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SPACE POWER 2010

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DISCLAIMER

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ABSTRACT

Today's US military space power is deficient. The US military has no space-based force application systems and no anti-satellite weapons, the latter being a key part of a space control capability. The US military also has serious limitations in its ability to deploy and sustain space forces, and minor limitations in its ability to perform the force enhancement functions. The US military must recognize and correct these deficiencies in order to remain a top space power. These deficiencies can be corrected with existing or emerging technology, especially with the aid of official policies focused to encourage growth in commercial space activities.

A working lexicon is created to assist in the process of analyzing US space power and in developing a desirable vision for its future. The authors first derive a definition of *space power* and *military space power* by drawing on scholarly interpretations of the notions of *space* and *power.* The authors then describe five elements of military space power.

Guided by this formal concept of military space power and its elements, the authors present six basic *Space Power 2010* concepts of operations (CONOPS). These six CONOPS are *space strike, information blockade, space denial, omniscience/ omnipresence, operational spacelift,* and *massively proliferated and networked microsat constellations.* Tailored to address current deficiencies in US military space power, these CONOPS are exhibited in notional future scenarios and classroom briefings in order to help the reader *visualize* a variety of effects. Finally, the authors present technological, organizational, and doctrinal requirements, as well as contextual elements, for the *Space Power 2010* vision.

The research methodology involved first imagining what operational and strategic effects space power ought to be able to produce fifteen years from now, then devising operations concepts needed to create those effects. The authors attempted to perform this creative process in an unconstrained fashion. Later they compared the capabilities required to conduct the conceived operations with existing capabilities to determine how to proceed today.

SPACE POWER 2010

Chapter 1: Problem Statement

Background

CONOPS 2010 is a look into the future of the United States Air Force (USAF). Its stated goal was to develop concepts of operations for the employment of aerospace power in the year 2010 and beyond. The inspiration for *CONOPS 2010* came from the Commandant of Air Command and Staff College (ACSC), Colonel John Warden. He proposed *CONOPS 2010* as a project that would look 15 years into the future and recommend operational concepts for the employment of aerospace power. This research proposal attracted over 70 students who subsequently organized themselves into thirteen smaller groups, each of which researched a different aspect of aerospace power employment. A guiding principal for this research was the idea that effort without vision is usually wasted--*CONOPS 2010* can give vision to Air Force plans today so that those efforts move us in the right direction.

The genesis of this research within the broader *CONOPS 2010* framework was the intuitive belief space control will be even more important to the national security of the United States (US) in 2010 than it is today. This belief was based on three factors: the evolving importance of space systems support to US terrestrial (i.e., land, sea, and air) forces, the growing threat to these space forces from potential adversaries, and the growing threat from potential adversaries' use of space forces to enhance their own terrestrial forces. Additionally, the end of the Cold War rather than removing the requirement for space control may actually make it more necessary.

The initial goal was to take a very imaginative and revolutionary approach to developing concepts of space control operations for the year 2010. The authors define *space control* as *ensuring friendly control and exploitation of space and preventing an adversary from controlling and exploiting space*. However, prompted by a personal interview with an experienced leader in military space research and development, Colonel Simon P. Worden, and reinforced by research findings, the authors began to develop a broader and bolder view of a possible and plausible world in 2010 with respect to space. It was this broader and bolder vision which drove a change in the title and focus of this research from Space *Control* 2010 to Space *Power* 2010. A definition of *space power* is developed later in this chapter.

Thesis

The purpose of this paper is to provide a vision of what US military space power could and should be in the year 2010. Today's US military space power is deficient. US space forces have no force application capability and no anti-satellite (ASAT) weapons to support a viable space control capability. The US ability to deploy and sustain space systems is seriously impaired and its force enhancement capabilities need minor improvements. The US military must recognize and correct these deficiencies in order to maintain the US status as a top space power. These deficiencies can be corrected with existing or emerging technology. However, correcting these deficiencies will be easier, cheaper and more efficient if official US government and military policies encourage growth in commercial space activities. In addition, several organizational and doctrinal issues will need to be addressed before US military space forces can ensure fully effective US space power.

Assumptions

Four major assumptions underpin this research. First, the US desires to remain a superpower. Second, commercialization of space worldwide and in the US will dramatically increase in the next fifteen years, especially if encouraged by the US government. Third, weapons of mass destruction with associated delivery technology and space technology will continue to proliferate. Fourth, because the US military is already dependent on space systems and because of a growing threat from space technology proliferation, US military space power is an important element of US national power and will only become more essential in the year 2010.

Methodology

The methodology followed in this research project had three central features: a basic philosophy, one important constraint, and specific phases.

Philosophy. The guiding philosophy of this research was to focus on ideas about military capabilities first, then tools or weapon systems later. This meant that rather than starting in the present and projecting into the future, research started in the future and mapped backwards toward today. The authors began by imagining what operational and strategic effects space power ought to be able to produce fifteen years from now and then devised operations concepts needed to create those effects. The authors then compared the capabilities required to conduct the conceived operations with existing capabilities to determine how to proceed today. This meant *Space Power 2010* would not be about creating new tools to perform existing jobs, or adapting existing tools to perform future jobs, but rather about devising the *right* jobs for future space power and creating the *best* tools with which to perform them. For this approach to work, research had to be as unconstrained as possible. Therefore, the authors attempted to avoid being constrained by factors such as fiscal realities, treaties, doctrine, and organization. In addition, the authors did not attempt to predict future threats as a basis for requirements.

Constraint. The only constraint the authors observed was classification. To comply with guidance from Air Command and Staff College faculty advisors, this paper could not refer to classified sources in any way. To ensure compliance, the authors used only unclassified sources. Happily, observing this constraint facilitates dissemination of information and ideas.

