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MEETING U.S. DEFENSE NEEDS IN SPACE: EFFECTS OF A SHRINKING DEFENSE INDUSTRIAL BASE ON THE SATELLITE INDUSTRY

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Abstract

U.S. defense industrial base (DIB) deterioration and increased DOD interest in space exploitation highlights the U.S. satellite industry as one DIB sector requiring analysis. Despite DIB problems, this industry must maintain the capability to produce advanced satellites for the DOD. Commercial-Military Integration (CMI) will, according to experts, eliminate problems inherent with a separate DIB.

This research focused on investigating satellite industry capability to meet DOD space requirements. Through literature review, case study analysis and interviews, effects of a shrinking DIB on the satellite industry were determined. A model for DIB strength was developed and analyzed through literature review. General Electric Aircraft Engines (GEAE) case study showed the potential for *commercializing* the DIB. Research focused on satellite industry executives whose perspectives illustrated industry capability to meet defense space needs.

Results indicated continued DIB deterioration unless Government and defense industry leaders intervene. GEAE sales performance demonstrated how commercializing the DIB can provide stability. Interviews confirmed the satellite industry's ability to meet defense needs, yet space architecture and launch vehicle issues must be addressed. Through flexible manufacturing, dual use and smaller, *smart* satellites/satellite services, this industry can produce high quality, inexpensive satellites for defense/commercial markets faster, providing additional surge/mobilization capability.

Chapter 1

Introduction

General Issue

The U.S. satellite industry's ability to produce state-of-the-art satellites is critical for national defense, especially to support the new Air Force vision -- *Global Engagement*. In fact, White House and senior defense officials claim, "Access to and use of space is central for preserving peace and protecting U.S. national security as well as civil and commercial interests" (White House, 1996:1). The continued efficacy of the satellite industry must be maintained in order to exploit the space environment through advanced satellite technology applications. The U.S. defense industrial base (DIB) has historically produced the weapon systems and supplies needed for defense, requiring a significant portion of the DOD budget. The satellite industry is the sector of the DIB responsible for the design, manufacture, and production of satellite systems and components. Escalating DIB problems pose significant concern among the defense community regarding its current and future capability to meet DOD space requirements.

The deteriorated condition of the DIB has been well-documented over the last 30 years and continues to be one of the most controversial issues among defense-related topics. Numerous studies indicate the DIB is both inefficient and ineffective in meeting

defense needs (Gansler, 1989:242). The cyclical nature of the defense industry, reduced DOD procurements, and a burdensome federal acquisition system are the driving factors for DIB deterioration and its diminishing ability to satisfy DOD objectives. Low levels of capital investment and economic support have led to lagging capacity, capability, productivity (Gulick, 1983:45) and shrinking numbers of defense contractors in the lower tiers, eroding the subcontractor base of the DIB (Gansler, 1989:258). Potential bottlenecks in these tiers could negatively influence the DIB's ability to surge and mobilize in times of national emergency. Increased dependence on foreign suppliers has led to vulnerabilities in source countries such as *buying-in*, strikes, political unrest and reaction to U.S. actions, or terrorist attacks against plants (Gansler, 1989:272). Considering the satellite industry is one important sector of the ailing DIB, there is concern that its continued viability is in jeopardy.

The satellite industry owes its growth and development to the vigorous military investment it has received since its inception; yet, recent defense budget cuts preclude this trend from continuing. Increasing commercial space applications, on the other hand, provide an optimistic future for this industry's expansion into new markets. (Sparaco, 1996:20). In order to possess leading-edge technology for many component and subsystem areas, the DOD must tap into the commercial satellite market.

It is imperative the U.S. Government capitalize on the commonality between military and commercial markets, particularly in the satellite industry, and take the necessary steps to ensure this industry is fully prepared to meet the demands of both markets. Commercial [Civil]-Military Integration (CMI) intends to expand and preserve the DIB for defense-related materiel production, through its integration with the commercial

industrial base. The underlying theory behind CMI is that most defense weapon systems contain parts used also in commercially-manufactured goods. Two current initiatives, Acquisition Reform and dual-use strategies, support the movement towards CMI. Acquisition Reform seeks to mirror commercial acquisition processes for the Federal Government, while dual-use technology and production strategies try to establish advanced technologies, processes and products that support both commercial and defense industries. Theoretically, successful commercialization of defense technologies can provide the DOD an accessible, affordable and stable industrial base (Boezer and others, 1997:39-41). Emphasis must be placed in these areas to ensure our nation's industrial preparedness.

> The role of industrial preparedness in military strategy is anomalous. Prospectively, the role is almost always ignored by military planners, but retrospectively it is agreed that industrial preparedness was either vital for success or instrumental in defeat. Americans tend to put off preparing until after the need actually has occurred. That reluctance to get ready applies particularly to industrial preparedness and the larger topic of national mobilization. (Brinkerhoff, 1994:38)

This quote by Colonel John R. Brinkerhoff (USA, Ret.), a consultant on national security matters, succinctly exposes a serious and recurring problem with our national defense strategy that directly ties in with current DIB problems. Americans are typically reluctant to support peacetime defense industrial preparedness. Since the Revolutionary War, "the nation has been able to mobilize men much more rapidly than it has been able to equip them" (Gansler, 1989:241). The end of the Cold War further perpetuates this problem. It is difficult to persuade the American people into supporting increased defense spending for industrial preparedness when there is no definable threat.

Consequently, domestic issues have taken priority. This change is reflected in recent federal budget plans.

> Democracies, particularly those blessed with good geography, usually favor domestic over defense needs in times of relative peace. This phenomenon reflects political realities which are sometimes—but not necessarily—related to perceived threats to national interests and to those of one's allies. Recent U.S. budgets and funding projections demonstrate that the United States presently is in such a period. (Boezer and others, 1997:26)

Industrial preparedness concerns can be scrutinized by assessing the ability of the DIB to meet U.S. defense needs. The United States has traditionally relied on the DIB for defense weapon system production and technology requirements and satellites are no exception. Historically, the DIB has been inefficient in meeting DOD requirements (Gansler, 1989:240-242). What does this mean for the U.S. satellite industry?

Specific Problem

American military history corroborates the notion that industrial strength is a critical factor for the success of any military engagement. This was demonstrated and proven decisive for U.S. victory in World War II. The question is, how can industry strength be measured? More specifically, how can satellite industry strength be measured, considering the ailing condition of the DIB? The answer to this question and the broader question regarding DIB strength can most appropriately be measured in terms of its ability to meet DOD objectives; thus, the DOD is very concerned with industrial preparedness issues. In general, the DOD requires the DIB maintain the capability and capacity to surge and mobilize during periods of conflict. There is no way to accurately

quantify DIB strength because of the difficulties encountered determining exactly who comprises it. As a result, there has been no attempt to measure DIB strength thus far.

In today's high technology environment, commercial industry dominates many markets and a multitude of the parts, components, and subsystems used for defense are also used commercially. An industry can be thought of as part of the defense market if the majority of its output is specifically destined for defense markets (Sandler and Hartley, 1995:182). However, unlike the prime defense contractors, exactly who comprises the defense industry in the lower tiers is difficult to assess. The lower tiers refer to the subcontractors and parts/materials suppliers who produce the parts, components, and subsystems that prime contractors integrate into the major weapon systems for the DOD.

> The 30 or so large defense contractors—the primes—now selling directly to DOD are supported by as many as 40,000 lower tier firms plus thousands of other industrial establishments that provide bits and pieces of materiel to the primes for the assembly of major end items. Single customer specialization by lower tier firms is not as pronounced as for the primes, although thousands of the lower tier industries depend heavily on DOD procurement. (Boezer and others, 1997:30)

Additionally, there are numerous qualitative and quantitative variables affecting the DIB's ability to meet DOD objectives, most of which are difficult to quantify. Among these variables are tax, trade, environmental, and socioeconomic policies as well as defense spending, the most influential of these variables. Throughout the literature, certain core factors are frequently discussed by defense industry analysts regarding DIB issues; these factors (production, competition, and technology) provide a basis for DIB strength. Many defense experts agree defense spending directly impacts DIB production capability; levels of competition at the prime contractor level, but especially at the

subcontractor and parts/materials supplier levels, and; DIB ability to develop state-of-the-art technology. Diminishing defense budgets are creating problems for each of these DIB strength factors; this, in turn, affects DIB preparedness. Defense spending, therefore, serves as an adequate proxy for DIB strength. In light of continued defense spending reductions, the continued strength of the DIB is at stake.

This has potentially far-reaching implications for the U.S. satellite industry. The emphasis on space by senior defense officials in concert with the weakened DIB raises considerable concern whether the satellite industry will be able to meet U.S. defense needs in space. A new global environment, changing domestic priorities, and shrinking defense budgets culminate in a complex and unique environment wherein the satellite industry must operate efficiently and effectively. To determine the ability of the satellite industry to meet DOD needs in space, analysis of this industry is imperative.

Research Objective

The objective of this research is to assess the effects of a shrinking DIB on the U.S. satellite industry and determine whether this industry will be able to meet defense space needs. This is crucial with the increased importance DOD has placed on space systems for future U.S. defense purposes. In order to provide the most comprehensive analysis, this objective is met through the sequential analysis of four interrelated propositions; each proposition builds on the previous one. See Table 1.

Table 1. Summary of Propositions

SUMMARY OF PROPOSITIONS:	
Proposition 1	There is a positive correlation between defense spending and DIB strength.
Proposition 2	The strength of the DIB is deteriorating.
Proposition 3	The relationship between defense spending and DIB strength is moderated by *commercializing* a defense industry.
Proposition 4	Due to the U.S. satellite industry being heavily *commercial* in nature, the shrinking DIB has not adversely affected it as might be suspected.

This research furnishes an exploratory analysis of the current DIB, its problems, future, and impact on the U.S. satellite industry as it continues to shrink. The complex nature of the aforementioned propositions prohibit a cost effective, timely as well as accurate quantitative analysis. Therefore, a combination of literature review, case study analysis and interviews provide the foundation for this study. The crux of the investigation is the subjective assessment of U.S. satellite industry experts from the top four satellite producers in the United States, supporting Proposition 4. These interviews provide a subjective, yet comprehensive outlook on the status of the U.S. satellite industry as well as insight on the impact fluctuating defense budgets, DIB deterioration, CMI, and growing commercial space applications have on it. Although hard data is not generated from this analysis, evaluation by satellite industry experts best purveys this industry's future outlook. Recommendations for further research are also detailed.

Investigative Questions

The following investigative questions were initially developed to guide this research effort. Answering these questions should shed light on the U.S. satellite industry's ability to meet U.S. defense needs in space.

1. Why is the DIB necessary for national security?
2. What is the current condition of the DIB?
3. What is being done by the Federal Government and the defense industry to ensure the continued viability of the DIB?
4. How will *commercial-military integration* (CMI) influence DIB strength? Will this paradigm shift alleviate, if not eliminate, many of the historical deficiencies that characterize the DIB?
5. What is the relationship between the DIB and the U.S. satellite industry?
6. How is the U.S. satellite industry faring, considering fewer DOD procurement dollars and CMI?
7. Will the U.S. satellite industry be able to meet U.S. defense needs in space now and in the future?

Definitions

The following definitions are taken from the *Glossary: Defense Acquisition Acronyms and Terms. 7th Edition*, unless otherwise noted:

Acquisition - The conceptualization, initiation, design, development, test, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services (including construction) to satisfy DOD needs, intended for use in or in support of military missions.

Capability - A measure of the systems' (industry's) ability to achieve mission (DOD) objectives, given the system (industry) condition during the mission.

Commercial (Civil)-Military Integration (CMI) - According to a report from the Congressional Office of Technology Assessment, "CMI is defined as the process of uniting the DIB and the larger commercial industrial base into a unified national industrial base. Under CMI, common technologies, processes, labor, equipment, material, and/or facilities would be used to meet both defense and commercial needs" (Boezer and others, 1997:39).

Dual-Use - Having defense and commercial application, whether as a technology, process or product. Dual-use technology refers to fields of research and development that have potential application to both defense and commercial production (Defense Conversion Commission, 1992:30-31).

Effectiveness - The extent to which the goals of the system (DOD) are attained, or the degree to which a system (DOD) can be expected to achieve a specific set of mission requirements.

Industrial Base - That part of the total private- and Government-owned industrial production and depot level equipment and maintenance capacity in the United States and its territories and possessions, and Canada. It is or shall be made available in an emergency for the manufacture of items required by the U.S. military services and selected allies.

Industrial Facilities - Industrial property (other than material, special tooling, military property, and special test equipment) for production, maintenance, research and development, or test, including real property and rights therein, buildings, structures, improvements, and plant equipment.

Industrial Mobilization - The process of marshaling the industrial sector to provide goods and services, including construction, required to support military operations and the needs of the civil sector during domestic or national emergencies. It includes the mobilization of materials, labor, capital, facilities, and contributory items and services. Mobilization activities may result in some disruption to the national economy.

Industrial Preparedness - The state of preparedness in industry to produce essential materiel to support the national military objectives.

Industry - The defense industry (private sector contractors) includes large and small organizations providing goods and services to DOD.

Prime Contractor - The entity with whom an agent of the United States entered into a prime contract for the purpose of obtaining supplies, materials, equipment, or services of any kind.

Production - The process of converting raw materials by fabrication into required material. It includes the functions of production-scheduling, inspection, quality control, and related processes.

Productivity - The actual rate of output or production per unit of time worked.

Quality - The composite of material attributes including performance features and characteristics of a production or service to satisfy a customer's given need.

Subcontractor - A contractor who enters into a contract with a prime contractor.

Surge - An increase in the production or repair of defense goods for a limited duration of time.

Surge Production - An increased rate of production necessary to meet demands for defense items due to a wartime or mobilization situation. This increased rate can be obtained by having excess production capacity available or by utilizing multiple shifts of normal capacity machines.

Summary

Increased globalization of national economies, a variety of unknown threats and weapons and overall dynamic change characterize today's security environment. In light of this unique environment, the Air Force is moving toward space for meeting defense needs in the future. Of particular importance is the U.S. satellite industry's ability to meet defense needs in space.

The weakened state of the DIB has been a serious concern for the DOD for many years. Numerous studies and testimonials by defense analysts have documented the DIB's deterioration over the years. Defense spending cuts, increased reliance on foreign suppliers for raw materials, overcapacity, lack of capital investment, and changing domestic priorities are among the biggest recent factors influencing the deterioration of the DIB.

Efforts to *commercialize* the DIB through CMI have been recommended to solve the historical deficiencies that have characterized the DIB for over two hundred years and the onset of current problems. CMI will involve integrating the DIB with the commercial industrial base, forming a consolidated national industrial base. Acquisition Reform and dual-use applications are meant to break down the acquisition and technology barriers between the commercial and defense industries. Reliance on a single national industrial base should help the DOD meet surge and mobilization requirements into the future.

The U.S. satellite industry seems to be faring well in today's environment. International markets and growing commercial space applications have made this trend possible. Dual use applications in the U.S. satellite industry make it marketable in both civilian and military markets.

Chapter II, **Literature Review**, develops an understanding of the DIB by highlighting the role it plays for DOD, considering the changing global environment; defines its relationship with the U.S. satellite industry; and illustrates the impact reductions in defense spending have on its ability to meet DOD objectives. Support is provided for *commercialized* industries that have the capability to serve both military and commercial markets. Current information on the U.S. satellite industry and its future outlook is furnished. Chapter III, **Methodology**, discusses the various research methods used to investigate each of the four propositions. Propositions 1 and 2 are supported via literature review. Proposition 3 is analyzed using literature review and case study analysis. The performance of a commercialized defense industry during periods of increased and decreased defense spending is analyzed. Lastly, interviews with U.S. satellite industry experts provide a comprehensive perspective on the current and projected status of this industry, particularly with respect to defense needs, supporting Proposition 4. Chapter IV, **Findings**, discusses each of the propositions in depth. Data collected through literature review, case study, and interviews is collected and analyzed. Finally, Chapter V, **Conclusions and Recommendations**, draws upon each of the investigative questions and propositions to provide a comprehensive analysis of the effects of a shrinking DIB on the U.S. satellite industry. Recommendations for further research are reviewed.

Chapter 2

Literature Review

> To maintain what is called in the business an adequate or *warm* defense technology and industrial base, the United States needs to be producing, year in and year out, sufficient modern weapon systems and sustaining components to allow us to maintain technological superiority in mission decisive areas and expand production on short notice. (Boezer and others, 1997:26-27)

Overview

The DOD is seriously concerned with the deteriorated condition of the DIB. In support of the new Air Force vision, *Global Engagement*, and DOD's increased interest in space exploitation, the U.S. satellite industry is one sector of the DIB that must be able to produce advanced satellite systems and maintain surge and mobilization capabilities. Current literature indicates this industry is healthy, growing and expanding into commercial markets worldwide. Increased dual use applications for both defense and commercial markets have made this trend possible. However, the effects of a shrinking DIB on this industry's growth and development must be fully explored to ensure it remains viable. After all, it was the defense market from which the satellite industry emanated.

The purpose of this literature review is threefold. Initially, it develops an understanding of the role the DIB plays in today's global defense environment; the

relationship the DIB has with the U.S. satellite industry, and; the impact reductions in defense spending have on its ability to meet DOD objectives. Evidence that the DIB is in disarray and shrinking is reviewed. Secondly, support is provided for *commercialized* industries involved in both military and commercial markets. These industries should be survive in spite of defense spending reductions. Third, with an understanding of the DIB's currently poor condition and the growing importance of space for future military applications, the satellite industry is targeted for analysis. Current information on the satellite industry and its future outlook is furnished. Due to the satellite industry being heavily *commercial* in nature, recent reductions in defense spending do not seem to have adversely affected its growth and performance. Many dual use satellite applications support this theory.

Growing Importance of Space

Our national security depends on access to and use of space now more than ever. It is through space in general, and satellites in particular, that the U.S. military performs many functions including: communications, environmental and remote sensing, meteorological support, missile defense, navigation, reconnaissance, surveillance, strategic early warning, and tactical warning/assessment (Mehuron, 1996:36). The satellite industry is therefore becoming more and more critical to space exploitation through satellite applications. The U.S. Air Force's new vision, *Global Engagement: A Vision for the 21st Century Air Force*, embraces air and *space* power as the strategic instruments of choice for future military confrontations. According to the authors,

Secretary of the Air Force Sheila Widnall and Air Force Chief of Staff General Ronald Fogleman:

> We are now transitioning from an *air* force into an *air and space* force on an evolutionary path to a *space and air* force. The threats to Americans and American forces from the use of space by adversaries are rising while our dependence on space assets is also increasing. The medium of space is one which cannot be ceded to our nation's adversaries. The Air Force must plan to prevail in the use of space.

According to Air Force General Howell M. Estes III, commander in chief of U.S. Space Command and NORAD and commander of Air Force Space Command, this "isn't a matter of changing philosophy or pioneering spirit but a practical recognition of risk, efficiency, commercial trends, and the fact that space will inevitably become a battle arena." He further emphasized "A tremendous amount of our economic strength is migrating to space." Between Government agencies and private industry, about 1,800 satellites will be put into orbit costing over a trillion dollars. "Dependence on these satellites will be akin to U.S. dependency on foreign oil and will represent a target to tempting to an enemy" (Tirpak, 1997:53). General Charles Horner, former Commander of U.S. Space Command, has been quoted having said, "The military DOD space program and the commercial space program are inextricably entwined. We all must become more competitive because our commercial program is just as vital to the strategic importance of this nation as is our military" (James, 1993:1). Former chief of long-range planning for U.S. Space Command, Colonel Steven J. Sloboda said, "The ability to gain and act on information more quickly than your opponent is the foundation for winning on today's battlefield – and space provides the tools critical to that advantage," (Scott, 1995:86). *Global Engagement* states:

> Space is already inextricably linked to military operations on land, sea and in the air. Several key military functions are migrating to space: Intelligence, Surveillance and Reconnaissance; warning; position location; weapons guidance; communications; and, environmental monitoring. Operations that now focus on air, land and sea will ultimately evolve into space.

Meeting U.S. Defense Needs in Space

> Adequate preparation for war has never yet in history been made after the beginning of hostilities without unnecessary slaughter, unjustifiable expense, and national peril. It is only in the years of peace that a nation can be made ready to fight. (U.S. Congress, 1980:7)

The U.S. Defense Industrial Base.

The relationship between the United States in its sovereign capacity and the American industrial base dates as far back as the Revolutionary War. The United States has traditionally relied on industrial strength for overwhelming the enemy and this industrial base for weapon system development and production. Historically, the DIB has been critical to the successful execution of U.S. military campaigns in most major conflicts. Table 2 summarizes the DIB's historical objectives.

Table 2. Historical Objectives of the DIB.

HISTORICAL OBJECTIVES OF THE DIB
Provide maximum deterrent and battle capability for dollars allocated.
Achieve maximum long and short term production efficiency with given resources.
Provide sufficient surge capability.
Achieve maximum technological advancement for future military advantage with resources available.
Minimize adverse effects on society and political process.

(Gansler, 1980:232)

The industrial might of the United States, according to most experts, became apparent in World War II and was the primary reason for U.S. and Allied victory

(Spenny, 1986:11). "During World War II, American industry mobilized to create the legendary *Arsenal of Democracy*, turning its output from consumer goods to war materiel and achieving extraordinary rates of production" (Correll and Nash, 1991:1). This *Arsenal* produced 310,000 aircraft, 88,000 tanks, 10 battleships, 358 destroyers, 211 submarines, 27 aircraft carriers, and over 900,000 trucks and motorized weapons carriers (U.S. Congress, 1980:8). Only after World War II did a distinct, national DIB emerge, when "capitalist economies militarized to an unprecedented degree" (Hartley and Sandler, 1995:453-468). Increasingly specialized defense systems and statutes and regulations that mandate unique buying practices for the Government established the basis for commercial-military segregation (Defense Conversion Commission, 1992:22).

Defense leaders emphasize the DIB's ability to respond with sufficient capacity and capability to meet any defense needs in times of war or large-scale mobilization (Gulick, 1983:2). According to President Bush's Defense Conversion Commission, the "Government has an enduring interest in ensuring that the capacity and capability of the DIB remain at an acceptable level" (Defense Conversion Commission, 1992:17). It also stated, "New-style conversion considers the preservation of a healthy defense production base to be a critical—perhaps *the* critical—goal. Special attention must be paid to ensuring sufficient industrial capability for national security" (Defense Conversion Commission, 1992:2). Also, n*ational protection* relies heavily on the efficiency in which the DIB supplies equipment (Sandler and Hartley, 1995:177). Table 3 summarizes the most important benefits obtained from maintaining an independent, national DIB.

The DIB is comprised of three dimensions. In one dimension, prime contractors establish the top tier. Major subcontractors and parts/material suppliers comprise the

second and third tiers, respectively. The lowest tier is the *dual use* tier, where commonality exists between defense industries and the rest of the commercial economy. Distinct major sectors of the defense industry make up the second dimension. Aerospace (including satellite), ship, and armament systems are among the largest of these sectors. In the third and last dimension, private and public ownership of the defense industry can be found. Approximately one-third of the plant and equipment in the aircraft industry is Government-owned; in the shipbuilding industry all shipbuilding yards (for new construction) are privately-owned; and in the munitions industry, the public sector owns almost all of the final-assembly operations (Gansler, 1989:239-240). In summary:

> The DIB can be defined as the prime contractors, subcontractors, and parts suppliers operating publicly and/or privately owned facilities supplying air, land, and sea systems. In addition to ensuring that the U.S. is self sufficient, the defense industry is required to expand rapidly in times of national emergency [surge capability]. (Gansler, 1989:Ch 8)

Table 3. Benefits of the DIB.

BENEFITS OF THE DIB	
Benefit	**Explanation**
National independence, security of supply (self-sufficiency) and responsiveness in emergencies and war	Frees nation from dependence on potentially unreliable foreign suppliers of essential defense equipment, particularly during a crisis or conflict.
Need to maintain a capability which a nation believes will be required in the future	Importing high technology means loss of a capability and integrating future weapons system development could be costly and time consuming.
Foreign supply leaves the buyer vulnerable to monopoly price increases	Once a nation is locked into a foreign supplier, the supplier is then able to charge monopoly prices for spares and support, so that life-cycle costs are higher than domestic alternative.
Foreign supply provides unsuitable equipment not tailored to a nation's requirements	Foreign suppliers may not be able to meet the unique needs of a particular country for defense.
Leverage	May enable a country to be a more informed buyer and improve its bargaining power when considering buying from foreign suppliers.
Provides national economic benefits	Jobs, technology, support for balance of payments, and contribution to tax revenue.

(Sandler and Hartley 1995:185-187)

The DIB can be categorized as *diverse*. It is composed of tens of thousands of companies, large and small, who directly or indirectly provide defense supplies and services to DOD. These companies can be categorized as prime contractors, subcontractors, or both and include some of the nation's largest and smallest businesses (Defense Conversion Commission, 1992:18). Essentially, the same large defense contractors supply the satellites, planes, ships, tanks, and munitions each year. Of these defense contractors, there are two types, those whose business is predominately made up of defense contracts, and those focused on commercial contracts but who have defense

divisions. The top 100 defense contractors do about 75% of the business, a ratio held since late 1950, indicating a highly concentrated DIB (Gansler, 1989:245).

Although effective in the majority of its engagements, the DIB has been characteristically inefficient in meeting production and surge requirements (Gulick, 1983:10). Eight significant structural features of the defense industry have evolved for over two hundred years, all of which lead to current DIB problems; see Table 4.

In order to fully comprehend the historical deficiencies characteristic of the DIB, it is necessary to understand the production factors supporting its existence; they are: labor, plants and equipment, money, materials and energy. The most significant characteristic of the defense labor market is the extreme long-term instability of defense needs, due in large part to the cyclical nature of the defense business. The increasingly high costs of labor are another factor because of an increased skill requirement of the labor force for manufacturing and engineering, long-term instability, and lack of price sensitivity in this market. The labor force is aging due to a shrinking and increasingly unattractive market; younger workers are seeking the stable, commercial market.

Table 4. Historic Problems with the Defense Industry.

HISTORIC PROBLEMS WITH THE DEFENSE INDUSTRY	
Problem	**Explanation**
Cyclical Nature of Defense Procurements	Since the Revolutionary War, the nation has gone through cycles of fluctuating defense spending. Defense planning is based on constant spending.
Lack of Structural Planning	The mix of Government-owned and privately-owned facilities has been based on chance. It has traditionally been assumed that a *free market* would achieve desired structural characteristics.
Inadequacy of Industrial-Preparedness Planning	Crisis planning is last minute and not performed during peacetime.
Lack of Actual Industrial Readiness	Mobilization of personnel is much faster than that of equipment, especially with the sophisticated equipment of today.
Importance of Technology and Research in Defense	The U.S. has always counted on technological superiority as the basis for a dominant military force. This directly leads industry to emphasize technology, not quality and cost. Industry focuses on new systems, not those in production.
Differences Among the Industries that Make Up the DIB	The Government insists upon *uniform procurement practices* across all sectors despite dramatic differences in these sectors. This standard approach for different industries further differentiates their structural characteristics.
High Concentration within Industrial Sectors	The cyclical nature of defense demands, complex nature, and extensive capital equipment cost of modern technology have increased the concentration of business to a few large firms.
Heavy Dependence on International Assistance	The DIB has become increasingly dependent on foreign sales of military equipment and on foreign supply sources for critical components/materials.

(Gansler, 1989:240-242)

A second production factor is plants and equipment. The plants and equipment in the DIB are characteristically old, inefficient, oversized, and productively slow. The reason for this can be traced to excess capacity necessary for the DIB to surge or mobilize and a lack of capital investment. A third production factor is money. There are severe financial problems from increased debt and DIB dependency on Government financing for operating capital and long-term investment. Lastly, materials and energy comprise the

fourth factor. A growing dependence on undependable foreign sources for raw and exotic materials, increased material and parts costs, and increased lead times for these items have created additional problems for the DIB (Gansler, 1980:50-71).

As a result of the Air Force emphasis on space, the U.S. satellite industry is recognized as one sector of the DIB deserving particular attention. It is imperative this industry have the capacity and capability to meet U.S. defense needs for the DOD to successfully control the space environment. Historically, DOD acquisitions have had a major impact on the satellite industry; its classified and unclassified programs have provided capital facilities for the U.S. satellite industry, making them more competitive (Moranville, 1993:13-14). Therefore, reduced DOD procurements may negatively impact its capability.

The U.S. Satellite Industry.

The U.S. satellite industry can be defined as that sector of the DIB that builds satellites, satellite earth terminals, and provides satellite services (Moranville, 1993:4). This industry provides the gateway to space the DOD requires for meeting current and future U.S. defense space needs. The satellite industry is highly concentrated, with the top five U.S. firms dominating the majority of contracts. See Appendix A. Currently, the largest U.S. companies in the satellite industry are: Lockheed Martin, Hughes, Boeing, TRW and Orbital Sciences Corporation.

Market forces have become increasingly more important for price setting in the satellite industry. The number of domestic and international manufacturers and buyers is increasing. A result has been free world market forces determining market prices. Barriers to entry for the satellite industry include a high degree of technical expertise,

specialized facilities such as climate controlled assembly rooms, capital investment, regulatory environment, and acquiring launch services (Moranville, 1993:11-12).

Satellite buyers consist of three areas of space activity – defense, civil, and commercial. The DOD has relied heavily on this industry for providing the satellites it needs to carry out its military space functions. NASA, NOAA and the Department of Commerce are heavily involved in civil space applications. Communications services are the largest segment of private space applications, affected by rapidly expanding technology and consumer demand (National Defense, 1993:11).

American military history establishes industrial strength as a critical factor for success in any military campaign. Therefore, it is critical that military strategists know what an industry is capable of doing for strategic planning purposes. If the defense industry cannot produce the weapon systems required by DOD in a timely manner, steps must be taken by Government to increase industrial capability and capacity. It is therefore necessary to assess the satellite industry's ability to meet future defense space requirements. An analysis of the factors affecting DIB strength will also determine, to a large extent, the strength of the satellite industry.

Strength of the U.S. Defense Industrial Base

Economic Perspective.

It is important to scrutinize the DIB from an economic standpoint. Economic analysis provides insight into how defense spending impacts not only the DIB in its entirety but also specific industries within the base. Probably the single-most important contributor to defense industry attractiveness is the size of the defense budget. In fact, it

has been determined that defense budget reductions have contributed to the accelerated decline of the DIB (Correll and Nash, 1991:45). There seems to be a definite correlation between defense spending and DIB strength. "The economic efficiency with which this industry operates during peacetime certainly bears directly on the strength and capability of the military in relation to the funds authorized annually by Congress" (Gansler, 1980:9).

