III. U.S. Objectives for Space

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America's interests in space are to:

- Promote the peaceful use of space.
- Use the nation's potential in space to support U.S. domestic, economic, diplomatic and national security objectives.
- Develop and deploy the means to deter and defend against hostile acts directed at U.S. space assets and against the uses of space hostile to U.S. interests.

The U.S. Government must work actively to make sure that the nation has the means necessary to advance its interests in space. To do so, it must direct its activities to:

- Transform U.S. military capabilities.
- Strengthen U.S. intelligence capabilities.
- Shape the international legal and regulatory environment that affects activities in space.
- Advance U.S. technological leadership related to space operations.
- Create and sustain a cadre of space professionals.

Concerted efforts in these areas are needed to enhance the nation's security by improving its capacity to deter aggression, to defend its interests and to pursue its civil space programs with modern and more capable systems. Deliberate, coherent policies in these areas also provide incentives to the commercial sector to pursue new activities in space and to develop new applications for goods and services derived from space systems. This essential combination of both government and private activity will be needed to keep the U.S. the world's leading space-faring nation.

A. Transform U.S. Military Capabilities

The United States must develop, deploy and maintain the means to deter attack on and to defend vulnerable space capabilities. Explicit national security guidance and defense policy is needed to direct development of doctrine, concepts of operations and capabilities for space, including weapons systems that operate in space and that can defend assets in orbit and augment air, land and sea forces. This requires a deterrence strategy for space, which in turn must be supported by a broader range of space capabilities.

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1. Deterrence and Defense Policy for Space

The 1996 National Space Policy states, "Purposeful interference with space systems shall be viewed as an infringement on sovereign rights." That policy directs that steps be taken to protect against attack through such measures as deploying sensors on satellites, hardening them to electromagnetic effects and radiation and improving the security of ground stations and communication links. It also directs that measures be taken to prevent attack on the communication links by encrypting messages, by tracking satellites and through warnings. Generally, commercial satellite operators have not seen a need to do this, as there are associated costs and customers have not demanded protection measures.

Current policy also calls for a capability to negate threats to the use of space by the United States. In 1999 then-Deputy Secretary of Defense John Hamre stated that the preferred U.S. approach was "tactical denial of capabilities" used by an adversary, not "permanent destruction." The U.S. "reserves the right to be able to retaliate and destroy" either ground sites or satellites, if necessary. The preferred approach to negation is the use of effects that are "temporary and reversible in their nature."

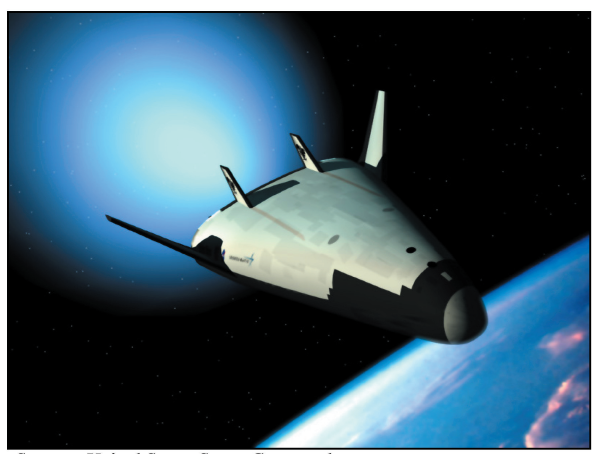
Such approaches rely on jamming signals or interfering with the function of hostile satellites rather than disabling or destroying them. Temporary and reversible approaches are technically elegant and valuable, but they may not serve equally well across the full spectrum of possible contingencies. This is especially true when it is important to know with high confidence that a satellite can no longer function.

The U.S. will require means of negating satellite threats, whether temporary and reversible or physically destructive. The senior political and military leadership needs to test these capabilities in exercises on a regular basis, both to keep the armed forces proficient in their use and to bolster their deterrent effect on potential adversaries. Besides computer-based simulations and other wargaming techniques, these exercises should include "live fire" events. These "live fire" events will require the development of testing ranges in space and procedures for their use that protect the on-orbit assets of the U.S. and other space-faring nations. While exercises may give adversaries information they can use to challenge U.S. space capabilities, that risk must be balanced against the fact that capabilities that are untested, unknown or unproven cannot be expected to deter.

