Report, "Inadequate investments are being made in large and small SRM research and development, reducing the reliability and cost-effectiveness of the SRM industrial base." The report continues that, "If there are no new development programs, the SRM industry will continue to lose its ability to design and produce new-generation SRMs." SRMs are a critical component of civil space, strategic nuclear, responsive space and missile defense launch systems and it is necessary to consider the industrial base implications of cross-agency programmatic decisions on SRMs. Decisions to cancel programs using SRMs will have repercussions elsewhere in the national security space industrial base.

V. AIA Recommendations

Budgets and funding levels for national security space systems must be matched with a coherent and long-range strategy.

Space systems are a critical utility of the 21st century and a vital component of U.S. national security in a dangerous world. These complex systems provide missile warning and defense; environmental monitoring; secure global communications; positioning, navigation and timing; intelligence, surveillance and reconnaissance and other key national security capabilities on which our nation and warfighters rely. Once seen strictly as strategic assets for use by the Intelligence Community and national leadership, today's space systems are now also helping power virtually every critical capability supporting the U.S. government and the warfighter and are intricately woven into the fabric of the U.S. and global economy.

However, strains in the industrial base and other challenges exist for the space sector. Many systems are operating in a degraded mode well beyond their design lives or no longer meet warfighter requirements. Budget and requirements instability, an inefficient procurement system and unpredictable "feast or famine" lead times between contracts have all contributed to a weakened space industry and increased space program schedule delays and cost overruns. When coupled with an aging workforce that is not being replaced by an adequate number of bright young minds and export restrictions that limit growth, it is evident that the space industry is severely strained. In some cases, we are losing domestic space manufacturing capabilities that we may not be able to regain.

Growing international competition threatens the health of our national security space industrial base and demands that our space industry be given the opportunity to compete on a level playing field. A contested and congested space environment means we need to make balanced investments in space and cyberspace protection, space situational awareness, space system modernization and responsive space capability.

Aggressive actions are needed now to retain the ability of our national security space industrial base to sustain and modernize the space systems that assure American preeminence in space and help guarantee our national security.

Government must make it a priority to develop and implement a predictable, long-term plan to sustain and modernize critical space systems, stabilize requirements and funding and reduce the barriers to competing overseas.

In order to avoid a crisis and maintain a healthy U.S. space industry that is able to meet economic and national security needs, AIA offers the following recommendations:

Recommendation #1: Establish Leadership and Program Stability.

National level leadership is needed for the space sector that provides:

- a long-term national security space system investment strategy
- multi-system procurement strategies important for space industrial base health
- balanced and stable budgets and funding that are critical to maintaining cutting-edge national security space programs

As called for in its report *The Role of Space*, AIA recommends the establishment of a national space management and coordination body that reports to the president, with the authority to coordinate across departmental and agency space efforts. With management, budget and acquisition authority for space programs currently spread across a variety of competing agencies, no one is in charge. Inadequate coordination and leadership in the space sector can be particularly damaging to second and third-tier suppliers, who often rely solely on government markets. A space coordination body – that is inclusive of U.S. industry – would provide the strategic, comprehensive and effective decision-making so important to the space industry.

GAO, Congress and the 2001 Commission to Assess United States National Security Space Management and Organization have all called for a National Security Space Strategy.[43] AIA strongly supports the development of a long-term strategy and architecture for space system investment, that would provide critical stability to our nation's space industrial base.

Multi-system procurement strategies should be investigated for space system purchasing. Space system procurement with low production rates, small quantities and long-lead times between major programs and program upgrades have contributed to a "win or die" environment for contractors that forces many space industry suppliers to refocus on non-space markets to ensure their survival. AIA recommends that multi-system procurement strategies be examined for all space systems – not just satellites – in order to increase the cadence of space system production, thereby providing greater stability to the national security space industrial base and potentially reducing costs.

Recommendation #2 – Modernize & Maintain Infrastructure.

