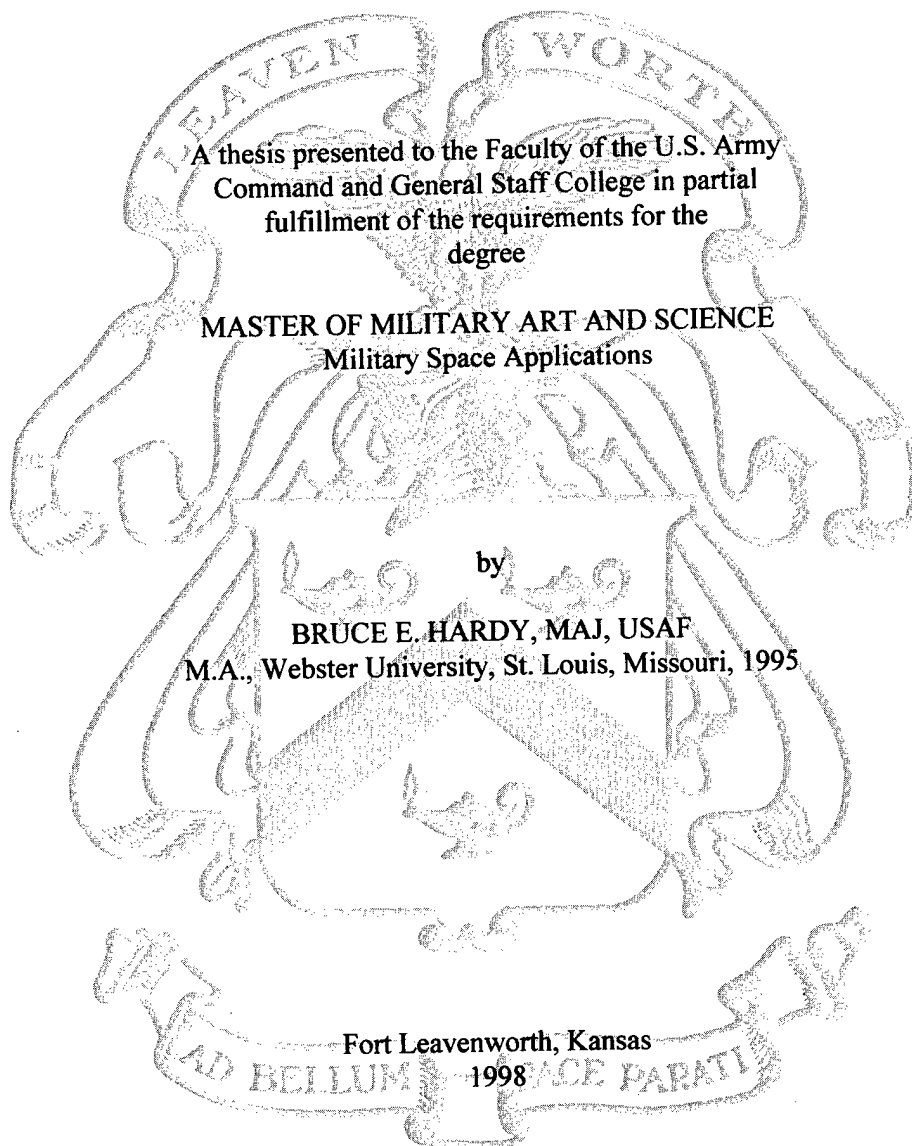


SPACE: A VITAL NATIONAL INTEREST?



A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE
Military Space Applications

by

BRUCE E. HARDY, MAJ, USAF
M.A., Webster University, St. Louis, Missouri, 1995

Fort Leavenworth, Kansas

1998

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

SPACE: A VITAL NATIONAL INTEREST? by Maj Bruce E. Hardy, USAF, 78 pages.

Current U.S. policy, including the *National Security Strategy* and the *National Space Policy*, declares that access to space has become a vital national interest of the United States. This study examines the justification for this assertion.

By examining the definition of vital national interest and U.S. national security policy, this study developed three criteria by which to judge the importance of space-based systems to U.S. national security. These criteria were used to evaluate the contribution of space-based systems to U.S. economic vitality, conventional military capabilities, and physical survival. A numerical model related these criteria, addressing their relative importances by applying different numerical weights to each.

This research indicates that the assertion that access to space is a vital national interest of the United States is indeed justified. Denying access to the services provided by space-based systems would have a very negative effect on U.S. economic vitality, conventional military capabilities, and physical survival. The United States should commit as a nation to maintaining leadership in the global space industry and insuring continuity of service from space-based systems in spite of environmental catastrophe or deliberate interference.

Now it is time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth.

I believe we possess all the resources and talents necessary. But the facts of the matter are that we have never made the national decisions or marshalled the national resources required for such leadership. We have never specified long-range goals on an urgent time schedule, or managed our resources and our time so as to insure their fulfillment.

—President John F. Kennedy
*Special Message to the Congress
on Urgent National Needs,
May 25, 1961*

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CHAPTER 1

INTRODUCTION

The United States is becoming increasingly reliant on systems operating in space. From communications and weather prediction to terrestrial surveillance and exploration, space systems are becoming more important to international stability and the global economy. The space age began in 1957 when the Soviet Union launched the first man-made satellite, Sputnik I. In the forty years since then, the world has witnessed an incredible pace of technological advance. Only twelve years after Sputnik made its first orbit of the earth, American Neil Armstrong set foot on the moon. While interplanetary exploration, especially manned, has slowed substantially since then, the use of space for military, civil, and commercial ventures has skyrocketed (Smernoff 1984, 17). In fact, U.S. policy now states that U.S. national security depends (at least in part) on the ability to operate freely in space. This leads to the question: Should the access to the region of space be declared a "vital national interest" in the *National Security Strategy*? This thesis proposes to qualify the extent to which space-based systems have become vital to the United States.

There are several subordinate questions which must first be answered to reach a conclusion on the primary research question stated above. These questions focus on the basic definition of a vital national interest. As defined in the current U.S. *National Security Strategy*, vital interests are those which are of "broad, overriding importance to the survival, safety and vitality of our nation. Among these are the physical security of

our territory and that of our allies, the safety of our citizens, and our economic well-being” (U.S. President 1998, 5). Space systems clearly affect these three areas. They provide early warning of ballistic missile launches (survival), help predict severe weather phenomena, such as hurricanes (safety), and communicate information around the world in the ever-expanding global market place (vitality). Would disruption of U.S. space activities negatively affect the survival of the nation? Would disruption of U.S. space activities negatively affect the safety of the American public or America’s economic well-being?

This research is significant because the *National Security Strategy* also states, “We will do whatever it takes to defend these [vital national] interests, including--when necessary--using our military might unilaterally and decisively” (U.S. President 1998, 5). If the ability to operate in space has indeed become a vital national interest, then the U.S. must be prepared to defend it as such. Unfortunately, defending U.S. space activities could be very expensive and is therefore highly contentious. It may require fundamental changes in defense priorities and resources. The national debate which surrounded President Ronald Reagan's proposed *Strategic Defense Initiative* highlights the contentiousness of this issue and continues today, in fact. Recently, the U.S. Senate rejected proposed legislation which would require deployment of a national missile defense system as soon as technically feasible. The defeat was partly attributed to lobbying *against* the measure by the Chairman of the Joint Chiefs of Staff. An article published in the *New York Times*, 10 September 1998, stated that many officials believe that a political commitment to a robust defense of U.S. space activities will draw scarce

resources away from other defense priorities. A thorough assessment of the primary research question will provide policy makers with rationale to deal with the difficult space defense issue. This research project is listed by the U.S. Air Force Institute of National Security Studies as a Tier 1 priority topic and is sponsored by the Headquarters, U.S. Space Command.

There is a precedent for declaring access to a region a vital national interest, as U.S. access to the Persian Gulf illustrates. Given the industrialized world's dependence on the oil contained in that region, it is not surprising that the U.S. uses its national power to prevent aggressive nations from dominating the region, or threatening the flow of oil in the Gulf. This policy was formally declared by President Jimmy Carter, who announced on 23 January 1980, that "an attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force" (Schubert and Kraus 1995). This policy became known as the Carter Doctrine and has been enforced militarily on a number of occasions, notably the 1988 U.S. reflagging of Kuwaiti oil tankers and the 1990 Persian Gulf War (Schubert and Kraus 1995).

In testimony before Congress, General Howell Estes III, Commander-in-Chief, U.S. Space Command, compared America's interests in space with those in the Persian Gulf. He stated the American public should understand that they are as dependent on space as they are on oil.

When World War II-era Americans understood oil's value to military operations, they could more readily accept a North Africa strategy in lieu of direct, perhaps expedient, attacks on German soil. They also had a framework to put the high-cost of air raids on Axis oil fields and refineries in context. The oil shock of

the 1970s forced Americans to also recognize their dependence on oil to commerce and their way of life. The result is an ingrained sense of oil as an military and economic center of gravity. . . . Americans recognize the need for a separate unified command covering the oil region, they accepted a permanent overseas presence there, they were ready to endure thousands of projected casualties in the Gulf War, they have maintained international sanctions against Iraq for an unprecedented duration.

. . . Americans seem unaware that just as oil drives the engine of today's industrial society, space will drive the engine of tomorrow's information society. As an emerging center of gravity, space capabilities impact almost every industry, every person, and every military strategy. . . . I believe the public must come to a better understanding of their basic dependence on space systems. (Senate, Committee on Armed Services 1998, 8)

The fact that access to the Persian Gulf is an accepted vital national interest makes it a logical standard by which to judge the results obtained by this study for access to space.

This parallel will be examined in chapter 4.

Definitions

There are several terms associated with this research project which require further explanation.

American space program. The U.S. space program is the aggregation of U.S. national security, civil, and commercial space programs. The national security space program can be further broken down into the U.S. military space program and U.S. intelligence space program (Committee on Government Operations 1994, 28). While these programs are closely related, the military program is run by the Department of Defense, and the intelligence program is run by the Central Intelligence Agency. The civil program is comprised of those U.S. governmental space activities not included above, such as the Space Shuttle Transportation System. The distinction of these

programs is not intended to imply that they exist in isolation; in fact, there are many instances where the programs intersect. For example, the U.S. government currently leases communications support from commercial ventures, and the Space Shuttle Transportation System is frequently used to launch commercial satellites (U.S. National Aeronautics and Space Administration 1988).

Disruption of space activities. This is the prevention of a particular space-based system's ability to accomplish its primary mission. This is an intentionally broad definition which does not require destruction of the system or any of its components. As illustrated by the above definition of space systems and their three segments, space systems are very complex, and generally vulnerable to disruption. Due to stringent size and weight restrictions inherent in lifting a vehicle off the planet and accelerating it to orbital velocity, the space vehicles themselves are relatively soft targets (Stares 1984, 37). The accuracy required for tracking necessitates relatively large antennae located at fixed ground facilities which are also relatively soft targets (U.S. Department of the Army 1995, 7-4). Even a temporary disruption of any of the three segments can cause mission failure.

Space. The region of space generally refers to the altitude at which atmospheric drag on an orbiting body decreases to the point that the body will maintain the desired orbit without additional thrust. For the purposes of this paper, 100 kilometers is an acceptable estimation of this altitude. It is only an estimation, because there is no definite point at which space begins. Ninety-seven percent of the earth's atmosphere is below thirty kilometers, and atmospheric pressure at eighty kilometers is only one millionth of

what it is at sea level. Yet, even though smaller satellites can orbit as low as 100 kilometers, the orbits of larger satellites can still decay from much higher altitudes (*Skylab* decayed from over 400 kilometers) (Durch and Wilkening 1984, 12).