Research Phases. *Space Power 2010* research was accomplished in three phases: creativity and brainstorming, development, and concept refinement. The first phase, creativity and brainstorming, centered upon generating ideas and was partially accomplished with the entire *CONOPS 2010* research group. Following exposure to the thinking of futurists like Alvin and Heidi Toffler, earlier projects like *SPACECAST 2020,* and the interview with Colonel Simon P. Worden previously mentioned, the authors generated numerous ideas relating to future space operations concepts and the effects they would create. During the second phase, development, the authors considered a variety of future space operations concepts, comparing them with existing data and experience. The authors considered factors such as operational problems in past wars, military theory, existing operational concepts and doctrine, current and future military missions, and emerging technologies, then analyzed their merits and chose six concepts worthy of further examination. In the final phase, concept refinement, the authors analyzed the actions necessary to make those concepts a reality and developed recommendations for overcoming barriers that might stand in the way. It was only in this latter phase that the authors considered real-world constraints. *The Space Power 2010 authors did not ignore the real world in their vision of the future; they simply considered it later in their research, looking at how it would shape their operational concepts.*

Space Power Defined

Social scientists and philosophers have struggled over the years to define the term *power*.[1] Many books have been written and intellectual rigor applied to defining this familiar concept.[2] Theorists have proposed different power types, resources, and relationships.[3] For the purpose of defining *space power*, *power is the ability of a state or non-state actor to achieve its goals and objectives in the presence of other actors on the world stage*.[4]

Defining the term *space* may be as difficult as defining the term *power*.[5] In fact, it appears there have been various incentives over the years to intentionally avoid defining the term *space* and, thus, where this unique environment begins.[6] The definition of *space*, or even the acknowledgment of the existence of space as a separate environment, depends very much on who's defining it and why.[7] For the purpose of defining *space power*, *space is the area above the Earth s atmosphere and extending out infinitely in all directions, beginning approximately 62 miles above the Earth s surface.*[8]

Having defined the terms *power* and *space*, *space power* may now be defined. *Space power is the ability of a state or non-state actor to achieve its goals and objectives in the presence of other actors on the world stage through control and exploitation of the space* *environment.*[9] One may think of space power as an element of an international actor's power. It is similar to air, land, and sea power in this respect.[10] However, it is essential to realize the term covers more than simply military power. As others have noted with respect to air power, sea power, and space power, an actor's entire capabilities with regard to the operating environment contribute to its power there.[11]

Elements of Space Power

With the definition of space power stated, it is possible to describe its elements. Many have attempted to describe and measure the elements of nation-state power.[12] Elements of national power may include natural resources, human resources, economic capacity, military force size and capability, as well as less tangible commodities like morale and culture. Similarly the elements of an international actor's space power may be technological, economic, military, and geographical strengths influenced by political and cultural factors. For the purpose of illustrating how various factors influence and are influenced by space power, the four commonly accepted instruments of national power, political, economic, informational, and military, are used below as a framework for discussion. These instruments provide a useful method for describing how space power supports national power, or a non-state actor's power, and how each instrument of power in turn supports, and is an element of, space power. The idea here is that the political, economic, informational and military instruments are functional ways of looking at power. Air, land, sea, and space may be thought of as environmental ways of looking at power. The four functional instruments of power are used for illustrative purposes as they each support the environmental element of power, space. Space power, in turn, supports each functional instrument.

Political. One way space power supports the political instrument is through enhancing prestige. The Soviet Union's prestige was enhanced by being the first to launch an artificial satellite in 1957, Sputnik. US prestige was advanced by being first to land a man on the moon and return him safely to Earth. In more recent years, French prestige was certainly enhanced by capturing more than half of the world's commercial spacelift market.[13] President Kennedy's decision to commit the US to landing on the moon before the end of the 1960's, and President Reagan's decision to commit the US to developing a strategic defense at least partially based on space systems are examples of the political instrument supporting space power. Similarly, the success of Arianespace, the French spacelift service operating in Kourou, French Guyana, in capturing more than half the world's commercial spacelift market would not have been possible without significant political commitment by France and other European states.

Economic. Space power supports the economic instrument by generating wealth. Wealth is generated from space through the use of space-derived and space-relayed information. Navigation data from the NAVSTAR Global Positioning System and remote sensing data from the LANDSAT multi-spectral imaging system are good examples of the former. Communications satellites (COMSATs) providing the global instantaneous communications necessary to link markets worldwide, illustrate the latter. Wealth is also derived from the sale of space-derived and space-relayed information, and the sale of spacecraft, spacelift hardware, and services. Examples of the former include income derived from the sale of SPOT satellite remote sensing data and the leasing of commercial communications satellite transponders. Examples of the latter are US-manufactured satellite sales to foreign countries and spacelift services provided by the US, France, China, and the former Soviet Union (FSU). In the near future, wealth may be derived from raw materials harvested on other celestial bodies. Whole new industries might be facilitated by the environment of space, such as materials-work possible only in a micro- or zero-gravity environment, or hazardous operations, such as genetic research, which may be acceptable to perform on another celestial body, but not on the Earth. Space power is supported by the economic instrument through industry's ability to produce spacecraft and spacelift vehicles, sensors, and many other commercial astronautical capabilities.

Informational. Space power supports the informational instrument in many ways. Secretary of the Air Force, Sheila Widnall described this support by saying "effective space systems will allow us to establish and maintain information dominance. Our space forces are central to. . .the gathering, processing and disseminating of information on a global basis."[14] Space power may be supported by the informational instrument through information warfare, through the development and dissemination of space-related knowledge and technologies, and through the exploitation of knowledge regarding the space power of potential adversaries.

Military. Space power supports the military instrument through the accomplishment of four functions: space control, force application, force enhancement, and space support.[15] Space control has already been defined. Force application suggests weapons delivery from space. Force enhancement involves providing a multiplying effect for terrestrial forces primarily through information. Space support includes areas such as spacelift and satellite command and control essential to space force operations. Space power is supported by the military instrument in innumerable ways. One way the other elements of military power, i.e., air, land, and sea forces, support space power is through a combined arms approach to space control. For actors like the US without an ASAT capability, non-space forces may be the only means of denying an adversary's ability to exploit space. These forces also make important contributions to space force protection, securing important ground-based space support infrastructure.