National security space systems are a critical infrastructure and they must be sustained and modernized across areas such as:

- liquid and solid rocket propulsion
- military satellite communications
- missile warning and defense
- Operationally Responsive Space
- positioning, navigation and timing
- selected space optics, overhead imaging and non-imaging sensors
- supply chain and components

Critical national security space satellites are aging and past their designed life span. Programs to replace and enhance these capabilities and protect them from potential attack have been delayed and could result in gaps in coverage.

AIA agrees with CAIG's conclusion that "stability starts with government's funding and plans, leads to efficient and productive industry workforce and results in well performing programs that deliver mission area success."[44]

AIA has identified the following technologies that provide vital skills and capabilities to the national security space industrial base: application-specific integrated circuit technologies, liquid rocket propulsion, military satellite communications, missile warning, overhead non-imaging/persistent infrared, positioning, navigation, timing, selected space optics and solid rocket motors and their components. Future plans and programs should maintain these critical sectors and their workforce. Unfortunately, there seems to be little consensus on the need to protect these core capabilities.

National security space systems rely on electronics, advanced chemicals, materials and other components that must endure long periods in difficult conditions with high performance requirements. Title III of the Defense Production Act of 1950 plays an important role in the maintenance of domestic supply chain and component parts used for military space systems. The U.S. government should investigate ways to ensure that the DPA and other tools provide effective, quick response to at-risk production capabilities essential for the national security space sector.

In addition, the industries that provide these components often employ an extensive global supply chain and are subject to regional and global regulations and policies related to environmental management. These regulations and policies can restrict production, availability and usage of chemicals, materials and components critical to the manufacture of national security space systems.

A proactive and well-defined strategy is needed to address the potential impacts of domestic and foreign chemical and material regulations on national security space systems. The strategy should address the identification of chemicals and materials subject to such regulations. Where substitutes and alternatives for these chemicals exist, specifications and performance requirements should allow for their use. Where substitutes and alternatives are not known, funding should be allocated towards identifying and qualifying replacements and exemptions from requirements obtained until such replacements are available.

Recommendation #3 – Modernize Export Control Policies and Promote Industry's Ability to Compete.

- AIA recommends that the U.S. government complete a careful review of space technologies – including commercial satellite technology – to reevaluate which technologies should be controlled at what level and to determine the most appropriate jurisdiction, while keeping our primary focus on national security concerns

The review should determine what actions are needed to modernize ITAR to ensure the right technologies are controlled the right way. This must be followed by the appropriate legislation and policy initiatives to modernize our export system in order to preserve U.S. leadership in space.

The U.S. government should also strengthen international partnerships and diplomacy with Europe, India and other key friends and allies to grow space-trade opportunities for U.S. businesses.

Trade restrictions such as ITAR have impaired the ability of the U.S. space industry to compete globally and have made it increasingly reliant upon a dwindling number of U.S. government contracts.

The time has come to take concrete steps to re-evaluate ITAR controls on space technologies and sharpen the provisions of the 1998 law, P.L. 105-261, to keep our country safe and industry strong. Commercial communications satellite technology restrictions are particularly in need of review. Without meaningful steps to modernize the U.S. export control system and enhance space trade among our allies, the United States faces a real and daunting possibility of losing our preeminence in space and our ability to compete in the global space industry.

Recommendation #4 – Support Current and Future Workforce.

- Make science, technology, engineering and mathematics (STEM) education a national priority. This includes continued support for NASA, NOAA and Defense Department STEM education initiatives

AIA's 2009 report, *The Role of Space in Addressing America's National Priorities*, cited a survey of more than 270,000 college freshmen, that found that only 7.5 percent said they intended to major in engineering – the lowest level since the 1970s. According to a 2008 study by the Office of the Secretary of Defense Cost Analysis Improvement Group, a large proportion of national security space industry scientists and engineers are nearing retirement age and our nation faces a significant shortage of workers in their thirties.[45] This condition applies to civil government and aerospace industry personnel in similar numbers.

Program cancellations and uncertainty about future programs impacts recruitment and retention as well as the cost, schedule and development of critical civil, commercial and national security space systems.

Recommendation #5 – Support Robust Funding for Research and Development and Science and Technology Efforts.