Trends in defense budget authorizations seem to affect the attractiveness of the market. Higher defense budgets are attractive whereas reduced defense budgets are not. Changes in defense appropriations affect both large and small firms and to a considerable degree, unit pricing. DOD acquires most of its weapon systems from prime contractors. In responding to DOD demand for these weapon systems, the prime contractors impose their demand for certain resources (materials, components, sub-assemblies, etc.) on other suppliers. Changes in defense appropriations bring about subsequent changes in demand for supplies and services which, in turn, alter the prices for these products. In times of defense buildup, with the economy working at near maximum capacity, raw materials and resources must be drawn away from their alternative uses, thereby increasing their costs as inputs. Likewise, if the economy is not operating near maximum capacity, pricing may not be impacted when these resources are deferred from alternative uses (Taliaferro, 1994:122-123). Additionally, many military technologies have no commercial application. Military technologies with no commercial application are dependent on DOD dollars; while those with commercial markets, however, need defense investment to keep them responsive to military requirements. There are some industries with both a commercial and military market which could be integrated. Examples of these include

electronics, communications, and computers sectors. Even so, decreased defense budgets culminate in decreased defense business in these industries (Blackwell, 1992:21).

Impact of Defense Spending.

A steady parade of literature has been written over the years about the impact defense spending has on the DIB and no one can deny the defense industry's primary motivation for supporting the *base* is profit. Defense dollars are critical to the health and well-being of the DIB. With the changing global environment and subsequent reductions in defense spending, instability has led to the "best-known and most troublesome problems associated with defense acquisitions, cost increases (*overruns*) and schedule slippage." Studies conducted by the General Accounting Office have shown defense program cost increases of between 50 and 100 percent as a result of annual cost overruns. Numbering in the billions of dollars, these costs and schedule slippage's that usually follow overruns delay delivery by about 30 percent. "Cost growth and schedule slippage interrelate and reinforce each other." Increasing costs on a fixed or decreasing budget are remedied in the short-term by either stretching out the scheduled delivery dates to *apply* the higher costs into the existing or diminishing budget or fewer units are acquired. Three sources of this instability have been identified. They are: (1) changes in the budget, (2) changes originated from within an individual program's budget, quantities, and/or technical requirements, and (3) changes within program requirements (Gansler, 1989:121-123).

> As annual quantities decline, unit costs rise. Equipment must be built at a less efficient rate, and all the *fixed* costs of plant, equipment, and management must be absorbed by fewer units. Thus begins the spiraling of costs. When units cost increase, still fewer weapon systems are bought. Significantly fewer units are procured, even if the programs themselves are otherwise perfectly managed. However, as history has shown, costs within most DOD programs have a tendency to grow; thus, if unit costs in each

> program grow, and total dollars are fixed, the quantities of each system that can be procured are smaller yet. This causes further reductions in annual production rates, a corresponding increase in unit costs, and still another reduction in quantities procured. The effect on the armed forces is clear: they get fewer weapon systems, and they get them later. (Gansler, 1989:124)

Norman Augustine addressed the issue of declining defense budgets with some concern. He said, "The natural result of rapidly declining U.S. military procurement budgets is an extraordinary degree of excess capacity in the defense industry, increased overhead, pushed up unit production costs, requiring the closing of plants and necessitating the elimination of jobs" (Augustine, 1993:53). He estimated that by 1998 more than 1.2 million defense workers will have lost their jobs.

> The financial health of the defense industry has deteriorated significantly. Over the period 1985 to 1992, profits on defense business have fallen, in real terms, by 28 percent while the assets required to earn those profits grew by 8 percent. During the same period, annual return on equity tumbled from 15 percent to 12 percent. Return on assets fell from 16 percent to 11 percent, and debt leverage increased from 28 percent to 35 percent. Aerospace companies, a prominent element of the defense industry, today sell at a 57 percent discount to the market average, based on price-to-earnings multiples. The combined market value of the five largest domestic aerospace/defense companies is today less than that of McDonald's hamburger chain. (Augustine, 1993:53)

Assessment of Strength.

An argument can be deduced from the aforementioned discussion that defense spending impacts the ability of the DIB to meet DOD objectives. Logically, this seems to be the foundation upon which an assessment of DIB strength can be measured. Assessing DIB strength is a precarious effort; a variety of quantitative and qualitative variables affect its performance, many of which are not easily measured. The Defense Science Board found in its October 1988 report, "The performance and capability of the DIB is

directly affected by changes in tax, trade, environmental and socioeconomic policies" (Pascall and Lamson, 1991:87). However, the impact of defense spending appears to be the dominate variable influencing DIB strength; see Figure 1.

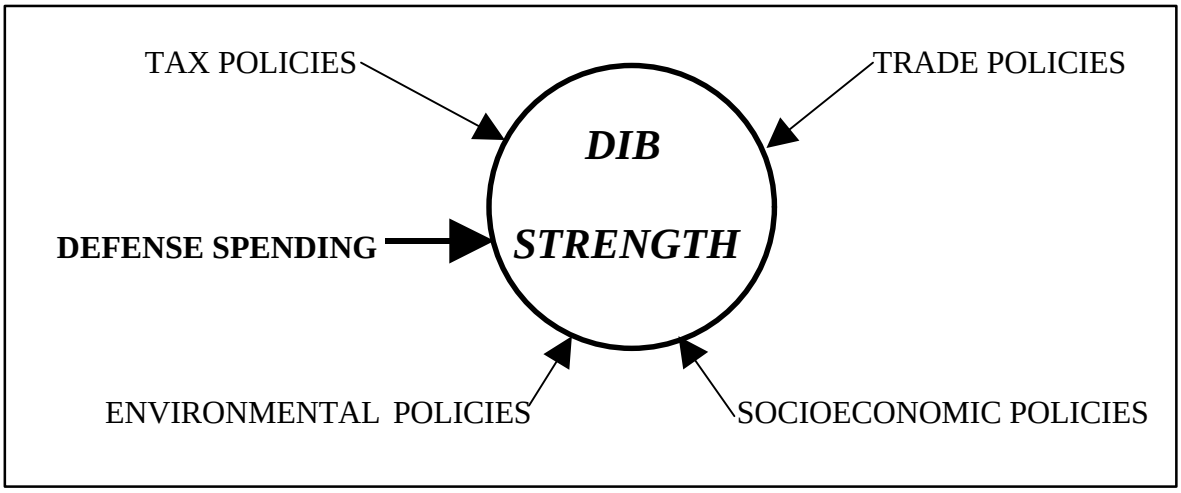


Figure 1. Variables Influencing DIB Strength

Despite the vast amount of literature and numerous studies conducted on behalf of the DIB, no one has developed a model measuring DIB strength. Yet, throughout the literature, certain core factors affected by defense spending are systematically addressed time and time again – production, competition and technology. These factors are either recognized as important attributes for DOD warfighting capabilities or issues that need to be addressed as a result of DOD downsizing and reduced defense spending.

The DOD identified four principal objectives for the DIB over the next 10 to 20 years. Perhaps the best way to measure the DIB strength is by assessing the degree to which it meets DOD objectives. Meeting these objectives, in turn, denotes the level of industrial preparedness the DIB maintains. These objectives are summarized in Table 5.

Table 5. DIB Objectives.

DIB OBJECTIVES
First, it must support the base force structure in peacetime.
Second, beyond peacetime, it must be capable of supporting contingency-related needs.
Third, the industrial base must be able to build up production capacity faster than any newly emerging global threat can build up its capacity.
Fourth, the industrial base must be as efficient and cost-effective as possible.

(Changing Defense, 1992:48)

The concept of *industrial preparedness* captures the essence of what objectives the DOD expects the DIB to meet. This concept has drawn the attention of many researchers. Its nemesis culminates in required production surges, equipment modifications, and new system demands which have not changed substantially since the end of the Cold War and continue to be important for DIB preparedness. In future crises, DIB response will have to be carefully tailored, increasingly smaller, quicker, and more sophisticated for the U.S. to remain dominant into the 21st century (Austin, 1994:29). DIB preparedness can be defined as:

> Having the capability to produce in a timely manner the additional goods and services needed to support military operations. In effect, industrial preparedness means getting ready for industrial mobilization, which involves providing war materiel to bring military units to wartime readiness and to sustain them in combat. Industrial preparedness seeks to assure that the combination of peacetime stocks and mobilization production will be sufficient to meet the needs of military units during a war. (Brinkerhoff, 1994:38)

Two terms frequently used in conjunction with the idea of industrial preparedness, surge and mobilization, deserve particular attention. "A *surge* is defined as increasing production to its maximum limits without adding new capacity in the form of additional equipment and facilities, which would be *mobilization*" (Polmar and others, 1988:11). Surge is the initial acceleration of production from peacetime rates to a rate some 50 to

200 percent higher. Later, conversion of the commercial economy to wartime production at higher output levels, represents mobilization. "A competent mobilization plan would have to concentrate first on *faster* production and second on *greater* production" (Libicki, 1988:14-15). In a discussion of surge and mobilization, Gulick bespeaks meeting these requirements through DIB capacity and capability (Gulick, 1983:25). The connection between defense spending, capacity, and capability can be summarized in the following statement. "A decade of declining defense expenditures coupled with the generic ills of U.S. heavy industry have led to a shrinking production base, with fewer producers and less capacity" (Libicki, 1988:13) and the prospects of future defense spending cuts will affect the size, structure and composition of the DIB (Sandler and Hartley, 1995:177-178). It seems logical there might be some correlation between defense budgets and DIB strength, in terms of capacity and capability.

> Industrial capacity and capability are two sides of the same coin. Capacity refers to volume that can be produced over a certain time period. In contrast, capability is a function of the ability of machinery to withstand a surge of continuous operation, the amount of raw materials available for use in the manufacturing process, and the adaptability of a firm to switch to producing *guns* instead of *butter*. (Gulick, 1983:2)

In discussing the historical deficiencies of the DIB, it was necessary to address the *factors of production* – labor, plants and equipment, money, materials and energy (Gansler, 1980:50). Likewise, in assessing the strength of the DIB, these production factors are equally important; the DOD can significantly increase DIB efficiencies by focusing on these factors. Defense work is characteristically labor-intensive, yet there is substantial instability in the DIB labor force (Gansler, 1989:248). Not to mention, many of the professional and technical skills that support the DIB are developed internally

through individualized, often lengthy, on-the-job training. Reductions in force pose significant problems in retaining these critical skills (Gordon, 1996:8-9). The Defense Conversion Commission stressed the importance of maintaining critical capabilities and skills, and went so far as to say the DOD may have to undertake special actions to preserve certain capabilities and skills not necessary now but possibly in the future (Defense Conversion Commission, 1992:20).

Modern plants and capital equipment combined with modern manufacturing methods are critical to producing complex, high-quality systems at lower costs (Gansler, 1989:251). Flexible manufacturing provides the capability to integrate commercial and military production, facilitating reduced plant overhead and labor costs. Integrated operations would also be an effective way of rapidly surging production during a crisis (Gansler, 1992:54). Smaller numbers of items can be produced more efficiently, reducing the reliance on economies of scale. The potential also exists here to use new manufacturing methods to sustain critical process capabilities, necessary for defense work (Changing Defense, 1992:48-49). Current DOD policies highlight design, production and technological capabilities critical to defense. Two DIB programs indicating DOD interest in manufacturing capability are: Manufacturing Technology (MANTECH) and Industrial Modernization Incentives Program (IMIP). MANTECH "seeks to improve productivity and responsiveness of the DIB by funding research efforts to develop manufacturing technologies," while IMIP "concentrates on modernization efforts that improve the production of existing facilities" (Correll and Nash, 1991:51-52). Another means of providing manufacturers proven manufacturing capability information and best manufacturing practices were the development of manufacturing extension centers. The

Defense Conversion Commission encouraged manufacturers to adopt current, more productive, capital equipment and production processes using these resource centers as a means of disseminating this important information (Defense Conversion Commission, 1992:29).

Tied directly with issues of plant and equipment are financial matters – money. Essentially, the concern with money is the difficulty defense firms have in raising money. This money is necessary for investing in modern plants and equipment (Gansler, 1980:59). The DIB generates its dollars from three sources, the financial community or through DOD progress payments and profit (Gansler, 1989:252). "Financial stability is essential for suppliers to assure continuity of supply and reliability of product quality" (Dobler and Burt, 1996:241). In the MILSTAR Program, financial analyses of MILSTAR suppliers' health and sales was calculated to determine overall risk ratings (Gordon, 1996:10-11).

The economic and strategic viability of the DIB center around raw materials and energy (Gansler, 1980:63). Rising prices of imported raw materials and energy and increased reliance on foreign suppliers for critical components is an issue of growing concern (Gansler, 1989:242,270). The DIB not only has to deal with increased prices for imported and exotic raw materials and parts but also increased lead times (Gansler, 1980:71). In the MILSTAR program, "Many suppliers report distributors and manufacturers of raw materials and critical components have discontinued stocking products required for production of military items, reducing availability. This impacts the suppliers' ability to produce military products in a timely manner" (Gordon, 1996:7).

Industry competition in all tiers of the DIB continues to be an issue of paramount importance to DIB analysts. Reduced competition among defense industry sectors and potential problems with lower tier firms are of particular concern (Boezer and others, 1997:46). Primarily, the focus has been on growing problems and reduced numbers of suppliers in the lower tiers. Subcontracting for the DIB is simply unattractive for a variety of reasons (Gansler, 1989:260). Obviously, prime contractors are vital to the DIB; unlike the lower tiers though, there is a need to reduce their numbers due to unhealthy financial conditions, aging plants and equipment, and excess capacity (Gansler, 1989:242). Only since the end of the Cold War have prime contractors begun to shrink in numbers. Concerns about sufficiency (Correll and Nash, 1991:4) bridge the notion of industry competition to issues of industrial capacity. Common sense dictates higher levels of industry competition indicate additional capacity and capability within an industry – not necessarily efficiency. The DOD has emphasized the need to stimulate efficiency and competition in order to receive the best services at a fair and reasonable price (Changing Defense, 1992:52). Accurately measuring industry competition is difficult in the lower tiers. Only those industries whose bulk of output is earmarked for defense markets comprise the defense industry (Sandler and Hartley, 1995:182).

> A direct measure of the DIB companies will tend to understate its importance as there are many sub-contractors who are dependent to different degrees on military-related orders but through the intermediary of other contractors. Indeed, some firms will not know they are part of the DIB if they are making intermediate products or components. (Hartley and Sandler, 1995:403)

Technology is at the apex of the DIB problem (Correll and Nash, 1991:35) and maintaining superior, cutting-edge technology is a driving issue in assessing DIB strength

(Gordon, 1996:7). Despite DOD downsizing, future challenges can be met by sustaining the type of technological edge demonstrated in Operation Desert Storm (Changing Defense, 1992:48). Research and development is not enough though; extraordinary efforts in science and technology must be combined with production in order to preserve the production infrastructure (Correll and Nash, 1991:55). Vulnerable, unique and critical technologies important to national defense must be secured and maintained (Gordon, 1996:7). Emphasis placed on dual use technology and production strategies pinpoints DOD's need to preserve the technological superiority of U.S. forces at an affordable cost (OSD, 1995:1). Similar to the programs used to develop manufacturing capabilities, the DOD supports advanced technology development through several other programs. One such program is the Advanced Research Projects Agency. This program promotes research and development of cutting-edge technology. Its purpose, among other things, is to provide the DOD access to all of the technology, manufacturing-processes technology and procedures being used in commercial industry today (Kitfield, 1993:31-32). Another approach, the Technology Reinvestment Program, provides funds for companies developing dual use technologies (Kitfield, 1995:37).

With the end of the Cold War, growing domestic problems, increased *globalization* of the world economy, and dwindling defense budgets, the DOD has entered upon a new age for defense and higher demands for the DIB. Among the plenitude of defense-related topics that have surfaced over the last twenty years, the DIB has continued to be a heated issue. Numerous DIB studies and research efforts reveal serious problems within the DIB. It is both inefficient and ineffective in meeting defense needs. Diminishing defense

budgets seem to be the catalyst for the shrinking DIB and its reduced strength in meeting DOD objectives.

Current Quandary

Environmental Context.

During the Reagan Administration, defense buildup increased to record-breaking peacetime levels (Gansler, 1989:3), commanding an impressive high budget of $96.8 billion in 1985 (Gansler, 1992:50). During this period, Government projected defense budgets in excess of $500 billion in the next few years. The DIB reacted with nearly a decade of facilities expansion to accommodate these projections. "Their multibillion-dollar investments, based on expectations that have not been realized, have left companies on every tier of the DIB with manufacturing capacity far exceeding market demand" (Allay Industry's, 1993:66). The overcapacity developed from the Reagan Administration coupled with the end of the Cold War has created numerous problems within the DIB, in addition to its historical deficiencies. There is concern the shrinking DIB will create problems regarding preparedness. Defense firms who were primarily engaged in defense-related contracts, now look to sources of income other than defense (Austin, 1994:27), particularly foreign markets and a global economy (Gansler, 1993:132).

The environmental context within which the defense industry currently operates is one of dynamic change, political and economic uncertainty, global competition and where "change itself has become the norm" (Austin, 1994:27). In recent years the Berlin Wall fell, the Warsaw Pact dissolved, the Soviet Union disbanded, and the Cold War conflict

came to an end after 40 years (Armstrong, 1993:339). As a result, Congress has mandated huge defense budget cuts. Reduced defense expenditures have consequently led to a shrinking defense force and increased competition within the various services of the armed forces for fewer major weapon systems. Defense budgets have been decreasing since the Reagan high in 1985 (Gansler, 1992:50), reflecting changing demands on the nation's resources other than defense (Gansler, 1989:1-2), shrinking the DIB.

Deterioration of the U.S. Defense Industrial Base.

The deterioration of the DIB has been well-documented in various industrial base investigations, Government-sponsored research projects, and defense expert testimonials since World War II. Concerns regarding the DIB have become especially prominent since the end of the Cold War, leading to increased Congressional interest and action. As early as 1980 however, the Committee on Armed Services convened the DIB Panel, one of the first investigations concerned with the condition of the DIB. This was an in-depth study chaired by Representative Richard H. Ichord. The panel listened to the testimonials from the defense industry and DOD, confirming and detailing the deplorable state of the DIB. Ichord warned "There has been a serious decline in the nation's defense industrial capability that places our national security in jeopardy" (U.S. Congress, 1980:1). The *Ichord Report* encouraged DOD to place reinvigorated emphasis on DIB issues.

Gansler stated in his 1980 book, The Defense Industry, "the overriding conclusion of this book is that the industrial base of U.S. defense is becoming both economically inefficient in the production of defense materiel and strategically unresponsive in terms of the production speedup required to meet an emergency" (Gansler, 1980:4). Several studies conducted in the 1980's by the Defense Science Board Task Force and Air Force

Systems Command concluded DIB problems centered around substantial peacetime inefficiency for normal operations and critical bottlenecks, resulting in a near complete lack of industrial preparedness. An emphasis on short-term objectives led to high costs and low quality products in the 1980's instead of the sought after high quality, low-cost products desired by the national industrial base (Gansler, 1989:9-10).

Currently, the DIB is almost entirely dependent on the DOD, isolated from the commercial economy by Government regulations and red-tape, thwarted by exorbitant debt, excess production capacity, a rapidly shrinking market, escalating unit costs, lengthening development cycles, and lack of confidence (Gansler, 1993:134). "The current weapons acquisition system involves a morass of laws, regulations, and Government practices that virtually force defense contractors to develop products, production processes, and business practices that are unique to a single customer – the DOD" (Gansler, 1992:51). Adding to the frustrated DIB's long list of problems, were problems even at the prime contractor level.

> At the prime-contractor level, the defense industry shows definite signs of a *sick* industry. The firms operate in a weakening market with heavy debt, difficulty of borrowing, considerable excess capacity, low cash generation, high and growing risks, old production equipment, too little capital investment, relatively low productivity, mixed quality, and rapidly rising prices. (Gansler, 1989:256)

Experts are concerned with potential bottlenecks caused by a shrinking DIB on the lower-tiered subcontractors. "The real problems could lie in the second and third tiers of specialty companies, because they don't have the staying power of the big companies, and they don't command the attention we get" said Augustine of Lockheed Martin (Kitfield, 1995:47). Furthermore, increased regulation of the defense acquisition process during the

1980's segregated military research and development and manufacturing, leading to billions of dollars in redundant capital and labor investment (Gansler, 1993:141). Three major concerns of the DIB can be summarized as follows:

- Can it meet the needs of the armed forces in peace and war?
- Are we becoming dangerously dependent on foreign sources for critical defense commodities?
- Is U.S. technology on the decline, along with the industrial infrastructure?

(Correll and Nash, 1991:1)

The conclusions reached by Correll and Nash regarding the above questions are: Generally speaking, there is a problem with the DIB; it is adequate in peace, yet questionable in war. Technology is critical, but research and development is not enough. Without production, those suppliers and manufacturers needed to convert research into production will vanish, leaving new technology in the laboratory and nowhere else. Increased dependence on foreign suppliers may lead to vulnerabilities and potential danger. The defense industry has become increasingly unattractive for many firms and this avoidance further perpetuates a shrinking DIB (Correll and Nash, 1991:55).

The Shrinking U.S. Defense Industrial Base.

Current literature and recent actions by defense industries clearly indicate the DIB is shrinking. During this turbulent period, major contractors have begun to adjust to reductions in defense spending and overcapacity by cutting their losses, diversifying, divesting, and disappearing (Correll and Nash, 1991:2-3); while others have turned to acquisitions and mergers as a means of consolidating (Kitfield, 1995:42); and still others have resorted to concentrating on their core defense capabilities (rationalizing) (Defense Conversion Commission, 1992: 19). Many firms diversified by seeking commercial

markets for their business. Diversification has been described "as a panacea for industries seeking alternatives to defense contracts" (Austin, 1994:31). Some firms even began to divest themselves of their defense divisions. Small suppliers have disappeared; companies went out of business; still others moved to nondefense markets (Correll and Nash, 1991:2-3). Augustine claimed there have been 300 defense-related mergers and acquisitions in the U.S. over the past decade. He further stated:

> The current defense consolidation is unprecedented because of its scale, its rapidity, the specialization of the firms involved, and its *political* roots – in other words, we are consolidating because there is a change in the *perception* of the threat that the U.S. faces, a perception which may or may not be borne out over the long term but which is nonetheless very real today. (Augustine, 1993:54)

The Defense Systems Management College reported "Of 244 firms responding to a survey in 1990, twenty-one percent said they were cutting back on or getting out of defense business" (Correll and Nash, 1991:3). The Defense Budget Project, in 1994 alone, tracked more than a dozen mergers and acquisitions, including mega-mergers that produced Lockheed Martin, Northrop Grumman, and E-Systems-Raytheon. "This provides a glimpse into a future DIB dominated by a very few mega-companies" (Kitfield, 1994:56).

According to Gansler, trends likely to continue in the defense industry include mergers, *teaming* of defense firms bidding on the few new available contracts, and a declining number of defense firms (Gansler, 1989:255-256). In a 1993 dinner known as *The Last Supper*, Pentagon leaders announced to the captains of American industry that more than half of them would not survive the impending drawdown. Defense Secretary William Perry told industry leaders, "the Pentagon could support perhaps two suppliers

where five or six existed in each category, whether it was aircraft or space systems." Augustine said it was very clear the need to consolidate (Kitfield, 1995:39). See Appendix B for recent acquisitions and mergers in the aerospace industry.

Alliances on major development programs helps spread financial risk among several companies and individual firms can be held responsible for their area of greatest strength, complementing the capabilities of participating teams. The problem resides in reduced defense demands for business. This forces firms to uneconomical levels of production, prohibits innovation, and requires capacity consolidation or removal. In contrast to decreased demand and substantial overcapacity for military aircraft, helicopter, and missile markets, "Satellites and space launch vehicles are expected to enjoy significant overall growth through the end of the decade. Even here, however, the proliferation of new, capable competitors will create growing pressure for consolidation" (Velocci, 1994:44).

Defense industry contraction is inevitable with a shrinking defense market (Gansler, 1992:50). Correll and Nash identified smaller defense orders, tougher environmental regulations, and better prospects in commercial markets among the main reasons for the deteriorating DIB. They also suggested the increased industrial base decline of the 1990's (compared to the 1980's) probably resulted from radical defense budget reductions. This is no surprise and is indicative of the declining DIB strength.

In the U.S. satellite industry, mergers and acquisitions have become prevalent over the last few years. The three main U.S. satellite producers have undergone extensive consolidations in recent years. "The competitive desirability of being able to offer customers one-stop, turnkey operations is encouraging corporate mergers, acquisitions

and joint ventures. The effect would be to reduce the number of space prime contractors" (Caceres, 1997:117). This trend of consolidation has become necessary because of the excess capacity rampant throughout the defense industry. "For example, Martin Marietta acquired GE Aerospace for $3 billion in November, 1992. This move enabled Martin Marietta to combine its Titan rocket boosters with GE's communication satellites, which gave the company an edge in future marketing efforts" (Moranville, 1993:20). Hughes has also diversified into the commercial market. GM Hughes Electronics, in particular, is now involved in a technically-related commercial venture offering DirectTV, the United States' first direct-to-home satellite system, after three decades of experience in making military satellites (Kitfield, 1995:42 and Swords, 1994:8).

The dilemma faced by our leaders today is rigorous. In order to maintain our defense superiority, the DOD must develop and produce specialized equipment for major regional conflicts around the world. Concurrently, increased dollars are required to pay for higher quality and numbers of people, modernization of facilities and equipment to support them on a global basis. Other demands on the nation's resources have detracted the public's attention away from defense, into other areas. In times of defense drawdowns, it is harder to continue the traditional solution of increasing the defense budget (Gansler, 1989:1-2).

The Need for Change.

> For the past 50 years America's national security threat was primarily defined by the global nuclear and conventional capability of the former Soviet Union. The collapse of Communism and end of the Cold War profoundly changed the way national security needs are defined. Today we face challenges that are different but no less complex: the spread of nuclear weapons and other weapons of mass destruction; major regional, ethnic, and religious conflicts; uncertainty about democratic reform in the former Warsaw Pact and the developing world; and potential challenges to

> the economic viability of industrial capabilities vital to our national security. (OSD, 1995:1)

Leaders of the United States are faced with profound challenges. In today's rapidly changing environment, the globalization of national economies, domination of domestic commercial markets for high-technology product development, diminishing defense dollars, and emphasis on technology for defense have become the norm; this phenomenon places an increased and unique demand on the defense industry for meeting defense needs. The United States has become increasingly dependent on foreign sources of supply for raw materials. "Because of foreign dependencies and other reasons, domestic industry has difficulty in meeting peacetime, let alone wartime, defense needs" (Austin, 1994:29). A long-term strategy must be developed by the United States to address the problems of the DIB, concurrently satisfying national security needs, while reducing dependence on foreign sales (Gansler, 1993:133).

The future challenges for the defense industry, in a time of smaller acquisition budgets, will be to maintain innovative and technological superiority, while shifting toward increasing emphasis in producing higher quality, lower cost weapon systems (Gansler, 1989:245) and retaining the capability of developing and manufacturing these systems in a cost-effective, timely manner (Gansler, 1993:131). Due to the high and growing costs of major weapons systems, we are getting less defense equipment each year and will continue to get less, especially in light of defense budget cuts, leading to the perception of declining national security. Industry must be able to produce and sustain weapon systems, incorporating technological advantages and using sophistication, rather than volume, to strategize (Austin, 1994:29). "In many product and process technologies,

commercial practice has surpassed defense practice, with the result that the DOD often pays more for less advanced products" (Polmar and others, 1988:i,1). According to General Estes, the increased market opportunity and profit potential has led to additional commercial investment, resulting in "commercial progress in space systems far outstripping anything we are doing in the military." "The Air Force won't be able to afford the technological steps necessary to become the space power it desires. It will have to take on industry partners for some technology, while others will be purchased or leased." Advanced commercial space systems make buying off-the-shelf a distinct possibility for the DOD (Tirpak, 1997:53).

> The need for DOD to reexamine its technology strategy is compelling. Maintaining access to the most advanced technologies at affordable prices will require fundamental changes. DOD must forge a new partnership with commercial industry, encouraging coordinated efforts that assure access to leading-edge technology in areas critical to the U.S. military. DOD must also make cross-cutting investments internally to facilitate the rapid adoption by the military of commercial products, processes, practices, and technologies. DOD will rely on defense-unique development and procurement only when a technology or system required for a national security mission has no commercial source, or where investment risks are large and time frame very long. (OSD, 1995:2)

Although much has been written since the mid 1970's concerning the weakened DIB and proposed solutions for its recovery, the DIB is a means to an end and not the end in and of itself. Rather than maintaining a separate DIB, *commercializing* the defense industry is now thought to be the most efficient and effective way to meet defense needs. Those industries with the capability to serve both commercial and military markets have the upper hand in today's environment. Four key changes in the environment wherein the DOD operates indicate the need to eliminate segregation and emphasize greater integration of the defense and commercial sectors. These changes significantly

influenced the paradigm shift that has taken place within the DOD regarding its acquisition practices and strategies.

1. DOD follows commercial industry in some key technologies.

2. As defense-unique procurement quantities go down, unit costs go up.

3. There is less potential for competition to keep costs down.

4. DOD plans to rely more on the commercial industrial base to satisfy future surges in demand. (Defense Conversion Commission, 1992:22)

Commercialization of the U.S. Defense Industrial Base

> At this juncture in history there is a rare coalescence—a dynamically changing geopolitical environment, a rapidly declining defense budget, and a willingness among the American people to cast aside old ways to reduce the federal deficit and catalyze the economy. It is this country's chance to garner support for sweeping change in the defense industry. (Gansler, 1992:57)

The Future U.S. Defense Industrial Base.

Senior defense officials envision a smaller, more flexible DIB, with traditional barriers between commercial and military markets removed. Without leveraging the booming commercial industrial base, DIB strength will continue to diminish. "The DOD acquisition system is large and extraordinarily complex. It needs to enable DOD to take advantage of the technological advances and efficient procurement practices of the commercial marketplace" (Gore, 1993:136). Former Defense Secretary William Perry said, "We'll be changing how we deal with the industrial base so that our procedures are more like commercial contracting procedures. We'll also try to integrate certain components of the DIB with the national industrial base" (Kitfield, 1993:42). The future

DIB will be leaner, more efficient, with only a few large prime contractors in each key market niche, such as satellites, aircraft, tanks, and nuclear submarines. Government will probably exert little influence in the future DIB, letting market forces determine its shape (Correll and Nash, 1991:55). Production lines in the future, in most cases, will satisfy both commercial and defense needs. Emphasis will be placed toward *silver bullet* research and development projects and upgrades (Kitfield, 1993:31), low-rate production (Kitfield, 1995:47), science and technology, including manufacturing process technology (Changing Defense, 1992:48).

Commercial-Military Integration (CMI).

