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The Defense Technology and Industrial Base: Key Component of National Power

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Democracies, particularly those blessed with good geography, usually favor domestic over defense needs in times of relative peace. This phenomenon reflects political realities which are sometimes--but not necessarily--related to perceived threats to national interests and to those of one's allies. Recent US budgets and funding projections demonstrate that the United States presently is in such a period.

This article examines the nature and status of that segment of US industry, science, and technology known to some as the defense technology and industrial base. The defense sector of the US economy comprises those business firms, laboratories, and academic institutions that provide products and services to the Department of Defense and to foreign customers. Three important and notable features of the defense technology and industrial base are:

- Customer demands are unstable.
- The skills and facilities of most suppliers are highly specialized.
- Many of the large defense contractors--known as the "primes"--produce defense products only.

To maintain what is called in the business an adequate or "warm" defense technology and industrial base, the United States needs to be producing, year in and year out, sufficient modern weapon systems and sustaining components to allow us to maintain technological superiority in mission decisive areas and expand production on short notice. Absent that level of activity during periods without a major conflict, our forces in being, supporting logistics stocks, and industrial capacity inevitably slip below what some consider prudent manning and readiness levels on the one hand and adequate production levels and capacity on the other. As the period between crises increases, the base grows "cold" from neglect; the risk to national security increases correspondingly.

The authors believe that without policy changes similar to those proposed in this article, the large reductions in defense research and development and procurement which began as the Cold War was ending, and are projected to continue, will result in a defense technology and industrial base inadequate to maintain US superpower status. This hypothesis encompasses:

- current and projected demands for defense-related material and the resulting effects of that demand on key components of the defense technology and industrial base
- the principal federal policies and programs aimed at maintaining a warm defense technology and industrial base
- responses to changing federal policies and declining defense procurement dollars by US defense contractors and by allies and friendly nations

We have a reminder from an earlier period of post-conflict euphoria about the importance of maintaining national power in a time of apparent peace. The National Security Act of 1947 (as amended) Title 1, Section 101, (a)(1) reads as follows:

> The National Security Council will assess and appraise the objectives, commitments, and risks of the United States in relation to our actual and potential military power, in the interest of national security, for the purpose of making recommendations to the President in connection therewith.

This article examines the contribution that the defense technology and industrial base makes to any assessment of actual and potential US national power.

Context

It is unfortunate--mystifying, even--that there is so little interest in the state of the defense technology and industrial base (DTIB) and even less appreciation for the close relationship between national power and our manufacturing capacity. For example:

. The US National Security Strategy (February 1996) makes no direct reference to the DTIB or to the contribution that our vast potential military power makes in keeping the peace and deterring aggression.

. Some apparently believe that being prepared to wage two nearly simultaneous major regional conflicts provides an adequate hedge against any threat that might exceed assumptions in vogue at the time the strategy was developed. Such assumptions naturally ignore mobilization potential, even as we come to terms with risks of domestic attacks by terrorists, the proliferation of weapons of mass destruction, and the range of meanings associated with the concept of "cyber warfare."

. Those who oppose the building of more *Seawolf* submarines and B-2 bombers correctly argue that the current threat does not justify more of these expensive weapon systems. But in that debate, few seem to understand that a yes or no vote on maintaining production potential can have a profound effect on perceived US military power. Preparedness need not include bombers in excess of current requirements, but it cannot ignore production capacity capable of responding in an emergency.

To ensure that national security structures can forestall inevitable challenges, the United States should be prepared to:

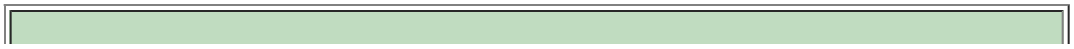
. Maintain levels of ground, sea, air, and space forces, along with the requisite supporting logistics, which are consistent with known and expected threats but which do not overburden the economy.

. Maintain an industrial and technological infrastructure with three characteristics: The first two encompass the capacity and technological superiority to equip our existing armed forces with the best weapon systems available, and the capability to support the mobilized force if deterrence fails. The third characteristic acknowledges that we will inevitably encounter adversaries whose national interests do not fall within the range of our convenient assumptions about adequacy. We must therefore at least remain aware of the level of effort needed to reconstitute our military strength in the event that we have to replace significant parts of the peacetime force.

The foundation of our superpower status, the defense technology and industrial base, is undergoing systemic change, and no one is monitoring the effects of that change on the state of the base. When the fires of change burn out we may not have the military power--actual plus potential--to keep the peace, protect our interests, and fulfill commitments to our allies.

The State of the Base

The current and future status of the DTIB depends mainly on the type and magnitude of domestic and foreign defense purchases. Most observers believe that US defense expenditures will continue to decline unless there is a grave crisis. Foreign military sales are also declining, primarily for two reasons: growing overseas competition, and the reduction of military forces throughout Europe. In the aggregate, production of US weapon systems and other defense-related materiel is projected to be less than one-half the levels of the early 1990s. Projections prepared by the Defense Logistics Agency (DLA) on the status of key elements of the DTIB, from 1992 to 2010, provide clear evidence of the radical changes taking place. (See Figure 1, below.)



Past, Current, and Projected Domestic Sources of Defense Materiel by Type			
	1992	**1996**	**2010**
Aircraft			
Bombers	3	2	1
Fighters	5	4	2
Helicopters	4	4	2
Related Materiel			
Ballistic Missile Defense	6	4	3
Expendable Launch Vehicles	3	2	1
Satellites	5	4	3
Rocket Motors	6	6	3
Strategic Missiles	1	1	1
Tactical Missiles	8	8	8
Tracked Vehicles			
Tanks	1	1	1
Armored Personnel Carriers	8	8	4
Munitions			
Small Caliber	5	5	3

Cannon Caliber	5	5	3
FASCAM	2	2	1
Pyrotechnics	1	1	1
Bombs	4	2	1
Mortars	3	2	1
Artillery Caliber	4	4	2
Propelling Charges	2	2	1
Fuses	22	13	8
Dispenser Munitions	2	2	2
Navy Guns	1	1	1
Tanks	3	3	2
Demolition, Grenades, and Mines	8	5	2
Rockets/Warheads	4	3	2

Source: Defense Logistics Agency, Industrial Analysis Support Office, December 1996.

Figure 1. Past, Current, and Projected Domestic Sources of Defense Materiel.

Drastic changes in US defense production levels due to budget cuts are not unprecedented. They have occurred on a rhythmic, periodic basis with high peaks and deep valleys throughout the 20th century. In what was something of a growth industry throughout the early 1990s, the many defense budget forecasts developed and publicized by DOD, other government agencies, and the private sector indicated significant decline in total DOD budgets and corresponding declines in the funds for operations and maintenance, procurement, and research and development. The analytical effort we suggest as necessary to maintain a sustainable DTIB, accompanied by equally necessary proposed policies and programs, is essential given the systemic changes taking place in the DTIB.