Research and development and science and technology efforts are critical to attracting and retaining the best and brightest national security space scientists and engineers. As identified by the director of the National Reconnaissance Office, S&T investments are the "seed corn of the future."[46] Yet R&D and S&T efforts are sporadic, unfocused and not sufficiently coordinated to systematically produce breakthrough technologies or significantly reduce the risk of inserting advanced technologies into our cutting-edge space programs.

S&T investment is especially critical in light of the burgeoning problem of space debris and the aggressive entry into the space-faring community by China, India and others. The United States must make significant investments in advanced inspace propulsion, space launch, protected wide-band communications and advanced sensor and antenna technology to meet the challenges as space becomes more contested.

Recommendation #6 – Ensure the Protection and Responsiveness of U.S. Space and Cyberspace Capabilities.

Steps needed to protect U.S. space capabilities:

- support robust funding for space and cyberspace protection including the Air Force Space Command and NRO joint Space Protection Program
- develop and fund significant investments in space situational awareness capability
- collaboratively address the issue of orbital debris mitigation and remediation
- implement a plan for leveraging commercial space situational awareness and sharing appropriate capabilities with commercial space operators
- maintain stable funding levels for Operationally Responsive Space that utilize industry capabilities to enable responsive, affordable, on-demand space support for national security operations and the U.S. warfighter

More than 60 nations are engaged in space efforts and tens of thousands of man-made objects currently orbit the Earth. In such a crowded and contested environment, we need strong investments in sensors, tracking, threat assessment and attribution, and ORS, as well as information sharing with government, industry and international partners. Both federal and commercial space systems must be treated as critical infrastructure and their protection must be a national priority. AIA supports Congress' position that the United States should place a "greater priority on the protection of national security space systems."[47]

In addition, our troops in isolated and hard to reach regions rely on space assets for mission-critical, time-sensitive, life-saving intelligence, communications and UAV support. While not a substitute for operational military and intelligence space systems, ORS – if adequately funded – has the potential to provide important response capabilities to unforeseen events or unanticipated gaps in space capabilities. Such reconstitution of space assets is a critical component of U.S. space protection efforts.

AIA strongly urges robust and stable budgets for the ORS initiative in order to provide the support U.S. warfighters' needs and operations success.

VI. Conclusion:

National security space systems provide missile warning and defense; global communications; global positioning, navigation and timing; launch capability and intelligence, reconnaissance and surveillance. They are the bedrock of our 21st century military capabilities and are now increasingly part of a critical infrastructure to our economy.

Yet in light of an increasingly contested, congested and competitive space domain – and a national security space industrial base that is increasingly fragile – it is more important than ever to match policy goals with strong leadership, integrated strategy and the long-term funding and stability needed to maintain cutting-edge, cost-effective space programs.

Without action we face a tipping point in the U.S. space industry and the loss of capabilities that may be near impossible to recover. We must take the necessary steps to restore and maintain the vitality of our national security space programs to prevent irreparable harm to our nation's defense and economy.

DEPARTMENT OF DEFENSE SPACE PROGRAMS
PROCUREMENT AND RDT&E

Fiscal Years 2008, 2009, and 2010[a]
(Millions of Dollars)

Agency and Program	2008		2009(E)		2010(E)	
	Procurement	RDT&E	Procurement	RDT&E	Procurement	RDT&E
AIR FORCE						
AEHF	$149.9	$612.3	$165.6	$386.4	$1,843.5	$464.3
Defense Space Recon Pgm	183.0	–	158.5	–	105.2	–
Defense Support Program	–	–	–	–	-	-
DMSP	115.8	–	97.8	–	97.8	-
EELV	1,091.8	6.5	1,350.3	33.6	1,295.3	26.5
Global Positioning System	251.5	707.4	135.3	916.2	59.6	1,004.8
Medium Launch Vehicles	116.9	–	5.7	–	–	-
MILSATCOM (DISA)	114.0	362.7	106.0	334.2	111.3	257.7
NPOESS	–	331.0	–	287.5	3.9	396.6
NUDET Detection System	15.8	38.3	27.5	41.1	15.4	84.0
Satellite Control Network	48.3	23.5	65.0	16.5	58.9	21.0
SBIRS-High	399.3	583.3	1,793.1	542.4	500.9	512.6
Space Test Program (STP)	–	50.0	–	47.7	–	47.2
Space Radar (SR) System	(b)	(b)	(b)	(b)	(b)	(b)
Spacelift Range System	130.5	25.1	101.3	12.3	100.3	10.0
Titan Space Boosters	0.0	–	–	–	–	–
TSAT	–	776.5	–	761.3	–	–
Wideband Gapfiller Satellite	312.3	21.0	21.6	52.1	264.1	71.0
ARMY						
NAVSTAR GPS	$135.8	$ –	$111.5	$ –	$137.1	$ –
NAVY						
MUOS	$214.4	$593.4	$342.9	$515.3	$516.1	$387.5
Satellite Communications	62.7	715.2	118.3	651.3	50.2	474.0