Defense conversion to commercial business practices, commercial products, commercial facilities, and *dual use* technology form what is now called Commercial (Civil)-Military Integration (CMI) (Gansler, 1993:135). According to a report from the Congressional Office of Technology Assessment:

> CMI is defined as the process of uniting the DIB and the larger commercial industrial base into a unified national industrial base. Under CMI, common technologies, processes, labor, equipment, material, and/or facilities would be used to meet both defense and commercial needs. (Boezer and others, 1997:39)

CMI is focused on expanding and preserving the DIB for defense-related materiel production. The underlying theory behind CMI is that most defense weapon systems contain parts used also in commercially manufactured goods. Additionally, Boezer cites Richard White's *Documentation for Forces Mobilization Model FORCEMOB: Theoretical Foundations*, on the essence of CMI; saying:

> Sufficient commonality between commercial and defense needs can be *designed into* military systems and weapons so that commercial capabilities can fulfill the vast majority of defense requirements. In

> research and development this goal is pursued through so-called dual use technologies that are both commercially viable in the competitive marketplace and militarily useful either directly or with limited modification. (Boezer and others, 1997:39-40)

Three interrelated components for a CMI strategy are: research and development integration fostering dual-use technologies critical for national defense and economic competition; engineering, manufacturing and logistic support integration to promote the most efficient allocation of productive resources; and an increased reliance on commercial items to reduce costs, compress lead times and improve reliability (Gansler, 1993:138). CMI is based on three significant technological shifts that occurred in the late 1980's.

> First, the commercial sector is now pre-eminent in many key technologies. Increasingly, commercial products are cheaper, more reliable and capable of operating in extremely rugged environments. Second, internationally competitive corporations are moving away from mass production and towards *flexible manufacturing*, in which high efficiency can be achieved even at low production rates. The revolution in advanced-process technology makes it increasingly attractive (and feasible) for firms to manufacture commercial and military products, with similar production requirements, in common facilities and on common production lines. Third, there is a growing commonality in the key technologies used in the development and production of sophisticated military and commercial products. (Gansler, 1993:135-136 and 1992:51)

Several CMI initiatives have already made some headway. President Bill Clinton's 1993 Defense Transition Program is one such effort. This package of programs includes an initiative to help the transition of industries heavily dependent upon defense. The Clinton Administration, for example, provided Advanced Research Projects Agency $1.4 billion of matching funds in 1993 to support companies using military technology to produce commercial products (Kitfield, 1993:32). Further, the DOD has been given authority to promote the commercialization of defense technology and manufacturing

techniques. "To broaden its access to the national industrial base, the department is shifting from military-unique products and processes to commercial counterparts wherever possible" (Changing Defense, 1992:52).

Acquisition Reform and dual-use technology and production strategies are the foundation for CMI. The *Acquisition Reform Mission* states the DOD must: (1) Be able to rapidly acquire commercial and other state-of-the-art products and technology, from suppliers who utilize the latest manufacturing and management techniques; (2) Assist in the conversion of U.S. defense-unique companies to dual use production; (3) Aid in the transfer of military technology to the commercial sector; (4) Preserve defense-unique core capabilities (e.g., submarines, armored vehicles, and fighter aircraft); (5) Integrate, broaden and maintain a national industrial base sustained primarily by commercial demand but capable of meeting DOD's needs; (6) Be able to adopt business processes characteristic of world class customers and suppliers (including processes that encourage DOD's suppliers to do the same), and; (7) Be free to stop applying Government-unique terms and conditions on its contractors to the maximum extent practicable (Acquisition Reform Mission, 1997:1-2). "DOD Acquisition Reform seeks to bring about a simplified commercial-style procurement system that gives priority to acquiring commercial products and processes, and wherever possible eliminates those unique contracting, technical, and accounting requirements that form a barrier to greater military/commercial integration" (OSD, 1995:1). This reformation of the federal acquisition system provides the foundation for DIB integration into the national industrial base.

"Dual use means having defense and commercial application, whether as a technology, process or product." Dual-use technology applies to research and

development fields that have potential defense and commercial production application. Examples of dual-use technology include: imaging-sensor technology which can be used in surveillance systems, video cameras and robotic-vision systems. Most of today's technologies can be considered dual use to some degree. Dual-use processes are those that can be used for manufacturing both defense and commercial products. Examples of dual-use processes include: soldering, process control, and computer-aided design. Dual-use products are items that can be used by both defense and commercial customers. Some examples include: global positioning systems used for navigation, aircraft engines, and medical equipment (Defense Conversion Commission, 1992:30).

> Dual use programs are instrumental to the DOD's goal of moving away from separate defense and commercial bases to an integrated, national industrial base. A dual-use technology and production strategy will allow the DOD to leverage the overall U.S. industrial base and keep our weapon systems on the leading edge of technology – the winning edge. (OSD, 1995:1)

Dunne cited Walker (1988) and Schofield (1993) for their system integration analysis and views of a hierarchy of products. They claim prime contractors are systems manufacturers integrating a myriad of subsystems into a finished product. "A hierarchy of products from systems to low level components have different generic and specific characteristics and a decreasing differentiation between military and civil products. Indeed, many of the low level technologies are *dual use*" (Hartley and Sandler, 1995:403). At the top of the continuum, products are characterized by high unit cost, complex systemic integration, with long product life. Low unit cost, mass-produced products are at the bottom. See Table 6.

The commercial market currently possesses leading-edge technology in many component and subsystem areas critical to modern defense weapon systems (OSD, 1995:1). Dual-use technology at these levels make applications for both the commercial and military markets possible. The Clinton Administration's policy on dual-use technology and production is arguably the predominate endeavor for preserving the DIB. DOD continues to pursue a dual use policy that will bring down the barrier between defense and commercial industry through the establishment of coherent development and acquisition processes for cooperative commercial and defense products. Theoretically, successful commercialization of defense technologies can provide the DOD an accessible, affordable and stable industrial base (Boezer and others, 1997:39-41). Boezer quoted President Clinton's goal for dual-use technology strategy as:

> To move toward a cutting-edge national technology and industrial base that will serve military as well as commercial needs. This dual-use technology strategy will allow the armed forces to exploit the rapid rate of innovation and market driven efficiencies of commercial industry to meet defense needs. (Boezer and others, 1997:40)

Table 6. Hierarchy of Products.

HIERARCHY OF PRODUCTS	
Product Description	**Examples**
Military Strategies and Concepts	Senior Level Planning
Integrated Weapon and Information Systems	National Early Warning Systems
Major Weapon Platforms and Communication Systems	Satellites, Aircraft, Battleships, Tanks, Submarines, Aircraft Carriers, Etc.
Complete Weapon and Communications Component Parts	Torpedoes, Missiles, Bombs
Sub-Systems	Gyroscopes
Sub-Assemblies	Sights, Fuses
Components	Integrated Circuits
Materials	Semi-Conductors

(Hartley and Sandler, 1995:403)

Increased dual use for DOD would mean increased size of the industrial base, state-of-the-art commercial products for defense use, greater federal research investment returns, and savings due to lower overhead costs from an increased business base (Defense Conversion Commission, 1992:31). Former Defense Secretary William Perry said:

> We want access to all the technology being used in commercial industry today, including manufacturing-processes technology and procedures. It reflects our view that the Pentagon would be better off if we could team with industry in such a way that not only are we getting access to their technology, but where our technology is dual use, it can then be applied to commercial products and derivatives. We want dual use technology to work both ways. (Kitfield, 1993:32)

Kaminski praised the Technology Reinvestment Program, which supplies matching funds for companies developing dual-use technologies, as a key tool for CMI (Kitfield, 1995:37). Gansler said dual-use technologies have reinforced U.S. defense capabilities, providing the U.S. satellite industry as an example of just such an industry.

> Many earth-resource satellites now have capabilities that approach those of U.S. intelligence satellites. In the coming years, it is possible that these non-military systems might become more capable that their military counterparts. Moreover, commercial navigation satellites are being designed to provide accuracy's comparable to those provided by military systems. (Gansler, 1993:144)

Dual use programs are important not only for DIB strength, but also for meeting increasing DOD space requirements. Through leveraging the thriving commercial U.S. satellite industry, many of these needs will more than adequately be met. In order for civil/commercial markets to satisfy DOD space system requirements, overlap must exist in four mission areas; they are: communications, imagery, navigation, and weather (James, 1993:12). However, certain defense unique requirements will still have to be supported through DOD specific programs. It was demonstrated in Desert Storm that

commercial satellites could satisfy military communications requirements, providing some jam resistance and survivability features. James noted in a 1992 study conducted by the Rand Corporation:

> Commercial communications satellite systems are likely to be used more and more frequently by the U.S. Army and the military in general. The escalating costs and longer product development cycles for the stringently specified military equipment often present a stark contrast to the technological dynamism, quick turnaround, and lower prices of the commercial marketplace. (James, 1993:27)

Military imagery requirements "focus on obtaining detailed information of a specific nature" (James, 1993:12). However, commercial remote sensing satellite systems are fast-approaching generating imagery of quality previously possessed only by military intelligence satellites (Anselmo, 1997:72). During Desert Storm, France's Spot satellite provided important satellite imagery. Other examples of successful dual use implementation include the "civil use of commercial remotely sensed imagery, supporting environmental control and monitoring; agriculture, soil, forestry, mineral, and energy resource management; and land use and urban planning" (National Defense, 1993:18). Both commercial and military markets have extremely demanding requirements for worldwide navigation accuracy. The Navstar Global Positioning System, originally developed for the military, now satisfies both markets. There is also an opportunity to reduce costs, combining the military and civilian polar-orbiting weather satellite programs (James, 1993:14-15). For examples of joint military-commercial satellite use on some existing satellite systems, see Table 7. "We in the DOD must take advantage of this commercial capability, sort out what requirements can be adequately met by this capability, and press ahead to make use of it" (James, 1993:28). An Industry Studies

Program (part of the Industrial College of the Armed Forces) report recommended "maximizing DOD efforts toward joint commercial versus military-only endeavors and integrating military with civil and commercial activities at every opportunity," (National Defense, 1993:37,38,40). "Given the reduced threat, declining budgets, and increased capabilities outside the DOD, utilization of these *dual use* assets must be pursued to reduce the costs of developing, producing and operating DOD space systems," (James, 1993:31). James concludes:

> In examining the four primary space mission areas, it is clear that requirements overlap (and capabilities convergence) between the DOD and commercial/civil areas exist to one degree or another in each of the areas. This is fundamentally different from many other DOD mission areas such as fighter aircraft or bombers, where no comparable commercial/civil requirement or capability exists. This requirements and capabilities overlap provides the DOD with the opportunity to seek areas of convergence with civil/commercial systems and synergistically integrate these systems into an overall DOD space capability, providing increased capability at lower DOD cost. (James, 1993:15)

To better position the U.S. commercial space industry, the U.S. Government has defined a space policy intended to promote a market-driven commercial space sector by minimizing regulation, buying commercial products and services where feasible, and not supplying products or services that could be commercially supplied unless national security or public safety dictated otherwise (National Defense, 1993:7). The challenge for the DOD, in an era of reduced defense spending, is using dual-use technologies among other alternative opportunities to develop and operate DOD space systems and accomplish mission objectives at reduced cost. "Doing so will also make the most efficient use of our *space* industrial base, and maintain the U.S. as the premier space power in the decade ahead" (James, 1993:1-2).

Table 7. Major U.S. Civilian Satellites in Military Use.

MAJOR U.S. CIVILIAN SATELLITES IN MILITARY USE	
Satellite	**Military Operation**
Advanced Communications Technology Satellite (ACTS)	Communications service to U.S. Army troops deployed in Haiti in 1994.
Geostationary Operational Environmental Satellite (GOES)	Monitors storms and tracks their movements for short-term forecasting.
International Telecommunications Satellite Organization (INTELSAT)	Routine communications and distribution of Armed Forces Radio and TV Services network and Very Small Aperture Terminal data network for field commanders in Bosnia-Herzegovina in 1996.
International Maritime Satellite (INMARSAT)	Peacetime mobile communications services. Used in Somalia and Bosnia for transmitting medical data/supply orders.
Landsat	Imagery used for mapping and planning for tactical operations.
NOAA-12 and NOAA-14	Provide global weather updates every six hours for civil and military users.
Orbcomm	Use for global data messaging and position locating services.
Orion Satellite (Global Broadcast System – GBS)	Provided GBS for troops deployed to Bosnia. Disseminate wide variety of information to military forces worldwide.
Satellite Pour l'Observation de la Terre (SPOT)	Purchases images for mission-planning systems, terrain analysis mapping, and humanitarian missions.
Tracking and Data Relay Satellite System (TDRSS)	Low-Earth orbit spacecraft use to communicate with a control center without an elaborate network of ground stations.

(Mehuron, 1996:35)

Benefits of Commercialization.

Studies conducted by the Defense Conversion Commission and defense analysts confirmed that commercializing the DIB provides numerous benefits. The Commission's chairman, Mr. David Berteau, thoroughly supported CMI.

> First, keeping a company in business with commercial orders is more efficient than sustaining it with nonessential defense orders. Second, expanding the commercial component of a firm's business operation spreads overhead costs more widely and reduces the share that must be

> covered by increasingly scarce defense dollars. Third, the defense side of an industrial concern could profit from infusions of advanced commercial technologies. In information systems, communications, and electronics, commercial technology is more advanced than available defense technology. (Auster, 1993:63-64)

CMI would help ensure DIB companies adequately adjust to lower defense spending while still maintaining a fully capable industrial base at lower cost. It would also facilitate the effective exchange of state-of-the-art technologies between commercial and defense industries, increasing DOD capabilities to acquire modernized, capable, cost-effective defense systems. Another advantage of CMI is the easy transition of defense-dependent companies to move between both defense and commercial markets. During a crisis, these companies could more readily convert resources to defense needs at lower cost. "The Commission recommends that efforts to foster CMI be strengthened, expanded, and accelerated considerably" (Defense Conversion Commission, 1992:22-23). Further, DOD will be able to rely on market forces rather than expensive Government oversight to ensure efficient use of public funds. Low-cost, high-quality products will be a direct result of competitive market pressures. Finally, CMI will provide adequate capacity to meet surge requirements, which DOD cannot afford on its own (Gansler, 1993:139). Other CMI benefits include contribution to an increasingly competitive and growing national economy (Gansler, 1993:135) and simplified DOD procurement practices (Defense Conversion Commission, 1992:23).

> By using commercial items, we capitalize on economies of scale and achieve efficiencies in peacetime. We also gain access to a larger industrial base that becomes an important foundation for a capability to regenerate forces to meet an emerging major threat. Commercial capability enables our downsizing to proceed more coherently; for example, commercial engine production is the foundation for automobile, truck and tank engine manufacturing. It is not necessary to specifically

> keep a tank engine industrial base in operation when efficient commercial processes exist. (Changing Defense, 1992:52)

Outlook for the U.S. Satellite Industry

Extensive research on the U.S. satellite industry suggests a healthy and viable industry, growing, despite diminishing defense budgets and a shrinking DIB. Increasing commercial space applications have made this possible. Satellite industry firms are not reducing capital investment as rapidly as the rest of the defense industry, due in part to growing defense needs in space, an optimistic outlook for future shares of the defense budget, and confidence about future commercial prospects, of which the DOD will increasingly become a customer. According to General Estes, "The commercial investment in space is set for a major expansion, with private enterprise offering services of all types, from Internet links to terrestrial imagery to telephone service for the two-thirds of the world which doesn't yet have it" (Tirpak, 1997:53).

> While Government spending on civil and military space is expected to decline or remain flat, the expansion of the commercial market – already growing at roughly 20% a year – shows no signs of abating. That means commercially-oriented space projects should continue to increase their already sizable share of the space market. (Anselmo, 1997:72)

Emphasis has been placed on NASA, the U.S. Air Force and the National Reconnaissance Office to develop smaller, cheaper, more flexible spacecraft that can provide new *information age* data capability technology into the 21st century. The surge in information technology is also driving other major new military space developments (Covault, 1997:73). The Clinton Administration's support for advanced Government space program development is evident from its shift to more stable budgets. "While most other defense programs are dropping sharply, the overall military space budget will

increase by nearly 5% in FY-98, with a further increase slated for FY-99" (Covault, 1997:73-74).

> The next few years should mark a turning point for space. The nature of the market is fast changing from one of reliance on national space programs to one driven by private industry. [C]ompanies are anticipating a large and diverse market. Manufacturers are positioning themselves to take advantage of as many space market segments as possible, trying to become everything to everyone. (Caceres, 1996:111)

According to Loral Space & Communications Chairman and CEO Bernard L. Schwartz, "The satellite business is in its early stage of commercial development and will continue to proliferate in a very, very big way." He further believes "Market demand and technological advances will continue to open up new applications for satellites and drive down prices" (Anselmo, 1997:72). Regarding our current environment, General Horner said "Space has come of age. You see in commercial satellites the growth, and that just continues. Certainly in our civil sector, we have a very robust program going" (James, 1993:6). U.S. satellites will dominate the commercial space market well into the 21st century, sales of which will dwarf both military and civil space agency purchases. "The commercial space sector has been growing at 10% or more annually for years. At that rate, revenues will double every seven years" (Asker, 1995:95). A new market study by SpaceVest finds that commercial space revenues have surpassed those of traditional Government activities (Anselmo, 1997:72). Lockheed Martin, Hughes, Boeing, TRW and Loral among others are still setting the pace technologically and commercially in the satellite world (Asker, 1995:97).

> Defense contractors are now looking to commercial satellites for salvation. Over the past three years the number of satellites in orbit has grown by a half to 2,400, as demand for mobile telephones, satellite television and data transmission has soared. Whereas GM Hughes Electronics used to

> have perhaps ten satellites on order, it now never has fewer than 30, with a combined value of $2 billion. (Swords, 1994:61)

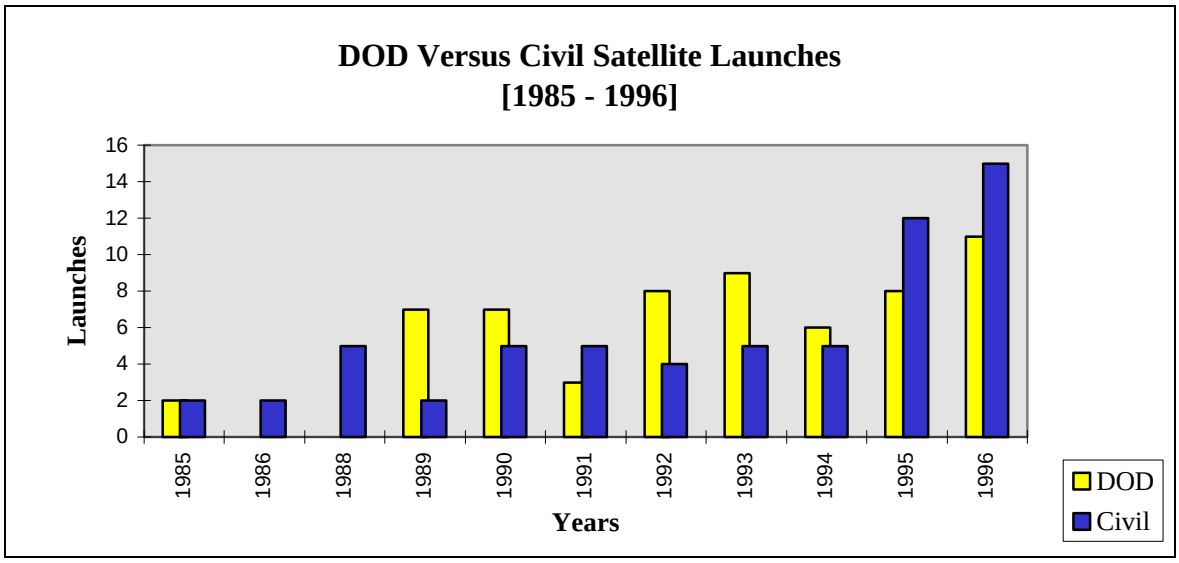
A review of the literature indicates that trends in U.S. satellite industry performance reflect optimistic times ahead. Revenues from complete satellite system (including satellites and earth terminals) sales and satellite services are increasing. U.S. firms have teamed with foreign companies in order to circumvent trade restrictions against the U.S. to get operating licenses. Commercial buyers include commercial satellite services companies in the U.S. and abroad as well as foreign governments, suggesting not only domestic but global market prospects (Moranville, 1993:9). Satellite sales will increase U.S. productivity in the near future. Reduced component costs and increased sales have led to decreased manufacturing costs. U.S. companies are still acknowledged world-wide as high quality communication satellite and earth terminal producers. The *big three* U.S. satellite producers are profitable compared to other defense companies (Moranville, 1993:20-25). Hughes, for example, has cut costs by building all of their satellites, commercial and military, to the same military specification requirements. Hughes, former Lockheed, and Loral have demonstrated they can handle defense down times through movement into non-defense business (Moranville, 1993:13-14).

In response to an explosion in satellite contracts and surprisingly, without Government funding, several companies have developed their own launch vehicles, further signifying commercial growth. "M-Star, a $6.4 billion system of 72 satellites designed to transmit massive amounts of information for U.S. businesses, and Teledesic, a $9 billion venture that plans to orbit over 900 small satellites for a variety of global

communications satellites" are just two of many new ventures planned in the near future (Anselmo, 1997:73).

The commercial sector might be just a small part of the overall space industry, but it is growing at an accelerated pace. For a comparison of DOD versus commercial satellite launches from 1985 through 1996, see Figure 2, and; see Appendix A for a complete breakdown by prime contractor and space system application. Voice communication systems, entertainment systems, data collection and remote sensing using space assets are commercial space applications that are becoming more commonplace (National Defense, 1993:7).

Three potential hot growth commercial areas are: mobile communications, remote sensing, and direct-to-home (DTH) television satellites. Iridium and Globalstar, two low-Earth orbit satellite systems, are poised to launch later this year, providing worldwide mobile telephone services for the $19 billion cellular industry market as early as 1998. Earth remote-sensing satellite markets will encourage space growth, especially with the prelude of a new wave of commercial high-resolution imaging systems (Caceres, 1997:117). The Clinton Administration currently allows U.S. companies to use intelligence satellite technology for real estate and travel purposes. Realtors and travel agents could provide virtual-reality flythroughs of prospective real estate property or vacation spots. DTH provides customers up to 200 channels of satellite-based programming and the market is growing internationally (Anselmo, 1997:73).



(Caceres, 1997:131-137)

Figure 2. DOD Versus Civil Satellite Launches.

The U.S. satellite communications industry, which by far comprises the largest segment of private space applications (National Defense, 1993:11), has an optimistic outlook (Moranville, 1993:26) and the outlook for telecommunications satellites on a global basis has never been more promising or more competitive (National Defense, 1993:22). The worldwide satellite communications and satellite communications services market should continue to steadily grow through the 1990's. Moreover, there is enormous market potential for the new light satellite low-Earth orbit technology. "These new commercial markets should provide those companies currently working solely on DOD contracts a reasonable chance of successfully converting to commercial efforts, and ensure a healthy industry" (Moranville, 1993:26). "The competitive advantage provided by working on Government programs will gradually diminish as more and more sales are generated by the commercial sector, especially if DOD and NASA programs are reduced" (Moranville, 1993:14). Market forces are starting in the U.S. satellite communications

industry and there is tremendous commercial activity potential. This would help ensure a healthy industry. During times of reduced defense spending, increased DOD expenditures for satellite communications are unlikely (Moranville, 1993:2).

> The space market is about to enter a period of peak growth and activity, largely centered around the commercial satellite communications market. The last three years of the 20th century will see the first generation of mobile communications satellites to be launched on a mass scale; a rapid expansion in the number of high-power, direct-to-home TV broadcast satellites; and the introduction of K_a-band satellites designed for the Internet and high-speed multimedia communications. (Caceres, 1997:117)

The DOD will increasingly rely on the commercial sector for meeting its needs in space. "A cash-strapped Pentagon will rely heavily on robust, commercially developed space systems and associated ground-based networks to conduct cost-effective *information warfare* over the next decade" (Scott, 1995:85).

> However, constrained defense budgets and the US Government's snail-paced, arcane acquisition system virtually preclude in-house development of a cost-effective, space-based Information Warfare capability. Military leaders acknowledge they must rely on a fast-moving commercial sector to provide the technology, new security methods and efficient systems necessary to wage information war. (Scott, 1995:86)

The Industry Studies Program analyzed the space industry to assess its ability to provide the weapons, products, and services to meet national mobilization requirements and its state of readiness to surge production for the armed forces now and in the future. The study determined "The Federal Government largely dictates the direction and level of effort expended by U.S. companies on space-related projects, with the exception of commercial satellites" (National Defense, 1993:8). DOD generally provides expenditures for satellite research and development. Due to decreased DOD budgets, commensurate reductions in satellite funding will follow. However, due to the critical nature of mobile

communications, more likely than not, DOD expenditures will not be reduced as much in this area (Moranville, 1993:18).

A somewhat recent market survey confirmed the civil/commercial sector of the U.S. satellite industry is healthy, providing sufficient capabilities (James, 1993:16), and the manufacturing infrastructure is healthy in terms of capital, plant, and technology (National Defense, 1993:18). "A healthy industry provides [DOD] quality production and services with reasonable cost, technological sophistication, and the ability to surge needed products and services. DOD gains immeasurably when the private sector is a large competitive commercial marketplace which drives innovation" (Moranville, 1993:2). However, decreased Government spending has resulted in substantial overcapacity (National Defense, 1993:18). In a period of recession for the aerospace industry and reduced defense budgets, space budgets have grown and the U.S. satellite industry still commands a dominant lead in the international market (James, 1993:16-17). Military spending impacts on commercial space markets are currently not a problem.

> In an era of reduced military budgets, the civil/commercial space programs have developed the maturity to survive and probably thrive. The dependence on military dollars is not the strong factor it was in the 1960's and 70's, and current worldwide military downsizing should have minimal impact on the availability of civil/commercial assets. (James, 1993:20)

The changing global environment and defense spending cuts have raised some concerns within the MILSTAR program. This program, administered by the Space and Missile Systems Center, provides satellite communications and data transmission for DOD (Mehuron, 1996:34). Changes within the MILSTAR industrial base pose potential risk to program production. In addressing this issue, an industrial base survey of the MILSTAR satellite program has been conducted annually for the past several years. "The

objective of this study is to provide program managers with information on key suppliers that they need to support proactive decision making and expeditious responses to supplier issues." In the *Final Report - Industrial Base Survey of the MILSTAR Satellite Program - FY 96*, the overall conclusion was "there were no *showstoppers*, in terms of significant negative impact on any specific program or on sustainment readiness, production, or supportability." Further, it was stated that the unprecedented reduction in suppliers probably resulted in increased efficiency and quality of those producers who remained (Gordon, 1996:4,18). Although this is only one program of many in the DOD and in the Air Force specifically, the overall impact of a shrinking DIB on this satellite program is probably going to be the same throughout the Air Force and DOD.

Summary and Propositions

Today's security environment is substantially different than during the Cold War. Increased globalization of national economies, a variety of unknown threats and weapons and overall dynamic change characterize this environment. The Air Force's vision, *Global Engagement*, emphasizes the increased importance of space for meeting defense needs in the future. Of particular importance is the U.S. satellite industry's ability to meet defense needs in space.

American industry has effectively served the United States in meeting its defense needs since the Revolutionary War, whether as a disparate array of companies or as a distinct DIB. Although effective, history portrays the defense industry as very inefficient. A structural breakdown of the DIB establishes a base comprised of three dimensions. Prime contractors, subcontractors, and parts suppliers provide one dimension. Each of

these *tiers* supports certain sectors of the defense industry (e.g., aerospace, shipbuilding, submarines, tanks), making up the second dimension. The third dimension breaks down the defense industry into either publicly or privately owned organizations. Production factors highlight elements affecting the structure and performance of the DIB.

Literature has been written over the last thirty years discussing the weakened state of the DIB. Cyclical defense requirements, increased reliance on foreign suppliers for raw materials, overcapacity, lack of capital investments and changing domestic priorities are among the biggest factors influencing the deteriorated condition of the DIB. Concern is evident by increased research efforts and publications made referring to its condition. Defense spending is the most influential variable for DIB strength, leading to:

Table 8. Propositions 1 and 2

PROPOSITIONS 1 AND 2:
1: There is a positive correlation between defense spending and DIB strength.
As defense spending fluctuates, there should be a corresponding fluctuation in DIB strength. Defense spending directly influences DIB: ability to produce (via labor, plants and equipment, money, materials and energy) weapon systems; levels of competition, in each tier, that provide the capability and capacity to produce these systems at a fair and reasonable price, and; ability to develop state-of-the-art technology necessary to dominate the battlefield. These DIB strength factors are necessary for DIB preparedness – the capability and capacity of the DIB to surge and mobilize as required by the DOD as well as meet any other DOD objectives. This level of preparedness is synonymous with level of DIB strength.
2: The strength of the DIB is deteriorating.
Based on the end of the Cold War and recent DOD budget trends, defense budget reductions are expected to continue. This trend coupled with the argument made in Proposition 1 indicates that, without any Government intervention and all other factors held constant, the strength of the DIB will decline to the point that it will be incapable of meeting DOD objectives efficiently, effectively, or not meet them at all. Literature indicates this is of grave concern to the DOD.

Efforts to *commercialize* the DIB have been highly recommended to alleviate, if not eliminate, the problems that have characterized the DIB for years. Commercializing the DIB will involve integrating it into the national industrial base through CMI. Acquisition Reform and dual-use technology and production strategies are the foundation for CMI. This leads to:

Table 9. Proposition 3

PROPOSITION 3:
The relationship between defense spending and DIB strength is moderated by commercializing a defense industry.
Senior defense leaders and defense industry experts believe CMI should produce a much more efficient and effective industrial base from which the DOD can meet its industrial base objectives. Commercializing the defense industry involves breaking down the formidable barriers between defense and commercial industries. Acquisition Reform and dual use technology and production strategies are two ways to make this integration possible. Dual use technology and production applications will provide industries access to both military and commercial markets.

The U.S. satellite industry seems to be faring well in today's environment. Literature has shown that international markets and growing space applications for commercial purposes have made this trend possible. Dual use applications in the U.S. satellite industry make it marketable in both civilian and military markets. This leads to the last proposition. See Table 10.

A thorough investigation into each of these propositions should establish the fact the current DIB is in bad shape and will continue to worsen if no intervention by Government and defense industry leaders is made. With the introduction and support of CMI, the DIB will be integrated into the national industrial base providing a more stable industrial base from which the DOD can extract its defense resources. The U.S. satellite industry already

seems to be on the right track; it is developing and expanding its commercial base to meet the many growing commercial applications that are currently underway. This *commercialization* should be advantageous to the DOD in meeting future defense space requirements and objectives. Chapter III provides a comprehensive discussion on the research methodology selected to investigate each of the propositions.

