A Special Report

The Unseen Cost:
Industrial Base Consequences of Defense Strategy Choices

July 2009

AEROSPACE INDUSTRIES ASSOCIATION

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The overriding goal of America's aerospace and defense industry is to develop dominant capabilities and turn them into systems that give our warfighters complete advantage on any battlefield. Maintaining technological dominance has been a key U.S. national security policy for decades, and our nation's success has resulted from a strong partnership between industry as a supplier of capabilities and the dedicated men and women who take those products into battle.

I am concerned that this partnership has been weakening and that our very success has led defense planners to take industrial capability as a given. That can be seen in a seemingly casual approach to defense industrial policy and it is a major concern as the current Quadrennial Defense Review proceeds.

The QDR is meant to be a thoroughgoing consideration of how our military will organize, train and equip to meet the challenges of the future. But in the current QDR, as in all previous versions, an increasingly vital piece is missing.

That piece is consideration of the capacity of industry to support the resulting strategy with the technological advantage America's military has relied upon in the past. The possibility of a significant shift in strategy could break our partnership — if the real industrial effects of new strategies are not included in the Pentagon's deliberations.

At a time when the Department of Defense is reorganizing its industrial relations, it is even more relevant to point out the interdependence among America's military and the people who produce its cutting-edge systems. This paper goes beyond that relationship to reveal the effects strategy choices and industrial capability have on each other — and how decisions taken today can limit the strategy choices available in the future.

AIA took a very serious approach with this study, and that shows in its results. A discussion of industrial capabilities by industry can be seen as self-serving, but here we discuss de minimis effects, as well as those that are gravely concerning, and above all we call for carefully calculated choices even when hard choices must be made. This is neither a polemic nor a fluff piece. It is the beginning of a new discussion about how to keep America's military strong across the spectrum of possible challenges.

I look forward to your comments.

Sincerely,

Marion C. Blakey
President and Chief Executive Officer

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Executive Summary

Since World War II, the U.S. defense industrial base has been a critical part of America's economic and military elements of power. The Department of Defense (DoD), however, has traditionally made decisions on its strategic postures — what kind of wars to prepare for and how to prepare for them — with the belief that the defense industry would be able to support whatever course DoD set.

This belief is no longer valid.

A significant gap has developed between DoD's view of industry as an always-ready supplier of military capabilities and how industry actually makes decisions on what capabilities to offer. And that gap is widening.

This matters to DoD because without considering and understanding how industry will react to strategy decisions and what industrial capabilities could be lost as a consequence, decisions made during and after this year's Quadrennial Defense Review might significantly reduce the strategy options available to future decisionmakers.

This hasn't always been true. Military technologies used to be much more closely related to civilian technologies. They even used common production processes. But because DoD is today the sole customer for industry's most advanced capabilities, the defense industrial base is increasingly specialized and separate from the general manufacturing and technology sectors. That means even a healthy general economy will not necessarily help underwrite the industrial capabilities DoD most needs.

DoD says it relies on market forces to ensure a healthy industrial base, yet the market forces DoD creates are often not the most significant ones acting on industrial companies. DoD buys decreasing numbers of systems, often with shorter production runs than anticipated. At the same time, industry has an obligation to increase efficiency and maximize shareholder value, which often drives industry to eliminate unprofitable assets. The less demand DoD has for military-unique capabilities, the more likely they are to be shut down, sold off or otherwise eliminated. This elimination can be accomplished in weeks, yet the lost capabilities take years to re-create.

That doesn't mean industry cannot or will not re-create them. But it does mean that DoD has to understand the timelines and costs of bringing industrial capabilities back on line.

A DoD that makes its plans for the future without both including industry as a partner in the planning process and understanding the forces that drive industry decisions is liable to find itself in a new world of declining industrial capabilities and far fewer employable weapons.

To avoid that outcome, this paper offers six recommendations to reconnect DoD and industry views and to ensure that the impact of decisions on the industrial base is included in DoD strategic planning:

- Institutionalize defense industrial base considerations into strategic processes, such as the National Security Strategy, the National Defense Strategy and future QDRs.
- Better account for defense industrial base considerations in the acquisition and planning, programming, budgeting and execution (PPBE) processes.
- Restore the Secretary of Defense/industry CEO forum.
- Continually assess the industrial base from a more strategic perspective.

- Reinvigorate congressional oversight/review of defense industrial base issues.
- Ensure that the military services and industry focus research and development on competitive design and development and efficient production.

A discussion of the widening strategic procurement gap between DoD and its industrial base and the consequences follows. Details of the above recommendations begin at page 17.

Introduction

Decisions Have Consequences

Decisions have consequences — both intended and unintended. The U.S. Department of Defense (DoD) Quadrennial Defense Review (QDR) currently underway considers force structure, capabilities and resources to establish a new balance point between the competing demands for wars of the present and challenges of the future. In the aftermath of the QDR, the department will make implementation decisions on programs and budgets. Those decisions will have the intended consequence of shifting resources among programs of record. Some programs will grow, while other, less favored programs will atrophy or terminate, and some new programs might be born.

It is not the purpose of this paper to argue for any particular defense strategies, policies or priorities that could emerge from the QDR process. That is the responsibility of those charged with assessing the risks of alternative strategic choices.

Rather, this paper argues that the decisions emerging from the QDR could have the unintended consequence of undermining or impairing the defense industrial base from which DoD expects future capabilities on demand. It follows, therefore, that DoD and Congress should carefully consider the industrial base implications of QDR decisions and implement corresponding industrial base policies and actions to ensure the future benefits of competition by reducing costs and spurring technological innovation, both key components of the recent Weapon System Acquisition Reform Act and DoD Instruction 5000.02.

The knowledge within America's defense industrial base related to design, development, production and support is critical to our ability to convert U.S. technological capabilities into superior military applications. That specialized knowledge, resident in the aerospace and defense industry's workforce and manufacturing processes, is applied via unique systems engineering and integration capabilities to convert technologies first into systems and then into systems-of-systems. The ability to pass on knowledge of these highly specialized military applications distinguishes the aerospace and defense market from the civil market. The United States needs to continuously facilitate and nurture a defense industrial base that enables these specialists and processes to work continuously.

Evolution of the U.S. Defense Industrial Base: How We Got Here

From America's earliest days our government has relied on a combination of both arsenals and private industry in the defense industrial base. The Department of Defense is now the world's premier consumer of modern military equipment, virtually all of which is manufactured by private industry. But, for most of U.S. history, military materiel requirements were fulfilled by an in-house, government-owned-and-operated arsenal system. In 1794, five years after adoption of the Constitution, the fledgling U.S. government decided to begin manufacturing its own small arms instead of purchasing them from foreign suppliers. President George Washington selected Springfield, Mass., and Harpers Ferry, W.V., as the sites for the nation's arsenals, each of which would manufacture muskets. In the beginning, these were small enterprises. In 1795, the Springfield Arsenal, previously an armory,[1] produced 229 flintlock muskets. In 1802, the newly constructed Harpers Ferry Arsenal also began musket production with one room and 25 employees. In addition to the two arsenals, Congress in 1798 authorized the military to contract with private firms for the manufacture of weapons.[2] By 1819, the government had 12 arsenals, and by 1840 there were 22, primarily engaged in manufacturing military equipment, small arms and artillery ammunition. They also provided maintenance and repair of weapons and equipment. The U.S. military, however, relied upon private foundries for artillery, even though government arsenals produced the carriages and assembled the guns.[3]

The Civil War resulted in the first large-scale military mobilization in U.S. history. From an initial force of 16,000 soldiers in 1861, the U.S. Army grew to more than a million by 1865. American private industry

made "… a significant contribution to the war effort aside from its small-arms production. All artillery casting was done by private industry, with the government arsenals providing carriages, caissons and accoutrements. Also, private industry provided all the gunpowder for the Union."[4] Among the significant industrial base outcomes of the war was the belief that "the United States had a strong weapons industry that could be mobilized, based on the twin pillars of government armories and arsenals and private industry."[5]

The next large mobilization came in World War I. Again, the relatively small U.S. defense industrial base struggled to adequately arm the military for such a large-scale and much more technologically sophisticated war than all those that had gone before.