Source: Department of Defense: *Program Acquisition Costs by Weapon System, Procurement Programs (P-1) , and RDT&E Programs (R-1).*

a. The amounts listed for Procurement and RDT&E represent the combined value of the base budget amounts and the amounts allocated in the Overseas Contingency Operations budget request.

b. Classified funding.

E. Estimate.

Key: AEHF = Advanced Extremely High Frequency
DMSP = Defense Meteorological Satellite Program
DSCS = Defense Satellite Communications System
EELV = Evolved Expendable Launch Vehicle
GPS = Global Positioning System
MUOS = Mobile User Objective System
NPOESS = National Polar-orbiting Operational Environmental Satellite System
NUDET = Nuclear Detonation
SBIRS = Space-Based InfraRed System
TSAT = Transformational Satellite Communications System

EMPLOYMENT IN THE AEROSPACE INDUSTRY[a]

Calendar Years 1994 – 2008
(Thousands)

Year	TOTAL	Aircraft, Engines, & Parts	Missiles, Space Vehicles, & Parts	Search, Detection, & Navigation Instruments
ALL WORKERS				
1994	728	454	98	175
1995	673	425	89	158
1996	672	432	82	158
1997	714	472	83	159
1998	741	495	84	163
1999	709	468	79	161
2000	666	438	78	149
2001	661	435	77	150
2002	618	397	74	148
2003	587	372	70	145
2004	592	370	72	151
2005	612	380	75	157
2006	632	399	76	158
2007	647	414	75	158
2008	657	427	77	153
PRODUCTION WORKERS				
1994	340	232	29	80
1995	313	216	26	70
1996	317	226	24	67
1997	346	261	23	62
1998	361	275	23	63
1999	337	252	22	63
2000	304	227	21	56
2001	297	226	19	53
2002	263	204	16	44
2003	250	189	15	45
2004	244	185	13	46
2005	270	192	21	57
2006	327	214	39	74
2007	360	243	47	70
2008	365	(D)	(D)	63

Source: Bureau of Labor Statistics and Aerospace Industries Association estimates.
Notes: BLS discontinued reporting employment-related statistics using the SIC in 2003; the NAICS is now used. Prior years revised for consistency.
a. Annual average. See Glossary for explanation of *Aerospace Employment*.

Overview And History Of National Security Space:

Overview of National Security Space Systems

An overview of a typical space architecture shows three main components: satellite systems, launch capability and infrastructure to place the satellite in orbit, and ground stations to control and communicate with the orbiting satellite.

Satellites consist of a bus and a payload. The bus is typically described as the infrastructure of the spacecraft. Payloads contain the sensors and other equipment needed for the satellite to carry out its mission. Once in orbit, satellite systems circle the Earth at a variety of distances depending on the satellite's mission. Common orbits are low-Earth (LEO), Molniya and geosynchronous (GEO). LEO satellites orbit the Earth at 2,000 km or less and typically provide weather monitoring and surveillance. Molniya, or highly elliptical orbits, can be used for communications focused missions. Satellites in GEO typically orbit the Earth at 35,790 km and are used for weather observation, communication and surveillance.[48] For more information on other common orbits, please see entries in the "glossary" section on medium-Earth orbit (MEO) and polar orbit.

