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RECOMMENDATION #4: The Commission recommends that the nation adopt a policy that invigorates and sustains the U.S. aerospace industrial base. This policy must include:

- Procurement policies which include prototyping, spiral development, and other techniques which allow the continuous exercise of design and production skills;
- Stable funding for core capabilities, without which the best and brightest will not enter the defense industry;
- Removing barriers to international sales of defense products;
- Removing barriers to defense procurement of commercial products and services;
- Propagating defense technology into the civil sector, particularly in communication, navigation and surveillance; and
- Sustaining critical technologies that are not likely to be sustained by the commercial sector, e.g., space launch, solid rocket boosters, etc.

Chapter 4

National Security: Defend America and Project Power

For at least the next quarter century or more, the effectiveness of the American defense posture will be a crucial determinant of world peace, prosperity, and stability. The relationship between advanced technology and national security is a metaphor for the manner in which our society will grow and prosper in the 21st century.[1] It is essential that the public policy environment in the 21st century reflect an appreciation of these circumstances.

During the 20th century, the development of advanced technology for national security applications stimulated the introduction and diffusion of such technology to the world. The policy and institutional setting of the 20th century will not work for the 21st. In the 21st century, the sources of the enabling technologies for vital military capabilities will be in both the commercial and the defense sectors. The co-dependence of the commercial and military sectors for advanced technology development and applications requires new approaches to the policy environment that sustains the defense component of the aerospace sector.

The core competencies of the U.S. defense industrial sector—systems engineering and system(s) integration—are the decisive enabling skills that must transform widely accessible technologies into superior military capabilities. The transformation of the U.S. defense posture, from one dependent on industrial

> Before the war in Afghanistan, that area was low on the list of major planning contingencies. Yet, in a very short time, we had to operate across the length and breadth of that remote nation, using every branch of the armed forces. We must prepare for more such deployments by developing assets such as advanced remote sensing, long-range precision strike capabilities, and transformed maneuver and expeditionary forces. This broad portfolio of military capabilities must also include the ability to defend the homeland, conduct information operations, ensure U.S. access to distant theaters, and protect critical U.S. infrastructure and assets in outer space.
>
> National Security Strategy, September 20, 2002

age technology to one led by the technologies of information and decision superiority, will require the modernization of existing policies, institutions, and public resource allocation.

The Contribution of Aerospace to National Security

Defending our nation against its enemies is the first and fundamental commitment of the federal government.[2] This translates into two broad missions—Defend America and Project Power—when and where needed.

In order to defend America and project power, the nation needs the ability to move manpower, materiel, intelligence information and precision weaponry swiftly to any point around the globe, when needed. This has been, and will continue to be, a mainstay of our national security strategy.

The events of September 11, 2001 dramatically demonstrated the extent of our national reliance on aerospace capabilities and related military contributions to homeland security. Combat air patrols swept the skies; satellites supported real-time communications for emergency responders, imagery for recovery, and intelligence on terrorist activities; and the security and protection of key government officials was enabled by timely air transport.

As recent events in Afghanistan and Kosovo show, the power generated by our nation's aerospace capabilities is an—and perhaps **the**—essential ingredient in force projection and expeditionary operations. In both places, at the outset of the crisis, satellites and reconnaissance aircraft, some unmanned, provided critical strategic and tactical intelligence to our national leadership. Space-borne intelligence, command, control and communications assets permitted the rapid targeting of key enemy positions and facilities. Airlifters and tankers brought personnel, materiel, and aircraft to critical locations. And aerial bombardment, with precision weapons and cruise missiles, often aided by the Global Positioning System (GPS) and the Predator unmanned vehicle, destroyed enemy forces. Aircraft carriers and their aircraft also played key roles in both conflicts.

Today's military aerospace capabilities are indeed robust, but at significant risk. They rely on platforms and an industrial base—measured in both human capital and physical facilities—that are aging and increasingly inadequate. Consider just a few of the issues:

- Much of our capability to defend America and project power depends on satellites. Assured reliable access to space is a critical enabler of this capability. As recently as 1998, the key to near- and mid-term space access was the Evolved Expendable Launch Vehicle (EELV), a development project of Boeing, Lockheed Martin and the U. S. Air Force. EELV drew primarily on commercial demand to close the business case for two new launchers, with the U.S. government essentially buying launches at the margin. In this model, each company partner made significant investments of corporate funds in vehicle development and infrastructure, reducing the overall need for government investment. Today, however, worldwide demand for commercial satellite launch has dropped essentially to nothing—and is not expected to rise for a decade or more—while the number of available launch platforms worldwide has proliferated. Today, therefore, the business case for EELV simply does not close, and reliance on the economics of a commercially-driven market is unsustainable. A new strategy for assured access to space must be found.