A policy of deterrence would need to be extended to U.S. allies and friends, consistent with U.S. treaty obligations and U.S. interests. In the case of NATO, the U.S. might consider whether a planning group should be formed to develop a common appreciation of the threats, discuss potential responses and consult on the formulation of alliance policy and plans to deter and defend against threats from space. Only by extensive prior consultation, planning and appropriate exercises will the U.S. have the cooperation it would need in a crisis.

2. Assured Access to Space and On-Orbit Operations

United States deterrence and defense capabilities depend critically on assured and timely access to space. The U.S. should continue to pursue revolutionary reusable launch vehicle technologies and systems even as the U.S. moves to the next generation of expendable launch vehicles (Figure 15). In addition, the U.S. must invest in technologies that will enable satellites to be operational shortly after launch. One key objective of these technological advances must be to reduce substantially the cost of



Source: United States Space Command

Figure 15: Reusable launch vehicles offer new approaches for operating to, from and in space.

placing objects and capabilities in orbit, while providing the means to launch operationally useful satellites, both on short notice and on routine schedules.

If the U.S. is to master space operations, its launch capabilities must respond both to national security needs and to commercial and civil sector requirements. This calls for a modern launch infrastructure and modern launch vehicles. Today's U.S. launch infrastructure, which includes launch complexes, processing facilities and tracking systems, needs modernization. The nation lacks an overall vision for launch that accommodates the evolving and essential partnership between the government and commercial industry.

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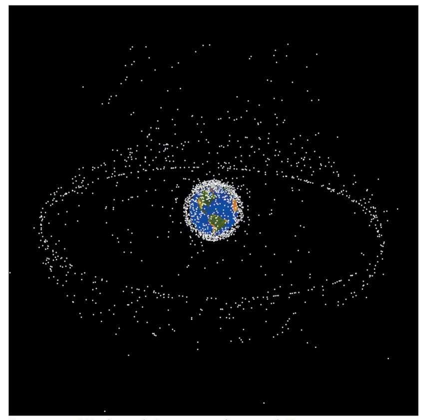
The ranges and their associated launch complexes, at Cape Canaveral AFB and Kennedy Space Flight Center on the east coast and Vandenberg AFB on the west coast, have enough capacity to meet the projected needs of all users under normal conditions. However, more capacity is needed to provide for margin and flexibility to handle launch "surges," to accommodate launch delays and to allow launch areas to undergo scheduled maintenance and modernization. The U.S. should seek to streamline the processes associated with integrating spacecraft with launch vehicles. The U.S. also needs to implement plans to reduce range costs and improve flexibility by using more efficient technology, such as GPS and satellite-based communications, in the areas of range safety and tracking.

Along with assured access to space, the U.S. needs to develop better ways to conduct operations once in space. New approaches to on-orbit propulsion can improve spacecraft maneuverability and safety, and on-orbit servicing can extend the life of space systems and upgrade their capabilities after launch. Autonomous, reusable orbit transfer systems can provide greater maneuverability in and between different orbits. In addition, the Defense Advanced Research Projects Agency, the Air Force and NASA are studying robotic microsatellites that can provide spacecraft servicing. When coupled with spacecraft that allow for modular component replacement while on orbit, these systems could provide significant life cycle cost savings, and would enable spacecraft and interchangeable payloads to be upgraded.

3. Space Situational Awareness

To use space effectively and to protect against threats that may originate from it, the U.S. must be able to identify and track much smaller objects in space than it can track today (Figure 16). The current space surveillance network, the earth-based radars and cameras used to track objects in space, needs modernization and expansion. An improved space surveillance network is needed to reduce the chance of collision between satellites, the Space Shuttle or the International Space Station and the thousands of pieces of space debris orbiting the earth. It will also have to track objects deeper in space, such as asteroids or spacecraft. And to reduce the possibility of surprise by hostile actors, it will have to monitor space activity. The evolution of technology and the character of this problem argue for placing elements of the surveillance network in space, including both electro-optical and radar systems.



Source: National Aeronautics and Space Administration's Orbital Debris Program Office, Johnson Space Center

Figure 16: Space situational awareness requires tracking and identifying many thousands of objects in space, not only the satellites illustrated here.

4. Earth Surveillance From Space

Space provides a unique vantage point for observing objects across vast reaches of air, land and sea. The U.S. needs to develop technologies for sensors, communication, power generation and space platforms that will enable it to observe the earth and objects in motion on a near real-time basis, 24 hours-a-day. If deployed, these could revolutionize military operations. For example, a space-based radar, such as the recently cancelled Discoverer II program, could provide military commanders, on a near-continuous and global basis, with timely, precise information on the location of adversary forces and their movement over time. Coupled to precision strike weapons delivered rapidly over long distances, even conventionally armed inter-continental ballistic missiles, space-based radar surveillance would enhance deterrence of hostile action. The same space-based technologies could revolutionize public and private transportation, traffic management and disaster relief operations by providing information on the location, routing and status of vehicles.