Launch systems consist of a launch vehicle or rocket, launch pad and range and other associated infrastructure. Launch vehicles can carry satellites and other payloads into the desired orbit depending on the mission at hand.

Once in orbit, satellite command and control is provided through ground stations. Ground stations are the terrestrial connection to the orbiting satellite, uploading and relaying information to and from Earth to cyberspace and into space. Command and control facilities help process information acquired by the satellite as well as help ensure the satellite continues to operate and maneuver safely in space. Often the least noted portion of a space system architecture, ground stations are absolutely necessary for successful space missions.[49]

National Security Space: The Early Years

Though the history of rocketry can be traced back as far as the Chinese Song Dynasty, it was not until American Robert H. Goddard's pioneering work on liquid-fuel rockets in the 1920s that rockets began to show real promise as space systems.

By the end of World War II, German, American and Soviet engineers were pushing ballistic missile technology to greater and greater heights. In 1945, German rocket engineer Wernher von Braun was brought to the United States to work on American rocket programs, helping create the American Redstone rocket and Juno 1 rocket. The U.S. Army-manufactured Juno 1 launched the first U.S. Earth satellite, Explorer 1, on January 31, 1958. The Redstone rocket was utilized for the first U.S. nuclear missile tests and a modified version was later used for NASA's Project Mercury – the first U.S. human spaceflight program.[50]

Just a year prior to the successful U.S. satellite launch, the Soviet Union successfully launched the world's first Earth satellite – Sputnik 1 – via the R-7 launch vehicle designed by Soviet engineer Sergey Korolyov. Korolyov, an avid space enthusiast, had been able to persuade Soviet premier Nikita Khrushchev that launching the Sputnik 1 satellite would benefit the Soviet nuclear missile program – of which the R-7 was a key element.

Sputnik 1 ushered in the space race and set off a competition between the United States and the Soviet Union in space and missile technology. In 1958, President Dwight D. Eisenhower signed into law the National Aeronautics and Space Act, creating NASA and with it the responsibility for U.S. space exploration efforts. The U.S. armed forces continued activities related to the military use of space, and in 1961 the National Reconnaissance Office was born to develop and operate space intelligence and reconnaissance satellites. NRO's birth gave way to the Corona program, a formerly classified effort by the United States to collect imagery of the Soviet Union from space.[51]

During the 1960s and 1970s, U.S. national security space programs experienced robust growth, with systems designed to give the United States and our military a maximum advantage over the Soviet Union. Communications satellites, missile warning satellites, weather satellites and navigation and reconnaissance satellites all were developed during this period. As government needs grew, space systems were no longer solely manufactured by U.S. government and U.S. industry became a critical production base.

For much of the Cold War, NASA enjoyed the robust and stable budgets it needed to surpass Soviet civil space efforts. NRO programs like Corona helped keep watch on the Soviet Union's military programs.[52] Innovative military space programs were helping grow a diverse and healthy industrial base that contributed to revolutions in global communications, global positioning and other critical capabilities. Failure to adjust to the end of the Cold War precipitated dramatic changes in the space sector that have resulted in the challenges discussed in this report.

Photo courtesy of NASA

On Mar. 16, 1926, Dr. Robert H. Goddard launched the world's first liquid-fueled rocket in Auburn, Mass., laying the foundation for rocket technology.

Photo courtesy of NASA

Eisenhower and Von Braun
Dr. Wernher von Braun, Marshall Space Flight Center's first director, points out details on a Saturn rocket to President Dwight D. Eisenhower. President Eisenhower was at Marshall to participate in the center's dedication ceremony, Sept. 8, 1960.

Glossary:

Architecture: The structure, relationships and principles governing the design and evolution of elements linked in accomplishing a common purpose.

Air Force Space Command (AFSPC): Created Sept. 1, 1982, AFSPC defends North America through its space and intercontinental ballistic missile operations – vital force elements in projecting global reach and global power. AFSPC's stated mission is to "Provide an integrated constellation of space and cyberspace capabilities at the speed of need."