Space system. Space systems consist of a space segment, a control segment, and a user segment (see figure 1). The space segment is comprised of the system's orbiting vehicles and the components used to launch them. The vehicle may be a ballistic missile (which completes less than one full orbit), an unmanned satellite, or a manned space station. Generally, the vehicle can be further separated into the platform and the payload. The platform provides the system's structure, power supply, propulsion, stabilization and attitude control, thermal control, and telemetry, tracking and command. The payload

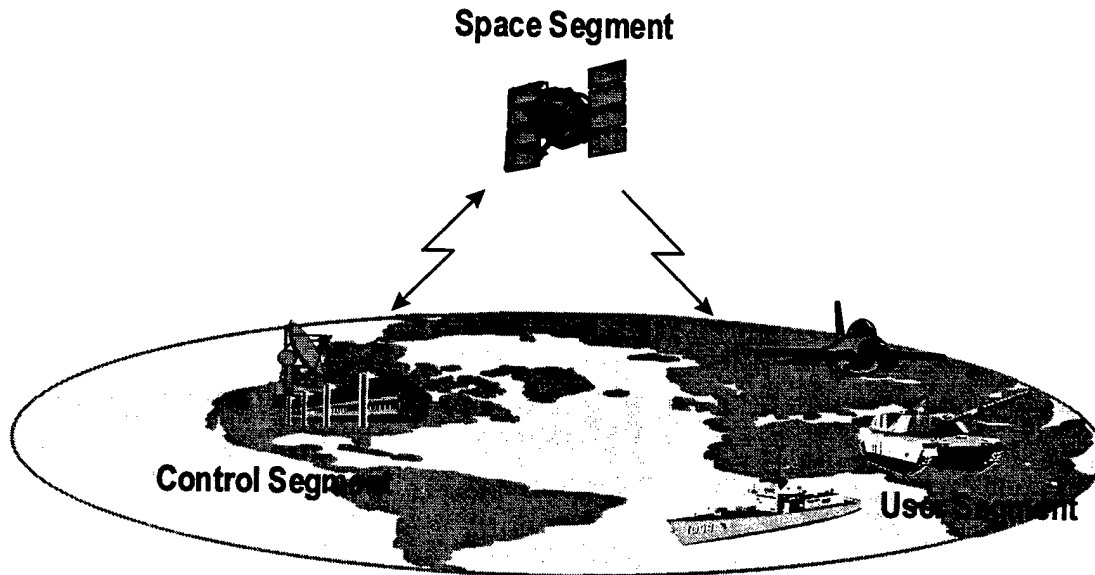


Figure 1. Components of a space system

provides the space-based capability for which the system was developed and launched. Typical payloads include communications, navigation, reconnaissance, weather observation, and science experimentation (U.S. Department of the Army 1995, 7-1 - 7-4).

The control segment performs those functions which operate the overall space system. It controls the platform, the payload, and any associated network of tracking and data acquisition stations. The ground command and control facility controls the space vehicle through telemetry, tracking, and commanding. Telemetry is information about the health of the orbiting system which is relayed to the control segment. The control segment also physically tracks the location of the space vehicle through a variety of means including beacon, radar, and optical systems. The space vehicle's orientation relative to some frame of reference is tracked by sensors on the vehicle itself and also relayed to the control segment. Finally, the control segment actually controls the vehicle through commanding. Through various maneuver and payload operation commands transmitted from the control segment, the platform maintains a proper orbit and attitude, and the payload performs the mission for which it was designed. Accurate tracking and positioning of the space vehicle is absolutely essential to the performance of the system. Tracking errors will cause the control segment to issue maneuver commands which cause the vehicle to deviate from the proper orbit. If these errors are large enough they can cause complete failure of the mission. For that period when the vehicle's orbit has carried it out of the field of view of the command and control station, the telemetry, tracking, and commanding information must be relayed via other ground sites or in some cases, via other communications relay satellites (U.S. Army 1995, 7-1 - 7-4).

The user segment is comprised of the personnel, equipment, and facilities which actually use the information provided by the payload. Types and configurations are as varied as the number of different payloads. In some cases, the information is first processed by the control segment before it is relayed (often via communications satellites) to the user segment. In others, the information is broadcast directly to the user segment from the space segment (U.S. Army 1995, 7-1 - 7-4).

Vital national interest. As stated previously, this affects the survival, safety and economic vitality of the nation, and will be defended militarily if necessary (U.S. President 1998, 5). This project will refer continuously to these three elements (survival, safety, economic vitality) and the tenant of justifying military operations.

Research Model

This project will follow a basic research model whose main steps are collecting evidence, analyzing the evidence, and drawing conclusions (U.S. Department of the Army 1998, 11). Collecting evidence is the initial step. Information from existing literature will be evaluated to ensure its relevance to the primary research question. This evaluation will be conducted with the following two criteria. First, the information must be suitable to the research. This means that the information must apply to the subordinate questions as stated previously. Additionally, the information must lie within the boundaries established by the assumptions and delimitations. The second criterion is the requirement for the information to be valid. To satisfy this requirement the information must be published by an accepted subject matter expert, substantiated or corroborated where

possible (or reasonably arguable where not), and reasonably able to address new or subsequent information, discoveries, or positions.

The second step in the research process is the analysis of the information. The specific research method will be critical interpretation. As described by Tyrus Hillway, this method is useful when drawing conclusions from areas where one deals with broad ideas and opinions more than discreet facts (1964, 101). For example, one of the subordinate questions asks if disruption of U.S. space activities will negatively affect the nation's economic well-being. The exact meaning of economic well-being is a matter of opinion, and many experts have published their opinions on the topic. From this body of opinion this study will develop a model of economic well-being, and draw conclusions as to the U.S. space program's contribution.

The ultimate criteria for the analysis are the subordinate questions themselves. The collected evidence will fall into two categories. First, it will provide data to model the particular condition of the subordinate question: physical survival, public safety, or economic well-being. Second, it will characterize the space program's contribution to the individual models. This will lead directly to the corresponding impact of denying this contribution.

The last step of the research process will be the evaluation of the results to draw conclusions about the subordinate research questions and ultimately the primary research question.

Assumptions, Limitations, and Delimitations

The major assumption of this research is that there exists and will continue to exist a genuine threat to U.S. operations in space. This assumption is plausible for several reasons. First, the former Soviet Union developed and fielded an active anti-satellite system (Robinson 1984, 71). Given the ongoing economic crisis in Russia, it is not unlikely that the technology or even the actual systems could be exported to countries who would use them against the United States. Furthermore, other threats to space systems exist that are unrelated to a potential adversary. Space in general is a harsh environment, and solar activity in particular frequently disrupts and degrades space systems. The two main phenomena that make up solar activity are sunspots and solar flares. Sunspots routinely interfere with communications, but they do not actually damage space systems. Solar flares, however, cause significant increases in solar particle emissions which can actually destroy satellites in orbit (U.S. National Aeronautics and Space Administration 1997). Regardless of the cause of a disruption in U.S. space activities, the impact on American survival, safety, and economic vitality will be the same.

The main limitation of this research is the fact that it is a subjective analysis based on an accurate estimation of the extent to which the American space program contributes to national security. Another limitation is the fact that many details of national security space systems are classified. This is especially true of those systems which comprise the U.S. intelligence space program. These systems will not be discussed in detail, and this

will limit the overall characterization of the space program's contribution to national security.

The focus of this research project will be the disruption of American space operations and the *effects* this would have on national security. This project will not examine the causes for such disruptions. As previously discussed, physical threats include both the actions of an adversary as well as the space environment itself. There are, however, nonphysical threats as well. Future political, diplomatic, or treaty restrictions might limit American space operations. Additionally, any inability of American commercial firms to compete in the space market would restrict U.S. participation in space-related commerce and might erode the nation's economic vitality. This project will not examine the likelihood or extent to which different scenarios might disrupt U.S. space activities. Finally, this project will also exclude any examination of the negative impact an adversary's use of space may bring to U.S. physical security or the ability to employ U.S. military forces in defense of other vital national interests.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the current U.S. national policy toward space. This policy is defined in a variety of published documents as well as speeches and congressional testimony by senior governmental officials. Published documents include the *National Security Strategy*, the *National Space Policy*, and the Department of Defense *Annual Report to the President and Congress*. Statements include the congressional testimony given by Mr. Keith Calhoun-Senghor, U.S. Department Of Commerce, and General Howell Estes III, Commander-in-Chief, U.S. Space Command. All of the policy documents and statements are unanimous in their conclusion that, in terms of the definition stated in the *National Security Strategy*, access to space has indeed become a vital national interest.

The National Security Strategy

The latest *National Security Strategy* significantly increased the amount of coverage it dedicates to space. In fact, it actually addresses all of the elements of vital national interest as defined in chapter 1. It asserts, "Unimpeded access to and use of space is essential for protecting U.S. national security, promoting our prosperity and insuring our well-being in countless ways" (U.S. President 1998, 25). It also addresses the defense of these interests, stating, "We will deter threats to our interests in space and, if deterrence fails, defeat hostile efforts against U.S. access to and use of space"

(U.S. President 1998, 25-6). Finally, the *National Security Strategy* also lists several commercial sectors and their dependence on space-based capabilities, declaring "over 500 U.S. companies are directly involved in the space industry, with 1996 revenues of \$77 billion projected to reach \$122 billion by 2000" (U.S. President 1998, 25).

The National Space Policy

The *National Space Policy* also stresses the importance of space to the United States. It also touches on all three areas of the definition of vital national interests, stating "access to and use of space is central for preserving peace and protecting U.S. national security as well as civil and commercial interests" (U.S. President 1996). It discusses U.S. resolve to protect U.S. access to space, stating "the United States considers the space systems of any nation to be national property with the right of passage through and operations in space without interference. Purposeful interference with space systems shall be viewed as an infringement on sovereign rights" (U.S. President 1996). It includes a discussion of the goals of the U.S. space program, which include strengthening and maintaining national security and enhancing economic competitiveness. It further defines these goals in specific guidelines for the each element of the U.S. space program. With respect to the national security space program, it directs that space activities shall support the United States' inherent right of self-defense and defense commitments; they shall deter, warn, and defend against enemy attack; and they shall assure U.S. access to space. It also provides guidelines for the civil space program, directing establishment of "a program of long-term observation, research, and analysis of the earth's land, oceans,

atmosphere and their interactions" (U.S. President 1996). It asserts space-based earth observation is a requirement for public safety. Finally, the *National Space Policy* provides guidelines for the commercial space program. It states, "The fundamental goal of U.S. commercial space policy is to support and enhance U.S. economic competitiveness in space activities while protecting U.S. national security foreign policy interests. Expanding U.S. commercial space activities will generate economic benefits for the nation" (U.S. President 1996).