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- The U.S. needs unrestricted access to space for civil, commercial, and military applications. Our satellite systems will become increasingly important to military operations as today's information revolution, the so-called "revolution in military affairs," continues, while at the same time satellites will become increasingly vulnerable to attack as the century proceeds. To preserve critical satellite networks, the nation will almost certainly need the capability to launch replacement satellites quickly after an attack. One of the key enablers for "launch on demand" is reusable space launch, and yet within the last year all work has been stopped on the X-33 and X-34 reusable launch programs

- The challenge for the defense industrial base is to have the capability to build the base force structure, support contingency-related surges, provide production capacity that can increase faster than any new emerging global threat can build up its capacity, and provide an "appropriate" return to shareholders. But the motivation of government and industry are different. This is a prime detraction for wanting to form government-industry partnerships. Industry prioritizes investments toward near-term, high-return, and high-dollar programs that make for a sound business case for them. Government, on the other hand, wants to prioritize investment to ensure a continuing capability to meet any new threat to the nation. This need is cyclical and difficult for businesses to sustain during periods of government inactivity. Based on the cyclic nature of demand, the increasing cost/complexity of new systems, and the slow pace of defense modernization, aerospace companies are losing market advantages and the sector is contracting. Twenty-two years ago, today's "Big 5" in aerospace were 75 separate companies, as depicted by the historical chart of industry consolidation shown in Chapter 7.

One of the key enablers for "launch on demand" is reusable space launch, and yet within the last year all work has been stopped on the X-33 and X-34 reusable launch programs.

> "Our goal is not to bring war into space, but rather to defend against those who would. Protecting U.S. military and commercial assets in space from attack from foreign aggressors must be a priority in the 21st century."
>
> Defense Secretary Donald Rumsfeld[3]

- Tactical combat aircraft have been a key component of America's air forces. Today, three tactical aircraft programs continue: the F/A-18E/F (in production), the F/A-22 (in a late stage of test and evaluation), and the F-35 Joint Strike Fighter (just moving into system design and development). Because of the recentness of these programs, there are robust design teams in existence. But all of the initial design work on all three programs will be completed by 2008. If the nation were to conclude, as it very well may, that a new manned tactical aircraft needs to be fielded in the middle of this century, where will we find the experienced design teams required to design and build it, if the design process is in fact gapped for 20 years or more?

- More than half of the aerospace workforce is over the age of 40[4], and the average age of aerospace defense workers is over 50.[5] Inside the Department of Defense (DoD), a large percent of all scientists and engineers will be retirement eligible by 2005. Given these demographics, there will be an exodus of "corporate knowledge" in the next decade that will be difficult and costly to rebuild once it is lost. There will be a critical need for new engineers, but little new work to mature their practical skill over the next several decades. Further, enrollment in aerospace engineering programs has dropped by 47 percent in the past nine years[6], and the interest and national skills in mathematics and science are down. Defense spending on cutting-edge work is at best stable, and commercial aircraft programs

are struggling and laying workers off. As the DoD's recent Space Research and Development (R&D) Industrial Base Study[7] concluded, "[s]ustaining a talented workforce of sufficient size and experience remains a long-term issue and is likely to get worse." In short, the nation needs a plan to attract, train and maintain a skilled, world-class aerospace workforce, but none currently exists.

- The current U.S. research, development, test and evaluation (RDT&E) infrastructure has a legacy dating back to either World War II or the expansion during the Space Age in the 1960s. It is now suffering significantly from a lack of resources required for modernization. In some cases, our nation's capabilities have atrophied and we have lost the lead, as with our outdated wind tunnels, where European facilities are now more modern and efficient. In the current climate, there is inadequate funding to modernize aging government infrastructure or build facilities that would support the development of new transformational capabilities, such as wind tunnels needed to design and test new hypersonic vehicles. The aerospace industry must have access to appropriate, modern facilities to develop, test and evaluate new systems.

Throughout this dynamic and challenging environment, one message remains clear: a healthy U.S. aerospace industry is more than a hedge against an uncertain future. It is one of the primary national instruments through which DoD will develop and obtain the superior technologies and capabilities essential to the on-going transformation of the armed forces, thus maintaining our position as the world's preeminent military power.

Objective: A Safe and Secure World

The U.S. aerospace industry's future contribution to national security is captured in the Commission's overall vision of "Anyone, Anything, Anywhere, Anytime". For national security, this provides the ability to:

- Rapidly, safely, and securely send and receive information;
- Move troops, equipment, and supplies to anywhere on the globe or into space, at anytime; and
- Prosecute effects-based warfare.

National security organizations must be able to monitor, detect, neutralize and/or defeat future conventional and asymmetric threats anywhere in the world by applying new technologies and operational capabilities to implement our national security strategy and address our national security needs.

Included in these capabilities are a better understanding of space situational awareness and more serious attention to the threat to global security posed by space debris and by Near-Earth Objects, such as asteroids. Space- and ground-based surveillance systems can provide time-critical detection of these threats, making a valuable contribution to this emerging and very demanding national security requirement. The issue of planetary defense is also discussed in Chapters 3 and 6.

To deliver the required capabilities and to address any national security needs quickly and affordably, the U.S. must possess an aerospace industry that is 'right-sized', healthy, highly flexible, and responsive to its customers. The government can help by removing unnecessary paperwork and oversight on government programs and eliminating restrictions on contractor-developed intellectual property. It can also help by continuing to increase investment in

DoD TRANSFORMATION GOALS[8]

- Defend the U.S. homeland and other bases of operation, and defeat nuclear, biological and chemical weapons and their means of delivery
- Deny enemies sanctuary—anytime, anywhere
- Project and sustain forces in distant theaters in the face of access denial threats
- Conduct effective operations in space
- Assure information security and conduct effective information operations
- Provide a common operational picture for joint forces

next-generation aerospace capabilities. Increased investment will have the dual effect of improving defense capabilities and attracting the "best and brightest" workforce to the aerospace sector.