The inadequacies of the system for providing weapons for the Army became manifestly apparent with the American entry into WWI. After three years of war, the principal European combatants had made enormous strides in weapons design. Machine guns, airplanes, poison gas, tanks and ever larger and more sophisticated artillery had taken their places as important implements of modern war. The United States did not have the capability to supply any of these modern weapons in the quantities it would need when it entered the war. Nor was private industry up to the task, largely because, as noted earlier, the Army's bureaus dominated the manufacture and procurement of weapons and equipment.[6] "In the end, the American Expeditionary Force (AEF) had to rely on the British and the French for virtually all of its ordnance needs, save small arms and ammunition."[7]

After WWI America again demobilized, reducing from 4.7 million military personnel to fewer than 200,000.[8] But this time the military recognized the need to prepare for industrial mobilization in advance of future conflicts. In the National Defense Act of 1920, Congress created a position for an assistant secretary of war, whose job would be to prepare for industrial mobilization in time of war. The resulting mobilization plans, while better than those made before WWI, were seriously flawed. [9]

> *To begin with, they had been prepared by "military agencies with some knowledge of industry but nreal depth." Furthermore, "[t]he Army and Navy Munitions Board…was unwilling to work with existing governmental departments." Finally, politicians were loath to put the military in charge of mobilization, as the plans recommended. Quite simply, "in addition to the political climate militating against implementation, superficial planning, and disharmony between operators and logisticians, the United States business world was not too keen on being mobilized until the president and Congress and the people were behind it. ...[t]he real change in perspective did not occur until the bombing of Pearl Harbor."*

Given the small size of military forces between WWI and WWII and the national economic stress of the Great Depression, the military ordered only small quantities of equipment. The procurement program developed in 1925 called for only 24 howitzers, 24 field guns, 54 tanks and 2,000 rifles — over 10 years.[10] With such low levels of output, the government chose to rely on its arsenals to manufacture defense-unique materiel and contracted for most supply and service functions. As a result, private manufacturers left the defense industrial base.[11]

In July 1941 President Roosevelt, anticipating the eventual American entry into the war raging across Europe, directed the Army and Navy to determine the materiel requirements for victory in a two-front war, including Lend Lease support to allies. The Army estimated a need for 122 armored or mechanized divisions and 93 infantry divisions — 215 divisions in all. The Navy envisioned a need for 35 battleships, 20 aircraft carriers and 88 cruisers. [12]

Upon entering WWII America underwent its greatest mobilization ever, with more than 16 million personnel donning the uniform. The defense industrial base was reinvigorated, and American private industry was called upon to an extent never before experienced. Due to the unprecedented magnitude of mobilization and military production needed, the government created attractive incentives to persuade

private sector manufacturers to convert to military production, including subsidies, low-interest federal loans and tax write-offs.

> *That was Stimson's [Secretary of War Henry Stimson] intention. "…[i]f you are going to ... go to war in a capitalist country," he wrote, "you have to let business make money out of the process or business won't work."*

During the war the nation was actually able to field and equip only 88 of the planned 215 U.S. divisions along with 10 (of 35 planned) battleships, 27 (instead of 20) carriers and 44 (of 88 planned) cruisers.[13] But U.S. industry out-produced the Axis powers — with four times as many tanks, 60 percent more aircraft and many more warships and cargo vessels. The only category in which the Axis was able to out-produce the United States was submarines.[14] Since WWII was a war of attrition, the greater production of the American defense industrial base was a key enabler of Allied victory.

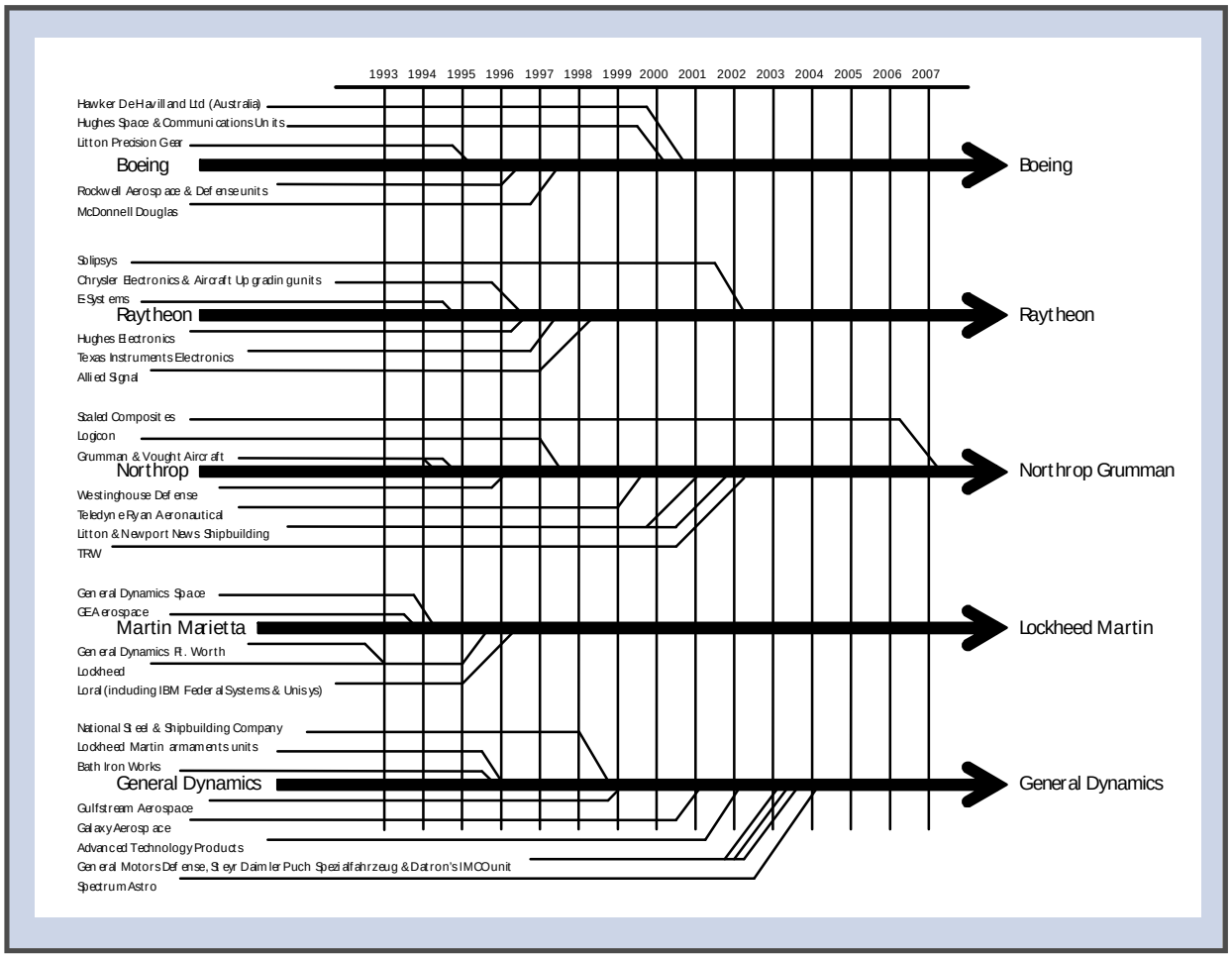
Post-World War II Development of the Aerospace and Defense Industry

Following WWII, most of private industry again returned to commercial markets. However, the Korean War and the onset of the Cold War provided enough defense business for many industrial contractors to continue to provide military products. For the first time America employed a large peacetime defense industrial base, most of which resided in private industry. During the Vietnam War the government moved to reduce its organic industrial capacity in order to eliminate excess capacity and reduce costs. By the mid-1970s, three more arsenals and all but 25 government-owned-government-operated (GOGO) depots and 10 maintenance depots had also closed.[15] Only two arsenals remain today.

In 1985 defense spending peaked at $557 billion (in constant fiscal 2009 dollars) and then began a downward trend. When the Soviet Union collapsed in December 1991, the Cold War came to an end, accelerating the decline of U.S. defense budgets.

In 1993 DoD leadership hosted a dinner at the Pentagon for a dozen executives of the largest defense companies. The executives were informed that there were twice as many defense suppliers as expected in the next five years and that the government was prepared to watch some go out of business.[16] This event, dubbed the "Last Supper," precipitated a tidal wave of consolidation — in less than a decade more than 50 major defense companies had consolidated into only six.[17] As part of this consolidation, what had been six aircraft primes narrowed to only two as Martin Marietta, General Dynamics' fighter division, North American, Rockwell International and McDonnell Douglas merged into or were acquired by Lockheed Martin and Boeing.[18] Well-known companies such as GTE, Lucent, Hughes, Magnavox, TI, IBM, Eaton, GE, AT&T, Unisys, Westinghouse, Tenneco, Ford, Chrysler, Teledyne and Goodyear left the defense market entirely. Others sold off their defense and space assets.[19]

Figure 1: Significant Industry Consolidations, 1993-Present. Derived from Watts, 2008, p. 37.