Ballistic Missile Defense (BMD): A layered, integrated system capable of destroying a ballistic missile in all phases of flight. The system requires accurate identification and tracking of the target with sensors and advanced interceptor missiles or directed energy weapons as well as the associated command and control, battle management and communication systems to direct and integrate a BMD system.

Catcher's Mitt: A study conducted by the Defense Advanced Research Project Agency to better understand the issues and challenges involved with removing man-made debris from earth orbit. Catcher's Mitt is intended to address the increasing hazard from orbital debris faced by all U.S. and international space assets.

Cost Assessment and Program Evaluation (CAPE): Formerly the Office of the Secretary of Defense Cost Analysis Improvement Group, the Weapons Systems Acquisition Reform Act of 2009 established the director of Cost Assessment and Program Evaluation. CAPE's responsibilities include the analysis and evaluation of plans and programs in relation to U.S. defense objectives; ensuring that costs of Defense Department programs, including classified programs, are presented accurately and completely; and assessment of the effects of Defense Department spending on the U.S. economy.

Cyberspace: The global computer network linking all people, machines and sources of information in the world, and through which one could move or "navigate" as through a virtual space.

Defense Advanced Research Projects Agency (DARPA): The research and development office for the Defense Department. DARPA's mission is to maintain technological superiority of the U.S. military and prevent technological surprise from harming U.S. national security. DARPA also pursues the advantage of technological surprise against U.S. adversaries.

Electromagnetic Spectrum: The full range of frequencies, from radio waves to gamma rays, that characterizes light. Spectrum is utilized for radio broadcast, radars, voice communication, weather satellite systems, defense satellite systems, flood warning and other services. Demand for spectrum is increasing.

Geospatial Intelligence: The exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the Earth. Geospatial intelligence consists of imagery, imagery intelligence and geospatial information.

Geosynchronous Orbit (GEO): An orbit with an orbital period that matches the rotational rate of the Earth. A satellite in such an orbit is at an altitude of approximately 35,790 km (22,238 mi) above mean sea level.

Global Positioning System (GPS): Developed by the Defense Department, the Global Positioning System uses a constellation of satellites that transmit precise signals that enable GPS receivers to determine their location, speed, direction and time. Similar satellite navigation systems include the partially completed Russian GLONASS system, the upcoming European Galileo system and the proposed Chinese BeiDou and Indian IRNSS systems.

Intelligence Community: A coalition of 17 agencies and organizations within the executive branch that work both independently and collaboratively to gather the intelligence necessary to conduct foreign relations and national security activities. A listing of agencies and functions can be found at: http://www.intelligence.gov/about-the-intelligence-community/

Intercontinental Ballistic Missile (ICBM): A ballistic missile with a long range (greater than 5,500 km or 3,500 miles) typically designed for nuclear weapons delivery. According to section six of the 2005 U.S. Space Transportation Policy, excess U.S. ICBMs shall be retained for government use only under certain conditions, including certification that their use limits the impact on the U.S. space transportation industry.

International Traffic in Arms Regulations (ITAR): A set of U.S. government regulations that control the export and import of defense-related articles and services on the U.S. Munitions List. These regulations implement the provisions of the Arms Export Control Act. The State Department interprets and enforces ITAR.

Low Earth Orbit (LEO): An orbit within the locus extending from the Earth's surface up to an altitude of 2,000 km.

Liquid Rocket Motor: Stored fuel and stored oxidizer are pumped into a combustion chamber where they are mixed and burned. The combustion produces great amounts of exhaust gas at high temperature and pressure. Exhaust passes through a nozzle, producing thrust. Liquid rockets are used to power the space shuttle, to place satellites in orbit and on high speed research aircraft.

Medium Earth Orbit (MEO): The region in space between Low Earth Orbit (2,000 km) and Geosynchronous Orbit (35,790 km). This orbit is commonly used by Global Positioning Satellites.

Military Satellite Communications (MILSATCOM): Typically categorized as wideband, protected or narrowband. Wideband systems emphasize high capacity. Protected systems stress anti-jam features, covertness and nuclear survivability. Narrowband systems emphasize support to users who need voice or low-data-rate communications and who also may be mobile or otherwise disadvantaged.