Table 10. Proposition 4

PROPOSITION 4:
Due to the U.S. satellite industry being heavily commercial in nature, the shrinking DIB has not adversely affected it as might be suspected.
The first three propositions have provided a solid foundation upon which Proposition 4 can be sustained. Investigation into this proposition should reveal whether the U.S. satellite industry will be able to meet DOD satellite requirements despite recent decreasing DOD budget trends. The U.S. satellite industry currently supports many commercial satellite market applications, including: communications, imagery, navigation, and weather. The commercial satellite market currently possesses leading-edge technology in many part, component, and subsystem areas that can be directly used or modified for defense satellite systems.

Chapter 3

Methodology

Introduction

As discussed in Chapter II, the DIB best meets DOD objectives by maintaining a constant state of industrial preparedness. However, its ability to meet these objectives has been compromised by numerous factors. Many of the deficiencies characterizing the DIB today evolved over two hundred years of evolution. Today, decreased defense spending among a myriad of other factors, makes the defense industry even more unattractive, especially to subcontractors, parts/materials suppliers, and the financial community. Deterioration in these lower tiers coupled with its historic deficiencies seem to be the major focus contributing to the DIB problem.

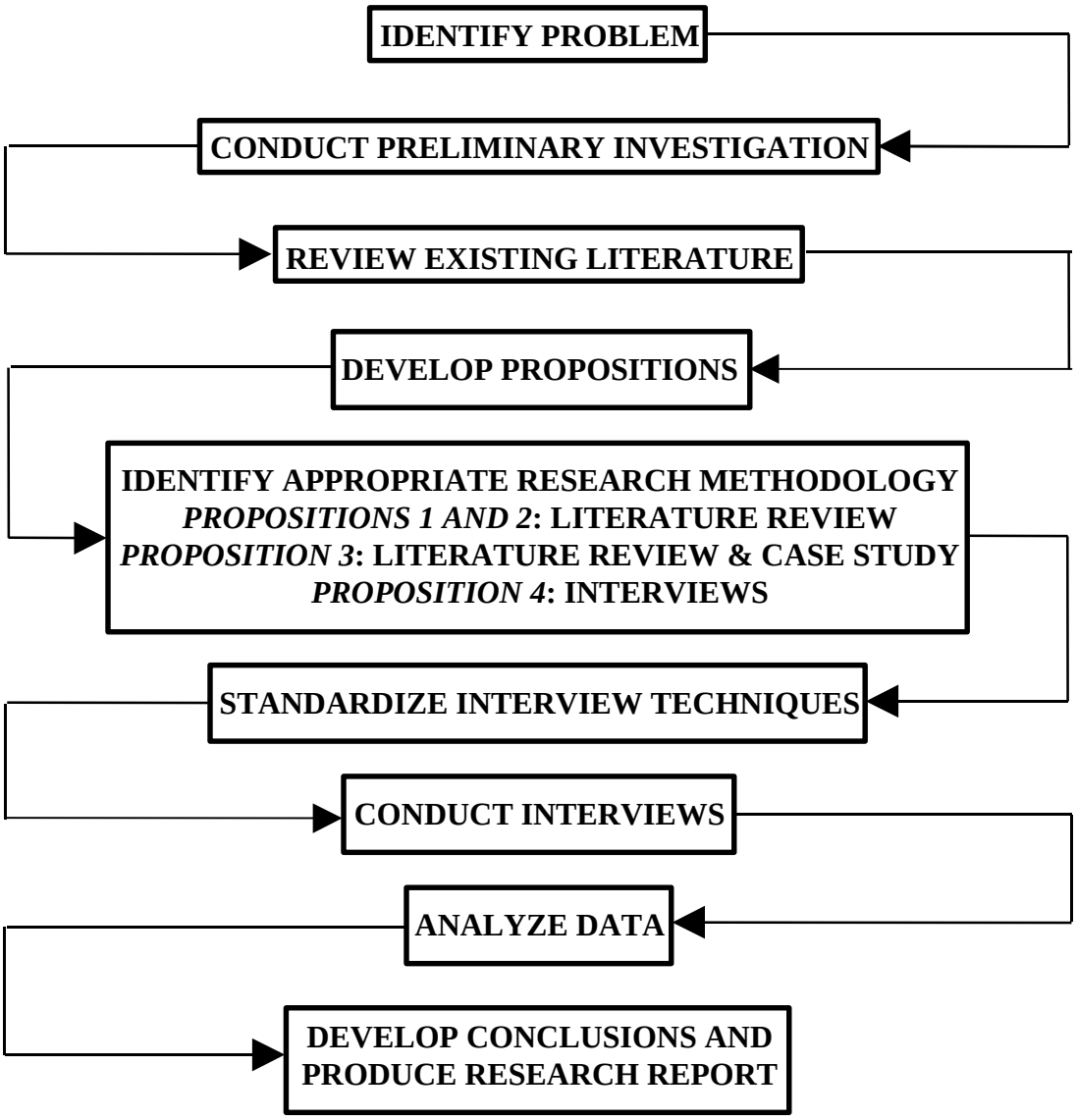
Currently, the perceived benefits of *commercializing* the DIB have attracted substantial attention and support from senior defense leaders, Congress, and the White House. There is a movement towards CMI, with Acquisition Reform breaking down the proverbial wall between commercial and defense acquisition practices. Dual-use technology and production strategies are making both commercial and military markets accessible to more companies. DIB integration into the national industrial base, according to most experts, will eliminate the bulk of problems that have historically

characterized a separate DIB. Whether this integration is the answer or not remains to be seen. The concept is valid enough for further investigation.

The Air Force has set its sights on space for future military operations. This highlights the U.S. satellite industry as especially important for its ability to meet U.S. Air Force needs into the 21st century. This industry has been strongly supported by defense spending for over thirty years. Decreased procurements, however, pose a potential risk that its ability to meet DOD satellite needs will not be met. Satellite industry research reveals it is becoming more commercialized, with increasing market potential for various entertainment, communications, imagery, navigation, and weather needs. Chapter II also indicated increased market potential and growth opportunity from domestic and international customers. Financially, this industry is doing well. Yet, the question remains, will it be able to apply its growing commercial know-how to meet future U.S. *defense* needs in space?

The goal of this research was to investigate satellite industry capability to meet DOD space requirements. Through literature review, case study analysis and interviews, effects of a shrinking DIB on the satellite industry were determined. The first two propositions were addressed and a model for DIB strength was developed and analyzed through literature review. Much has been written on the topics covered in these propositions which provided ample information to use for analysis. Second, a literature review and case study was used to support Proposition 3. The literature review addressed the impact commercializing a defense industry is supposed to have on the DIB through the analyses of defense industry analysts and leaders. A case study on General Electric Aircraft Engines (GEAE) showed the potential for *commercializing* the DIB. Regarding

Proposition 4, perceptions of U.S. satellite industry *experts* were investigated through a series of telephone interviews. The interview questions were structured to provide a comprehensive analysis in several key areas. An overall picture of this industry was made regarding its *dual use* nature, ability to satisfy both commercial and defense markets, financial status, and future outlook, considering the unstable nature of the defense market and declining U.S. defense dollars. Figure 3 illustrates the general research methodology approach used in this research study.



Adapted from: (Cooper and Houck, 1985:49)

Figure 3. General Research Methodology.

PROPOSITIONS 1 AND 2:

1: There is a positive correlation between defense spending and DIB strength.
2: The strength of the DIB is deteriorating.

Methodology Justification

To determine whether the DIB, specifically the U.S. satellite industry, will be able to meet DOD needs in space, it was first necessary to assess those factors affecting the DIB's ability to efficiently and effectively meet DOD objectives – *DIB strength*. The first two propositions relate to DIB strength measurement and current strength levels. First, the factors affecting DIB strength were identified from the literature review. Second, a determination was made as to whether the DIB, in its current form, is strong or weak. Measuring DIB strength is no easy task; a truly quantitative analysis would require extraordinary effort and would probably be inaccurate. Literature supports the concept that defense spending influences DIB strength factors (production, competition, technology) which directly affect the preparedness of the DIB. The degree to which the DIB is industrially prepared indicates its strength. Therefore, the best way to assess DIB strength was through a literature review, using defense spending as a proxy for DIB strength. According to Emory and Cooper, a literature review is an organized collection of secondary data sources that act as a basis for study; secondary data are used for three research purposes.

> First, they fill a need for a specific reference on some point. Another major use of secondary data is as an integral part of a larger research study. In essence, the researcher tries to keep from *reinventing the wheel*. Finally, secondary data may be used as the sole basis for a research study. In many research situations, one cannot conduct primary research because of physical, legal, or cost limitations. (Emory and Cooper, 1989:286)

Variables affecting DIB strength are typical of those affecting almost any industry. Chapter II discussed those pertaining to the DIB specifically, providing the basis for DIB strength assessment. Upon initial investigation, it seemed plausible to quantify these factors, perform a statistical analysis, and then measure DIB strength. However, identifying exactly who comprise the DIB at all tiers is necessary. Prime contractors are not the problem; the lower tiers (subcontractors and parts/materials suppliers) who serve both commercial and military markets make measurement difficult. As previously mentioned in Chapter II, the bulk of goods/services an industry markets must be designated for defense purposes to be a part of the defense industry. Many of the lower tiers do not even know to whom they provide goods and services, whether commercial, military, or both markets. Companies seem to move in and out of the defense industry at these lower tiers, depending on the size of defense budgets. Therefore, a quantitative assessment would be inaccurate. One possible model of DIB strength, incorporating the factors identified in Chapter II, is as follows:

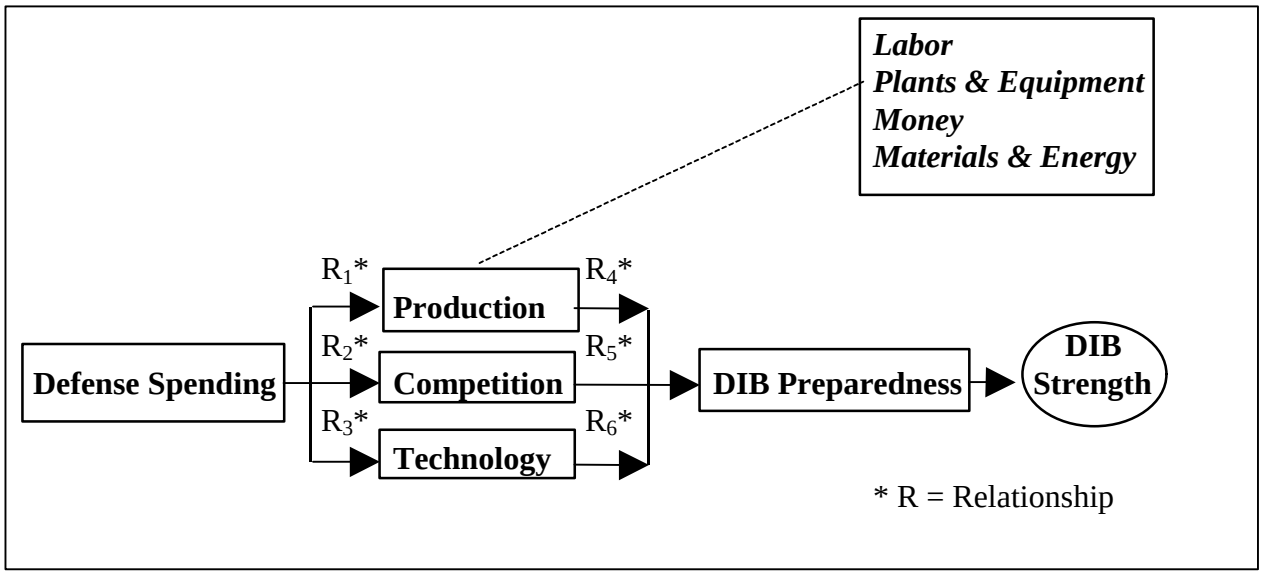


Figure 4. Model of DIB Strength

In an effort to not *reinvent the wheel*, and as stated, a literature review was the most sensible approach to defending the first two propositions. Defense analysts and experts have made considerable effort measuring trends in these areas over the last 30 years. Duplicative effort would have been extremely costly and time consuming. A literature review compared these factors to actual defense spending trends over the last thirty years. Specifically, each relationship (R_1 - R_6) was discussed. The expectation was that DIB strength would reflect defense spending fluctuations. This may directly impact the satellite industry's capability to produce satellites.

Obviously, as with any research method, there are advantages and disadvantages. Use of secondary data can be attained quickly and cheaply. Disadvantages include information that does not meet the specific needs of the researcher and information that is out of date (Emory and Cooper, 1989:287). However, in this situation, the information directly corresponds to the first proposition. Since an historical perspective is needed for this research, information provided through a literature review is up-to-date for the respective time periods they represent.

Literature Review Design

Ample literature has been written regarding the factors influencing DIB strength. The literature review was made, exposing significant facts, trends and relationships. This review highlighted the impact defense spending has had on DIB production, competition and technology over the last thirty years. Each relationship was further explored to determine how changing DOD budgets eventually influence DIB preparedness, an indication of DIB strength levels. Descriptive statistics, in the form of a line graph, was

used to depict defense spending trends, thus providing a visual reference for DIB strength.

Data Collection

Literature was collected from various publications, including: books, journal articles, defense industry expert testimonials, research reports, and industry panel studies. Aside from the literature review portion of this analysis, a summary of quantitative archival data was depicted in line graph form to show defense spending trends. This data was extracted from the Directorate for Information Operations and Reports (DIOR) database, via the world wide web. It was then adjusted for inflation, using FY 1997 Office of the Secretary of Defense (OSD) raw inflation rates. The rates used were the average of both aircraft/missile procurement (3010/20) and other procurement (3080).

Limitations

The biggest limitation with this research design approach was the use of secondary data sources. However, as previously mentioned, this was a quick and economically feasible means of acquiring what is probably the best data, considering the sources. Several assumptions were made concerning variables and factors influencing DIB strength. It was assumed defense spending was the most influential variable, moreso than tax, trade, environmental, and socioeconomic policies. DIB strength determination is subject to many interpretations. To counter this, strength was precisely defined in terms of meeting DOD objectives. In order for this research design to be effective, these assumptions must be correct. The power defense spending has on DIB preparedness, via the core DIB strength factors, qualifies it to be an adequate proxy for DIB strength.

PROPOSITION 3:

The relationship between defense spending and DIB strength is moderated by commercializing a defense industry.

Methodology Justification

The third proposition concerns the *commercialization* of a defense industry. Theoretically, DIB integration with the national industrial base will solve current DIB deficiencies leading to a more efficient and effective method of meeting DOD objectives. In the event DIB strength is deteriorating, DOD space requirements may better be met in the future by a defense industry capable of serving both commercial and military markets.

Again, literature review was used to discuss how commercialization efforts moderate the relationship between defense spending, DIB strength factors, and DIB preparedness. Justification for this approach was the same, to some extent, as for the first two propositions, but the overriding factor was because the movement towards commercialization is so new. Subsequently, there is nothing but literature available to address the impact it has on the DIB. See Figure 4 for a model of this relationship.

Additionally, case study research provided the best way to determine the performance potential of a *commercialized* defense industry. "In general, case studies are the preferred strategy when *how* or *why* questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context" (Yin, 1989:13).

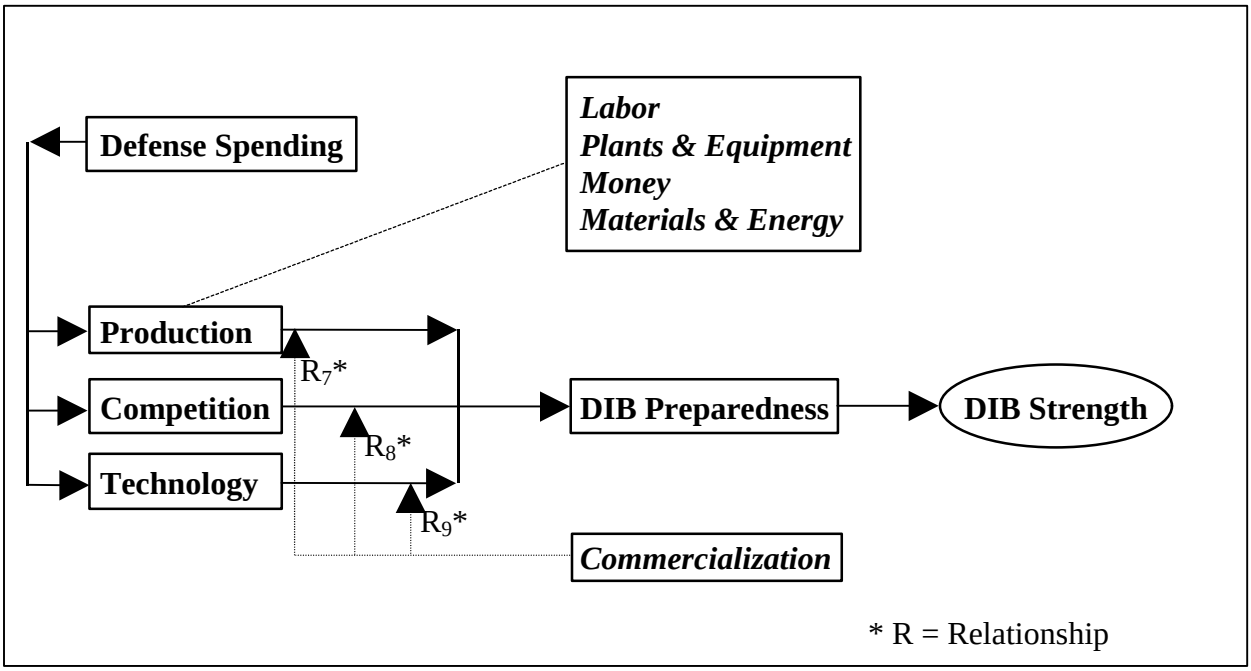


Figure 5. Model of DIB Strength Moderated by Commercialization Programs

The intent behind CMI is to integrate the DIB into the national industrial base. Acquisition Reform seeks to desegregate the barriers between commercial and federal acquisition practices. Dual-use technology and production applications will provide industries access to both military and commercial markets. The DOD and those involved in the defense acquisition business hope this movement will benefit both defense and commercial markets. Why and how does *commercializing* a defense industry, considering the cyclical nature of defense, better enable an industry to meet DOD objectives?

To answer these questions, a case study analysis demonstrated the potential a commercialized defense industry has, considering different levels of defense spending. Defense spending, as developed in Propositions 1 and 2, serves as a proxy for DIB strength. "A single, well-designed case study can provide a major challenge to a theory

and provide a source of new hypotheses and constructs at the same time" (Emory and Cooper, 1989:143). The theory here is the positive impact commercialization has on a defense industry.

Three traditional prejudices against the case study strategy are its: (1) lack of rigor, (2) inadequacy for scientific generalization, and (3) time consuming and resulting massive, unreadable documents (Yin, 1989:21). In response to these concerns, a carefully constructed and objective case study was developed, using quantitative archival data. The objective was to look at the potential a commercialized defense industry has during periods of both increased and decreased defense budgets. From this single case study, a scientific generalization for commercialization potential can be made. "Case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. The case study does not represent a *sample*, and the investigator's goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization)" (Yin, 1989:21). This case study provided a concise analysis of commercialization potential through graphical interpretation coupled with literature review.

Literature Review Design

The design here was identical to the literature review design used for the first two propositions. The only difference was relationships (R_7 - R_9) were discussed. Data collection to support these propositions was similar as well. Unlike the previous literature review, this literature was a compilation of arguments by various scholars supporting commercialization. Once again, this movement is too new to provide adequate quantitative analyses.

Case Study Design

There are five components of research design applicable to case studies. They are: (1) a study's questions; (2) its propositions, if any; (3) its unit(s) of analysis; (4) the logic linking the data to the propositions; and (5) the criteria for interpreting the findings (Yin, 1989:29). The study questions were identified as the *Why* and *How* questions pertaining to commercialized defense industries stated above. The proposition in this case was Proposition 3. Unit of analysis was related to case problem definition. The case here was the specific commercialized defense prime contractor. Their performance during cyclical defense spending trends was analyzed. From this analysis, it could be determined whether commercialized defense industries are better able to adapt to defense budget cutbacks and downsizing. Dual use applications for both military and commercial markets should facilitate this better performance. "The fourth and fifth components have been the least well developed in case studies. These components represent the data analysis steps in case study research, and a research design should lay the foundations for this analysis" (Yin, 1989:33). Sales revenues for both commercial and defense business were analyzed to determine performance during fluctuating defense spending levels.

The choice of a single-case versus multiple-case designs largely rested on whether a single case study could meet the researcher's objectives. The objective of this case study, again, was to look at the potential a defense industry has when it becomes commercialized. A reasonable generalization for commercial defense industry potential could be derived from a single defense company that efficiently serves both commercial markets (during periods of decreased defense spending) and defense markets (during periods of increased defense spending), and effectively balances its resources to meet the

needs of each market during these respective periods. The company chosen was General Electric Aircraft Engines (GEAE). Consequently, in the interest of simplicity, time, and economic feasibility, the author chose to pursue a single-case design. Further, it is purported that a single-case design is appropriate under the following circumstances:

> First, a single-case study is analogous to a single experiment, and many of the same conditions that justify a single experiment also justify a single-case study. A second rationale for a single case is where the case represents an *extreme or unique case*. A third rationale for a single-case study is the *revelatory case*. This situation exists when an investigator has an opportunity to observe and analyze a phenomenon previously inaccessible to scientific investigation. (Yin, 1989:47-48)

The single-case study design met, for this particular analysis, each of the three circumstances. Regarding the researcher's objectives, a single-case design could be used "To confirm, challenge, or extend the theory meeting all of the conditions for testing the theory" (Yin, 1989:47). From the definition of the DIB mentioned in Chapter II, it is apparent there are relatively few true defense industries that have both commercial and military market potential. Albeit there are some, those that exist can be considered unique in the literal sense. Unknown to the author are any scientific experimental analyses regarding the objective of this case study. Therefore, a single-case study met the last circumstance as well.

Data Collection and Analysis

Two types of data were necessary to perform this case study, defense procurement dollars and sales revenues. Specifically, sales revenue information was compiled from the archival financial databases of GEAE. Sales revenues best depicted the extent to which GEAE maintained its financial posture during cyclical changes in defense spending. It provided hard numerical data on how defense spending fluctuations can be

offset by commercial market sales over time, using a GEAE as a surrogate for defense industries. The data for this analysis was extracted from: (1) the DIOR database for defense spending trends (also used for *Propositions 1 and 2* analyses), and; (2) a combination of General Electric's annual report and GEAE's executive overview. This data was tabulated over many years and displayed in descriptive format using a line graph, providing a visual representation of company financial performance during historically erratic defense spending trends. It was expected that GEAE's financial performance remained stable.

Limitations

A weakness inherent in the single-case design is the potential that a case may later not turn out to be the case it was initially thought to be in the first place (Yin, 1989:49). To minimize this potential vulnerability, careful investigation of the potential prime defense contractor was made. The intent was to reduce the chance of incorrectly selecting a non-representative sample, while maximizing exposure to data availability.

PROPOSITION 4:

Due to the U.S. satellite industry being heavily commercial in nature, the shrinking DIB has not adversely affected it as might be suspected.

Methodology Justification

Propositions 1 - 3 have provided the foundation upon which Proposition 4 can be sustained. This proposition should determine whether the U.S. satellite industry will be able to meet DOD needs in space, despite a shrinking DIB. An overall picture can be construed from expert testimony of those personally involved in the day-to-day operations

of U.S. satellite industry companies, particularly top level managers. The method best able to embrace this expert testimony, providing the most comprehensive analysis was the survey method, specifically the telephone interview.

Quantitative analyses are generally preferred in most research efforts, but they are not always practical or comprehensive. Much of the hard data available cannot be directly attributed to the DIB, particularly the U.S. satellite industry for this case, because of difficulty defining exactly who comprises its lower tiers. Further complicating this pitfall are growing commercial satellite commitments. Therefore, any data collected presents potential sources of error. The best way to accurately assess whether the U.S. satellite industry will be fully capable of meeting DOD space requirements now and in the future was to interview industry experts on their perspectives. Senior company representatives were preferred interviewees because of the broader perspective and deeper insight they possess on the industry than lower level managers; also, they better understand impact of cyclical defense spending trends on their particular company as well as their own corporate strategies and goals. Data collected from these interviews was subjective, yet comprehensive in nature, providing the best perspective in addressing Proposition 4. Despite its subjective content, a more exhaustive portrait can be deduced from this expert testimony than any statistical analyses, and more accurately.

> The researcher should be motivated by a desire to conduct the best possible study that can be designed for the problem at hand. However, limitations imposed by time, resources, equipment, and other factors may force the researcher to *compromise* on the preferred choice of design; but, compromises do no have to mean that a less-than-adequate study will be conducted. Attention to the tenets of good research is always retained, however, regardless of the extent of the limitations faced by the investigator. (Frey, 1989:34)

The choice of interview over the mail survey was largely due to the need to probe responses or add clarification to questions if they were confusing or answered incompletely. "More difficulties exist for asking complex and probing questions in mail surveys than in either of the other interview methods". The ability to ask open-ended questions is possible with an interview, not the case for mail questionnaires (Frey, 1989:72-73). The ability to probe, investigate, and explore the minds of the interviewees is crucial, and made it possible to fully understand the status of the U.S. satellite industry. The decision to use the telephone interview over the personal interview was attributed to the advantages characteristic of the telephone interview method of survey collection.

There are many advantages when using a telephone interview including: (1) lower costs than a personal interview; (2) expanded geographic coverage with little increase in costs; (3) reduced interviewer bias; (4) fastest completion time; (5) better access to hard-to-reach respondents (Emory and Cooper, 1991:338), and; (6) quality control (Lavrakas, 1986:11). "When properly organized, interviewing done by telephoning most closely approaches the level of unbiased standardization that is the goal of all good surveys" (Lavrakas, 1986:12).

The main reason for choosing the telephone interview over the personal interview was economic. The costs associated with traveling to various prime defense contractor locations, billeting, and the time required were not justified. The same information was compiled telephonically in much less time and at lower cost. Additionally, reduced interviewer effects resulted from a telephone interview over a personal interview. "The potential for compromises in data quality as a result of interviewer differences is a greater problem for face-to-face surveys than for the telephone survey" (Frey, 1989:62).

Telephone Interview Design

Lavrakas identifies ten basic steps in the telephone survey process. However, only three steps applied to this particular telephone survey. They are: (1) deciding upon a sampling design, including the method of respondent selection within a sampling unit; (2) developing and formatting a draft questionnaire, and; (3) printing final questionnaire (Lavrakas, 1986: 18-19). Since the respondents and sampling design have already been identified (see Respondent Selection below), the only steps remaining were to draft and finalize the questionnaire.

> In order for the questionnaire to meet the research objectives it is important to conceptualize the research problem in terms of important factors, expected relationships or hypotheses, and even models of behavior or attitude outcome. It is also a good practice to take a second step and list possible ways the variables mentioned in each conceptual component might be measured. (Frey, 1989:117)

A completed interview is an additional design goal of the questionnaire. Of the respondents selected, it is important that they: (1) commit to participate, and; (2) participate in a truthful manner, "giving replies that reflect actual feelings, knowledge, and behavior rather than responses that represent a desire to please the interviewer or are otherwise distorted and unrepresentative of true positions" (Frey, 1989:122).

The questionnaire used for this research was geared towards probing issues related to Proposition 4. Therefore, the questions directly related to various topics developed in Chapter II. Question order and content was critical to obtaining needed data from the respondent. The questions tended to move from general to specific and provided the interviewer the ability to maintain a conversational tone while administering the questionnaire. "The arrangement of the questions should be such that the sequence makes sense to the respondent, maintains respondent interest, is easy to administer, and

contributes a sense of organization and legitimacy to the research project" (Frey, 1989:147).

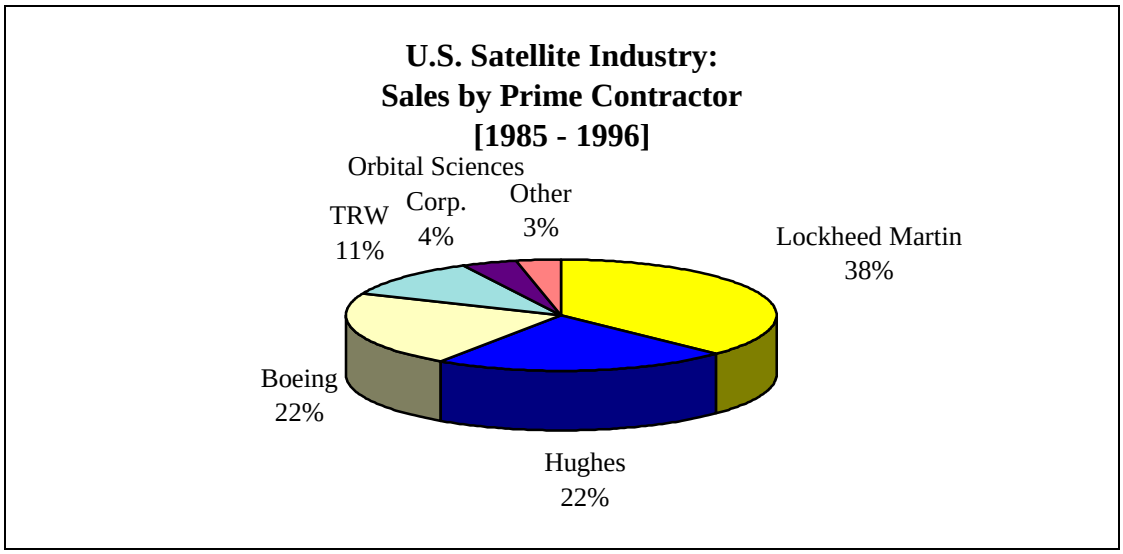
Respondent Selection

The U.S. satellite industry was the population from which a representative sample was chosen; of the companies selected, one representative from each was interviewed. Respondents initially selected had to be willing to serve at least the defense market, if not both defense and commercial markets. A small sample was selected because this industry is so highly concentrated. Specifically, five firms targeted for interviews dominate the market (about 97%) of U.S. firms producing satellites; they are: Lockheed Martin (including all former defense business from Loral, who no longer serves the defense market), Hughes, Boeing (including all former Rockwell satellite business), TRW, and Orbital Sciences Corporation (Caceres, 1997:131-137). See Figure 6. Unfortunately, TRW was unable to participate in the interview because of other pressing matters, so the other four firms were interviewed – totaling 86 percent of the market. Since these firms dominate the bulk of U.S. satellite production, it was not necessary to survey the small percentage of other firms supporting the industry. However, it was imperative that the respondents from each of the *top four* be knowledgeable in the issues which the questionnaire addressed. The objective was to investigate the ability of the U.S. satellite industry to meet current and future DOD satellite demands. An assumption was made by the author that if these satellite producers are fully capable of meeting the dual demands of both defense and commercial markets, then their ability to survive the unpredictable nature of the defense industry, particularly defense budget swings, should be enhanced by its commercial attributes.