Military Space Power: Definition and Elements

Military Space Power Defined. Discussing space power in terms of the four instruments of national power is enlightening and leads to the focus of this paper, military space power and its elements. For the purpose of this paper, *military space power is the ability of an actor s military space forces to successfully contribute to achieving the actor s goals and objectives in the presence of other actors on the world stage through control and exploitation of the space environment.*[16] With a definition of military space power established, its elements may now be elaborated. But first, a caution. One can quickly fall into the trap of thinking about military space power only in terms of military satellites, tracking sites, rockets and space-based weapons. As the discussion of relationships between space power and the four national instruments of power indicates, power comes from more than simply deployed hardware. Another trap might be confusion between systems which traverse rather than operate in an environment.[17] Just because a vehicle passes through space does not necessarily make it a space system and an element of space power any more than the fact an artillery shell passes through the air makes it an element of air power.

Military Space Power Elements. There are five elements of military space power. These elements may be described in terms of the forces deployed, the ability to deploy them, the ability to employ them, the ability to sustain them, and the ability to deny an adversary control and exploitation of space.[18] These five elements must be supported by a capable industrial base and a cadre of *spacemen*.[19]

Forces Deployed. To assess military space power in terms of forces deployed one must first ask if the systems can accomplish all the assigned functions, i.e., force enhancement, force application, space control, and space support? Can they provide the information dominance Secretary Widnall highlighted? Can they apply force and control space? How about their quality? Are they technically capable and manufactured to be reliable? How about their quantity? Are they deployed in numbers so small as to provide an extremely lucrative target for an adversary?

Ability to Deploy. The ability to deploy military space forces is key, not only during peacetime operations, but in war when on-orbit forces may require augmentation to meet mission requirements and when an adversary's attrition of friendly forces on-orbit may require rapid replenishment. Key features of this ability include not only responsive spacelift, but the ability to begin useful spacecraft operations immediately upon reaching orbit without a lengthy on-orbit checkout period.

Ability to Employ. The ability to employ space forces is based on factors ranging from national will to effective and secure command and control, and appropriate and useful doctrine and organization. To effectively bring military space forces to bear in support of national objectives, national leaders must have the will to use them. The reins of command must work free from interference by friendly and adversary forces, and organizations must exist which are capable of bringing our entire military space power to bear in accordance with coherent doctrine.

Ability to Sustain. The ability to sustain military space forces is partly derived from the nature of the force structure, partly from the ability to replenish forces, and partly from the ability to protect them. A force structure very dependent on few, large, expensive spacecraft might be relatively easy to sustain from a command and control perspective, i.e., there are few satellites to worry about. But this presents great vulnerability to attack; losing one may have grave impact. On the other hand, a force structure including many, small, cheap spacecraft might make routine command and control more demanding, but vulnerability to attack is reduced. The ability to replenish forces is based not only on responsive spacelift and spacecraft ready for immediate deployment and operation, but also on the vulnerability of launch bases as well. A military space force's power depends as much on the ability to secure friendly launch bases from attack as much as it depends on protecting on-orbit forces. The same holds true for other ground-based space systems and infrastructure. In this sense, air, land, and sea power used to protect terrestrial space systems very much contribute to military space power.

Ability to Deny. Air, land, and sea power also contribute to the final element of military space power, the ability to deny an adversary control and exploitation of space. In the case of the US today, these non-space powers provide the only means for accomplishing this denial mission since the US has no operational ASAT capability. Any strike capability used for denial must be used based on complete and accurate space surveillance information. Whether striking ground-based or on-orbit space force targets, it is critical to know the mission and location of the on-orbit system one is trying to affect.

Industrial Base and Spacemen. For all the five elements of military space power to be wielded effectively, they must be supported by a capable industrial base and a cadre of spacemen. The industrial base must be capable of providing appropriate technology and services to support military space efforts at reasonable costs. The military space force must be led, operated and supported by true spacemen who understand and appreciate the capabilities and limitations of the environment and systems operating there. An airman trained, educated and experienced in air warfare could no more be expected to lead the development of space power to its full potential today than a soldier trained, educated and experienced in land warfare could have been expected to lead the development of air power to its full potential after World War I.

Overview

The next chapter provides a brief introduction to US military space power history. After a brief discussion of this history, the chapter ends with an assessment of where US military space power is today. After this discussion, chapter 3 describes a vision for US military space power in 2010. This vision is not evolutionary and is presented very much like science fiction, using scenarios to illustrate the application of the concepts. The scenarios were not used as requirements to be satisfied or threats to be addressed, but simply to demonstrate how US military space power capabilities might be employed in 2010. This presentation should also suggest the desirability of US military space power envisioned for 2010. Chapter 3 concludes with a view of the future beyond 2010.

After the vision presentation, chapter 4 makes the case for its feasibility and suggests courses of action to facilitate realization. The necessary technology is either already available or feasible to develop by 2010. Chapter 4 does not concentrate on the doctrinal or organizational changes necessary to facilitate the vision, except to suggest some issues which must be addressed. Full treatment of these doctrinal and organizational issues is beyond the scope of this research. However, chapter 4 does identify productive changes in commercial space policy to facilitate US military space power development, some of which are already underway. Chapter 5 concludes the paper with a restatement and summary of the major conclusions drawn from this research.

Chapter 2: Background

Introduction

Before exploring where US military space power should be in the year 2010, it is important to look at the historical background of US military space power. This chapter examines US military space power from its beginnings using the elements of military space power described in chapter 1. In terms of these elements, recent years have seen the US lose ground, or at best not gain any, in its ability to accomplish the functions of space control and force application, and in its ability to deploy and sustain its space forces. There is also room for improvement in accomplishing the force enhancement mission.

US Military Space Power--Cold War Genesis

US military space power was born of the cold war. The rivalry between the US and the Soviet Union provided motivation and objectives for early developments and early thinking. This rivalry guided US military space power, as it did overall US space power, for some 30 years. With the demise of the Soviet Union and the end of the Cold War, US military space power finds itself in a new context which likewise affects the motivations and objectives for today's developments and thinking.[20] In fact, the most recent US National Security Strategy document states the "end of the Cold War fundamentally changed America's security imperatives."[21] Like the US civil space program after the end of the Apollo era and the Challenger disaster, US military space power today is at a crossroads.[22]

While man's venture into space would probably have occurred eventually, progress was significantly hastened by the international order which emerged after World War II. The bipolar nature of the world pitted two ideologies and their two major world power proponents against one another in a struggle involving all elements of their national power. But, as the descriptive term for this period implies, the belligerents in the Cold War never met directly on the battlefield. This major transformation in the nature of the international structure heightened the urgency and increased resources for government-sponsored, high technology development in the aerospace arena.[23] These advances included longer range bombers, faster fighters, intercontinental ballistic missiles (ICBMs) and, of course, orbital spacecraft.