Despite the substantial consolidation following the "Last Supper," the private component of the defense industrial base is still capable of producing the world's highest technology military weapons systems. Unfortunately, in recent years Pentagon weapons acquisition policies have also had the effect of reducing the number of weapons systems sought, thus producing fewer new starts further and further apart and providing fewer contract opportunities for the industrial base.

This contraction has necessarily changed the behavior of the industry as a whole. Previously, industrial base decisionmaking was predicated on the likelihood that sufficient defense business would be available to justify continued investment in plant, equipment, technology and skilled labor. Today, the loss of a single competition could mean that a corporation might be driven out of a line of business entirely or elect to exit the business altogether. Increasingly, this dynamic results in reduced competition at the prime level where sometimes only two or three prime contractors are capable of competing for a contract.

The Issues

"The defense industrial base is a decisive contributor to U.S. foreign policy purposes, but it is no longer your grandfather's defense industrial base — it cannot be created only when needed."

– William Schneider, Chair, Defense Science Board

The Gap Between Strategy and Industrial Base Capability

With the dawn of a new administration, DoD has undertaken a broad review of its ability to carry out the new president's strategic guidance. That review began with a survey of likely global national security challenges through the next two decades or more and the capabilities needed to meet them. As DoD begins this year's review, though, defense industrial capability, long assumed to be constant, has changed significantly.

DoD has traditionally made strategy decisions independent from any consideration of industrial capabilities, believing that whatever course DoD set, industry would be there to support. This belief is no longer valid.

The Defense Science Board in its 2008 report, "Creating an Effective National Security Industrial Base for the 21st Century,"[20] listed 13 changes driving transformation in the likely missions DoD will receive and in the way the department will conduct its business.[21] Only one of the 13 items referred to the forces driving change inside industry. This omission only exacerbates a long-standing gap between DoD expectations of perpetual industry availability and the manner in which industry actually makes decisions on what capabilities to offer. That disconnect is at the core of this report.

Two Views

DoD is a consumer of military capabilities. Many believe that DoD views the defense industry as if it were a government arsenal, a constant repository of capabilities perpetually accessible to DoD in much the same way that government-owned facilities are. Over the long term that perception could turn out to be counterproductive. Indeed, industry has fulfilled this role over the years with such success that DoD's strategic planning processes do not include formal consideration of industry's future ability to support the resulting strategies and force postures.

Industry must live by a set of business rules that turn on the realities of market forces. Company officers and executives are bound by both law and market forces to maximize value to the company's shareholders. Maintaining good relationships with key customers could improve the odds of winning future government contracting opportunities, but companies cannot maintain unproductive or excess capabilities to please government customers who are unwilling to pay for them. Corporate strategic decisions on use of resources are made on the basis of profit and loss, with a much shorter time horizon than DoD uses and with alternative uses for resources in mind as well. The government looks at capability requirements 10 to 20 years out, and plans program budgets 5 to 6 years out. Industry, in contrast, makes judgments about keeping capabilities based on revenues and costs for the near term, i.e., on a quarterly or annual basis. Decisions impacting longer time frames depend on the customer awarding contracts over that period.

Because having capabilities creates ongoing costs, a defense company is viable only when its revenue stream from goods and services provided to government customers is sufficient to cover the costs associated with those capabilities plus a return on equity (e.g., profit). Because of this dynamic, industry will be motivated to eliminate capacity excess to near-term needs while DoD might assume that currently unused capability will

continue to be available until needed again years later. Another essential difference between the two models is that government subsidizes its arsenal system to maintain capabilities that might be needed sometime in the future even when there is little or no current demand for them. Government rarely gives industry the resources to do the same.

Furthermore, the gap between what DoD wants and what industry can supply is widening as a result of three factors:

- Industry consolidation. Fewer suppliers are available for each capability due to the ongoing elimination of smaller, niche players that service low- or occasional-demand markets.
- DoD's shrinking procurement and research budgets. The defense investment budget is expected to contract relative to commercial market projections, potentially making the department a less attractive economic player for companies struggling to survive in a declining defense market.
- The current economic downturn. The U.S. economic downturn puts greater pressure on companies to pare spending on unnecessary or speculative lines of business, including those DoD doesn't require today but contends it might require sometime in the future.

Why The Gap Matters

The June 2008 Defense Science Board (DSB) report, "Creating an Effective National Security Industrial Base for the 21st Century: An Action Plan to Address the Coming Crisis," observes that DoD consideration of industrial matters centers on how the department does business with industry, i.e., focusing on the mechanics of transactions. That view is reinforced by DoD's industrial relations approach, which resides within the under secretary for Acquisition, Technology, and Logistics, with minimal involvement by broader policy offices. Such an arms-length, customer/client approach overlooks the significant impact that DoD's strategic posture decisions can have on whether industry retains capabilities relevant to doing business with DoD in the first place.

As this study demonstrates, industry must be viewed in a wider strategic context. Because industry is not a static entity but one reacting continually to changes in current market conditions, decisions made during and after this year's Quadrennial Defense Review might unwittingly tie the hands of future administrations. Without considering how industry must react to this year's strategy decisions and what industrial capabilities could be lost as a consequence, DoD could inadvertently encourage industry to reduce or eliminate capacities that the department might actually require in the future. As Barry Watts of the Center for Strategic and Budgetary Assessments has noted, for the defense industry to continue to remain an enduring source of strategic advantage, "the federal government will need to embrace a more consistent, thoughtful, longer-term and active strategy for influencing the structure and capabilities of the defense-industrial base."[22]

The superior technological competence of America's current aerospace industry was built over 50 years in response to long-term, ongoing defense challenges. Meeting those challenges required developing increasingly technologically sophisticated design and production capabilities that set them apart from non-defense companies. America was able to produce more than 300,000 aircraft during WWII by greatly expanding the capacity of the existing military aircraft industrial base. Ordinary commercial manufacturing companies were able to convert to defense production relatively easily in the 1940s. Singer sewing machine plants, for example, converted to manufacture aircraft components, including B-29 gun sights, bomb sights and wooden propellers.

This conversion of commercial manufacturing lines for military products was feasible because the aircraft of that time were much simpler and easier to manufacture than today's aircraft. Aircraft then did not have the sophisticated integrated electronics systems and other advanced technologies that are required in modern combat. Consequently, the weapons systems of WWII would be unacceptably ineffective and very

vulnerable in a modern combat environment. As an example of the complexity of modern weapons systems, consider that the famed P-38 Lightning of WWII, which weighted 17,500 pounds fully loaded, flew at 414 mph and had a combat radius of 1,300 miles. Today's F-22, by comparison, weighs 83,500 pounds, flies in all weather at more than twice the speed of sound, is stealthy, has ~ 2,000 miles unrefueled range, is refuelable in flight, can engage enemy aircraft beyond range-of-sight, employs laser-, GPS- or radar-guided precision weapons, is constructed of composite materials stronger than metal and is more effective and maneuverable than any fighter in history.

Another example of the evolution of military technology is the C-47, the workhorse cargo aircraft of WWII, which could carry only 6,000 pounds at 207 mph over a range of 2,125 miles. By comparison, a single C-17 today carries a payload equivalent to that of 28 C-47s, is 2½ times faster, can fly virtually anywhere in the world nonstop with aerial refueling and can even carry an M-1 tank weighing 70 tons. The military capabilities of the C-17 are well beyond those required for commercial roles. Hence the production line will close when U.S. and international military orders end.

So, while today's weapon systems are expensive, it's because they require technologies undreamed of in previous eras. Only the companies already in today's defense industrial base are capable of developing these modern weapons systems and their successors. The barriers to entry are generally much too high for commercial companies to successfully cross over to higher technology defense products when a future competition occurs, not to mention the difficulty and cost of complying with government acquisition laws, regulations and procedures. Once a company decides to exit the modern defense industrial base, the expense of re-entry is so high that the exit will likely be permanent. An unintended consequence of fewer companies that might take on new projects would be less competition and innovation for future new starts.

The Market Force Disconnection

As DoD's "2009 Industrial Capabilities Report to Congress" notes, "The industrial strategy of the Department of Defense is to rely on market forces to the maximum extent practicable to create, shape, and sustain those industrial and technological capabilities needed to provide for the nation's defense."[23]

The problem with this formulation is that the DoD requirements cycle, DoD's acquisition cycle, and industry's response to market forces are on very different timelines. DoD's strategy-driven requirements are determined in four-year cycles,[24] and the creation process is largely opaque to industry. The "market forces" — the actual funded programs created to meet the requirements — appear later than the requirements. Creating new industrial capabilities in response to those forces can take years more.

