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EVALUATING FOREIGN-SOURCE DEPENDENCIES IN THE U.S. ARMY'S M1 ABRAMS TANK

by

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The purpose of this thesis is to inform the acquisition community of the growing concerns related to foreign-source dependencies for parts and components of the United States Army's M1 Tank. The overall extent of foreign-source use in the production and support of the M1 tank are unknown, due to the lack of data. The M1 program management office has little awareness of the extent of foreign-source use in the weapon systems, particularly beyond the prime contractor and their immediate subcontractors. Failing to gain accurate and timely data concerning foreign-source dependencies at the sub-tier levels of production and support of the weapon systems, may present risks to the program. Failing to manage foreign-source dependencies can cause production stoppages in an emergency. Although there are directives and instructions to program managers indicating their responsibilities to monitor foreign-source dependencies within their weapon systems, there is little guidance and resources provided to conduct this task. The foreign-dependency issue was examined from the point of view of the Government, economists, and industry. Interviews of the PM, the prime contractor, and sub-tier producers were conducted. Proposed evaluation methodologies, foreign-dependency, and solutions were reviewed.

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EVALUATING FOREIGN-SOURCE DEPENDENCIES IN THE U.S. ARMY'S M1 ABRAMS TANK

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ABSTRACT

The purpose of this thesis is to inform the acquisition community of the growing concerns related to foreign-source dependencies for parts and components of the United States Army's M1 Tank. The overall extent of foreign-source use in the production and support of the M1 tank are unknown, due to the lack of data. The M1 program management office has little awareness of the extent of foreign-source use in the weapon systems, particularly beyond the prime contractor and their immediate subcontractors. Failing to gain accurate and timely data concerning foreign-source dependencies at the sub-tier levels of production and support of the weapon systems, may present risks to the program. Failing to manage foreign-source dependencies can cause production stoppages in an emergency. Although there are directives and instructions to program managers indicating their responsibilities to monitor foreign-source dependencies within their weapon systems, there is little guidance and resources provided to conduct this task. The foreign-dependency issue was examined from the point of view of the Government, economists, and industry. Interviews of the PM, the prime contractor, and sub-tier producers were conducted. Proposed evaluation methodologies, foreign-dependency, and solutions were reviewed.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to inform the acquisition community of the growing concerns regarding foreign-source dependence for parts and components of the M1 Abrams Tank. Additionally, this thesis investigates the location of the suppliers that support the prime contractor in the production and support of the weapon systems. An analysis is conducted to determine if any of the identified foreign-sources for the weapon systems pose a threat to the continued support and production of the M1 Tank.

B. BACKGROUND

For the last fifty years the United States, as leader and peacekeeper of the world, has evolved a defense industrial base that served to protect not only its own shores but also other areas of the world, most notably Europe. The resulting requirements meant high volume tank production which created a private sector dedicated to the defense business and a public sector comprised of twenty-four military depots to maintain the fleet. [Ref. 1:p. 4]

The Abrams tank assembly line in Lima, Ohio, is the only operational tank factory in the United States. The last tank produced for the U.S. Army was completed March 1993. As a result, General Dynamics Land Systems Inc., the prime contractor for the M1 tank series, is attempting to sustain this factory and their subcontractors through foreign military sales (FMS) and M1A1 tank conversions to M1A2. [Ref. 2:p. 15]

Department of Defense (DoD) officials have stated that during these changing times, domestic manufacturers should seek out suppliers based on factors other than location, such as cost, quality, performance, and delivery time. When these factors are considered, a domestic manufacturer may determine that a foreign supplier provides the greatest benefit. [Ref. 3:p. 2]

If domestic manufacturers continue to select foreign-based suppliers for production of parts and components instead of domestic producers, the contractors and the U.S.

defense agencies accept certain risks to the manufacture and support of their weapon systems.

C. THESIS OBJECTIVES

The objectives of this thesis are to inform the acquisition community regarding the current levels of dependence on foreign-sources that are being utilized in the manufacture and support of the Abrams tank. Also in the conduct of this study, the methods for discovering, monitoring, and measuring the influences of the use of foreign-sources are explored to evaluate their efficiencies.

D. RESEARCH QUESTIONS

1. Primary Research Question

What parts and technologies utilized by the M1A1 Tank are currently being threatened by the increase in globalization of producers?

2. Subsidiary

* What determines if a part or technology is threatened, how is it identified, and who conducts the threat identification?

* What causes a part or technology to become threatened?

* Are current plans to mitigate risk of foreign dependence of M1A1 parts or technologies adequate for the current threat environment as identified by the National Military Strategy.

* How does the current National Military Strategy allow for risk avoidance by utilizing the attributes of reconstitution.

* How is the migration from domestic to globalization of parts production of the M1A1 Tank currently being monitored.

E. SCOPE OF THESIS

The thrust of this thesis is to examine the current threat posed to the United States main battle tank by increased globalization of the defense industrial supply base. This study investigates what plans have been made to monitor the foreign dependence of the weapon systems and if these plans have been adjusted to accommodate the current threat described by the National Military Strategy.

F. METHODOLOGY

The research methodology used in this thesis includes a comprehensive literature review and personal and/or telephonic interviews with appropriate Army project management and readiness agency personnel. The telephonic and personal interviews are used to help define the processes utilized in defining critical parts or technologies and describe current plans for mitigating foreign-source dependency risks.

G. LITERATURE REVIEW

Background and policy information was obtained from the Defense Technical Information Center (DTIC)/Defense Logistics Studies Information Exchange (DLSIE) databases, the National Military Strategy, the National Security Strategy, professional journals, and published studies. Additional information was obtained by corresponding with the Army Material Command, the Office of the Program Executive Officer for Armor Systems Modernization, the Office of the Project Manager for the Abrams tank, the Office of Project Manager for the M1A1 tank, and representatives from both the prime and subcontractors of the M1 series tank. Analyses conducted by the Government Accounting Office (GAO) and other Federal agencies were utilized to determine current and potential risks associated with an increasing globalization of the defense industries.

II. BACKGROUND

This chapter discusses the history of the defense industry and how it has been formed into its present condition. There are several views of the historical perspective of how and why the U.S. defense industry is in its present condition. One fact is present in all theories on this subject; the U.S. defense industry as well as U.S. economy are both in decline. Through a thorough search of present documentation one theme rings clear as to the number one cause for this decline: consumption has exceeded production in the U.S. by a minimum of 1 trillion dollars from 1980 to 1990. The first annual report to the President and Congress by the Competitiveness Policy Council points out that the United States increased its debt much faster over the last decade than it did to finance World War II. [Ref. 4:p. 13]

> The only way a country can consume more than it produces is to import the difference from abroad. Nations with trade deficits are spending more than their incomes. They must be borrowing from the rest of the world or selling domestic or foreign assets. Conversely, nations with trade surpluses accumulate claims on others or reduce others' claims on them. [Ref. 5:p. 516]

During the 1980s the American trade deficit primarily resulted from the borrowing of funds from abroad by the U.S. Government to pay for its increasing budget deficits. In general, when the Government increases its borrowing, either the private sector must increase its lending, or the country as a whole, must borrow from abroad. For the private sector to lend more, it must save more. During the 1980s, the actual saving rate of the private sector within the U.S. declined. Consequently, the U.S. Government was forced to increase in overall borrowing from abroad and ultimately increasing the trade deficit. [Ref. 5:p. 516]

The trade deficits alone are not inherently "bad." To illustrate, assume that a national firm desires to expand and selects your home town as the location to build a new multi-million dollar manufacturing plant. In order for this firm to build the manufacturing plant, they are required to borrow 30 million dollars. The firm petitions the city for the funds and projects that the plant will pay for itself within 25 years, plus employ several

hundred local workers. The city managers reviewed the firm's proposal and determined that their community would be better off if the firm locates in their city. They determined that the firm will create income-earning assets that will aid in future repayment of any funds loaned to them for its creation, plus bring more wealth into the city. Initially, the firm created a deficit for themselves by consuming more than they produced, the loan of 30 million dollars. But ultimately the firm repaid the city and both entities gained by producing more than they consumed. This is an example of the positive use of a deficit. [Ref. 5:p. 516]

The U.S. trade deficit in the eighties however, reflected increased borrowing for consumption rather than investment. From 1980 through the early 1990s, gross national savings declined from 20% of Gross National Product (GNP) to 16% of GNP, reflecting a growth in the federal deficit (Government dissaving), a decline in state and municipal surpluses, and a fall in private household and business savings. [Ref. 6:p. 201]

Over the same period, the consumption and savings patterns of our major economic rivals, Germany and Japan, have been in many ways the mirror image, with production exceeding consumption by $954 billion, generating trade surpluses of the same magnitude. Their savings rates, meanwhile, have maintained an average of 23% and 32% of GNP, respectively. In the process, Europeans and Japanese have been compensating for some of the decline in American savings by doing it for us, reaching a high in the late 1980s of supplying approximately half of all our domestic investment. [Ref. 6:pp. 202-226]

With the public realization of the growing National deficit, the Congress and current the administration began attempting to reduce U.S. Government consumption. Some believe that the burden of military spending has been the chief cause of America's relative decline. But this argument presumes that if the United States had not spent as much on defense, it would have used the funds saved from defense spending for technological improvements and domestic investment. [Ref. 5:p. 516]

To reinforce the public's perceptions of excessive military spending, Congressional leaders as well as the current administration point to the reduced threat to National

interests throughout the world, as originally portrayed in Les Aspin's report, "The Bottom-Up Review: Forces For A New Era."

> The Cold War is behind us. The Soviet Union is no longer. The threat that drove our defense decision-making for four and a half decades -- that determined our strategy and tactics, our doctrine, the size and shape of our forces the design of our weapons, and the size of our defense budgets -- is gone. [Ref. 7:p. 1]

With the end of the Cold War, the National leadership has been attempting to capitalize on this perceived reduced need for military forces by cutting the Department of Defense's budget and increasing U.S. domestic investment. Economists refer to the transfer of funds from the defense sector to the domestic sector, directly following the successful culmination of a war, as the "peace dividend."

Following World War II, the peace dividend was effectively channeled into capital assets of the manufacturers that supported the war effort. Several leading economists have stipulated that even with a shift of resources away from military spending, the decline in relative economic performance will persist so long as the "peace dividend," itself, is <u>not</u> invested in productive uses. Investments, such as, health care for the elderly or poor, are not classified as productive uses. Productive uses are capital investments, such as investments in plant and equipment. [Ref. 8:pp. 8-9]

The structure of the defense industry is the result of an historical evolution, which in some cases has been going on for several decades. A study of this history indicates significant features, all leading directly to many of the current problems.

1. Extremely cyclical nature of defense procurements.

2. Lack of structural planning, (the mix between Government and privately-owned manufacturing plants).

3. Inadequacy of industrial-preparedness planning.

4. Importance of technology and defense research.

5. High concentration within industrial sectors (Each rapid buildup and rapid sell-off has increased the concentration of the share of the business in a few large firms).

A. ECONOMIC FEATURES OF THE DEFENSE INDUSTRY

Other problems which contribute to the decline in the current defense industrial base:

* At the prime-contractor level
  - unhealthy financial conditions
  - aging plants and equipment
  - excess capacity
  - high cost of weapon systems
* At the lower tiers
  - diminishing number of sources
  - growing foreign dependency
  - development of bottlenecks [Ref. 9:p. 240]

1. Extremely Cyclical Nature of Defense Procurements

Following World War II, the public's perception was that the last great war had been fought. It was perceived that defense production and Government procurements needed to be reduced.

Within five years following the war, 115 billion dollars was granted by the U.S. Government to private industry to assist in a transformation from producing weapons to producing civilian goods. [Ref. 10:p. 8]

This grant represented a true peace dividend which was effectively derived without levying additional taxes or increasing the national deficit. This effective re-capitalization of industry from the peace dividend increased industry capacity by 40 percent. [Ref. 10:p. 8]

With the industrial base being dominated by largely commercial industries at the advent of the Korean War, a controversy arose regarding which industries would accept the defense contracts over commercial interests. The commercial industries were unsure of the extent of the growing American involvement, the perceived duration of the conflict, and the political attitudes of the time. The President signed the Defense Production Act of 1950 which accelerated defense production over commercial needs and provided

guaranteed Government loans for production and modernization of newly-converted defense facilities. [Ref. 10:p. 10]

Following the conclusion of the Korean War, there was another down-turn in Government procurements and a subsequent build-up for the Vietnam Conflict. The periods of large increases in defense expenditures followed by dramatic reductions, led to the breakup of the defense industrial base. Figure 1 graphically illustrates the continued fluctuation in defense funding from the end of World War II to present funding projections.