Prior to World War II and the maturation of strategic airpower, nations derived a degree of territorial security from their geographic circumstances. Nations in favorable geographic positions, such as the United States protected by seas, or Switzerland shielded by mountainous terrain, enjoyed natural strategic security. Nations in less favorable circumstances compensated with alliances, man-made land fortifications, armies and navies.

Although the decisiveness of World War II strategic airpower is still subject to historical debate, there is no question airpower technology transformed the realities of national territorial security. The German V-2 missile terrorized the urban populations of Great Britain. Japanese carrier aircraft staged a surprise attack against US territory at Pearl Harbor. Strategic bombers crossed ocean channels and mountain ranges to destroy factories and torch cities. These events culminated with the aerial delivery of atomic devastation to the people of Hiroshima and Nagasaki, Japan. Suddenly oceans, mountain ranges, and benevolent neighbors offered little guarantee of domestic security.

As the US faced this new reality of the nature of warfare, it also faced the new, more malignant threat of international communism. The US, historically an isolated power, was this new era's leading actor. The Soviet Union raced to keep stride with post-war US global leadership, and achieved its first atomic explosion in 1949. This event, along with the further possibility of the Soviets developing the hydrogen bomb, prompted President Truman to order "a re-examination of our objectives in peace and war and of the effect of these objectives on our strategic plans, in the light of the probable fusion bomb capability and possible thermonuclear bomb capability of the Soviet Union."[24] NSC-68, a blueprint for dealing with the Cold War, was one result of Truman's directive.

This Cold War soon propelled mankind into space. In the wake of NSC-68 the Air Force began work on the Atlas rocket in 1951. In 1954 the Atlas became a top priority and in 1955 the US began development of the WS-117L reconnaissance satellite.[25] During the same period, American rocket experts warned the Defense Department that the Soviets were pushing for early development of intercontinental ballistic missiles for nuclear delivery without first developing an extensive manned bomber or cruise missile program. Some believed the Soviets were likely to launch an artificial satellite into Earth orbit much earlier than the US could possibly deploy a satellite into orbit.[26] True to predictions, the Soviets launched Sputnik I on 4 October 1957.

Virtually all subsequent space achievements and setbacks were influenced by the Cold War stalemate. Following Sputnik, US policy makers feared a direct Soviet military threat from space. The US response was to organize its space program into civilian and military branches.[27] Virtually from the start, US military space policy emphasized the observational potential of satellites, especially for arms limitation treaty verification. President Eisenhower emphasized the idea of open skies as a means of ensuring a verification capability. A means of verification would be critical to the success of future treaties.[28] This observational bias is also evidenced by the US decision to conceal its satellite reconnaissance program.[29] This concealment was primarily intended to protect reconnaissance satellites' political vulnerability.[30]

Elements of US Military Space Power

US military space power during the Cold War developed quickly and was able to accomplish a wide variety, but not all, of the necessary missions. The accuracy of this assessment may be seen by examining US military space power during the Cold War using the elements of military space power elaborated in the previous chapter: forces deployed, the ability to deploy, employ and sustain friendly space forces, and the ability to deny an adversary the ability to control and exploit space.

Forces Deployed. Chapter 1 listed several questions regarding forces deployed which relate to an actor's military space power. One of the first was can the systems accomplish all the assigned functions, i.e., force enhancement, force application, space control, and space support?

From the start, the US military space forces began providing force enhancement. This can be easily seem in the burst of US space achievements in 1960, including Tiros I, a joint military-civilian weather satellite, Transit 1B, the first navigation satellite, and Discoverer 14, the first successful film reconnaissance satellite.[31] Even earlier, the first successful satellite communication repeater, known as SCORE (Signal Communicating by Orbiting

Relay Equipment), was launched by the USAF on 18 December 1958.[32] This early initiative continued to the point where US military space forces deployed covered the complete range of force enhancement capabilities, including reconnaissance, surveillance, early warning, nuclear explosion detonation, communications, meteorological, geodetic, and navigation. Nevertheless, today, after more than 30 years of development, there is room for improvement in the force enhancement area. During the Gulf War, communication requirements were so great additional COMSAT bandwidth was required. US leaders decided to relocate an on-orbit Defense Satellite Communication System satellite from 180 degrees East to 65 degrees East longitude.[33] While successful, this action took several weeks to accomplish, fast enough given the circumstances of DESERT SHIELD, but woefully slow for a fast breaking contingency which doesn't allow a long build-up. Notably, deploying a new operational communication satellite to orbit was not an option taken in this scenario. But two experimental multiple access communications satellite (MACSAT) spacecraft were deployed on a SCOUT, a small expendable rocket operated by NASA primarily for scientific experiments.[34]

Another area for potential improvement in the force enhancement area is in remote sensor coverage. If low-Earth orbit (LEO) remote sensing vehicles only have a few satellites in their constellation, there will be hours between sensing opportunities, allowing an adversary time to move forces or engage in activities which they'd rather not be seen from orbit. Continuous coverage would better support US commanders in the field and keep an adversary in the spotlight.

As early as 1962, military leaders, such as General Curtis LeMay, also recognized the potential of space systems to perform the force application mission. LeMay warned that "beam-directed-energy weapons would be able to transmit energy across space with the speed of light and bring about the technological disarmament of nuclear weapons."[35] This warning appears to have gone unheeded as no space-based force application system, for missile defense, space control, surface strike or any other purpose has ever been fielded by the US. However, the requirements of the Cold War did create our most ambitious space weapons research and development program, the Strategic Defense Initiative (SDI). On 23 March 1983, President Reagan challenged American scientists to develop a technology for ballistic missile defense. Critics would call his proposed concept of strategic defense by the name Star Wars even though the president never mentioned space or death beams in his speech.[36] Throughout the eighties, SDI explored the gamut of space weapons in a dramatic about-face from previously passive US military use of space. Although these efforts were opposed by many as strategically destabilizing, some experts credit SDI with the collapse of the Soviet Union and the end of the Cold War.[37] Ironically, the collapse of the Soviet Union and the end of the Cold War must be credited with the end of SDI. The program has since been refocused with ground-based theater missile interceptors as the top priority, thus the renaming of the SDI Organization into the Ballistic Missile Defense Organization. With this refocus, the only US effort to field operational space-based force application systems ended.

