SECTION 2: IMPLICATIONS FOR THE U.S. DEFENSE INDUSTRIAL BASE

Key Findings

- The U.S. defense establishment is increasingly reliant on the private sector for its technologies. As industries such as software and integrated circuits developed faster in the private sector than in the defense sector, the Department of Defense (DoD) turned toward the private sector to acquire state-of-the-art technologies.
- China and other foreign governments provide incentives to attract investment from the United States and other countries in advanced technology industries, which results in transfers of technology and production capacity offshore. Partly as a result of such incentives, the U.S. technology sector has moved offshore much of its production and is beginning to move offshore some of the design for civilian technologies with applications in the defense sector.
- China's incentives for technology industries are part of a coordinated, strategic effort to obtain dual-use technologies. This strategy is focused on the software and integrated circuits industry—the two industries the U.S. defense establishment identifies as vital to today's information-based, network-centric warfare.
- While the U.S. defense industrial base is not dependent on Chinese imports at the present time, the Chinese government's coordinated strategy of utilizing incentives and subsidies to spur development of domestic capacity in dual-use technology industries is weakening the health of key U.S. commercial sectors on which the U.S. defense establishment relies.
- DoD's "trusted" and "assured" supply of high-performance microchips is in jeopardy due to the restructuring of the U.S. commercial integrated circuit industry that has moved operations offshore to Taiwan, Singapore, and China.

Overview

The nature of modern warfare has changed since the Cold War. While the previous defense acquisition model was premised on obtaining from domestic sources the necessary materiel to enable the United States to fight two and one-half wars simultaneously, today's model relies on utilizing whatever current capacity, both in the United States and among our allies, is present when hostilities commence. In response to these changes, DoD changed its acquisition model to reflect the current nature of a globalized defense industrial base.

DoD currently defines the defense industrial base by the following five functional concepts: battlespace awareness, command and control, force application, protection, and focused logistics. To assess the health of the defense industrial base, DoD identifies the critical technologies required to meet the goals of these functional concepts. Then it identifies and assesses the health and accessibility of industries critical to those technologies.

Today's defense industrial base is more network-centric than platform-centric as it was in the past. In essence, the present day

U.S. military draws its strength from the knowledge of processes and its effectiveness in integrating information in each operation. This locates the critical aspects of the defense industrial base in the ability to produce and integrate information technology and its supporting systems.[47] The Commission has examined how the globalization of technology production is affecting the U.S. defense industrial base, with a particular focus on the implications for that base of China's position as a central player in the global supply chain of technology goods.

The U.S. Defense Industry's Reliance on the Private Sector

The U.S. defense establishment today relies almost entirely on the private sector for its technology, particularly information technology, a profound change from the Cold War era when weapons systems, components, and other materiel frequently were designed and manufactured specifically for the military using unique military specifications. There are two current trends that could harm DoD's ability to acquire appropriate technology resources.

First, notwithstanding its significant level of purchases, the DoD has become a minor player in many sectors of the U.S. economy. Globalization is shaping certain technology industries more than DoD and this has led to fewer civilian firms producing military-specific technologies. In the materials and metals industries and the machine tool industry, DoD is "typically a minute fraction of overall production. [DoD] directly buys only 0.4 percent of steel production."[48] And it is responsible for the consumption of only 1 percent of global IT products, giving it little leverage or influence over how IT products are developed.[49]

> *The underlying problem is that the economic incentives for globalizing the supply chain are omnipresent and are affecting almost every industry, and it is necessarily the case that what is an optimum solution for least cost production of software or least cost production of electronic equipment is not one that produces an effective security system and indeed a determined player can exploit the globalization of the supply chain.*[50]

Second, as industries such as software and integrated circuits developed faster in the private sector than in the defense sector, the Defense Department turned toward the private sector for these state-of-the-art technologies. However, the commercial demand driving changes in commercial technologies may not always coincide with DoD's technology needs in these industries. The companies in the private sector are increasingly focusing resources on further developing an existing product rather than developing new technologies.[51] Meeting some defense technology product needs in a way that maintains defense technology supremacy requires cutting-edge basic research. Increasing reliance on the private sector, whose profit goals are better met by product development than groundbreaking research, may prove detrimental in the future. William Schneider, Chairman of the Defense Science Board (DSB),[52] told the Commission that "one of the things that I think is especially interesting about the current time in defense technology is it's the first time . . . since the '50s where defense require-

ments are, in a number of areas, considerably more demanding than civil applications."[53] The DSB currently is conducting a study with the British Ministry of Defense to identify technologies important for national defense that are not being developed by the private sector.