The 30 or so large defense contractors--the primes--now selling directly to DOD are supported by as many as 40,000 lower tier firms plus thousands of other industrial establishments that provide bits and pieces of materiel to the primes for the assembly of major end items. Single customer specialization by lower tier firms is not as pronounced as for the primes, although thousands of the lower tier industries depend heavily on DOD procurement. The term "lower tier" describes the thousands of small manufacturing entities that produce nuts, bolts, parts, components, and subsystems to be used by the primes in final assembly of major end items of military equipment. Reductions in defense "procurement" have already had, and will continue to have, significant consequences for the business of the primes as well as for their lower tier contractors.

Reduced research, development, test, and evaluation (RDT&E) expenditures exacerbate the problems of primes and their suppliers. Commercial firms engaged in activities related to research and development--DOD's budget subcategories 6.2 (Applied Research) and 6.3A (Large-scale Experimentation)--have been affected as well by lower profit margins. Additionally, private firms engaged in defense-related research, covered for the most part in DOD subcategory 6.1 (Basic Research), are facing declining business and profits; as a result, these firms will probably request remuneration for any future defense-related R&D activities.

What follows is an appraisal of the consequences of DOD's decisions to postpone or to cancel outright the development, production, and fielding of some existing and new weapon systems. Each appraisal illustrates the kinds of systemic changes occurring in one of the major defense production sectors of US industry.

Munitions

There are two types of ammunition, smart and dumb. The former includes precision guided munitions (PGMs), while the latter describes all types of conventional munitions, from bullets to bombs. Peacetime ammunition production levels for both categories are determined by three factors: training requirements, authorized reserve stock levels, and the requirement for sufficient production capability to replenish stocks expended in wartime.

It is quite difficult to determine the adequacy of the munitions production base because the requirements to support operational planning cannot be determined with any degree of accuracy. This difficulty in determining wartime requirements arises primarily from two considerations. First, the services have multiple capabilities for attacking the same target; the Army, for example, can launch a precision strike on mobile land targets with the Army Tactical Missile or it can seek to eliminate them by firing a large number of dumb munitions. The Air Force might attack the same sorts of targets with Maverick missiles, the Navy with its Walleye missile. Second, planners can make only crude estimates as to how long a war might last and the intensity at which it will be fought. Experience indicates, however, that ample ammunition stocks contribute to short wars and low casualties.

Thus it is difficult to arrive at a judgment regarding the risks associated with a shrinking ammunition base; see, for example, the Defense Logistics Agency's projections for munitions in Figure 1. Production capability in the ammunition sector--fuses, propelling charges, motors--will be significantly reduced by the year 2010.

Foreign-source dependency also poses a potential problem for US precision guided munitions, all of which contain foreign components. Most of the components are produced in allied or friendly countries, so the prospect of losing offshore sources in peacetime is not of great concern. In a deep crisis or wartime situation involving the United States and significant numbers of its allies, the reliability of foreign sources becomes much less certain. Similarly, decisions about the size of the US domestic munitions industry do not take into consideration requirements that would be generated in a crisis by allies armed with US weapon systems.

The ammunition base is unique because there are no civilian customers for larger caliber ammunition or for PGMs. Thus the US ammunition base contains the remnants of the arsenal infrastructure developed before and during World War II--10 plants that are government owned and government operated and 11 that are government owned and contractor operated.

In 1977, the Army was designated as the single manager for conventional ammunition. In this capacity the Army assumed responsibility for the storage, management, and disposal of ammunition and explosives inventories for all the services. The Army therefore carries a line item in its budget for production base support--$231 million in FY 1996,

$230 million in FY 1997, $196 million in 1998, and $174 million in 1999. Ammunition stockpile demilitarization accounts for about $100 million of these amounts.

Finally, a GAO report concludes that the military overrated the effectiveness of PGMs used during the Persian Gulf War. The unclassified summary reports that "only eight percent of the delivered munitions tonnage was guided, but at a price that represented 84 percent of the total munitions cost." The inference is clear: dumb munitions offer more bang for the buck. So in the years ahead the debate will continue not only as to the size of the production base for munitions, but also the division of budget dollars between smart and dumb munitions. Whatever the outcome of this debate, weapon systems that cost millions of dollars each are useless without munitions. It is useful also to recall that casualties increase when we must severely ration munitions, as we have done routinely in all previous conflicts except Vietnam and the Persian Gulf.[1]

Armored Vehicles

A study by the Office of Technology Assessment summarizes DOD policies regarding production of armored vehicles in the 1990s:

> The Army is currently reviewing its plans for manufacturing armored combat vehicles. The diminished threat of large-scale conventional hostilities in Europe, the signing of the Conventional Forces in Europe Treaty, the impressive performance of current armored vehicles in the Persian Gulf War, and projected budget reductions have left the Army with a large supply of advanced armored vehicles and an over capacity for production. The Army had planned to phase out production of current combat vehicles and begin the development of a new family of six armored vehicles under the Armored Systems Modernization program. It now appears, however, that this family will be restructured around three vehicles, with the other three deferred indefinitely.[2]

Variants of the Abrams tank and the Bradley fighting vehicle are the principal armored vehicles fielded by DOD since 1977. DOD has also acquired relatively small quantities of other armored vehicles (the Armored Combat Earth Mover and the Command Post Carrier) whose low production rates have a limited effect on the armored vehicle industry as a whole.[3] Consequently, termination of tank and fighting vehicle procurement has had a significant effect on the US armored vehicle manufacturing base.

Armored vehicle manufacturing facilities are not, at this writing, producing for our armed forces. The production lines for the Abrams tank, at Lima, Ohio, and for the Bradley fighting vehicle, at San Jose, California, remain open only to support foreign sales. But it is unlikely that the volume of foreign sales for these vehicles will allow the primes--General Dynamics Land Systems for the Abrams and FMC Corporation for the Bradley--to keep open for any appreciable period what are essentially idle production lines.

Termination of Abrams and Bradley procurement by DOD also affects a large number of supporting industries. Estimates identify some 560 lower tier contractors for the Abrams and over 300 for the Bradley, which probably understate substantially the number of lower tier subcontractors affected by the business plans of the primes. Just two subsystems for the Abrams--the thermal imager and laser range-finder--together have more than 100 lower tier suppliers.

Finally, DOD plans for modernizing existing materiel will not take place as scheduled; planned upgrades of armored vehicles (so-called "Block III" improvements) have been postponed until the next century. And it is not likely that the configuration and technology of the next-generation tank will be agreed on before the year 2010 or later. Thus, unless the foreign sales market improves significantly, it is likely that General Dynamics and FMC will terminate their contracts with DOD. The facility and equipment for producing the Abrams tank are owned by the federal government, which may decide to mothball it at significant cost. FMC owns the San Jose facility where the Bradley has been produced and probably will either close it or convert it to the manufacture of non-defense products. Once these two facilities have been closed, it could take the United States four to five years to reconstitute current production capability. Timely repair of existing vehicles also will pose a problem if the foregoing scenario plays out as stated.