Issues

Enhancement and, indeed, the preservation of our current military capabilities in air and space require a comprehensive, cross-cutting national industrial base policy. Many elements of such a policy are discussed in this report.

The Commission believes that the key to any policy is maintaining the manufacturing capacity and human capital required to build, integrate and maintain aerospace systems. There are three key elements of such a policy: (1) sustaining the defense industrial base; (2) building experience in the workforce; and (3) maintaining our critical national infrastructure.

The Defense Industrial Base: Consolidations and Unstable Demand

In the past, the DoD had the luxury of drawing on a large workforce employed in a large number of U.S. aerospace companies that, as a whole, dominated world markets. That is not the case today. The number of U.S. aerospace companies has significantly reduced over the past 22 years. The total U.S. aerospace workforce has shrunk by approximately 700,000 in the last decade.[9] There is significant over-capacity and limited international demand in both satellite production and space launch, which is likely to lead to further consolidations and additional lay-offs in the near-term.

The Commission, in its Interim Report #3, requested the Secretary of Defense to task the Defense Science Board (DSB) to review and recommend overall DoD policy toward future military industrial base consolidation, including its policies toward mergers and acquisitions. In particular, as part of this review, the DSB should:

- Address the aerospace industry consolidation and workforce challenges resulting from today's diminishing number of system design programs;
- Assess approaches for aligning consolidation policies with procurement and budgeting policies;
- Consider specific measures (metrics) on the health of defense contractors, such as magnitude and longevity of a contractor's production base and product development work; and
- Assess the long-term sustainability of the nation's high-performance aircraft and solid rocket booster design and development capabilities, including the potential of increasing/initiating high payoff technology development programs and/or continuing low-rate production of strategic systems to bridge industry capabilities to a succeeding generation.

Unstable demand for air and space systems has been a major contributor to an age imbalance in both industry and government aerospace workforces. Younger workers have been laid off first and have more readily taken voluntary separations. At the same time, students do not see a bright future in the aerospace industry and seek other professions. To get out of this trap, government policy must focus on both the demand and supply sides of the aerospace

ISSUES

- The Defense Industrial Base
  - Funding
  - Transnational Partnerships and International Sales
  - Defense Procurement of Commercial Products and Services
  - Transition of Defense Technologies to Civil Applications
  - Technology Insertion and Operational Support for Defense Systems
- Experience in the Workforce
  - Opportunities to Learn
  - Skills Transfer to the Next Generation
  - Intellectual Capital
- Critical National Infrastructure
  - Facilities
  - Capabilities

labor market, particularly since defense spending could be one of the few sources of stable demand in the U.S. aerospace sector.

On the demand side, government must increase and then stabilize funding for research and development and for the prototyping, spiral development, and production of new systems. In addition, government should reduce barriers that inhibit demand for the aerospace products and services needed for national security.

The barriers that inhibit demand could be reduced by the following actions. First, as discussed in Chapter 6, government must remove unneeded government-imposed barriers on the export of defense products. Second, since the civil and military aerospace workforces are highly integrated, DoD can improve its access to trained workers by removing the remaining barriers to its use of commercial products and services and, more importantly, by buying commercial products and services on a priority basis when appropriate. Third, government should move military aerospace products into the commercial sector in areas such as air-to-air and satellite-to-air communications, where DoD has significant technology that could meet civilian needs, and integration could capitalize on international demand for modernized aerospace systems.

Our overall national security depends on the efforts of multiple government departments and agencies, working as partners, with stable and sufficient budget lines.

Prototype unmanned combat air vehicle.

"The Wright Brothers Institute in Dayton, Ohio is building collaborative partnerships … of government, industry, and academia… to expand the base of science, technology, engineering, and design integration available for air and space applications."

General Lester L. Lyles, testimony submitted to the Aerospace Commission, August 22, 2002