5. Global Command, Control and Communications in Space

Development of a Global Information Grid—a globally interconnected, end-to-end set of information capabilities and associated processes that will allow the warfighter, policy makers and support personnel to access information on demand—will rely on space assets to provide the command, control and communications (C3) required by enroute, mobile and deployed military forces.

6. Defense in Space

Assuring the security of space capabilities becomes more challenging as technology proliferates and access to it by potentially hostile entities becomes easier. The loss of space systems that support military operations or collect intelligence would dramatically affect the way U.S. forces could fight, likely raising the cost in lives and property and making the outcome less sure. U.S. space systems, including the ground, communication and space segments, need to be defended to ensure their survivability.

Providing active and passive protection to assets that could be at risk during peacetime, crisis or conflict is increasingly urgent. New technologies for microsatellites, hardened electronics, autonomous operations and reusable launch vehicles are needed to improve the survivability of satellites on orbit as well as the ability to rapidly replace systems that have malfunctioned, been disabled or been destroyed.

7. Homeland Defense

Some believe the ballistic missile defense mission is best performed when both sensors and interceptors are deployed in space. Effective sensors make countermeasures more difficult, and interceptors make it possible to destroy a missile shortly after launch, before either warhead or countermeasures are released.

8. Power Projection In, From and Through Space

Finally, space offers advantages for basing systems intended to affect air, land and sea operations. Many think of space only as a place for passive collection of images or signals or a switchboard that can quickly pass information back and forth over long distances. It is also possible to project power through and from space in response to events anywhere in the world. Unlike weapons from aircraft, land forces or ships, space missions initiated from earth or space could be carried out with little transit, information or weather delay. Having this capability would give the U.S. a much stronger deterrent and, in a conflict, an extraordinary military advantage.

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B. Strengthen Intelligence Capabilities

The U.S. needs to strengthen its ability to collect information about the activities, capabilities and intentions of potential adversaries and to overcome their efforts to deny the U.S. this information. Since the end of the Cold War, the number, complexity and scope of high-priority tasks assigned to the Intelligence Community have increased even as its human resources and technical advantage have eroded. This has reduced the Intelligence Community's ability to provide timely and accurate estimates of threats and has correspondingly increased the possibility of surprise.

1. Tasks of the Intelligence Community

The growth in collection requirements is a result of the broader nature of U.S. security interests in the decade since the end of the Cold War. Once concerned primarily with the Soviet Union, the Intelligence Community is now tasked to monitor political, economic and even environmental developments in many places around the globe. Tasking related to national security has expanded as well. The Intelligence Community is tasked to collect scientific, technical and military information on countries potentially hostile to the U.S. or its allies. It is tasked to collect intelligence to support anti-drug efforts and anti-terrorism operations, such as the pursuit of the terrorist Osama bin Laden. Amidst these tasks, the Community has as its highest priority support for forward-deployed military forces engaged in a variety of missions to include peace enforcement operations.

2. Revolutionary Collection Methods

With the growth and use of fiber optic cable and the employment of active denial and deception measures by potential adversaries, intelligence collection from space is increasingly difficult. Information published on the Internet or elsewhere, available through unauthorized disclosure or through espionage is used by adversaries to avoid and disrupt U.S. intelligence collection efforts. This, in turn, increases the time, effort and money needed to collect information and can reduce the value of the resulting intelligence product. Nevertheless, collection from space will continue to be critical to meeting difficult intelligence collection challenges.

To meet the challenges posed to space-based intelligence collection, the U.S. needs to review its approach to intelligence collection from space. Current strategy seeks to capitalize on known technologies to improve collection capabilities in ways that will provide intelligence users, especially military forces in the field, with information in a timely fashion.

While the current collection strategy has been a boon to military forces and crisis managers, planned and programmed collection platforms may not be adaptable enough to meet the many and varied tasks assigned. The U.S. must invest in space-based collection technologies that will provide revolutionary methods for collecting intelligence, especially on difficult intelligence targets. This is essential if the U.S. is to conduct complex diplomatic initiatives successfully, provide strategic warning of significant political and military events, support research into countermeasures to the weapons of potential adversaries, and maintain its other activities not directly related to military operations.