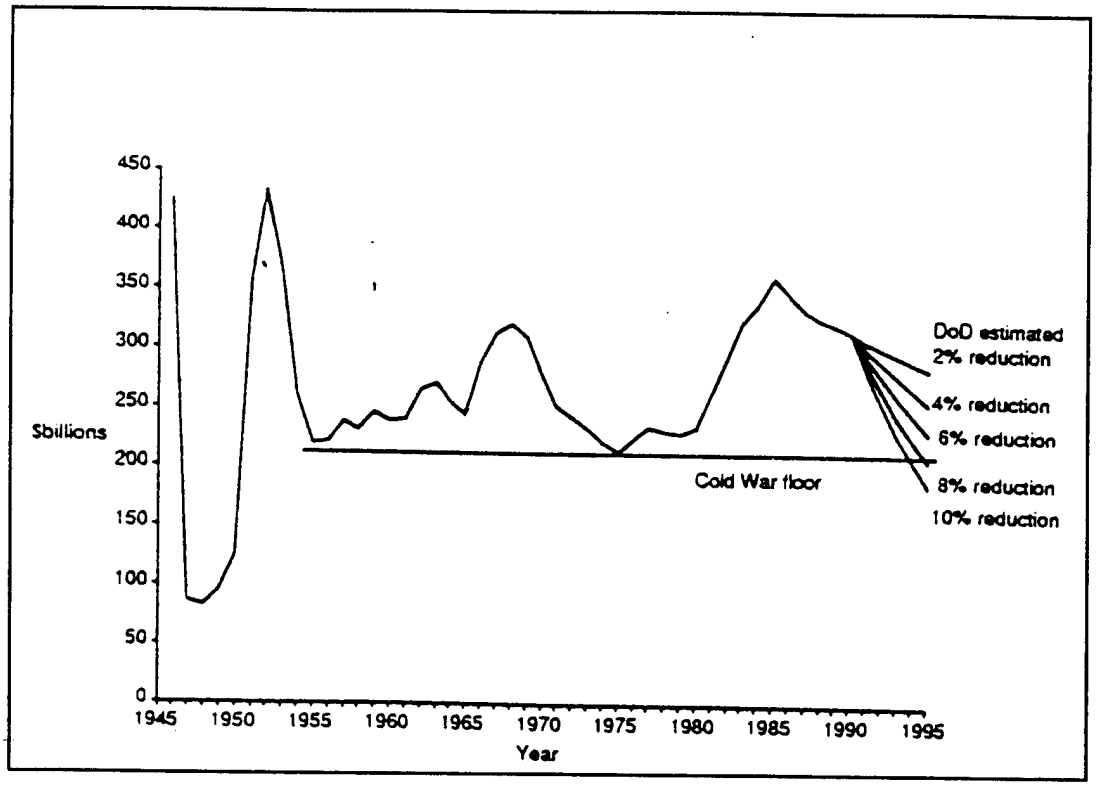


Figure 1. Defense Department Budget Authority, 1946-95--Estimated (In 1991 constant $ billon) [Ref. 10:p. 11]

2. The Lack of Structural Planning

The structure of the defense industrial base is made up of three principle levels; the material level, the subcontractor level, and the prime contractor level. [Ref. 9:p. 241]

The material level is composed of firms which provide raw materials, parts, and sub-components for the next higher level of the manufacturing. Some of these firms are small and concentrate their efforts in providing only one part or sub-component for a specific weapon systems. [Ref. 9:p. 241]

The next level in the defense industrial structure is the subcontractor. Generally, the subcontractor receives and combines parts and materials from the material producer level and provides components for the prime contractor's manufacturing operations. [Ref. 9:p. 241]

The final level within the defense industrial structure is the prime contractor. The prime contractor usually retains a contractual obligation to the military service for production and delivery of the particular weapon systems. The prime contractor generally receives components from the subcontractors and assembles them to produce the final product, the weapon systems. [Ref. 11:p. 22-3]

The lack of structural planning within the defense industrial base indicates that there is no definitive plan for which, if any, of these levels within the industrial base should be occupied by a Government financed production firm. The DoD has not constructed a structural framework to produce or sustain the weapon systems for the defense of our nation. The following describes some of the hazards inherent within DoD's current acquisition system stemming from the lack of a Government structural planning. For example, the military service provides the defense industry with a requirements document, in the form of a request for proposal (RFP), which outlines a specific need for the development of a particular weapon systems. Once the prime contractor receives this information they develop a preliminary plan for the production of the weapon. [Ref. 11:p. 4-3]

To ensure their success, the prime contractors seek collaboration for production of the system from their known subcontractors. It is through these collaborative efforts that the production and support structure will be formed for a particular weapon systems. [Ref. 1]

It is primarily the prime contractor who searches the U.S. defense industrial base for vendors who are willing and capable of producing specific materials and components

which make-up the total weapon systems. The military service has never established a structural plan for identifying the material producers and subcontractors. This has provided them an opportunity to use subcontractors to develop their own structure. The prime contractor may form a structure of multiple subcontractors who produce and assemble over 50% of the system. [Ref. 9:p. 258]

Using subcontractors in this manner allows for possible reduced governmental oversight.

> Just as the Government has issued standard clauses for all its prime contractors, so too, most of these prime contractors will, in turn, issue their own standard subcontract clauses. But, since there are multiple prime contractors, there are variations in their terms and conditions, depending on the specific desires and interests of the prime contractor who issued them.
>
> [T]the Government contract clauses which are mandatorily required to "flow-down" to a subcontractor sometimes need not be passed down verbatim. Therefore, a prime contractor could propose modified mandatory flow-down clauses which secure more or varying rights for the prime (perhaps at the subcontractor's expense) as long as the minimum governmental requirements remain in effect. The Contracting Officer will normally not be concerned about the clauses that a prime contractor attempts to impose on his subcontractor.... [Ref. 11:p. 22-3]

The Federal Acquisition Regulation (FAR) contains a uniform set of procurement regulations which govern all governmental contracting. Most subcontractors and material producers are not responsible for reporting to any military service agency. It is the prime contractor who is selected by the service to develop and produce on schedule a product for the particular military service. It is the prime contractor who selects the subcontractor and material producers and it is their responsibility to develop an adequate supporting structure.

In defense of the military services, it must be noted that throughout the acquisition cycle of a particular weapon systems, a great deal of planning and program review is conducted by governmental officials to ensure that the Government gets a quality system at the best possible price. Also, during the initial phases of a major weapons system's development, a defense industrial base analysis is conducted to determine if the

capabilities are present within the industry to produce the system. Plus, during the early phases of competitive development and production, the contracting military service is knowledgeable of the majority of the contributors to the system's production.

While questioning program managers of presently existing mature weapon systems, concerning the locations and possible impacts of their subcontractors and material producers, none expressed any knowledge of their status. And, none of the program managers questioned had any present knowledge of the solvency or national origin of the subcontractors or material producers. [Refs. 12 and 13]

The basic economic laws of supply and demand also effect the defense industry. If the Government chooses to purchase fewer weapon systems, there will be fewer subcontractors and material producers. As the defense budgets continue to decrease, the defense industrial base will also proportionally decrease. [Ref. 9:p. 261]

When a large defense prime contractors begin to feel the pinch of dwindling defense acquisition dollars, they notify the Government or governmental military Service directly. In an interview with the public relations representative of General Dynamics Land Systems (GDLS), he revealed that he and his associates held a conference in Washington D.C. to discuss future funding for tank production. He stated that current yearly production of 120 U.S. produced tanks and the production of 120 tanks for foreign military sales (FMS) would sustain the current industrial base, anything less would force 32% of their key suppliers to leave the market and a dramatic increase in production costs. When asked why GDLS conducted the meeting in Washington, D.C., he replied that the decisions are made in Washington and we wanted to inform the decision makers of possible problems in the continued production and support of the M1A1/M1A2 series tank. [Ref. 1]

When subcontractors or material producers feel the pinch of reduced acquisition dollars, they notify the prime contractor. Within the tank industrial base, GDLS monitors the solvency and location of the subcontractors and material producers. At the prime contractor level, it is GDLS who determines when to consider a product critical. According to GDLS, when they discover that one of their critical producers is beginning to encounter insolvency problems, they send representatives to the subcontractors location

to assist them in overcoming their obstacles. If the subcontractor or material producer cannot overcome their problems, GDLS finds a substitute or replacement producer. Very seldom in this rehabilitative/replacement process is it required for GDLS to notify or request permission from the Government to take action. [Ref. 1]

If the changes in the sub-tier producers are one tier away from the prime contractor, such as below the subcontractor level, the Government has little or no visibility in their replacement or substitution. The subcontractor may scour the world for the best deal in providing a replacement without Government restrictions such as The Buy American Act, or other governmental provisions contained within prime contractor's contractual obligations.

Because of the lack of structural planning from the Government within the defense industry, the services have reduced control and decreased visibility of who is producing what for a particular weapons system. Reduced funding of the military budget may unknowingly force a highly specialized U.S. material producer out of business, only to be replaced by their foreign based competition. Because of the lack of present structural planning, the military services must place tremendous trust and confidence on the capabilities of the prime contractor to provide an uninterrupted supply and support for the Nation's weapon systems.

3. Inadequacy of Industrial-Preparedness Planning

Historically, when conflicts developed, there had been an absence of peacetime planning to adequately confront the crises. [Ref. 9:p. 241]

a. World War II

Prior to World War II, the U.S. possessed an abundance of raw materials plus an extensive industrial infrastructure. [Ref. 15:p. 11] At the outbreak of war, the Army was composed of 200,000 men and 1800 planes. Many of the planes were considered obsolete. [Ref. 16:p. 49] Public support for the war activities were positive and contributed dramatically to the successful conversion of industries from the civilian to defense production. As a result, the defense industrial base produced prodigious amounts of weapon systems to be employed in the war effort. In one month, March 1944, the defense firms produced 9,114 military aircraft. [Ref. 10:p. 8]

Prior to 1940, the average rate of industrial output increase was 4 percent per year, whereas, during the period of 1940 - 1944 it was 300 percent. [Ref. 16:p. 65] Prior to 1940, production of a merchant vessel required thirty-five weeks. By 1943 the production time diminished to seven weeks. [Ref. 16:p. 186]

Reviewing the above information suggests that the U.S. was not prepared for war production at the outset of hostilities in WW II, but made a successful transformation within adequate time to successfully resolve the crisis. There were several factors that made this transformation possible which pertain to this thesis. First, prior to the mobilization for WW II, the U.S. was in support of its allies' war effort in Europe and was moving towards partial mobilization. Second, in 1941 the U.S. did not accept or require foreign support for weapon systems.

b. The Vietnam Conflict

In contrast to World War II, the Vietnam Conflict appears totally different. During World War II the Nation mobilized its efforts in support of the war effort. During the Vietnam Conflict, the Nation did not undergo complete mobilization. Public opinion did not fully support the war effort and manufacturers displayed reluctance to convert their profitable civilian manufacturing plants to defense production. The manufacturers' reasoning was that their plants were currently operating at close to full capacity and the defense contracts were insufficient in quantity to justify their conversion to military production. [Ref. 17:p. 186]

The defense industrial base prior to Vietnam, exhibited a shortage of suppliers. The ball bearing industry is representative of the industrial base supplier groups. During this period there were three domestic ball bearing producers. The following quote from a Joint Logistics Review Board demonstrates the severity of the condition of the ball bearing industry during the first years of the Vietnam War.

> ...of these, [ball bearing industries], one just became sales agent for a Japanese manufacturer, one is operating at a loss, and one is vacating the market through diversification. Continuing this trend, U.S. aircraft and missiles will soon become dependent on factories that are located on foreign soil and are not necessarily dependable in the event of hostilities. [Ref.17:p. 120]

Unlike WW II, the Vietnam Conflict did not obtain a high level of support from the existing administration or industry. During Vietnam, the military procurements had to compete with private consumption. The following is testimony given by General (Ret) Miley of the Army Material Command before the House Armed Services Committee concerning military procurements during the Vietnam War:

> In the Vietnam War, planning agreements with planned producers were not exercised. In most cases competitive solicitations were issued and contracts negotiated and awarded before production was initiated. Since solicitations were not limited to planned producers, except in a few instances, contracts were awarded on the basis of price to firms which were not qualified, in many cases, by experience or capacity to produce. As a result, long production delays were experienced. [Ref. 19:p. 423]

Reviewing the preparations for World War II and the Vietnam War indicates a trend. When there is considerable positive public support and national unity in favor of the war effort, the U.S. industrial base has been willing to expeditiously convert from civilian commercial production to production of military equipment. But during times of limited involvement, such as the Vietnam Conflict, the U.S. industrial base has displayed a measured response in their conversion from civilian production to military production. Examining both situations, WWII and the Vietnam Conflict, it appears that the greater the public support for a war effort, the more freely firms within the industrial base convert to military production. But, during limited U.S. involvement, private industries must receive increased incentives to convert their production efforts or remain in production of military equipment.

4. Importance of Technology and Defense Research

Technology development and defense research are expensive and time-consuming. Prior to World War II, Research and development (R&D) expenditures for both industry and Government were approximately $1 billion per year. However, in the 40 years after the end of World War II, investment in R&D grew to almost $100 billion per year. Approximately half of this R&D is Government-sponsored. By 1985, the DoD alone was spending over $30 billion per year for R&D on defense systems. [Ref. 20:p. 215]

> In 1984 total federal R&D expenditures were $44.2 billion, of which $29.3 billion went for national defense (66%). [for comparison] The next largest item was $4.8 billion for health, followed by $2.6 billion for energy and $2.3 billion for space.... This represented a dramatic buildup in defense R&D, from $13.6 billion in FY 1980 to $31.3 billion in FY 1985. [Ref. 20: p. 374]

The current trend of R&D spending for the military is revealed in the Draft 1994 National Military Strategy. The below mentioned excerpts from the Draft 1994 National Military Strategy, are presented to highlight that DoD intends to continue a trend of technological advances in future weapon's procurement.

> We intend to remain the best equipped force in the world. Modernization programs preserve the essential combat edge that U.S. forces now possess.... We intend to continue our programs to improve sensor-to-shooter links using the most modern technologies.... Major programs involving significant investment are being undertaken.... Add-on modernization of existing platforms will be continued to take advantage of rapid technological change. [Ref. 21:pp. 13, 16]

In direct opposition to the National Military Strategy is The Military Reform Group. This is an organization that opposes continued investment for technological force advancements. This group's strategy in providing weapons for the defense of the Nation is not to continue research and development (R&D) and technical improvement of the current systems, but to provide more of what the military is currently using. This group believes in greater numbers and less technological advancement. [Ref. 21: p. 13]

Following the logic of the Military Reform Group, it seems unusual that the military would abandon weapon systems which are finally made to work and invest billions into experimental research. By investing a large portion of the DoD budget into R&D and the use of advanced technology to achieve maximum performance in each weapon, it has encouraged industrial management to focus its attention on new systems under development, rather than on those in current production or already deployed. [Ref. 22:pp. 225-260]

The advocates of quantity note that in World War II the United States "never had a tank that was good as a German tank, but we had lots more." [Ref. 20:p. 42] The advocates of quality argue that there is no way that the U.S. can catch up with the

overwhelming quantities of the Soviet equipment so "we must make one of ours better than three of theirs." [Ref. 20:p. 42] These views indicate the beginning of our current National Security Strategy.