Shipbuilding

It has been forecast that the future US naval shipbuilding base will consist of one carrier yard, one submarine yard, two combatant yards, and two auxiliary yards.[4] The decline in naval construction is related to the condition of the US commercial shipbuilding industry, as one source reported several years ago:

> The national shipbuilding industry is currently in a severe--some say terminal--slump. The bottom fell out of the commercial shipbuilding market in the 1980s. At the beginning of the decade, 69 commercial ships were either on order or under construction. By 1988, this number had fallen to zero. The order book remained blank until a single new ship was ordered in 1990. If it were not for the US Navy's pursuit of a 600-ship Navy, the US shipbuilding industry might have completely collapsed from the lack of commercial work. Now, some analysts are projecting a reduction in naval forces to 400 ships or fewer, which will result in a further consolidation of the industry.[5]

It should be noted that almost all of the commercial ships under construction were small vessels used for coastal commercial transportation. Many in-depth studies have observed that once the US shipbuilding industry becomes an oligopoly it will create significant problems for DOD.[6]

Several programs have sought to advance US shipbuilding technology, which is at least ten years behind the shipyards in other countries.[7] These include the National Shipbuilding Research Program (NSRP), a cooperative program between the government and industry; the US Navy's MANTECH program and, most important, DARPA's MARITECH program initiated by President Clinton and aimed at improving the shipbuilding industry's technology base. These and related initiatives have not had significant effects on the US shipbuilding sector because of limited procurement of commercial and naval vessels.

There have been few orders for large ocean-going cargo or passenger commercial ships for several decades; fewer than a dozen deep-seagoing ships were built in US shipyards in the 1980s. As of early 1997 US shipyards are building nine such ships and a dozen or so smaller vessels such as oceanographic research vessels. Current commercial vessel activities are significantly below the capacity of US shipyards.[8]

Construction activities of surface vessels (combatants and others) for the US Navy are also limited.[9] Existing orders will sustain the principal US shipyards until the year 2000, but the volume of orders will decline precipitously after current naval shipbuilding programs are concluded. Litton Industry's Gulf of Mexico yards will be fully engaged in the construction of *Admiral Arleigh Burke* destroyers (DDT-51) and sealift ships (ELPD-17) until the turn of the century, and assuming the US Navy will have 300 to 400 ships (proposed by the 1993 Bottom-Up Review), new naval construction will consist of 10 to 13 surface ships a year with some additional work for overhaul and repair.[10]

The United States has essentially one shipyard for building submarines, at Groton, Connecticut, operated by General Dynamics' Electric Boat Division. The only other capability is at Newport News Shipyard, where submarines can be overhauled. Future (admittedly very limited) submarine construction for the US Navy may take place in both Newport News Shipyard and Groton, if a "modular" construction concept is approved that would retain the experienced and skilled workforce needed for submarine construction. The Groton shipyard may have a near monopoly on submarine construction, but even at that, it is underutilized.

In the immediate past, Groton produced both Trident missile and *Seawolf* attack submarines; prior to the demise of the Soviet Union, the US Navy had planned for 29 *Seawolf* submarines, at a cost of some $58 billion. As of spring 1997, there were under construction a total of four submarines at Groton: three of the *Seawolf* type (SS21, SS22, and SS23), and one Trident. It is likely that the Congress and the current Administration will continue to fund the construction of one or two submarines on a continuing basis, to maintain the required skills and experienced personnel. Such a schedule would, at best, retain a warm--barely warm--submarine construction base.

Once again the problems of lower tier suppliers are significant. Approximately 60 to 70 percent of the total value of typical naval combatants, and about 40 to 60 percent of noncombatant vessels, is in parts, components, and systems supplied to the shipyards by other industry sectors, subcontractors, or lower tiers. The number of such lower tier subcontractors for a "typical" combatant may exceed 5000 firms; for an auxiliary vessel it can be 600. Recent analyses of lower tier contractors suggest that a large proportion have either stopped producing line items for marine and naval

vessels or will do so in the near future. For many parts, components, and systems that are required in naval vessels, the US Navy has become and will remain increasingly dependent on foreign sources.

A few US shipyards capable of building and maintaining naval vessels--with considerable off-shore support--adequately describes the rapidly diminishing status of the US naval shipbuilding industry.

Military Aircraft

DOD has discontinued procurement of a number of military aircraft, much as it has for land combat systems. Production of the F-16, which the Air Force bought at an annual rate of 180 in the 1980s, and of the F-15 and F/A-18 C/D, will end in the near future, although some in Congress disagree with the decision. The follow-on F/A-18 E/F aircraft is not expected to be produced until 1998 or later, and it will be purchased in relatively small numbers. The prime contractors for these aircraft will depend principally on foreign sales to keep their assembly lines in operation. To date, foreign sales of US military aircraft have been substantial, such as $2 billion worth of F-15s sold to Israel in 1994. Trends in such sales, however, are uncertain.

The key question for primes is whether foreign sales plus the projected limited procurement by DOD can sustain the six principal US military aircraft manufacturing entities operating in 1997. Many believe that the future composition of the military aircraft manufacturing sector depends on the winner(s) of the contracts for the Joint Strike Fighter (JSF), intended as the replacement for F-16 and A-6 aircraft during the second decade of the next century. This program began in 1993 with acquisition strategies similar to the F-22/F-23 fighter competition of the 1990s. The competitors for the contract, with DOD funding of $2.9 billion through 1999, are Lockheed Martin; Boeing Military Airplane Division; ITT Defense and Electronics Incorporated; McDonnell-Douglas, and a consortium consisting of Northrop Grumman and British Aerospace Company. The winner(s) of this competition will be assured a significant place in the military aircraft manufacturing segment of the DTIB. The losers will face an uncertain future.

Prospects for the military helicopter segment of the aircraft industry are also poor. In sharp contrast to the past decade, during which DOD spending for helicopters amounted to about $5 billion per year, current DOD plans call for the next helicopter, the Comanche, to be produced only after the year 2001. In the interim, the demand for military helicopters and major subassemblies will justify only limited production runs.

Sikorsky Aircraft, owned by United Technologies, is the largest US military helicopter producer, with average annual sales of $2 billion over the last decade. Starting in 1997, Sikorsky's production of military helicopters will be negligible. McDonnell-Douglas, with annual sales of about $800 million, manufactures the AH-64 Apache helicopter. Production of AH-64s for DOD ended in 1993, although AH-64 "Longbow" platform improvements will continue. The production line for the AH-64 helicopter at Mesa, Arizona, may be kept open to fill foreign sales. Boeing, manufacturer of the CH-47D Chinook cargo helicopter, with annual helicopter sales of $600 million, has experienced declining defense purchases since 1989. Bell Helicopter Company, owned by Textron, is the largest manufacturer of helicopters for the civilian market, with total annual sales of about $1.3 billion. Bell's defense sales have declined, and civilian helicopter sales face very strong competition from Italian and French firms. Conversely, Bell Helicopter's V-22 program (the tilt-rotor Osprey) has received additional funding. Curtailment of major procurement programs may well lead to mergers among the four US helicopter firms in the next few years.

In summary, unless there is a drastic change in the international situation, the US military aircraft sector will probably have been reduced to two or three prime contractors as we enter the next century.

Electronics

Since World War II, the electronics sector of the DTIB has been expanding. During the last decade, total national sales of electronic products averaged $215 billion per annum (constant 1993 dollars) with military electronics accounting for approximately $55 billion annually. However, DOD's procurement of electronic components began to decrease in the 1990s; by 1995, purchases were estimated at $38 billion, and DOD and industry authorities expect the decline to continue. Significant resources will continue to funnel into this sector, primarily in the form of funding for R&D and for programs to upgrade the technology in fielded weapon systems.