The United States must invest in revolutionary space-based collection technologies.

3. Leveraging Commercial Products

To the extent that commercial products, particularly imagery from U.S. commercial remote sensing companies, can meet intelligence collection needs, these should be incorporated into the overall collection architecture. Current policy endorses and encourages this use.

The reasons for the policy are clear and compelling. Commercial imagery providers are now licensed to provide half-meter imagery, a resolution that allows the human eye to see objects as small as an automobile or differentiate between classes of military vehicles (Figure 17). Informed estimates suggest that data of this resolution and quality would satisfy approximately half of NIMA's requirements for information on the location of objects on the earth.

In particular, commercial imagery systems could be used for wide-area surveillance, freeing government satellites for more challenging, point-target reconnaissance. More aggressive government use of commercial imagery would also help to solidify the position of American companies in a fiercely competitive international market. However, the government has neither established a systematic process for tasking, processing and disseminating commercial imagery, nor budgeted the resources to use commercial products to meet customer needs.

1.0 meter 0.5 meter

Source: Intelligence Resource Program of the Federation of American Scientists, http://www.fas.org/irp

Figure 17: The U.S. Government has recently approved the sale of half-meter commercial imagery

Freed from providing so-called "commodity products," the Intelligence Community would be able to concentrate on more innovative technologies and take greater risk in designing future systems to overcome the growing challenges to collection. This approach should include demonstration efforts that could provide the foundation for new approaches to collection.

In designing and funding both current and revolutionary collection systems, the Intelligence Community needs to take new initiatives and dedicate more resources to planning and funding its tasking, processing, exploitation and distribution system for intelligence. If not delivered in a timely way to the user, even the best information is worse than useless.

C. Shape the International Legal and Regulatory Environment

U.S. activity in space, both governmental and commercial, is governed by treaties and by international and domestic law and regulations, which have contributed to the orderly use of space by all nations. As interest in and use of space increases, both within the United States and around the world, the U.S. must participate actively in shaping the space legal and regulatory environment. Because of its investment in space and its increasing dependence on space-based capabilities, the U.S. has a large stake in how this environment evolves. To protect the country's interests, the U.S. must promote the peaceful use of space, monitor activities of regulatory bodies, and protect the rights of nations to defend their interests in and from space.

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1. Impact on the Military Use of Space

International Law

A number of existing principles of international law apply to space activity. Chief among these are the definition of "peaceful purposes," the right of self-defense and the effect of hostilities on treaties. The U.S. and most other nations interpret "peaceful" to mean "non-aggressive"; this comports with customary international law allowing for routine military activities in outer space, as it does on the high seas and in international airspace.

There is no blanket prohibition in international law on placing or using weapons in space, applying force from space to earth or conducting military operations in and through space. There are a number of specific prohibitions on activity to which the U.S. has agreed:

- The 1963 Limited Test Ban Treaty prohibits “any nuclear weapon test explosion, or any other nuclear explosion” in outer space.

- The 1967 Outer Space Treaty proscribes placing weapons of mass destruction in space or on the moon or other celestial bodies, and using the moon or other celestial bodies for any military purposes.

- The 1972 Anti-Ballistic Missile (ABM) Treaty prohibits the development, testing, or deployment of space-based components of an anti-ballistic missile system.

- A number of arms control treaties are intended to prohibit the U.S and Russia from interfering with the other’s use of satellites for monitoring treaty compliance.

- The 1980 Environmental Modification Convention prohibits all hostile actions that might cause long-lasting, severe or widespread environmental effects in space.

It is important to note, however, that by specifically extending the principles of the U.N. Charter to space, the Outer Space Treaty (Article III) provides for the right of individual and collective self-defense, including “anticipatory self-defense.” In addition, the non-interference principle established by space law treaties would be suspended among belligerents during a state of hostilities.

Emerging Challenges

To counter U.S. advantages in space, other states and international organizations have sought agreements that would restrict the use of space. For example, nearly every year, the U.N. General Assembly passes a resolution calling for prevention of “an arms race in outer space” by prohibiting all space weapons. Russia and China have proposed to prohibit the use of space for national missile defense. The U.S. should seek to preserve the space weapons regime established by the Outer Space Treaty, particularly the traditional interpretation of the Treaty’s “peaceful purposes” language to mean that both self-defense and non-aggressive military use of space are allowed.