Hence, the National Security Strategy as well an the National Military Strategy both encourage technological improvement. It has been documented that DoD allocates funds for continuous product improvement. In a previous section within this thesis it was noted, that current program managers of developing systems commonly know the majority of contributors for the production of their systems. Within the current acquisition cycle, the majority of governmental documentation and systems review revolve around the product conception, the initial development, and the initial production. It is this dedication to advancing systems which allows for less emphasis to be placed on existing systems. Once the weapon systems are in full production or when production is completed, the Government's visibility of the material producers and supporting subcontractors begins to become limited. [Ref. 28]

There are faults with following either The Military Reform Group's or the National Military Strategy's ideals to an extreme. Following the strategy of The Military Reform Group, the program manager's main mission would be to insure production and support of existing weapon systems. While this would provide for adequate support and increased visibility of the production at all levels within the defense industrial base, it would not hasten the advancement of life saving, technologically advanced weapon systems. Weapons such as the Patriot, which was very instrumental in protecting the lives of American service men during the Persian Gulf War, would have not been developed if we strictly adhered to the Military Reform Group's strategy. But if DoD continues to spend proportionally more resources towards weapon systems innovation with a decreasing defense budget, sustainment of present systems will receive proportionally less attention.

But the ever increasing complexities in producing highly technical weapon systems requires highly specialized producers. As demonstrated in the support of the weapon systems during the Vietnam Conflict, many of the systems that needed support required experienced and qualified producers. The extent of qualifications, required for production, increases the number and time of production delays. It appears that the more complex

a production process is, the longer it will take to manufacture production equipment, train employees in the operation of that equipment, and ultimately get the weapon systems in the hands of the soldiers. [Ref. 9:p. 264]

In the future, because of continued DoD budget reductions, it will not be possible to provide the same level of financial provisions for either R&D or support for current weapon systems. Decision makers must make a choice as to which to adequately fund, either current weapons or R&D. This thesis contends that the present leadership is primarily focused on the development and production of technologically advanced weapon systems and not on the continued support of present weapon systems. And because of the current leadership's position, they have dangerously neglected to monitor who is providing the support for the United States Army's main battle tank and make determinations if the support for this weapon systems will be adequate in a time of crisis.

5. The High Concentration Within Industrial Sector

The rapid expansion of defense industries at the beginning of hostilities and the rapid liquidation of these industries following the end of a war has increased the concentration of the share of the business in a few large firms.

> During World War II, $26 billion was invested in new plants and equipment.... The lion's share went to the large firms. Thus, when the war ended and these facilities were sold [by the Government to large prime contractors] (at attractive prices), it was not surprising that 250 of the nation's largest firms acquired more than 70% of the plants sold. [Ref. 20:p. 379]

The defense industry also is concentrated into the top 100 firms conducting 75 percent of the business. This ratio has been in effect since the late 1950s. These industries become extremely concentrated when they specialize in providing the specific weapon systems, such as a tank or missile. [Ref. 20:p. 245]

Combined with specialization, the defense industry results in high levels of concentration because of the sporadic buying habits of DoD. Historically, DoD procures a new weapon systems of a certain type once every 10 to 15 years. The procurement contract for the new system usually goes to one prime contractor, which results in higher concentration ratios for selected weapon areas than are found in the typical commercial

sectors. The following is a list of percentages of business conducted in the military market by the top four firms:

surveillance satellites	100%
nuclear submarines	99%
space boosters	97%
fighter aircraft	97%
attack aircraft	97%
missile inertial guidance systems	97%
aircraft inertial navigation systems	96%
missile reentry vehicles	95%
aircraft fire-control systems	95%
helicopters	93%
jet aircraft engines	93%

[Ref. 9:p. 246]

Adding to the problem of concentration, is the growing concern about the viability of the large defense firms in a shrinking defense market. During the 1970s and early 1980s, it was identified that the defense industry was moving into decline. Numerous studies indicated that the contractors' investment in new manufacturing equipment and technologies were only about half the rate of comparable commercial firms. In 1977 and again in 1987, the Government shifted to a new profit policy that allowed higher profits for those firms that made capital investments. A follow-up study conducted by the Air Force determined that while defense industry profits had increased, their level of capital investment remained minimal. [Ref. 9:p. 251]

6. Problems at the Subcontractor Levels

The defense industry is basically a dual economy, with an upper level [the large defense contractors] and a lower level [the subcontractors and part suppliers]. The two levels differ in many respects. The large defense contractors or prime contractors conduct business directly with Government representatives. The subcontractors deal primarily with the requests placed by prime contractors. The majority of regulations passed down from

Congress directly effect the prime contractors and may be passed down to the subcontractors through contractual requirements. [Ref. 9:p. 257]

Typically, between 40 and 60 percent of the dollar value of a weapon systems is subcontracted by the prime contractor to smaller firms or parts producers. Small inventor-lead firms have made many of the qualitative breakthroughs in military technology. Historically, DoD has not been overly concerned about the dependence on subcontractor innovation and technology but, has primarily depended on the prime contractor to ensure continued product viability. Governmental and prime contractor's concerns have been realized through the drastic reduction in subcontractors, from 6000 to 300 in the aerospace industry alone. [Ref. 9:p. 258]

Through the reduction in the number of suppliers, many of the remaining suppliers are now operating at or near full capacity. Thus, an increase in demand due to a defe[illegible] build-up or crisis could cause substantial backlogs and bottlenecks within the system. The following is an example of what may happen in the future if we depend heavily on a prime contractor's ability to project and provide surge capabilities.

> In 1974 Congress authorized a doubling of tank production to replace the tanks the U.S. had given to Israel, which had lost almost all its tanks in the 1973 war. The sole plant producing the M-60 tank had a large amount of excess capacity and had assured the Army that increasing the production of tanks rapidly, should it ever be required, would not be difficult. However, over a period of years the Army had gradually forced the reduction of armor-casting subcontract firms to a single source (due to the reduced quantities of M-60s procured in the post-Vietnam era), and that plant was operating at close to full capacity. Thus, when the orders doubled, all the casting supplier could do was try harder. Costs increased significantly, and it was a long time before the armor castings, and eventually the tanks, could be produced in increased quantities. Unfortunately, this is a typical case. Surge capability (including extra capital equipment) was built in at the prime-contractor level, but at the lower level there was neither sufficient capacity nor competition. Thus, both the benefits of peacetime competitive efficiencies and benefits of wartime surge capability were totally lost. Perhaps most surprising, the DoD had failed to notice the problem. [Ref. 9:p. 259]

Few suppliers remain in the lower tiers of the defense industry and they are highly specialized. The specialization of the firms in defense subcontracting means that DoD

loses the economies of scale that could be realized by combining defense and non-defense production.

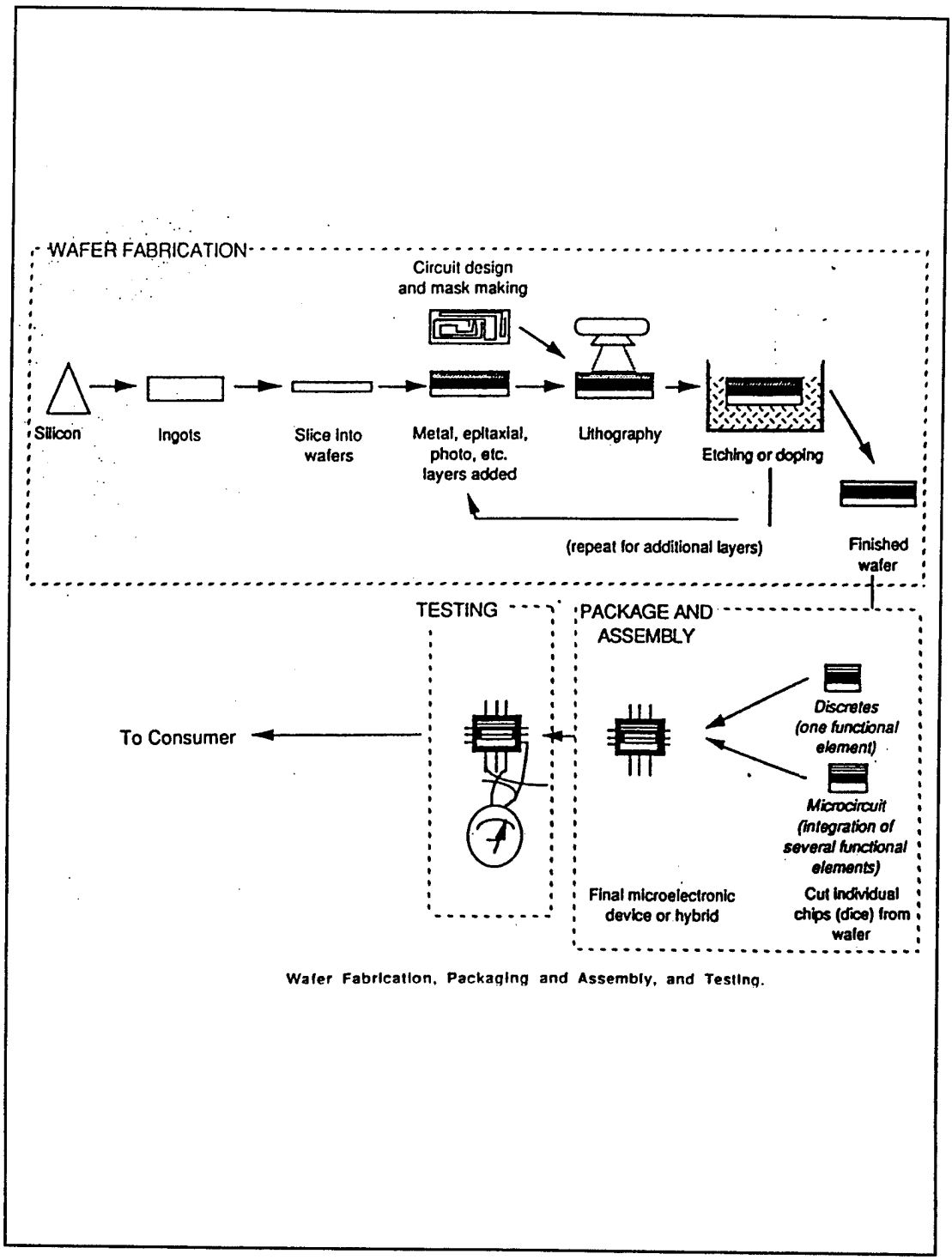
Along with specialization comes foreign support for niche markets not currently occupied by U.S. producers. Recent studies indicate several markets that are crucial to the production and support of the military's latest sophisticated weaponry are supported by offshore subcontractors. Four key technological areas exhibit a trend toward exclusive offshore suppliers. These trends raise concerns about circumstances in which the U.S. might become vulnerable.

> Individual system studies found such trends in: micro-electronic device production, including packaging, assembly, and fabrication of both discrete and microcircuits; advanced materials, including ceramic packaging and gallium arsenide; production equipment, including machine tools and lithography equipment; and flat panel display technology. [Ref. 14:p. 9]

To put these dependencies into perspective, studies indicate that the majority of today's modern weapon systems require at least one of the above four key technologies. Of the four dependencies listed, three of them relate directly to two types of devices: discrete devices and integrated circuits (IC). A discrete device is an electrical component, such as a resistor or transistor, which performs a single independent function. The IC, however, is an electrical network, active or passive, composed of two or more circuit elements interconnected to perform an electronic circuit function. [Ref. 14:p. B-II-17]

Integrated circuits and discrete devices have become critical to military applications. Semiconductors are the brains of the U.S. high technology weaponry. Electronic components enhance a system's capability and allow the U.S. to maintain significant technological superiority and a credible conventional deterrent over our adversaries.

Figure 2 displays the process for production of discrete and microcircuits. In reviewing the process, note the lithography function. This function is an integral part of the manufacturing process. During this phase the circuit is projected on to the surface of a micro-thin slice of silicon. To obtain reliability and quality, the process must be uniform to exacting standards. Cannon and Nikon, both Japanese companies, are the largest producers of this type of equipment. Nikon alone produces 500 units per year,



Wafer Fabrication, Packaging and Assembly, and Testing.

Figure 2. Wafer Fabrication, Packaging and Assembly, and Testing [Ref. 14:p. B-II-16]

whereas, the largest U.S. producer, General Signal, produces 60 units. An Institute for Defense Analyses (IDA) study concluded:

> The international market for lithography is at a critical threshold. While Japanese industry is pursuing actively both optical and X-ray approaches using research consortia and guided by a national goal, U.S. lithography equipment companies are struggling to stay in business. Failure to meet this challenge would be substantial disadvantage for U.S lithography equipment suppliers and semiconductor manufacturers. [Ref. 14:p. B-II-20]

In 1989, the then Defense Advanced Research Projects Agency (DARPA) recommended that the IDA investigate Aircraft Radar: the APG-66 and APG-68. These radars are used in all U.S. and most foreign F-16s. These radars are considered among the most successful fire control radars in the world. DARPA recommended that IDA investigate these radars to determine the extent of U.S. foreign-source dependence in their production. DARPA also wanted IDA to use these radars because they believed that they would be representative of the microelectronic technologies used in the majority of contemporary weapons. [Ref. 14:p. 4] Figure 3 indicates their findings and the location of the microelectronic producers.