Developing new platforms is a challenging enterprise even for the world's leading aerospace companies. Modern aerospace systems are incredibly complex and have to interact seamlessly with many other complex systems. The process of design, integration, testing and initial production can take over a decade — and that's when industry knows well in advance what requirements are coming and has staff and facilities dedicated to meeting them. Inventing cutting-edge technology is extremely difficult, and few other countries are capable of competing with the capabilities of the U.S. defense industry. These capabilities and the advanced technologies they produce must be continually nurtured and cannot be turned on and off. The industrial base to turn those technologies into deployed military systems needs to be maintained.

Critically, the market forces DoD creates are not the only ones — or, in many cases, the most significant ones — acting on industrial companies. An obligation to increase efficiency and maximize shareholder value drives industry to eliminate unprofitable assets. This elimination can be accomplished in weeks, yet the capabilities take years to re-create. Therefore, a DoD that makes its plans for the future without both including industry as a partner in the planning process and understanding the forces that drive industry decisions is liable to find itself in a new world with declining industrial capabilities and far fewer employable weapons. This will translate ultimately into far fewer strategy options for national security decisionmakers.

Design and Development: A Perishable Commodity

As mentioned previously, aerospace and defense contractors require substantial financial resources and infrastructure to sustain their unique production and engineering capabilities. One of the most significant factors in assuring that this industry remains viable over the long term will be its ability to retain minimum sustaining technical capabilities in advanced military aircraft design and development. The issue has been evaluated on numerous occasions since the end of the Cold War and consolidation of the industry but perhaps most thoroughly in the RAND Corporation study of competition and innovation in the military aircraft industry.[25]

In that study RAND noted "the size and cost of that minimum core, together with the firm's expectation of future business opportunities, play an important role in a firm's decision whether to remain in the business and in an 'outsider' firm's decision whether to attempt to enter the business."[26] Certain key technology and manufacturing capabilities are needed to maintain the ability to "ensure that the industry retained a strong capability to produce innovative designs of new aircraft weapons systems."[27] In most cases, the scope and magnitude of such capabilities pose a significant barrier to entry by fledgling and commercial firms and even second-tier competitors.

The size and cost of sustaining a "minimum core" or cadre of design and development engineers is substantial. At the highest level, those capabilities cut across a broad range of highly specialized skill sets, such as:

- Finance.
- Engineering, Production and Management.
- Facilities.
- Technology Development and Laboratories.
- Institutional Structures and Management Organizations.[28]

These core capabilities support an expanse of industrial activities related to the maintenance of highly specialized military aircraft design: studies and analyses; science and technology (including basic research, exploratory development and applied research); a wide array of engineering disciplines, including but not limited to aeronautical, electrical and mechanical; technology applications; technology demonstration; and the integration of design, development, production and support activities. A comprehensive and well-integrated military aircraft design capability must be sustained at some minimum level or that capability will begin to atrophy. The earliest RAND studies concluded that a minimum viable organization was "about 1,000 engineering and technical management personnel, and operating with an annual budget of about $100 million (in 1992 dollars)."[29] More recent data cited by RAND suggests that the size of such teams might range from 1,000 to 2,000 engineers at an annual cost of $250 to 500 million.[30]

While core design teams might survive for a few years between programs without R&D funding, they cannot survive in perpetuity.[31] Interruptions in design and development activity will ultimately have serious consequences — intended or unintended — that will change the composition and technical capabilities and the aerospace and defense workforce itself. While industry can "work around" such interruptions with adaptations, such as increased teaming, changing the roles of primes and suppliers and other innovations, the overall corporate business base for the enterprise will be challenged and minimum core capabilities begin to atrophy.

Reconstituting lost production, design and engineering capabilities could take many years. This has been seen on the few occasions when systems like the B-1 and C-5 endured significant production gaps. The current defense program of record pursued by this and previous administrations of both political parties has already led to the decline of critical capacities in areas such as rotorcraft and long-range bomber design. Industrial capability can often be regenerated but only with considerable time and expenditure. DoD should

be conscious of those costs when making strategic posture decisions in order to understand the constraints that those decisions might place on future leaders just as attention is paid to effects on end strength and force structure.

Giving "leaner" companies needed time to plan and respond to alternative defense policies goes beyond the traditional notion of making industry a partner as advocated by the Defense Science Board report. The DSB recommends "establishment of DoD and private sector councils for finance, information technology (IT), human resources (HR), and logistics," all meritorious ideas. The most important element, however, is missing — a common DoD/industry view of the future requirements for industrial capabilities. Only when industry understands what will be needed in the years ahead can it begin to assess what issues it will face. Conversely, only with an appreciation of industry's broad capabilities and limitations can DoD ensure that its strategies will be supported by available and relevant industry capabilities.[32]

In this way, DoD's goal and industry's are similar. "Suppliers with sufficient industrial capabilities are flexible and react positively to changing DoD requirements and priorities, particularly during times of conflict — indicative of the adaptability of both production lines and technology," wrote the under secretary of defense for Acquisition, Technology and Logistics in 2009.[33] That flexibility and reaction time, however, vary significantly, depending on which capabilities are maintained in the industrial base and which are allowed to atrophy.

For example, a lack of new rotary-wing designs in the current program of record has already led to significant reductions in the rotary-wing design and engineering industrial base, increasing the execution challenge that any new program would pose and requiring greater lead time before industry could meet the requirements of a new strategy.[34]

Lessons of History

Experience indicates that even if anticipated and planned for, brief gaps in one phase of the acquisition lifecycle can result in a significant delay in delivering subsequent capabilities. An historical example illustrates that:

The B-1 bomber experienced a break early in its production phase when the B-1A was cancelled in June 1977. A restart decision for a modified design, called the B-1B, was made in 1981, some four years after cancellation.

Importantly, the prime contractor, Rockwell International, expected restart and was able to retain its major and supporting subcontractor team, material, tooling, facilities and people after the B-1A cancellation. Rockwell also maintained material and parts for a production restart — nearly 40,000 items and more than 500,000 pounds of aluminum and titanium. Rockwell was also able to get its major subcontractors to commit to the program during this period. Even so, selected "DX priority" requirements were needed to meet the planned schedule when restart occurred.

Rockwell forecast its capital investment at the four production locations as approximately $250 million — about $80 million for the land and buildings and $170 million for machinery and equipment. The costs were unusually low because three government plant facilities were required for the program. It appears that 7,000 to 8,000 of the 26,000 people required for peak production were kept on at these facilities.

This is an example of a best-case scenario in which a company invested heavily to retain excess capability in the hope that it would soon be needed, and government made the restart decision (barely) within the time frame that the contractors had decided to retain the capability. More than three years were required from production go-ahead to the first production flight, and another year passed before entry into service of the modified B-1B. Today, it is likely that the timeline would be even longer.

Rockwell was able to justify this investment to shareholders and its board of directors in the 1970s business

environment. In addition to their staff retention, a robust local defense industry meant that workers laid off from the B-1 program could find jobs at other contractors fairly easily instead of leaving the industry with some prospect that they could be rehired should the B-1 line restart. That strong industry also meant that the skills needed to restart production would be readily available even if previous B-1 workers chose not to come back. At the same time, one of the major candidates for president had made restart of the B-1 a cornerstone of his campaign, and so there was a good chance the restart would actually happen — enough, at least, to justify an investment in maintaining capacity through the election.

In today's business environment such investments would be unjustifiable, and with a significantly smaller defense workforce, reconstitution would require far more time even if facilities and materials were retained. To replicate a program restart today similar to that of the B-1B would be very difficult. The capital investment costs for plant, machinery, equipment and tooling would be substantially higher even if workforce plans were roughly similar simply due to the inflated cost of money over the intervening years. It would be likely that the costs for a similar restart today would be in the billions of dollars.

The Effects of Strategic Choices

"We had a procurement holiday and we never made it up. So we've got systems being used in two wars without buying much to replace them. The Defense Department is going to face a huge procurement challenge in the years ahead."

– Norm Augustine, former CEO, Lockheed Martin

Unless managed with the industrial base consciously in mind, the development of alternative strategic choices can ultimately result in the eventual elimination of existing industrial capabilities and long-range policy options for U.S. national security decisionmakers.