National Aeronautics and Space Administration (NASA): Responsible for the nation's civil space program and accountable for long-term aerospace research. NASA's mission is to pioneer the future in space exploration, scientific discovery and aeronautics research.

National Geospatial-Intelligence Agency (NGA): Provides timely, relevant and accurate geospatial intelligence in support of national security objectives and fields support teams worldwide. NGA is a member of the U.S. Intelligence Community and a Defense Department Combat Support Agency.

National Oceanic and Atmospheric Administration (NOAA): Located in the U.S. Commerce Department and focused on the conditions of the oceans and the atmosphere. NOAA warns of dangerous weather, charts seas and skies and conducts research to improve understanding and stewardship of the environment. NOAA runs the National Environmental Satellite, Data and Information Service (NESDIS) that operates the nation's environmental satellite programs and manages the data gathered by its departments. NESDIS operates and manages many of our geosynchronous satellites.

National Reconnaissance Office (NRO): Develops and operates unique and innovative overhead reconnaissance systems and conducts intelligence-related activities essential for U.S. national security. NRO is one of 16 Intelligence Community Agencies. It is a hybrid organization that is jointly staffed by members of the armed services, Central Intelligence Agency and Defense Department civilian personnel.

National Security Space: Space infrastructure and industrial base critical to the U.S. economy and national power. Typically, National Security Space systems are built by U.S. industry for the Defense Department and other government agencies.

National Security Space Office (NSSO): Facilitates the integration and coordination of defense, intelligence, civil and commercial space activities. The NSSO was established in May 2004 by combining the National Security Space Architect (NSSA), the National Security Space Integration (NSSI) office, and the Transformational Communications Office (TCO).

National Space Council: A coordination body that existed from 1958 until 1973 and again from 1989 to 1993 reporting to the president to encourage improved interagency cooperation. The latter council was chaired by the vice president and included the following members: the secretaries of state, treasury, defense, commerce and transportation; the director of OMB; the chief of staff to the president; the assistants to the president for national security affairs and science and technology; the director of the Central Intelligence Agency and the administrator of the National Aeronautics and Space Administration.

National Space Policy: Establishes overarching national policy that governs the conduct of U.S. space activities. The administration of President William Jefferson Clinton authorized a national space policy on September 14, 1996. The administration of President George W. Bush authorized a superseding policy on August 31, 2006. The policy goals and objectives have been relatively consistent across administrations. Current versions of U.S. National Space Policy can be accessed at: http://www.ostp.gov.

NSS Architectures: Architectures focused on the National Security Space enterprise, or a segment (e.g., Collection, Tasking), capability (e.g., ISR, COMM), or attribute (e.g., robustness) of the NSS enterprise. These architectures address non-materiel and materiel solutions, and may include capabilities in domains other than space, including cyberspace.

Operationally Responsive Space (ORS): A DOD concept designed to satisfy Joint Force Commanders' needs for readily available information and intelligence during ongoing operations. The concept is based on three tiers: Tier 1 is the rapid exploitation of existing capabilities; Tier 2 is the ability to replenish, augment or reconstitute with existing technologies/capabilities, and Tier 3 is the ability to rapidly develop and employ new technologies/capabilities.

Orbital Debris: Any man-made objects in orbit around the Earth that no longer serve a useful purpose. According to NASA, over 19,000 objects larger than 10 cm are known to exist. The estimated population of particles between one and 10 cm in diameter is approximately 500,000. The number of particles smaller than one cm could exceed tens of millions.

Original Equipment Manufacturer (OEM): A manufacturer of products or components that are purchased by a company and retailed under the purchasing company's brand name.

Polar Orbit: A satellite orbit that passes over both poles of the Earth. This allows the satellite the ability to monitor all points on the Earth during a one day period. Polar orbits are commonly useful for spacecraft that perform mapping or surveillance operations.

Quadrennial Defense Review (QDR): A legislatively mandated review of Defense Department strategy and priorities. The QDR will set a long-term course for DOD as it assesses the threats and challenges that the nation faces and re-balances DOD's strategies, capabilities and forces to address today's conflicts and tomorrow's threats. The current QDR can be found at: http://www.defense.gov/qdr/.