While the U.S. government has previously dominated American space activities, the *National Space Policy* attempts to reverse this fact by encouraging the commercial sector to continue increasing their investment in space technologies. It emphasizes "to stimulate the private sector investment, ownership, and operation of space assets, the U.S. government will facilitate stable and predictable U.S. commercial sector access to appropriate U.S. government space-related hardware, facilities and data" (U.S. President 1996). Governmental dominance has been most prevalent within the space launch arena. The *National Space policy* addresses this area directly when it states:

Free and fair trade in commercial space launch services is a goal of United States. In support of this goal, United States will implement, at the expiration of current space launch agreements, a strategy for transitioning from negotiated trade in launch services towards a trade environment characterized by the free and open interaction of market economies. (U.S. President 1996)

The Department of Defense Annual Report

The Department of Defense dedicated an entire chapter of the 1998 *Annual Report to the President and Congress* to a discussion of space forces. It asserts "space has

become as important to the nation as land, sea, and air power. The evolution toward a global economy will depend as much upon the information lines of communication through space as it will on the transportation lines of communication across the sea" (U.S. Department of Defense 1998). It also addresses access to space in the terms of a vital national interest when it states U.S. "dependence on space forces for military operations, as well as for civil and commercial uses, is growing" (U.S. Department of Defense 1998). In terms of military operations it notes that space systems are frequently the only sources of information about countries to which access is otherwise denied. With respect to U.S. dependence on space for commercial uses, the report predicts that the annual contribution of space activities to U.S. economy may reach hundreds of billions of dollars by the year 2000. Finally, the report calls space operations a new national center of gravity with the following rationale:

The world is increasingly transitioning to economies in which information is a major engine of prosperity. While U.S. national security interests focused in the past on assuring the availability of oil, the future may require greater interest in protecting and accessing the flow of information. As a result, the importance of space as a principal avenue for the unimpeded flow of information throughout a global market increases. DoD recognizes these strategic imperatives and will assure free access to and use of space to support U.S. national security and economic interests. (U.S. Department of Defense 1998)

The report concludes that "the strategic significance of space to the nation's security and prosperity will continue to increase as the world evolves towards a global market" (U.S. Department of Defense 1998).

Testimony

Mr. Keith Calhoun-Senghor, Director, Office of Air and Space

Commercialization, U.S. Department of Commerce, stated that the world has entered a new era of commercial space operation. In this new era, space is just another place to do business. However, there are still significant hurdles which must be crossed before space reaches its full potential. While most of these are technological, he also believes that the public is unaware of the importance of space systems. He feels the public perception of space is "frozen in time somewhere after the first moon landing and reflects where we were 20 to 30 years ago, rather than where we are now, or more importantly, where we're heading" (Committee on Science 1997, 6). Mr. Calhoun-Senghor believes that the public must be made aware of the role space systems play in their everyday lives.

Space is providing consumer oriented products, services and revenues here on Earth--improving crop yields and estimates through satellite imagery, aiding drivers with up to date digital maps and car navigation systems, assisting insurance companies and relief workers with disaster assessments using before and after images, tracking and visualizing moving cargoes, producing accurate terrain and elevation maps for utilities and telecommunications firms, and mapping populations for market assessments--on a global scale. (Committee on Science 1997, 7)

Once the public becomes aware of the products and services that are being provided by space systems, they will come to the realization that "Space is the Earth's new economic frontier. [It] is to its investors . . . what the Indies and the New World were to investors in the British East India Company and Hudson's Bay Company: a source of limitless potential" (Committee on Science 1997, 7).

Finally, General Estes concluded that the region of space has indeed become a vital national interest. In testimony before Congress, he stated:

Today, the region of space is a military and economic center of gravity. Life on earth is being inextricably linked to space capability. Because of our military strategy, economic investment, and social dependence on space systems, space has become a region of vital national interest. (Senate, Committee on Armed Services 1998, 10)

In summary, U.S. public policy plainly states that access to space is indeed a vital national interest. Systems operating in space are critical to U.S. national survival, safety, and economic vitality. While this assertion is made in a variety of policy documents and statements, specific details to justify this claim are largely not provided.

CHAPTER 3

METHODOLOGY

This chapter describes the methodology used to analyze whether or not access to space is a vital national interest of the U.S. It describes the specific research method used, the model for the research project, and the rationale for the selection and weighting of the criteria used in the analysis.

Research Method

The specific research method used in this project will be critical interpretation. As described by Tyrus Hillway, this method is useful when drawing conclusions from areas where one deals with broad ideas and opinions more than discreet facts (1964, 101-3). This process involves the analysis and classification of the opinions, using logic to reason out their strengths and weaknesses, and combining them with other opinions to draw new conclusions. Critical interpretation has three main characteristics. First, it must be based upon, or at least agree with, the basic facts in a given field. Second, the arguments used in such research must follow a clear chain of logic, and that chain must be expressed definitively. According to Hillway, this is actually the central tenet. "The basic procedure in critical interpretation is reasoning, but this reasoning should be so impeccably honest and so thoroughly complete that the reader will be able to follow the argument without any difficulty and be impelled by it to accept the scholar's conclusions" (Hillway 1964, 103).

The third characteristic of critical interpretation is a generalization or conclusion resulting from the reasoning process. This, obviously, is the outcome of the entire process, and must rest upon the foundation established by the first two characteristics. It must be fully supported by the basic facts of the area of interest, as well as the logic of the argument (Hillway 1964, 103).

Research Model

This project will follow a basic research model whose main steps are collecting evidence, analyzing that evidence, and drawing conclusions (U.S. Department of the Army 1998, 11). Evidence collection is the initial step of the process. Information will be gathered from existing literature. Every effort will be made to collect information from as wide a variety of sources as possible. Sources will include books, government documents, and journal articles. The literature will be evaluated to ensure its relevance to the research question. This evaluation will be conducted with the following two criteria. First, the information must be relevant to the research, meaning that the information must apply to the subordinate questions as stated previously. Additionally, the information must lie within the boundaries established by the assumptions and delimitations. The second criterion is the requirement for the information to be valid. To satisfy this requirement the information must be published by an accepted subject matter expert, substantiated or corroborated where possible (or reasonably arguable where not), and reasonably able to address new or subsequent information, discoveries, or positions.

The second step in the research model is the analysis of the information. Criteria will be developed to determine if access to space is a vital national interest. The selection and weighting of specific criteria will be discussed later. The collected evidence will support the analysis in two ways. First, the data will model the particular conditions of developed criteria, and second, the evidence will characterize the space program's contribution to the individual models. A numerical system will be used to facilitate the use of multiple criteria which may have different relative importance in the analysis. The contribution that space-based systems make to each criterion will be assigned a numerical value within the range shown in figure 2.

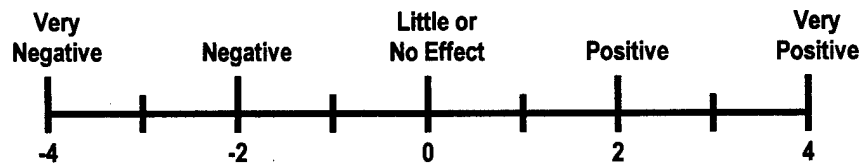


Figure 2. Criterion value scale

The value determined for the contribution of space-based systems to each criterion will be multiplied by the corresponding weight assigned that criterion. The resulting values will be summed to determine an overall numerical score as follows:

$$\text{Total Value} = \sum_{i=1}^n w_i v_i$$

where

w_i is the weight of the i th criterion

v_i is the value assigned the contribution of space systems to the i th criterion

Furthermore, the maximum possible value will be calculated using the same process:

$$\text{Maximum Possible Value} = \sum_{i=1}^n w_i v_{\max}$$

where

w_i is the weight of the i th criterion

v_{\max} is the maximum possible value of the contribution of space systems to any criterion, shown in figure 2

The final step of the research model is the evaluation of the results. The total value will be compared to the maximum possible value, and if the total value is a sufficiently large percentage, access to space will reasonably be considered a vital national interest. What percentage actually constitutes "sufficiently large" will be determined later.

Criteria Selection

As discussed previously, the *National Security Strategy* defines a vital interest as one which has broad, overriding importance to the nation's physical survival, public safety, and economic vitality. However, this basic statement does not provide sufficient information to determine if something is or is not a vital national interest. For example, everything that promotes public safety is not necessarily a vital national interest.

Standing alone, the definition does not specify the extent to which something must affect one of the three areas to merit recognition as a vital national interest. Additionally, this definition does not discuss which, if any, of the three areas are most important. Without

such information, one is left to draw the unreasonable conclusion that all three areas are equally important. However, further examination of the more general concept of U.S. national security provides the required information.

National security is defined as the preservation of the United States as a free nation with our fundamental institutions and values intact (Peterson 1992, 57). Studying the national security policies of U.S. Presidents since World War II reveals that national security has two primary facets; the military and the economy. The emphasis placed on either these facets has varied through the years. Early in the period, the National Security Council focused as much on economic issues as it did military. The Marshall Plan, which rebuilt the shattered economies of Europe and Japan, received as much attention as did the formation of NATO or the U.S.-Japan security agreement (Peterson 1992, 57-8). The first president of this period, Harry S. Truman, stated, "We have learned that a healthy world economy is essential to world peace" (May 1992, 100). The administration of President Dwight D. Eisenhower also stressed the economic aspect of national security. He stated that the U.S. should not "undermine from within that which we are seeking to protect from without" (Peterson 1992, 58). Furthermore, Eisenhower's Secretary of State John Foster Dulles said "the first priority of national security is the health of the nation's economy" (Allison and Treverton 1992, 47). Finally, President John F. Kennedy provided the following expression of the economy's importance to national security. In his 1963 State of the Union Address, he stated:

We shall be judged more by what we do at home than by what we preach abroad. Nothing we could do to help the developing countries would help them half as much as a booming U.S. economy. And nothing our opponents could do to encourage their own ambitions would encourage them half as much as a

chronic lagging U.S. economy. These domestic tasks do not divert energy from our security--they provide the very foundation for freedom's survival and success. (U.S. President 1964, 15)

Presidents of the postwar era also stressed the importance of the military aspect of national security. This was especially true considering the growing Cold War between the United States and the Soviet Union. In 1960, President Eisenhower stated:

With both sections of this divided world in possession of unbelievably destructive weapons, mankind approaches a state where mutual annihilation becomes a possibility. No other fact of today's world equals this in importance--it colors everything we say, plan, and do. (U.S. President 1962, 3)

President Lyndon B. Johnson also echoed this sentiment, once stating, "My first responsibility to our people is to assure that no nation can ever find it rational to launch a nuclear attack or to use its nuclear power as a credible threat against us or against our allies" (May 1992, 102).

While Presidents Eisenhower and Johnson both emphasized the defense of the nation against a nuclear threat, the military instrument of national security also includes U.S. conventional forces. In fact, the importance of conventional forces in the nuclear age was highlighted by the quick demise of the deterrence theory of Massive Retaliation. This theory predicted that the mere possession of a nuclear arsenal would deter any nation from threatening U.S. national interests. In practice, however, the sheer destructive power of nuclear weapons dictated that their use be restricted to only those situations threatening the nation's very existence. Any other use would cause a magnitude of suffering well out of proportion with the intended military objective, and would therefore be highly immoral. For this reason, Massive Retaliation was quickly discarded as a national security policy. As borne out in major regional conflicts such as Korea and

Vietnam, conventional forces remained the most relied upon means to militarily defend U.S. interests.

In his landmark book *On War*, Carl von Clausewitz first stated the principal that “War is merely the continuation of policy by other means” (von Clausewitz 1976, 87). The fact that a nation's military is essentially a political instrument has been illustrated repeatedly throughout history. U.S. involvement in the Persian Gulf War is a timely example. As noted previously, the Carter Doctrine declared that access to the oil region of the Persian Gulf was a vital U.S. national interest, and U.S. would defend this interest militarily if necessary. When Iraqi President Saddam Hussein invaded Kuwait and threatened Saudi Arabia, the U.S. assembled and led a coalition of nations to eject his forces from Kuwait. While the diplomatic, informational, and economic instruments of national power were all used, the military was eventually required to force Iraq to withdraw. The critical implication here is the fact that the U.S. military is not focused solely on the defense of the American homeland and population, but as von Clausewitz theorized, it is also an instrument with which the United States sometimes defends its other vital national interests.