As a result of these trends, many large US defense contractors have acquired electronic component firms. And while this trend toward vertical integration of their business lines could have adverse effects on some of the smaller suppliers of electronic parts and subcomponents, major defense electronic producers could experience modest growth when compared to other US industrial sectors. Platform upgrading via the insertion of advanced technologies will help to sustain this element of the DTIB, offering many prime contractors and associated lower tier suppliers an opportunity to keep their defense-related production lines active. Furthermore, parts and even components of the projected advanced technology upgrades may have civilian as well as defense applications. Thus DOD's programs to integrate the defense technology base with the commercial base are of particular importance in the electronics sector.[11]

Defense Research and Development

Reductions in DOD procurement of goods and services will also affect defense-related research and development (R&D) activities by reducing the independent research and development and bid and proposal (IR&D/B&P) efforts of contractors that heretofore have been supported by DOD. Essentially, all defense contractors support some of their research and development activities using IR&D/B&P funding allowed by DOD as overhead costs. Now, however, the legal status of this category of defense spending is apparently under review.[12]

The sums involved in IR&D/B&P work have been significant. During the early 1980s, defense contractors' research and development and related allowable expenses annually averaged $8 to $9 billion. The numbers began to decline in the early 1990s; by 1996, these expenditures were estimated at approximately $4.5 billion. The importance of such funding to the advancement of defense as well as private sector technologies is portrayed in Figure 2, below. Only about a third of the IR&D/B&P funds were routinely allocated to unique defense applications; they are the first five listed in Figure 2. The other two-thirds of IR&D/B&P funding for technology advancement may be applicable to both defense and civil sector markets; while those investments could advance DOD's dual-use initiative, over the long term the decline in such funds will fundamentally affect the sustainability of the DTIB.[13]

Distribution of IR&D/B&P Funds by Technology Areas, 1980-1993

Technology	Distribution (percent)
Air breathing propulsion	18.0
Passive sensors	10.0
Weapon system environment	2.0
Hypervelocity projectiles	1.0
Pulsed power	1.0
Semiconductor materials	12.0
Signal processing	9.0

Simulation and modeling	8.0
Composite materials	7.0
Parallel computer architecture	5.0
Sensitive radars	5.0
Software	5.0
Photonics	4.0
Computational fluid dynamics	4.0
Data fusion	4.0
Machine intelligence/robotics	3.0
High energy density materials	1.0
Superconductivity	0.5
Biotechnology	0.5
Total	100.0

Source: Ivars Gutmanis, *Analysis of the Civil-Military Integration Feasibility for Selected U.S. Industry Sectors*, for US Congress, Office of Technology Assessment (Washington: Hobe Corp., 1993), p. 167.

Figure 2. Distribution of IR&D/B&P Funds by Technology Areas.

Adapting to Reduced DOD Budgets

Reforms in procurement regulations and adoption of policies aimed at changing the structure and infrastructure of defense-related industry constitute the primary responses by the Clinton Administration, the Congress, and DOD to the decline in defense spending. Changes in the regulations are discussed below; the policies in question promote evaluation of industry structure to determine which firms can operate efficiently in both civilian and defense markets.

It should be noted that the achievement of greater "economies of scope"--the ability of an industrial firm to produce varieties of goods and services--may occur principally through two activities. The first includes vertical and horizontal

integration of firms--mergers, acquisitions, and similar actions--undertaken with varying degrees of success by many of the primes.[14] The second activity consists of installing advanced manufacturing technologies, increasing manufacturing flexibility, adopting rapid prototyping and agile manufacturing processes, and undertaking related investments for the advancement of process technology. Many of DOD's programs are aimed, directly or indirectly, at the concepts in the second group.

Reforming DOD Procurement Regulations

Government and industry have long agreed that DOD's contract management and administration procedures are costly and cumbersome. There is indeed a dire need for reforms, as former Secretary of Defense William Perry reported in his testimony on the Federal Procurement Reorganization Act:

> The Carnegie Commission on Science, Technology, and Government, using an indirect measure of the cost of the DOD regulatory system, calculated that the overhead, or management and control costs, associated with the DOD acquisition process were about 40 percent of the DOD acquisition budget, as compared to 5 percent to 15 percent for commercial firms.[15]

The Congressional Office of Technology Assessment estimated annual indirect costs of DOD procurement regulations to range from $15 to $75 billion. Other authoritative studies have identified costs attributable to government contracting requirements that make the cost of goods and services procured by DOD as much as 30 percent more expensive than in identical commercial contracts.

DOD began significant reforms of its contracting procedures in the early 1990s; most were in place by 1996. Under the proposed changes, DOD contract personnel gain considerable freedom in negotiations, narrowing the gap between the way negotiations are conducted by DOD and comparable procedures in commercial contracting. There is evidence that the procurement reforms have, as of 1997, simplified some DOD contracting procedures. Since late 1995, DOD's procurement offices have also emphasized the desirability of purchasing commercial products--the so-called commercial-off-the-shelf (COTS) items and non-developmental items (NDI). The latter include defense-related products whose costs of design and development are not included in the purchase price of the latest procurement.

It should also be noted that DOD procurement reforms have not as yet been generally endorsed by the business community. While the Aerospace Industries Association has supported procurement reforms, other associations and some firms have voiced strong opposition. Many industrial giants--AT&T, Bell Atlantic Corporation, Oracle Corporation--and several national associations, including the US Chamber of Commerce and the Computer and Communications Industry Association, have opposed the reforms. Some industry executives maintain that the new rules were adopted without public hearings or contributions from industry to the rule-making process. Furthermore, some executives claim, the reforms make it too easy for the government to pick and choose contractors without a proper bidding process.[16] There is no question, however, that procurement reform is under way.

Administration Policies

In conjunction with reform of DOD's procurement regulations, the current Administration initiated policies aimed at modifying the very structure of the US defense-related industrial base. The policies, which acknowledge DOD's constrained budgets, have as their goal the preservation of as much as possible of industry's defense-related manufacturing capability. Common to all current policies is the mandate for DOD to procure defense-related material from commercial entities, rather than to depend solely on establishments approved and certified by DOD. Among the more important of these policies and programs are: Procurement of Non-Developmental Items (NDI); Commercial-Military Integration (CMI); and the Dual-Use Technology and Production Initiative.

. *Procurement of Non-Developmental Items (NDI).* DOD procurement of any product had been based on prescribed military specifications and standards established in some 32,000 documents commonly known as "Milspecs." As DOD modified its procurement processes in the early 1990s, it began to acquire non-developmental items using procedures common in commercial transactions. The NDI regulations also have significantly expanded the industrial base that can supply DOD with goods and services. DOD's increasing emphasis on simplifying the procurement of non-

developmental items has been an important component in its procurement reform efforts.