Of the key technological areas that exhibit a trend toward exclusive offshore suppliers, the fourth is machine tools. Machine tools are required to cut metal to a prescribed specification. High quality machine tools hold better tolerances and offer greater manufacturing repeatability. Repeatability assists greatly in predicting and sustaining reliability. Military personnel depend heavily on the reliability of their equipment. [Ref. 14:p. B-IV-14]

According to the engineering staffs at leading U.S. heavy equipment manufacturing firms, foreign suppliers now dominate the U.S. market for high-end machine tools. U.S. companies remaining in business to produce machine tools are heavily dependent on foreign-sources for technology and parts. They can no longer procure from a domestic source the microcircuits and dynamic random access memories (DRAMs) that go into the machine controllers. [Ref. 14:p. B-IV-14]

		Lead Frame		
		APG-66	APG-68	APG-68 (new)*
883 on shore	(%)	86	80	68
883 off shore	(%)	14	20	32
38,510 on shore	(%)	99	81	70
38,510 off shore	(%)	1	19	30

		Ceramic Base		
		APG-66	APG-68	APG-68 (new)*
883 on shore	(%)	0	0	0
883 off shore	(%)	100	100	100
38,510 on shore	(%)	2	1	1
38,510 off shore	(%)	98	99	99

		Cover		
		APG-66	APG-68	APG-68 (new)*
883 on shore	(%)	5	8	9
883 off shore	(%)	95	92	91
38,510 on shore	(%)	5	17	26
38,510 off shore	(%)	95	83	74

* Parts in the new configuration APG-68 and not used in the APG-66.

Figure 3. Sources of Packaging/Assembly Materials [Ref. 14:B-II-24]

B. SUMMARY

In summary, this chapter identified five features of the defense industrial base which could cause problems of weapon systems production and support. First, the cyclical nature of defense procurements, where the U.S. Government increases procurements during war time mobilization followed by drastically reducing procurements during peace time. It was shown that the large defense contractors withstand these fluctuations better than the supporting subcontractors and material producers. It is during the down-turn in defense procurements that many small and less prepared firms leave the defense business in pursuit of a more stable and profitable sector of the economy. Second, the lack of structural planning, [the mix between Government and privately-owned producers] is not determined or considered during the systems acquisition process.

These two factors constitute a major dysfunction within the systems acquisition process. Because of these two factors, firms which support the weapons acquisition process, enter into National support only for the duration of the war effort when participation is mandatory. Then following the conclusion of the crisis, when production quantities and profits are reduced, they leave the defense sector.

During periods of limited involvement, such as operations other than war, it is not mandatory for firms to participate in the production of weapon systems. Also, during these same periods of limited involvement and reduced defense procurements, it may not always be profitable to produce small amounts of specialized weapon systems, so production firms may choose to leave the defense sector in pursuit of a more profitable sector of the economy. Because of these two factors alone, it is apparent that DoD must monitor the viability and production capabilities of the firms that support the structural foundation for defense weapon systems production.

Third, it was demonstrated that in 1973 the production capabilities of the support base were inadequate to support a minor surge in production capabilities for the production of M60 tanks. DoD had provided surge capabilities within the production plant for the M60 tank, but had failed to ensure that the subcontractor and material producer support was adequate. It is this thesis' contention that if the present tank industrial base was called upon, to produce similar numbers of tanks, within a limited

time-frame, that the current prime contractor would have the same problems as demonstrated in 1973.

Fourth, because of perseverance of the current leadership in DoD, the majority of our acquisition efforts revolve around the procurement of developing systems. Because of their focus, they fail to monitor the continued globalization of support for current weapon systems within the subcontractor and material producer levels.

Fifth, the high concentration of few producers within the defense industrial sector limits competition and places increased power within the hands of few capable prime contractors. When the subcontractors and material producers begin to leave the defense industrial base, because of lack of structural planning and the cyclical nature of defense procurements, it is the powerful prime contractor who negotiates and provides DoD with a viable substitute producer. Because it is the prime contractor who locates the producers, the knowledge of the location of the actual production of the parts and technologies for the total weapon systems is not always considered by the military service customer. The following chapter will investigate the extent of the knowledge of the military service for production of parts and technologies.

III. ASSESSING THE SIGNIFICANCE OF FOREIGN DEPENDENCE

This chapter identifies how and DoD monitors foreign-source dependence. This chapter reviews and evaluates the most current studies of the U.S. military's foreign dependence of parts and technologies. A review of these studies will assist in determining the methodology and completeness of current DoD attempts to detect and monitor the present foreign dependence of the U.S. military. These studies also are utilized by the author to provide criteria for defining what is considered to be foreign-source of production, how to determine foreign dependency, and how parts and technologies are defined to be critical for the continued support of U.S. military weapon systems.

The DoD Directive 5000.1, Major and Non-major Defense Acquisition Programs, and DoD Instruction 5000.2, Defense Acquisition Program Procedures serve as an instruction guide for program managers. The directive and instruction require program managers to analyze the capability of the U.S. industrial base to meet production requirements for weapon systems, including surge and mobilization requirements. These documents also require an assessment of the capabilities of the U.S. defense industrial base to include consideration of foreign-sourcing and dependency. [Ref. 23:p. 5-E-2]

A recent General Accounting Office (GAO) report indicates that, although there are directives and instructions to program managers indicating their responsibilities to monitor the supportability of their programs, there is little or no specific guidance on how to accomplish this task. The GAO report also expressed concern about whether program managers, without assistance, could effectively assess the capabilities of the U.S. defense industrial base, including the risks inherent in foreign-sourcing, to produce their weapon systems. [Ref. 24: pp. 24, 25]

The following definitions were formulated through the use of the studies contained within this chapter. They are presented here to assist in the understanding of those studies.

Critical: A part or technology is defined as critical if its absence does not allow the weapon systems to perform its intended mission.

Foreign: The term "foreign" corresponds to production facilities located out-side of the continental borders of the United States.

Foreign Dependence: Foreign dependence or foreign-source dependence occurs when there is a limited number of producers and the majority of them reside outside of the continental borders of the U.S.

Risk: This thesis contends that if 100% of all assets required for production and sustainment of all weapon systems for the defense of the National interests is not produced within the U.S. continental boundaries, that U.S. interests, as well as DoD interests, except some level of risk. Assessing whether the U.S. dependence on a foreign-source for a particular military item entails a substantial national security risk requires answering two questions. First, how critical is the item to various national security needs? And second, how great is the likelihood that the U.S. will not have access to the item or technology when needed?

To narrow the set of DoD purchases and militarily relevant technologies to a group most likely to entail unacceptable risk, a measure or screen can be used. Screening for criticality to the defense mission is the first step in identifying potential risks.

Concerned that DoD has not established criteria for determining acceptable levels of dependence of foreign-sources, the GAO requested their National Security and International Affairs Division review and submit a proposed framework for evaluating the national security risks associated with the purchasing of military products and technologies from foreign-sources. [Ref. 24:p. 1]

Table 1 shows the risk factors identified by GAO's internal National Security and International Affairs Division. The factors are listed in four categories; the first one relates primarily to criticality and the next three relate primarily to lost access of the item or technology.

Criticality

- The importance of the item or technology to the specific weapon systems and the overall defense mission.

- Stockpiling potential, the ability to stockpile adequate amounts of product.

- Technical substitution possibilities -- the existence of feasible technical substitutes or the ability to develop them in an acceptable time frame.

- Linkages to other goods, industries, or technologies in terms of industrial or technological spill-overs from domestic production that could affect the nation's ability to compete in other important areas.

- In the case of technologically sophisticated goods, the degree to which the technology is considered mature as opposed to fast moving.

Disruption

- Distance from source, in terms of required shipping time.

- Location of engineering and manufacturing facilities, if different from assembly and shipping facilities.

- Transportation exposure.

- Risk of natural disturbances interrupting supply.

- Political stability of supplying country or region, including political and diplomatic ties to the United States.

- The Country's economic stability in terms of foreign debt, exchange rate control, labor strife, or other factors.

- Trade stability -- potential for the supplier's own supply from another country to be interrupted.

- Country's internal business environment, such as the nature of the regulatory environment.

- Supplying firm's economic stability.

Availability of alternative supply sources

- Supply concentration-the extent to which a few sources worldwide control the production of goods or distribution of technology.

- Dual-use options, or potential availability of the same or similar goods from a commercial supplier.

- Scale effects on U.S. industry -- the potential negative impact of decreased purchases from U.S. firms.

- The potential for a U.S. industry to be reconstituted if lost.

Adequacy of surge capabilities

- The ability to acquire additional units of goods from an existing supplier during a crisis.

- The timely availability of additional units of goods from other suppliers during a crisis.

Table I. GAO Report on Criticality [Ref. 24:p. 21]

GAO selected a team of experts from industry and Government. This team was chartered to determine methods for defining critical parts and technologies. They were also to present ideas and a possible framework for assessing risks associated with dependence of foreign-source parts and technologies of current military weapon systems. The National Security and International Affairs Division submitted four possible frameworks for DoD adoption. A wire diagram of the framework and a brief description of each process is submitted. Following the description of the proposed processes, a cumulative analysis is submitted to identify their major differences, strengths, and weaknesses.

A. THE ANALYTIC SCIENCE CORPORATION

The Analytic Science Corporation (TASC) is a $295M applied information technology company specializing in the development and integration of advanced information systems and services. Founded in 1966, TASC has over 2,200 employees, and offices in 24 locations in both the United States and the United Kingdom.

TASC is the largest of the parent company Primark's three information services companies, and is the "technology engine" that supports all parts of Primark. TASC has had twenty-eight years of consecutive growth, and is well positioned to capitalize on the revolution in information systems and services that is underway as a result of the emergence of the Information Superhighway, proliferation of multimedia and accelerating changes in computing technology. [Ref. 25]

TASC conducted a study of the foreign vulnerability of critical industries. In this study, they propose measures to distinguish between foreign dependencies that pose little or no threat to national security and those that could have critical impacts on national security.

Definitions:

Foreign-source

TASC defines foreign-source as "the purchase of goods, services, or technologies from outside the United States or Canada." [Ref. 24:p. 23]

TASC states that foreign-sourcing is pervasive and a part of DoD's normal way of doing business and an important way of obtaining the highest quality goods and services for DoD. It may or may not lead to a condition of foreign dependence or vulnerability that requires monitoring or action by DoD.

Foreign Dependency

TASC defines foreign dependency as "a situation where goods and services are purchased from a foreign-source of supply with no adequate alternative source or substitute within the United States or Canada." [Ref. 24:p. 23]

Foreign Vulnerability

TASC defines foreign vulnerability as "a situation where a foreign dependency exists and national security could be threatened by a disruption in supply. In many cases, a few firms in foreign countries can control access to state-of-the-art parts, components, processes, and technologies." [Ref. 24:p. 23]

Initial Screening

The initial screening process suggested by TASC begins with a qualitative analysis of an item's criticality to national security based on a number of considerations. First, a review of historical information compiled by TASC and agencies of DoD. Second, a review of items listed within the Defense Manufacturing Board's Task Force report on critical industries.

TASC's specific factors perceived to contribute to the criticality of an industry or technology include:

> Its ability to be reconstituted once lost; the ease with which the know-how embodied in an industry can be defused; the rate of technological change and research and development expenditures; linkages between one industry and another; spill-over effects in which the loss of one capability would damage or lead to the loss of others; and industry structure, which permits or precludes the entry of alternative suppliers. Additional criticality factors considered included geographical location, various types of liability (e.g., political, financial condition, and diversity of sources), and the ability to stockpile and substitute items. [Ref. 24:p. 24]

Dependence/Vulnerability Assessment

Once criticality has been established, the authors of the TASC study perform a quantitative assessment of the vulnerability based on the Herfindahl-Hirschman Index (HHI), a measure of the number of firms and distribution of market shares among them in a well-defined market. The HHI serves as an indicator for the potential for effective collusive activity on the part of foreign nations to deny the U.S. access to products and services. The HHI for an industry is calculated by summing the squares of the market shares of individual firms in a selected market. Squaring market shares emphasizes the relative power of firms in a market. The TASC study distinguishes firms with an HHI of 1000 or less to be relatively secure and the likelihood of disruption through collusive action is low. On the other hand, a firm with an HHI of over 1800, with no prominent U.S. or Canadian producers, would be considered as vulnerable. A score of 1800 or higher indicates a high concentration of market power and a possibility of collusion by current suppliers and could restrict the potential access by new suppliers.

Once an HHI figure is placed on a firm in a particular market, the authors conduct a statical assessment based on three different measures. First, a geographical index which is calculated by grouping shares by nation of origin. Second, a foreign dependence index is calculated by grouping international producers' shares of the U.S. market. Third, the entry barrier index, which is, derived from international firms' international market shares. These indices measure the U.S. vulnerability to the denial of critical parts by individual foreign nations, the extent of U.S. dependence on foreign nations, and the extent to which production of a commodity is concentrated in only a few firms worldwide.