The U.S. should review existing arms control obligations in light of a growing need to extend deterrent capabilities to space. These agreements were not meant to restrict lawful space activity outside the scope of each treaty. For example, ABM Treaty prohibitions on space-based ABM systems should not apply to other types of space-based systems that do not meet its definitions. Similarly, while international treaty law holds that arms control and other treaties may be suspended between belligerents during a state of conflict, the changing character of conflict requires careful consideration of U.S. obligations when the status of belligerents may be unclear.

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The U.S. must be cautious of agreements intended for one purpose that, when added to a larger web of treaties or regulations, may have the unintended consequence of restricting future activities in space. One recent example is the agreement signed between the U.S. and Russia on a Pre- and Post-Launch Notification System (PLNS), intended to minimize the consequences of a false missile attack warning. It requires at least 24-hour advance notice of every significant launch. The PLNS may establish a precedent for using international agreements to regulate space launch. Its specific provisions, which apply both to ballistic missiles and conventional space launch vehicles, could prove to be a significant burden if applied to systems now being designed to provide "better, faster, cheaper" access to space.

2. Satellite Regulation

U.S. satellite companies face many new legal and regulatory challenges. Traditional priorities and alliances are shifting, and international negotiations are becoming less predictable and more complex. Globalization is increasing. Foreign satellite services entering the U.S. market may bring competitive advantages to the United States and may also raise national security concerns. At the same time, more governments are expanding their use of satellite systems, raising critical near-term regulatory issues. For example:

- ***Radio Frequency Spectrum.*** Demands for radio frequency spectrum are escalating because of the pro-competitive market-opening effects of the 1997 World Trade Organization Agreement, as well as new and expanded uses of radio-frequency spectrum. As a result, the allocation, assignment and coordination of radio-frequency spectrum for government and non-government purposes is becoming more difficult and time-consuming. Nations and international organizations are addressing these issues, which have significant security and economic implications worldwide.

- ***Export Controls.*** Different arms of the U.S. Government have widely differing and sometimes contradictory perspectives toward exports. While export controls can prevent technology from falling into dangerous hands, a process that is too onerous and time-consuming can needlessly restrict U.S. companies in the international market, weaken the U.S. space industry in the global market and eventually erode U.S. technological leadership.

Looking toward the future, the U.S. challenge is to shape a domestic and international legal and regulatory framework that ensures U.S. national security and enhances the commercial and civil space sectors. This means strengthening and supporting the competitive position of U.S. interests in space commerce. An effective interagency process needs to be put in place to identify and address the multiple U.S. interests, sort out the implications of U.S. policies and positions and avoid uncoordinated decisions.

D. Advance U.S. Technological Leadership

To achieve national security objectives and compete successfully internationally, the U.S. must maintain technological leadership in space. This requires a healthy industrial base, inproved science and technology resources, an attitude of risk-taking and innovation, and government policies that support international competitiveness. In particular, the government needs to significantly increase its investment in breakthrough technologies to fuel innovative, revolutionary capabilities. Mastery of space also requires new approaches that reduce significantly the

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cost of building and launching space systems. The U.S. will not remain the world's leading space-faring nation by relying on yesterday's technology to meet today's requirements at tomorrow's prices.

1. Investment in Research and Development

Research and development investment is a powerful engine to drive industrial growth. Aerospace research and development investments of the 1960s through the 1980s propelled the U.S. into world leadership in the space business. Since the 1980s, however, the aerospace sector's share of the total national research and development investment has decreased from nearly 20 percent to less than 8 percent, an amount insufficient to maintain the nation's leadership position in space in the coming decades.

The problem is compounded by how industry is investing its research and development resources. U.S. companies are investing most of the independent research and development funds available to help win modernization contracts rather than invest in "leap ahead" technologies.

2. Government/Industry Relationship

The U.S. Government needs to develop a new relationship with industry to ensure U.S. space technological leadership.

The recent *U.S. Space Industrial Base Study* that surveyed 21 major defense contractors found the space industry plagued by deteriorating financial health, a high debt burden, and a rate of return that is often less than the cost of raising funds. The government should be sensitive to this situation and ensure that its policies allow industry to realize a reasonable rate of return on its investment in the space business.

The U.S. Government needs to develop a new relationship with industry to ensure U.S. space technological leadership.