However, the US did field space control weapons. In fact, the very first ASAT test conducted by any country was the US Bold Orion test, also known as USAF 7795, successfully launching a missile from a B-47 aircraft toward Explorer VI on 13 October 1959.[38] The US also had the first operational ASAT system, a nuclear warhead-tipped Nike Zeus missile system operated by the US Army and known as Program 505, first declared operational in August 1963.[39] The USAF followed with a Thor intermediate range ballistic missile (IRBM) ASAT system, also nuclear warhead-tipped, declared operational in May 1964.[40] The Soviets responded to this activity in 1968 with the testing of a non-nuclear satellite interceptor.[41]

In 1977, the US initiated its own non-nuclear interceptor program.[42] This program was a response to resumed Soviet ASAT testing in 1976 after they had ceased testing in 1971.[43] However, the resulting F-15 Miniature Homing Vehicle (MHV) ASAT system was only tested on a live satellite once because of congressionally set test limitations. The DoD canceled the MHV program in 1988.[44] A subsequent ground-based US ASAT program was also canceled leaving the US in its current position of having no ASAT capability, one key portion of a space control capability.

While deploying the shooting elements of a space control capability, the US also developed its space detection and tracking capabilities, in particular the Navy's Space Surveillance system and the USAF's SPACE TRACK system which have together grown into today's Space Detection and Tracking System (SPADATS). SPADATS provides the ability to locate and identify space objects to assess their hostile intent and provide targeting information as necessary.[45]

What about the support structure required by, and a key element of, US military space power? Space support is reliant on the systems and infrastructure necessary for *care and feeding* of on-orbit forces, such as satellite command and control networks and centers, and the systems and infrastructure necessary to place these forces on orbit in the first place, rockets and their associated launch bases and ranges. The US military did develop and operate the necessary networks and control centers to support its on-orbit force structure. Today, the largest part of this system is the Air Force Satellite Control Network operated by the 50th Space Wing, Falcon Air Force Base, Colorado.

With respect to spacelift, decisions made very early in the development of launch systems still impact heavily today. With the exception of the Space Shuttle, every space booster the US military uses dates from the 1950's.[46] While these systems have been greatly modified over the years, they are still based on the original Atlas ICBM, Titan ICBM, and Thor IRBM--today's Atlas II, Titan IV, and Delta II. The question of how this spacelift force structure has affected the US military's ability to deploy space forces is addressed next.

Ability to Deploy. The lack of operational spacelift systems impairs the US military's ability to deploy space forces.[47] In addressing the fact that the US operates space boosters based on decades-old technology, Lt Col John R. London III, author of *LEO On The Cheap, Methods for Achieving Drastic Reductions in Space Launch Costs,* claims the "problem with these boosters. . .is not that their *technology* is decades old; the problem is that their *designs* are decades wrong."[48] Major Jeffrey L. Caton, author of *Rapid Space Force Reconstitution, Mandate For United States Security,* does not hesitate to point out how these systems are based on 30- to 40- year old technology--they've undergone, at most, two generations of evolution since their inception in the late 1950's while US military jet fighters have undergone five generations from the F-86 to the F-22.[49] However, Caton does finally settle on the meat of the issue for US military space power--today's systems are not operational and they are not cheap. The research and development approach to spacelift characterizing the historical and current US military space launch paradigm results in reduced error margins, increased support requirements, increased processing times, and increased operating costs.[50] While the reasons why the US military is in this position are beyond the scope of this research, the impact on US military space power is relevant.

Ability to Employ. The ability to employ space forces depends on factors ranging from national will to effective and secure command and control, and appropriate and useful doctrine and organization. This section focuses on the latter two.

The priorities of the Cold War shaped the evolution of unofficial schools of space warfare doctrine. In his book *On Space Warfare: A Space Power Doctrine*, Lt Col David E. Lupton divides these Cold War space doctrines into four categories: the sanctuary school, the survivability school, the high-ground school, and the control school.

The sanctuary school viewed the military value of space forces in terms of the ability to perform treaty verification and enhance nuclear stability. Proponents believed any military use of space risked the loss of peaceful overflight rights and sought to maintain space as a war-free zone, a sanctuary. The sanctuary doctrine resulted in visible and invisible space activities, such as NASA manned space missions, and satellite reconnaissance, respectively. They saw no need for a military organization to operate or advocate space forces.[51]

The survivability school may have been better named the vulnerability school as proponents saw space systems as inherently less survivable than terrestrial forces. They would not depend on space forces in wartime believing they would not survive, and saw space wars as tit-for-tat affairs, thus requiring a balancing force to maintain the ability to negate opposing space forces. Redundancy between terrestrial systems and space forces reduced their value as targets and provided for wartime backup. Passive survivability measures were key. Survivability schoolers usually favored a unified or specified command to operate and advocate space forces.[52]

Control school advocates saw the value of space forces as analogous to air power and sea power. The capacity to control space would yield control over the surface of the Earth. They envisioned the existence of space lanes of communication which, like sea lanes of communication, must be controlled to win a war. They believed the capability to deter war would be enhanced by the ability to control space and that in future wars space control will be as important as air and sea control. These analogies continued in the concept of space superiority. First space superiority would be established over the environment, then space efforts would shift to support of surface forces. The idea was to defend friendly forces while denying the environment to the enemy. Control school advocates generally favored making space an Air Force mission using the *aerospace argument*.[53]

High-ground school disciples advocated space-based ballistic missile defense (BMD). They envisioned combining space forces' global-presence characteristic with directed-energy and kinetic-energy weapons to make possible radically new national strategies. They believed space-based defensive forces would reverse the Cold War stalemate, replacing the strategy of assured destruction with one of assured survival. High-ground advocates claimed BMD systems would have built-in space control capabilities. BMD systems could destroy an enemy's launch systems before they could successfully deploy their satellites, denying them access to the environment. They argued for the establishment of a Space Force as a separate service, acknowledging the space environment as a distinct operating environment analogous to land, sea, and air.[54]