B. INSTITUTE FOR DEFENSE ANALYSIS

The IDA is a federally funded, independent, nonprofit, research and development center that focuses on national security and defense. It conducts research, systems evaluation, and policy analysis for DoD and other agencies. [Ref. 26:p. 583]

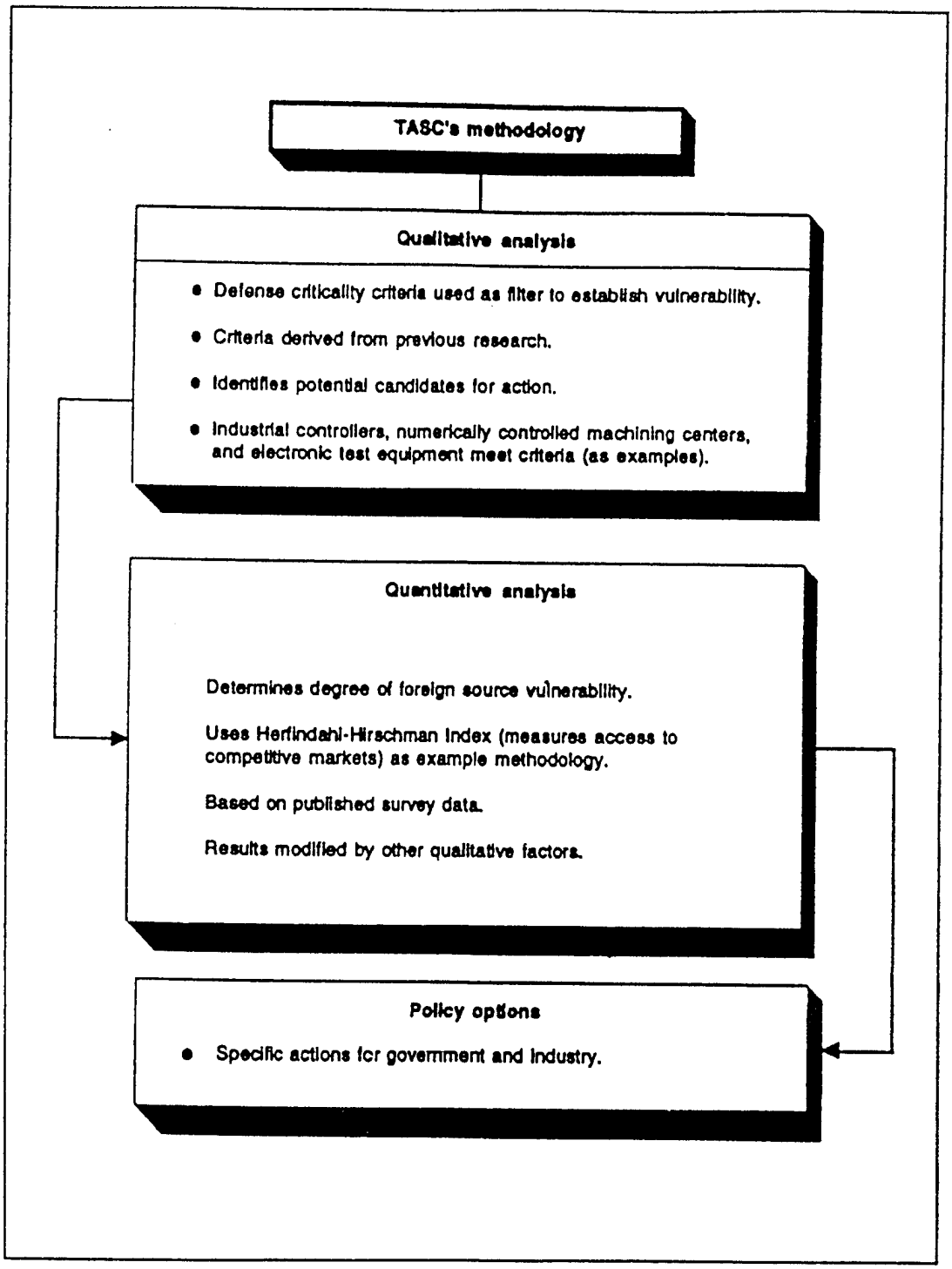


Figure 4. TASC Framework for Assessing Risk of Foreign-sourcing [Ref. 24:p. 22]

Definitions:

Foreign-Source

The IDA study did not use the term foreign-sourcing, but considered any item or technology provided by a firm whose ownership was not U.S. derived as foreign. IDA considered U.S. owned firms whose production plants which resided outside of the continental U.S. borders to retain some level of risk associated with similar firms which were not U.S. owned. IDA also placed limited levels of risk on production facilities contained within the U.S. borders but whose ownership was primarily foreign. The only firms considered not foreign were firms whose production facilities resided within the continental borders of the U.S. and ownership was also primarily domestic.

Foreign Dependency

IDA considered foreign dependence as context-specific, in that a key consideration was the ability of the U.S. to obtain alternative suppliers when necessary.

Initial Screening

The IDA study elicited expert opinions in a systematic manner, usually involving iterative questionnaires administered to individual experts with feedback of results accompanying each iteration of the questionnaire. DARPA also provided IDA a criteria which stressed the selection of systems that would be representative of critical technology areas, cover technology currently used in important defense systems and would play important roles in the future, and included systems procured by different armed services.

Dependence/Vulnerability Assessment

IDA identifies foreign dependency through an investigative process. Initially IDA, through the guidance from DARPA and expert sources, identifies an end product, such as an aircraft, tank, or missile. Then, IDA investigates that system's six product levels (system, subsystem, component, element, material, and raw material) in search of foreign suppliers.

Once a determination is made that a foreign supplier is being used, IDA investigates to determine if any agreements, plans, or alternate sources have been established by the manufacturer. If the manufacturer is using a sole-source foreign

supplier, as defined by IDA, then a level of risk is placed on the manufacture of the system being produced.

Once the foreign-source is identified, IDA works with the system producer to determine the level of influence the foreign supplied product has on the manufactured system's performance. It has been determined that the level of risk and vulnerability associated with that of foreign dependence is directly related to the level of influence exhibited by the foreign product on the total system effectiveness. The greater degree of influence exhibited by the foreign product on the system's performance or effectiveness, the greater the risk and vulnerability to the system.

IDA has formulated twenty-six vulnerability factors to assist them in determining varying degrees of risk. The broad categories of the vulnerability factors are: location, political-military, economic-commercial, supply and technology, procurements and program-control.

The IDA study did not pursue an investigation of the identified alternate suppliers/sources to determine if in fact they could produce the required parts or technologies. By not investigating the alternate suppliers, the conclusions may not be as accurate as portrayed. [Ref. 27:p. 1]

C. NATIONAL DEFENSE UNIVERSITY

The National Defense University (NDU) was established by DoD on January 1976. NDU's mission is to ensure excellence in professional military education and research in essential elements of National security.

The university conducts short and long range studies of National security policy, military strategy, and the allocation and management of resources for national security.

A goal of the university research is to create a National repository of expertise on mobilization, military strategy, and joint or combined policy and plans. [Ref. 26:p. 268]

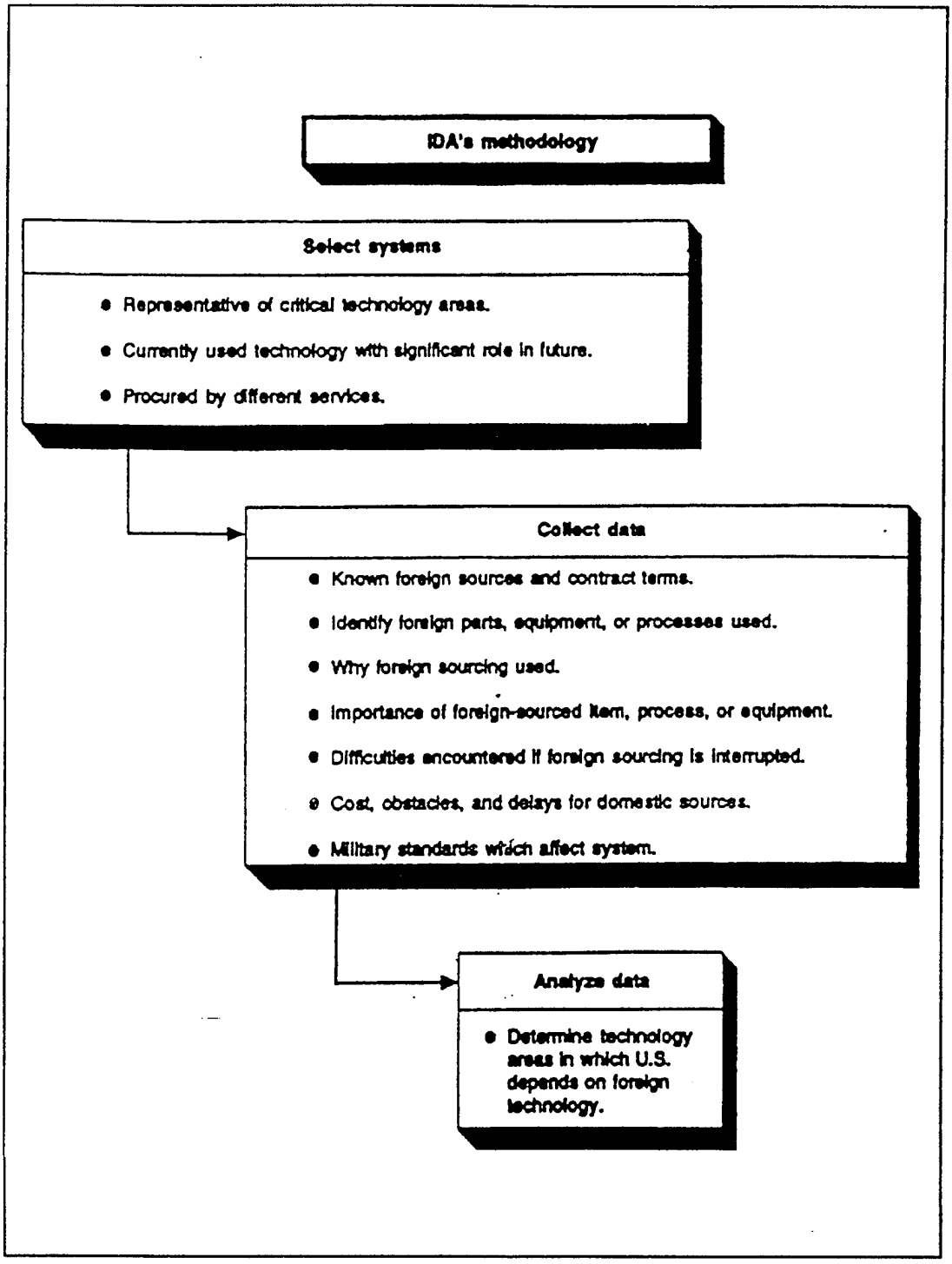


Figure 5. IDA Framework for Assessing Risk of Foreign-sourcing [Ref. 24:p. 29]

Definitions:

Foreign-Source

Any source of supply, manufacture, or technology outside the United States or Canada.

Foreign Dependency

Any source of supply, manufacture, or technology outside the United States or Canada for which there is no immediately available alternative source in the United States or Canada.

Foreign Vulnerability

Any source of supply, manufacture, or technology outside the United States or Canada for which there is no immediately available source and whose lack of reliability and substitutability jeopardizes national security by potentially precluding the production, or significantly reducing the capability of a critical weapon systems. [Ref. 28:p. iv]

Dependence/Vulnerability Assessment

This study examines the circumstances under which a foreign dependency might become a vulnerability. It develops a framework for determining priorities to deal with the foreign vulnerability issue. This study uses case study format indicating areas of foreign dependency which might evolve into a vulnerability for National security. This study states that not everything that is sourced abroad, nor everything that the U.S. may be foreign dependent upon, should be considered as a foreign vulnerability.

This study considers foreign vulnerability as a subset of all items sourced off-shore. The NDU distinguishes foreign dependency from vulnerability, by defining vulnerability as, "those dependencies demanding action." [Ref. 28:p. 3] This study considers three categories of where the U.S. may become vulnerable: surge capability, mobilization capabilities, and the technology base.

> **Surge Vulnerability** is the accelerated production, maintenance, and repair of selected critical items to sustain conflict and/or equip the active force. A surge foreign vulnerability exists when a foreign dependency has a high probability of preventing this rapid increase in the given time-frame by precluding production...thus causing those systems that are fielded to be less effective than required.

Mobilization Vulnerability is related to either full or total mobilization and involves: 1) a period from 12 months to years (the duration of the conflict), and 2) the production of the total range of weapons and supporting systems to conduct a conflict. A vulnerability exists if there is a high probability that the production of key weapons and supporting systems, or a range of systems, will be prevented or slowed, thus jeopardizing the capability of the United States to support its national defense objectives.

Technology Base Vulnerability The United States has periodically expressed concerns over the possibility of a technological surprise by the Soviet Union that would drastically alter the military balance. Thus the technology base vulnerability concern is not over orderliness of the production, but over access to the most advanced technology for development and production of weapons. [Ref. 28:p. 6]

First, the NDU study selected various scenarios, levels of threat, time-urgency, alternatives, and unfilled requests as their criteria for the level of military system production. Second, they prioritized these types of systems required for various scenarios, to determine which systems will be required first. As an example, they selected precision guided missiles as their number one priority followed by ammo, spares, weapon systems platforms, and Strategic Systems.

Following scenario and weapon selections, NDU analyzed the production requirements of their number one selected weapon for a given scenario. They estimated how many of the particular weapon systems would be required to conduct a small conflict, allied support, and U.S. theater conflicts. They calculated the production and support levels required to sustain these operations from historical experience.

Once the production and support levels were determined, they investigated who were the producers and where they were located. They estimated the possibility of disruption in supply for those items produced off-shore during periods of peacetime, theater conventional conflict, theater nuclear conflict, and global conflict.