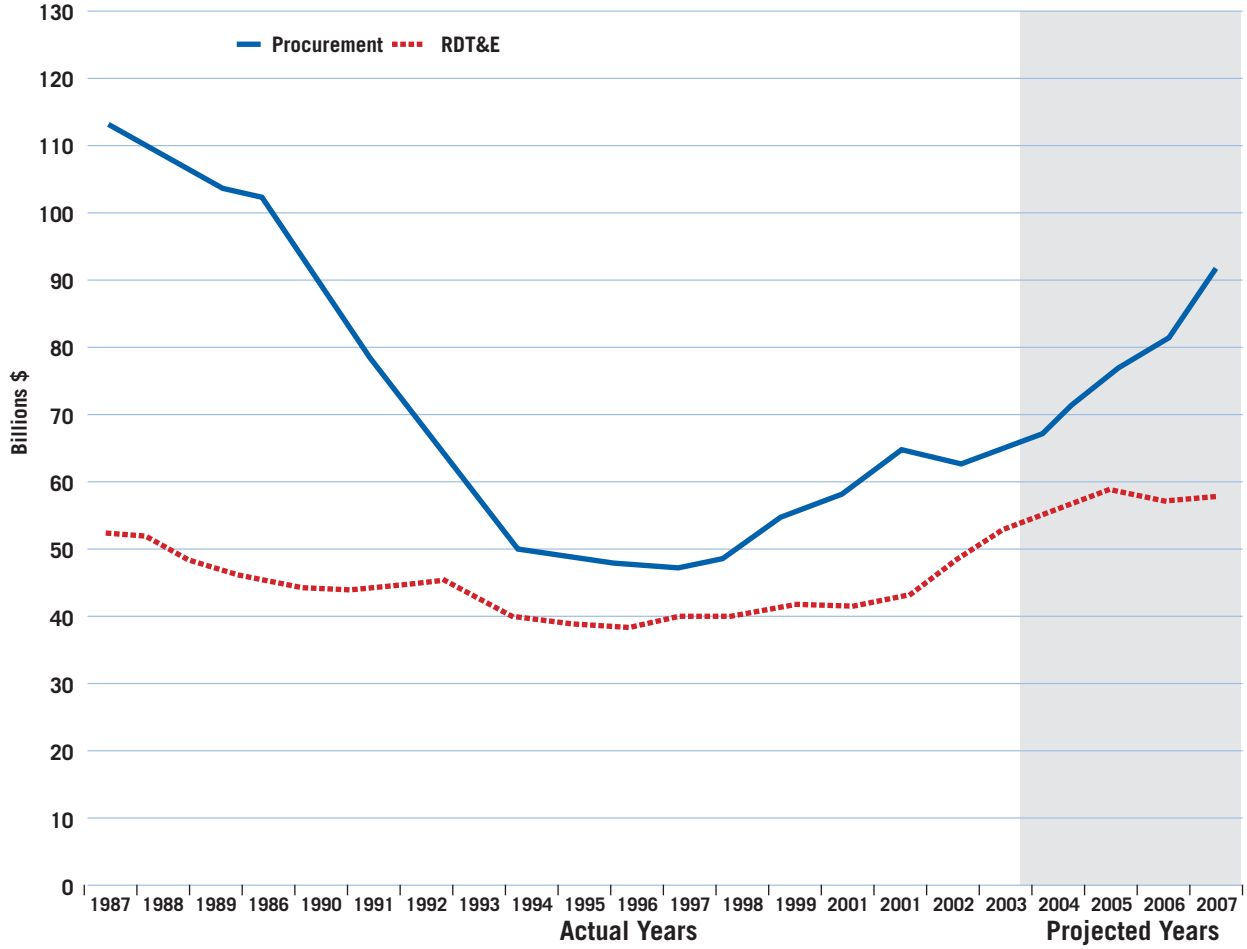
If stabilization of demand through increased funding for cutting edge research and development/prototyping programs is insufficient to develop a sufficient supply of talented engineering and factory workers, a program of targeted grants, loans or tax credits for apprenticeship and graduate education programs might also be considered.

FUNDING. Our overall national security depends on the efforts of multiple government departments and agencies, working as partners, with stable and sufficient budget lines. However, all departments and agencies suffer from conflicting priorities and annual congressional authorization and appropriation processes, which may lead to unstable funding over time.

The inability to fund all the competing demands within the defense budget often leads to unrealistic initial cost estimates, a mismatch of program requirements and budget, service-imposed "taxes", and insufficient management reserves to address major unforeseen events. In addition, the large operations and support costs associated with legacy systems, and the need to support ongoing military operations, drain funding away from R&D, infrastructure modernization, and force transformation.

The Secretary of Defense has expressed concern about the impact of unstable funding in the defense

Figure 4-1 FY 1987 – FY 2007 DoD Budget Authority



Source: National Defense Budget Estimate for FY03, Office of the USD (Comptroller)

sector. See Figure 4-1. He has specifically recommended that defense in the 21st century be seen as one where the military forces cannot be optimized against a specific threat. Instead, he suggests that defense spending be understood to be closer to an investment that is subject to a stable fraction of national income, suggesting 3-3.5 percent per annum—about one third of the Cold War peak in 1962.[10] This could be considered a constructive alternative concept to address the subject of how "stable funding" might be achieved.

The Commission's recommendations to enhance DoD budget stability and flexibility in Interim Report #3 addressed these issues, in part. Further, the Commission supports DoD's Fiscal Year (FY) 04 Legislative Priority #9, "Streamline DoD Processes," to shorten the Planning, Programming, and Budgeting System and the acquisition cycle time.[11] Refer to Chapter 5 for actions the Congress can take to improve their authorization and appropriation process for aerospace.

Further, the Commission believes that DoD's annual science and technology (6.1-6.3) funding must be sufficient and stable to create and demonstrate the innovative technologies needed to address future national security threats. An amount no less than three percent of DoD Total Obligational Authority, "fenced" from budget cuts, would be sufficient. The use of more joint technology development and acquisition programs would also help to spread the funding burden and promote interoperability.

To help reduce the high development and production costs of advanced military systems, the U.S. must also increase the number of international joint programs, such as the Joint Strike Fighter.