The unofficial doctrinal schools outlined above are related to the second factor affecting the ability to employ space forces to be discussed, organization. As previously mentioned, the US satellite reconnaissance program went *black* early on to decrease its political vulnerability. This led to the creation of the National Reconnaissance Office (NRO) in August 1960 as a highly classified organization.[55] Looking back at Lupton's unofficial doctrines, we see this early organizational move as a result of the sanctuary school of thought. At the same time, both the Army and Air Force were responsible for operating the early ASAT systems, and the Air Force alone was launching and operating the majority of military satellites. The Navy had its own space activities in early satellite programs such as the Transit satellite navigation system, not to mention the unsuccessful project Vanguard which was to have launched the first US satellite on a Viking rocket.[56]

With all this activity on the part of the military services to control and exploit space from the earliest days, it is surprising no single organization was created to coordinate and direct these efforts, let alone begin planning for warfare in the new environment. As early as 1959, leaders such as Chief of Naval Operations Arleigh Burke proposed a unified space command be created, but the proposal was shot down.[57] Instead, US military space power would be diluted with the NRO fielding and operating reconnaissance satellites and the military services dividing, unequally, the remainder of military space functions and programs. Paul Stares, author of *The Militarization of Space: US Policy, 1945-1984*, claims the USAF was a key culprit in preventing the early organizational unification of military space power by adamantly opposing a unified space command out of fear it would prevent their drive to own all of military space.[58] To be fair, the USAF might argue the other services prevented organizational unification by opposing the USAF campaign for the space mission. Regardless, it would be 1982 before the first military space command, Air Force Space Command, would be created. Three years later, in 1985, came the long awaited creation of a unified space command, US Space Command.

As one might expect, the organizational changes of the last decade have facilitated development of new official doctrine for military space forces. There is now a joint publication, Joint Pub 3-14, *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) For Space Operations*, addressing space operations. The USAF is currently drafting new space doctrine, Air Force Doctrine Directive 4 (AFDD 4), *Air Force Operational Doctrine: Space Operations*, to go beyond what currently exists in Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force*.[59] Both Joint Pub 3-14 and AFDD 4 promise to improve the US military's ability to employ space forces.

Ability to Sustain. The ability to sustain space forces is the fourth element of military space power and is partly derived from the nature of the force structure, partly from the ability to replenish forces, and partly from the ability to protect them. The ability to sustain space forces undergoes its truest test in the face of an adversary's attempt to control space. This is a test no military space force has yet to face.

The nature of the US military space force structure, based largely on survivability school assumptions, may put it at a disadvantage when facing an adversary trying to control the space environment. The US typically fields small numbers of highly sophisticated and very expensive satellites when compared to a country such as Russia whose systems are greater in number but less complex and capable.[60] Knowing this, the US began a serious effort to incorporate survivability measures into many of its satellites in the late 1970's.[61] Today's manifestation of this work can be seen in the Milstar military communications satellite, designed to continue functioning through a nuclear conflict, a capability downplayed by many today in light of the lower threat of global nuclear war in the post-Cold War era. Regardless, the US is still left with few high-value targets from an adversary's perspective.

Another aspect of sustainment ability, the ability to replenish forces, has already been addressed. The US is woefully lacking in this area. Related to this, is the ability to secure launch bases from adversary attack. Given that the US military has only two large, soft, and fixed launch facilities, Cape Canaveral and Vandenberg Air Force Bases, an adversary has a relatively easy targeting task, assuming of course attack on the US homeland is a viable option.

Ability to Deny. As already described, for the earliest part of its spacefaring history, the US military maintained an ASAT capability as part of its space control arsenal. While the early direct ascent ASAT weapons were crude and limited in their range, accuracy, usefulness, and ability to counter the FSU co-orbital ASAT, at least they were available.[62] Today the only US space control tools are air, land, sea, and special operations forces which might be used to attack an adversary's space support infrastructure.

Industrial Base and Spacemen. The five elements of military space power must be supported by a capable industrial base and a cadre of spacemen.

Although Cold War requirements drove the initial successes of US military space power, did this national security domination impede later progress by delaying the entry of private and commercial interests in space? More than one author has argued that the Cold War created a government monopoly over US space programs and policies which is still negatively affecting the US space industrial base today.[63] Even in the one area where commercial activities did grow, COMSATs, the US government intervened and created the Communications Satellite Corporation, disrupting free enterprise.[64]

Consider how the private sector weighed so heavily in the evolution of aviation science. Modern aviation began outside government with the Wright brothers' invention of powered flight. Many of aviation's most celebrated heroes, such as Charles Lindbergh and Amelia Earhart, achieved their fame in the course of private aviation ventures. Clearly, no parallel private citizen space pioneers are likely to emerge in this century; however, the kind of entrepreneurial space industry emerging today may have flourished earlier without the security constraints of the Cold War. The impetus of the Cold War may have hastened the dawning of the space age, but the rivalry also meant US space power development would be a government-run affair with few exceptions, thus artificially limiting commercial growth.

The final factor supporting the elements of US military space power is related to the men and women required to operate space forces--spacemen. While no separate service of spacemen has been created since the dawn of the space age, the USAF has recognized the importance of developing personnel with the necessary knowledge and experience. Even before establishing the first military space command, the USAF created a career field, a well-defined training and job experience path to follow throughout a career, for space operations officers and enlisted men and women. More recently, the USAF has created a Space Warfare Center to accomplish several functions, not the least of which is education. In just the last year, the center has begun teaching the Space Tactics Course, a course for space operators analogous to Fighters Weapons School. The trend in the

USAF at least has been to increasingly emphasize the operational nature of space forces, decreasing the reliance on engineers and technicians to perform operations tasks.

Conclusion

US military space power was born of the Cold War. The end of the Cold War leaves military space forces at a crossroads. Given this opportunity to reassess itself and set a vision, the US military must recognize and correct current deficiencies in its military space forces' ability to accomplish the force application, space control, and, to a lesser extent, the force enhancement missions. The US must also recognize and correct deficiencies in its ability to deploy and sustain military space forces. The next chapter provides a vision of how US military space forces might overcome these deficiencies by the year 2010.