In that context it is possible to weigh industrial base impacts of strategy choices in each phase of the acquisition lifecycle. Those impacts would be seen in their effects on facilities and manpower, the limiting factors in how fast lost industrial capability can be reconstituted:

Design and Development – As highlighted earlier, design and development is probably the most fragile portion of the industrial base. Due to changing demographics, engineers (particularly aerospace engineers) are in short supply, and the steady reduction in the number of new programs has made the cost of maintaining a design base increasingly hard for many companies to justify.[35] Strategies that focus primarily on recapitalization and/or less-advanced technologies will reduce the work available for design teams, erode design competencies by slowing the pace of technology maturation and might ultimately result in the nation having at best one design team for a particular capability.

Production – Quite simply, certain strategies might require less production volume than others. Companies make decisions about retaining facilities or a workforce that makes such production possible based on the projected future need for those assets. Re-creating facilities and a skilled production workforce are the pacing factors of the time needed to reconstitute a previously discarded capability.

Support – Whether contractor logistics support for deployed systems, depot operations or other sustainment, this category refers to the workforce and facilities needed to keep existing deployed systems in operation.

Three Notional Strategic Scenarios

As an exercise to determine general impacts of some possible strategic choices, planners and corporate strategists from a group of major defense contractors were asked to compare industrial facility and workforce impacts of three notional scenarios:

- The current National Defense Strategy.
- An increased focus on irregular warfare vice traditional warfare.
- An "East of Suez" withdrawal to a CONUS-based power projection strategy.

Although the three notional strategies above were chosen to illustrate a range of different stresses on the industrial base, the same form of analysis could be used with any other strategy. A more accurate and detailed analysis would need to be based on the specifics of proposed implementations of QDR defense strategies.

Observations

It is not the goal of this paper to be the last word on the industrial base consequences of strategic choices. Indeed, we hope for the opposite — being among the first to advocate a constructive dialogue leading to an on-going industry/DoD partnership to provide detailed analyses. However, some broad observations follow.

While the study found many defense industry sectors that might be relatively unaffected by a particular notional change in strategic posture, the bad news is that it was often because a given sector's industrial capacity is already overstressed or nonexistent. Sectors fell into three broad categories:

- Those significantly affected by changes in strategy included tactical aviation, large military aircraft and ballistic missile defense. For these sectors, differing demands in the notional strategies had significant impacts on industry.
  - The **tactical aviation** industrial base impact was most adverse in the case of irregular warfare, which led to a significant reduction in both design expertise and production facilities, imposing high financial and time costs to implement future tactical aviation development and next-generation designs.
  - In **large military aircraft** (tankers and airlifters) the power projection scenario entailed a significantly increased requirement for both lift and refueling capability. Curtailed production of strategic airlifter production capability driven by other scenarios would entail significant workforce reductions and plant closure, delaying fulfillment of a power projection scenario. Restart timelines, even if tooling had been mothballed, would be several years, assuming an appropriate site could be found and developed. The irregular-warfare scenario increases demand for tactical airlift.
  - In **ballistic missile defense** scenarios, other than the current program, found significant reductions in BMD-unique design workforce because both the irregular and power projection scenarios would emphasize deployable BMD systems that employ existing, mature technologies (such as THAAD, AEGIS and PAC-3.)

- Sectors minimally affected by our notional changes in strategy because of roughly equal demand included unmanned aerial systems, strategic systems and C4ISR.
  - Demand for **unmanned aerial systems** is high in all three strategies considered. The UAV/UAS industrial base will have to increase in both workforce and facilities to meet demand under any of our strategic scenarios although details of which elements of the base will require investment change from one strategy to another.
  - **C4ISR** is the key to network-centric warfare. It involves a suite of technology tools that allow the national security team to rapidly and continuously gather, share and analyze critical tactical information in real time, construct a common picture of the battlefield, identify friend and foe, make decisions and connect sensor to shooter — all faster than the adversary can react. The industrial base effects of our notional strategic postures with regard to C4ISR are generally neutral because the United States military is heavily dependent on these capabilities no matter what type of strategy is pursued. The U.S. military is currently progressing toward net-centric operations in which ISR creates a common picture of the battlespace. Military force structure might change in response to an alternative strategic posture, but whatever that force structure is, it will need robust C4ISR to complete its mission.
  - **U.S. strategic (i.e., nuclear) capabilities** stand largely outside the structure of this report. The need to deter strategic attack on the United States is a constant whether U.S. conventional

forces are postured for irregular warfare, power projection, the current threat or some other scenario. However, strategic delivery system capabilities have declined along with an aging strategic workforce and a steady erosion of U.S. focus on the strategic mission. Since the end of the Cold War, U.S. industrial base strategic infrastructure and skills have significantly eroded; the only strategic ballistic missile the U.S. continues to produce is the Trident II SLBM. The science and technology (S&T) base for the entire nuclear weapons enterprise has aged and eroded. As a result, whichever strategy is pursued, the United States faces the lack of a coherent and adequately funded sustainment strategy.

- Sectors minimally affected by changes in strategy because of existing industrial base degradation included rotary-wing, long-range strike, space systems and science and technology.
  - As discussed earlier, a lack of new designs in the current program of record has already led to atrophy in the **rotary-wing** design and engineering industrial base, increasing the execution challenge that any new program would have in this sector.[36] At the same time, legacy designs are being produced in such low quantities that adding a new program would necessitate significant investments in facilities and additional production workforce. Both of these facts decrease industry's capability to respond quickly to changes in strategy or requirements, regardless of what those changes are.
  - With **long-range strike platform** design dormant and the B-2 development plant at Pico Rivera now a Walmart shopping center, any strategy that involves long-range strike systems will require considerable lead time for industry to support. Design teams will have to be created, production facilities located, built and equipped, a workforce hired and trained and support facilities and workforce reoriented from other aircraft and/or expanded. The time required to ensure the viability of the manufacturing facilities and trained workforce will depend on the timing of the long-range strike requirements, the level of unique requirements associated with those systems and when DoD desires the weapon system to be operational.
  - **Space power** is critical to all scenarios considered. In an irregular warfare scenario, attention will be required to the facilities and workforce needed to produce new kinds of operationally responsive systems. Regardless of which approach is taken by the next QDR, however, critical industrial base challenges already exist for the space sector. Many on-orbit systems are already well beyond their design lives and operating in degraded mode. Low production rates, highly specialized facilities and long intervals between new designs already add to the challenge of maintaining an efficient space systems infrastructure.
  - Decisions made by DoD regarding alternative strategic postures would not significantly affect the need for continued increases in funding for defense science and technology. By its nature S&T (the 6.1-6.3 budget lines) is general research not tied to particular platforms. Generally, however, a lack of near-term funding for the variety of technologies comprising S&T will inhibit our ability to adequately prepare for future threats (10-15 years +). U.S. defense planners should look at the benefits of evolutionary development as a vehicle by which to keep critical design teams together.

The fact that many sectors would be relatively unaffected by changes in strategy should not mask nor trivialize the serious effects on the sectors that are more strongly affected. Further, the fact that some sectors are already weakened as a result of prior decisions should underscore the sensitivity of the aerospace and industrial base to DoD's acquisition policies that do not consider industrial base consequences.

Summary

The American aerospace industrial base is a perishable national asset. Like any military asset, it requires well-synchronized planning and management to remain healthy and vital. Unlike other military assets, however, it is responsible to entities and forces not under the department's control and operates according to different rules and imperatives and on a separate timeline.

If DoD were to make significant strategic policy decisions without full awareness and appreciation of the likely effects on industry, given the rules under which industry actually operates today, America's strategic defense policy choices could unintentionally damage the defense industry's ability to service our broad national security objectives whether in the short or long term. That would be a decidedly negative outcome for national defense.

The sooner that close partnership and coordination become normalized, the more likely American policy will succeed in the future. The consequences of continued inaction are potentially very severe for the country unless an action plan is undertaken soon.

Recommendations

"If one examines U.S. national security or defense strategy documents, or the last three Quadrennial Defense Reviews (QDRs), there is almost no mention of the industrial base. The latest QDR does not use the word 'company' once, and the word 'industry' has but a single occurrence."

– Barry Watts, Center for Strategic and Budgetary Assessments

In order to help pave the way for a fundamental shift in U.S. defense planning and better accommodate U.S. defense industrial base considerations into our strategic posture, AIA offers the following recommendations:

1. Institutionalize defense industrial base considerations in DoD strategic processes. The current administration has emphasized the concept of "soft power" in national security planning and execution. Under this concept, all instruments of national power — economic, diplomatic, political, informational and military — would be integrated into the National Security Strategy and coordinated with the development of the National Defense Strategy.