. *Commercial-Military Integration (CMI)*. CMI is being considered as a means for expanding and preserving the base for the production of defense-related materiel. And while there is no standard definition of CMI, the best unofficial explanation of what is meant by commercial-military integration is in a report from the Congressional Office of Technology Assessment:

> Civil-Military Integration (CMI) is defined as the process of uniting the Defense Technology and Industrial Base (DTIB) and the larger Commercial Technology and Industrial Base (CTIB) into a unified National Technology and Industrial Base (NTIB). Under CMI, common technologies, processes, labor, equipment, material, and/or facilities would be used to meet both defense and commercial needs.[17]

The theory behind CMI is that most defense-related materiel, including weapon systems, contain parts that are used in goods manufactured for the civilian market.

> The essence of CMI is that sufficient commonality between commercial and defense needs can be "designed into" military systems and weapons so that commercial capabilities can fulfill the vast majority of defense requirements. In research and development this goal is pursued through so-called dual-use technologies--technologies that are both commercially viable in the competitive marketplace and militarily useful either directly or with limited modification.[18]

Successful use of CMI depends on the willingness of US manufacturers to modify--expeditiously--their manufacturing and assembly lines and their process technologies. Measurable progress has been reported by those manufacturers that focused on production process technologies, rather than on the products themselves. Nevertheless a number of experts continue to point to industry's reluctance to modify their manufacturing process technologies because of the high costs involved and the time that it takes for investments in the required modifications to be reflected in profit margins.[19]

. *Dual-use Technology and Production*. The policy on dual-use technology and production is arguably the principal undertaking by the current Administration to preserve the DTIB. Under this policy, DOD seeks to break down the formidable barriers that exist between commercial and defense industries by instituting compatible development and acquisition processes for joint defense and commercial products. This policy vastly enlarges all of the foregoing programs and initiatives.

As stated by President Clinton, the goal of the dual-use technology strategy has been:

> To move toward a cutting-edge national technology and industrial base that will serve military as well as commercial needs. This dual-use technology strategy will allow the armed forces to exploit the rapid rate of innovation and market driven efficiencies of commercial industry to meet defense needs.[20]

In 1994, then-Secretary Perry translated President Clinton's objectives into practice, directing the military services to "use performance and commercial specifications and standards instead of military specifications and standards unless no practical alternative exists to meet the user's needs."[21] In 1995, DOD issued a special report on dual-use strategy to the effect that:

> Making greater use of commercial technologies in defense systems and transitioning defense-sponsored technologies into commercial production facilities will mean that other government policy concerns--export controls, restrictions on foreign investments in domestic industries, the rules regulating national subsidies in international trade, the industrial organization of international industries supplying products and technologies used by DOD and its domestic suppliers, and the international regime protecting intellectual property--will be ever more tightly linked to dual use technology policy and strategy. Hence, DOD actions will be coordinated with agencies such as Commerce, Energy, State, Treasury and others, including the US Trade Representative, as needed. Likewise, the success of defense investments in R&D on dual use technologies will be fostered by increased cooperation with other federal government agencies and programs that are working with industry to develop and deploy leading-edge technologies (e.g., the

national information infrastructure).[22]

The dual-use concept supports the need for manufacturing firms to seek technology advances in industrial processes because US manufacturing firms have fallen behind other industrial nations in redesigning those processes. As a result US industry has lost some of its competitiveness in world markets. The theory is that if advanced technologies, for both process and product, are adopted and improved by commercial firms, then military systems will also benefit.[23] And by strengthening those segments of the technology and industrial infrastructure upon which DOD depends, successful commercialization of defense technologies can increase the likelihood that these technologies remain accessible and affordable for military use.

The dual-use program is not, however, a panacea. DOD divides the sources of defense-related goods and services into two industrial groups: goods and services that are purely commercial and those that are purely defense- related. At the defense end of this continuum, dual-use programs will provide goods and services--military aircraft, munitions, warships, and weapons--that are manufactured exclusively for defense uses. However, certain parts, components, and systems of such materiel may also have civilian applications. The industrial entities that manufacture common-use parts and components may therefore be engaged in production simultaneously for both defense procurement and civilian markets.

In its promotion of the dual-use policy, DOD apparently assumes trouble-free supply production throughout the civilian industrial sectors of the US economy. In fact, the civilian marketplace does not always function smoothly. Any number of civilian market forces may significantly affect both the supply and the demand for goods and services, potential problems that DOD should subject to critical analyses.

Defense Contractors Respond

While executives within US defense-related industries have for the most part expressed satisfaction with the dual-use policy, they have also actively pursued their own initiatives for coping with reduced DOD expenditures for goods and services. Most of the lower tier defense industrial firms participate in the programs just described; many of them have successfully converted their defense-related production lines to produce products for civilian markets. Even some large defense entities, such as Rockwell, have had considerable success establishing viable commercial product lines to offset the loss of government business.

Conversely, some executives of leading US defense contractors rejected any move toward the manufacture of products for civil sector consumption. One observer noted:

> William A. Anders, chairman of General Dynamics, the giant manufacturer of M1 tanks, jet fighter planes, and nuclear submarines, gave fair warning of this in a little-noticed speech that has become the military industry's Gettysburg Address. That speech, on 31 October 1991, in St. Louis, is now widely cited by chieftains of other big military contractors as a prudent call for a do-or-die policy: make weapons or shut down. It is not just that conversion cannot work, Mr. Anders said; it should not work. Making plowshares is not so easy for a military contractor, and not as profitable as simply making fewer swords. What contractors should do is lobby for every military dollar that can be squeezed from Congress and the Administration, and from foreign sales. And as the revenue flow inevitably lessens in the post-cold war era, Mr. Anders told an industry conference, weapons makers should shut factories and send home workers, eliminating over capacity and improving efficiency.[24]

This type of response by defense prime contractors to defense procurement reductions and to the government's attempts to encourage civil-military integration is at least partly based on failed attempts to convert existing military production facilities to manufacture commercial products. In the mid-1980s Grumman unsuccessfully attempted to enter private sector markets for trailers, pleasure boats, and related goods. Likewise, Boeing Company's Vertol division failed in its effort to manufacture subway cars. Large defense contractors that have failed in their efforts to enter civilian markets probably did so because the "culture" of the defense business differs radically from that found in private sector industry.

As an alternative to venturing into civilian markets, an increasing number of large US defense-related firms have been

involved since 1990 in mergers, acquisitions, and other forms of business collaboration with the explicit objective of continuing to produce weapon systems and other defense material. The following estimated value of defense firms involved in mergers as a strategy for survival suggests the significance of this trend: $300 million in 1991; $740 million in 1992; $6.4 billion in 1993; $14.2 billion in 1994, then down to $5.5 billion in 1995, only to increase to an estimated $14 billion in 1996.

The industrial entities created by these mergers are very large, vertically integrated firms capable of producing a wide variety of defense-related products. For example, Lockheed Martin/Loral, the world's largest defense company, was formed in a two-step process: the merger between Martin Marietta and Lockheed in 1995 was followed in 1996 by the acquisition of Loral's defense electronics unit, which added an in-house capability in that subsector of the economy. Another vertical merger occurred when Northrop Grumman, itself an entity formed by a 1995 merger, a year later acquired Westinghouse Electronics, a defense-electronic product manufacturer, from the Westinghouse Corporation. Finally, in August 1996, Boeing purchased Rockwell Corporation's defense and space divisions for over $3 billion, following heated competition with McDonnell Douglas Corporation.[25]

The participants in the mergers, investments, and buyouts are not only defense firms. US financial entities, such as venture capital firms or buyout companies, have also entered the defense industry sector via outright purchases, mergers, and other types of acquisitions of defense contractors. The Carlyle Group made investments in 1991 and 1992 in several large defense contractors, among them BDM International, Vought Aircraft Company, GDE Systems, and Magnavox Electronic Systems. In 1994 and 1995 Carlyle resold Vought and Magnavox to Northrop Grumman with average annual gains on the transactions of 90 and 208 percent respectively.