Telephone Interview Technique

Emory states, "What we do or say as interviewers can make or break a study" (Emory and Cooper, 1991:321). In order to assure accurate and meaningful responses from each respondent, it was important the interviewer establish rapport with the interviewees and ask questions properly. According to Emory, establishing a cooperative environment between interviewer and interviewee is essential; three factors influence the receptiveness of the respondent. Respondents must:

1. feel that the experience will be pleasant and satisfying,
2. believe that the survey is important and worthwhile, and
3. have any mental reservations satisfied (Emory and Cooper, 1991:322).



(Caceres, 1997:131-137)

Figure 6. U.S. Satellite Industry: Sales by Prime Contractor.

Several guidelines were established for the telephone interviews in order to build rapport with the respondents, while creating a cooperative atmosphere. First, each respondent was contacted in advance to determine their willingness to participate. Second, they were assured complete anonymity; the academic nature of the research was stressed to guarantee responses were kept in the strictest confidence. An explanation of

the presentation of the data was discussed with each respondent to demonstrate how responses were kept confidential while providing useful information for the research. Third, a package was sent to each receptive respondent providing a cover letter and attachments. This reduced the element of surprise associated with an unexpected phone call, and gave the respondent time to consider any benefits and thoughts regarding the interview topic (Frey, 1989:127). The cover letter included information about the survey purpose, importance of their responses, and a reminder of the time and date of the interview. The letter was intended to provide a sense of *authenticity* and formality for the telephone survey and the importance of conducting the research. The attachments included: terms and definitions used in conduct of the research as well as a list of the interview questions. This helped expedite the process and prepared the respondent for the upcoming interview. A sample of the introductory correspondence, including cover letter, list of terms and definitions, and summary of the interview questions is provided as Attachment C to this thesis. Fourth, during the course of the telephone interview, respondents were provided an opportunity to voice personal opinions and otherwise comment as needed.

The conduct of the interview was standardized to the maximum extent practical for each of the four interviews. This helped eliminate any interviewer bias and provided more standardized data collection procedures. Length of the interview was planned for no more than one hour and date and time of interview were specified in the preinterview letter. Each respondent was asked identical questions. A draft questionnaire was screened by the thesis advisor prior to the final questionnaire being sent to the respondents.

Limitations

The major disadvantage of the telephone interview was the limitation on the complexity and length of the interview (Lavrakas, 1986:12). To quell this problem, a preinterview letter containing a list of definitions and interview questions was sent to each respondent prior to actual interview. This provided each respondent the ability to prepare their thoughts in anticipation of the interview. The questions were straightforward and interview time kept to a minimum. "Unlike the dynamics of face-to-face interviewing, it is tiresome to keep the average person on the telephone for longer than 20 or 30 minutes" (Lavrakas, 1986:12). Another disadvantage was the inability to use visual aids. Nonetheless, there is increasing evidence that complex questions could be asked via telephone without visual aids (Frey, 1989:73). Carefully worded questions mailed in advance minimized this problem.

Summary

Analysis of these four propositions revealed insight into the current and projected strength of the DIB, the positive impact commercialization has on a defense industry, and an increasingly optimistic outlook for the U.S. satellite industry. Support was made for the positive correlation between defense spending and strength of the DIB. Based on this argument, current downward trends in defense spending diminish the strength of the DIB substantially. See Table 11 for a review of these propositions.

However, with CMI, Acquisition Reform, and dual-use technology and production strategies, hope for the DIB is on the horizon. With these commercialization efforts, the DIB will be somewhat integrated with the commercial industrial base. A new national

industrial base will provide a much more stable base for both defense and commercial markets. These two markets should be able to feed off of advances in technology at the part, component, and subsystem levels serving one market or another, for the mutual benefit of each market. The U.S. satellite industry has already made headway into commercializing their formerly defense-only markets. It is expected this industry will grow, supporting both defense and commercial markets.

Table 11. Summary of Propositions and Research Methods

SUMMARY OF PROPOSITIONS AND RESEARCH METHODS	
Propositions/Methods	**Explanation**
Proposition 1: There is a positive correlation between defense spending and DIB strength. *Proposition 2: The strength of the DIB is deteriorating.* *Method: Literature Review*	A model was developed denoting how defense spending directly influences DIB production capability, levels of competition, and ability to develop advanced technology. These DIB strength factors determine how industrially prepared the DIB is – *DIB Preparedness*. The degree to which the DIB is prepared to meet any and all DOD objectives depicts how strong it is. Therefore, it can be deduced that defense spending qualifies as an adequate proxy for DIB strength. Using Proposition 1 as a basis, it can be construed that since defense spending has been declining since 1985, its strength is deteriorating as well. Relationships 1 - 6, as illustrated in Figure 4, and defense spending trends are addressed through reviewing the literature of various defense industry experts and the DIOR database.
Proposition 3: The relationship between defense spending and DIB strength is moderated by commercializing a defense industry. *Methods: Literature Review and Case Study*	Most DIB analysts, DOD leadership, and defense industry executives strongly support *commercial-military integration*. They argue this movement to integrate the DIB into the commercial industrial base should alleviate the historical deficiencies of the DIB. Relationships 7 - 9, as illustrated in Figure 5, moderate the relationship between defense spending and DIB strength, providing new opportunities for growth and development; they are addressed through a literature review. A case study of General Electric Aircraft Engines demonstrates how sales revenues remain relatively stable given fluctuating defense spending trends. This single defense company provides a surrogate for the entire DIB if it is commercialized.
Proposition 4: Due to the U.S. satellite industry being heavily commercial in nature, the shrinking DIB has not adversely affected it as might be suspected. *Method: Telephone Interviews*	Since the U.S. satellite industry is becoming more and more commercial in response to growing commercial space applications, telephone interviews with senior leadership in the satellite industry provided the opportunity to probe whether they would continue serving the DOD and to what degree they could efficiently and effectively meet U.S defense space requirements.

Chapter 4

Findings

PROPOSITIONS 1 AND 2:

1: There is a positive correlation between defense spending and DIB strength.
2: The strength of the DIB is deteriorating.

Proposition 1

In Chapter II the groundwork was laid for using defense spending as a proxy for DIB strength. The variables affecting DIB strength were identified as: tax, trade, environmental, and socioeconomic policies, but most importantly – *defense spending*. The argument was made that DIB strength is an end result of DIB preparedness – having the capability and capacity to surge and mobilize the defense industry to meet DOD objectives. Several critical factors directly influencing DIB preparedness were discussed; they are: production, competition, and technology. In Chapter III a model was developed showing how defense spending indirectly impacts DIB strength and therefore can serve as its proxy. To summarize this relationship, defense spending has a direct impact on DIB production, competition, and technology which directly influences DIB preparedness, ultimately resulting in DIB strength. In this chapter, each one of the relationships presented in the Chapter III model is discussed via literature review.

Relationship 1: Defense Spending - Production.

The first factor discussed in the model of DIB strength is production; this term was further broken down into four specific areas (labor, plants and equipment, money, materials and energy), discussed below. Not surprisingly, defense spending has a direct effect on the labor market found within the DIB. Increasing procurement dollars lead to additional DOD contracts, requiring additional labor. Defense budget cycles directly affect total employment in the industry (Gansler, 1989:248). In its 1992 report, the Defense Conversion Commission stated "As defense purchases are reduced, some of the skills and capabilities in the DIB may no longer be required in order to meet DOD's needs" (Defense Conversion Commission, 1992:17,20) and this effect is amplified by award or completion of a large contract (Gansler, 1989:248). It was estimated by the Commission that 960,000 jobs would be lost from 1991 through 1997 due to reduced DOD procurements affecting workers in many occupational groups, not just scientists, engineers and production workers (Defense Conversion Commission, 1992:40,61). In the aerospace industry, for example, reduced defense dollars have greatly diminished military aircraft shipments over the last several years and resulted in a loss for corresponding workforce levels. "This loss in workforce is significant because it represents a true loss in talent. Aerospace manufacturing jobs required special skills. Some of these skills are unique to the aerospace industry" (Bowlds, 1994:8). Reductions in defense spending resulted in falling employment levels by more than 25 percent from 1988 through 1994 (Schoeni, 1996:1). In contrast, increases in defense spending create a significant need for additional labor (Gansler, 1989:250). Changing DOD procurement budgets are more of a problem than budget totals (Correll and Nash, 1991:45), leading to long-term instability

and an unattractive market for younger workers (Gansler, 1980:54). The concern of DIB labor markets is that when layoffs occur because of reduced defense procurements, highly skilled personnel leave the DIB, especially in the lower tiers. And, totally defense-dependent companies directly relate employment to sales (Gordon, 1996:8-9).

Plants and equipment within the DIB are characteristically old and unproductive, due in large part to defense spending trends. The lack of capital investment for modernizing manufacturing capability by the DIB emanates from one main reason – lack of incentive. "The problem is that there are inadequate incentives to encourage defense firms to make the long-term capital investments necessary to drive down costs and improve quality" (Gansler, 1989:251). Future business is uncertain in the defense industry. Defense budgets change, while there is little profit incentive from defense sales. Cyclical DOD requirements make it difficult and expensive for DIB companies to raise equity or debt money. Acquisition costs for new plants and equipment exceed depreciation allowances and heavy, high-cost debt consumes excess cash (Gansler, 1980:58-59). In addition to budget instability, "Most studies of the DIB over the years have found that the tangle of incentives and disincentives embodied in the vast number of laws, regulations, and requirements undercut the growth and health of the defense industry" (Polmar and others, 1988:15).

Diminished defense spending has impacted DIB manufacturing capacity. The DIB has reacted to these reductions by reducing excess capacity. A direct result of this consolidation is less manufacturing facilities. Defense spending cuts have led to aerospace industry collapse and consequently, reduced production capacity (Bowlds, 1994:8,9,28). Decreased DOD procurements mean excess DIB capacity (Gordon,

1996:11), increasing overhead costs and inefficiency (Gansler, 1980:57). Sometimes DIB companies can even go out of business because of reduced DOD dollars. Excess capacity from fewer DOD contracts leads to increased costs. If sales do not cover these costs, floor space is sold, resulting in capacity loss, reduced production, even fewer orders, followed by decreased revenues, personnel layoffs, additional reductions, and possibly going out of business (Gordon, 1995:25).

The third factor of production is money – originating from either the financial community or DOD progress payments and profit (Gansler, 1989:252). Wall Street placed DIB firms in a low price-to-earnings ratio, resulting in difficulties attracting investors from the financial community. Two factors heavily influence this low ratio. First, progress payments for work completed by the DOD are made at a slow rate; these progress payments are used to provide an incentive for defense companies to do business with the DOD. In the early 1980s progress payments were made at 90 percent; this later shifted down to 75 percent (Gansler, 1989:252) in 1986 in order to meet Gramm-Rudman-Hollings deficit reduction ceilings. Some relief was granted to DIB contractors when in 1988 progress payment rates increased to 80 percent and then to 85 percent in July 1991 (Correll and Nash, 1991:48). However, a tremendous increase in debt during the Vietnam-era expansion spawned the beginning of serious financial problems that continued to plague this industry (Gansler, 1980:59). Between 1985 and 1990, defense industry debt grew by 81 percent and earnings dropped by 45 percent (Correll and Nash, 1991:45). Second, DIB companies realize a substantially lower profit, as mandated by Government regulations, than their commercial counterparts (Gansler, 1989:253). This all amounts to an unattractive market for the financial community, resulting in less

available money for the DIB to invest in capital equipment, modernization efforts, and any other innovative means to become more efficient and effective in meeting DOD needs. Defense spending directly impacts the available money pool from which DIB companies have to draw progress payments and profit. Less procurement dollars mean fewer DOD contracts; those smaller companies who rely on volume to sustain their business are affected to a large extent (Gordon, 1995:17). "There is no denying the defense industry's cash flow problem, and few would dispute that Government policies have had more than a little to do with it" (Correll and Nash, 1991:48). Therefore, it can be deduced that reductions in defense spending exacerbate the problem of low profits and unattractiveness to the financial community.

The fourth production factors, materials and energy, are indirectly affected by defense spending. Lack of available money, as discussed above, inhibits any incentive DIB contractors may have to upgrade antiquated and inefficient manufacturing plants and equipment. In Chapter II, the issue of increased foreign dependence of critical materials, components and energy sources was discussed. Much of the raw materials needed for manufacturing current weapon systems are exotic and not available domestically (Gansler, 1980:70). Furthermore, these raw materials must be processed before being manufactured. Unlike DIB suppliers, foreign suppliers have upgraded their processing facilities, making it cost effective to have them process these materials before shipping to the United States (Polmar and others, 1988:33). The impact of decreased defense procurements culminates in decreased demand for exotic alloys and raw materials, leading to increased lead times and a significant cost driver in future procurements (Gordon, 1995:22). In the MILSTAR Program, many suppliers reported distributors and

manufacturers of raw materials and critical components discontinued stocking products, reducing stock availability, and increasing production lead times. Fewer DOD dollars have enticed distributors and manufacturers to reduce finished goods inventory costs by accumulating orders before making any orders (Gordon, 1996:7). "Reduced order quantities drive yields down and costs up, thus making marginally profitable work unprofitable. Also, spreading overhead costs over this lower volume of work makes many very good producers non-competitive under present contracting standards" (Gordon, 1995:19).

Relationship 2: Defense Spending - Competition.

Defense spending has a profound impact on the level of competition in all tiers of the DIB. "Consolidation and restructuring are the defense industry's inevitable and natural responses to lower revenues" (OSD [Economic Security], 1995:5). A direct result of decreased spending is a massive scaling down of many firms while others terminate defense production and liquidate fixed assets (Gansler, 1993:131).

> With defense spending declining since 1985, tens of thousands of firms have ceased doing business with DOD and no longer manufacture military products or are out of business. As the military drawdown continues, the U.S. faces the prospect that entire industries may disappear, further eroding U.S. technological leadership. (Blackwell, 1992:21)

In response to reduced DOD procurements, some defense contractors have opted to pursue commercial markets exclusively or in combination with defense business. While some success has been achieved in such efforts, a heavy burden still remains on the lower tiers as a result of these reductions; the impact is more severe in these tiers than on the prime contractors. The end result is reduced competition among defense industry sectors and entities (Boezer and others, 1997:41,44,46). Ironically, under the Reagan

Administration's monumental defense spending spree, a significant number of firms left the DIB, indicating that defense spending is not the only factor keeping defense companies interested in defense business.

> One of the most specific estimates of the decline was made by the Center for Strategic and International Studies in 1989. Drawing on information from Government data bases, CSIS concluded that more than 80,000 suppliers had left the defense market between 1982 and 1987. There is no reliable count of how many more have gone since then. (Correll and Nash, 1991:3)

Reduced DOD procurements diminish the desire for many firms to remain in the defense business at all. In the MILSTAR Program, it was determined the "Defense cutbacks and insufficient business volume to support fixed costs and investment for future production have a direct effect on a company's will and ability to remain in the defense business, or even in business at all." Additionally, the most quoted reason for leaving the DIB in this program, was the reduction in defense-related procurements. It was further determined the effect compounded itself as it progressed to the lower tiers (Gordon, 1995:9,16).

> As large and small companies alike struggle to remain competitive and survive in this era of defense downsizing, they are moving in increasing numbers from defense into the commercial sector. Many of the companies reported that the decreasing defense budget had forced them to turn more of their manufacturing effort to the pursuit of commercial business. (Gordon, 1996:12)

Relationship 3: Defense Spending - Technology.

Defense spending also impacts the development of technologies used in major weapon systems. The implication was made by the Defense Conversion Commission that reduced DOD expenditures lead to the disappearance of critical maintenance and research capabilities (Defense Conversion Commission, 1992:33). In the area of research and

development, continued high levels of financial support from the DOD are necessary to preserve unique defense capabilities (Gansler, 1993:137). As of 1991, the DOD absorbed 34 percent of total research and development spending in the United States, while the entire Federal Government supported about 50 percent (Pascall and Lamson, 1991:42). "Reductions in DOD procurement of goods and services will also affect defense-related research and development activities by reducing the independent research and development and bid and proposal efforts of contractors that heretofore have been supported by DOD" (Boezer and others, 1997:36). DIB contractors are reluctant to invest in independent research and development because of the short-term focus by U.S. investors and the skeptical outlook about future profits from defense budgets (Pascall and Lamson, 1991:71). The result of these research and development efforts for both military and commercial applications has been extraordinary (Boezer and others, 1997:36), especially for the many advances in weapons technology (Pascall and Lamson, 1991:71). The United States has since lost its technological leadership role because of its lack of investment in research and development (Polmar and others, 1988:21). Reduced defense dollars amount to fewer technologies for production (Bowlds, 1994:15).

Relationship 4: Production - DIB Preparedness.

The labor market supporting the DIB is a crucial factor for DIB preparedness. Labor stability is necessary for the efficiency in a production facility – "learning by workers, using trained workers, achieving group unity, and having supervisory continuity." This efficiency is required for the DIB to have the capability and capacity to meet DOD objectives. The instability caused by fluctuating DOD budgets causes defense contractors to have to pay 20 percent more for their workers (Gansler, 1989:248). Increased labor

costs result in cost cutting in other areas to remain competitive, resulting in inefficiency, reduced quality or increased equipment costs. The DIB labor pool provides a wide variety of critical skills that are necessary to operate specialized equipment and perform many of the professional and technical tasks necessary for effective operation (Gordon, 1996:8,9). "Many of the skills typically found at the lower tiers, especially in the sector of the base supporting the spare and repair parts requirements, although perhaps not representative of high technology themselves, are nevertheless critical to successful production of those parts" (Gordon, 1995:23).

Plants and equipment – a firm's manufacturing capability – are vital to the capability and capacity of the DIB to be industrially prepared. "To produce complex, high-quality, low-cost systems requires very modern automated manufacturing equipment" (Gansler, 1989:251). For a long time, the DOD has argued that excess plant and equipment capacity must be provided and maintained for surge or mobilization capability. However, excess capacity raises production costs and deters any incentives companies may have to modernize current capacity (Gansler, 1980:56,57). Recent defense cutbacks have led many defense companies to downsize, resulting in reduced capacity and in some extreme cases, complete reliance on foreign suppliers for certain key technologies. This increased dependence leads to U.S. vulnerability (Bowlds, 1994:10).

Tied directly to plants and equipment is the issue of money. As expected, money must be available for defense companies to make capital investments. "In the period going into the peak of the Vietnam defense expenditures, defense contractors borrowed heavily in order to increase their plant and equipment capacities for the expected increase in production" (Gansler, 1980:59,60). Modernization results in higher quality, less costly

defense systems; the unavailability of money inhibits defense contractors from modernizing plants, equipment and manufacturing processes to improve the efficiency of operations. Although not directly influencing DIB preparedness, money indirectly impacts the ability of DIB contractors to make capital investments which lead to improved preparedness.

Materials and energy provide the basic resources the DIB requires to produce the weapon systems the DOD needs. The economic and strategic viability of the DIB center around levels of raw materials and energy (Gansler, 1980:63). Finished goods require the availability of raw materials to manufacture (Polmar and others, 1988:31).

> At its most basic level, virtually every manufactured article requires some raw material extracted from the ground, and seemingly the more complex the article the more likely it is to require scarce materials. The prevalence of numerous high-technology systems in the U.S. armed services means that many of the components critical to national security contain rare materials, many not readily extractable in this country. Many of these materials come from areas of the world that are politically volatile or that are inherently hostile to the United States and therefore unlikely to supply needed raw materials during times of national crisis. (Polmar and others, 1988:31)

The availability of raw materials is critical for timely delivery. In an effort to save scarce dollars, some material distributors and manufacturers wait until orders accumulate before placing any orders, increasing lead times and driving costs up for suppliers who now must warehouse them. These delays also cause cash flow problems for the lower tier suppliers (Gordon, 1996:7).

Relationship 5: Competition - DIB Preparedness.

One might think that increasing levels of industry competition – in each tier – indicate higher levels of capacity and capability within the DIB. This is true to some

extent; more companies will have more plants and equipment. Yet, this does not address issues of efficiency and effectiveness, which may be more important than pure numbers for meeting DOD objectives. In fact, as previously mentioned, the DIB is crippled by outdated, inefficient and oversized plants and equipment. So, having more of it does not enable the DOD to better meet its objectives. It is also a well known fact that in Government contracting, competition is supposed to ensure the acquisition of a quality product or service at a fair and reasonable price. With limited DOD procurement dollars, too much competition will result in excess capacity, increased overhead costs, rising unit prices, and overall inefficiency – as discussed in Chapter II. But, on the other hand, too few suppliers will result in too little capacity and a general lack of capability. As the defense market shrinks, industry contraction is inevitable. The question is whether the remaining DIB will be capable of producing state-of-the-art equipment and weapon systems in a timely manner at a reasonable price (Gansler, 1992:50). The changing global environment and end of the Cold War left the DOD challenged with a reduced number of firms capable of developing and producing defense materiel and weapon systems (Boezer and others, 1997:46). Maintaining DIB manufacturing capability requires two things. First, existing manufacturing capability must be in operation, producing critical weapon systems at a low rate. Second, technological advancements must be incorporated into the existing manufacturing capability to improve manufacturing efficiency (Bowlds, 1994:19). The importance of DIB competition for purposes of manufacturing capability can not be overstated. "If whole segments of the base supporting defense programs are eroded past a certain point, then the Government may be appropriately expected to intervene." For the MILSTAR Program, a defense-to-

commercial sales ratio showed there was a potential for loss of capability, since many companies formerly dedicated to supporting Government contracts have left the DIB (Gordon, 1996:12).

Relationship 6: Technology - DIB Preparedness.

The integration of state-of-the-art technology into defense weapon systems is critical for DIB preparedness. The need to maintain technological superiority and avoid technological surprises, if developed by potential adversaries, could significantly alter the balance of power (Gansler, 1980:10-11). "The DIB must also maintain strong research and development capabilities to ensure the continued technological superiority of U.S. military forces, while preserving the ability to expand the production of spare parts and weapons when crisis conditions demand it" (Gansler, 1993:131). This is especially critical considering the current DOD philosophy of *doing more with less*. U.S. armed forces must be able to use advanced technology in lieu of large numbers of people and equipment to maintain national security. The 1988 Defense Science Board stressed "the role of technology as a *force multiplier*, the qualitative edge that enables us to match an adversary whose weapons are numerically greater" (Pascall and Lamson, 1991:57). Desert Storm displayed the importance of superior technology for winning wars and saving lives. "Technological advantage is so important to U.S. forces that an extraordinary effort in science and technology becomes imperative. Leadership in this regard is a main measure of the DIB." However, advanced technology is the heart of the DIB problem (Correll and Nash, 1991:35,55). The United States has relinquished its traditional lead for state-of-the-art technologies. There are two main reasons for this current phenomenon. First, the Federal Government has not invested in innovative

research programs. Second, the DIB is more interested in short-term profits (Polmar and others, 1988:21). It is through research and development that the Federal Government promotes the advancement of technology. The difference between past and future research and development is the reduced opportunity to integrate advanced technology into a producible item (Bowlds, 1994:15). Table 12 summarizes Proposition 1.

Table 12. Summary of Proposition 1

SUMMARY OF PROPOSITION 1
There is a positive correlation between defense spending and DIB strength.
Defense spending indirectly influences DIB strength. Levels of defense spending, however, directly influence certain core factors (production, competition, and technology) which impact the ability of the DIB to meet DOD objectives. Since DIB strength has been specifically defined, for the purposes of this research, to mean the capability and capacity of the DIB to meet these objectives, levels of defense spending positively correlate with DIB strength. The factors of production – labor, plants and equipment, money, materials and energy – require defense spending to: sustain the critical skills necessary to support defense-unique requirements; upgrade, or otherwise maintain modernized plants and equipment – *manufacturing capability*; provide the funding necessary to support defense programs and invest in capital equipment; acquire and stockpile exotic raw materials and energy needed for program development. Fluctuations in defense spending preclude a stable market, which in some cases, can be worse than actual dollars spent; instability in the defense market deters the inflow of skilled labor and any incentives for investment from the financial community. However, continued decreases in defense spending are worse; this trend culminates in fewer DOD procurements meaning excess capacity, which leads to increased unit costs. The only way for the DIB to handle this situation is to reduce labor, excess capacity, spend less on modernization and stockpile less required raw materials and energy. This creates a situation where the DIB has less ability to meet the demands of the DOD, resulting in diminished strength.

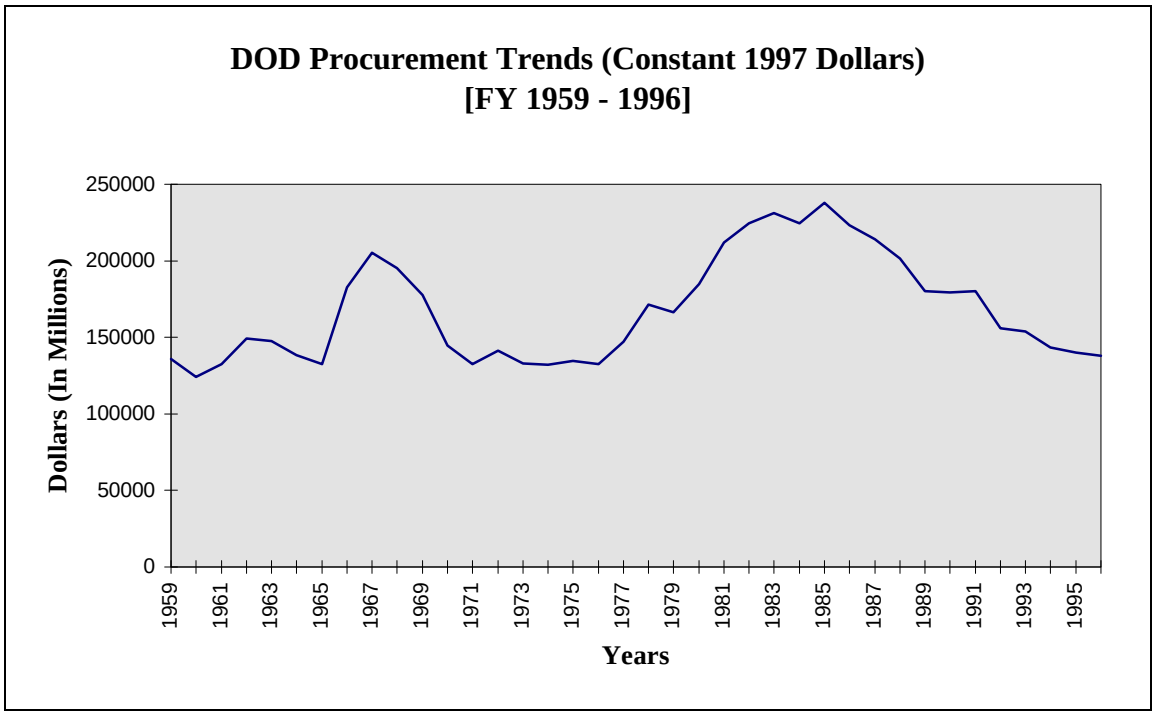
Proposition 2

The aforementioned discussion highlights the relationships developed in the Chapter III model of DIB strength. It was hypothesized that defense spending can serve as a proxy for DIB strength. In the first three relationships, it was determined that defense spending has a significant impact on production (labor, plants and equipment, money, materials and

energy), competition and technology. Increases in defense spending improve each of these factors and the opposite can be held true for decreases in defense spending. However, defense budget fluctuations can be worse than budget levels for two of the production factors (labor and money). Instability leads to an unattractive market for both younger workers to enter and the financial community to provide loans and investments.

Each of the factors were determined to be critical to DIB preparedness. The production factors are critical to producing effective weapon systems for the DOD. Specifically, critical labor skills are necessary to maintain specialized equipment. Plants and equipment as well as manufacturing processes provide the vehicle for actual production. Money is necessary for capital investment, while materials and energy are the building blocks from which these weapon systems evolve. Competition, to some degree, provides capacity and capability for meeting DOD requirements. Although excess capacity currently exists, some industry contraction is necessary, but only to a point. Advanced technology not only leads to top-of-the-line weapon systems, but also improved manufacturing processes, leading to a more cost effective means of weapon system development. Therefore, it is reasonable to conclude that defense spending significantly impacts DIB factors of production, levels of competition and technological leadership, all crucial features necessary for DIB preparedness. In this light, the capability and capacity for the DIB to surge and mobilize in periods of national crises as well as meet any other DOD objectives – DIB preparedness – indeed provides a measure of DIB strength. Figure 7 shows DOD procurement trends from 1959 until 1996. As depicted, it is cyclical with peaks in 1967 (peak of Vietnam War procurement spending) and again in 1985 under the massive defense spending era of the Reagan Administration.

However, DOD procurement spending has been diminishing since 1985 and at the current rate, will continue to decline, indicative of deteriorating DIB strength. This debilitated condition concerns senior DOD leadership. What can be done now to remedy the problem? Table 13 summarizes proposition 2.



(DIOR)

Figure 7. DOD Procurement Trends.

Table 13. Summary of Proposition 2

SUMMARY OF PROPOSITION 2
The strength of the DIB is deteriorating.
Proposition 1 provided the foundation for how defense spending positively correlates with DIB strength. With this concept in mind and from the visual reference of Figure 7 above, it is obvious that DIB strength is diminishing. Without any intervention by the Federal Government and the defense industry, it is very possible this deterioration will continue to a point where the DIB cannot meet DOD objectives and the United States will be extremely vulnerable in the event of war.

PROPOSITION 3:

The relationship between defense spending and DIB strength is moderated by commercializing a defense industry.

> Higher costs, longer lead times, diminished crisis responsiveness, and growing foreign dependency must be arrested. Yet to ensure the effectiveness and safety of U.S. fighting forces, continued improvement in weapons performance is needed. The only effective solution to this dilemma is to end, wherever possible, the DOD's dependence on a captive defense industry and to fully mobilize the creative potential of the commercial sector to meet most defense requirements. (Gansler, 1992:53)

Several programs, sponsored by the Federal Government, are currently underway to integrate the DIB into the commercial industrial base. These programs should help the DIB not only survive but thrive given recent global changes and the end of a drawn-out Cold War. Whether these programs will reduce the burden the DIB has traditionally carried, considering the unstable nature of defense, is yet to be determined. In Chapter III it was hypothesized that commercialization efforts moderate the relationship between defense spending and DIB strength, possibly alleviating a great deal of this burden. Commercialization positively affects each of the DIB strength factors (production, competition and technology), increasing DIB preparedness and thereby maximizing DIB strength. Each of these relationships (R_7 - R_9) is discussed below. Gansler summarizes the benefits of CMI for both the DOD and commercial industry; see Table 14 for a summary of these benefits.