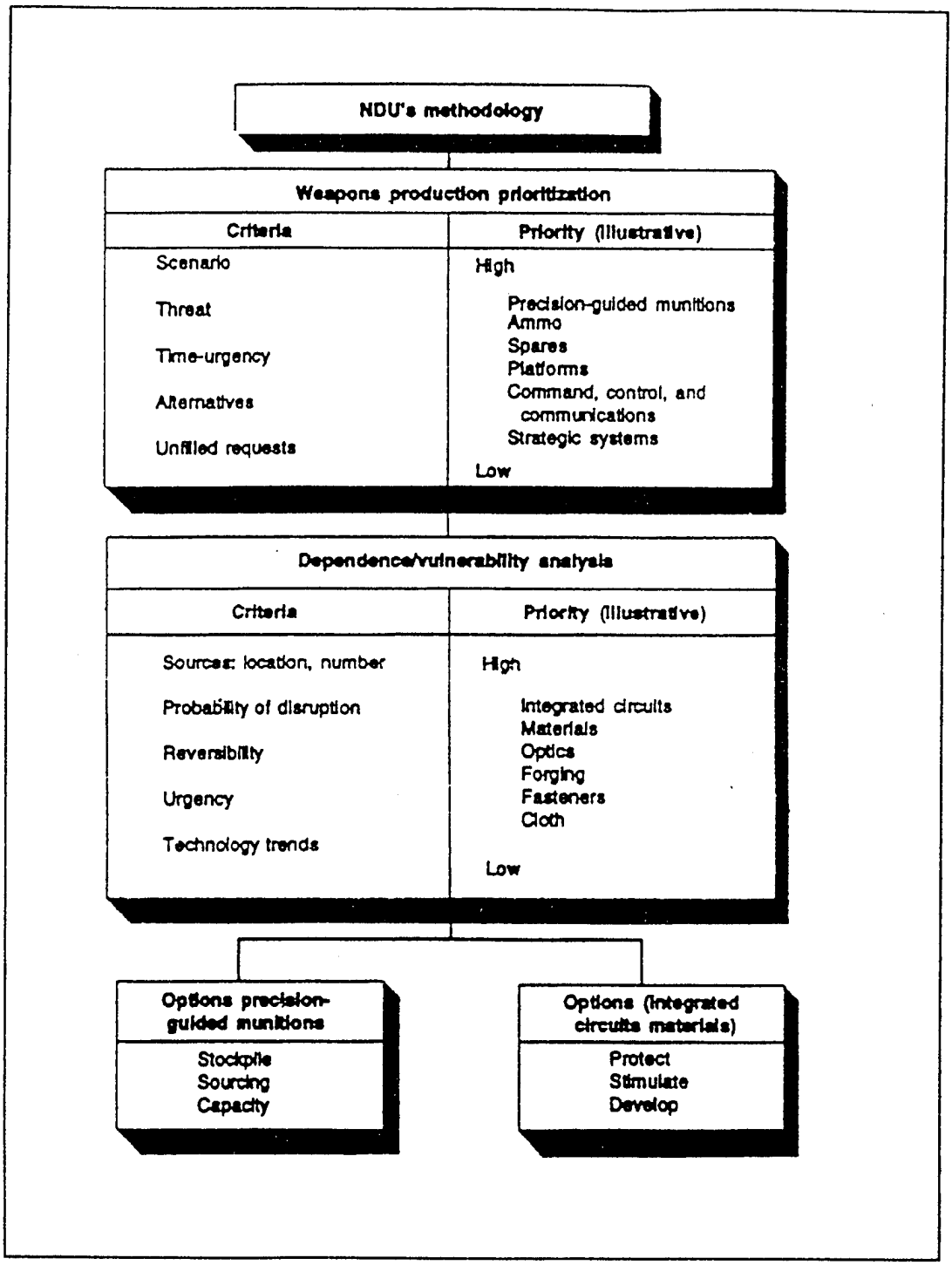


Figure 6. NDU Framework for Assessing Risk of Foreign-sourcing [Ref. 24:p. 35]

D. THEODORE MORAN

Theodore H. Moran is a Karl F. Landegger Professor and Director of the Program International Business Diplomacy, School of Foreign Service, Georgetown University. Dr. Moran is also Professor and member of the Executive Council, Georgetown School of Business Administration.

Professor Moran has taught at Harvard, Vanderbilt, the Paul H. Nitze School of advance International Studies, and the Colorado School of Mines. He received his Ph.D. in Government from Harvard in 1971. Since then he has been a consultant to corporations, Governments, and multilateral agencies on investment strategy, international negotiations, and political risk assessment.

In addition to some fifty scholarly articles, he has published nine books.... [Ref. 29:p. 99]

Definitions:

Foreign-Source

A foreign-source includes any firm or industry outside the United States, Canada, and -- with the implementation of the North American Free Trade Act-- Mexico. [Ref. 19:p. 43]

Foreign Dependence

Moran does not specifically define foreign dependence. He states that foreign dependence is not a public policy issue unless suppliers are concentrated. [Ref. 29:p. 44]

Foreign Vulnerability

Moran stipulates that a foreign vulnerability is defined by the concentration rule of 4/4/50. This rule states that a vulnerability will exist when either four foreign firms or foreign countries control 50 percent or more of a particular market. [Ref. 29:pp. 46, 68]

Dependence/Vulnerability Assessment

Moran does not seek to define critical parts or technologies. He does however, advocate the implementation of the 4/4/50 rule to determine concentration as an initial means of screening for vulnerability. [Ref. 24: p. 43]

He argues that while strictly determining the concentration of supply is the most important factor in the process, the breakout between foreign and domestic suppliers

should also be considered. Moran believes that the U.S. should not depend on political arrangements. He believes that a greater extent of concentration is acceptable if the suppliers are primarily domestic, although reliance on a large number of foreign suppliers is preferable to reliance on a small number of domestic suppliers. [Ref. 24: p. 44]

Moran indicated that promoting cutting-edge technologies is the first step toward achieving a goal of protecting the defense industrial base from foreign dependence. He advocates the use of Government funds for innovation. He also explains that the funds for innovation should be weighted toward military-use-only technologies. His reasoning is that, dual use technology development mainly benefits the producer and not DoD. He explains that the majority of dual use technologies would be produced anyway by private funding (where there is a market need, private industry will provide). [Ref. 24:p. 44]

If a vulnerability is identified through the use of the 4/4/50 rule and the U.S. national interest becomes at risk, then the domestic industry must be assisted. He suggests quick implementation of a tariff on the foreign importing industry/industries. [Ref. 24:p. 44]

Finally, Moran believes in monitoring and regulating foreign acquisitions and foreign investment within the United States. Moran notes that foreign direct investment can be considered a penetration of the defense industrial base and that acquisition of a U.S. defense company by a foreigner can represent a loss to the base. [Ref. 24:p. 45]

E. STRENGTHS AND WEAKNESS

The Analytic Science Corporation's framework and process to identify foreign dependencies can be characterized as statistical process. The Herfindahl-Hirschman Index provides a quantitative measure of risk.

Strengths

- The HHI is a quantifiable. The index provides a number for each market segment. The numbers will provide an indicator of which areas should be studied more closely.

- If the users of the HHI accurately select correct assumptions, the index will provide accurate and easily defendable risks.

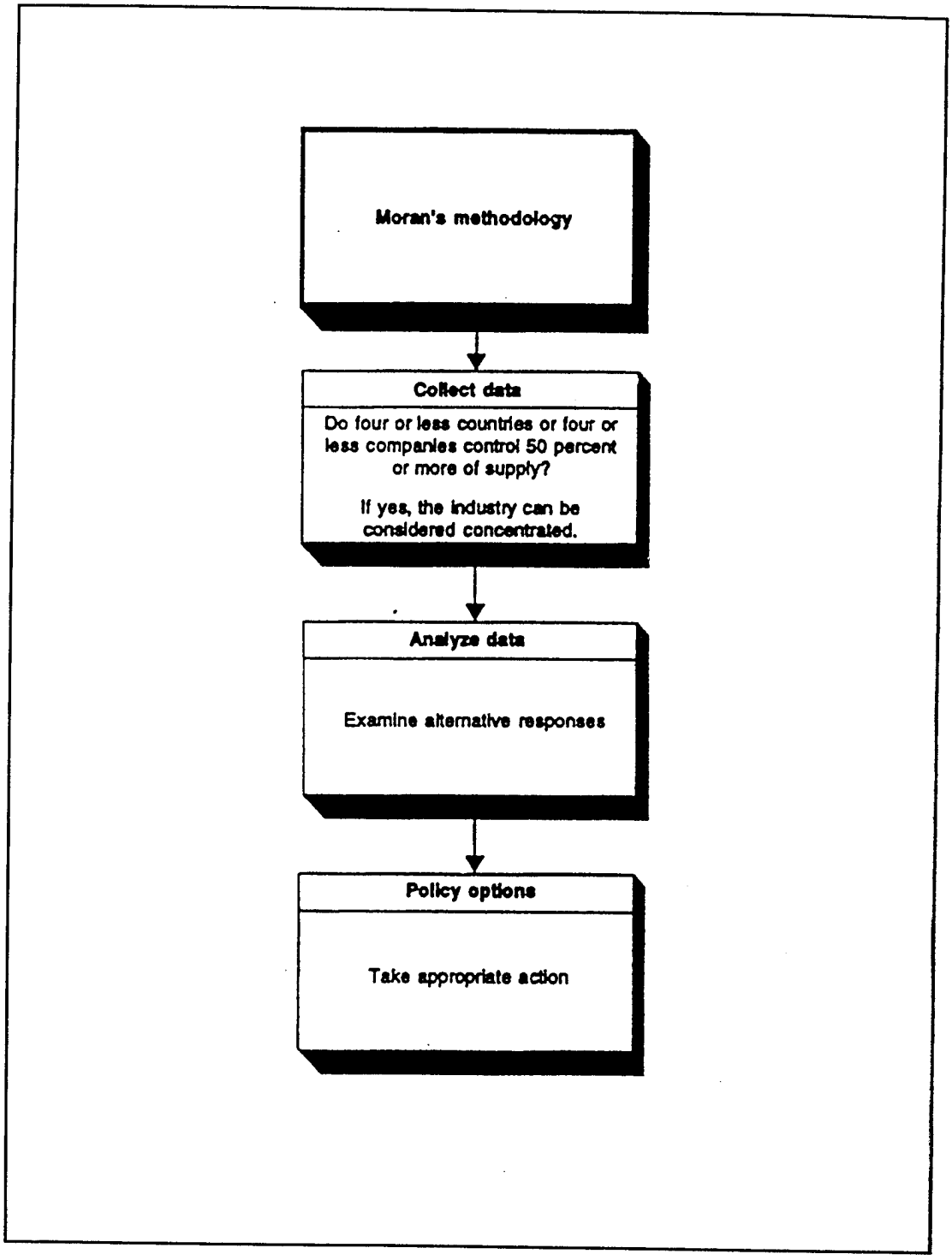


Figure 7. **Moran's Framework for Assessing Risk of Foreign-Sourcing [Ref. 24:p. 42]**

- HHI is an accepted device currently being used by the Justice Department and Federal Trade Commission.

Weaknesses

- The HHI could be costly and time consuming. The data required to perform the HHI analysis comes from published sources as well as industry surveys. The cost and difficulty of obtaining the data depends on the definition of the market (narrow or broad) and the availability of information on that particular segment.

- Selection of incorrect assumptions can provide an easily defendable incorrect risk assessment. Too broad an industry definition (e.g., micro-electronics) would provide little insight into DoD's vulnerability in critical product areas.

The Institute for Defense Analysis's framework and process to identify foreign dependencies can be described as a systems approach. This study investigates the foreign dependencies within a specific weapon systems.

Strengths

- This study identified actual foreign dependencies within weapon systems currently being deployed.

- This framework allows for accurate evidence of foreign dependence. Because this framework focuses on the actual weapon systems, the authors could trace the production of parts and components from the prime contractor, who assembles the total weapon systems, to sub-tier parts suppliers. The authors produced factual data of current foreign dependence within a currently deployed weapon systems.

- This framework allows for quick analysis. The IDA study took three months and twenty investigators to examine nine components from four weapon systems.

Weaknesses

- Identifying current dependencies is similar to twenty-twenty hindsight. By identifying weapon systems that are currently foreign dependent only suggests a problem after any opportunity to preclude it. It does not provide any alarms or indicators for what may happen in the future.

The National Defense University's framework and process to identify foreign dependencies, can be described as a scenario approach. NDU first calculated the number of weapon systems required to operate within a specific scenario, such as, to counter an army the size of Iraq. After determining this number, then made estimates of the manufacturing capabilities required to produce the determined quantity. This approach is currently being used by DoD to determine U.S. troop strength.

The then Secretary of Defense Les Aspin, formulated The Bottom-Up Review: Forces For A New Era. It was in this document that he calculated the number and composition of U.S. forces to support and defend our National interests. He believed that in planning future force structure and allocating resources, that we should establish force levels and support which should enable us to win one Major Regional Conflict (MRC). It appears that the NDU authors took the MRC building blocks and estimated what it would take to support one MRC in different scenarios. [Ref. 30:p. 10]

Strengths

- This approach provides a basis for estimating the number of systems required for selected scenario. These numbers allow planners an opportunity to investigate possible requirements for manufacturing capacity under peacetime, mobilization, and surge for a specific weapon systems.

- This is one of the first studies to consider the possibility of limited nuclear war. The other studies considered in this thesis never suggest that supply may be cut off by nuclear devastation.

Weaknesses

- This study does not provide hard evidence of foreign-source vulnerability. The study does suggest that some weapon systems contain integrated-circuits produced off shore that may be vulnerable during certain circumstances.

Theodore Moran's approach to determining foreign dependency, should be described as a national economic evaluation. Moran begins his essay by introducing the idea that U.S. economic mismanagement of economic policy is placing the U.S. in danger. The identified dangers are: loss of crucial economic and technological capabilities within

our own country, the growing dependence on foreign goods, services, and technologies that are vital to our national well being.

Strengths

- Moran provides an analysis of the total economic picture for the United States. Foreign dependencies that were mentioned in other studies are also discussed within his essay. The difference between his identification within his essay and the other studies is that, he provides the basis for the dependency's beginnings coupled with projections for the future. He provides an all knowing, all seeing approach to economic ramifications of foreign dependencies.

- He does not just provides an opinion, he supports his position fully with relevant facts.

- He provides methods to manage dependency through the 4/4/50 rule. Using this rule is quick, accurate, and proven by Moran to be beneficial.