Transnational Partnerships and International Sales. DoD and the U.S. aerospace industry share a long history of forming global partnerships and conducting joint operations with our allies. However, the current regulatory environment, especially in the area of export controls, provides too little security, restricts American companies from marketing their products, and prevents effective international technology collaboration. In addition to increasing international commercial trade tensions, today's regulatory environment hinders the development of national security partnerships and sales of U.S. defense equipment to our friends and allies.

The Commission believes that the federal government must remove unnecessary barriers to international sales of defense products, and implement other initiatives that strengthen global partnerships to enhance national security. To help reduce the high development and production costs of advanced military systems, the U.S. must also increase the number of international joint programs, such as the Joint Strike Fighter, and continue to foster international interoperability of defense and commercial aerospace systems-of-systems. At the same time, we must also ensure that our truly militarily critical technologies are protected in the international marketplace, and compliance must be strictly enforced. These issues are discussed in more detail in Chapter 6.

The Commission believes that the federal government must remove unnecessary barriers to international sales of defense products, and implement other initiatives that strengthen global partnerships to enhance national security.

Defense Procurement of Commercial Products and Services. DoD procurement policies must be modernized in a manner that will allow the DoD to access the full range of modern technology. Accessing this technology—most of which will originate as "commercial" technology—will allow the specialized defense industrial base to transform them into products and services that create superior military capabilities. The manner in which DoD procurement is currently structured prevents the DoD and its industrial base from doing so. As a consequence, defense technology is falling behind the pace of development in the civil sector rather than leading it.

Unfortunately, many commercial companies are electing to avoid government work due to onerous paperwork and the risk of losing intellectual property. This hinders the

application of the latest technology to military products. The government must revise policies and processes to encourage commercial vendors to provide their products and services for national defense applications. Use of commercial technology is critical to integrated national security systems of the future.

The Commission believes DoD acquisition policies should encourage greater use of commercial standards, impose government requirements by exception only, allow commercial entities to protect intellectual property, and remove other burdensome regulations that deter providers of commercial pro-ducts from doing business with the government.

Transition of Defense Technologies into Civil Applications. There are numerous other government missions that would benefit from defense technology and capabilities, such as in the areas of communications, navigation, surveillance, and reconnaissance. The Commission believes that these technologies could be adapted and transitioned into other government applications, such as those that would significantly enhance the capacity of our air traffic management system and simultaneously enhance our national defense and homeland security. These topics are also discussed in Chapters 2 and 3.

Technology Insertion and Operational Support for Defense Systems. Aging aerospace systems and infrastructure create a large and growing operations and support cost burden that adversely impacts warfighter readiness, morale and retention. Many aerospace systems, like the B-52, are on the path to an operational life of 50-75 years, though their original design life was only 20-30 years. See Figure 4-2. These aging systems face inadequate spares support, increased inspections and maintenance costs. In some cases, these aging systems pose flight safety risks.

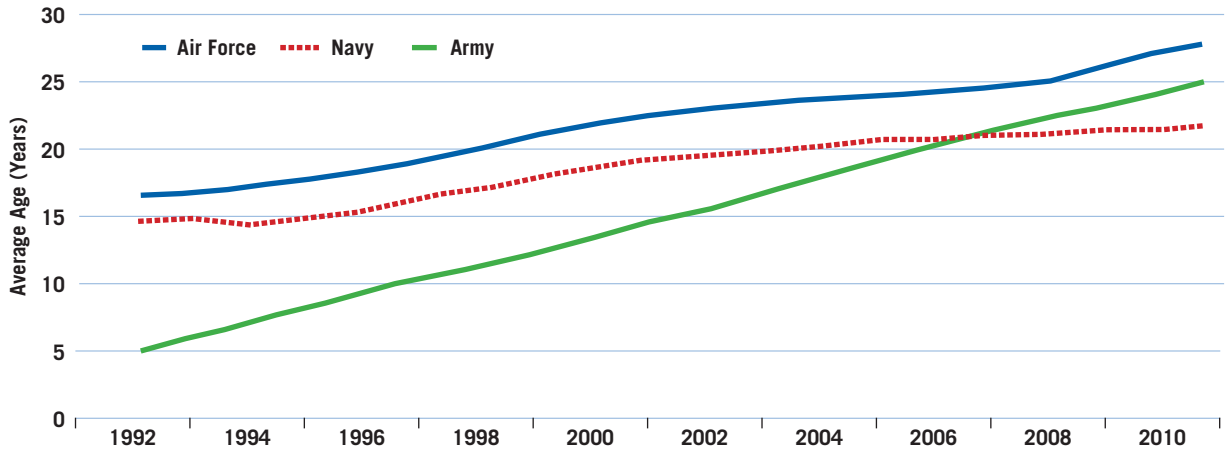
As the military transforms with new aerospace systems to meet future threats, the operational readiness and capabilities of defense platforms will need to be sustained and upgraded.

The high cost to develop and procure new systems is one cause for legacy systems to be retained in service. New operational concepts are also causing legacy systems to be used much differently than originally intended. The high cost to retrofit legacy platforms with improvements to enhance their operational readiness and capability is equally problematic.