Clearly, national security policy in the post World War II period placed great emphasis on the economic and military instruments of national power. When compared with the current definition of U.S. vital national interests, one concludes that economic vitality and physical survival are the primary issues relating to national security. With regard to the military instrument, however, history has shown that it involves not only the nation's physical survival, but also defense of the nation's other interests, a role which has

fallen on conventional forces. **Therefore, this analysis will focus on the U.S. space program's contribution to these three elements (economic vitality, physical survival, and conventional military capabilities) as the criteria to determine if access to space is a vital national interest.**

Determining "Sufficiently Large"

It is difficult to overstate the significance of something which has been declared a vital national interest. Ultimately, the nation will defend such an interest with the lives of its sons and daughters. In terms of the equation developed above, this fact implies that the total value should be a large percentage of the maximum possible value. However, requiring the total value to *equal* the maximum possible value seems unreasonable because it is unlikely that anything could have the maximum positive impact across all criteria.

To determine a more reasonable percentage by which to judge the final results, the above model was used to calculate total values for different combinations of criteria values from the range defined in figure 2. Equal criteria weights were used to isolate the impact of the criteria values. These results, presented in appendix A, show that a total value which is 85 percent of the maximum possible value corresponds to the second-highest possible score. It occurs when two criteria receive the maximum value, and the third receives one less than the maximum. Whereas the highest possible score seems too restrictive, the second highest score seems an acceptable standard. Therefore, for the purposes of this analysis, **a total value that is at least 85 percent of the maximum**

possible value will constitute reasonable evidence that access to region of space is indeed a vital national interest of the United States.

Criteria Weights

The final step in the development of the analytical methodology is to determine the relative importance of the criteria and assign appropriate weights to each. Again, post World War II national security policy will be examined in order to derive this information.

Many experts believe the growing intensity of the Cold War caused the military aspect of national security to become paramount (Treverton and Bicksler 1992, 408). As evidence of this fact, they estimated that nearly 80 percent of the money that the U.S. spends for national security goes to the Department of Defense (Allison and Treverton 1992, 48). This culminated in the 1970s and 1980s, when national security policy became synonymous with military policy. Peter G. Peterson, U.S. Secretary of Commerce during this period, described the situation:

Rarely, if ever, were domestic economic challenges seriously considered to be a significant part of the national security agenda. When I joined the government in the early 1970s, "high politics," to Henry Kissinger and its other masters, meant the metaphysics of MIRVs and other more seductive issues of managing the superpower balance of terror. By contrast, as the president's assistant for international economic affairs focused on trade, productivity, and the dollar, I was consigned to the realm of "low politics." (Peterson 1992, 58)

The end of the Cold War has brought calls for reassessment of the relative importance of the military and economic aspects of national security. As the threat of a direct confrontation, especially nuclear, with former Cold War adversaries declines, the

attention of the U.S. policy community as well as the general public is increasingly focused on economics. This focus includes two areas. First, the U.S. must have the ability to insure and improve its own economic prosperity. Second, the U.S. must have the ability to affect the international economy to meet its national security objectives. This latter concept, known as economic power, is being used increasingly as the first response to foreign policy and national security problems. Measures, such as trade sanctions, embargoes, and freezing of financial assets, are being used more and more frequently to influence the actions of other nations (Neu and Wolf 1994, xi). This underscores what many experts believe is a shift in supremacy in national security matters from the military instrument of power to the economic. Again, Peter G. Peterson wrote, "Our failure to invest in productive capacity, research and development (R&D), and infrastructure . . . may have greater *direct* impact on [national security] than the threats from abroad, such as a possibility of Soviet nuclear attack, which have traditionally preoccupied the national security community" (Peterson 1992, 59).

Up to this point, the discussion of the importance of economic power to national security has focused on economic strength as its own end. Admiral B. R. Inman, U.S. Navy (Retired), former Deputy Director, Central Intelligence Agency, asserted that economic power is now required to maintain military power. This is a result of the fact that commercial industry now drives state-of-the-art technology whereas the military once did. According to Admiral Inman, the U.S. military's dependence on high-technology, as illustrated by the Persian Gulf War, translates into a dependence on a thriving U.S.

economy which maintains leadership in high-technology industries (Inman and Burton, Jr. 1992, 117-8).

From the preceding discussion, it follows that the economic instrument of national power has become the most important of the three criteria. Within the realm of the military instrument, an examination of the threats facing the U.S. leads to the relative importance of the remaining two criteria. As will be discussed in the following chapter, the role of insuring the nation's physical survival fell on U.S. strategic forces. During the forty plus years of the Cold War, these forces successfully deterred the nuclear aggression of any adversaries (Committee on Government Affairs 1997, 21, 41). While the U.S. still maintains its formidable strategic nuclear forces, Lieutenant General Patrick M. Hughes, Director, Defense Intelligence Agency, testified that since the end of the Cold War the threat of a nuclear attack has greatly diminished (Senate, Committee On Armed Services 1997, 28). In contrast, however, the conventional threat has not. Regional states such as North Korea and Iraq continue to pose a serious conventional threat to U.S. interests. The changing nature of warfare, including the incorporation of new technologies and development of asymmetric threats, will continue to challenge U.S. forces. Lastly, social, demographic, and economic conditions throughout the world will continue to place a high demand on U.S. conventional force participation in peacekeeping and humanitarian operations (Senate, Committee On Armed Services 1997, 28). The result of the changing threat to the U.S. and its interests has been a dramatic reduction in U.S. strategic forces. As of 1997, strategic force personnel had been reduced by 50 percent and weapons systems and been reduced by 45 percent (House, Committee On Armed Services 1997,

179). Furthermore, since 1991 the portion of the defense budget dedicated to strategic forces has declined from approximately 6.5 percent to 2 percent (U.S. Department of Defense 1999a).

As a result of the above analysis, the order of importance of the three criteria is readily apparent; the impact of space systems on U.S.: (1) economic vitality, (2) conventional military capabilities, and (3) national survival. However, the actual weights assigned the criteria are more subjective.

The purpose of assigning weights is to reflect the reality that the criteria are not equally important; however, the least important criterion should maintain some influence on the final result. In order to determine appropriate weights, trail and error were used to evaluate several different combinations. The results, presented in appendix B, lead to the following weighting shown in figure 3.

	Criterion	Weight
The contribution of space-based systems to:	economic vitality	3
	conventional military capabilities	2
	national survival	1

Figure 3. Criteria weights

CHAPTER 4

ANALYSIS

This chapter implements the research model defined in the previous chapter. For each criterion, it first models the conditions specified by the criterion, and second determines the corresponding contribution of space-based systems. It begins with an examination of U.S. economic vitality, followed by U.S. conventional military capabilities and then U.S. physical survival. The contributions of space-based systems to each criterion are assigned a value in the range -4 to $+4$ (as defined in figure 2), and a total value is calculated according to the equation developed in chapter 3. Finally, the total value is compared to the maximum possible value to address the primary research question, "Is access to space a vital national interest?" Finally, U.S. access to the Persian Gulf is briefly examined using the same methodology in order to provide an indication of the model's utility.

Economic Vitality

This section examines the importance of space-based systems to the first criterion, U.S. economic vitality. It begins with the development of a definition of economic vitality, followed by a discussion of how space-based systems contribute to this criterion, and concludes with the assignment of a value in the range -4 to $+4$ as defined in figure 2.

Economic Vitality Defined

In the preface to the *National Security Strategy*, President William Clinton stated that one of the strategy's core objectives is "to bolster America's economic prosperity" (1998, iii). The document also states that prosperity is dependent on, among other things, economic growth. This relationship between growth and prosperity is a recurrent theme in the study of economics.

Webster's New Universal Unabridged Dictionary, 2d ed., defines prosperity as "successful progress in any business or enterprise; success; wealth." This definition takes the point of view of an individual; someone who is participating in an economy. This is the realm of the field of study known as microeconomics. Study of this field was begun by Adam Smith when, in 1776, he published his landmark book *The Wealth of Nations*. So influential were his ideas that he has been called both the founder of modern economics and the father of the free market system (Baumol and Blinder 1994, 68-9).

One of the foundations of Smith's work is the fact that nearly all people naturally desire to improve their material conditions.

But the principle which prompts to save is the desire of bettering our condition, a desire which, though generally calm and dispassionate, comes with us from the womb, and never leaves us till we go into the grave. In the whole interval which separates those two moments, there is scarce perhaps a single instant in which any man is so perfectly and completely satisfied with his situation, as to be without any wish of alteration or improvement of any kind. An augmentation of fortune is the means by which the greater part of men propose and wish to better their condition. (Smith 1994, 372)

The fact that this desire to better one's conditions remains present regardless of one's current situation is very significant. Prosperity, then, can be thought of as successfully improving one's conditions, or standard of living, throughout one's life.

Standard of living is a complex concept. It encompasses both tangible and intangible elements. Probably the most tangible are the material goods, both durable and nondurable, accumulated or consumed by an individual. Also tangible is an individual's savings, stored to fuel later consumption. Intangible elements include access to adequate medical care, the cleanliness of one's environment, and freedom from crime. Another important element is the amount of leisure time one has to enjoy. Standard of living is measured in terms of Gross Domestic Product per capita. This can be thought of as a nation's total production as could be distributed to each person (Baumol and Blinder 1994, 856-8, 961).

At this point, it becomes useful to broaden the perspective to an examination of an entire economy, also known as macroeconomics. The basic process by which an economy functions is called production. It is the combination of resources, capital, and labor to produce a good or a service (Heilbroner 1970, 10). The money value of the nation's total production is called the Gross Domestic Product or GDP. One way of measuring an economy's efficiency is in terms of GDP per unit of labor input. This is called productivity. From the above definitions, productivity and standard of living are clearly related (Baumol and Blinder 1994, 30, 856).

History has shown that the single most important factor in increasing standard of living is increasing productivity. Increasing productivity increases the goods and services which could be distributed among the nation's population. The increased goods and services generate increased revenues, which can raise the wages of labor. Furthermore, increased productivity decreases the amount of labor required, thereby increasing leisure

time. Finally, with the increased revenues generated by the increased production, society can afford to address the intangible elements of standard of living discussed previously (Baumol and Blinder 1994, 859). The significance of productivity growth to nation's standard of living is overwhelming:

It is hardly an exaggeration to say that, in the long run, almost nothing counts for the determination of a nation's standard of living but its rate of productivity growth—for only rising productivity can raise standards of living in the long run. Over long periods of time, small differences in rates of productivity growth . . . can make an enormous difference to a society's prosperity. Nothing contributes more to reduction of poverty, to increases in leisure, and to the country's ability to finance education, public health, environmental improvement, and the arts. (Baumol and Blinder 1994, 859)

In the public sector, President Clinton, after his first full year in office, published his administration's economic strategy. The *Economic Report of the President* provided his economic vision and the overall policy which his administration would pursue in guiding the nation's economy. Specifically, he stated “raising the living standards of all Americans is the fundamental economic goal of my administration” (U.S. President 1994, 6). Furthermore, he also stressed the fundamental importance of raising productivity, calling it “key” to raising the standard of living (U.S. President 1994, 4).

Private economists and public economic policy agree that the rate of productivity growth is the most important factor in raising the living standard. They also agree on the most significant cause of productivity growth; the incorporation of technology into the economy. As defined previously, productivity is the amount of a good or service produced for given quantity of labor input. There are several ways in which productivity can be increased. Increases in the education of the labor force, as well as increases in capital stock are effective measures in increasing productivity. However, both of these

areas will reach a point of diminishing returns. At some point the production process itself will become the limiting factor, and labor force, regardless of its level of education, will be unable to overcome these limitations. Henry Ford's original assembly-line, even if manned by Ph.D.'s, could still have only produced a certain number of Model Ts. Once this limit is reached, further investment in labor force education produces smaller gains in productivity.