To advance technological leadership, the goal is to ensure conditions exist such that the U.S. commercial space industry can field systems one generation ahead of international competitors and the U.S. Government can field systems two generations ahead. These goals can be attained if the U.S. Government is a responsible investor, consumer and regulator in the space industry. The U.S. Government needs to:

- Increase its space research and development *investment* and focus on those critical technologies unique to national security.

- Become a more reliable *customer* of commercial space products and services.

- Establish *regulatory* policies that encourage rather than restrict the availability of space products worldwide, while maintaining the U.S. technological lead.

Continued investment in research and development will help discover revolutionary and innovative advances for national security. At the same time, earlier-generation technology can migrate to the domestic and international commercial sectors.

3. New Approaches to Space

The cost of transporting payloads to space has two separate aspects: the cost-per-unit of weight and the cost-per-unit of capability. In the near term, it will be easier to reduce the cost-per-unit of capability, through miniaturization and related technologies, than to reduce the cost-per-unit of weight. Beyond these technical advances, mastery of space requires new approaches that will lower the cost of building and launching space systems.

Two fundamental changes could revolutionize U.S. space capabilities and lead the way to reducing the cost of operating in space:

- Align payload value to risk by separating manned space operations from cargo launches, making both manned and unmanned space operations more economical. For example, manned space flights could be supported by smaller reusable launch vehicles that incorporate the range of safety measures required for manned flights. On the other hand, cargo could be launched on more economical vehicles, either unmanned reusable launch vehicles or expendable vehicles, without the expensive, time-consuming safety measures required for manned flight.

- Shift from hand-tooled, custom-built space hardware to an infrastructure based on standardized hardware and software.

E. Create and Sustain a Cadre of Space Professionals

Since its inception, a hallmark of the U.S. space program has been world-class scientists, engineers and operators from academic institutions, industry, government agencies and the military Services. Sustained excellence in the scientific and engineering disciplines is essential to the future of the nation's national security space program. It cannot be taken for granted.

Military space professionals will have to master highly complex technology; develop new doctrine and concepts of operations for space launch, offensive and defensive space operations, power projection in, from and through space and other military uses of space; and operate some of the most complex systems ever built and deployed. To ensure the needed talent and experience, the Department of Defense, the Intelligence Community and the nation as a whole must place a high priority on intensifying investments in career development, education and training to develop and sustain a cadre of highly competent and motivated military and civilian space professionals.

1. Developing a Military Space Culture

The Department of Defense is not yet on course to develop the space cadre the nation needs.

The Department of Defense is not yet on course to develop the space cadre the nation needs. The Department must create a stronger military space culture, through focused career development, education and training, within which the space leaders for the future can be developed. This has an impact on each of the Services but is most critical within the Air Force.

Leadership

Leadership is a vital element in gaining mastery in any military area of endeavor. U.S. air power is the product of pilots such as Billy Mitchell, Hap Arnold and Curtis LeMay. It was Hyman Rickover who blazed the trail that led to the nuclear Navy. These individuals succeeded because they drew upon the talents of thousands of flyers or nuclear naval officers leading at all levels of command and staff. In the Air Force pilot and Navy nuclear submarine career fields, military leaders have spent about 90 percent of their careers within their respective fields.

In contrast, military leaders with little or no previous experience or expertise in space technology or operations often lead space organizations. A review by the Commission of over 150 personnel currently serving in key operational space leadership positions showed that fewer than 20 percent of the flag officers in key space jobs come from space career backgrounds (Figure 18). The remaining officers, drawn from pilot, air defense artillery and Intercontinental Ballistic Missile (ICBM) career fields, on average had spent 8 percent, or 2.5 years, of their careers in space or space related positions. Officers commanding space wings, groups and squadrons fare only slightly better; about one-third of the officers have extensive space experience, while the remaining two-thirds averaged less than 4.5 years in space-related positions (Figure 19).