As the military transforms with new aerospace systems to meet future threats, the operational readiness and capabilities of defense platforms will need to be sustained and upgraded:

- Extending aircraft mission range would reduce the need to forward stage fuel and supplies, resulting

Figure 4-2 Military Aircraft Age Trend



Source: Joint Aeronautical Commanders Group

Many aerospace systems, like the B-52, are on the path to an operational life of 50-75 years though their original design life was only 20-30 years.

in potentially enormous cost and operational benefits.

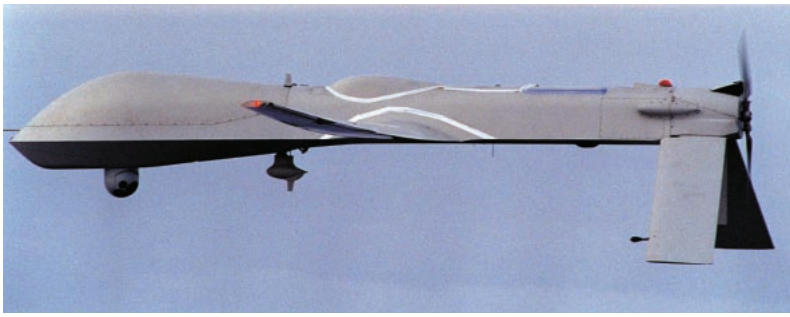
- Investments to improve reliability, maintainability and safety in legacy systems would increase materiel readiness, reduce maintenance and inspections, reduce maintainer workload, and raise morale and retention.
- Reducing the noise and emissions of legacy and new high-performance military aircraft would alleviate current basing issues, community lawsuits, the need to pay for soundproofing homes, as well as potential U.S. and foreign flight-path issues in the future.
- Use of advanced information technologies, such as modeling and simulation, would reduce development, acquisition and support costs of new and legacy systems.
- Adopting commercial build standards, contractor or shared government-industry logistics support, and performance-based logistics incentives would accelerate technology insertion into new and legacy systems, reducing the cost and improving the logistics support.

Technology insertion in the defense establishment is expensive, in part, because of the procurement and budgeting systems. These systems cause the unnecessarily expensive practice of upgrading ancient computers (e.g., 80286-based microprocessors) rather than throwing them away, as is done in commercial practice. Technology insertion is highly desirable and, in principle, should emerge from evolutionary "spiral" development practices. A well-structured "spiral" development program, that is adequately funded to create and field new military capabilities, can facilitate technology insertion into legacy platforms as the threat and the availability of appropriate technology requires and/or justifies.

In sum, the Commission believes that the federal government and the aerospace industry must partner to sustain and enhance the operational readiness and capability of our military aerospace systems. The government should fund research and technology development programs to reduce total ownership costs and environmental impacts; implement performance-based logistics support; create a structured, timely and adequately funded technology insertion process; and reform its procurement practices as recommended in Chapter 7.

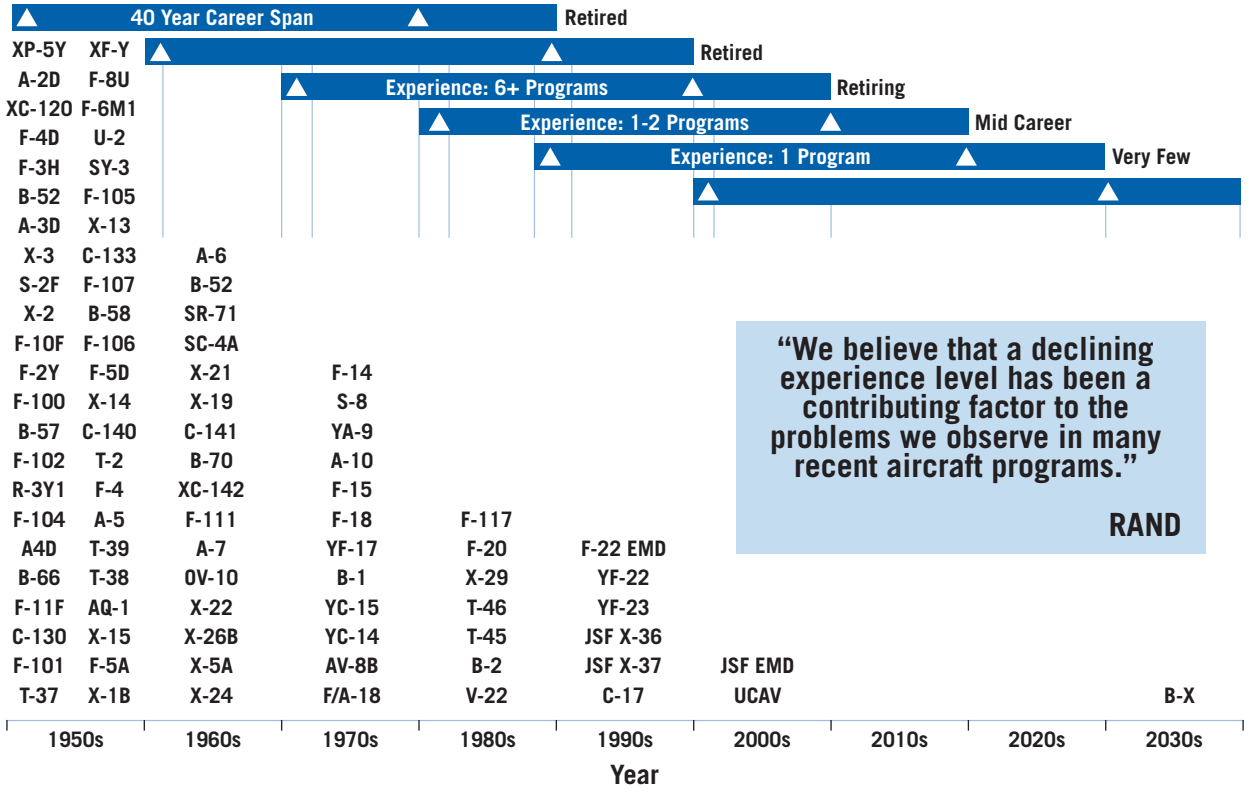
Experience in the Workforce: Few Opportunities and Limited Skills Transfer