Research and Development (R&D) and the Defense Industrial Base

A lack of investment and human capital is leading to a decline in U.S. defense industry R&D. One reason is that the industry consolidation resulting from acquisitions by U.S. defense firms of U.S. or foreign firms may contribute to a reduction of innovation in defense industry R&D. In a 2003 Defense Acquisition University study, Maj. David R. King and Lt. Col. John D. Driessnack found that "the average research and development (R&D) intensity for acquiring firms was significantly below the average for firms in their industry, suggesting that firms use acquisitions as a substitute for R&D or that acquired technology is used as a substitute for internal innovation."[54] As commercial technologies continue to set the direction for military technologies, a lack of innovation in the private sector could have serious detrimental effects on the capability to produce innovative military technology.

Since 2001, the Commerce Department has been asked by DoD to produce 18 studies on the state of the U.S. industrial base in a variety of defense-related sectors. These studies found that many U.S. firms that had been supplying the U.S. defense sector have been unable to maintain adequate R&D levels, invest in production and process improvements, and retain qualified engineers or scientists. As a result, some companies that were committed to supplying DoD have migrated to commercial sectors or downsized their operations.[55]

DoD is reliant on new technologies to improve the effectiveness of and enhance U.S. military capabilities. Most of these technologies, particularly in the IT sector, resulted from private sector activities, without DoD guidance. The relationship between the private sector and the Defense Department regarding technology development has not been well coordinated. Early last year, the Commerce Department conducted an *Assessment of Industry Attitudes on Collaborating with the U.S. Department of Defense in Research and Development and Technology Sharing*. The results showed that few companies surveyed have entered into agreements with any federal government agency since 1998. Of those surveyed that held defense contracts, two-thirds would be willing to provide R&D project information for a DoD database. But only 41 percent of non-defense contractors were willing to do so. They cited "loss of proprietary data, limited economic benefit, and reduced competitive advantage" as their major concerns.[56]

DSB Chairman Schneider expressed concern to the Commission about the decline in basic research, and offered a possible prescription to address that problem:

> *[D]efense laboratories have tended to be focused on the application of advanced technology for military purposes and have not focused very much on basic technology, but it*

may be necessary for DoD to acknowledge the fact that there is a lot of technology that's now being produced in the civil sector that has applications to defense and focus on industry making that transition, perhaps by reducing some of the institutional barriers to more effective collaboration between the non-defense sector and the defense sector and getting the government laboratories to work in a more focused way on supporting some of the work in basic research and in collaboration with universities which are ultimately the source of a lot of this work.[57]

DoD has recognized that cutting-edge R&D is most often being conducted by emerging defense industry players, but such new technologies are not fostered to the point of a DoD product. To remedy this situation, DoD included in its FY 2006 budget proposal an Industrial Base Investment Fund that will function as a "Chairman's Innovation Fund" managed by the Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics. The aim of the fund is to invest in technologies "and put them in programs across numerous warfighting applications."[58]

Furthermore, declines in the development of needed human capital are a concern for DoD. Former Under Secretary Michael Wynne deemed the declining number of American students in engineering and sciences to be an area of concern for the defense industrial base.[59] Some legislators have called for passage of a successor to the National Defense Education Act that was enacted in 1958 to encourage education in math and science.[60]

China's Impact on U.S. Defense-Related Industries

Foreign Acquisitions

Section 163 of the Defense Production Act of 1992 requires a quadrennial report on whether any foreign governments or foreign companies are pursuing a strategy to acquire U.S. firms dealing with critical defense technologies. The President designated an interagency working group led by the Treasury Department to complete the first report in 1994. That report found no "credible evidence" that any countries or companies have such a strategy.[61] (The report did not specifically look at China or Chinese companies due to a lack of Chinese activity in global acquisitions at the time.) China has since made global acquisitions a part of its coordinated strategy for science and technology development. (See Chapter 2, Section 1.) While it is clear new players have pursued international acquisitions since 1994 and they may have a coordinated strategy to acquire critical technologies, *no further reports have been produced, and no agencies have been designated to take part in preparing such reports*.