- Forward-looking approach to foreign dependence management. Moran suggests that all segments of the economy and the industries within those segments constantly monitor, investigate, and remain informed of their position within the world market. Currently, one of the biggest problems within U.S. industries is their lack of knowledge of their competitors. This lack of knowledge allows foreign competition to by-pass domestic industry without conflict.

Weaknesses

- It would take an act of Congress to implement the majority to Moran's policies to reduce foreign dependence.

IV. DETERMINATION OF RISK OF FOREIGN DEPENDENCE

The studies documented in Chapter III of this thesis provided four different methodologies for identifying foreign dependency risks. First, The Analytic Science Corporation (TASC) determined a level of risk through identifying critical parts and technologies, then assessed their vulnerability to foreign dependence through mathematical computations. Second, the Institute for Defense Analysis determined a level of risk through identifying critical parts and technologies, then utilized twenty-six vulnerability factors to evaluate their foreign-source dependence. Third, the National Defense University selected a scenario in which the U.S. military could be deployed, then determined a level of risk of foreign dependence through examining the manufacturing capabilities and locations of high priority (critical) weapon systems demanded for the identified scenario. Fourth, Moran identified a level of risk of foreign dependence through the use of identification of foreign based suppliers and the limit of alternate suppliers within the world. Moran, through the use of the 4-4-50 rule, established an unacceptable level of concentration of suppliers that produce critical parts and technologies for the U.S. military weapon systems.

Chapter IV of this thesis investigates the foreign dependence of parts used for the production of the M1A1 tank. Utilizing selective investigative procedures from the previously documented studies, this chapter investigates what parts of the M1A1 tank are considered critical, then determines if any of these parts are being produced by a small number of foreign producers. Also, this chapter investigates the procedures for monitoring which firms produce selected parts of the M1 tank weapon systems.

First, this thesis determines which parts of the M1 tank are considered critical. To assist in this, interviews were conducted with the program managers office and the prime contractor. These two groups were asked to provide which parts of the M1 tank they considered critical and how they managed these parts. These groups were also asked to provide information to assist in the determination of the location and ownership of the critical parts producers. This information provides the essential information required to determine if the critical parts of the M1 tank are foreign dependent.

A. THE OFFICE OF THE PROGRAM MANAGER

To determine which parts are considered critical, interviews were conducted with representatives of the M1 tank program manager's office. The program manager (PM) is primarily responsible for the weapon systems acquisition and support. Within the broad definition of the PM's duties and responsibilities the DoD Instruction 5000.2 lists numerous specific responsibilities of this position. Part 5, Section E, Industrial Base, of the DoD Instruction 5000.2 states,

> **Foreign Dependencies and Diminishing Sources**
>
> Plans will include procedures to identify and minimize potential foreign dependencies and diminishing manufacturing sources and material shortages. If such item/materials must be used, the plans must describe actions to ensure the availability of the items/materials during production and support and, as applicable, under surge and mobilization conditions. [Ref. 23: p. 5-E-2]

The above instructions require plans to be made to monitor and predict the influence of foreign-sources on the production and support of military weapon systems. The office of the PM is responsible for constructing these plans. Interviews conducted with the M1 tanks PM's office, questioned whether is determined and what actions are currently being undertaken to avoid undue risk to the continued support of the weapon systems. [Ref. 13]

Selected representatives of the PM's office were questioned to determine the procedures for classifying a part or technology to be critical. Their procedures for this type of classification were determined to be similar to the procedures of the organizational units selection of the parts listed on the Parts Logistics List (PLL).

A unit's PLL consists of replacement parts. The leadership of the armor battalions perform an informal trade-off analysis to determine which parts should be included into the PLL list. Usually the parts selected at the battalion level for inclusion to the PLL are the parts which break the most. [Ref. 31] In comparison, the PM's office conducts informal meetings to consider parts for special attention. The parts selected for special attention may consequently be the parts with a high demand history, but are usually parts from producers which have a demonstrated poor delivery record or the PM's office is

directly responsible for providing the part to the prime contractor or maintenance depot for production. [Ref. 12]

Representatives of the PM's office were asked if they considered the parts listed for special attention to be critical. They responded that all of the parts of the M1 tank could be considered critical, it depends on whom is asked. The PM's office was provided the definition of critical from Chapter III of this thesis, which states that for a part to be considered critical, its absence does not allow the weapon systems to perform its intended mission. Then the PM's office was asked if the parts on the special attention list were considered critical in accordance with this definition. The PM's office explained that most parts on their list should be considered critical, but to differentiate between which ones are and which ones are not would be a matter of personal opinion. There is not presently a list of critical parts of the M1 tank produced by the PM's office. [Ref. 12]

When questioned as to which parts are most closely monitored within the PM's office, they listed the government furnished parts, which are produced by a subcontractor specifically for the Government then, delivered to the prime contractor for inclusion into the M1 tank weapon systems. The representatives of the PM's office stated that the problems created by not insuring that Government furnished parts were at their designated place at the designated time, were considered tremendous. All facets of Government furnished parts are extensively monitored. [Ref. 13]

When questioned how certain parts are selected for special attention, they stated that the program manager along with a staff of logistics personnel conduct periodic informal meetings. During these meetings all logistical problems for the support of the M1 tanks are discussed. This group makes an informal analysis to determine what parts should be considered for special attention. Their primary concern in the selection of a part to be monitored is the continuation of uninterrupted supply. The PM attempts to insure that the weapon systems in the armor units, as well as those in production, receive continuous logistics support. [Ref. 13]

The PMs office was asked to provide a list of all foreign manufacturers and the parts they produce. They stated that three parts are foreign-sourced.

[1] Optics in the gunner's primary sight

[2] The ammunition storage racks

[3] The microcircuits in the ballistic computer -- a component of the target acquisition/fire control system [Ref. 12]

When asked the reasons for the foreign acquisitions and if these parts constituted a foreign dependency they explained that most of the optical glass in the gunner's primary sight is foreign produced. Low cost is the reason they stated, that the majority of these types of optics are produced in Germany and there is no domestic producer who could produce the same high quality optic at the same low price. [Ref. 12]

When asked if the supply of optics from this foreign-source was interrupted, would it cause serious problems in the support of the M1 tank fleet, they responded, that foreign-sourcing of these types of optics by the domestic industry appears to be widespread, therefore, loss of these foreign-sources would likely create an increased demand for optics from domestic producers. If domestic manufacturers cannot meet this broader and more intense demand, the M1 tank fleet could possibly be affected. Although, since current tank production is limited to the conversion efforts of the M1 tanks being upgraded to M1A2, the effects of the loss of the foreign-sourced optics producer would be minimal to the present fleet. The present M1 fleet has the optics in place. Once the sights are installed in the tanks they rarely require replacement. [Ref. 12]

When questioned about the use of foreign-sources for the microcircuits in the ballistic computer, they explained that, the ballistic computer used in the M1 tank is built by Computing Devices Company of Canada (CDCC). This firm utilizes some off-shore agencies for the assembly and testing of particular microcircuits. They stated that representatives of CDCC could conduct the testing and assembly in their domestic plant if economic considerations were deemed secondary. However, if the microcircuits were mandated to be domestically produced, the CDCC representatives estimated that production could begin to within a year depending on the particular microcircuit. [Ref. 12]

When asked to explain the use of a foreign-source for the ammunition storage racks they explained that, GDLS currently has a sole-source contract with Wegmann and

Company, a German firm, for the production of the storage racks. In 1987 Wegmann won the design competition for the ammunition rack based on technical merit, but the production contract was awarded to Wegmann, mostly because of its claims of extensive proprietary data rights to the rack design. [Ref. 12]

When questioned about alternate sources they replied, some domestic manufacturers have experience producing other ammunition storage racks, but estimates indicate it would take approximately ten to twelve months to establish a domestic producer. Also, if a domestic producer were utilized, the problem of Wegmann's proprietary data rights claim on the technical data package would still exist. [Ref. 12]

Evaluation of the Foreign-Sources

This section first determines if the three foreign-sourced parts of the M1 tank are considered critical. Second, using one of the methodologies discussed in Chapter III, it can be determined if the continued foreign-source use of these parts poses a threat to the continued support of the M1 tank.

Criticality

Critical: A part or technology is defined as critical if its absence does not allow the weapon systems to perform its intended mission.

Representatives of the PM's office were asked to determine if the M1 tank could conduct its intended mission without the foreign produced optics, ammunition storage racks, and microcircuits in the ballistic computer. The PM's office representatives stated that these three parts are essential for the operation of the M1 tank's main gun. They stated that without any one of these three parts the tank would become significantly less effective during combat situations. [Ref. 13]

Representatives of the PM's office were asked the following questions to aid in the determination of foreign dependence of the three foreign produced parts.

1. Are there less than four producers of the type of optics used in the M1 tank?

2. Are the producers of these types of optics concentrated in less than four countries outside of the U.S.?

3. Do the identified producers of the optics (located outside of the U.S.) control over fifty percent of the optic market?

The above questions were also asked concerning the ammunition storage racks and the microcircuits.

The program office did not have the numbers of the producers for the optics, ammunition storage racks or the microcircuits. However, they did provide an explanation as to how they mitigate risks associated with foreign-sourcing.

First, the PM's office prefers that all parts for the M1 tank to be produced within the U.S. Parts not produced within the U.S. are by exception only. The optics, ammunition storage racks, and the microcircuits are allowed to be produced by foreign-sources because of cost reasons. In all three instances, domestic capabilities have been assessed and proven to be available but, in most circumstances, at double to triple the cost of the foreign produced part. [Ref. 12]

If a foreign-source is used, the PM office in conjunction with the prime contractor attempt to locate an alternate domestic source. Both the PM's office and the prime contractor try not to sole-source any parts of the M1 tank. It has been determined that if more than one production source exists, the price of the product is competitive and supply security exists. [Ref. 1:p. 12]

In these three cases of foreign-sourced parts, the PM's office has identified an alternate domestic producer. There are also time estimates of how long it will take to begin domestic production it the foreign-source is not available. The current estimates for domestic producers to begin in these three cases are all within one year. [Ref. 13]

Summary

The PM's office is aware of their responsibilities as outlined in the DoD Instruction 5000.2. They have developed plans to provide supply support for the M1 tank. They have identified foreign-sources through the use of information provided by contractual agreements and lists of suppliers provided by the prime contractor.

The PM's office closely monitors the producers of Government furnished parts and materials. They conduct periodic meetings to determine if these producers are on schedule and within budget.

Currently, the PM's office does not have the resources to conduct in-depth studies of foreign dependence, such as those documented in Chapter III. They do however have a policy to seek a domestic supply source if a foreign supply source is used.

The PM's office could not list the number of producers within a single market and did not have the knowledge of the market shares for a particular manufacturer. The limit of their knowledge did not allow for the application of any of the methodologies listed in Chapter III.

The Prime Contractor

General Dynamics Land Systems Division (GDLS) is the sole-source developer, integrator, and manufacturer of the M1 series tanks. GDLS is a profit-orientated business. GDLS does not define critical parts, but does define critical suppliers. GDLS uses the following procedures to identify their critical or key suppliers:

1. Sales to GDLS exceed $500k annually
2. Source-Controlled or extensive qualification required
3. Posses Government-owned machinery

GDLS has identified 121 critical suppliers, three of which are considered foreign. These three foreign suppliers are the producers of the optics for the gunner's primary sight, the ammunition storage racks, and the microcircuits in the ballistic computer which were covered in a previous section of this chapter.

An investigation was conducted to determine if any of the suppliers for GDLS utilized foreign-sources in the production of parts for the M1 tank. It was stated that of the 121 critical suppliers, three were considered foreign-sources. GDLS was asked of the remaining 118 suppliers, do any of them use foreign-sources for the production of parts supplied to GDLS? GDLS did not provide any information concerning the suppliers for their subcontractors or parts producers.

To investigate the foreign influence of suppliers and material producers, certain sub-tier producers were interviewed. The methodology was as follows: There are 600 industrial base suppliers for the M1 series tanks. Of this 600, there are 121 which are considered key or critical suppliers. Of the 121 key suppliers, there are 27 unique M1 tank vendors. Unique vendors are sole-source firms within the U.S. that produce a

specific part for the M1 series tanks. To focus this investigation further, of the unique vendors, there are only a select few which only produce parts for the M1 tank; as opposed to those which also produce parts for the M1, M1A1, M1IP, M1A2, and the M1A2 Heavy.

The two firms chosen and the analysis is discussed below.

Kearfott Guidance and Navigation Corporation

Kearfott is the sole producer of the M1 line of sight unit, the gun trunnion re-supplier, and servo drive for the laser range finder of the M1 tank. The primary weapon of the M1 tank is the 105 main gun. These parts and components combined make-up the fire control system for the main gun of the M1 tank.

A representative for Kearfott explained their relationship with GDLS. He stated that GDLS retains the top level technical data package while Kearfott retains the sub-tier manufacturing technical data package. The information that GDLS retains provides a general overview of the internal working relationships of the components, such as, how the line of sight unit is linked to the gun trunnion resupplier to produce accurate targeting of the main gun system. The information within the technical data package retained by Kearfott actually reveals how to build the line of sight unit and the gun trunnion resupplier. The majority of the components of the fire control system produced by Kearfott are produced under their control in North Carolina. However, the gun trunnion re-supplier in manufactured in Mexico under their control. The nine circuit cards and transistors which also go into the fire control unit are produced off-shore.

When questioned as to the availability of alternate sources to produce the circuit cards and transistors, the representative explained, it is like going to the store to purchase an item. There is ample supply and selection everyday of the year. We determine which supplier can consistently deliver a standard product and remain with them until problems develop. If and when problems develop we effortlessly change suppliers with minimal delays. There is a vast inventory of suppliers who could produce the circuit cards and transistors.