Another method of increasing productivity is economic organization. Again, a point is reached at which the organization is optimal for the particular economic activity. The real catalyst in productivity increase, and the only one which has virtually limitless potential, is an increase in technology (Nelson, Peck, and Kalachek 1967, 15-7). Again, from President Clinton's first economic report, public economic policy is in complete agreement: "Over long periods of time, rising productivity and hence advances in living standards depend on the upward march of technology" (U.S. President 1994, 43). Furthermore, it asserts "advances in technical know-how have accounted for at least one-quarter of our Nation's economic growth over the past half-century" (U.S. President 1994, 190).

The Contribution of the Space Industry

The extent to which the space industry exists in the realm of high-technology should be evident even to the most casual observer. In *Trends in Commercial Space - 1996*, Mr. Keith Calhoun-Senghor, Director, Office of Air and Space Commercialization,

U.S. Department of Commerce, points out that the space industry brings together many of the highest technology fields, and most critical policy issues, within the U.S. economy.

Space incorporates some of the most important areas of high technology: software development, chip technology, sophisticated electronics, telecommunications, satellite manufacturing, life sciences, advanced materials, and launch technology. Space also captures some of the most significant issues of international trade: global markets, gaining access to remote areas, government subsidized competition, and international standardization and regulation. The fact is that the most important issues of technology and trade converge in space. Advanced technologies have always been a part of space, and with the commercialization and internationalization of this industry, the most challenging international trade and defense conversion issues are also very relevant to our future space policy. (U.S. Department of Commerce n.d.)

Current estimates are optimistic about the future growth of the space industry, both U.S. and worldwide. Revenues are projected to grow into the hundreds of billions of dollars throughout the next decade, which is certainly large enough to positively influence U.S. economic vitality (Klotz 1998, 7). However, the space industry is making contributions to the standard of living beyond revenues. As discussed previously, standard of living is also comprised of less tangible elements. If, for example, an individual's disposable income is very large but there are few consumer goods available to purchase, his standard of living is questionable. The space industry is now providing consumer products which were previously not possible. The best example is within the personal communications services arena. Communications satellites, such as the Iridium system, are ushering in a new era of worldwide wireless communications. For the first time in history an individual with a small handset can communicate with anyone, anywhere on the globe. Furthermore, video services, such as Direct Broadcast Satellite television and satellite broadcast of cable television, continue to provide ever-increasing

choices for consumers. Competition will continue to reduce the prices of these services and consumer demand will continue to skyrocket (SpaceVest 1997).

The U.S. space industry is directly linked through widely accepted economic theories to the standard of living. As a premier high-tech industry, it increases the productivity of American labor. A single satellite, constructed largely from components produced by other high-tech, high productivity industries (such as electronics and computers), can sell for hundreds of millions of dollars. According to an Institute for Defense Analysis report, in 1991 the U.S. space industry generated over five billion dollars of export revenues, roughly the equivalent of the U.S. automobile industry exporting 500,000 cars (Wick 1994, S-3). A single satellite, sold as a capital good to a telecommunications company, can route enormous volumes of communications, twenty-four hours a day for the life of the satellite. This can generate a tremendous revenue stream, yet it requires relatively little human intervention. Such productivity is among the leaders in the U.S. economy. Furthermore, the space industry is providing consumer goods and services which are possible only through space. Given the rapid market growth within the U.S. for personal cellular telephones, satellite-based global wireless communications could rapidly become considered a virtual necessity. While the U.S. economy is so immense it would be difficult to assign the highest possible value for the contribution of space systems, given the space industry's tangible and intangible contributions to the U.S. standard of living, the next highest value seems reasonable. Therefore, in terms of the model developed in chapter 3, **the space industry's**

contribution to U.S. economic vitality is assigned a value of 3 for the purposes of the numerical evaluation presented later.

Conventional Military Capabilities

This section examines the importance of space-based systems to the second criterion, U.S. conventional military capabilities. It begins with the development of a definition of U.S. conventional military capabilities, followed by a discussion of how space-based systems contribute to this criterion, and concludes with the assignment of a value in the range -4 to +4 as defined in figure 2.

Conventional Military Capabilities Defined

The second criterion examines the contribution of space-based systems to U.S. conventional military capabilities. Recent history has shown that these capabilities are extremely impressive. In the Persian Gulf War, U.S. forces completely overwhelmed the Iraqi military, which at the time was the fourth largest in the world. While the size of the U.S. military has been considerably reduced, senior U.S. military officials still maintain that the U.S. Armed Forces are the strongest in the world. The U.S. *National Military Strategy* states, "Our Armed Forces are the preeminent military force in the world, persuasive in peace and decisive in war" (U.S. Department of Defense [1997b]). In the annual *Posture Statement* given by the Chairman of the Joint Chiefs of Staff to the Congress, General Henry Shelton agreed, stating, "The U.S. is the dominant military power in the world today" (U.S. Department of Defense 1999b).

In terms of specific capabilities, the U.S. is what author John E. Peters called a first-order state. Dividing countries' conventional military capabilities into three levels, first order states fully integrate the latest technology. They possess superior reconnaissance and command and control systems, which allow them to detect and target enemy systems throughout the depth of the battlefield. They also possess extremely long-range and precise weapon systems which allow them to attack those same enemy systems. Furthermore, first-order militaries are capable of operating day or night, and in all-weather conditions (Peters 1993, 27).

The driving force which continues to determine the overall capabilities of the U.S. military is the requirement to win two, nearly simultaneous, major regional conflicts. The Department of Defense 1999 *Annual Report to the President and the Congress* states:

Maintaining this core capability is central to credibly deterring opportunism--that is, to avoiding a situation in which an aggressor in one region might be tempted to take advantage when U.S. forces are heavily committed elsewhere--and to ensuring that the United States has sufficient military capabilities to deter or defeat aggression by an adversary that is larger, or under circumstances that are more difficult, than expected. (U.S. Department of Defense 1999a)

This requirement is especially significant because U.S. forces have been reduced by over one-third in the last ten years, and the defense budget has declined for the last fifteen (U.S. Department of Defense 1999a). In the face of such large reductions, the U.S. military has met its requirements by increasing lethality of its forces through high technology. In fact, the 1997 *Joint Warfighter Science and Technology Plan* states:

Technological superiority has been, and continues to be, a cornerstone of our national military strategy.... Today's technological edge allows us to prevail across a broad spectrum of conflict decisively and with relatively low casualties. Maintaining this technological edge has become even more important as the size

of U.S. forces decreases and high-technology weapons are now readily available on the world market. (U.S. Department of Defense [1997a])

In his article "The Emerging System of Systems," Admiral William A. Owens, Vice Chairman of the Joint Chiefs of Staff, developed a framework to address the ongoing revolution in military affairs. This framework shows the relationship between battlespace awareness, advanced command, control, communications, computers, and intelligence (C4I), and Precision Force Use. Significantly, he stated that one of the three core technologies the framework (and therefore the revolution in military affairs) relies upon is global positioning (Owens 1995, 35). Space-based systems make major contributions to all three areas of Admiral Owens' framework, and therefore to U.S. conventional force capabilities.

The Contribution of Space-Based Systems

The Navstar Global Positioning System (GPS) is a constellation of twenty-four satellites, and it is the only system capable of providing extremely accurate location information to U.S. military forces worldwide (Space Command n.d.). GPS saw its first widespread use in the Persian Gulf War. In spite of the fact that the system was not fully operational, GPS played an enormous role in the overwhelming victory of the U.S.-led coalition. Lieutenant General John J. Yeosock, commander of all U.S. Army forces in the war, called GPS "indispensable" (McMichael 1991, 30). Possibly the strongest testament to the importance of GPS to the U.S. military is the fact that Congress mandated in 1993 that GPS be incorporated into all major weapons platforms by the year 2000 (Johnson, Pace, and Gabbard 1998, 36). Simply put, U.S. forces rely on GPS for precision

maneuver and engagements, enabling today's smaller force to meet national security requirements. As a final example of the degree to which GPS has been integrated into the U.S. military, some authors have argued that U.S. forces are too dependent on GPS, and will be unable to function effectively if the system is denied or degraded (Papadakis 1998, ii).

Returning to Admiral Owens' framework, space-based systems also make a major contribution to his concept of battlespace awareness. This concept is dependent, in part, on intelligence, surveillance, and reconnaissance (ISR) systems to collect information throughout the environment. As stated in the Department of Defense 1999 *Annual Report to the President and the Congress*, "Space is often the sole medium that allows access to otherwise denied areas of foreign countries without violating their sovereignty" (U.S. Department of Defense 1999a). While specifics of space-based ISR systems are classified, it should be clear from the previous statement that sometimes space-based systems are the only source of critical information necessary for Battlespace Awareness.

A final area in which space-based systems make a significant contribution to U.S. military conventional capabilities is in the area of communications. The *National Military Strategy* discusses the necessity for the U.S. to be able to quickly project military power from the continental United States to remote locations worldwide. It emphasizes that this requirement exists regardless of the pre-existence of any U.S. presence or infrastructure (U.S. Department of Defense [1997b]). This was precisely the case in the Persian Gulf War, as documented by the Center for Army Lessons Learned.

In excess of 1,500 satellite communications terminals were deployed to theater, of which over 75 percent were single-channel manportable military and commercial

units. The satellite usage requirement was for both inter- and intra-theater communications. Intra-theater satellite communications were especially important because of the vast operational area in which there did not already exist a communications infrastructure. (U.S. Department of the Army 1997)

Furthermore, once engaged in enemy territory, U.S. forces rely on space-based systems to provide a reliable beyond line-of-sight communications capability. The Department of Defense 1999 *Annual Report to the President and Congress* states, “[Satellite communications] provide networked multi-party and point-to-point narrowband links to tens of thousands of rapidly-moving warfighters” (U.S. Department of Defense 1999a). Again, this was illustrated during the Persian Gulf War. A commander within the 3d Armored Division stated: “[Satellite communications] proved indispensable and became our primary means of coordinating our actions with 1AD and 1ID to our flanks and the VII Corps staff” (U.S. Department of the Army 1997).

A final indication of the importance of space-based systems into the U.S. military is the degree to which space forces are addressed in joint doctrine. In *Joint Warfare of the Armed Forces of United States*, Joint Pub 1, U.S. military forces are repeatedly specified as “air, land, sea, space, and special operations forces” (U.S. Department of Defense 1995c, i). Joint Pub 1 also discusses the positive effect that space forces have on all terrestrial forces, being especially crucial to C4I (U.S. Department of Defense 1995c, I-2, IV-9). U.S. *Doctrine for Joint Operations*, Joint Pub 3-0, describes the importance of space control before and during conflict, and points out that space forces are not only employed during sustained combat operations, but also during military operations other than war (U.S. Department of Defense 1995b, IV-3, IV-7, V-1).