Table 14. Benefits of CMI.

BENEFITS OF CMI	
DOD	***Commercial Industry***
Lower costs	Greater availability of billions of dollars of Government research and development funds
Higher volume	State-of-the-art engineering talent
Greater factory automation	High-technology management skills
Higher quality	Significant Government investments in advanced manufacturing technologies and equipment
Increased competition	
Greater surge capacity	

(Gansler, 1989:274)

Relationship 7: Production - CMI - DIB Preparedness.

In Chapter II, many potential benefits were realized from CMI. The overriding theme, however, was the introduction of stability into mainstream defense business by forging a single national industrial base from what has evolved into two separate and distinct commercial and defense industrial bases. The affect on DIB production factors by commercializing it are intertwined. Labor instability and defense industry avoidance from the financial community could be eliminated as a result of CMI. From the above discussion regarding defense spending, labor and money, it was determined that labor instability and lack of interest from the financial community is a result of fluctuating DOD procurement budgets. CMI should provide the DIB stability necessary to keep a more than adequate workforce employed because of the balance introduced from commercial business (Defense Conversion Commission, 1992:23). The stabilization introduced should entice highly qualified managers and technicians to enter and remain in the DIB. Fear of job elimination would be as it would in the commercial sector. This stability might attract investors enticed by commercial ventures.

Also discussed in Chapter II was the fact that CMI would motivate traditionally reluctant DIB contractors to invest in modernization efforts for what are currently antiquated plants, equipment and manufacturing processes. Future prospects for defense business and the introduction of commercial business would provide sufficient incentives to make plants, equipment and manufacturing more cost effective and efficient (Gansler, 1989:274). Advanced technology and automation could replace unnecessary labor, while additional labor would be needed in other areas to support additional business. The end result for DOD and the newly commercialized DIB would be labor stability and the retention of more qualified workers and increased capital investments, lowering defense weapon system costs. Additionally, increased capability and capacity for surge and mobilization requirements would be created from larger, more efficient contractors and the entrance of new defense contractors who previously would not do business with the DOD. Materials and energy do not seem to be directly impacted by commercialization but may be indirectly. An increased base from which DIB contractors may draw might also find substitutes for exotic raw materials and energy, reducing the dependence on foreign suppliers. Consequently, the vulnerabilities created by this dependence would be reduced if not eliminated altogether.

Relationship 8: Competition - CMI - DIB Preparedness.

Competition would be enhanced from a larger national industrial base. Additional business and stability should produce sufficient incentives for American industry to enter what used to be forbidden territory for many highly qualified contractors. CMI would assist defense-dependent companies transition into commercial markets; access to these new markets would enable them to shift their resources in periods of decreased defense

spending (Defense Conversion Commission, 1992:23). The increase in competition would help DIB preparedness by expanding its capacity and capability (Gansler, 1989:274). Competition and free market forces from CMI would enable the DOD to acquire high quality products and services at an affordable price (Gansler, 1993:139). With CMI, competition in the lower tiers would be enhanced and its rapid deterioration should be halted (Boezer and others, 1997:46).

Relationship 9: Technology - CMI - DIB Preparedness.

Numerous technological benefits from CMI were identified in Chapter II through the implementation of dual-use technology strategies. Both commercial and defense industries could gain the benefits of technological advances encouraged by CMI. Dual-use technology and production strategies would enable both commercial and defense businesses to gain access to the technological ingenuity created by the other (Defense Conversion Commission, 1992:31-32). The commercial sector currently leads in many key technology areas; the DOD would greatly benefit from access to this technology (Gansler, 1993:136). The bottom line – a larger industrial base will provide both defense and commercial businesses access to technological advances not usually available under separate industrial bases and national security will greatly benefit from access to *spin-on* advanced commercial technology (Defense Conversion Commission, 1992:31). "And by strengthening those segments of the technology and industrial infrastructure upon which DOD depends, successful commercialization of defense technologies can increase the likelihood that these technologies remain accessible and affordable for military use" (Boezer and others, 1997:41). The following case study demonstrates how a commercialized defense industry can be successful despite reduced defense spending.

General Electric Aircraft Engines (GEAE): A Case Study

CMI is touted by captains of the defense industry, senior defense leaders and defense industry analysts as the best current solution for the ailing DIB. So far there has been no comprehensive analysis of the impact commercialization has on the DIB; it is probably due to the infancy of this paradigm shift. However, anecdotal evidence shows the potential of CMI. General Electric Aircraft Engines (GEAE) – a division of General Electric – demonstrates this potentiality.

> GEAE is the world's leading manufacturer of military and commercial aircraft jet engines. The company produces and services large and small jet engines for airlines, charter and leasing companies, and military aircraft. GEAE also supplies marine and industrial engines based on successful jet engine designs and provides extensive aviation services. (History of GE, 1997:1)

GEAE has been producing aircraft engines for more than 75 years. This is when the first aviation-related Government contract was made, paving the way for many more years of Government service in the aircraft engine business. Based on years of Government experience, GEAE launched a campaign to enter the civil market in 1971. "Today, GEAE designs, develops, and manufactures jet engines for a broad spectrum of military and commercial aircraft and produces aeroderivative engines for marine and industrial applications" (History of GE, 1997:1-2).

Sales revenues for GEAE are shown in the two figures below for the period 1980 through 1996. Both figures have been adjusted for inflation using OSD raw inflation rates. Figure 8(a) shows the breakdown between commercial and military sales revenues. Figure 8(b) shows aggregate sales revenue and DOD procurement trends. When considering both figures simultaneously, it can be determined how well GEAE performed for both commercial and military sectors in terms of sales revenues during changing DOD

procurements. Overall, it looks like sales revenues remained above $5.8 billion no matter how much DOD was spending on procurements. In fact, there was a period between 1986 and 1991 where there were substantially higher sales revenues, ranging from $8.44 billion to $9.13 billion, before they dropped back down to around $6 billion. Peak military sales revenues did not occur until 1987, two years after the defense spending apex under the Reagan Administration. Since 1985 defense spending has gradually, but consistently, been decreasing. Likewise, military sales revenues for GEAE have been decreasing at about the same rate.

The impact on overall sales revenues, from serving both military and commercial markets, is increased stability. This is evident from an established mean of $7.27 billion over the course of 17 years. The combined military and commercial sales revenues ranged from a low of $5.82 billion to a high of $9.37 billion, a difference of only $3.55 billion. Standard deviation throughout this 17 year period was only $1.35 billion with a variance of $1.81 billion. This statistical analysis indicates a relatively stable performance for total commercial and military aircraft engine sales. This is one positive example of what commercializing a defense industry can do for the DIB if commercialization is possible. Figure 9 displays GEAE sales revenues for the military market only. From visual inspection, it is evident that military aircraft engine sales revenues change with DOD procurement fluctuations. Relying solely on military dollars results in fluctuating sales revenues and prospects for continued reductions.

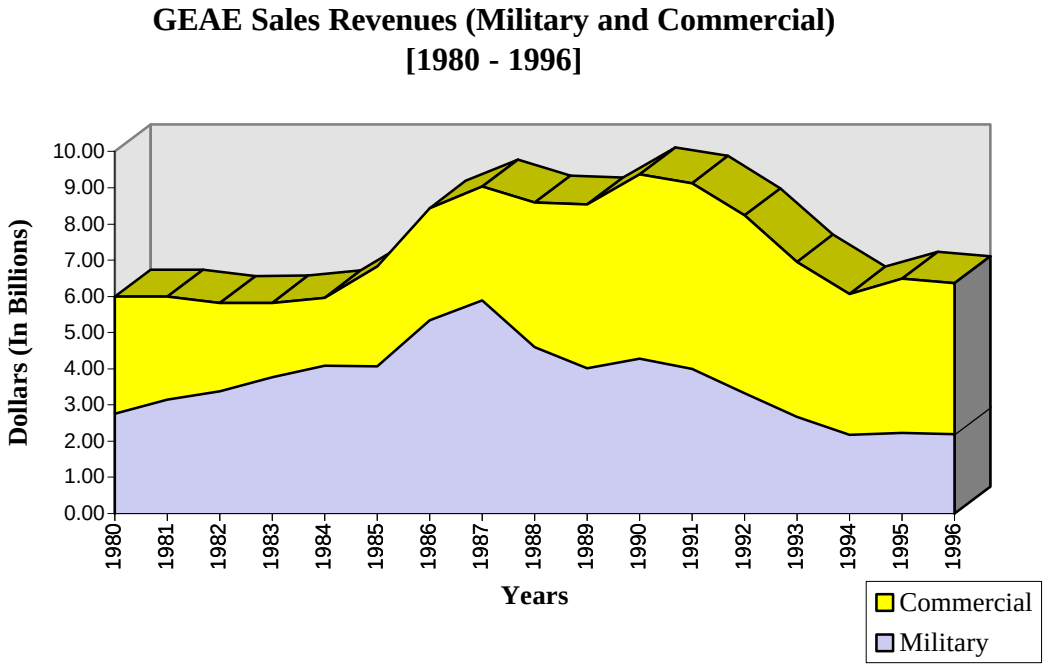


Figure 8(a)

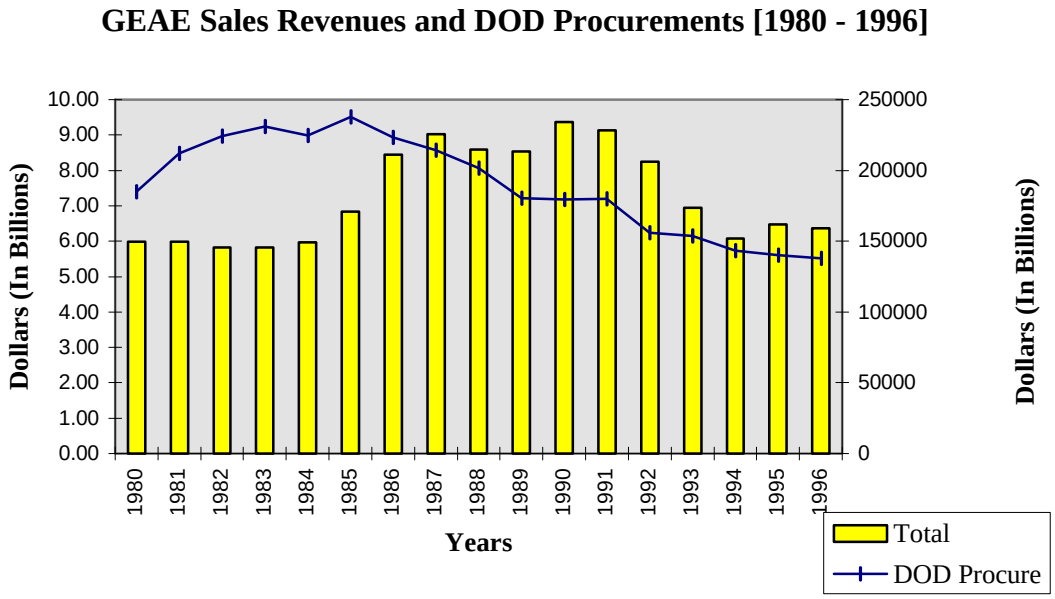
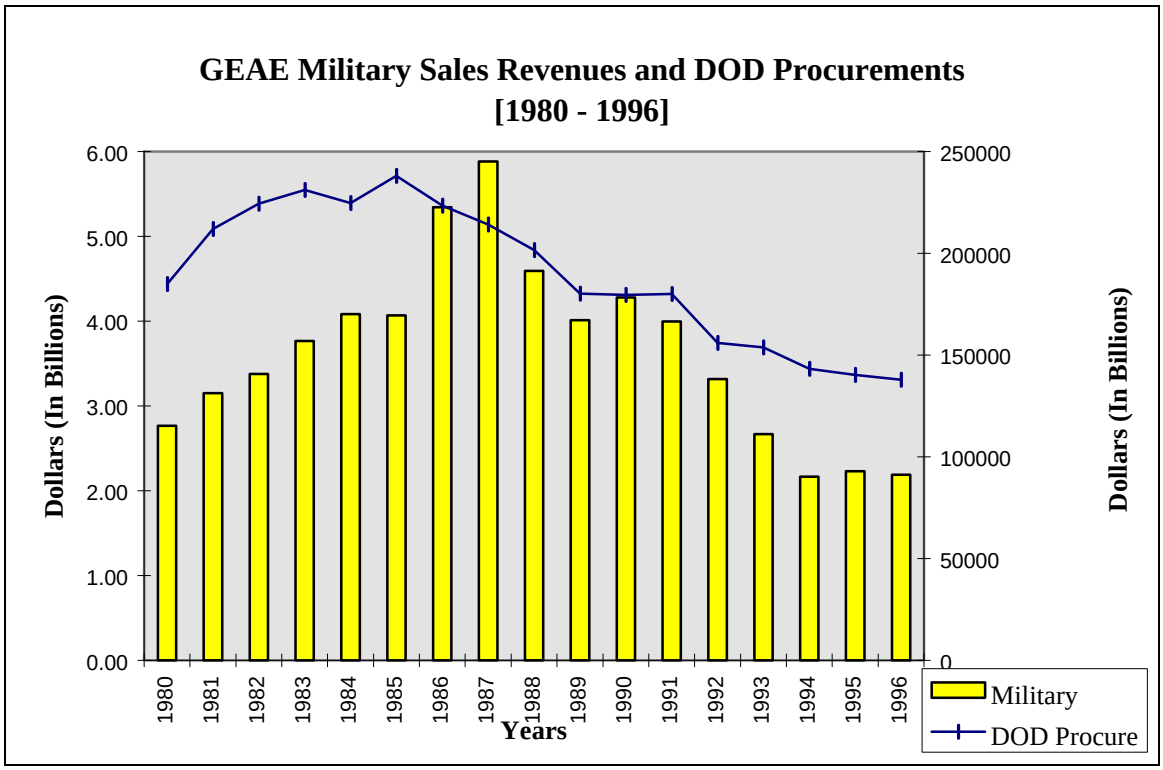


Figure 8(b)

(GEAE Executive and DIOR)

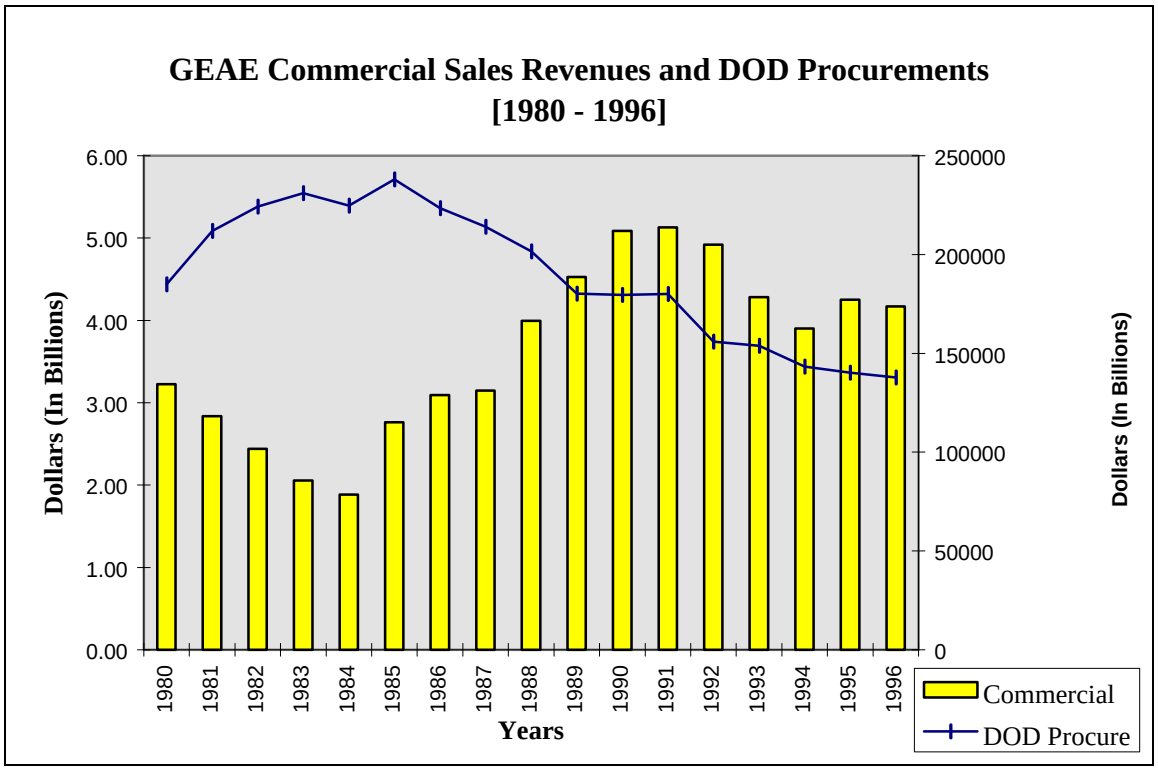
Figure 8. GEAE Sales Revenues During Fluctuating DOD Procurements.



(GEAE Executive and DIOR)

Figure 9. GEAE Military Sales Revenues and DOD Procurements.

Figure 10 shows how commercial aircraft engine sales revenues increase while DOD spending goes down. The large procurement dollars spent by the DOD in the early through mid 1980s, coincidentally, resulted in lower commercial sales revenues and a corresponding increase in military sales. While recent DOD cutbacks have resulted in less sales revenues for GEAE, increased commercial sales revenues have offset the reduction. The DIB can also compensate the way GEAE has when fewer DOD dollars are spent, by increasing commercial sales. Although this is just one company in one industry, the overall implication can be conveyed to other companies in the aerospace industry and other sectors comprising the DIB. Now, it is time to look at an entire industry within the DIB that is evolving with a commercial flavor – the U.S. satellite industry.



(GEAE Executive and DIOR)

Figure 10. GEAE Commercial Sales Revenues and DOD Procurements.

PROPOSITION 4:

Due to the U.S. satellite industry being heavily commercial in nature, the shrinking DIB has not adversely affected it as might be suspected.

Introduction

Four telephone interviews were conducted between the period of 24 July 1997 and 5 August 1997. Each of the interviewees was a senior level representative from each of the top four U.S. satellite producers (Lockheed Martin, Hughes, Boeing, and Orbital Sciences Corporation). The market share these companies hold totals roughly 86 percent of all U.S. satellite producers. Each of the respondents enthusiastically supported this research

through their willingness to interview over the telephone, insightful responses and interest in the research. The telephone interviews ranged from 35 minutes to a little over an hour.

Responses to each of the sixteen interview questions is thoroughly documented in this chapter. A sample of the introductory correspondence sent to each of the interviewees and a list of their names, titles and addresses are provided in Appendices C and D, respectively. Additional comments and recommendations for the DOD are also incorporated in this chapter. This provided the interviewees an opportunity to give their insight on actions the DOD can take to help meet its challenge of maintaining superior satellite technology and industrial capability at an affordable price. Following, are the sixteen interview questions and data collected from the interviews.

Interview Question #1

> *What percentage of your company's satellite sales are commercial? Defense? Are these percentages changing? In what way?*

This question was designed to determine whether DOD would continue to be a valued satellite customer in the future, taking into account continued DOD downsizing. Specifically, the question accomplished two things: (1) it established to what extent these companies relied on DOD versus commercial/civil satellite sales, and (2) determined whether this fact would remain the same. Knowledge of the balance between commercial and defense satellite sales highlights where most satellite business is concentrated for each contractor. Whether this percentage will remain the same, was determined by present corporate strategy and forecasted satellite sales in the next few years. Movement from one area, whether defense or commercial, to another shows where the most market potential is found.

The responses greatly varied, denoting a diverse satellite producer base. Percentages ranged from a breakdown of 100% DOD with no commercial sales to 60% commercial and only 25% DOD (the remaining 15% was either classified or civil). The remaining satellite producers varied somewhere in the middle.

All of the interviewees agreed there is enormous commercial satellite market potential. The industry has also begun to focus its attention on service rather than new satellite system production. In fact, the completely defense-dependent contractor has future commercial prospects. His company plans on pursuing several specific commercial contracts already underway. Another company representative said, "A growing percentage of commercial space sales are a result of strategic market redirection over the past several years. The market consists of launch vehicles, spacecraft, telecommunications services, ground systems and commercial remote sensing (predicted surge for remote sensing in 5 years)." The same company is moving to create lines of business in space, whether through industrial enterprises or the creation of new markets, to enter the satellite services market.

Another representative said that only 5 years ago, 15 percent of their business was DOD and 85 percent was civil/commercial. Today, 30 percent is DOD with the remaining 70 percent civil/commercial. The big picture is this – the commercial satellite market is quickly growing with an emphasis on services rather than systems. According to several interviewees, the DOD plans to tap into this service market rather than design, develop and manufacture their own unique satellite products.

Interview Question #2

> *To what degree does defense spending impact your company's capability to effectively and efficiently produce satellites?*

Not surprisingly, the companies who have both commercial and defense customers do not believe defense spending greatly impacts their capability to effectively and efficiently produce satellites. However, the one company totally reliant on defense satellite acquisitions claimed dramatic company impact from defense spending. Further, he said it was not the amount of DOD dollars spent, but rather the fluctuations that affected his company the greatest. Furthermore, he said funding stability would lead to additional resources and multi-year funding would help cover long lead-time procurements. One company representative said they were happy with their 60% commercial and 40% DOD/civil satellite business split, providing them a nice balance between each market; they are still pursuing additional new market opportunities. All companies stated that because of defense downsizing, they have begun to focus on new and growing commercial markets. Concern was voiced by an interviewee about maintaining a skilled workforce because of reduced DOD business. In order to maintain defense-unique labor skills, there must be more DOD business. One representative went so far as to say, "We have focused on new markets, such as commercial telecommunications, that continue to support our core competencies. However, we have adapted new, innovative streamlined processes such as our commercial satellite production facility here to meet the supply demands of emerging commercial space opportunities."

Interview Question #3

> *How have declining DOD procurement budgets affected your company's satellite business?*

One hundred percent of the company representatives agreed that declining DOD procurement budgets affect their company's satellite business to some degree. Yet, not one of them said the effect was negative. In fact, the company with 60% commercial satellite business just said an emphatic "No." The company 100% dependent on DOD dollars for satellite sales said declining budgets do not impact the company's satellite business to any extent because right now they are engaged in one classified contract that is over a year old and just received two new DOD contracts – one of which is classified. Bottom line – they do not have much current satellite business to be impacted; they do, however, foresee numerous possibilities in the future for both DOD and commercial markets. One interviewee was very specific on how defense downsizing has impacted his company's satellite business saying, "Defense declines have caused us to restructure through consolidation of facilities and construction closure, reduced cycle times, reshaping our portfolio with increased emphasis upon the commercial sensing and telecommunications markets, use of common products and supplier partnerships, commercial procedures and processes, leveraging the synergy throughout our corporation…all with continued attention to mission success and customer satisfaction." Another one said there were less opportunities, especially for research and development.

Interview Question #4

> *How has the shrinking DIB influenced your company's satellite business? Assuming your company is the prime contractor for a particular defense satellite contract, are you well-supported (in terms of industry competition) by subcontractors and parts/material suppliers? Are they*

able to provide the critical materials, components, and parts necessary for satellite production, whether commercial or defense?

All but one respondent claimed the shrinking DIB has not had a negative influence on their satellite businesses, with no *horror stories* to tell. Essentially, DIB shrinkage has, according to one representative, "ironically spurned a new generation of spacecraft products which are responsive to new market needs and competitive in the open market." Emphasis has been placed on small satellites (smallsats) by both commercial and defense markets. The Government is currently attempting to capitalize and to a certain extent, influence smallsat technology to meet issues of affordability. Increasingly, the Government is moving away from large, dedicated satellites. Smallsats provide *better-faster-cheaper* capabilities, requiring less launch capacity and therefore, lower cost systems. One company has invested in the commercial remote sensing market by introducing an entirely new family of spacecraft which provides industrial quality, capable of supporting dual use commercial and defense requirements for precision terrain mapping. Another respondent said that as a result of shrinkage in the DIB, they are now in acquisition mode, growing to meet new market potential. The dissenting opinion just felt there were fewer defense opportunities because of the shrinking DIB, otherwise the industry is growing commercially.

All respondents but one agreed they were well-supported by subcontractors and parts/materials suppliers. In fact, the number of subcontractors and parts/materials suppliers has been increasing. However, there was some concern mentioned in the area of radiation hardened parts as a necessary material for certain DOD satellite systems. They are not cost effective to produce for spacecraft production lines; they increase costs

and add to already long lead times. These parts are critical because they are not susceptible to nuclear explosions – a concern for the DOD. The one exception was because of the shrinking DIB, delivery times have gone up and suppliers have gone down. He qualified his answer as only applying to defense-unique (military specification) items. Examples he mentioned were integrated circuits and gyros.

Interview Question #5

> *Do you have the industrial capacity and facilities to produce quality, state-of-the-art satellites for defense and commercial business now and in the future? Is your company planning on reducing or expanding capacity and/or facilities?*

One hundred percent of the respondents claim they have the capacity and facilities to produce quality, state-of-the-art satellites for both defense and commercial markets now and in the future. One company, 80% of whose satellite business is DOD, is committed to continuing support for national needs. DOD has also proven to be their most profitable customer. Additionally, they have necessary skills retention programs in-place and long-term, legacy defense programs that support both commercial and defense requirements. Many commercial practices are now used for defense applications.

Regarding the reduction or expansion of facilities and overall capacity, all respondents claim they are expanding their facilities and capacity to accommodate future market growth potential. Each company representative stated they were well-situated for design and production capability and capacity. Two interviewees said they were specifically expanding their telecommunications facilities.

Interview Question #6

> *How are you maintaining the vulnerable, unique, and critical technologies, capabilities and skills necessary to produce defense satellites?*

Each respondent approached the issue of maintaining vulnerable, unique and critical technologies, capabilities and skills necessary to produce defense satellites by emphasizing a proactive corporate strategy that addressed this concern. Consolidation proved to be quite valuable to one company. By 1998, their labor force will have been reduced by nearly 6,000 positions as a result of restructuring. This effort will result in overall savings of approximately $800 million per year. He further stated, "We have uniquely blended technology with state-of-the-art systems and reengineered processes which lower costs, reduce cycle times, allowing us to become more efficient with less resources. The skill level required to support our commercial spacecraft product line is very synergistic with those required to support defense programs. Highly skilled resources from our product centers are used interchangeably to support commercial as well as defense-type programs and hence, provide the mechanism needed to bridge the best qualities of both." Another company claims they are maintaining these factors well, probably due to the fact they are not heavily pursuing research and development work. Yet, another company is seeking stability through maintaining strong supplier ties. They are also in a hiring mode for new skills and capabilities. Another interviewee stated they were expanding into commercial business in order to maintain defense capability.

Interview Question #7

> *The DOD is challenged with maintaining superior satellite technology and industrial capability at an affordable price. How is this possible?*

One hundred percent of the respondents agree that the key strategy for the DOD to maintain superior satellite technology and industrial capability at an affordable price is to rely on the commercial market, except when it comes to defense-unique systems. This will enable the DOD to operate better satellites, delivered more quickly and at lower cost. The DOD will benefit from using cutting-edge commercial satellite technology, *spinning-on* this technology wherever possible. Where applicable, defense-unique requirements can also *spin-off* to appropriate commercial satellite applications. The DOD must accept commercial approaches and practices. Dedicated satellite lines must be a concept of the past.

Interview Question #8

> *Does your company engage in flexible manufacturing between commercial and defense business? If not, how is your production line set up to accommodate both commercial and defense business?*

All interviewees but one claim they engage in flexible manufacturing to accommodate both commercial and defense satellite business. The one who does not, currently supplies only DOD satellites. But, they are planning to expand into the commercial market and will begin flexible manufacturing. Currently, their setup for the DOD and expected commercial satellite sales is physically separated clean rooms for each market, but both clean rooms are in the same building. The company who recently consolidated reaffirmed the interchangeability of resources for both commercial and DOD business. Through consolidation, they have collocated all critical DOD and civil space programs. Key DOD programs, personnel and skills have transitioned from remote locations to a single location. He said, “Our highly trained product center skill resources

have now even greater exposure to varied spacecraft technologies from acquisitions and consolidation efforts we have made."

Interview Question #9

> *If the need arose and in your expert opinion, would your company be able to meet DOD surge and mobilization requirements now and in the future?*

Each respondent agreed they could meet DOD surge and mobilization requirements now and in the future. They all qualified their answers, however, based on the magnitude of the requirements. According to one interviewee, surge demands are preceded by either a request for information or request for proposal from the Government. Companies, U.S. satellite producers in this case, can usually anticipate these initiatives before they are official. This provides ample time to ramp-up and phase-in existing and new resources required to support such demands. One company representative provided an example of how they were able to surge during Operation Desert Storm, using commercial satellites to off-load overused military satellite communications satellites. However, the same interviewee pointed out that had his company not been aware of any surge requirements and DOD required a surge within one year, they could not meet the requirement and would not forward a proposal. Specifically regarding capacity, one company produces 12 to 13 satellites a year with the additional capacity to produce up to 20 satellites. Another company representative claimed they produce 3 satellites a year and have the capacity to build 17 satellites. This indicates the excess capacity that might be necessary to surge production for future DOD needs. One interviewee claimed capacity was not the problem, it is the skilled labor force. Whether they had adequate skilled labor available or not may preclude them from meeting surge and mobilization requirements.

Interview Question #10

Does your company desire to remain in the defense satellite business? Why or why not?

All respondents emphatically agreed their desire to remain in the defense satellite business, considering it has proven quite profitable. Now that commercial technology leads in many areas, it has synergistic applications to defense. Also, there is not only increasing commercial satellite potential but also increasing defense satellite potential as well. Although one company has restructured its former image as solely producing defense satellites to be recognized as a commercial space company, they have concentrated their efforts on dual use synergistic solutions. This will help meet DOD surge and mobilization demands. For example, commercial telecommunications provide the means to meet DOD surge demands during major regional crises. Specifically, their commercial communications satellites are configured for bandwidth-on-demand. What this means for the DOD is the opportunity to subscribe to services and high data capacity on a pay-for-bandwidth basis, an excellent economic alternative to a DOD dedicated system. Also, their commercial remote sensing products enable the DOD an economic alternative to direct ownership while providing accessibility to another operational satellite. Furthermore, he said, "We are constantly seeking System of Systems solutions and architectures for the DOD and this is now becoming the preferred approach to doing business." Another interviewee claimed that it was a good business to be a part of; advanced technology still emanates as a part of DOD satellite development.

For the following questions, answer them as they affect your company and the U.S. satellite industry in general.