For example, Chinese titanium factories are eyeing foreign acquisitions of upstream assets, as China does not have an abundance of titanium mines. Titanium is a vital component of a variety of defense systems. As China's demand for specialty metals like titanium rises and it appears prepared to secure supply through global acquisitions, competition for this metal will increase and this will have availability and price consequences for U.S. defense acquisition. Dr. Jack Shilling testified before the Commission that the

Chinese have aggressively and repeatedly sought to buy western technology in the specialty metals industry in exchange for market access. According to Dr. Shilling, the Chinese strategy to acquire technology is "a highly coordinated, systematic, strategic initiative which, left unchallenged, will result in transfer of specialty metals technology in China."[62]

Another example is the rare earth mineral market. Rare earth magnets are used in missile guidance systems. In 1992, Chinese Premier Deng Xiaoping announced an expansion of China's role in the rare earth market, proclaiming "There is oil in the Middle East; there is rare earth in China." Thus, the Chinese government embarked on a detailed strategy to control the rare earth market. As part of this strategy, two Chinese firms acquired a U.S. rare earth magnet producer. In 1995, San Huan New Materials and China Non-ferrous Materials Corporation partnered with U.S. investors to purchase Indiana-based Magnequench, whose parent company was General Motors. Magnequench manufactures rare earth magnets and magnet powders, used in computer hard drives, a variety of other consumer electronics, and guidance systems. Due to concerns about the defense applications of the magnets, CFIUS reviewed the case, yet approved the transaction partially based on a commitment that the Indiana facility would remain in the United States. Eventually the whole facility was moved to China. This deal and subsequent deals around the globe have allowed China to come closer to cornering the market in rare earth minerals. Of equal concern is the transfer of technology, including patents, allowing China to control development of next-generation products using rare earth minerals. Additionally, the recent bid for Unocal by the Chinese company CNOOC may have been another piece of this strategy, as Unocal owns Molycorp, a U.S. rare earth mineral mine.

The Committee on Foreign Investment in the United States (CFIUS)

Pursuant to the 1988 Exon-Florio Amendment (Public Law 100–418) to the Defense Production Act of 1950, the President has authority to review mergers of U.S. companies with foreign companies and acquisitions and takeovers of U.S. companies by foreign entities to determine if the transactions pose any threats to national security. In Executive Order 12661, the President designated CFIUS to perform such reviews. CFIUS is chaired by the Secretary of the Treasury and includes eleven other members: the Secretaries of State, Defense, Commerce and Homeland Security, the Attorney General, the Director of the Office of Management and Budget, the U.S. Trade Representative, the Chairman of the Council of Economic Advisors, the Director of the Office of Science and Technology Policy, the Assistant to the President for National Security Affairs, and the Assistant to the President for Economic Policy.

A review of a proposed transaction may be initiated by CFIUS "either upon a voluntary filing by either party to the transaction or upon an agency notice filed by one of the members of CFIUS. . . . A compelling reason for a party to file voluntarily prior to consummation of the transaction is to avert a post-closing CFIUS investigation of the transaction. If the parties do not file voluntarily, the transaction is subject to potential review at any time,"[63] and

a post-closing review that produced a Presidential decision to prohibit the transaction could force the parties to negate it.[64] Once a transaction is filed, CFIUS has 30 days to determine whether to commence a 45-day formal investigation. After any such investigation, the President has 15 days to announce whether he will block the transaction and, if necessary, require divestment on national security grounds. The law requires a report to Congress following any Presidential determination.

CFIUS to date has rarely initiated the 45-day investigation process. In fact, of the over 1,500 filings it has received, CFIUS has only required a 45-day investigation in 25 cases. Only three of the 25 cases have required a Presidential decision, and only one of those, which occurred in 1990, has resulted in a divestment: the investment of a Chinese company, China National Aero-Technology Import and Export Corporation's (CATIC), in MAMCO Manufacturing Inc., a U.S. manufacturer of metal parts for aircraft.

Figure 2.1 Notifications to CFIUS and Actions Taken

Year	Notifications	Acquisition	Investigation
2000	72	71	1
2001	55	51	1
2002	43	42	0
2003	41	39	2
2004	53	50	2

Source: GAO Report: GAO–05–686 based on Department of Treasury data.