To summarize the contribution of space-based systems to the conventional capabilities of the U.S. military, one is drawn once again to the Persian Gulf War. In *The Conduct of the Persian Gulf Conflict: An Interim Report to Congress*, the Department of Defense called the conflict the first “space war” and said space-based systems were “critical to many phases of the war” (U.S. Department of Defense 1991, 18-2). Furthermore, the report noted that throughout the conflict U.S. space systems were able to continue supporting other U.S. forces worldwide (U.S. Department of Defense 1991, 18-2). Therefore, in terms of the model defined in chapter 3, space-based systems have a **very positive impact on U.S. conventional military capabilities and are assigned a value of 4 for the purposes of the numerical evaluation presented later.**

Physical Survival

This section examines the importance of space-based systems to the third criterion, U.S. physical survival. It begins with the development of a definition of U.S. physical survival, followed by a discussion of how space-based systems contribute to this criterion, and concludes with the assignment of a value in the range -4 to +4 as defined in figure 2.

Physical Survival Defined

The third criterion examines the contribution of space-based systems to U.S. physical survival. While defining the nation's physical survival seems intuitive, developing a working definition was difficult. The closest information available actually

dealt with U.S. strategic force planning during Robert S. McNamara's tenure as Secretary of Defense. This planning involved a determination of the proper size of U.S. nuclear forces to serve as an effective deterrent. The question naturally centered on how much destruction of the Soviet Union would be sufficient in a U.S. retaliatory strike.

McNamara and his advisers determined that destruction of least 25 to 30 percent of the Soviet population and two-thirds of its industrial capacity were required. They also determined that achieving this level of destruction would require destroying the hundred largest Soviet cities (Nunn 1982, 208). Published literature states the only practical threat to U.S. national survival, that is, the only force capable of inflicting this level of damage on the United States, is a massive attack using nuclear weapons (Buchan 1994, 11). In his testimony before the U.S. Senate, General Andrew J. Goodpaster, U.S. Army (Retired), former Staff Secretary and Assistant for National Security Activities for President Dwight D. Eisenhower, also made this assertion. "As so often emphasized by President Eisenhower (who had talent for getting to the heart of such questions) nuclear weapons are the only thing that can destroy the United States of America" (Committee on Government Affairs 1997, 30). A 1980 U.S. Senate report which predicted the effects of a conflict in which nuclear weapons were used confirmed the stark reality of national destruction. It stated that a nuclear attack using a large fraction of the existing arsenal would cause between 20 million and 160 million immediate deaths. In the midterm, the complete breakdown of society and its institutions could lead to the deaths of many tens of millions more. In the long-term, cancer, genetic damage, and ecological devastation could prolong the suffering for many years (U.S. Congress [1979], 10). In his book *Can*

Deterrence Last? Peace through a Nuclear Strategy, Timothy Garden wrote that this “amounts to the destruction of the state” (1984, 25).

In spite of the end of the Cold War, Lieutenant General Patrick M. Hughes, Director, Defense Intelligence Agency, testified, “Russia and China retain strategic nuclear forces capable of threatening the U.S. homeland” (Senate, Committee on Armed Services 1997, 20). While he stated that it is unlikely for other states to develop or acquire intercontinental ballistic missiles within the next fifteen years, he did not rule it out. “I believe we could encounter some form of technological surprise, where rogue states could acquire the capability to build and use a missile which could threaten our vital interests” (Senate, Committee on Armed Services 1997, 20). Dr. Paul Kaminski, Under Secretary of Defense for Acquisition and Technology, also made this point in congressional testimony. He stated that the long-range ballistic missile threat from so-called “rogue nations . . . could be accelerated if those nations acquired this capability from beyond their borders” (Senate, Committee on Armed Services 1996, 164).

In spite of the fact that such a threat to our national survival actually exists, the U.S. does not possess any capability which could prevent its own destruction from a massive nuclear attack. President Ronald Reagan sought to change this fact when he authorized the *Strategic Defense Initiative* (U.S. President 1984). While the *Strategic Defense Initiative* has been scaled back substantially, the Department of Defense continues development of a national missile defense system. This program is designed to develop promising technologies, while explicitly delaying any decision to deploy a system until such a time as a definite threat emerges (implicit is the assumption that the

threat from Russia has decreased to nearly zero). At that point, the system could be deployed within three years (Senate, Committee on Armed Services 1996, 415).

Deterrence

Because the U.S. has never possessed a defense against nuclear attack, it has had to rely on the concept of deterrence. In general, deterrence is the condition in which any potential aggressor realizes that an attack on U.S. interests could result in unacceptable damage being inflicted upon it. Deterrence is based on four conditions; the first three based on nuclear forces, and the last based on psychology. First, a nation must have the capability to ensure that any aggressor will profit less from attacking than from not attacking. Second, the nation must possess the will to use this capability. Third, the nation's capability and will must be well known to potential aggressors, that is, it should be credible. Last, potential aggressors should be rational, acting in their own best interest with respect to the first three conditions (Garden 1984, 24). Deterrence has been the cornerstone of U.S. post-World War II strategy, and it continues today (U.S. Department of Defense 1995a, I-1). The *National Security Strategy* states, "We continue to emphasize the survivability of the nuclear systems and infrastructure necessary to endure a preemptive attack and still respond at overwhelming levels" (U.S. President 1998, 12). While the morality of deterrence has been debated, its contribution to the prevention of global nuclear war is generally accepted (Blair 1985, 16; Committee on Government Affairs 1997, 21, 41).

In his book *The Past and Future of Nuclear Deterrence* Stephen J. Cimbala stated that deterrence is actually based on uncertainty. An adversary can not be certain of the specific U.S. response in the event they launch a nuclear attack. The possibility exists that the U.S. would launch on warning of such an attack and not wait until detonations began on U.S. soil. Thus, no matter how large an attack is launched, and no matter how vulnerable U.S. forces are, as long as the attack can be detected in sufficient time to commit U.S. forces, an adversary can not be sure that their strike will sufficiently disarm the U.S. to prevent destruction of their own country (Cimbala 1998, 15). The merits of a policy of launch on warning have been much debated. Critics claim that such a policy for the employment of nuclear weapons raises the risk of accidental use (launching on faulty warning) to unacceptable levels (Garwin 1986, 192-8). The United States' specific policy on the employment of nuclear weapons, especially with regards to launching on warning or waiting to absorb a first strike, is classified. But the possibility of launch on warning casts significant doubt on the success of a disarming first strike, and thus, it is this uncertainty that actually deters an attack.

It is clear that Cimbala's concept of uncertainty relates well with Garden's definition of deterrence. Recall Garden's first three conditions were possession of nuclear capabilities, the will to use them, and credibility with one's adversaries. To Cimbala, uncertainty is created in the rational mind of an adversary based on the credibility of nuclear capabilities and the understood will to employ them. In the specific case of the U.S., the sheer destructive power of the strategic nuclear triad (the capability to destroy an adversary) is well documented. However, the capability of the United States' strategic

command, control, and communications (C3) system to direct the employment of the nuclear forces, especially after absorbing a first strike, is generally not accepted. If United States' will to use nuclear weapons is assumed (a safe assumption given the close of World War II) then the only remaining "variable" of credibility is the United States' strategic C3 system.

Strategic C3

The credibility of U.S. nuclear forces, then, rests more with strategic C3 than the destructiveness of individual systems (Cimbala 1998, 15; Pringle and Arkin 1983, 223; Ford 1985, 25). In testimony before Congress, Donald Latham, Assistant Secretary of Defense (Command, Control, Communications and Intelligence), stated,

Strategic C3 is the essential link for translating employment plans into mission capability, and is therefore a critical element of deterrence. For a credible deterrent, the strategic C3 system must of itself be absolutely credible, because its purpose is to support and enable implementation of the gravest decisions that any President may ever have to make. The system must retain that credibility under the most severe stresses imaginable, and it must retain the capability to implement force employment decisions--made in accordance with national security policy--under those stresses. (Committee on Government Operations 1985, 120)

In his book, *Strategic Command and Control: Redefining the Nuclear Threat*, Dr. Bruce Blair provided a succinct summary, "If command and control fail, nothing else matters" (1985, 4). Unfortunately, many experts believe that the United States' strategic C3 system would be completely unable to operate after the first several minutes of a massive nuclear attack. They attribute this vulnerability to fragile C3 systems as well as the personal vulnerability of the president and his designated successors (Ford 1985, 122-46; Blair and Steinbruner 1991, 3; Pringle and Arkin 1983, 223-4). In fairness, some Department of

Defense officials counter that such catastrophic vulnerability exists only within the context of a complete surprise attack. They maintain that such surprise would be extremely difficult if not impossible to achieve. In response to the strategic warning which would accompany an impending nuclear crisis, the increased readiness posture of all strategic forces, including strategic C3 systems, would reduce such catastrophic vulnerability (Committee on Government Operations 1985, 129-31).

The strategic C3 system is designed to accomplish a three-step process. First, the warning system must detect and assess the incoming attack as rapidly as possible. Second, the National Command Authority must decide on the appropriate response. Last, that decision must be disseminated to the fielded nuclear forces (Miller and Nolan 1997, 47). The first step, detection and assessment, has three key elements. It must be timely enough to support the rest of the system, it must identify the attacker, and it must provide an accurate assessment of the scale of the attack (from a single, possibly accidental, launch to a massive attack) (Buchan 1994, 33). Furthermore, the warning system must satisfy the nearly opposite requirements for 100 percent accuracy in the absolute minimum amount of time (Blair and Steinbruner 1991, 5-6).

The emphasis on timeliness is justified by the relative speed of a ballistic missile attack. The flight time of intercontinental ballistic missiles can be as little as thirty minutes, and submarine-launched ballistic missiles can reach coastal targets in as little as seven minutes (Blair 1985, 142; Committee on Government Operations 1985, 50). Given 2-3 minutes to confirm the validity of an attack and notify the president, the National Command Authorities may have as little as five minutes to determine a course of action

and notify the fielded forces. Thus, the absolute criticality of warning time is apparent. In his testimony before Congress, General Robert T. Herres, U.S. Air Force, Commander in Chief, North American Aerospace Defense Command, recognized this fact when he said that attack warning and assessment are the "very cornerstone of our nation's deterrence strategy" (Committee on Government Operations 1985, 65).

The United States' ballistic missile warning system is comprised of ground-based radars and space-based infrared satellites. Ground-based radars designed to detect submarine launched ballistic missiles are located in California and Massachusetts. Radars optimized to detect intercontinental ballistic missiles flying over the North Pole are located in Alaska, North Dakota, Greenland, and Great Britain (U.S. Department of the Air Force n.d.). Although these radars have a 3,000 nautical mile range, the earth's curvature prevents detection until the ballistic missiles have climbed above the horizon. For submarine launched missiles fired from close range, detection could be within the first two minutes of the missile's flight. However, intercontinental missiles flying over the North Pole do not enter the radar's field-of-view until approximately fifteen minutes of flight time has elapsed (Blair 1985, 223, 255).

The Contribution of Space-Based Systems

The space-based portion of the United States' ballistic missile warning system is comprised of the infrared satellites of the Defense Support Program. These satellites are parked in geosynchronous orbits (a satellite whose orbital period is twenty-four hours remains in the same place relative to a point on the earth) from where they monitor most

of the earth's surface. They detect and track the hot exhaust plume of ballistic missiles during their initial boost phase. Depending on cloud cover, they can detect ballistic missiles within seconds of launch. For intercontinental ballistic missiles, this *doubles* the warning time provided by ground-based radars from fifteen minutes to thirty (Blair 1985, 141-2). For submarine launched ballistic missiles fired from close range, the increase in warning time, while smaller, is nonetheless significant. As stated above, missile flight times for such a scenario could be as short as seven minutes. Given that both systems require a finite period of time to confirm the validity of the launch indication and notify the president, the two-minute advantage in warning time provided by the Defense Support Program satellites could double the amount of time the National Command Authorities have to choose the course of action and disseminate it to fielded strategic forces.