The preservation and further development of the unique and highly creative design talent, labor skills, technologies, facilities, tools and equipment of the defense industrial base are vital to the military's ability to carry out its missions and to the national economy. They should, therefore, be among the considerations in shaping a National Security Strategy. Likewise, as the institution that creates the world's best equipment to give combat advantage to American military forces, preserving a healthy, innovative and competitive defense industrial base should be among the considerations of planning and executing a National Defense Strategy.

Institutionalizing defense industrial base planning considerations into strategic thinking processes would do much to shift the prevailing dynamic away from ad-hoc, ex-post-facto correction of defense industrial base problems after they become evident and more toward a full integration of them with broader national security policy and strategy development. This year's initiative to have the undersecretary of defense for Acquisition, Technology, and Logistics address defense industrial base issues as part of the 2010 QDR is an important first step in that direction. This must not become a one-time-only event, however, without any continuity for the future. The process should be part of developing each update to the National Security Strategy and the National Defense Strategy as well as future QDRs. All these should be structured to fully engage the USD (AT&L) office early on in the QDR planning process and, where appropriate, work with industry to benefit from its technological and manufacturing expertise in addressing the defense industrial base implications of alternative strategic postures and policies.

2. Better account for defense industrial base considerations in the acquisition and planning, programming, budgeting and execution (PPBE) processes. Too often industrial base implications of acquisition decisions are not fully considered in the interaction between the Defense Acquisition System and the PPBE process. Once the Defense Acquisition System starts a new program, the PPBE fits it into the approved spending levels for the budget year and out-year FYDP.

As programs develop and defense spending levels change, adjustments to acquisition programs are sometimes made to match budget levels rather than industrial base circumstances. These adjustments need to more fully consider the effects they can have on the industrial base and carefully account for the impact on facilities and the industrial work force. Greater discipline in program costing and a freer exchange of information between the industry and its customers on budget-driven adjustments would greatly assist in efforts to keep complex programs on schedule and on budget.

Because the acquisition and programming processes are annual exercises that change allocations of funds, both should have a means of systematically evaluating attendant industrial base consequences and, where necessary, triggering remedial actions.

3. Restore the secretary of defense/industry CEO forum. Before 2001 the secretary of defense met with industry CEOs on a regular basis to discuss defense industry issues through the Defense Policy Advisory Committee on Trade. That forum was discontinued without a suitable successor. Restoring the face-to-face meetings between customer and supplier would result in better coordination and greater understanding of current and future needs on each side as in commercial business. The forum could particularly focus on achieving the most responsible revisions to the Defense Acquisition System. Meetings could be quarterly or as events progress.

4. Continually assess the industrial base from a more strategic perspective: Current DOD industrial policy can best be described as laissez faire and ad hoc with program offices delegating responsibility to prime contractors to identify and address potential loss of critical capabilities on a program by program basis. Limited resources result in no more than a couple of broad strategic industrial base analyses beyond the program level.

In the last two decades DoD has let its industrial base assessment capability become severely constrained. What limited industrial analysis expertise is left at DoD resides with a few analysts in OSD's Office of Industrial Policy and at DCMA's Industrial Analysis Center in Philadelphia, Pa. The military services and program offices gave up most of their industrial base expertise as the acquisition workforce declined.

Building up this capability should be a key goal of the department over the next five years. DoD needs to be more proactive in identifying cross-cutting industrial base issues that could potentially impact several current or future programs. It should emulate its experience addressing key component and material shortages on the MRAP program across a much wider swath of DoD industrial base sectors and capabilities, including aerospace.

The MRAP program benefited greatly from a previously conducted, broad-based industrial assessment of the commercial truck industry. Knowledge gained from these strategic assessments of both key defense-unique and commercial industry capabilities could help DoD optimally manage workflow through more effective contracting strategies and better use of Defense Production Act authorities with the goal of maintaining the health of needed defense-unique suppliers and allowing for greater civil-military integration of commercial suppliers.

5. Reinvigorate congressional oversight/review of defense industrial base issues. Focused and structured congressional oversight of defense industrial base policy issues, especially as they relate to U.S. strategy considerations, should be welcomed by DoD and industry. Congressional oversight should concentrate on specific policy issues affecting the defense industrial base, particularly how well DoD is meeting the policy goals articulated in Title 10, Section 2501.[37]

A good approach would be establishment of an industrial base panel by one or both of the armed services committees. In this way, the perspectives of the department, the aerospace and defense industry and the science and technology base throughout the country could be brought together to address critical emerging issues related to the defense industrial base.

Congress has set up such panels several times over the past 30 years. In the late 1970s and early 1980s, the House Armed Services Committee's industrial base panel, chaired by the late Rep. Richard Ichord, said in its committee report — "The Ailing Defense Industrial Base: Unready for Crisis"[38] — that a serious decline was occurring in the nation's defense industrial capability. The House Armed Services Committee once again created a defense industrial base panel in the early 1990s under Rep. Dave McCurdy to address issues related to the structure of the defense industrial base as the industry was beginning to consolidate.[39]

To do this right, the panel should set aside one to two years to do its work, be well-resourced and have a dedicated, highly professional staff. Specific state or district concerns would not be addressed by the panel but by Armed Services subcommittees during the regular congressional hearing cycle.

6. Ensure that the military services and industry focus research and development on competitive design and development and efficient production. Since its inception, the Quadrennial Defense Review process has been about how to best plan for future security. The role of research and technology in developing future military applications is critical to planning that future.

Throughout military history and especially during the 20th century, advances in military technology — whether in mechanized warfare, radar, supersonic flight or intercontinental ballistic missiles — have literally been "game changers" that the U.S. defense establishment and its industrial partners had to not merely adapt to, but in many cases, anticipate and drive. Those advances were enabled by the presence of competitive design and development activities within industry and efficient production capability.

The fast pace of military technology development is relevant from a defense planning perspective precisely because it relates to the decision cycle. Future QDRs should address the implications that the military application of advanced technology have on defense planning decisions and investment choices the United States might have to make in the future. This should become a much more prominent element of QDR planning, especially as it impacts the aerospace domain.

The United States cannot afford to lose its technological superiority in aerospace. In this regard, it will be critical to sustain defense industrial base manufacturing technologies, design and development capabilities and the information-based analytical tools needed to support defense industrial and technology planning.

The three appendices that follow give more detailed examinations of individual sectors, illustrating the kind of analysis employed in all sectors during the preparation of this report.

APPENDIX A:

LONG-RANGE STRIKE SYSTEMS

Because of past program decisions and regardless of the scenario chosen, re-establishment of a long-range strike (LRS) capability will require substantial effort. From an industrial base perspective, the U.S. bomber program has been characterized over the last 40-50 years by an on-again, off-again production pattern that is dramatically different from that of tactical aviation, for example.

The history of Air Force bomber production over the last several decades is highly instructive in this regard. The B-52 was produced by the hundreds during the 1950s and 1960s. Following that production run, the history of the bomber shows the cancellation of the B-70 in the mid-1960s; a limited FB-111 buy; the start, cancellation and restart of the B-1 program (100 deployed aircraft); and, finally, a very limited production of 21 B-2 stealth bombers, truncated from an original planned buy of 132 in the "two-bomber" program of the 1980s. Given that the last B-2 was delivered to the Air Force in the mid-1990s and no follow-on bomber designs have been in production since then, the industrial base is not optimized to provide new capability in long-range strike in a manner it can for other aerospace products.

Irregular Warfare

LRS platforms have seen extensive use in irregular warfare, particularly in Afghanistan. While this is the least stressing scenario for the long-range strike force due to generally permissive air environments, emerging concepts of operations take advantage of the weapons flexibility and long loiter times unique to long-range aircraft. Use of LRS in other irregular operations will depend on the target set and the requirement for long-endurance assets with multiple payloads.

From an industrial perspective, a focus on irregular warfare that did not include renewed LRS design and/or production would result in a loss of U.S. capability to create such systems. Given the higher costs, lower workforce and financial imperatives of doing business today, it is unlikely that a firm would decide to absorb losses for as long as Rockwell did on the B-1B program discussed earlier. Rather, that experience might be a "lesson learned" that would encourage companies to cut their losses quickly and dispose of costly assets that are not earning revenue.

Current/Near-Peer

This case includes today's use of LRS in irregular warfare and adds the requirements to support a near-peer contingency, particularly the requirement to penetrate sophisticated hostile air defense environments. As high-end air defense systems proliferate, the requirement for stealth, sophisticated electronic warfare capabilities and managing a greater array of weapons increases. This is true wherever such air defense systems exist. Because many sophisticated systems are also mobile, a mission might not require attack within a hostile country to encounter such a system. Near-peer states could deploy them to protect targets in third nations or other disputed territories. Therefore, this scenario would require more sophisticated and modern LRS platforms than those needed for irregular warfare. Design of LRS systems for a near-peer contingency would also be complicated by unique requirements for nuclear capability.