CFIUS usually informally mitigates any concerns about a transaction by working with the parties either prior to any filing or after the filing but prior to the launch of a formal investigation. Once the parties to a transaction file, CFIUS agencies may inform the parties of circumstances of the transaction that would require a 45-day investigation or a decision to block the transaction. Parties then may request to withdraw from the review process. CFIUS generally will grant such a request when the parties intend to modify the transaction to address CFIUS concerns; the parties then refile it in modified form. Since a public report is required only following a Presidential decision, the CFIUS practice of encouraging parties to a transaction to withdraw and re-file after resolving all CFIUS security concerns effectively undermines the public reporting requirement pertaining to Presidential decisions. This makes CFIUS deliberations and decisions largely opaque to Congress and the public.

The U.S. Government Accountability Office (GAO) has conducted several studies of the CFIUS review process. In 2000, GAO found that "the identification process the Committee on Foreign Investment currently uses does not enable it to effectively identify all foreign acquisitions with possible effects on national security."[65] GAO subsequently recommended that the Secretaries of Commerce, Defense, Treasury, and State "require agency officials to submit all known foreign acquisitions of companies with potential national se-

curity implications."[66] Furthermore, in 2002, GAO found that the CFIUS practice of alerting filers to possible issues and recommending withdrawal and refiling "negate[s] the effectiveness of the Exon-Florio statute."[67] GAO's latest report on the CFIUS process in 2005 found that this practice continues unabated and that "when companies that have already completed the acquisition are allowed to withdraw, there is a substantially longer time before they refile, and in some cases they never do, leaving unresolved any outstanding concerns."[68]

In early 2005, CFIUS began a 45-day investigation of the Chinese company Lenovo's bid for IBM's personal computer (PC) manufacturing and sales operations. According to press reports, to facilitate CFIUS approval, IBM made several concessions noted in the prior section.[69] By allowing IBM to make the concessions and by considering and acting on the modified, re-filing rather than evaluating and acting on the original filing that likely would have required a Presidential decision, CFIUS was not required to report to Congress on its findings. Thus, CFIUS was not accountable to anyone outside the executive branch concerning its decision in this case.

Another major concern about CFIUS is the narrow definition of national security it uses in reviewing a transaction. As discussed above, the U.S. defense industrial base is heavily reliant on the private sector. As a consequence, U.S. national security is heavily linked to U.S. economic health. The Commission heard testimony from the Chairman of the Defense Science Board, William Schneider that, "it's the national economy that's ultimately the source of our military power. There are very few precedents for a country being able to do much in the way of maintaining a comprehensive military capability without a strong national economy." However, CFIUS does not appear to consider economic security when it reviews a transaction for national security concerns. Notably, the Congressional conference report that was issued when the Exon-Florio Amendment was enacted calls for a broad interpretation of national security:

> *The standard of review in this section is 'national security.' The Conferees recognize that the term 'national security' is not a defined term in the Defense Production Act. The term 'national security' is intended to be interpreted broadly without limitation to particular industries.*[70]

The lack of transparency in the CFIUS review process played a role in another significant CFIUS case, and it is possible that CFIUS' failure to apply a sufficiently broad definition of the term "national security" also was a factor. Because CFIUS's review of the Magnequench transaction did not require a Presidential decision, there is no public report of either what definition of national security CFIUS reviewers applied or whether they considered China's aforementioned strategy to dominate the market in rare earth minerals. This case highlights the need for a more transparent process.

Preserving the Supply of Key Items for U.S. Defense Needs

Microchips

The head of the DSB's task force on high performance microchip supply, Dr. William Howard, testified before the Commission that the United States' secure supply of "trusted" and "assured" high-performance microchips is in jeopardy, and that this problem requires an urgent response.[71]

DoD traditionally has relied on private sector production of chips for its supply. This has proven cost efficient given the extremely high cost of maintaining government production facilities that cannot take advantage of the same economies of scale available to private sector manufacturers. As the commercial semiconductor industry has restructured over the past several years, manufacturing capacity moved abroad, mostly to Taiwan, Singapore, and China. Dr. Howard testified to the Commission that chip design is beginning to follow manufacturing offshore.[72] These trends likely will continue as China pursues its aggressive strategy to rapidly develop its semiconductor sector. This threatens DoD's ability to ensure a sufficient and safe chip supply, particularly its application-specific integrated circuits.