At the end of World War II, a typical manager of a military aircraft development program had worked on the development of 15 programs. By the end of the 1990's, that number had fallen to one. See Figure 4-3. What this statistic reflects is the loss of "corporate knowledge" in our design teams, a loss with parallels in the skilled workforce that builds our aerospace systems. There is already evidence that loss of "corporate knowledge" has been costly. A 1999 study of rocket launch failures found that inadequate



The current success of the Predator program shows the military value of moving leap-ahead demonstrators into the hands of warfighters at a very early stage of development.

Figure 4-3 Declining Experience Levels in Military Aircraft Programs
(Vertical Bars: Military Aircraft Program Starts, Horizontal Bars: Typical 40 Year Career Span)



Source: RAND Study (Chart by Northrop Grumman, Aerospace Industries Association

engineering experience was a major contributing cause. More recently, the Secretary of the Air Force has pointed to the decline in systems engineering skills as a major contributor to cost overruns in military space programs.

Opportunities to Learn. To rebuild the U.S. knowledge base and to keep it "up-to-date," a core of design and production teams must be continuously exercised, even in periods when the country does not want to fund extensive production programs. This requires DoD to continuously fund prototyping programs and, where possible, move to spiral development of major systems. Such a policy would strongly support current DoD efforts on experimentation and transformation by providing a small supply of "leap-ahead" systems for use in the field. The current success of the Predator program—itself a technology demonstrator—shows the military value of moving leap-ahead demonstrators into the hands of warfighters at a very early stage of development. At the same time, programs providing opportunities for cutting edge work should create additional incentives for the "best and brightest" to come to aerospace.

The Commission believes that the United States must continuously develop new experimental systems, with or without a requirement for production, in order to sustain the critical skills to conceive, develop, manufacture and maintain advanced systems and potentially provide expanded capability to the warfighter.

Skills Transfer to the Next Generation. The ultimate goal of government policy must be to create an extremely high quality workforce in the aerospace sector, a workforce that continuously transfers knowledge and experience from one generation to the next in all areas that may be needed by future military systems. A continuous transfer of skills is a byproduct of stabilized funding.

There is a need for a joint government and industry planning function to ensure that attention is paid to areas where skill sets would disappear if government/DoD did not support a segment of the aerospace industry. Areas like radiation-hardened computer chips and solid rocket booster motors are likely to become extinct, if DoD does not maintain them. While obsolete technologies should be allowed to disappear if no longer needed, government/DoD should have a planning process in place to ensure that skills do not disappear before the need is truly gone.

Intellectual Capital. An aerospace worker's intellectual capital includes technical knowledge, process knowledge and network knowledge—what to do, how to do it, and who can help. All of these are necessary to get the job done. With an aging workforce about to leave, the intellectual capital must be passed on to the continuing workforce to avoid losing the "corporate knowledge." A concerted effort by both industry and government must be initiated to understand the impact of this loss of knowledge and how to transfer it to the workforce of the future.

Critical National Infrastructure: In Jeopardy

Maintaining the nation's critical infrastructure is a joint responsibility between industry and government. The critical national infrastructure includes both facilities and capabilities.

Facilities. The aerospace industry lacks an adequate business case in several areas critical to national security. This includes solid rocket boosters and radiation hardening capabilities. In addition, there is inadequate funding to support and modernize aging government RDT&E infrastructure, such as existing space launch facilities and new facilities that would support the development of transformational capabilities, such as wind tunnels for new hypersonic vehicles. The aerospace industry needs these facilities to test and evaluate new systems. Compounding the funding shortfalls, political pressures also make it difficult to consolidate or realign infrastructure in ways that could eliminate inefficiencies and/or unnecessary duplication. The result is that higher operating costs are being passed to the user.

European sources in many cases offer better alternatives for testing new capabilities. For example, U.S. companies are using foreign wind tunnels for testing because they are less costly and more capable. The U.S. must retain world-class infrastructure for test and evaluation of future technologies.

The Commission believes the federal government must assume responsibility for sustaining, modernizing, and providing critical, often high-risk, defense-related technologies and infrastructure when it is in the national interest. Chapter 3 contains specific recommendations addressing our space launch infrastructure. As political circumstances permit, the government must also address the broader issue of RDT&E infrastructure as part of future facility consolidations and realignments.