Up to this point, the discussion has focused on the detection of the actual launch of ballistic missiles. More specifically, detection of an attack in progress is known as tactical warning. The warning function of strategic C3 is also comprised of strategic warning. In contrast, strategic warning is warning that an attack is likely before it actually begins. The U.S. intelligence community provides strategic warning through vast array of sources. The main purpose of strategic warning is to monitor the readiness posture and deployment of worldwide nuclear forces, especially within the context of the larger global political and socioeconomic situation (Bracken 1983, 5). In 1978, President Jimmy Carter publicly acknowledged that the United States' "national technical means" of verifying arms control treaties were satellites (Mark 1984, 11). Furthermore, these

national technical means have the inherent ability to provide strategic warning of the nuclear attack (Bracken 1983, 28).

In summary, space systems provide the unique ability to routinely access denied areas of the globe. This access is crucial to provide adequate warning, both tactical and strategic, of the one thing that could destroy the United States; a massive nuclear attack.

Robert L. Pfaltzgraff, Jr., Professor of International Politics at the Fletcher School of Law and Diplomacy, Tufts University, and President of the Institute for Foreign Policy

Analysis, summarized the importance of space systems as follows:

Without satellite systems in orbit, the United States would find it impossible to maintain existing strategic nuclear capabilities. The destruction of surveillance, communications, and early warning satellite systems would render unviable American strategic nuclear forces within prevailing doctrinal principles. (Pfaltzgraff 1984, 258)

This relationship between national survival and space-based systems is shown in figure 4.

As this analysis has shown, U.S. national survival is directly dependent upon space-based systems. In terms of the model defined in chapter 3, space-based systems have a **very positive impact on national survival, and are assigned the numerical value of 4 for the purposes of the numerical evaluation presented later.**

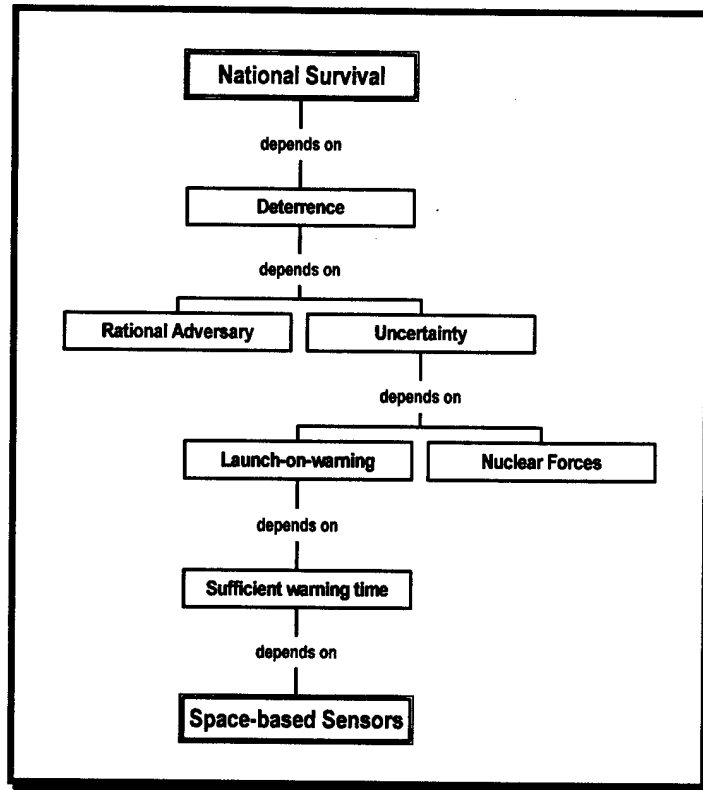


Figure 4. Dependency chain

Numerical Evaluation

The preceding analysis assigned values to the contribution of the U.S. space program to U.S. economic vitality, conventional military capabilities, and national survival according to the scale developed in chapter 3. This scale equates a value of -4 to a very negative impact and +4 to a very positive impact. The weighted values are now summed to determine the overall value of the U.S. space program. The equation developed in chapter 3 becomes:

$$\text{Total Value} = (w_1 * v_1) + (w_2 * v_2) + (w_3 * v_3)$$

$$\text{Total Value} = (3 * 3) + (2 * 4) + (1 * 4)$$

$$\text{Total Value} = 21$$

This value is compared to the maximum possible value, found with the same equation.

$$\text{Maximum Possible Value} = (w_1 * v_{1\max}) + (w_2 * v_{2\max}) + (w_3 * v_{3\max})$$

$$\text{Maximum Possible Value} = (3 * 4) + (2 * 4) + (1 * 4)$$

$$\text{Maximum Possible Value} = 24$$

Therefore, the total value calculated for the U.S. space program is the following percentage of the maximum possible value:

$$\frac{\text{Total Value}}{\text{Maximum Possible}} = \frac{21}{24} = 87.5 \%$$

Evaluation of Access to the Persian Gulf

In chapter 1, an analogy was drawn between U.S. access to space and U.S. access to the Persian Gulf. As stated previously, access to the oil resources of the Persian Gulf is of such vital importance, the U.S. will use force if necessary to prevent a hostile nation from seizing control of the region. This policy was declared in the Carter Doctrine. Given the purpose of this paper, evaluating the results produced by the model for a

known vital national interest (access to the Persian Gulf) may provide an indication of the model's utility.

Petroleum products are ubiquitous in the industrialized world in general and the United States in particular. The U.S. accounts for 25 percent of the world's annual oil consumption. Not only does oil supply 40 percent of United States' primary energy requirements, it is a critical element in the production of lubricants, plastics, fertilizers, paints, some medicines, and various other petrochemicals (U.S. Department Of Energy n.d.).

It is important to note that loss of access to the Persian Gulf would not mean a loss of all petroleum-based products to United States. Indeed, less than 10 percent of Persian Gulf oil goes to the U.S. However, 85 percent of Persian Gulf oil is exported to our allies in Europe and Japan (U.S. President 1998, 32). Furthermore, most of the world's oil resources are located in the Persian Gulf. Saudi Arabia alone possesses over 25 percent of the world's oil reserves (U.S. Department of State 1998). If a hostile power gained control of this region, they could dangerously disturb the world's oil supply potentially leading to an extreme supply reduction and price increase. If prolonged, the result on the world economy could be disastrous. Therefore, U.S. interest in Persian Gulf oil is focused on the stability of the worldwide oil market. A stable market with plentiful supply is tremendously important to the U.S. economy because it keeps the price of energy, as well as the vast multitude of oil-based products, relatively low.

The stability of the worldwide oil market is equally important to the U.S. military. Every aircraft, land vehicle, and most naval vessels use oil-based products for

propulsion. All of the above depend on oil-based lubricants. Again, disruption of the oil flow from the Persian Gulf could cause dramatic increases in the military's operating expenses. Among other things, training would probably be reduced to lower expenses. Other budgetary accounts such as procurement, military construction, and personnel would also face reductions to help fund operations.

It is clear that, in terms of the model developed in chapter 3, access to the Persian Gulf has a **very positive** impact on both U.S. economic vitality and conventional military capabilities. Therefore, for the purposes of numerical evaluation **both of these criteria are assigned the value 4.**

The impact of access to the Persian Gulf on the third criterion, U.S. national survival, is not as immediately clear. From the dependency chain shown in figure 4, national survival, as threatened by a massive nuclear attack, depends on the United States' ability to employ its strategic forces. These forces include both the weapon systems and the command and control network (which includes space-based systems). These systems almost certainly incorporate oil-based products such as lubricants and plastics. However, determining the extent to which increases in oil prices, resulting from a loss of access to the Persian Gulf, would affect these forces would take a significant amount of research, and is beyond the scope of this paper. However, due to the extent to which oil-based products have penetrated the industrialized world, it seems safe to assume that access to the Persian Gulf has some positive impact on U.S. strategic forces, and therefore U.S. national survival. Therefore, for the purposes of numerical evaluation, **this criterion is conservatively assigned the value of 1.**

The numerical evaluation was conducted using the same process used to evaluate the value of U.S. access to space. The results are presented in table 1, with the results for access to space included for reference.

	<i>Criteria 1. Impact on Economic Vitality.</i>		<i>Criteria 2. Impact on Military Capabilities.</i>		<i>Criteria 3. Impact on National Survival.</i>		Total Value	Percent of Maximum
	Weight 3	Value	Weight 2	Value	Weight 1	Value		
Access to Space		3		4		4	21	87.5 %
Access to Persian Gulf		4		4		1	21	87.5 %

Table 1. Comparison matrix

As expected, the value calculated for access to the Persian Gulf exceeds 85 percent, which is the standard developed in chapter 3 for something to be judged a vital national interest. It is important to re-emphasize that the value assigned for criteria 3 was the lowest possible positive value. As stated previously, due to the universal nature of oil in industrial societies, this value is quite likely higher. This, in turn, would increase the overall score and percentage for access to Persian Gulf.

CHAPTER 5

CONCLUSION

This chapter presents conclusions drawn from the results of the analysis in the preceding chapters. It begins with a summary of the results and their answers to the subordinate research questions developed in chapter 1. This is followed by three specific conclusions and a discussion of their implications. The chapter concludes with a suggestion for another area of possible research.

Summary of Results

This research project began with an examination of current U.S. policy regarding access to space. The review included policy documents written by the Office of the President as well as the executive branch departments of defense and commerce. The review also included congressional testimony provided by senior members of the civilian and military leadership. All of the policy statements reviewed were unanimous in their implication that access to space is a U.S. vital national interest. However, the statements offered only limited justification for this assertion, more rigorous justification lying outside their scope.

An analytical model was developed to examine the extent to which access to space has indeed become vital to the U.S. A numerical approach was used to allow the use of criteria of different importance. The criteria were assigned a numerical value, weighted, and then summed. The resulting numerical value was then compared to a

standard to determine if it was sufficiently large to declare access to space a U.S. vital national interest.

The first step was to select appropriate criteria against which to judge the contributions of space-based systems to the United States. The selection process began with the definition of vital national interest as stated in the *National Security Strategy*. This definition focused on three areas: national survival, safety, and economic vitality. However, when these three areas were reviewed in the larger context of post-World War II national security policy, it became clear that the areas of national survival and economic vitality were paramount. Furthermore, the history of this period, up to and including the end of the Cold War, further indicated the concept of national survival did not sufficiently address the military aspect of national security. The recent reduction of the nuclear threat combined with the exclusive employment of conventional forces (when military force was used at all) implied that conventional force capability was also an appropriate criterion. Therefore, the three criteria selected were the contribution of space-based systems to economic vitality, conventional force capability, and national survival.

Examination of the same period also revealed that the three criteria were not equally important in the analysis. Again, with the end of the Cold War there has been a significant reduction in the likelihood of a confrontation, nuclear or conventional, with another superpower. Furthermore, modern military capabilities now depend on technologies driven by commercial industry. These facts lead to the conclusion that economic vitality is the most important criterion. As stated above, in the post-World War II period only conventional forces have been engaged when the military has been used to

pursue U.S. national interests. While this is understandably a result of the overwhelming destructive power of U.S. nuclear forces, it nonetheless indicates that the conventional forces will continue to be tested. Therefore, the contribution of space-based systems to conventional force capabilities is more important (as an analytical criterion) than their contribution to national survival.

In order to relate these three criteria, each was weighted according to its relative importance. The weights were determined through a process of trial and error in which different proposed weighting schemes were examined with systematically varied criterion values. The weighting scheme which produced the most reasonable results for the given criterion values was selected.