In February 2005, the DSB Task Force on High Performance Microchips released its report on the health of defense readiness with regard to integrated circuits. The report found that:

> *[T]he relocation of critical microelectronics manufacturing capabilities from the United States to countries with lower cost capital and operating environments . . . [is] directly contrary to the best interests of the Department of Defense for non-COTS [commercial off the shelf] ICs. The shift from United States to foreign IC manufacture endangers the security of classified information embedded in chip designs; additionally, it opens the possibility that 'Trojan horses' and other unauthorized design inclusions may appear in unclassified integrated circuits used in military applications. . . . Beyond the threat of IC device compromise described above, dependence on off-shore or foreign-owned semiconductor component production subjects the United States to several risks, such as lack of quick response or surge capacity in time of war, that could threaten its access to state-of-the-art microelectronics. As capacity moves to potential adversary countries, the United States is vulnerable to a governmental 'reverse-ITAR'[73] by which critical technologies are denied to the U.S. international trade.*
>
> *A longer term risk lies in the historical fact that leading-edge R&D tends to follow production. The most attractive positions for talented process scientists and engineers moves with advanced production. Additionally, a separation of design from production could render the close collaboration between process engineers and designers required for leading edge chip development ineffective for U.S. defense industry.*
>
> *The Defense Department does not directly acquire components at the integrated circuit level. Individual circuits are most often specified by designers of subsystems; even system*

primes have little knowledge of the sources of the components used in their system-level products. Any DoD acquisition plan to address IC trustworthiness and availability must focus on defense suppliers as much as DoD itself.[74]

The DSB report echoes many of the concerns raised by U.S. semiconductor firms (discussed in Chapter 1) about the inadequate response by the U.S. government to date to counteract incentives provided by China and other developing countries to semiconductor and other technology firms to relocate their operations to those countries.

Since the end of the Cold War U.S. export controls have become less effective in restricting the flow of advanced semiconductor manufacturing equipment (SME) and design technology and equipment to China. . . . On several occasions, the U.S. government has sought to persuade other Wassenaar members to restrict exports of SME to China, but has been rebuffed. . . . Today the driving force behind the 'alienation' of foundry business from the United States to other countries is the lower cost of capital available in developing countries, made possible by foreign nations' tax incentives, market access requirements, subsidized infrastructure, and low-cost financing. . . . The primary beneficiary countries of the foundry trend have been in the Far East (Taiwan, Singapore, PRC, Korea, and Japan), some of whose future interests may not align with the United States. . . . Taiwan dominates global foundry production with about two-thirds of current capacity; China, a relatively new entrant with 8 percent of global capacity, is rapidly increasing its market share.[75]

Furthermore, the DSB report warned that a cross-Strait conflict scenario could start a worldwide run on commercial wafer capacity that would take years to rectify. "During such a time, DoD and its contractors would have little leverage to obtain needed fabrication services."[76]

Currently there are only three integrated circuit fabricators in the United States: IBM, Intel, and Texas Instruments. Because only IBM has agreed to conduct business with the federal government, in 2004 IBM was designated a "Trusted Foundry" and was given a take-or-pay contract by DoD worth $600 million over ten years. While such a program helps address near-term supply concerns, there is a danger in using a sole-source supplier because of the possibility that the supplier's ability to produce chips could be substantially degraded in the future.[77] Thus there is a need for the government to devise a broader strategy to ensure a long-term supply of chips for defense purposes that is both trusted and assured.

The Aerospace Industry

The ability of the U.S. aerospace industry to attract investment and sustain a base for high-technology development is also reportedly at risk and may deteriorate further as more aerospace technologies migrate offshore. The Commission on the Future of the Aerospace Industry found that the U.S. civil industrial base continues to increase its focus on knowledge generation rather than

creation of hardware. According to Dr. Schneider, "That does pose a challenge for how the U.S. will ... maintain its leadership and be able to sustain a capability to support the national strategy of maintaining a decisive technology edge in military performance."[78] The problem is exacerbated by the fact that U.S. aerospace companies may not be investing enough in R&D. For example, Heidi Wood of Morgan Stanley testified before the Commission stating, "Boeing has been ... possibly insufficiently innovative. ... Boeing's commercial R&D-to-sales ratio we project to be 4.8 percent in 2005. In comparison, Airbus we are projecting at eight and a half to nine and a half percent in 2005."[79]

Furthermore, Pierre Chao of the Center for Strategic and International Studies testified that after the corporate consolidation of much of the aerospace industry, aerospace subcontractors have been driven to look offshore for new work because there are fewer contractors that are potential purchasers and fewer U.S. aerospace projects need work done in the United States.[80] As discussed in Chapter 1, China is becoming increasingly, and increasingly inextricably, intertwined in U.S. aviation production. Securing access to the China market has required U.S. firms to offset important components of production and may therefore accelerate current trends toward offshore migration of the industry. Ironically, China presents a vast market opportunity for Boeing and some other aerospace firms and so constitutes a critical component of their future health and, to some extent, the health of this vital element of the U.S. defense industrial base.