To date, most of the mergers in the defense industry sector have been successful. Taking a short-range view (five to seven years), the mergers will help sustain the DTIB in the face of the reductions in DOD procurement budgets, partly because international sales of weapon systems and other defense materiel will contribute to business activity. In the long term, however, the new defense industry behemoths may not be so successful; mergers reduce competition and could significantly increase the cost of defense materiel, and the level of foreign military sales is always an uncertain proposition.

The requirement exists for a continuous and comprehensive assessment of the US defense-related industrial base. As one observer has noted:

> Developing a credible assessment process for potential national security resource problems, regardless of perceptions of probability, is a crucial task if the United States is to remain a strong world leader. The United States must understand how to employ, sustain, and replenish the existing military force in a number of widely divergent threat situations. Managing and reducing the associated risk are essential elements of our national security strategy. The country cannot and should not be called upon to do everything, but it can--and must--lead, both in conducting assessments of a whole range of potential problems and in formulating and implementing plans to address them should they arise.[26]

Allies and Friends Respond

There has been an increasingly close level of cooperation during the last four decades between DOD and our NATO allies in R&D, production, procurement, and fielding of defense-related materiel. There also exists considerable evidence that the nations that comprise the European Union, as well as others--notably Japan, Korea, Taiwan, and Brazil--are engaged in building their own R&D and defense manufacturing bases, for domestic use and, increasingly, for international sales.

Competition in the defense business from European allies may increase substantially as a result of transnational mergers, purchases, and joint undertakings of defense-related programs in Europe. The bulk of the European participants in this wave of restructuring represent the principal European arms makers, as the following examples suggest. In 1996 British Aerospace (BAe) joined forces with the France's Matra (Lagardere Groupe) to develop an airborne cruise missile called "Storm Shadow" with joint funding of $1.2 billion, under a new entity, "Matra BAe Dynamics." Germany's Daimler-Benz Aerospace (DASA) is negotiating a merger of its missile subsidiary with France's Aerospatial. DASA, Matra, Britain's GEC, Sweden's Saab, and Italy's Alenia are working on a joint project to

develop a medium-range air-to-air missile that would compete with the newest Sidewinder AIM-GX produced by the United States. A consortium of French, British, and German defense entities--Alvis, Vickers, and Thyssen Henschel--is competing with another German-British consortium (GKN, Krauss-Maffli, Rheinmetale, and Wegmann) to design and manufacture a multi-role armored vehicle. These and other European defense materiel ventures will compete directly with US firms for sales in NATO, the rest of Europe, and third-world countries.

Defense-technology transfers from the United States will provide advantages to these potential competitors and will be detrimental to US defense contractors. There are several channels for such technology transfer. Unintended and undesirable US technology transfer to foreign nations occurs as the result of so-called offsets, comprising trade concessions and technology transfers from the United States in exchange for DOD contracts with foreign industrial entities. The total value of offsets is increasing rapidly. This development could have important effects on the DTIB; it is an aspect of strategic defense planning that should be considered explicitly in future DOD policies. In particular, three areas related to foreign defense production and R&D should be monitored by DOD and other government or private sector entities:

- the degree to which foreign defense production reduces the demand for materiel made in the Unites States
- the projected reliability of foreign sources in time of crisis or war
- the overall effects of globalization on our ability to maintain technological superiority

The Plight of the Lower Tier

Reduced DOD procurement has placed a heavy burden on the 40,000 or so US industrial entities supplying various services, parts, components, and materials to the major defense contractors. Some of these lower tier suppliers, while small in all measures of industrial activity, provide strategically important components to the primes. Partial assessments of lower tier firms indicate significant overcapacity, excess employment, and financial and related problems arising from the decline of the defense market. DOD has not evaluated the effects of reduced defense expenditures on these firms. Methodologies and procedures for such an assessment are in place, but they have not been applied systematically to the problem.

Anecdotal evidence suggests the obvious: many lower tier firms that in the past were engaged in production for both defense and civilian markets have thus far been able to adjust successfully to procurement reductions. Atchinson Casting is an example of such a firm. During the 1970s and 1980s, the company produced eight castings for each Abrams tank through a contract that represented over 70 percent of the company's total business volume. The end of Abrams production forced the company to seek other markets for its products, a search that was only partly successful. The firm has been able to remain in business, albeit with sharply reduced employment, sales, and profits. It should be noted that Atchinson Casting belongs to a class of manufacturers that could be called "important national assets"; it is the sole surviving firm in the United States capable of producing large-scale ferrous metal castings.

Many lower tier manufacturers that produce only defense goods have had trouble developing products or services suitable for the civilian sector. J-Technologies, for example, a small firm engaged in the design and manufacture of specialty computers for DOD, closed because of the reduction in Department of Defense procurement. Several firms engaged in the supply of advanced composites--superior materials for critical aircraft parts--have begun to manufacture various sporting goods (golf clubs, tennis rackets) and sell them below the true production costs in order to remain in business.

It has been reported that a large number of small manufacturing concerns that supplied mechanical components for US naval vessels have closed down their product lines. The fact that approximately 60 to 70 percent of a typical US Navy combatant (in terms of the cost) is supplied by small civilian industrial entities underscores the importance of the lower tier in the US Navy's procurement programs.

An evaluation procedure that could help us understand the implications of the changes taking place in the DTIB--primes and lower tier--is available; it is the concept known as Graduated Mobilization Response (GMR). Often mistaken for an action-focused program used only to place US industry on a war-footing schedule, this program offers a way to remain aware of defense- related capabilities of US industrial sectors, including lower tier suppliers of

defense-related goods and services. One specialist observed:

> The basis of GMR is the preparation and presentation of requirement assessments to key national security decisionmakers. Through its focus on assessing how long it takes to improve military preparedness under different priorities and scenarios, a fully implemented GMR process could strengthen decisionmaking in the incipient stages of a crisis. The old concept of M-Day activating a giant "off-on switch" or of M-Day coinciding with D-Day is a formula for disaster. The services know full well what their wartime requirements are in terms of all the elements of military power--force structure, modernization, readiness, sustainability, and strategic lift.
>
> As the war clouds darken, DOD should come forward with these requirements to the President and the Congress. "This is what we need to reinforce deterrence or to win quickly and decisively."[27]

The idea of using our potential military power to reinforce or augment gradually the existing or already mobilized force in response to crises will be particularly important in the wake of the findings of the Quadrennial Defense Review (QDR). Barring a sudden change in world conditions, it is almost certain that the QDR panel will recommend further reductions in all of the elements of our military power. While being prepared via GMR to augment our armed forces in time of need is not a panacea, GMR offers a capability that can reduce the risks associated with a smaller, less modern, less ready, less sustainable, and less mobile post-QDR force. The matching of requirements against industrial capability also will provide periodic DTIB assessments.