The Leach Corporation

The interview with a representative of the Leach Corporation revealed that they produce only one part for GDLS, a power source. Their knowledge of what this part did for the overall effectiveness of the M1 system was lacking. They did however know the market level competition for this part was limited. They stated, "Originally there were two suppliers of this device. The reliability and effectiveness of the other supplier's device proved to be less than ours, allowing Leach to become the sole-source producer."

Further investigation revealed that Leach, in partnership with the German firm LRE Relay and Electronics, actually produce the device. A Leach representative stated that the partnership is what provided Leach the expertise to produce the part.

B. SUMMARY

This chapter identified the procedures or lack of procedures that the U.S. Army and the prime contractor use in determining critical parts or technologies of the M1 tank. It established that the criteria for establishing a part to be critical is different among the Program Manager's office and the prime contractor.

The PM's office indicated that they monitor known foreign-sources and attempt to mitigate risks associated with their influences by developing alternate sources. They also stated that with their limited resources that they are not capable of conducting in-depth analysis of current suppliers.

The prime contractor has identified foreign-sources at the subcontractor levels. The prime contractor did not provide any insight into foreign dependence at the material and parts producer levels.

A limited investigation of parts producers revealed some foreign-source dependencies. It is concluded, that more knowledge needs to be gained about the sub-tier level suppliers. The level of foreign dependence of the M1 tank can not be determined without knowing the extent of sub-tier foreign-dependence.

V. ANALYSIS

The first four chapters of this thesis investigated the different facets of the defense industrial base to analyze the extent of foreign-source dependence in the production of the M1 tank. This chapter analyzes the issues discovered in that investigation.

A. THE IMPACT OF THE DECLINING DEFENSE BUDGET

It was discussed in Chapter I that the defense budget is continuing to decline. Through interviews with GDLS it was determined that 32% of their critical parts suppliers would exit the defense industrial base if tank production dropped below 120 units per year. GDLS also noted that a 30% price increase in the M1 tank also would occur at this production level. [Ref. 1]

Noting production rates and manpower decline, GDLS was asked to identify the essential skills which are affected the most by the decline in production. They provided the following:

> There are various skills required to fabricate, machine, assemble and test the M1 Abrams. GDLS has identified a grouping of skills which maintains the "sufficient mass" for continuation of the M1 program. They are as follows:
>
> - Armor Fabrication and Welding
> - Complex Armor and CNC Machining
> - Vehicle Assembly, Integration and Test
> - Optics and Electronics
> - Product Acceptance and Test
> - Production and Supplier Quality Technical Support
> - Procurement Supplier Base and Material Management
> - Process and Product Technical Support
> - Maintenance and Repair
>
> Most of these skills have few counterparts in the rest of the defense industry and virtually none in the commercial industry.

> As production rates decline each of these skills suffers deterioration resulting in loss of product knowledge, flexibility, worker retention, cost over[-]runs, inefficiencies and customer support. [Ref. 1]

The question is then, if the sole source producer of the M1 tank loses the majority of these critical skills, who is going to replace them? It is conceivable that foreign producers would replace these domestic suppliers exiting the defense industry.

Israel, Germany, and the United Kingdom all have viable domestic defense industries. They have structured their defense industrial base to meet their individual needs. The foreign defense producers have designed a structure for continued defense production. They have assigned their defense production to large conglomerates which are not solely dependent on defense business. Through this arrangement, these countries have been able to maintain a defense industry in spite of fluctuations in defense demand.

If GDLS does lose several of the skills listed above and the U.S. still requires tank parts that these skills produce, it is only logical to assume that one alternative is to increase foreign dependence and buy from the countries that have maintained some military capability.

Another important point related to the loss of critical suppliers, is that it is difficult to get them to come back to the defense industrial sector once they have left. It was noted in Chapter I that private industry is not willing to convert their plants to defense production unless there is a Presidential mandate and tremendous public support for the war effort, such as was exhibited during WWII.

Currently, there is no major war and public opinion about the U.S. Army's presence in Bosnia-Herzegovina, Korea, Rwanda, and Somalia is not always supportive. The U.S. military has to have equipment to fulfill its mission requirements. If the U.S. Army was called upon to conduct a peace mission in any of these four areas for an extended period of time, they would require an increase of equipment and supplies. The question then would be whether enough of the defense industrial base is left to respond for the requested increase.

B. PREDICTED AFFECTS AT THE SOLDIER LEVEL

To determine the affects of the declining defense industrial base on the soldiers in combat, an understanding of the National Security Strategy and latest Industry Sector Survey is necessary. The National Security Strategy outlines how much military force is currently required and the Industry Sector Survey examines if the industrial base can support the requirement.

A National Security Strategy of Engagement and Enlargement, February 1995 states:

> With program enhancements, the forces the administration is fielding will be sufficient to help defeat aggression in two nearly simultaneous major regional conflicts. [Ref. 35:p. 9]

A Major Regional Conflict (MRC) equates to the forces required to win a war the magnitude of the Persian Gulf War. The current administration has determined that the U.S. military force must be capable of defeating the aggression in two MRCs almost simultaneously. A review was conducted to determine the magnitude of military forces required to accomplish this task. Once this was accomplished, DoD conducted a defense industrial sector survey to determine if the U.S. possessed what was required to meet the administration's mandate. [Ref. 2:p. 6]

It was determined that the Tank Automotive Command currently cannot support the mandated two MRC scenario. They indicated the following short-falls for the M1 tank series.

COMMODITY	WAR RESERVE REQUIREMENTS	SHORTFALL
Engines	1,659	1,376
Transmissions	1,568	869
Roadwheel Arms	295	288
Final Drives	992	663
Track	265,919	88,803
Roadwheels	8,769	4,038
Sprockets	8,980	7,161
Shock Absorbers	204	37
Torsion Bars	2,066	1,451

In addition, Donaldson, the only full-service air filter supplier, recently advised the Army that they were discontinuing Nuclear, Biological, and Chemical (NBC) filter production. Also, Textron Lycoming, the sole producer for the M1 engine, was scheduled to cease engine production in March 1995.

If the U.S. undertakes the mission of conducting two almost simultaneous MRCs, many of the previously mentioned parts will not be present in adequate quantities for weapon systems support. Using the information provided by the sector survey, the U.S. Army will be in need of basic repair parts.

When repair parts shortages such as those previously mentioned occur, the probability of a tank losing its self-propelled capability is increased. If tanks can not move by themselves, they are collected and placed within the Unit Level Collection Point (UMCP) to await repair. Actions such as this, temporarily reduce the armor fighting force on the battlefield. The severity of the repair parts supply shortages will determine the number of disabled vehicles and the length of time the vehicle must remain at the UMCP. In addition, if an armor company loses more than two vehicles for any reason, they are considered combat ineffective. [Ref. 36:p. 7-32]

C. MANAGEMENT OF FOREIGN-SOURCE USE

The Government has a mandate to monitor known foreign-source uses. The PM's office for the M1 tank has identified three instances of foreign-source use within the M1 program. The prime contractor also monitors most known instances of foreign-source uses. They have identified the same three instances of foreign-source use within the M1 program. Neither of these two had any information of a foreign-source dependence at the sub-tier levels of production for the M1 tank. This lack of knowledge could seriously jeopardize the continued success of the M1 tank.

Interviews with two sub-tier producers for the M1 tank disclosed that there is some foreign-sourcing of parts in their production. Without visibility into the extent of foreign-sourcing however, the prime contractor has limited ability to mitigate the risks associated with foreign-source dependence.

Additionally, the fact that the PM's office had no knowledge of sub-tier foreign use is alarming and dangerous. It is alarming, because it displays a lack of concern by DoD to monitor who is producing what for the defense systems of the Nation. It is dangerous, because unbeknownst to DoD, the actions in one particular region of the world may have a dramatic impact to the continued supply of parts for a major component of the key weapon systems in the military. The following is an example of an unpredicted action which happened that could have had an affect on most weapon systems in the U.S. Army:

> .... a process known as Chemical Vapor Deposition (CVD). CVD is a state-of-the-art process used in the production of some DoD-critical semiconductors, such as application-specific integrated circuits (ASIC's). The U.S. leads the world in CVD technology, with domestic firms owning a 75 percent share of the world market for CVD equipment. A critical step in the CVD process involves ozone being bubbled through several liquified chemical elements before being deposited on the silicon wafer surface. The ozone used is generated commercially. The only source of ozone in the world is in Kobe, Japan. On January 17, 1995, the city of Kobe Japan was devastated by a major earthquake. The earthquake was the second worst in Japan's history, destroying 88,000 buildings. Fortunately, the ozone production facility was not damaged, but much of the city's harbor, Japan's largest, was severely damaged and the flow of goods out of the city was constrained. [Ref. 34:p. 108]

This example raises the following questions: Do the ASICs within the M1 tank need ozone? Do the PM's office and the prime contractor consider the need for ozone a critical foreign dependency? What special considerations should be identified within other parts of the M1 tank.

The lack of knowledge of where the sub-tier suppliers get their resources is critical and needs to be determined. To continue to depend on sub-tier production without this knowledge is dangerous.

VI. CONCLUSIONS AND RECOMMENDATIONS

The primary and subsidiary research questions are examined and conclusions presented in this chapter. In addition, recommendations for future actions are offered.

A. EXTENT OF GLOBALIZATION OF FOREIGN PRODUCERS

1. Conclusions

There is no solid way to measure the extent of the M1 tank's dependence on foreign-sources. The overall extent of foreign-sourcing and foreign dependency and their significance to M1 production are unknown because, the program office has only limited information on foreign-sources of supply at lower tiers of the supplier base. No criteria have been established for determining what levels of foreign dependence tolerance should be for the M1 tank and what actions the program office should take to reduce the associated risks.

2. Recommendations

All parts within the U.S. Army inventory possess a National stock number. It is recommended that the U.S. Army form a data base using the National stock numbers of the parts for the M1 tank. A portion of the National stock number could be reserved for use to designate the parts producer. When the manufacturer produces the part he could stamp his producer's identification number along with the National stock number. Utilizing this simple procedure would allow any one with a listing to determine the manufacturer of any part produced for the M1 tank.

B. DETERMINATION OF LEVELS OF THREAT

1. Conclusions

The Program Manager of the M1 tank has little awareness of the extent of foreign-sourcing or dependency in their weapon systems, particularly beyond the prime contractor and their immediate subcontractors. Additionally, DoD has not provided the U.S. Army with any guidelines to accurately determine unacceptable levels of foreign dependency.

2. Recommendations

The program manager needs to establish guidelines of acceptable levels of foreign dependence. The studies listed within this thesis provided four such methodologies.

C. CAUSES OF SUPPLY DISRUPTION

1. Conclusions

The number one reason documented for the use of foreign-sources was price. The PM's office, the prime contractor, and the material producers all use foreign-sources because of price.

Also, the current DoD budget projections indicate the defense budget to continue to be reduced. GDLS, recognizing this fact, has informed the Government that more than 32% of their critical suppliers would leave the defense industrial base if continued reductions occur in tank production.

The mass exodus of 32% of critical domestic suppliers from the defense industrial base will provide an increased opportunity for foreign producers to enter the market.

2. Recommendations

Allow foreign producers to enter the defense industrial base, but require them to conduct all manufacturing and production efforts within the continental borders of the U.S.

If the U.S. has a requirement for a substantial number of defense weapon systems and the current private sector will not support the required production, there is no one else available to produce them but foreign-sources. Allowing foreign-owned firms to operate within the U.S. has provided continued support for several domestic markets, such as, the automobile market.

D. PLANS TO MITIGATE RISK

1. Conclusions

Current plans to mitigate risk revealed by the PM's office are reactionary. The PM's office monitors the supply of Government furnished parts and deliverables from the prime contractor. This approach is inefficient and of limited effectiveness. It offers only a little insight into foreign dependencies at the subcomponent level. It is at the

subcomponent level that the majority of the current globalization of production is occurring.

2. Recommendations

The PM's office needs to continuously investigate all levels of production within their weapon systems. Only a continuous thorough monitoring of all levels of production will provide information worthy of identifying notable trends within the defense industrial base. By identifying trends, the PM's office will be enabled to formulate long range plans, support ailing contractors, and discover growing foreign dependencies.

E. MONITORING OF THE DEFENSE INDUSTRIES GLOBALIZATION

1. Conclusions

Historically, the Pentagon and other Government agencies have been trying to collect and analyze defense industrial data systematically, but these efforts have been sporadic. The four studies listed in Chapter III are good examples of DoD's efforts to determine the extent of foreign influence on the defense industrial base. It should be noted that these studies used different methodologies and drew different conclusions about different areas of the industrial base. The studies were also conducted in different years. But in lieu of these short-comings, these studies constitute the majority of the current evidence of the globalization of the defense industrial base.

Reliance on ad hoc data collection, puts DoD and the U.S. Army Armor force in a reactive role and limits their ability to identify trends in critical industrial sectors.

2. Recommendations

Adequately staff and resource the PM's office to conduct studies within their own specialties. The PM is currently responsible to insure production and support of the weapon systems. His organization presently retains more information concerning the specific weapon systems than another agency in DoD. All the PM needs is to conduct continuous in-depth analysis of the producers within his weapon systems production structure.

It would appear to be much more cost effective to provide a little more continuous information to one agency than to totally educate an ad hoc investigative committee, that

will only take a snapshot view of the systems production structure. The benefits from providing continuous information would allow the PM to formulate plans instead of causing a crisis by overtly reacting to a snapshot study.

F. RECOMMENDED AREAS FOR FURTHER RESEARCH

Although many studies have been conducted in an attempt to determine the extent of foreign dependency of the defense industrial base, there are many areas of research that could be beneficial to the acquisition community. The following areas for further research are recommended:

- A cost-benefit analysis of the studies conducted to determine foreign dependence of defense industrial base.
- Investigate to determine which foreign defense producers are seeking to expand into the U.S. defense market.
- The examination of the Buy American Act to determine its contribution to the life cycle costs of the weapon systems.

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