The Software/Information Technology Industry

Process knowledge is becoming more important to defense needs than hardware knowledge. Thus, while the hardware for certain systems may be mundane by current-day technology standards, the software that directs these systems and enables them to perform particular functions is "exotic and the industry that creates that software is a national asset."[81] The Commission heard testimony that the globalization of the software development industry may diminish the level of software innovation in the United States. Furthermore, it poses a potential risk to U.S. security, because foreign-produced software may contain various vulnerabilities that are very difficult or effectively impossible to identify, and adversaries can exploit those vulnerabilities at a later date.[82]

The Machine Tools Industry

Machine tools are critical to national defense. The United States imposes export controls on machine tools and supporting systems because of their importance in manufacturing products on which the military relies. These export controls are generally guided by the concept that manufacturing technology is often more important than the products of that technology. Yet, there is a contradictory relationship between export controls for U.S. national security purposes and the ability to maintain a healthy U.S. machine tool industry.

The inconsistencies between U.S. export controls and the controls that are imposed by other nations that are major manufacturers of machine tools have led to a decrease in U.S. global market share

for machine tools. However, the U.S. share of the China market for machine tools has remained steady at around 7 to 8 percent from 1998 to 2004. The United States is the fourth largest machine tool exporter to China, far exceeded by Japan, Taiwan, and Germany, in that order.

Dr. Paul Freedenberg, Vice President of the Association for Manufacturing Technology, testified that a decrease in the capacity of the U.S. machine tool industry has hurt the United States' ability to mobilize in the event of a national emergency. The machine tool industry saw its domestic market share decrease by 60 percent from 1998 to 2002, with a slight increase in 2003.[83]

The Specialty Metals Industry

Specialty steel, aluminum, beryllium, nickel, superalloys, titanium, and other specialty metals are critical to U.S. weapons systems and are elements of virtually every U.S. military platform. "[W]eapons systems can neither be built [n]or operated without these materials, whether it's missiles, jet aircraft, subs, helicopters, Humvees, or munitions."[84]

DoD's recognition of and response to the criticality of specialty metals has been mixed. Recently it allocated $6 million to establish a domestic production facility for high purity beryllium metal.[85] But recent defense capabilities studies by DoD have not included assessments of the health of the specialty metals industry and the adequacy of the supply of these metals for U.S. defense needs.

In an encouraging step, DoD is currently undertaking a study of how China's increasing demand for such items is affecting U.S. access to specialty steel for defense needs. DoD stated in a letter to the Commission:

> *Recent price and schedule trends for metals important to defense, such as steel, aluminum, and titanium, appear to be influenced by China's increasing internal demand; which is likely to persist for years to come. The prices of aerospace grade steel, aluminum, and titanium have risen considerably over the last two years. In addition to these price increases, acquisition lead times for these materials also have increased. Some experts believe that China is responsible for these trends while others are of the opinion that the increases are caused by economic trends associated with widening industrial globalization. Whatever the case, the Department is taking steps to understand the potential impact of these trends and inform planning for future acquisition budgets accordingly.*[86]

The Shipbuilding Industry

In May 2005, the Deputy Under Secretary of Defense for Industrial Policy completed a *Global Shipbuilding Industrial Base Benchmarking Study* that examined the six largest private shipyards in the United States in comparison to the world's ten leading shipyards. The study found that the U.S. shipbuilding industry has improved significantly over the last five years, but that large technology gaps still exist in some U.S. shipyards, and shipbuilding designs need to be optimized for state-of-the-art military vessels. According to the study, one major hindrance to industry improve-

ments is the lack of competition caused by a series of acquisitions that have led to a duopoly in the United States between General Dynamics and Northrop Grumman.

For the first time in 50 years, the United States is not currently developing a new submarine design. Amy Praeger of the American Shipbuilding Association (ASA) testified that this is having a devastating effect on the ability to ensure the continued availability of qualified ship design engineers. Since 1991, 24,000 engineers and production jobs have been lost in the United States.[87] Additionally, many skilled workers are leaving the shipbuilding industry because the sector does not have consistent and stable contracts. Should new skilled employees need to be found, it could take 15 years to replicate the lost skill level.