Satellite: An object that has been placed into orbit by humans (as opposed to natural satellites like our moon). Satellites generally consist of a bus and the payload. The bus includes supporting systems like telemetry, power, thermal control and attitude control. The payload provides instruments for the satellite service (communications, remote sensing, surveillance, scientific measurements, etc).

Schriever War Game: A series of wargames conducted by Air Force Space Command, named in honor of retired Gen. Bernard A. Schriever. According to Air Force Space Command, the sixth Schriever War Game examined the contributions of space and cyberspace to future deterrent strategies. It included the participation of a variety of U.S. agencies and allies.

Science, Technology, Engineering and Mathematics (STEM): The study of workforce disciplines that require knowledge of science, technology, engineering and mathematics.

Solid Rocket Motor: Used on air-to-air and air-to-ground missiles, on model rockets and as boosters for satellite launchers. In a solid rocket, the fuel and oxidizer are mixed together into a solid propellant which is packed into a solid cylinder. Hot exhaust gas is passed through a nozzle which accelerates the flow and produces thrust.

Space Posture Review (SPR): A legislatively-mandated review of U.S. national security space policy and objectives, conducted jointly by the secretary of Defense and the director of National Intelligence. The SPR analyzes the relationship between military and national security space strategy and assesses space acquisition programs, future space systems and technology development. Information on the SPR can be found at: http://www.defense.gov/spr/.

Space Protection: Encompasses all elements of maintaining robust space capabilities. This includes physical protection of satellite systems through radiation hardening, added fuel for maneuvering or some other form of physical protection from attack or disruption. Improvements in SSA and ORS also play a role in Space Protection, as do international agreements with other nations that utilize space. Through U.S. Air Force Space Command and the National Reconnaissance Office, the joint Space Protection Program helps address concerns regarding an increasingly contested and congested space environment.

Space Situational Awareness (SSA): The understanding of what objects are in space and what capabilities they have or to know if a satellite's operations have been intentionally affected by an adversary.

Space and Missile Systems Center (SMC): A subordinate unit of the Air Force Space Command, it is the center of technical excellence for researching, developing and purchasing military space systems. The center is also responsible for on-orbit check-out, testing, sustainment and maintenance of military satellite constellations and other Department of Defense space systems.

Space Industrial Base: Companies that develop and manufacture spacecraft, launch and other associated infrastructure. More information on the Space Industrial Base can be found at: http://www.aia-aerospace.org/about_aia/our_members/.

Team America Rocketry Challenge (TARC): The world's largest rocket contest, sponsored by AIA and the National Association of Rocketry.

United States Strategic Command (USSTRATCOM): One of ten U.S. unified commands under the Defense Department. The Command, including components, employs more than 2,700 people, representing all four services, including Department of Defense civilians and contractors, who oversee the command's operationally focused global strategic mission. Missions include deterring attacks on U.S. vital interests to ensure U.S. freedom of action in space and cyberspace and to synchronize global missile defense plans and operations.

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The Aerospace Industries Association was founded in 1919, only a few years after the birth of flight. The nation's most authoritative and influential voice of the aerospace and defense industry, AIA represents nearly 150 leading aerospace and defense manufacturers, along with a supplier base close to 200 associate members.

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The Birth of Stars
This new Hubble photo is but a small portion of one of the largest seen star-birth regions in the galaxy, the Carina Nebula. Towers of cool hydrogen laced with dust rise from the wall of the nebula. Reminiscent of Hubble's classic image of the Eagle Nebula dubbed the 'Pillars of Creation' this image is even more striking in appearance. Captured here are the top of a three-light-year-tall pillar of gas and the dust that is being eaten away by the brilliant light from nearby bright stars. The pillar is also being pushed apart from within, as infant stars buried inside it fire off jets of gas that can be seen streaming from towering peaks like arrows sailing through the air.

Photo courtesy of NASA, ESA, and M. Livio and the Hubble 20th Anniversary Team (STScI)

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