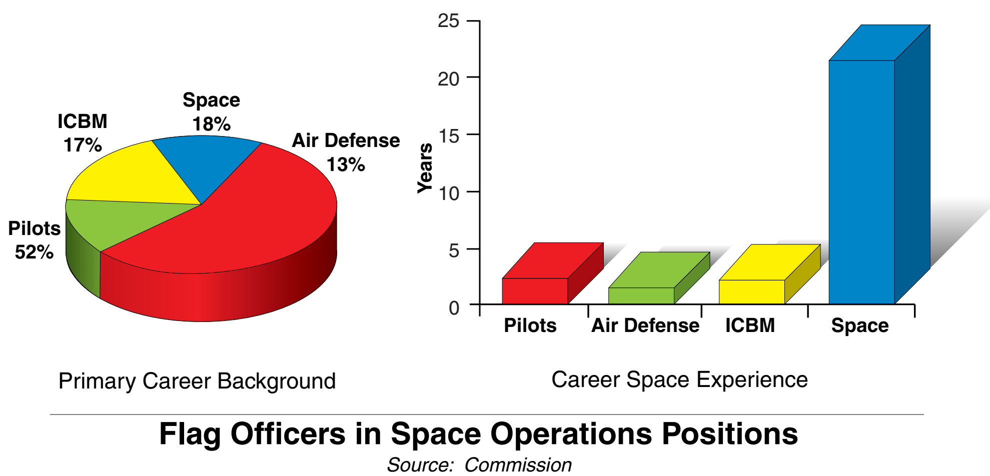

Figure 18: Career space experience of flag officers

This lack of experience in leadership positions is a result of several factors. The space force is young and small, but it has been around long enough for a few to reach four-star rank and the number of personnel is growing. There has been an infusion of personnel from the ICBM force into space organizations in an effort to broaden career opportunities for the missile launch officers. Over time, this will create a larger cadre of space professionals, but in the short term it has had an impact on the overall level of experience of space personnel. Military officers with space training are in high demand in the commercial world. As a result, there has been a

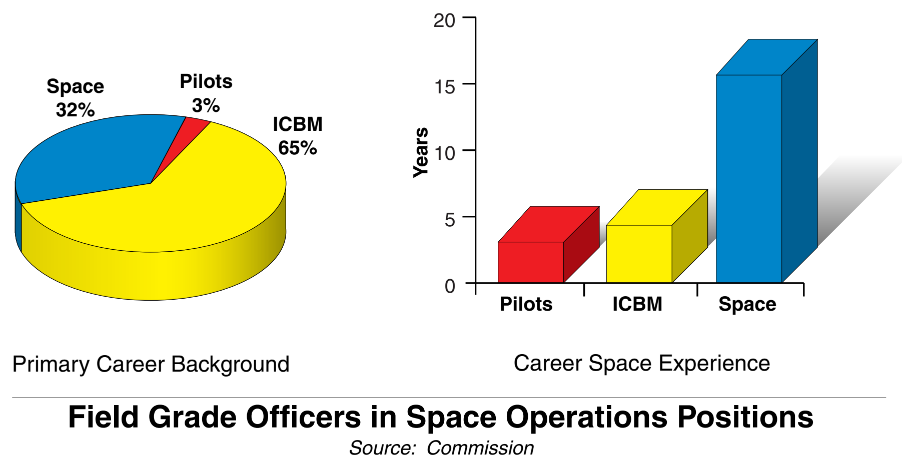

Figure 19: Career space experience of Air Force field grade officers

drain of space talent as evidenced by the low retention of first term space engineers and operators. Finally, there is a lack of focused career development in the space community.

Space leadership in the military will require highly trained and experienced personnel at the very senior positions and throughout all echelons of command. These leaders must provide the vision, the technological expertise and doctrine, concepts and tactics to generate and operate space forces in this new era of space and to generate the cadre of space professionals future military operations will require. New space personnel management policies and new career paths are needed to develop leaders with greater depth and breath of experience in the space career field.

New Career Paths

Depth. Space professionals need more depth of experience in their field and more extensive education and training. In the past, space forces have relied on accessions of highly educated officers who are trained in space once in the job. Instead, career tracks need to be developed that will provide commanders at all levels more expertise within their mission areas. To achieve this, specific criteria should be developed for the selection, training, qualification and assignment of space personnel who will design, develop, acquire and operate military space systems. Training programs need to be refined to provide the basis for qualifying space professionals to occupy specific positions in the space force.

Breadth. Tomorrow's space professionals need a broader understanding of operations across the range of space mission areas and the size of the space cadre will need to grow, as space becomes increasingly important to military operations. Perhaps more than other areas, space benefits from a unique and close relationship among research, development, acquisition and operations, as spacecraft are usually procured in far fewer numbers, sometimes as few as one or two, than are tanks, airplanes or missiles. Exchange of personnel across space communities, between the operational and acquisition commands and between the Air Force and the NRO, is clearly desirable but at present there are barriers that restrict the cross flow of personnel among these communities.