The effects of reduced US defense expenditures on defense-related industries in the lower tier have been and will continue to be much more severe than on the primes. Fewer procurement orders combined with the industry-wide trend toward vertical integration has had a detrimental effect on many of the smaller suppliers of defense goods and services. It is in this segment of the defense industrial base where government policies, programs, and financial assistance for conversion to civilian markets or dual production are of paramount importance. Frequent and detailed assessments of this industry segment should become an integral part of our efforts to understand the DTIB.

Conclusions

This Administration and its predecessors have recognized the importance of maintaining an adequate defense technology and industrial base. The clearest evidence of this commitment on the part of both the executive and legislative branches of our government is to be found in the orderly and prudent manner in which the United States continues to demobilize its armed forces following the end of the Cold War. After every other war in our history, we have demobilized hastily to force levels that could not possibly defend our national security interests without a prolonged period of mobilization. That traditional, albeit unwise, pattern courted high casualties, even defeat in the initial stages of regional and world conflicts. It is by no means certain, however, that projected levels of defense procurement will sustain levels of technological superiority and industrial capacity sufficient to support major armed interventions on short notice.

These analyses of key segments of the DTIB, while limited, represent the only current attempt to examine holistically the defense technology and industrial base to determine the state of the base and the value of supporting government policies and programs. This void is inexcusable given the following systemic changes that are taking place in the base.

Reduced Competition Among Defense Industry Sectors and Entities

DOD is confronted with a sharply reduced number of firms capable of developing and producing weapon systems and other defense materiel. We already face a monopoly or at best an oligopoly in procuring submarines and warships. There are no readily available policy remedies to maintain competition among defense-related industries in the face of very significant declines in government expenditures on defense materiel.

The United States could revert to the system that sustained its armed forces for nearly 200 years by establishing an arsenal system. That form of government monopoly would avoid having to deal with commercial monopoly or oligopoly. Whether such a solution would be preferable to the continued existence of a few private sector firms should be investigated.

Potential Problems with Lower Tier Firms

DOD and other federal government programs and initiatives to maintain a viable DTIB have not adequately emphasized the lower tier of suppliers. Some of those suppliers are of paramount importance in R&D, design, and production of essential components for our weapon systems. In the manufacture of a military helicopter such as the Apache, about 80 percent of its value is supplied by lower tier firms. Clearly, DOD should pay increased attention to the problems facing those firms.

The dual-use initiative will help some lower tier contractors maintain defense-related manufacturing capabilities. It should not, however, be assumed that the dual-use initiative is a panacea. Many lower tier defense contractors will not return to defense production; as a result, primes will look for foreign suppliers to meet their needs for an ever-increasing number of key weapon system components.

The Need to Foster Research and Development Among Commercial Entities Focused on Defense Needs

DOD's emphasis on dual-use programs will foster increased dependence on R&D activities aimed primarily at civil sector market goals. This dependence will require DOD officials to become intimately familiar with the state of the art of R&D activities in many commercial firms. Tracking R&D activities and advances in both product and process technologies should therefore be integral to DOD acquisition policy, a conclusion emphatically recommend by the US Government Accounting Office:

> DOD does not systematically maintain data on firms at lower production tiers that provide important specialized technology. Consequently, DOD generally does not know whether and to what extent it relies on foreign technology and products to meet its critical needs. Such information is necessary to assess national security risks.[28]

It should be noted that reports of breakthroughs in research and development among private firms, whether related to products or processes, are not likely to be available on the Internet. They are the lifeblood of the corporation, the guarantee of future profitability. Do not expect civilian firms to share the information willingly with anyone else.

The Need to Reappraise US Defense-Related Industry Relations with Foreign Suppliers

In the final analysis, and regardless of political or other expedients offered as justifications, the US technology base can be eroded by any of the following conditions, alone or in combination. First, we can simply give away our hard-earned and taxpayer-funded technology, often as pawns in larger games of dubious merit. That the recipients have no obligation to protect the military edge that the technology represents--submarine technology acquired by the Soviets from Japan comes to mind--is generally of little consequence to the deal makers.

Second, others can set out to counter specific forms of US technology acquired second- or third-hand as a consequence of a technology transfer, seeking to nullify the military advantages we thought we had acquired through our investments in US defense firms. This outcome becomes serious when the counter-technology is developed in secrecy; our forces may not discover what they don't know about a prospective adversary's ability to neutralize or defeat our gadgets until the battle is joined.

Finally, the general decline in investments in basic military-oriented research and development means that our choices of what to explore and what to ignore have consequences far beyond the obvious. If our allies and friends discern a gradual loss of support for new developments in our technology and industrial base, they may rightfully ask how the decline plays into US guarantees of their security. A substantial part of those guarantees rests on the perceived will of the United States to remain ahead of the rest in matters of defense.

We should not be surprised, therefore, if nuclear-capable allies in Europe and the Far East decide to develop their own guarantees of strategic security in anticipation of our loss of will--and the means--to guarantee it. The concept applies

equally to more prosaic aspects of conventional defense cooperation related to NATO, its next expansion, and the remaining suitors grouped together in the Partnership for Peace program. How long before a declining US defense technology and industrial base affects our potential military power to the degree that it hampers US initiatives in matters other than defense? Without the will to maintain a technology edge, at least at the levels of basic research and prototype development, how long before the lack of means to protect ourselves, our allies, and our friends justifies a decision not to do so?

Recommendations

Several steps can be taken by the executive and legislative branches of the federal government to reestablish the importance of US potential military power.

President and Congress

Reestablish the National Security Resources Board (NSRB) to oversee the US defense technology and industrial base. The National Security Act of 1947 created the NSRB as the equal of the National Security Council (NSC) in the correct belief that economic security was equal in importance to military security--a nation cannot have one without the other. Charge the revitalized NSRB with developing policies and programs that will maintain a defense technology and industrial base that is commensurate with and supportive of US superpower status; monitor and establish policies for technology transfers, foreign military sales, trade treaties, and economic sanctions, and assess the war potential of rival states.

Consolidate and update US national emergency legislation and authorities. Most existing laws and authorities were designed to meet our immediate needs following World War II. Consequently they do not allow the executive branch to take full advantage of warning, because many necessary actions must await a presidential and draconian declaration of a national emergency. Others, such as the Food and Forage Act, date back to the Civil War and are woefully inadequate for current and future threat environments. In their place adopt an omnibus national emergencies act using the model developed by Canada.

Department of Defense

Describe the US defense technology and industrial base in terms of capacity and technological superiority levels that can support US national security strategy by determining the extent to which existing forces and logistic supplies are not fully adequate to support that strategy. This analysis should be stated in terms of force structure, modernization, readiness, sustainability, and mobility. Use the analysis to calculate differences between current capabilities and the desired status, then match the differences against the assessed capability of the DTIB to fill the shortfalls in a time certain. This procedure will define a DTIB--R&D, primes, lower tier, and strategic materials--that will assure that the US can:

- Maintain technological superiority in mission-decisive functions and capabilities.
- Deter regional wars or, if deterrence fails, provide the military power to win quickly and decisively.
- Provide the resources needed to fulfill the government's responsibilities under the Federal Response Plan to deal with major natural disasters and terrorist attacks.[29]

Joint Staff and Services

Where and as necessary, factor potential military power into operational planning and be prepared to come forward to the President and the Congress with recommendations for correcting known force deficiencies as justified by warning indicators--in effect, readopt the policy of Graduated Mobilization Response. The formula used in the two World Wars and Korea--that mobilization day (M-Day) is the equivalent of C-Day (deployments begin) and D-Day (hostilities begin)--is still the basis for US response to a crisis. It is a formula for defeat.