With the model defined, the contribution of space-based systems to each criterion was assigned a numerical value over a specified range in which -4 represented a very negative impact and +4 represented a very positive impact. The first criterion evaluated was the contribution of space-based systems to the U.S. economy. Basic economic theory related the nation's prosperity to growth in productivity. Productivity growth was shown to depend primarily on the incorporation of technology into the economy. At the forefront of technology, the space industry makes major contributions to U.S. economic prosperity. Furthermore, the space industry is making consumer goods available, especially in the area of personal communications, which would otherwise be impossible. While these contributions are arguably "very positive," it would be difficult to justify a maximum rating due to the sheer size of the U.S. economy. Therefore, this criterion was assigned a value of three.

The second criterion evaluated was the contribution of space-based systems to the conventional force capabilities of the U.S. military. These capabilities were defined as fully incorporating the latest technology to increase force lethality. This increase of lethality is especially critical due to the continuing requirement to win two, nearly simultaneous major regional contingencies in spite of significant overall force reductions. The emerging system of systems was shown to depend significantly on space-based assets. Nowhere is this more evident than in the case of GPS, the U.S. military's only method of providing precise, worldwide location information. This precise location data is so essential, some authors have argued that the U.S. military could not operate without GPS. Because of GPS as well as other systems, this criterion was given the maximum value of four.

The final criterion evaluated was the contribution of space-based systems to U.S. physical survival. Expert opinion stated that the only threat to U.S. physical survival is a massive attack using nuclear weapons. As the U.S. has no active system to defend against such an attack, it must rely on deterrence. Deterrence depends on, among other things, uncertainty. A potential adversary must be uncertain as to whether or not a nuclear first strike on the U.S. would successfully prevent the U.S. from destroying the aggressor in a retaliatory strike. This uncertainty is guaranteed by the U.S. ability to launch its nuclear arsenal on warning of a hostile attack, before hostile weapons begin detonating on U.S. soil. The ability to launch on warning is absolutely dependent upon the ability of the Defense Support Program satellites to detect the launch of

intercontinental ballistic missiles from denied areas of the globe. Because no other system can provide this warning, this criterion was assigned the maximum value of four.

With the criterion values assigned, **the analytical model yielded a total value for the overall contribution of the U.S. space program which was greater than the value required for access to space to be declared a vital national interest.** In order to examine the robustness of the methodology, a brief evaluation of access to the Persian Gulf was conducted. This region was chosen because access to the Persian Gulf is an accepted vital national interest. The methodology produced the expected result as the total value was greater than the value required.

Before drawing conclusions, it is helpful to view the results in relation to the subordinate questions established in chapter 1. The first subordinate question asked, Would disruption of U.S. space activities negatively affect the survival of the nation? The results show that the U.S. strategy of nuclear deterrence is partially dependent upon the space-based warning satellites of the Defense Support Program. The second subordinate question, Would disruption of U.S. space activities negatively affect the safety of the American public? was rejected as a criterion due to the examination of U.S. national security policy since World War II. The last subordinate question established in chapter 1 asked, Would disruption of U.S. space activities negatively affect America's economic well-being? Again, the results show that the space industry, as one of the nation's premier high-technology fields, has a positive impact on the United States' productivity growth and therefore standard of living. Finally, the criterion developed in chapter 3 implied the following subordinate question, Would disruption of U.S. space

activities negatively affect America's conventional military capabilities? As with the others, the results answer this question affirmatively. The U.S. military, in both the doctrine defined by joint publications as well as the recent history of operations (especially the Persian Gulf war), is very dependent upon space-based systems for worldwide precision location information, high-volume mobile communications, and intelligence collection.

Conclusions

This analysis indicates that access to space is a vital national interest for the United States. Space-based systems make enormous contributions to the military aspects of national security. The abilities of both the strategic and conventional forces to perform their basic missions would be doubtful if U.S. access to space was denied. The long-term health of the U.S. economy would also suffer without continued dominance of the worldwide space industry. Productivity growth, upon which a continuously improving standard of living rests, would be reduced. The information-age services which dominate the post industrial economy would lose access to high bandwidth, inexpensive international communications. U.S. consumers would lose access to the impending revolution in personal communications services. Finally, beyond today's contribution, all predictions for the future of the commercial space industry are for continued, increasing growth. As the industry grows, so will its importance to the U.S. economy.

The model used to conduct this analysis is sound. The numerical model allowed for the use of multiple criteria of different importance to the overall analysis.

While the assignment of individual values was a subjective process, the criteria selected and the method of evaluating them can be used in other analyses. This model may prove especially helpful when considering future space projects, such as the International Space Station or National Missile Defense. Both of these projects are significant because they will cost U.S. taxpayers a tremendous amount of money. The model developed for this analysis could be used to compare either of these programs to a large program of the past, such as the Apollo Program. Such a comparison would not focus on national interests per se, but would be helpful in determining the relative merits of the individual programs.

More research of this topic is required. Official U.S. policy has declared that access to space is a vital national interest. However, this study did not discover any significant research conducted in this area as justification. While this study attempted a more rigorous determination of such justification, more attempts would definitely be beneficial. Specifically, other specific research methods could be employed to determine the individual criterion values. Instead of critical interpretation, a survey technique could be used to collect the opinions of subject matter experts, or a panel technique could be used to assemble subject matter experts to form a consensus. In any event, regardless of the research method used or the results obtained, if this study stimulates other investigations of this topic, the field will improve.

Implications

The main implication of this analysis is the fact that the U.S. needs to treat access to space as a vital national interest. First and foremost, the U.S. needs to commit as a

national priority to maintaining its leadership in those sectors of the space industry which it currently dominates, and gaining that leadership in those sectors which it does not.

Space-based systems are clearly a primary enabler of the information age. If the U.S. is to maintain its position as an economic superpower, it is crucial to remain at the forefront of the space industry. Secondly, as the U.S. has become dependent on space-based systems, a national strategy needs to be developed to protect these assets. Space-based systems have become a military center of gravity which hostile nations will definitely try to counter with all measures, active and passive, at their disposal. As stated in chapter 1, adversaries are not the only threat to space-based systems. The hostile space environment itself poses a serious threat. Such phenomenon as elevated levels of solar activity could seriously damage significant portions of the United States' space-based infrastructure. There are countermeasures which negate the effects of interference with U.S. space activities, deliberate or otherwise. Such measures include further hardening of space vehicles, larger constellations of redundant, less expensive satellites, or fast constellation reconstitution through more flexible and less expensive space launch services. Whatever the correct strategy may be, the U.S. must develop a strategy to ensure continuity of space-based services, and invest in the capabilities to implement the strategy.

Further Research

One area of further research would produce valuable results with respect to this topic. It also addresses the parallel between access to space and access to the Persian Gulf. Because access to the Persian Gulf is accepted as a vital national interest, a study

which examines the Persian Gulf's importance to the U.S. as it developed over time would be very beneficial. The research should focus on determining the point in history at which access to the Persian Gulf could justifiably be declared a vital national interest and the U.S. military's ability to adequately protect it at that time. If a capability gap ever existed, such research would highlight any consequences suffered or vulnerabilities endured. If no capability gap existed, the research might be able to draw conclusions about the force structure that existed to protect U.S. access, as well as the resources expended to maintain that force.

APPENDIX A
EQUAL WEIGHT ANALYSIS

The purpose of this analysis was to determine the percentage which corresponds to criterion values which should reasonably result in the conclusion that something is a vital national interest. Using the equation developed in chapter 3, total values were calculated using different combinations of criterion values. Equal criterion weights were used to isolate the effects of variations of criterion values. It is important to emphasize that this methodology using percentages was developed to allow the use of different weights. Once these different weights are applied, raw criterion values which produce positive results will not necessarily correspond to those shown in table 2.

Table 2. Equal weight analysis

Weight 1	Criterion Value 1	Weight 2	Criterion Value 2	Weight 3	Criterion Value 3	Total Value	Percent of Maximum	Comment
1	4	1	4	1	4	12	100.00%	Maximum
	4		4		0	8	66.67%	
	4		4		1	9	75.00%	
	4		4		2	10	83.33%	
	4		4		3	11	91.67%	
	4		4		4	12	100.00%	

As discussed in chapter 3, the status of vital national interest should only be granted to those interests of overwhelming significance. While a maximum score seems to be an unreasonable requirement (because it is unlikely that anything would have the

maximum positive impact on all criteria), the next highest score seems reasonable for interests having such overwhelming significance.

From table 2, any percentage greater than 83.33 percent will include only the two highest possible scores. **Eighty five percent was selected as the appropriate standard to judge the final results.**

APPENDIX B

CRITERION WEIGHT DETERMINATION

The purpose of this analysis was to determine appropriate weights to apply to the three criteria developed in chapter 3. These criteria were developed to evaluate if a proposed interest, in this case U.S. access to space, is a vital national interest. Trial and error were used to examine the effects different weighting schemes had on different sets of criterion values. This procedure was repeated until some combination of criterion values failed to produce reasonable results with the proposed weighting scheme. The results are shown in tables 3-5.

Table 3. Case 1. 10-5-1

Weight 1	Criterion Value 1	Weight 2	Criterion Value 2	Weight 3	Criterion Value 3	Total Value	Percent of Maximum	Comment
10	4	5	4	1	4	64	100.00%	Maximum
	4		4		-4	56	87.50%	Rejected

This weighting scheme was rejected because criterion 3 has too little influence on the total value. The assigned score of -4 indicates that the interest in question has a very negative impact on the criterion; however, the resulting total value still exceeds the 85 percent standard. It does not seem reasonable that such an interest could be considered a vital national interest.

Table 4. Case 2. 6-5-4

Weight 1	Criterion Value 1	Weight 2	Criterion Value 2	Weight 3	Criterion Value 3	Total Value	Percent of Maximum	Comment
6	4	5	4	4	4	60	100.00%	Maximum
	4		4		0	44	73.33%	Rejected
	4		4		1	48	80.00%	

The weighting scheme (table 4) was rejected because now criterion 3 has too much influence. In this case, the proposed interest has the maximum positive effect on the two most important criteria. Having any positive effect on criterion 3, the least important, should be sufficient to consider the proposed interest vital; however, when criterion 3 was assigned the value of 1, the total value did not exceed the 85 percent threshold as desired.

Table 5. Case 3. 3-2-1

Weight 1	Criterion Value 1	Weight 2	Criterion Value 2	Weight 3	Criterion Value 3	Total Value	Percent of Maximum	Comment
3	4	2	4	1	4	24	100.00%	Maximum
	4		4		0	20	83.33%	
	4		4		1	21	87.50%	
	4		4		2	22	91.67%	
	4		4		3	23	95.83%	
	4		4		4	24	100.00%	
	4		3		0	18	75.00%	
	4		3		1	19	79.17%	
	4		3		2	20	83.33%	
	4		3		3	21	87.50%	
	4		3		4	22	91.67%	
	3		4		0	17	70.83%	*****
	3		4		1	18	75.00%	
	3		4		2	19	79.17%	
	3		4		3	20	83.33%	
	3		4		4	21	87.50%	
	3		3		0	15	62.50%	
	3		3		1	16	66.67%	
	3		3		2	17	70.83%	
	3		3		3	18	75.00%	
	3		3		4	19	79.17%	

This weighting scheme was accepted. In table 5, those combinations of criterion values which are bolded fall above 85 percent standard established in appendix A. The criterion combination which is marked with asterisks is especially significant. It is the only combination which exceeds the 85 percent standard where the value assigned to criterion 1 is less than the maximum. In this particular case, the values assigned to criteria 2 and 3 are maximum. Considering the fact that criterion 1 is the most important, this result is reasonable.

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