Chapter 3: Concepts of Operations

Introduction

The concepts of operations (CONOPS) presented here were derived based on extensive literature review, interviews with experts, and brainstorming, in the context of an overall vision for space power in 2010. Every effort was made to develop this vision unconstrained by the familiar and conventional. In this chapter, following a brief synopsis of the CONOPS, these ideas are illustrated in science fiction-like narratives to help bring the vision to life and demonstrate the desired effects. These future scenarios are told as *first-person* accounts of military space operations, a description of the space power environment, and classroom lectures explaining the *present* state of US military space power *in 2010.*

Concepts of Operations

The specific *Space Power 2010* concepts of operations are *space strike, information blockade, space denial, omniscience/omnipresence, operational spacelift,* and *massively proliferated and networked microsat constellations.* These CONOPS address the US military space power deficiencies identified in the last chapter (see table 1). The six CONOPS are described in the following sections.

Table 1. **CONOPS Address US Military Space Power Deficiencies**

Space Power Deficiencies / CONOPS	Force Application	Space Control (ASAT)	Force Enhancement	Ability to Deploy	Ability to Sustain
Space Strike	X	X			
Information Blockade	X	X			
Space Denial		X			
Omniscience/ Omnipresence			X		
Operational Spacelift				X	X
Microsat Constellations			X		X

This table shows how the *Space Power 2010* concepts of operations described in this chapter help address deficiencies identified in chapter 2.

Space Strike

Space strike operations entail the space-based capability to strike targets anywhere (in space, in the air, on land, or at sea), any time (with strike operations commencing after little or no notice). This ability to produce destructive effects from space addresses two US military space power deficiencies identified in the last chapter. Space strike could serve as the force application component of the deployed space force structure *(forces deployed)*. In space control applications, space strike would provide weapons for space control. *Deep Penetration*, a futuristic concept of space strike, would provide a space-based, super bunker-buster in order to destroy deep underground fortresses and command centers. Envisioned for years beyond 2010, this capability would employ extremely agile spacecraft to grab near-Earth crossing natural space debris and steer them toward precision impact on top of an adversary's deep or hardened facilities.

Information Blockade

An information blockade would involve the application of space forces to sever an adversary from the infosphere. This might involve destructive or non-destructive applications of friendly space systems. Like space strike, the capability to impose an information blockade would provide a means of force application and might act as a space control mechanism as well.

Space Denial

Space denial effects would result from offensive operations intended to deny an adversary control and exploitation of space. The ability to deny space access is itself one of the elements of military space power, and helps address the deficiency in forces deployed, the lack of an ASAT. *Controlling the Space Lines of Communication*, a futuristic concept of space denial, goes beyond just controlling the space near Earth, to controlling lines to and from other celestial bodies. This concept anticipates that mankind's ongoing competition for resources and territory will transcend the Earth and Moon, eventually spreading deep into the solar system, and beyond.

Omniscience/Omnipresence

This broad, powerful effect would be obtained from the complete *instrumentation of the planet* from space, providing 24 hours-a-day, 365 days-a-year, continuous multi-spectral sensor data, instantly fused and synthesized into processed information. The ability to simultaneously observe all Earthly activity, from the surface outward, would improve force enhancement.

Operational Spacelift

Operational spacelift requires prompt, responsive spacelift systems and satellites capable of full operation immediately upon achieving orbit (with no on-orbit check-out required). This concept of operations would address the deficiencies in the ability to deploy and sustain space forces.

Massively Proliferated and Networked Microsat Constellations

This concept describes space forces deployed in extremely large numbers and networked in a powerful way. The space forces deployed in these orbital constellations would primarily comprise very small, but capable, satellites. This concept helps address the deficiency in sustainment of space forces.

A Vision of Space Power for 2010

The use of the fictional scenarios below is to help illustrate possible applications of the concepts of operations. The fictional adversaries should not be interpreted as potential threats from which one would derive requirements. Now, it's time step into the future.

It's the year 2010. American space forces are respected by the entire world community and feared by some. . . .

Scenario: Counter Proliferation

2317Z 13 February 2010, North Africa. In a north African country, three men are on the night shift guarding a facility producing weapons of mass destruction (WMD). The cold and clear desert night is warmed by the heat and light from a bonfire burning in an old 55 gallon drum not far from the guard shack where these men are supposed to be posted. Suddenly, they hear the crack of thunder and feel a tremendous concussion that knocks them to the ground. When they shake away the confusion and dust, they see a hole in the ground where their guard shack used to stand.

2317Z 13 February 2010, Europe. At the same time, in a *third wave* European country a financial operations center is filled with economists, bankers, traders, and systems analysts.[65] They are shocked to see their financial markets suddenly paralyzed when connectivity with the global economic web is completely lost. Bids and offers from around the world cease to be seen. Queries are answered by error messages. Voice communications are unavailable with many overseas customers. It appears contact with and communication through the global infosphere has been severed. The phones are ringing off the hook with calls from central bank and treasury officials wanting to know what has happened.

0103Z 14 February 2010, Asia. Within hours, a south Asian country launches a rocket carrying a weapon with which to challenge the United States' lead among spacefaring nations. This south Asian country learned the United States has once again exercised its space-based dominance of the planet to prevent other nations from developing similar power. The United States' space strike using an on-orbit kinetic-impact munition against the weapons plant of a north African ally, and its information blockade of the European nation which supplied the technology and information necessary to construct and operate the weapons plant, must not go unchallenged. Thirty-seven seconds into flight, the rocket explodes in a flash. There will be no challenge today. US military space power once again ensured freedom of space for the benefit of global commerce.

The 2010 Space Power Environment

Commerce in space has virtually exploded in the last 15 years. One of the greatest factors contributing to this growth was the development of very small satellites made possible by miniaturization. The *microsats* can weigh less than 5 kilograms and have more power than the thousand pound satellites of the 1980's and early 1990's. The spreading knowledge or information revolution also drove demand for enormous capabilities to exchange data. The first LEO satellite networks of the 1990's coupled with cellular technology only hinted at the networks to come. Demands for remote sensing, navigation, weather, and other information from space platforms contributed to drive more and more of the planet's, and especially the United States' wealth into space.