Personnel managers in the Air Force need to have a comprehensive view of all space career positions within the national security space community and the means to manage individual assignments among the acquisition, operations and intelligence communities. Improving the exchange of personnel among these organizations, would expand the space manpower base and could also help to reverse the retention problem among space acquisition officers by opening up new career paths and leadership opportunities within the Air Force.

Education

To ensure the highly skilled workforce needed, technical education programs will have to be enhanced. Space systems under development, such as the Space-Based Infrared System and the Global Positioning System III, and future systems envisioned, such as a space-based radar and a space-based laser, will be far more complex than today's systems. New concepts for space launch, offensive and defensive space control operations and projection of military power in, from and through space will give rise to increasing technology innovation.

Other career fields, such as the Navy's nuclear submarine program, place strong emphasis on career-long technical education. This approach produces officers with a depth of understanding of the functions and underlying technologies of their systems that enables them to use the systems more efficiently in combat. The military's space force should follow this model. In addition, career field entry criteria should emphasize the need for technically oriented personnel, whether they be new lieutenants or personnel from related career fields. In-depth space-related science, engineering, application, theory and doctrine curricula should be developed and its study required for all military and government civilian space personnel, as is done in the Naval Nuclear Propulsion Program.

Tour Length

Military officers typically remain in their assignments for only a year or two, especially as they rise in rank. Short assignments can make it difficult for officers in leadership positions to establish sufficient continuity to create and execute a vision for the job. If the officers have experience and training in their specialties, however, problems of this sort can be mitigated.

In general, leadership in the space field today suffers on all counts: limited experience in the field, little technical education and tour lengths that average less than a year and a half. This keeps space organizations from reaching their potential. Space leaders spend most of their assignments learning about space rather than leading. This can weaken their effectiveness as military leaders, as they of necessity come to depend on civilian subordinates, whether civil servants or contractor personnel. Until space leaders have more extensive experience and technical training in space activities, longer and more stable tour lengths would be desirable.

2. Professional Military Education

Space capabilities are already integral to all traditional air, land and sea military operations. They have contributed to U.S. successes in conflicts during the past decade, from DESERT STORM in 1991 to the air campaign against Serbia in 1999. Soldiers, sailors, marines and airmen need an understanding of how space systems are integrated into nearly all military operations, particularly as new systems and applications emerge.

Professional military education does not stress the technical, operational or strategic application of space systems to combat operations.

Programs in the four Services' professional military education institutions are key sources of space education programs. In all the military schools, space education is gaining in prominence. Within the Air Force, space education is now integrated into all phases of professional military education. New Air Force lieutenants who attend the Aerospace Basic Course are taught space fundamentals and how space systems are integrated into the tactical and operational levels of war. Other Service schools offer space electives as well as optional space focus areas. The Naval War College offers several elective courses allowing students at both its intermediate and senior service schools to focus on space. The Army Command and General Staff College offers a focused study program requiring 81 hours of space-related instruction. Students completing this program are awarded a special skill identifier qualifying them to serve in space-related positions in Army and Joint commands.

Despite the increased attention given to space within the military education system, the core curriculum does not stress, at the appropriate levels, the tactical, operational or strategic application of space systems to combat operations. Military commanders and their staffs continue to rely on "space support teams" assigned to them in time of crisis to advise on the use of space capabilities. Commanders would be better able to exploit the full range of combat capability at their disposal if they were educated from the beginning of their careers in the application of space systems.

3. Science and Engineering Workforce

To build a cadre of space professionals, the Department of Defense needs to draw on the nation's best scientists and engineers. However, both industry and the U.S. Government face substantial shortages in these fields and an aging workforce. Experienced personnel from the Apollo generation are nearing retirement and recruitment is difficult. The aerospace and defense industries overall have seen their appeal battered by declining stock prices, steady layoffs, program failures and cost and schedule overruns. Without a sufficient base of interesting, leading edge technology programs, it is increasingly difficult for both industry and government to attract and retain talent.

Senior leaders in the space industry are unanimous in identifying recruiting and retention of qualified people as their number one problem.

Senior leaders in the space industry are unanimous in identifying recruiting and retention of qualified people as their number one problem. Their talent pool is aging and many experienced engineers are leaving industry. Filling the pipeline is a growing challenge, with the space industry being one of many sectors competing for the limited number of trained scientists and engineers.

The National Science Board recently reported that the U.S. has fewer science and engineering graduates than many major industrialized and emerging nations. At the same time, the demand for scientists and engineers is expected to increase in the next ten years at a rate almost four times that of all other occupations. The growing need for scientists and engineers is a national concern.