Capabilities. The government uses the term "ubiquitous" to describe capabilities that are critical to the national security and economic prosperity of the United States and the world. GPS and frequency spectrum are two of these ubiquitous capabilities and, as such, must be protected as critical national infrastructure.

Global Positioning System. GPS provides global positioning, navigation and timing information for a wide range of military, commercial, and civil applications. It enables the military to place precision munitions on target. Its timing enables the financial markets, power grids, and the Internet to synchronize their operations around the world. The nation's air transportation system is becoming more dependent upon GPS for global navigation and precision landings. GPS is becoming more embedded throughout national and international infrastructures and operations.

Though it is managed by the U.S. government through an interagency process, GPS is fundamentally paid for and operated by the DoD. Its critical contributions to national security and to the global economy require that senior leadership in

both the executive and legislative branches of the government be conscious of its role, take the necessary steps to ensure its continuous robust availability, and expedite its improvement. In addition, our global leadership in space-based positioning, navigation, and timing will be lost if we do not continue to focus resources and attention on this asset.

As part of the national imperative for protection of critical national infrastructure, the Commission believes the federal government should identify and protect funding that enables the DoD to accelerate the launch of the next generation of GPS satellites for the enhancement of anti-jam capabilities and creation of worldwide dedicated civil signals.

Frequency Spectrum. Rapidly changing and emerging information and communications technologies are placing significant strains on the finite radio frequency spectrum and on the management processes that control how it is allocated and used. Globally, the radio frequency spectrum is an extremely valuable resource essential to national and international security and commerce.

The Commission believes that the U.S. should create a national spectrum strategy to preserve and protect access to radio frequency bands that are dedicated to public safety and scientific applications, while enabling the U.S. to remain in the forefront of global electronic commerce.

Conclusions

The Commission concludes that aerospace capabilities and the supporting defense industrial base are fundamental to U.S. economic and national security. While the nation's defense industrial base is strong today, the nation is at risk in the future if the United States continues to proceed without a policy that supports essential aerospace capabilities.

Develop a U.S. Military Industrial Base Policy. The Department of Defense should task the Defense Science Board to develop a national policy that will invigorate and sustain the U.S. aerospace industrial base. The policy should address issues, such as mergers and acquisitions, procurement and budgeting policies, research and development investments, technology transition, international sales and workforce development.

Sustain the Defense Industrial Base. Today's national defense industrial base is robust, but without constant vigilance and investment, vital capabilities will be lost.

- DoD's annual science and technology (6.1-6.3) funding must be sufficient and stable to create and demonstrate the innovative technologies needed to address future national security threats. An amount no less than three percent of Total Obligational Authority, "fenced" from budget cuts, would be sufficient. The use of more joint technology development and acquisition programs would spread the funding burden and promote interoperability.
- The federal government must remove unnecessary barriers to international sales of defense products, and implement other initiatives that strengthen transnational partnerships to enhance national security. To help reduce the high development and production costs of advanced military systems, the United States must also increase the number of international joint programs (like the Joint Strike Fighter), and continue to foster international interoperability of defense and commercial aerospace system-of-systems.
- DoD acquisition policies should be revised to encourage greater use of commercial standards. DoD should impose government requirements by exception only, allow commercial entities to protect intellectual property, and remove other burdensome regulations that deter providers of commercial products from doing business with the government.
- There are numerous government missions that would benefit from defense technology. For example, the U.S. military has developed capabilities in the areas of communications, navigation, surveillance, and reconnaissance. These technologies could be adapted and transitioned into other

government applications that would significantly enhance the capacity of our air traffic management system and, hence, our national defense and homeland security.

- The federal government and the aerospace industry must partner to enhance the operational readiness and capability of new and legacy military aerospace systems. The government should: fund research and technology development programs to, reduce total ownership costs and environmental impacts; implement performance-based logistics support; create a structured, timely and adequately funded technology insertion process; and reform its procurement practices accordingly.

Increase Opportunities to Gain Experience in the Workforce. The U.S. must continuously develop new experimental systems, with or without a requirement for production, in order to sustain the critical skills to conceive, develop, manufacture and maintain advanced systems and potentially provide expanded capability to the warfighter. Furthermore, the federal government and industry must develop approaches to retain and transfer intellectual capital as the workforce retires in greater numbers in the next few years.

Maintain and Enhance Critical National Infrastructure. The federal government must assume responsibility for sustaining, modernizing, and providing critical, often high-risk, defense-related technologies and infrastructure when it is in the nation's interest. This includes critical design capabilities, solid rocket boosters, radiation hardening, space launch facilities, critical RDT&E infrastructure, GPS, and frequency spectrum.

RECOMMENDATION #4

The Commission recommends that the nation adopt a policy that invigorates and sustains the U.S. aerospace industrial base. This policy must include:

- Procurement policies which include prototyping, spiral development, and other techniques which allow the continuous exercise of design and production skills;
- Stable funding for core capabilities, without which the best and brightest will not enter the defense industry;
- Removing barriers to international sales of defense products;
- Removing barriers to defense procurement of commercial products and services;
- Propagating defense technology into the civil sector, particularly in communication, navigation and surveillance; and
- Sustaining critical technologies that are not likely to be sustained by the commercial sector, e.g., space launch, solid rocket boosters, etc.