Because the gap in design and production following the end of the B-2 program has led to considerable reductions in LRS design and development capabilities, industry is ill-prepared to replace these capabilities quickly. The recent decision to delay the long-range strike program beyond a 2018 initial operating capability will have further important industrial base ramifications. The previous program of record assumed

development and production timelines of roughly 10-12 years. The deferral of a long-range strike program now risks stretching out development and production timelines even further.

Power Projection

The most stressing case for LRS is a power projection scenario with most or all LRS assets based in CONUS. It combines the requirements of the irregular and near-peer cases with a need for significantly greater numbers of aircraft in order to yield the same presence over target areas due to long flight and recovery cycles.

In all three scenarios the age of most current LRS platforms and the low numbers of newer ones lead to a need for new systems in order to maintain LRS capability over the long term. That is particularly true for power projection due to the increased flight hours that would accrue to aircraft that are in many cases already over 45 years old.

An industrial base to meet even modest LRS requirements does not now exist. Long-range strike programs require the cultivation and retention of large military airframe design and manufacturing know-how along with the ongoing evolution of other key technologies and disciplines, such as stealth, composite materials and advanced avionics. Additionally, technical issues related to electronic warfare and the integration of weapons strike capabilities must also be addressed.[40] Design teams will have to be retained at a minimal level. But beyond any low-level design commitment, once a policy decision is made to eventually "ramp up" the program, industry will have to make conscious decisions to expand engineering and production teams as designs progress from concept development to advanced technology development and, ultimately. to system design and demonstration.

A successful, long-range strike program will require a decade or longer commitment of time, assets and fiscal resources. Less than a handful of aerospace contractors are capable of being prime contractors for such a program. With very few major fixed-wing aircraft programs in development or on the horizon, dedicated corporate capital investments in long-range strike would be difficult, if not impossible, to justify without a clear demonstration of a government-backed policy and program commitment to the program over the long term.

All of this activity will necessarily occur over a much longer time frame than the five-year case for the B-1B case described above. A successful program will undoubtedly take a decade or more to bring to fruition.

APPENDIX B:
TACTICAL AVIATION

Current/Near-Peer

Structuring the U.S. military and defense industrial base for a potential conflict with a near-peer adversary largely constitutes a continuation of the existing posture and would likely represent the smallest relative or near-term impact to the tactical air industrial base of the three scenarios contemplated here.

A defense industrial base geared toward deterrence of and/or protracted conflict with a near-peer attracts large investments in advanced research and draws procurement of sufficiently high volumes of complex weapons systems to sustain the industrial base. At present the tactical air industrial base is adequately suited for such a scenario because facilities and the workforce are aligned with the requirements of these larger programs, longer time horizons and more intensive technological emphases. Thus, a near-peer strategic posture would lead to little dislocation of the existing tactical air industrial base facility structure and workforce. However, the trend of fewer new-start, high-capability tactical aircraft programs (manned or unmanned) and the projected shortage of graduating engineers relative to the demographics of the aerospace industry might combine to cause further industrial consolidation or restructuring regardless of the political palatability of such prospects.

Irregular Warfare

To the extent that emphasis shifts to irregular warfare at the expense of traditional tactical aircraft, virtually all aspects of the U.S. tactical air industrial base would be adversely affected. Such a reorientation in policy would generate new and different requirements for air vehicles and thus alter the existing structure, scale and robustness of the tactical air industrial base.

Modern tactical aircraft have demonstrated their applicability and utility in supporting irregular warfare operations, providing survivable, quick-response support for ground forces. They also provide the air dominance necessary for other types of aircraft to operate in theater. Vehicles optimized for irregular warfare, though, would differ in design and operation from today's tactical force. These multirole aircraft — both rotary and fixed-wing — would likely be smaller, less expensive and less technically sophisticated with increased emphasis on C4ISR, sensors, counter-insurgency/close air support (CAS), net-centric operations, precision strike and visual and acoustic stealth. Technology-intensive areas such as agile air-to-air combat, long-range strike, full-spectrum stealth and speed and maneuverability at medium and higher altitudes would all be superfluous to irregular operations. These vehicles would also require higher levels of field reliability at elevated operational tempos and in dispersed and rugged environments and would need to be sustainable for prolonged periods in areas with limited infrastructure.

These less complex airframe requirements would alter the underlying business case for a significant portion of the existing tactical air industrial base. Decreasing direct procurement and RDT&E funding for today's tactical aircraft programs would deprive the base of revenue and lead to higher unit costs for the remaining aircraft procured through these programs. These rising costs and declining procurement volumes would narrow U.S. manufacturers' historical cost advantage and make them less competitive in export markets versus foreign competitors. The relatively simple manufacturing processes required to produce counterinsurgency (COIN) aircraft would lower the barriers to entry for competitors in this market space, and given the comparatively small potential size of this market compared with traditional tactical aircraft, profitability would deteriorate for existing OEMs. Further, air vehicle designs with less intricate maintenance demands could harm OEMs' value proposition for offering comprehensive sustainment solutions, further eroding their potential revenue stream.

Even with replacement production of smaller, lighter information warfare (IW)-centric aircraft, declining procurement for existing "elite" tactical aircraft programs could lead to a drop in required facility capacity by perhaps one third or more. This base of fewer and/or smaller facilities could hamper future efforts by the defense industrial base to rapidly respond to the evolving needs of the U.S. military as threats change over time (e.g., emergence of a near-peer or existential threat). Once production facilities and tooling are shuttered, reactivating them would be expensive and time-consuming, especially considering that those facilities and tooling would not have benefited from years of continual maintenance, investment and improvement.

Less complex requirements, lower procurement and an altered business case would also decrease the need for highly skilled engineering and design talent to oversee the development and maturation of emerging technologies. This could hamper efforts to transfer knowledge among different generations of workers and exacerbate the existing challenge of a naturally declining aerospace workforce due to long-standing demographic shifts. As experienced engineers retire or are furloughed as a result of falling activity in the tactical air industrial base, fewer new workers will graduate from universities with the necessarily skills to take their place. And even those who can be persuaded to enter the shrinking industrial base workforce will not benefit from constant contact with the experienced workers they will need to learn from.

Power Projection

A strategic posture focused on defense of the homeland and swift insertion into critical areas around the globe when required would alter the tactical air industrial base — though not to the same magnitude or in the same way as an irregular warfare posture. This structure would necessitate two primary changes: first, the realignment of U.S. tactical air combat assets from foreign bases to U.S. bases and, second, an increasing reliance on long-range assets and carrier-based tactical aircraft to project power during a major combat or security operation.

Realigning American forces to U.S. territory would pressure defense budgets due to the necessity for expanding domestic infrastructure and the loss of effective subsidies formerly provided by host nations as part of their contribution to mutual defense. This would lead to a diminished force structure to correlate with the diminished need and would place an increased premium on advanced technological capabilities for the remaining tactical air force.

A singular focus on homeland defense would require fewer tactical combat aircraft. The United States, taking advantage of its geographic position (buffered by the expansive Atlantic and Pacific oceans) and its inherent ability to intercept an adversary's long-range strategic or naval-based fighter aircraft, would need only enough tactical aircraft to defend U.S. borders and urban areas, combat incoming airborne threats (aircraft, cruise missiles, etc.) and neutralize enemy warships at stand-off ranges. This would require fewer aircraft than are needed to also defend U.S. allies and interests from forward bases overseas.

A retrenchment to basing within U.S. borders would not, however, eliminate America's need to secure access to global markets and resources. Satisfying this geopolitical imperative would require the ability to swiftly deploy credible strike and/or expeditionary forces globally in the face of any adversary's access-denial capabilities. Thus, increasing emphasis on power projection would tend to increase reliance on long-range strike systems and carrier-based tactical aircraft that could be deployed into locales worldwide should the need arise. Even if additional aircraft carriers were fielded, each would represent only a small increase in naval tactical aircraft. This carrier-based system would also be extremely costly and would constrain procurement and RDT&E budgets, particularly if combat air programs are directly competing with other weapons platforms such as long-range strike and tactical/strategic airlift, both of which would take on increasing importance in a rapidlydeployable power projection scenario.