Federal Departments and Agencies Supporting War Plans
and the Federal Response Plan

Restructure the National Defense Stockpile which today constitutes a $9 billion array of 99 strategic and critical materials that would supposedly be needed to fight a three-year war. Replace the contents of this World War II relic with finished products that would be essential in the early stages of a domestic disaster--natural or terrorist--or military crisis. Requirements could be determined by reviewing, and as necessary amending, the 23 planning assumptions now used to forecast US requirements for strategic materials.

The United States has remained a free and prosperous nation for a variety of reasons, not the least of which is that we possess greater potential military power than any other nation or group of nations. We have been able to bring this potential power to bear in crises because geography and strong allies traditionally have given us the time needed to do so. As we begin a new century and face new challenges and dangers, it is appropriate to remember that the perception of national power rests on a combination of actual and potential strengths and weaknesses. The time that it will take to bring national power to bear depends on the state of the US defense technology and industrial base. We should pay at least as much attention to our potential power as we do to our actual military power; the capacity of the defense technology and industrial base is as important to our security as existing stocks of weapons and other defense materiel.

NOTES

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Most of those who reviewed this article were pessimistic that there could be much if any interest generated in this subject. We were told that "the industrial age is past, we're now in the information age," and that "you're trying to make the case for a return to the `arsenal of democracy' when all future wars will be `come as you are wars.'" Others contended that the ongoing globalization of the base has and will continue to produce such fundamental changes that the DTIB we now know will cease to exist and that interventions to stem the tide of change are futile.

1. See Jim Courter, L. Steve Davis, and Loren B. Thompson, "US Military Ammunition Policy: Reliving the Mistakes of the Past?" *Parameters*, 24 (Autumn 1994), 98-110.

2. US Congress, Office of Technology Assessment (OTA), *Building Future Security: Strategies for Restructuring the Defense Technology and Industrial Base*, OTA-ISC-530 (Washington: GPO, June 1992), p. 85.

3. Over 8000 M1A1/M1A2 tanks ($2.5 million each) and some 6000 M2/3 armored personnel carrier ($1.4 million each) were purchased by US forces between 1977 and 1996. Prices are in 1993 dollars.

4. US Congress, OTA, 1992, p. 159.

5. Ibid., p. 190.

6. Jack P. Janetatos, personal communications, 1995.

7. US Congress, OTA, 1992, p. 163.

8. Nine 46,000 dead weight ton, double hull tankers; two chemical tankers; four container ships; four ferries (for Alaska Marine Highway Systems, and Puget Sound)

9. As of spring 1997, the surface ship construction includes 19 destroyers, two aircraft carriers, and some 16 auxiliary sealift and other naval vessels.

10. US Congress, OTA, 1992, p. 50

11. Jay Mandelbaum, "The Global Microelectronics Industry," unpublished paper, Washington, D.C., 1995.

12. In 1991, Public Law 102-190 required DOD to revise its IR&D/B&P regulations to encourage contractors to engage in research and development activities that (1) strengthen the defense industrial and technology base, (2) enhance the nation's industrial competitiveness, (3) promote the critical technologies, (4) support dual-use technologies, and (5) address the IR&D/B&P work. See 102d Congress, House of Representatives, Report 102-311 National Defense Authorization Act for Fiscal Years 1992 and 1993, Conference Report HR 2100, 18 November 1991, pp. 127-29, 567-69.

13. This in particular is the case because the R&D activities selected by the defense contractors have been, since early 1990s, increasingly focused on the commercial markets with increasingly shorter time frame. No recent information on this issue is available from any source.

14. Gregory Tassey, *Technology and Economic Growth: Implications for Federal Policy*, NIST Admin 1000 (Gaithersburg, Md.: National Institute for Science and Technology, October 1995).

15. William Perry, "Defense Strategy," US DOD press release, 11 February 1995.

16. Louis Uchitelle, "Arms Makers: Rather Fight than Switch," *The New York Times*, 20 September 1992, p. B-1.

17. Assessing the Potential for Civil-Military Integration," US Congress/OTA, 1994, p. 5. Commercial-military integration has been scrutinized by many, including DOD; non-profit "think tanks"; the Center for Strategic and International Studies, and the Carnegie Commission on Science, Technology, and Government, both in 1991; the US Congress, in 1992; and the congressional Office of Technology Assessment in 1992, 1994, and 1995.

18. Richard H. White et al., *Documentation for Forces Mobilization Model FORCEMOB: Theoretical Foundations*, IDA Paper P-2716, Vol. 1, Washington, D.C., July 1992.

19. Herman Pollock, "International Ratios in Science and Technology--An Informal Commentary on the Past 25 Years," internal document of the Center for International Science and Technology Policy, Washington, D.C., 1990.

20. William J. Clinton and Albert Gore, Jr., *Technology for America's Economic Growth: A New Direction to Build Economic Strength* (Washington: The White House, 22 February 1993).

21. William Perry, "Acquisition Reform: A Mandate for Change," US DOD press release, 24 February 1994.

22. US Department of Defense, *Dual Use Technology: A Defense Strategy for Affordable, Leading-Edge Technology* (Washington: February 1995), p. 30.

23. Tassey, p. 21.

24. Uchitelle.

25. See Ivars Gutmanis, "The Future of the Defense-Related Industrial Base in the United States," *Parameters*, 24 (Summer 1994), 61-76.

26. James S. Thomason, "Assessing Resource Options for National Security Preparedness," *Parameters* 24 (Summer 1994), 59.

27. James S. Thomason et al., *Graduated Mobilization Response Planning for the Department of Defense: Concepts, Responsibilities, and Options*, Institute for Defense Analyses, IDA Paper P-2517, Alexandria, Va., August 1991.

28. General Accounting Office, *Defense Industrial Base Industry's Investment in the Critical Technologies*, GAO/NSIAD-92-4, Washington, D.C., 15 January 1992; General Accounting Office, *Defense Industrial Base: An Overview of an Emerging Issue*, GAO/NSIAD-93-68-2, Washington, D.C., March 1993.

29. The Federal Response Plan (for Public Law 93-288, as amended), establishes the basis for all federal assistance to a state and its local governments affected by a catastrophic or significant disaster or emergency which results in a requirement for federal response assistance. There are 12 Emergency Support Functions (ESF) contained in the FRP: transportation, communications, firefighting, public works and engineering, mass care, resource support, health and medical services, urban search and rescue, hazardous materials, food, energy, and information and planning. The 26 federal departments and agencies tasked to provide response assistance in a disaster or emergency situation will need the full support of the industrial base to meet any requirements that are not stockpiled.

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