Interview Question #11

> *Is there an increase in commercial satellite applications? What are these applications?*

All respondents agreed there is an impressive array of emerging commercial applications. Among them are: telecommunications (Internet, video, television, pagers, real-time video), remote sensing (surveillance, sensors, imagery, microwave data collection and infrared and visual applications), and air traffic control (data fusion of GPS with wind velocity measurements). All respondents agreed that telecommunications is immediately the most active commercial market. According to one interviewee, within 5 years commercial remote sensing is expected to surge. He also said "New emerging commercial markets are now being driven by economic needs and are no longer being paced by technology."

Interview Question #12

> *How have recent commercialization efforts (i.e. commercial-military integration through acquisition reform and dual-use technology and production strategies) by the Federal Government affected satellite technology and production? Which initiative makes the biggest impact? Is it positive or negative?*

The common thread weaving all respondent answers together regarding this question was that *commercialization* efforts have had a positive impact. No single CMI program was regarded as especially great, but DOD's adoption of commercial procurement practices has been accepted favorably. One program, the Single Process Initiative was highlighted as positively impacting the U.S. satellite industry. Under this initiative, the Government accepts commercial practices and lets the contractor conduct self inspections. One respondent claimed the overall Acquisition Reform effort was a *guiding*

star for one of their ventures. The elimination of military specifications was very well received, providing this industry more of a commercial flavor and making DOD acquisitions easier. The cost structure has been commercialized. Also, the DOD has moved towards reliance on services rather than dedicated systems. The Technology Reinvestment Program, one respondent claimed, was not needed for the bigger companies (more flexibility gained using other means), but would benefit the research and development efforts of smaller companies, potentially producing appropriate pay-offs. One interviewee purported that there has been a lot of talk, but little action. "There is a dearth of real programs. One potentially good concept, Warfighter, has supported the notion of commercial leveraging. But, this is as close to any positive effort as anything." There have been some failures under Acquisition Reform, as pointed out by one of the interviewees. "NASA several years ago sponsored the Lewis and Clark Missions under what NASA referred to as the Small Satellite Technology Initiative. Both the Lewis and Clark missions have not met their flight schedule commitment dates. This was perhaps the Government's first attempt to do commercial space under Acquisition Reform – streamlining, better, faster, cheaper." [*See Recommendations for Further Research for more details*].

Interview Question #13

> *Do you consider the current U.S. satellite industry serving mainly defense or commercial markets? In the future?*

One hundred percent of the respondents agree that the U.S. satellite industry has traditionally served primarily the defense market. Likewise, all agree there is a tremendous movement of this industry towards emerging growth in the commercial

satellite sector. In the future, the commercial market will dominate with the DOD tapping into advanced commercial technology, except for defense-unique requirements. Less money is becoming available for independent research and development and bid proposal funds, with the emphasis now on corporate money going to commercial telecommunications. As one interviewee succinctly phrased it, "Where is the market and the most profit to be made? In the future, I believe they will be transparent to one another with particular emphasis placed on communications." Concern was voiced by one interviewee that today the DOD is mainly supported by one satellite producer, with its other suppliers providing a substantially smaller percentage of DOD satellite sales.

Interview Question #14

> *In your opinion, will there be dual-use technology and production opportunities for commercial and defense satellites in the future? To what extent will they mutually benefit each other? In what way(s)?*

Every interviewee supported dual-use technology and production strategies. They further believed there would be ample opportunities to apply these strategies for commercial and defense satellites in the future. Both markets will be able to draw on the same capabilities. This will help lower costs and lead times. As the DOD moves towards becoming more and more of a satellite service rather than a defense-unique, dedicated system customer, it will increasingly rely on commercial technologies that are in-place. One interviewee said through the Global Broadcast Service, both commercial and defense customers will be able to use satellite broadcasting to meet user needs quickly. Spin-off technology for the commercial market and spin-on technology for the defense market will become more prominent. However, the only real spin-off capabilities in the future will be from defense-unique requirements – making these few and far between. One respondent

pointed out, dual-use technology and production for both defense and commercial markets “will complement each other principally in the revenue model as a result of higher bandwidth use by the DOD.” One respondent said the Government would have to be sensitive to commercial business opportunities. "The DOD must keep other commercial ventures in mind when placing demands on these contractors."

Interview Question #15

> *What is the financial and growth outlook for the U.S. satellite industry? In your opinion, will the U.S. satellite industry be able to meet DOD satellite requirements in an efficient and effective manner?*

All respondents agreed that the financial and growth outlook for the U.S. satellite industry is very positive. Pointed out by one respondent, and supported by all of the others, was that growth was mainly in the communications market. Future growth will also emanate from the commercial remote sensing market in the next five years. It was proposed that there would be 20% growth per year for the next 5 years in this industry.

All agreed also that the U.S. satellite industry would be able to meet DOD satellite requirements in an efficient and effective manner. Specifically, one interviewee said, “DOD needs will assuredly be met. However, the satellite constructs will become more of a smart-user design capable of serving various disciplines and missions within the Government at greater overall economic efficiency.” The elimination of value-added specifications will result in more effective and efficient products for the DOD, better meeting their requirements than before. According to one respondent, "There should not be a problem if DOD becomes more flexible on current requirements. Military specifications must decrease, except for defense-unique systems."

Interview Question #16

> *Do you foresee any problems with the U.S. satellite industry in the future? Do you have any recommendations for the DOD to help them meet their challenge of maintaining superior satellite technology and industrial capability at an affordable price? Other comments?*

Each respondent did foresee some problems for the U.S. satellite industry as a whole in the future. Interestingly, one respondent highlighted what appears to be quite a large problem within the Government – specifically, the integrated space-ground architecture. "Currently, the industry lacks a common protocol for satellite operations and control (telemetry, tracking and control). There is no single agency which attempts to consolidate satellite control management throughout all elements of the U.S. Government." What this means is that there are many different satellite configurations under Government control that cannot communicate with each other. The Federal Government spends in excess of $806 million per year to operate these systems. However, in December of 1995, the Joint Space Management Board was established by the Secretary of Defense and the Director for Central Intelligence to coordinate an effort whose goals are: "*To ensure that defense and intelligence needs for space systems are satisfied within available resources, using integrated architectures to the maximum extent possible*" (Note: this effort does not include the civil sector – NASA or NOAA). Another potential problem was that there are too few satellite suppliers. One interviewee showed concern that the defense satellite market is dominated by one supplier. Another interviewee predicted that by the year 2005, the growth in the U.S. satellite industry would diminish – in terms of production. Both the low-Earth orbit and the geosynchronous Earth orbit may become saturated. A respondent brought up the issue of decreased skilled labor and training as another possible problem, especially regarding surge and mobilization.

Another potential problem concerns launch vehicles. With the introduction of smallsats and other more cost effective satellite systems, the high cost of the launchers presents a problem of getting these satellites into orbit. One possible solution currently underway that should dramatically reduce launch costs is the single-stage-to-orbit system. This system encompasses a reusable single-stage rocket that can take off like a rocket and land like an airplane, while maintaining the ability to boost payloads into either LEO or GEO.

Several recommendations were made by the interviewees to help the DOD meet their challenge of maintaining superior satellite technology and industrial capability at an affordable price. These recommendations are as follows:

1. As an informed taxpayer, consolidate and initiate interoperability and connectivity of a unified space architecture having common protocol and non-stovepiped architectures.
2. Use commercial acquisition procedures. Be flexible and innovative. This will allow the U.S. satellite industry to be more efficient and effective, without massive Government interventions.
3. Use satellite services more, not large, dedicated, defense-unique systems or lease a system.
4. Explore options for more cost effective satellite launchers.

Summary

Four propositions were developed in this chapter. The first two addressed, via literature review, the impact defense spending has on DIB strength and its current status. Defense spending was determined to be the most influential variable among tax, trade, environmental, and socioeconomic policies. Therefore, it was used as a proxy for measuring DIB strength. It was demonstrated how defense spending impacts the DIB strength factors – production, competition and technology. These factors are all critical to DIB preparedness – a fundamental measure of how well the DIB can meet DOD objectives. Increased defense spending was viewed in a positive light, while decreased

defense spending was deemed directly attributable to its deteriorated condition. The DIB has been deteriorating for some time now as depicted by reductions in defense spending over the last 12 years.

Analysis of the third proposition, through a combination of literature review and case study, showed how commercializing a defense industry can be successful. CMI just may be the answer the DOD and defense industry leaders are seeking for the continued survival of a fully capable DIB. It was shown how commercialization efforts directly or indirectly impact each of the three DIB strength factors. Commercialization moderates the relationship between defense spending and DIB strength and should prove to be a workable solution to the ailing DIB. In the case of GEAE, reductions in DOD aircraft engine procurements were offset by increased commercial aircraft engine sales. Sales revenues were relatively stable throughout fluctuating DOD procurements.

Although the U.S. satellite industry evolved from the defense market, defense downsizing has not negatively affected it. In fact, commercialization has given it renewed life. Since the U.S. satellite industry has become commercialized to the degree that it has, as postulated in the fourth proposition and supported through interviews, the shrinking DIB does not seem to impact its continued growth and development. Defense downsizing in concert with a unique opportunity for commercial satellite growth has spawned innovation, ingenuity, and even prosperity into what could have been the end of an industry.

Chapter 5

Conclusions and Recommendations

Introduction

The DIB has played a pivotal role for our nation's security, whether as part of the national industrial base or as a separate entity. The DOD has grown to rely on this part of the industrial base to meet its acquisition needs. Over the last 30 years, however, the DIB has come under the scrutiny of many defense analysts, senior defense leaders, industrial base panels and studies as well as defense industry executives. It has been in a state of deterioration and if this continues, it will not serve its purpose for defense.

Since the end of the Cold War, the American people have been searching for their *peace dividend* and the defense budget is their target. Action must be taken by the Government and appropriate politicians to mediate DIB decline while satisfying their constituents. CMI is the hopeful solution. Through this approach the DIB will be integrated with the commercial industrial base forming one national industrial base. Acquisition Reform and dual-use technology and production strategies are the foundation for this movement. It is hoped that Government acquisitions will eventually mirror, to a large extent, commercial acquisition procedures. Likewise, dual use programs are needed to foster the free flow of advanced technologies from defense to commercial markets and

vice-versa. Today, the commercial industry leads in many key technology, process and product areas. It is the hope of the DOD to tap into this market. For defense-unique systems this will not be achievable, but there may be the possibility to *spin-off* this technology back into the commercial market. The end result is better products and services delivered in less time at lower cost.

This research has centered around one industry in particular – the U.S. satellite industry. The Air Force is evolving into a Space and Air Force because of increased potential for military applications in space. This interest has raised some concern among the Air Force's space community about whether the U.S. satellite industry will be able to meet DOD needs in space, considering the weakened condition of the DIB. This chapter will address the investigative questions brought up in Chapter I through the literature reviews, case study and especially the interviews with U.S. satellite industry experts. Additionally, recommendations for further research will be annotated.

Investigative Question #1

Why is the DIB necessary for national security?

The DIB is the infrastructure that provides the aircraft, missiles, spacecraft, ships, combat vehicles, munitions, and electronics necessary to defend our country. It was this DIB that helped win World War II. Commercial factories were converted to support the war effort by providing the weapons necessary to win. Since then, the DIB has provided not only industrial strength for battle but also employment and economic benefits. Many skilled workers have been hired in support of defense market needs; engineering and technical skills are among the most important. The dollars spent on defense have a

multiplier effect; each dollar spent on defense weapons and support equipment is exponentially transferred into the rest of the economy. For many years, the DIB has supported research and development ventures for advanced technology that could be spun-off to improve commercial industrial applications. It is evident the DIB serves an important role for defense and the national economy.

However, it is not the DIB per se but the function it serves for national security that is important. The DIB produces and maintains state-of-the-art weapon systems for deterring or winning wars. Industrial strength is the key to sustaining this function efficiently and effectively. It is imperative the Federal Government and defense industry leaders proactively and cooperatively search for the best ways to preserve this DIB function, whether as a separate entity or as an integrated national industrial base. If the DIB shrinks beyond a certain point, it may never be recovered or prohibitively expensive to do so. The DIB can be thought of as the backbone for defense. If this backbone is destroyed, the U.S. military will be paralyzed. Without the weapon systems and equipment to support them, the capability to dominate the battlefield will be lost to the enemy. The issue is critical. The time for change is now.

Investigative Question #2

What is the current condition of the DIB?

Many deficiencies that characterize the current DIB have evolved from as far back as the Revolutionary War. However, these and others emerged after the DIB separated from the national industrial base after World War II. These problems have continued to plague the defense industry, raising concern among the defense community. Defense spending is

the most prominent variable influencing DIB strength. It directly affects DIB production capability, levels of competition, and technological superiority, providing the foundation for DIB preparedness and ultimately DIB strength. Since the Reagan Administration high in 1985, reductions in defense spending have continued. At this rate, the DIB will continue to weaken until it is no longer capable of meeting DOD needs.

Probably the biggest factors diminishing DIB capability, besides its historical deficiencies, are the decreased defense spending and the bureaucratic Federal Government acquisition system. The global environment is not conducive to stability so defense contractors find it difficult to plan for the future when requirements change every year. The DOD has typically reacted to national security threats with uncertain swiftness and peril; just as quickly as defense is ramped up for battle so to does the DOD cutback funding, personnel and requirements. Tremendous Government oversight, a myriad of regulations, scrupulous cost accounting standards, low profit potential, among other things make the defense industry quite unattractive to many potentially worthwhile suppliers.

This also makes the defense industry unattractive to those who are not part of the infamous *military industrial complex*, including the financial community who are reluctant to invest or provide loans to those desiring defense business. Lack of money has led the DIB companies to seek short term profits at the expense of capital investment. This perpetuates a growing problem of antiquated, inefficient, ineffective manufacturing capability that drives up weapon system unit costs and increases lead times. Those who have been a part of this world have fallen prey to a unique global environment. The end of a long Cold War has brought with it an unidentifiable threat for the United States to

focus its national defense objectives on and changing domestic priorities that have taken their toll on the DIB. Action must be taken by Government and industry leaders to maintain both an efficient and effective DIB. Inaction could prove fatal for the DOD. If allowed to continue on its present course, the DIB will be rendered virtually useless in meeting DOD objectives. The implications of a non-existent DIB for the DOD are numerous and widespread. In answering the first investigative question, it was determined the U.S. military is unable to fight without industrial strength. As the military drawdown continues, the U.S. military will rely more and more on advanced weapon systems to mitigate personnel losses. Without adequate intervention, the DIB will not have the capability to meet DOD objectives efficiently and effectively.

Investigative Question #3

What is being done by the Federal Government and the defense industry to ensure the continued viability of the DIB?

The Federal Government and defense industry leaders are concerned with the condition of the DIB. The Federal Government, in an effort to preserve the capability of the DIB while focusing on domestic priorities, has supported numerous industrial base panels, studies and research efforts to find a practicable solution. What they have come up with is CMI; this is the integration of the DIB with the commercial industrial base.

The reaction by companies within the DIB has been mixed. But, their response has been overwhelming. There is no doubt the DIB is shrinking and it has been doing so at an unprecedented rate. Companies are diversifying into commercial business, divesting themselves of all defense business, or disappearing altogether. Another phenomenon has

been the magnitude of acquisitions and mergers. What or who remains in the DIB is yet to be determined.

At first glance, the concept of CMI appears to be a valid initiative for preserving the DIB function. Its tenets support many of the objectives the DOD requires for national security. However, several issues must be addressed. First, once the barriers to integration have been identified and conquered to the extent possible, the remaining forces influencing industrial strategy must be dealt with. The commercial industrial base is driven by profit, while the DIB will continue to be driven by political pressure, regulations, Government oversight, and fluctuating defense requirements, an inescapable condition when the public trust is at stake. Therefore, it is necessary for any commercial company involved in the defense market to be amenable to tailoring normal business operations in order to accommodate some level of bureaucratic red-tape when supporting the DOD. An end result will be acquisitions tailored to the each respective market. Second, the shrinking DIB has resulted in thousands of companies exiting the defense market. This attrition may have been the aftermath of natural selection (survival of the fittest) or unfortunate circumstances. But, for whatever reason, there is less available capability and capacity for the DOD. Whether CMI will attract those long-gone, yet fully qualified firms, back into the industrial base to once again support the DOD is unknown. On the flip side, those firms who did not measure up to DOD standards may try to infiltrate the market once again. Suffice it to say, the DOD desires adequate competition in each tier and sector of the DIB so that its objectives will be met. However, as portrayed in the past, too many firms in the defense market result in excess capacity and inefficiency. Regardless of CMI, defense downsizing equates to fewer DOD

procurements. The defense market cannot afford too many defense contractors chasing too few defense programs, whether the commercial and defense industrial bases are integrated or not. Third, although an integrated industrial base provides additional capacity, there will still be a limited amount. If both the DOD and private industry demand the products or services of a particular company operating at maximum capacity, whose requirements will be met? Further, what criterion will be established to determine whose needs will be met first?

Investigative Question #4

How will commercial-military integration (CMI) influence DIB strength? Will this paradigm shift alleviate, if not eliminate, many of the historical deficiencies that characterize the DIB?

CMI may very well be the answer to decreasing DOD procurements and changing domestic priorities for the DIB. Through CMI, it is expected that not only will the DIB be saved, but also that it will flourish. The impetus behind this movement centers around the advanced technology prominent in the commercial sector. Unlike years past where defense technology could be spun-off for commercial applications, commercial technology can be spun-on for defense application. Also, it has become apparent the quagmire of laws, regulations and Government oversight has received negative reaction by those companies in the DIB as well as those refusing to do business with the Government.

Through CMI, the DOD and commercial industry will be able to free float advanced technology for the benefit of each market. The DOD will be able to acquire higher quality products and services, in less time, at lower prices. The commercial sector will

also benefit from technology gained from defense-unique requirements. The movement towards Acquisition Reform programs, will make Government procurement more in tune with that of commercial business, making it more attractive to not only DIB companies but also those formerly not interested in DOD business.

In one case study, GEAE demonstrated the potential a commercialized defense industry has, in light of fluctuating DOD procurements. As DOD acquires fewer aircraft engines, the commercial market purchased more and the opposite held true as well. GEAE maintained a certain level of sales revenues regardless of DOD spending. Commercialization, in this case, provided the needed element of stability. It is quite possible this stability can be introduced into the whole DIB through CMI despite reduced DOD procurements.

Investigative Question #5

What is the relationship between the DIB and the U.S. satellite industry?

The DIB is three dimensional, with prime contractors, subcontractors and parts/materials suppliers making up three tiers of the first dimension. The second dimension comprises the various sectors (aircraft, missiles and spacecraft, ships, combat vehicles, munitions, and electronics). The last dimension is public or private ownership. The U.S. satellite industry is part of the missiles and spacecraft sector (second dimension), supported by each tier of the first dimension as well as public and private ownership (plants and equipment). The variables traditionally influencing the DIB, also affect the U.S. satellite industry (defense spending, tax, trade, environmental, and socioeconomic policies). Therefore, defense downsizing will affect the satellite industry

by reducing the number and/or magnitude of future contracts. The DOD must keep this in mind when planning future space budgets. A certain amount of stability, whether through funding or contracts, is necessary to maintain the critical skills, technologies, and materials required to produce advanced space systems.

Investigative Question #6

How is the U.S. satellite industry faring, considering fewer DOD procurement dollars and CMI?

The U.S. satellite industry is growing, despite fewer DOD procurement dollars, and quite possibly regardless of CMI. The extent to which CMI has influenced anything has not been explored, considering its infancy. The tremendous market potential for commercial space applications has opened many opportunities for the satellite industry. Telecommunications is by far the fastest growing commercial space application. However, it is expected that commercial remote sensing applications will surge in the next five years also. Industry growth is expected to increase around 20 percent per year for the next five years. On the international scene, there are numerous growth opportunities also. This provides the satellite industry increased domestic space opportunities, but also additional market potential internationally. With the trend towards a more service-oriented industry, there is tremendous profit potential. Overall, the financial health and stability of the satellite industry is good and will continue to be good in the future. This is good news for the DOD. Technology developed in the commercial space market has surpassed that of the defense space market in many key areas. With a healthy and growing commercial market that is developing this advanced satellite system technology, the DOD has a larger industrial base from which it can acquire state-of-the-

art satellites and satellite services. A larger industrial base also provides additional capacity and capability to meet surge and mobilization requirements. One issue to be addressed concerns the trade-off a satellite producer must make when deferring commercial orders and higher profits to support DOD space requirements. The DOD must develop a strategy to address this concern.

Investigative Question #7

Will the U.S. satellite industry be able to meet U.S. defense needs in space now and in the future?

The U.S. satellite industry should be able to meet current and future U.S. defense needs in space. DOD downsizing and increased commercial satellite applications have forced this industry to consolidate, reduce excess capacity, seek commercial markets and become more efficient and effective in satellite production. Acquisition Reform has helped facilitate this industry's transition to commercial ventures by moving towards commercial procurement practices. With rapidly growing commercial and Governmental space applications on the horizon, the satellite industry should have the capability and capacity to meet surge and mobilization requirements as well as any other DOD demands.

Interviews with satellite industry executives provided unique insight into their industry's reaction to DOD downsizing as well as restructuring efforts, current trends, and any concerns about future business with the DOD. In an effort to reduce costs, satellite producers are searching for ways to not only increase the efficiency of their plants and equipment, but also for maximizing the services available for both commercial and defense markets. This might also be a reaction to a rapidly growing commercial space

market. Whatever the reason, the fact is the U.S. satellite industry is becoming smaller, yet more cost effective, efficient and multifunctional.

Satellite configurations and manufacturing facilities are undergoing significant change. Smaller, multifunctional, *smart* satellites are the strategy for the future. Smaller satellites will be cheaper to produce and maintain. Having the capability to use one satellite to serve both commercial and defense roles has also become critical for cost reduction. Flexible manufacturing capability enables satellite producers to produce what the market demands, whether commercial or defense. Commercial satellite technology now equals or surpasses what used to be dominantly defense technology. With technology as the cornerstone, there has been a movement to integrate commercial and defense satellite functions on the same satellite, applying smart technology to serve both markets. Commercial satellite telecommunications and remote sensing technology if not already farther advanced than current defense technology will be in the near future. This will allow the satellite industry to deviate away from dedicated systems of the past to serving both markets with multifunctional systems. In the future, satellites will not be manufactured to the extent they have traditionally been. Instead, already existing satellites will provide services as needed to meet market demands.

Increased potential for commercial and Governmental space applications has laid the foundation for the U.S. satellite industry to become more efficient and effective satellite producers. Increased space demands have led this industry to become more creative, cost effective, and flexible in the methods they employ to meet market demand. Flexible manufacturing methods, multifunctional, smaller satellite systems, and advanced technology provide the capability and capacity to meet DOD objectives. This allows the

DOD to leverage the commercial space industry to meet its space required defense systems in the future. For the Air Force, *Global Engagement* will become reality.

Summary

Air Force leadership underscores space as vital to national security. More and more, space is the dominant medium for not only military communications, navigation, imagery, and surveillance requirements, but also a potential threat from adversarial relationships. It is through satellites that the future Air Force will gather intelligence data, communicate with troops, provide navigation for pilots, and detect enemy attacks. The U.S. satellite industry is vital to maintaining our national security.

With the end of the Cold War, changing domestic priorities, defense downsizing and the deterioration of the DIB, the continued viability of the satellite industry seemed to be in jeopardy. However, through this research it has been determined that the shrinking DIB has not yet negatively affected this industry and probably will not. As a result of increased commercial space applications, this industry is thriving. Although there are fewer satellite producers remaining in the DIB, they are top quality. Through interviews with industry experts, it can be concluded that the capability and capacity of this industry is growing more efficient and effective. Through flexible manufacturing and dual use as well as smaller, smart satellites and satellite services, this industry is able to produce high quality, low cost satellites much faster than before. The impact on the DOD is that the capacity, capability, and flexibility to produce defense satellites will be available if a surge or mobilization need arises. The movement towards smart satellites and services rather than dedicated systems, will further enable the DOD to tap into already existing

systems. Although there is an increase in commercial space market potential, the senior company executives interviewed are excited about the prospects for applying new, flexible satellite systems and manufacturing methods for the DOD. The DOD still provides tremendous profit potential for these companies and with merging commercial and defense space applications, this profit can be maximized.

Despite the enormously positive feedback, some concern was raised by several interviewees about current space architecture, limited suppliers, and satellite launch capability. Space architecture was highlighted as one potential problem for the U.S. Government that results in their spending millions of dollars a year on a wide array of satellites for numerous organizations that cannot communicate with each other. They also cannot be controlled by the other organizations. This has culminated in massive inefficiency and high costs. Action must be taken to integrate these systems so that they can communicate with each other. Again, concern was raised whether fewer suppliers will be able to produce the required satellites. Whether this is a potential problem, or the natural result of a shrinking defense market is not known. It may very well be better to have fewer, but higher quality suppliers, than more that are inefficient. Lastly, while satellites are becoming less costly, their launch vehicles are prohibitively expensive. Emphasis is now placed on reusable rockets that can take off like a rocket, deliver a payload into low-Earth orbit or geosynchronous Earth orbit, and return to Earth like an airplane. The single-stage-to-orbit concept is underway to alleviate this problem.

Conclusions

National security for the United States demands the exploitation and domination of space by the DOD. Increasingly, the U.S. military will rely on advanced satellite systems to meet its future communications, environmental/remote sensing, navigation, meteorological support, missile defense, reconnaissance and surveillance, strategic early warning, and tactical warning/attack assessment needs. Coincidentally, the benefits prevalent from accessing the space environment for meeting defense needs also expose the United States to enemy attack. The end of the Cold War created many new challenges for the DOD. The lack of a definable threat, a growing global economy, and changing domestic priorities have resulted in defense downsizing, a shrinking DIB, and increased reliance on foreign sources of supply. The dilemma the DOD faces in this dynamic environment is to dominate the space environment through advanced satellite systems and services with less money, personnel, and a smaller DIB, while maintaining its national independence to the maximum extent possible.

It is therefore incumbent upon the U.S. satellite industry to grow and develop without defense as its primary market. This industry must maintain technological superiority, while advancing satellite systems that are more cost effective and multifunctional. Through this research, it became apparent the satellite industry is indeed growing and developing from the onset of numerous commercial space applications, expanding into many different functional areas. Commercial satellite technology has surpassed its defense counterparts in many key areas. The time has come for the DOD to tap into this thriving commercial market to satisfy its own needs.

The satellite industry has not been left unblemished from the shrinking DIB. Fewer DOD procurements have resulted in industry contraction similar to the rest of the DIB. However, those companies remaining are top quality. Downsizing has forced, what used to be a predominately defense industry, to consolidate, reduce excess capacity, seek commercial markets and become more efficient and effective in satellite development and production. On the negative side, defense-unique requirements may be harder to meet with fewer orders; the critical skills, technologies, materials, and components needed for these defense systems are sometimes lost forever as a result of the labor and companies exiting the defense market altogether. Fewer suppliers for defense-unique satellite systems may result in longer lead times for certain rare materials and components, some of which still require military specifications.

Left unkempt, the DOD would have a serious problem on their hands. However, senior DOD and Government officials fully support a concept known as CMI. According to many experts, integrating the commercial and military industrial bases would provide the answer to the DOD dilemma. A national industrial base would provide the DOD access to the modernized plants, equipment and manufacturing processes of the commercial industrial base, and increased competition that would ensure the DOD acquires lower cost, higher quality satellite systems, and greater surge capacity.

Acquisition Reform and dual-use technology and production strategies are the foundation for CMI. In order for CMI to be successful, the barriers between commercial and military markets must be identified and eliminated to the maximum extent possible. Acquisition Reform is meant to do just that. This movement is geared towards integrating commercial and defense acquisition practices. Dual use applications are

another initiatives that seek the integration of common defense and commercial technologies, processes, and products. If CMI works to the degree expected from senior defense officials, the new national industrial base would be a tremendous asset to commercial and defense markets, in addition to the national economy. Yet, there will still be advanced defense satellite systems that require military specifications the integrated industrial base will not have the ability to provide. Concessions will have to be made by certain companies to address these unique requirements. Also, with the booming commercial satellite business, the DOD may no longer be the number one customer. The DOD must proactively seek ways of ensuring national security is not jeopardized, while addressing the concerns of other commercial business priorities.

Finally, the DOD needs to be cognizant of space architecture and space launch vehicle issues. Research revealed a significant and costly problem with the Government's current space architecture. Primary concerns are the overlap among systems and the inability to communicate between systems. Each year the Government spends millions of dollars on advanced satellite systems that cannot communicate with each other and, in some cases, these systems perform similar functions. As satellites become increasingly smaller, cost effective, and multifunctional, demand for them will continue to increase. But, the current launch vehicles are still very expensive, so much so that many satellite launches are held back for indefinite periods. In a time when the DOD is particularly cost conscious, these issues must be addressed. Still, with the strong growth and development of the satellite industry, the DOD and the Air Force, can access the space environment to the degree it requires to carry out its vision – *Global Engagement*.

Recommendations for Further Research

Through this research, some opportunities for further study have been uncovered. The following recommendations pertain to the shrinking DIB, space and CMI. Specifically, they are as follows:

1. Conduct similar research, but target the aircraft industry. Through this research, it became apparent that the aircraft industry might be in trouble. Recommend interviewing executives from the major aircraft producers to assess whether defense downsizing has had an impact on this industry's growth and development.
2. Research the space launch industry to determine what is currently being done to reduce costs. The satellite industry is coming close to the point of producing small, inexpensive, yet highly versatile satellites. Yet, the launch capability is too expensive to warrant frequent launches. Perform a cost analysis on reusable launch vehicle systems versus space shuttle systems.
3. Explore the space architecture problem. Determine what exactly the problem is and make recommendations for improvement. This costs the Federal Government millions of dollars a year.
4. Do a case study on the failed Lewis and Clark satellite missions – the first CMI effort sponsored by the Government*.

* The following information was provided during one of the interviews. The respondent recommended researching this failed effort.

> *In the April 21-27 issue of Space News, it was reported that Clark's Earth imaging satellite program (designed to conduct advanced small spacecraft missions under strict budget and schedule constraints) was in danger of being canceled due to cost overruns exceeding the 15% cap imposed by NASA. Consequently, the spacecraft producer, CTA Space Systems, forfeited the incentive pay it was to receive for completing the spacecraft on schedule. It may very well be that in an attempt to drive down costs to commercial levels, the Government is placing at risk incentive for contractors to produce. Further, many contractors are finding it more profitable to stick to the commercial market and avoid attempts by DOD to participate at all. They may feel that it is industry that has made the investments into their own commercial enterprises and as such, they dictate the rules.*

Appendix A

U.S. Satellite Industry Contract History [1985-1996].