A shift away from U.S.-basing on foreign soil could lead to increased international demand for tactical aircraft. Without a direct U.S. presence abroad some nations might feel the need to acquire more advanced

combat aircraft themselves. With some allies bound to feel somewhat less integrated into the global U.S. defense structure, though, it is far from certain that they would feel the need to procure American combat aircraft systems. In this setting, interoperability of allied forces with U.S. air forces might become less imperative, and, thus, the U.S. defense industrial base could not be certain of capturing this business to compensate for declining domestic procurement.

Production facilities and workforce would presumably decline as priorities shifted and procurement slowed although not as much as under an irregular warfare scenario. Unlike an irregular warfare environment, long-range power projection would continue to require advanced technologies like speed, air-to-air capabilities (e.g., for self defense) and low-observability. Rapid response over great distances could also result in an increased RDT&E funding emphasis on technologies, such as hypersonics. Thus, it is possible that while a power projection scenario could lead to fewer production jobs in the industrial base, its impact on highly skilled aerospace engineering and design jobs might be minimal.

APPENDIX C:

ROTARY-WING AIRCRAFT

The lack of new rotary-wing aircraft designs in the current DoD program of record has led to an atrophying of the design and engineering industrial base in this sector, increasing the execution challenge that any new program would have.[41] At the same time, legacy designs are being produced in such quantities that adding a new program would necessitate significant investments in facilities and additional production workforce. Both of these facts decrease industry's capability to respond quickly to changes in strategy or requirements.

Therefore, impacts across the three strategy scenarios are fairly consistent for the rotary-wing sector. Supply base concerns and lack of design and developmental activities are quickly becoming issues while capacity growth to meet projection for current product lines present near-term risks. Because these effects cut across all three scenarios, they are presented by function.

Design/Development

Regardless of the scenario, the rotorcraft design workforce must be increased to replace the specialized skills lost through retirement. Industry faces a substantial risk of losing this knowledge base due to the lack of new program initiatives that facilitate shared learning and impart experience to younger engineers. This would lead to a requirement for substantial reconstitution time before any major new design could be undertaken.

Also, the lack of new programs has led to undercapitalization of business systems, IT systems and design and modeling tools, all of which should be modernized in order to support any new program.

Production

While the rotorcraft design workforce atrophies from lack of work, production lines are at or near capacity building and modifying legacy designs. The supply base for such essential parts as bearings, forgings, and castings is at capacity. Existing facilities could increase capacity but only with substantial capital investment in manufacturing technologies, tooling, business and IT systems and a substantial increase in workforce.

Because the domestic supply base is at capacity, rotorcraft primes are moving to add foreign suppliers. However, restrictions such as the Berry Amendment, ITAR and Buy American policies make expanding the supply base difficult.

Support

Current operating tempo means that a substantial increase in workforce is required to support performance-based logistics (PBL)-type contracts. Substantial investment is required in business, IT and PBL systems to maintain current levels of support. Spares volumes continue to challenge industry as a result of high rates of war usage, especially because suppliers are reluctant to take on additional risk to grow capacity in the current economic climate. Indeed, the whole rotorcraft industrial supply base is becoming very rigid and slow to reconstitute.

APPENDIX D:

GLOSSARY

acquisition lifecycle	The process by which a system is specified, built, deployed, used and ultimately retired.
Berry Amendment	A 1941 law (subsequently amended) requiring DOD to give preference in rocurement to domestically produced, manufactured or home-grown products, notably food, clothing, fabrics and specialty metals.
C4ISR	Short for command, control, communications, computers, intelligence, surveillance and reconnaissance. Systems that do not actually deliver weapons on the battlefield but provide warfighters the connectivity and situational awareness that enable them to be effective on the battlefield.
CONUS	The continental United States.
defense industrial base	The government and private sector industrial entities with capabilities to perform research and development, design, produce and maintain military weapon systems, subsystems, components or parts to meet military requirements.
Defense Policy Advisory Committee on Trade	An industry panel active from 1984 to 2001 that provided advice to the secretary of defense on industrial matters.
Defense Production Act	A law giving the federal government the ability to create, maintain or expand a domestic production capability needed for national defense.
design and development	The first stage of creating a system to fulfill a requirement, including concept definition, initial designs, prototyping and the steps required to make the system production-ready.
irregular warfare	DoD defines irregular warfare as "a violent struggle among state and non-state actors for legitimacy and influence over the relevant populations." Operationally, its salient characteristics are actions by non-uniformed personnel, often hiding among civilian populations, acting as independent cells and using non-traditional tactics.
ITAR	International Trade in Arms Regulations, the laws that control what systems and technologies U.S. firms can export.
MRAP	Mine-Resistant-Ambush-Protected vehicles, a type of truck developed and put into production very quickly during the conflict in Iraq.
OEMs	Original Equipment Manufacturers, the major companies that produce systems.
power projection	Engagement at a distance, such as the use of aircraft carriers or long-range aircraft to influence events.
production	The actual creation of a system, converting raw materials to a finished deliverable.

Quadrennial Defense Review	A congressionally-required report, due in the first year of a new administration, stating DoD's current view of strategic objectives, likely threats and the military doctrine and preparations required to meet them.
support	The set of functions, including maintenance, logistics and others, that keep a system operating after it has been built and deployed.
traditional warfare	Officially "recognized military capabilities and forces in well-understood forms of military competition and conflict." Combat operations are characterized by organized forces in uniform, usually representing a state.

END NOTES

1. The distinction is that an arsenal manufactures weapons, while an armory is a military depot for storing weapons and ammunition.
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END NOTES continued

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22. Defense Science Board, "Creating an Effective National Security Industrial Base for the 21st Century: An Action Plan to Address the Coming Crisis," June, 2008.
23. The 13 challenges include (Ibid): Holistic View of Security; Domestic Economics; Warfighting Changes; Globalization; Technology Changes; New Missions; Unpredictability; Intelligence Changes; Government and Industry Workforce Changes; Defense Budget Shifts; Isolationist Moves; Uncertainties Regarding China and Russia.
24. Barry Watts, The U.S. Defense Industrial Base: Past Present and Future, (Washington, DC: Center for Strategic and Budgetary Assessments, 2008) p. xi.
25. Annual Industrial Capabilities Report to Congress, supra.
26. As distinct from operational requirements, which may appear suddenly.
27. John Birkler, et. al., Competition and Innovation in the U.S. Fixed-Wing Military Aircraft Industry, (Santa Monica, Calif.: RAND Corporation, 2003). See also Jeffrey A. Drezner, et. al., Maintaining Future Military Aircraft Design Capability, (Santa Monica, Calif.: RAND Corporation, R-4199-AF, 1992).
28. Birkler, op. cit., p. 24.
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31. Drezner op. cit. Birkler, op. cit., p. 26
32. Ibid., p. 37.
33. Design and development capabilities will generally begin to erode within five years and certainly well inside of ten years.
34. A significant process improvement in most major American industries over the last 20 years is including suppliers in the product planning process to ensure that needed capabilities are available on schedule to support the end product. Doing so yields much more predictable and stable results than the previous practice of issuing a request for proposals only after the final design had been determined.
35. Office of the Under Secretary of Defense (Acquisition, Technology & Logistics), Annual Industrial Capabilities Report to Congress, March, 2009, p. 2.
36. This is discussed in greater detail in "U.S. Defense Modernization: Today's Choices for Tomorrow's Readiness," Aerospace Industries Association, August 2008.
37. See "Launching the 21st Century American Aerospace Workforce," Aerospace Industries Association, December 2008. See also John Birkler, et. al., "Competition and Innovation in the U.S. Fixed-Wing Military Aircraft Industry," (Santa Monica, Calif.: RAND Corporation, 2003).

END NOTES continued

38. "U.S. Defense Modernization: Today's Choices for Tomorrow's Readiness," supra.

39. This section of the U.S Code deals with national security objectives concerning national technology and the industrial base.

40. "The Ailing Defense Industrial Base: Unready for Crisis," Report of the Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives, Ninety- Sixth Congress, Second Session, December 31, 1980 (Washington, DC: U.S. Government Printing Office, 1980).

41. See "Future of the Defense Industrial Base," Report of the Structure of the U.S. Defense Industrial Panel of the Committee on Armed Services, House of Representatives, One Hundred Second Congress, Second Session, April 7, 1992 (Washington, DC: US Government Printing Office, 1992).

42. The Air Force is considering finding additional ways to provide electronic attack capability in its legacy bombers (the B-1B and the B-52). See David A. Fulghum, "Where's the New Bomber?" *Aviation Week and Space Technology*, April 27, 2009, p. 23.

43. "U.S. Defense Modernization: Today's Choices for Tomorrow's Readiness," supra.

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