(Spacecraft, 1997:131-137)

U.S. SATELLITE INDUSTRY CONTRACT HISTORY [1985 - 1996]			
SATELLITE NAME	**PRIME CONTRACTOR**	**USER**	**REMARKS**
CIVIL SATELLITES			
Communications			
ACTS	Lockheed Martin	NASA	Launched 9/12/93; lifetime, 4 yrs.
AMSC-1	Hughes	American Mobile Satellite	Launched 4/7/95; lifetime, 12 yrs.
Aurora 2	Lockheed Martin	AT&T Skynet	Launched 5/29/91; lifetime, 12 yrs.
DBS 1, 2, 3	Hughes	Hughes Communications	Launched 12/18/93, 8/3/94, 6/10/95; lifetime, 15 yrs.
Echostar 1, 2	Lockheed Martin	E-Sat	Launched 12/28/95, 9/10/96; lifetime,12yrs.
Galaxy 1RR, 3R, 4	Hughes	Hughes Communications	Launched 2/19/94, 10/95, 6/25/93; lifetime, 10-15 yrs.
Galaxy 5, 6, 7, 8, 9	Hughes	Hughes Communications	Launched 3/14/92, 10/12/90, 10/28/92, 12/14/95, 5/24/96; lifetime, 10-15 yrs.
GE 1	Lockheed Martin	GE Americom	Launched 9/8/96; lifetime, 15 yrs.
Gstar 1, 2, 3, 4	Lockheed Martin	GE Americom	Launched 5/8/85, 3/28/86, 9/8/88, 1/20/90; lifetime, 10-13 yrs.
Orbcomm 1, 2	Orbital Sciences	Orbcomm	Launched 4/3/95; lifetime, 5 yrs.
PAS-1	Lockheed Martin	PanAmSat	Launched 6/15/88; lifetime, 11 yrs.
PAS-2, -4, -3R	Hughes	PanAmSat	Launched 7/8/94, 8/95, 1/12/96; lifetime, 15 yrs.

U.S. SATELLITE INDUSTRY CONTRACT HISTORY [1985 - 1996]			
SATELLITE NAME	**PRIME CONTRACTOR**	**USER**	**REMARKS**
CIVIL SATELLITES			
Satcom C1, C3, C4	Lockheed Martin	GE Americom	Launched 11/20/90, 9/10/92, 8/31/92; lifetime, 12 yrs.
Satcom K1, K2	Lockheed Martin	GE Americom	Launched 1/12/86, 11/27/85;lifetime, 10yrs.
SBS 5, 6	Hughes	Hughes Communications	Launched 9/8/88, 10/12/90; lifetime, 10 yrs.
Spacenet 3R, 4	Lockheed Martin	GE Americom	Launched 3/11/88, 4/13/91; lifetime, 10 yrs.
TDRS I-F3, -F4, -F5, -F6, -F7	TRW	NASA	Launched 9/29/88, 3/13/89, 8/2/91, 1/13/93, 7/13/95; lifetime, 10 yrs.
Telstar 401, 402R, 403	Lockheed Martin	AT&T Skynet Satellite	Launched 12/15/93, 9/23/95, planned launch in late 1996; lifetime, 12 yrs.
Temposat 1	Loral	Tempo Satellite	Planned launch in late 1996; lifetime,12yrs.
Earth Observation			
Clark	CTA	NASA	Planned launch in late 1996
Earthwatch-Earlybird	CTA	Earthwatch	Planned launch in late 1996; lifetime, 5 yrs.
TOM-EP	TRW	NASA	Launched 7/2/96; lifetime, 3 yrs.
Scientific			
FAST	NASA	NASA	Launched 8/21/96; lifetime, 1 yr.
FORTE	Los Alamos N. Lab	Department of Energy	Planned launch in late 1996
Galileo	Hughes	NASA	Launched 10/18/89; lifetime, 8 yrs.
HETE	AeroAstro	NASA	Planned launch in late 1996; lifetime, 1.5 yrs
Hubble Space Telescope	Lockheed Martin	NASA	Launched 4/24/90; lifetime, 15 yrs.
Mars Global Surveyor	Lockheed Martin	NASA	Planned launch in late 1996
NEAR	Aerojet General	NASA	Launched 2/17/96; lifetime, 4 yrs.
UARS	Lockheed Martin	NASA	Launched 9/12/91; lifetime, 4 yrs.
XTE	NASA	NASA	Launched 12/30/95; lifetime,

U.S. SATELLITE INDUSTRY CONTRACT HISTORY [1985 - 1996]			
SATELLITE NAME	**PRIME CONTRACTOR**	**USER**	**REMARKS**
CIVIL SATELLITES			
			5 yrs.
Weather			
GOES-8, -9	Loral	NOAA	Launched 4/13/94, 5/23/95; lifetime, 5 yrs.
NOAA-12, -14, -15	Lockheed Martin	NOAA	Launched 5/14/91, 12/30/94, planned launch in late 1996; lifetime, 2 yrs.

U.S. SATELLITE INDUSTRY CONTRACT HISTORY [1985 - 1996]			
SATELLITE NAME	**PRIME CONTRACTOR**	**USER**	**REMARKS**
MILITARY SATELLITES			
Communications			
DSCS II-F16	TRW	Air Force	Launched 9/4/89; lifetime, 7.5 yrs.
DSCS III-F2, -F3	Lockheed Martin	Air Force	Launched 10/3/85; lifetime, 10 yrs.
DSCS III-F4, -F5, -F6, -F7	Lockheed Martin	Air Force	Launched 9/4/89, 2/11/92, 7/2/92, 7/19/93; lifetime, 10 yrs.
DSCS III-F8, -F9	Lockheed Martin	Air Force	Launched 11/28/93, 7/31/95; lifetime,10yrs.
Leasat 5	Hughes	Navy	Launched 1/9/90; lifetime, 7 yrs.
MILSTAR I-F1, -F2	Lockheed Martin	Air Force	Launched 2/7/94, 11/6/95; lifetime, 10 yrs.
SDS	Hughes	Air Force	Launched 7/2/96
UFO 2, 3, 4, 5, 6, 7	Hughes	Navy	Launched 9/3/93, 6/24/94, 1/28/95, 5/31/95, 10/22/95, 7/25/96; lifetime, 14 yrs.
Navigation			
NAVSTAR GPS 13, 14, 15, 16, 17, 18, 19, 20, 21	Rockwell	Air Force	Launched 2/14/89, 6/10/89, 8/18/89, 10/21/89, 12/11/89, 1/24/90, 3/26/90, 8/2/90, 10/1/90; lifetime, 7.5 yrs.
NAVSTAR GPS 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,	Rockwell (Boeing North American)	Air Force	Launched 11/26/90,7/4/91,2/23/92, 4/10/92, 7/7/92, 9/9/92, 11/22/92, 12/18/92, 2/2/93,

U.S. SATELLITE INDUSTRY CONTRACT HISTORY [1985 - 1996]			
SATELLITE NAME	**PRIME CONTRACTOR**	**USER**	**REMARKS**
MILITARY SATELLITES			
32, 33, 34, 35, 36, 37			3/29/93, 5/14/93, 6/26/93, 8/30/93, 10/26/93, 3/9/94, 3/27/96; lifetime, 7.5 yrs.
NAVSTAR GPS 38, 39	Lockheed Martin	Air Force	Launched 7/15/96, 9/12/96; lifetime, 10 yrs.
Early Warning and Reconnaissance			
Aquacade	TRW	NRO	Launched 5/3/94
DSP-15, -16, -17, -18	TRW	Air Force	Launched 11/13/90, 11/25/91, 12/22/94, planned launch in late 1996; lifetime, 5 yrs.
Jumpseat	TRW	NRO	Launched 7/10/95
KH-11 #10		Air Force	Launched 12/5/95
Scientific			
ARGOS	Rockwell	Air Force	Planned launch in late 1996; lifetime, 3 yrs.
MSTI-3	Spectrum Astro	BMDO	Launched 5/17/96; lifetime, 1 yr.
MSX	Johns Hopkins U.	BMDO	Launched 4/24/96; lifetime, 4 yrs.
REX-II	CTA	Air Force	Launched 3/8/96
Weather			
DMSP 35	Lockheed Martin	Air Force	Launched 11/28/91; lifetime, 4 yrs.
DMSP 36, 37	Lockheed Martin	Air Force	Launched 8/29/94, 3/24/95; lifetime, 5 yrs.
GFO 1	Ball Aerospace	Navy	Planned launch in late 1996; lifetime, 8 yrs.

Appendix B

Recent Acquisitions and Mergers in the Aerospace Industry.

RECENT ACQUISITIONS AND MERGERS IN THE AEROSPACE INDUSTRY

LOCKHEED MARTIN

1997: Announces plan to buy Northrop Grumman

Northrop Grumman acquisitions:

- 1996: Westinghouse defense
- 1994: Northrop buys Grumman
- 1992: Northrop buys LTV Aircraft

1996: Buys Loral's defense unit

Loral acquisitions:

- 1995: Unisys defense
- 1994: IBM Federal Systems
- 1992: LTV Missiles
- 1991: Ford aerospace
- 1988: Goodyear aerospace

1995: Lockheed merges with Martin Marietta

Martin Marietta acquisitions:

- 1994: General Dynamics rockets
- 1993: General Electric aerospace

Lockheed acquisitions:

- 1993: General Dynamics military jets
- 1987: Sanders Associates

BOEING

1996: Announces plan to buy McDonnell Douglas

1996: Buys Rockwell defense and space

RAYTHEON

1997: Buys Texas Instruments defense

RECENT ACQUISITIONS AND MERGERS IN THE AEROSPACE INDUSTRY
1996: Agrees to buy Hughes Aircraft
Hughes Aircraft acquisitions:
• 1995: Magnavox defense
• 1994: CAE Link
• 1992: General Dynamics missiles
1995: Buys E-Systems

(Mintz, 1997:G1)

Appendix C

Introductory Correspondence

July 18, 1997

XXX
XXX
XXX

Dear XX

Thank you for agreeing to participate in my research. I am a candidate for the degree of Master of Science in Contracting Management at the Air Force Institute of Technology, Wright-Patterson AFB, Ohio. My research is being sponsored by Major Caisson Vickery, Ph.D., Assistant Professor, Contracting Management, Department of Graduate Acquisition Management.

This research is geared toward determining U.S. satellite industry capability to meet current and projected Department of Defense satellite requirements. Your responses will provide the needed insight and perspective on assessing the industry's strength in light of defense procurement budget cuts, commercial-military integration, as well as commercial and defense market potential and corporate strategy. As we previously discussed, the purpose of this interview is to record your perspective on the aforementioned issues. I assure you that your responses will be kept strictly confidential.

As a reminder, the telephone interview has been scheduled for _____ p.m. (Pacific Coast Time) on _____.

A list of definitions and interview questions is attached for your review prior to the interview. It would be helpful if you had these attachments available during the course of the interview.

Again, thank you for your cooperation. If you have any questions, please contact me at home (937) 427-3266.

Sincerely,

RONALD B. COLE, Captain, USAF

Attachments

Definitions

The following definitions are taken from the Glossary: Defense Acquisition Acronyms and Terms. 7th Edition, unless otherwise noted:

Acquisition - The conceptualization, initiation, design, development, test, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services (including construction) to satisfy DOD needs, intended for use in or in support of military missions.

Capability - A measure of the systems' (industry's) ability to achieve mission (DOD) objectives, given the system (industry) condition during the mission.

Commercial (Civil)-Military Integration (CMI) - According to a report from the Congressional Office of Technology Assessment, "CMI is defined as the process of uniting the DIB and the larger Commercial Industrial Base (CIB) in to a unified National Industrial Base (NIB). Under CMI, common technologies, processes, labor, equipment, material, and/or facilities would be used to meet both defense and commercial needs" (Boezer et al., 1997:39).

Dual-Use - Having defense and commercial application, whether as a technology, process or product. Dual-use technology refers to fields of research and development that have potential application to both defense and commercial production (Defense Conversion Commission, 1992:31).

Effectiveness - The extent to which the goals of the system (DOD) are attained, or the degree to which a system (DOD) can be expected to achieve a specific set of mission requirements.

Industrial Base - That part of the total private and government owned industrial production and depot level equipment and maintenance capacity in the United States and its territories and possessions, and Canada. It is or shall be made available in an emergency for the manufacture of items required by the U.S. military services and selected allies.

Industrial Facilities - Industrial property (other than material, special tooling, military property, and special test equipment) for production, maintenance, research and development, or test, including real property and rights therein, buildings, structures, improvements, and plant equipment.

Industrial Mobilization - The process of marshaling the industrial sector to provide goods and services, including construction, required to support military operations and the needs of the civil sector during domestic or national emergencies. It includes the

mobilization of materials, labor, capital, facilities, and contributory items and services. Mobilization activities may result in some disruption to the national economy.

Industrial Preparedness - The state of preparedness in industry to produce essential materiel to support the national military objectives.
Industry - The defense industry (private sector contractors) includes large and small organizations providing goods and services to DOD. Their perspective is to represent interests of the owners of stockholder.

Prime Contractor - The entity with whom an agent of the United States entered into a prime contract for the purpose of obtaining supplies, materials, equipment, or services of any kind.

Production - The process of converting raw materials by fabrication into required material. It includes the functions of production-scheduling, inspection, quality control, and related processes.

Productivity - The actual rate of output or production per unit of time worked.

Quality - The composite of material attributes including performance features and characteristics of a production or service to satisfy a customer's given need.

Subcontractor - A contractor who enters into a contract with a prime contractor.

Surge - An increase in the production or repair of defense goods for a limited duration of time.

Surge Production - An increased rate of production necessary to meet demands for defense items due to a wartime or mobilization situation. This increased rate can be obtained by having excess production capacity available or by utilizing multiple shifts of normal capacity machines.

Interview Questions

The U.S. satellite industry is an integral sector of the U.S. Defense Industrial Base (DIB); its ability to produce state-of-the-art satellites is critical to the Department of Defense (DOD). The DOD has identified four principal objectives for the DIB over the next 10 to 20 years. These objectives are summarized in the following table. Essentially, the DOD requires the DIB be industrially prepared; it must be able to maintain superior technology and industrial capabilities at an affordable price as well as surge, surge production, and/or mobilize to ensure national security. Please keep DOD's objectives in mind when answering the following questions. Also, answer the questions as they affect your company only, unless otherwise noted, and feel free to elaborate where you feel it is necessary.

DIB OBJECTIVES
First, it must support the base force structure in peacetime.
Second, beyond peacetime, it must be capable of supporting contingency-related needs.
Third, the industrial base must be able to build up production capacity faster than any newly emerging global threat can build up its capacity.
Fourth, the industrial base must be as efficient and cost-effective as possible.

Source: *Defense Industrial Base White Paper*, May 20, 1992

1. What percentage of your company's satellite sales are commercial? Defense? Are these percentages changing? In what way?

2. To what degree does defense spending impact your company's capability to effectively and efficiently produce satellites?

3. How have declining DOD procurement budgets affected your company's satellite business?

4. How has the shrinking DIB influenced your company's satellite business? Assuming your company is the prime contractor for a particular defense satellite contract, are you well-supported (in terms of industry competition) by subcontractors and parts/material suppliers? Are they able to provide the critical materials, components, and parts necessary for satellite production, whether commercial or defense?

5. Do you have the industrial capacity and facilities to produce quality, state-of-the-art satellites for defense and commercial business now and in the future? Is your company planning on reducing or expanding capacity and/or facilities?

6. How are you maintaining the vulnerable, unique, and critical technologies, capabilities and skills necessary to produce defense satellites?

7. The DOD is challenged with maintaining superior satellite technology and industrial capability at an affordable price. How is this possible?

8. Does your company engage in flexible manufacturing between commercial and defense business? If not, how is your production line set up to accommodate both commercial and defense business?

9. If the need arose and in your expert opinion, would your company be able to meet DOD surge and mobilization requirements now and in the future?

10. Does your company desire to remain in the defense satellite business? Why or why not?

For the following questions, answer them as they affect your company and the U.S. satellite industry in general.

11. Is there an increase in commercial satellite applications? What are these applications?

12. How have recent "commercialization" efforts (i.e. commercial-military integration through acquisition reform and dual-use technology and production strategies) by the federal government affected satellite technology and production? Which initiative makes the biggest impact? Is it positive or negative?

13. Do you consider the current U.S. satellite industry serving mainly defense or commercial markets? In the future?

14. In your opinion, will there be dual-use technology and production opportunities for commercial and defense satellites in the future? To what extent will they mutually benefit each other? In what way(s)?

15. What is the financial and growth outlook for the U.S. satellite industry? In your opinion, will the U.S. satellite industry be able to meet DOD satellite requirements in an efficient and effective manner?

16. Do you foresee any problems with the U.S. satellite industry in the future? Do you have any recommendations for the DOD to help them meet their challenge of maintaining superior satellite technology and industrial capability at an affordable price? Other comments?

Appendix D

Interview Participants

1. Glaysher, Robert. Telephone Interview. VP & General Manager Satellite & Space Defense Systems, Boeing North American Space Systems, 12214 Lakewood Blvd., Mail Stop BA 09, Downey, CA 90241, 28 July 1997.

2. Lynch, William. Telephone Interview. Manager Advanced Programs, Lockheed Martin, 1111 Lockheed Martin Way, Sunnyvale, CA 94089, 24 July 1997.

3. Rosen, Stan. Telephone Interview. Director of Strategic Planning, Hughes Space & Communications, 2260 East Imperial Highway, El Segundo, CA 90245, 25 July 1997.

4. Schade, Chris. Telephone Interview. Senior Director Defense & Advanced Programs, Orbital Sciences Corporation, 21700 Atlantic Blvd., Dulles, VA 20166, 5 August 1997.

Appendix E

Interview Data Collection Instrument

DATE OF INTERVIEW:_____
START TIME:_____
STOP TIME:_____

PRELIMINARY/DEMOGRAPHIC INFORMATION
1. NAME:
2. TITLE:
3. OFFICE SYMBOL:
4. COMPANY:
5. DIVISION:
6. ADDRESS:
7. PHONE:
8. FAX:

REMINDER: Have you had a chance to review the package I sent you? I would like to remind you that this information is for purely academic purposes and that your answers will be kept confidential. If you do not feel comfortable answering a question, please feel

free to say so. If we get disconnected, I will immediately return the call so we can finish. The following questions are exploratory in nature and I would like to discuss each one, but do not feel constrained to address only these issues. If you feel there is something pertinent that needs to be discussed, please bring it up. If you are ready and do not have any questions, lets get started.

Interview Questions

The U.S. satellite industry is an integral sector of the U.S. Defense Industrial Base (DIB); its ability to produce state-of-the-art satellites is critical to the Department of Defense (DOD). The DOD has identified four principal objectives for the DIB over the next 10 to 20 years. These objectives are summarized in the following table. Essentially, the DOD requires the DIB be industrially prepared; it must be able to maintain superior technology and industrial capabilities at an affordable price as well as surge, surge production, and/or mobilize to ensure national security. Please keep DOD's objectives in mind when answering the following questions. Also, answer the questions as they affect your company only, unless otherwise noted, and feel free to elaborate where you feel it is necessary.

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Fourth, the industrial base must be as efficient and cost-effective as possible.

Source: *Defense Industrial Base White Paper*, May 20, 1992

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1. ***What percentage of your company's satellite sales are commercial? Defense? Are these percentages changing? In what way?***

2. ***To what degree does defense spending impact your company's capability to effectively and efficiently produce satellites?***

3. ***How have declining DOD procurement budgets affected your company's satellite business?***

4. ***How has the shrinking DIB influenced your company's satellite business? Assuming your company is the prime contractor for a particular defense satellite contract, are you well-supported (in terms of industry competition) by subcontractors and parts/material suppliers? Are they able to provide the critical materials, components, and parts necessary for satellite production, whether commercial or defense?***

5. ***Do you have the industrial capacity and facilities to produce quality, state-of-the-art satellites for defense and commercial business now and in the future? Is your company planning on reducing or expanding capacity and/or facilities?***

6. ***How are you maintaining the vulnerable, unique, and critical technologies, capabilities and skills necessary to produce defense satellites?***

7. ***The DOD is challenged with maintaining superior satellite technology and industrial capability at an affordable price. How is this possible?***

8. ***Does your company engage in flexible manufacturing between commercial and defense business? If not, how is your production line set up to accommodate both commercial and defense business?***

9. ***If the need arose and in your expert opinion, would your company be able to meet DOD surge and mobilization requirements now and in the future?***

10. ***Does your company desire to remain in the defense satellite business? Why or why not?***

For the following questions, answer them as they affect your company and the U.S. satellite industry in general.

11. ***Is there an increase in commercial satellite applications? What are these applications?***

12. ***How have recent "commercialization" efforts (i.e. commercial-military integration through acquisition reform and dual-use technology and production strategies) by the federal government affected satellite technology and production? Which initiative makes the biggest impact? Is it positive or negative?***

13. ***Do you consider the current U.S. satellite industry serving mainly defense or commercial markets? In the future?***

14. ***In your opinion, will there be dual-use technology and production opportunities for commercial and defense satellites in the future? To what extent will they mutually benefit each other? In what way(s)?***

15. ***What is the financial and growth outlook for the U.S. satellite industry? In your opinion, will the U.S. satellite industry be able to meet DOD satellite requirements in an efficient and effective manner?***

16. ***Do you foresee any problems with the U.S. satellite industry in the future? Do you have any recommendations for the DOD to help them meet their challenge of maintaining superior satellite technology and industrial capability at an affordable price? Other comments?***

Bibliography

"Allay Industry's Antitrust Concerns," *Aviation Week & Space Technology*: 66 (September 27, 1993).

Anselmo, Joseph C. "No End in Sight For Space Business Boom," *Aviation Week & Space Technology*: 72-75 (March 17, 1997).

Armstrong, C. Michael. "Reinventing Government-Industry Relations." Delivered at the MICOM Advance Planning Briefing for Industry. Huntsville AL, 9 November 1993.

Asker, James R. "Commercial Growth Key to Space Sector," *Aviation Week & Space Technology*: 95-97 (March 13, 1995).

Augustine, Norman R. "Antitrust in the Era of Perestroika: What is Happening in the Defense Industry?" Delivered before the American Bar Association, Section of Antitrust Law/Section of Public Contract Law. New York NY, 10 August 1993.

Auster, Bruce. "A Few Swords Along With the Plowshares," *Air Force Magazine*: 63-66 (March 1993).

Austin, Mike. "Managing the US Defense Industrial Base: A Strategic Imperative," *Parameters*: 27-37 (Summer 1994).

Blackwell, James A. Jr. *Defense Industrial Base Restructuring*. Washington DC: Center for Strategic & International Studies (CSIS), 1992.

Boezer, Gordon, Ivars Gutmanis, and Joseph E. Muckerman II. "The Defense Technology and Industrial Base: Key Component of National Power," *Parameters: US Army War College Quarterly, Vol. XXVII, No. 2*: 26-51 (Summer 1997).

Bowlds, Ted F. *Maintaining the Defense Industrial Base*. Air War College, Maxwell AFB AL, 1994.

Brinkerhoff, John R. "The Strategic Implications of Industrial Preparedness," *Parameters*: 38-47 (Summer 1994).

Caceres, Marco Antonio. "Satcoms Growth on Upswing," *Aviation Week & Space Technology*: 117-120 (January 13, 1997).

———. "Space Market Shifts to Private Sector," *Aviation Week & Space Technology*: 111-112 (January 8, 1996).

"Changing Defense Industrial Base, The," *Defense*: 47-52 (July/August 1992).

Cooper, Stephen R. and Charles Houck. *Measuring the Effectiveness of the Industrial Modernization Incentives Program (IMIP).* MS Thesis, AFIT/GLM/LSP/85S-36. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1985 (AD-A161240).

Correll, John T. and Colleen A. Nash. *Lifeline Adrift: The Defense Industrial Base of the 1990s*. Arlington VA: The Aerospace Education Foundation, September 1991.

Covault, Craig. "$27 Billion Spurs Military, Civil Space," *Aviation Week & Space Technology*. 73-75 (March 17, 1997).

Department of the Air Force. "Acquisition Reform Mission." WWWeb, http://www.acq.osd.mil/ar/mission.htm (25 May 1997).

Department of the Air Force. *Global Engagement: A Vision for the 21st Century Air Force*. Washington DC: HQ USAF.

Department of the Air Force. *Glossary: Defense Acquisition Acronyms and Terms* (Seventh Edition). Washington DC: GPO, 1996.

Department of the Air Force. "USAF Raw Inflation Indices." WWWeb, http://www.saffm.hq.af.mil/SAFFM/FMC/raw97.html (22 July 1997).

Department of Defense, Defense Conversion Commission. *Adjusting to the Drawdown*. Washington DC, GPO, 1992.

Department of Defense, Directorate for Information Operations and Reports (DIOR). "Department of Defense Procurement." WWWeb, http://web1.whs.osd.mil/DIORHOME.HTM (22 May 1997).

Department of Defense, Office of the Assistant Secretary of Defense (Economic Security). *Assessing Defense Industrial Capabilities: A DOD Handbook*. Washington DC: GPO, 1995.

Department of Defense, Office of the Secretary of Defense (OSD). "A Defense Strategy for Affordable, Leading-Edge Technology." WWWeb, ttp://www.acq.osd.mil/es/dut/dup1.html (February 1995).

Dobler, Donald W. and David N. Burt. *Purchasing and Supply Management: Text and Cases* (Sixth Edition). New York: The McGraw-Hill Companies, Inc., 1996.

Emory, C. William and Donald R. Cooper. *Business Research Methods* (Fourth Edition). Homewood IL: Irwin, 1991.

Frey, James H. *Survey Research by Telephone* (Second Edition). Newbury Park CA: SAGE Publications, Inc., 1989.

Gansler, Jacques S. *Affording Defense*. Cambridge MA: The MIT Press, 1989.

———. *The Defense Industry*. Cambridge MA: The MIT Press, 1980.

———. "Restructuring the Defense Industrial Base," *Issues in Science and Technology*: 50-58 (Spring 1992).

———. "Transforming the US Defence Industrial Base," Survival, Vol. 35, No. 4: 130-146 (Winter 1993).

General Electric Company. *GE Aircraft Engines Executive Overview*. Cincinnati OH, March 1997.

Gordon, Edward. *Final Report Industrial Base Survey of the MILSTAR Satellite Program FY-96.* Delivery Order 18, Contract F33615-93-D-5101. Los Angeles: Space and Missile Systems Center, July 1996.

———. *Final Report Industrial Base Survey of the MILSTAR Satellite Program FY-95 (Executive Report).* Los Angeles: Space and Missile Systems Center, October 1995.

———. *Space and Missile Systems Sector Industrial Base Analysis*. Task Order - 0004, AF Contract No. F33615-93-D-5101. Los Angeles: Space and Missile Systems Center, March 1995.

Gore, Albert. "From Red Tape to Results: Creating a Government That Works Better & Costs Less," *National Performance Review*. Washington DC: GPO, September 7, 1993.

Gulick, Clyde E. *The Defense Industrial Base: Prescription for a Psychosomatic Ailment*. Airpower Research Institute, Air University, Maxwell AFB AL: Air University Press, August 1983.

Hartley, Keith and Todd Sandler. *Handbook of Defense Economics, Vol. 1*. Amsterdam: Elsevier, 1995.

"History of GE Aircraft Engines, The," WWWeb, http://www.ge.com.aircraftengines/history.htm (2 August 1997).

James, Larry D. *DOD Space Systems – Reducing the Cost*. Air War College, Maxwell AFB AL, 1993.

Kitfield, James. "Industrial Base Gets Smaller, Colder," *Government Executive*: 39-47 (August 1995).

———. "Mega-Merger Recasts Industrial Base," *Government Executive*: 56 (October 1994).

———. "Paul Kaminski," *Government Executive*: 32-39 (August 1995).

———. "Shrinking the Industrial Complex," *Government Executive*: 29-38 (August 1993).

———. "William Perry: Guarding the Base," *Government Executive*: 40-47 (August 1993).

Lavrakas, Paul J. *Telephone Survey Methods: Sampling, Selection, and Supervision*. Newbury Park CA: SAGE Publications, Inc., 1987.

Libicki, Martin C. *Industrial Strength Defense: A Disquisition on Manufacturing, Surge and War*. Washington, DC: National Defense University, 1988.

Mehuron, Tamar A. "Space Almanac," *Air Force Magazine*: 28-43 (August 1996).

Mintz, John. "How a Dinner Led to a Feeding Frenzy," *The Washington Post*: G1 (July 4, 1997).

Moranville, Mark S. *Satellite Communications Industry*. Industrial College of the Armed Forces, National Defense University, Ft. McNair, Washington DC, 1993.

National Defense University. *Industry Study Summaries (Space)*. Industrial College of the Armed Forces, Washington DC, 1992-1993.

Pascall, Glenn R. and Robert D. Lamson. *Beyond Guns & Butter: Recapturing America's Economic Momentum After a Military Decade*. Washington DC: Brassey's (US), Inc., 1991.

Polmar, Norman, John T. Correll, Scott C. Truber, and Robert L. Anderson. *Lifeline in Danger: An Assessment of the United States Defense Industrial Base*. Arlington VA: The Aerospace Education Foundation, September 1988.

Sandler, Todd and Keith Hartley. *The Economics of Defense*. Cambridge: Cambridge University Press, 1995.

Schoeni, Robert F., Michael Dardia, Kevin F. McCarthy, and Georges Vernez. *Life After Cutbacks: Tracking California's Aerospace Workers*. Santa Monica CA: RAND, 1996.

Scott, William B. "Information Warfare Demands New Approach," *Aviation Week & Space Technology*: 85-88 (March 13, 1995).

"Spacecraft," *Aviation Week & Space Technology*: 131-137 (January 13, 1997).

Sparaco, Pierre. "Commercial Programs Spur Space Growth," *Aviation Week & Space Technology*: 20 (August 5, 1996).

Spenny, David E. *An Evaluation of the Effectiveness of the Industrial Modernization Incentives Program (IMIP).* MS Thesis, AFIT/GLM/LSM/86S-81. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1986 (AD-A174374).

"Swords Into Satellites," *The Economist*: 60-61 (September 3, 1994).

Taliaferro, Richard T. *Microeconomics and the Industrial Economy*. Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 1994.

Tirpak, John A. "The Rise of Space," *Air Force Magazine*: 52-55 (August 1997).

U.S. Congress, House of Representatives, Committee on Armed Services, Panel on Defense Industrial Base. *The Ailing Defense Industrial Base: Unready for Crisis*. Hearings, 96th Congress, 2d Session, 1980. Washington DC: Government Printing Office, 1980.

Velocci, Anthony L. "Consolidation Outlook Stormy," *Aviation Week & Space Technology*: 42-44 (March 14, 1994).

White House, National Science and Technology Council. "National Space Policy." WWWeb, http://www.whitehouse.go…P/NSTC/html/fs/fs-5.html (19 September 1996).

Yin, Robert K. *Case Study Research: Design and Methods*. Newbury Park CA: SAGE Publications, Inc., 1989.