The US has begun returning to the Moon, although modestly. The serious concerns about the Earth's environment and limited resources have made exploitation of this off-shore island more desirable. Again, the microsats make this economically feasible. Recent tests of microsats sent to the Moon demonstrate the capability to find and exploit raw materials, and conduct hazardous experiments, such as biological and genetic research too risky for the planet. Unlimited energy from solar or nuclear sources allows rudimentary microrobots to operate continuously in developing facilities which might someday be suitable for human inhabitants. In the years to come, continuing population growth and limited Earth resources may accelerate the realization of this possibility. This commercial development is a subject of heated debate domestically and internationally as the United States has made implicit claims to the Moon in opposition to international treaties.

Earth-crossing asteroids offer many of the same attractions as the Moon (e.g., raw materials and a base on which to conduct hazardous experiments and operations) along with the threat they pose to human life should they intersect our orbit. Of course, the newly fielded planetary defense system against asteroids and comets provides a virtual shield against this occurrence.

Along with this shift of wealth above the planet, the spacecraft manufacturing and spacelift industries have grown tremendously. These industries are much less dependent on government business for their livelihood. Accordingly, keen competition in the marketplace has made efficiency and customer service paramount. In fact, a new space service industry has grown from the need to control the thousands of satellites in orbit. A few *Tracking, Telemetry and Command (TTC) Carriers* have staked-out the market for care and feeding of spacecraft whose owners don't have the desire to maintain in-house satellite command and control infrastructures. Even the USAF uses this network for many of its less critical or non-warfighting systems. This service industry helped remove barriers to entry in the space market by decreasing the amount of overhead required to field and operate a constellation of satellites. Any public or private organization that can afford the price of the satellites themselves may field a network. Not only have launch costs decreased because of commercial booster developments and microsat technology, but now the TTC Carriers provide the necessary operations and maintenance infrastructure at a reasonable rate.

Of all nations on Earth, the United States has capitalized on space commerce to the greatest extent. To protect US interests, the USAF deploys and operates space forces unparalleled in their ability to survey, reconnoiter, and strike the planet and the surrounding region of space. USAF space forces essentially instrument the planet, providing the US an omnipresence and omniscience never before achieved by any nation.

These forces also provide the ability to apply force at any time, anywhere on or above the surface of the planet. These capabilities allow for the conduct of operations across the spectrum of conflict to successfully persuade other actors on the international stage to observe the rules of civilized international behavior.

Lecture: Information Effects

1630Z 7 Nov 2010, Falcon AFB, Colorado. *Senior Master Sergeant (SMSgt) Smith began his lecture just as the second hand on the classroom clock swept past 12. It was comforting to still have an analog clock somewhere in his life. The Space Warfare Center where he taught was filled with enough high-technology toys for security, training, education, simulation, and research and analysis to make your head spin. He liked the feeling of stability he got from the clock. Greeting his class, he began. . .*

Our nation's revolution in space activity is applied very effectively as an information weapon. Our space dominance allows us to exercise information power in four interrelated ways: knowledge supremacy, information attack, precision targeting, and precision strike guidance. We'll discuss each of these briefly and focus on how they allow us to achieve military objectives.

Knowledge Supremacy. As stated earlier, our burgeoning space presence has allowed us to fully instrument the planet. With this instrumentation we have achieved *knowledge supremacy*, the unchallenged knowledge of any forces potentially threatening to national interests.[66] Our space-based sensors combine to provide incredible detail on military, economic, social, and political activities worldwide. We can now acquire continuous, multi-spectral image data of the entire globe--no interruptions in coverage from any part of the planet.[67] Likewise, sensor networks scoop in any electromagnetic emanations piercing into space. All data is processed instantly on space-based integrated sensor networks. The entire space sensor network combines to host a massive artificial intelligence-based computer system, reducing data, fusing results, and detecting important objects or events.

In addition to supporting the active measures to be discussed below, space sensor networks provide indications and warning, strategic planning support, and detailed intelligence to support weapons acquisition. Potentially hostile activities, such as an attempted surprise attack on an allied nation, are detected well before the situation gets out of our control. Our options are expanded by a much earlier understanding of enemy capabilities, intentions, and order of battle.

For example, our space sensors help us detect emerging WMD threats with much greater certainty. We can promote global stability by detecting the roots of potential crises, and initiate proactive measures to head off a major regional conflict.

Information Attack. One possible course of action against an adversary is a non-destructive information attack. Our powerful space-based sensor and processing systems allow us to modify, disrupt, or deny data streams associated with unfriendly space systems. We exploit our access to and understanding of adversary sensor data to manipulate and distort their perception.[68]

For example, consider an opponent using space-based imagery to assess our force posture. In response, we maneuver microsats into position, intercept key imagery data downlinks, modify specific details in the represented images, and then transmit the altered downlink streams. The enemy is unaware they are the victim of our information attack.

Perhaps we have masked the presence of friendly weapon systems, or perhaps we have exaggerated our deployed strength.[69]

We could also sever a nation's access to global information exchange, as with the third wave European country in the financial operations center scenario above. Surgical denial operations can be executed in close proximity by highly maneuverable microsats or at longer range from quasi-positional space control assets.[70]

Precision Targeting. With our space sensors we can study hostile systems in great detail and optimize our targeting strategy. The refined and continuous coverage helps identify exact spatial coordinates and estimate the most ideal timing for a strike. In our recent WMD facility *space strike*, our knowledge supremacy helped us identify the guard shack as the right target for a demonstration of force and identify the exact moment to strike in order to avoid human death or injury.

Precision Guidance. Finally, our space instrumentation enables precision guided space weapons. We have a variety of ways of applying destructive force from space, to be described later, but they are all driven by processors linked to our space sensor networks. The deadly aim from above is provided by the cooperative real-time inputs from thousands of integrated microsats.

SMSgt Smith opened the floor for questions. He liked this part better. At least he could now hear his students even if he couldn t see them. For some reason, the center still wouldn t provide distance learning instructors with video input of their students. The students could see him on their screens in real-time, but he taught to a camera.

Scenario: Major Regional Conflict

1523Z 02 August 2010, California. The Non-Commissioned Officer in charge of payloads got his crew back behind the safety line and into their transportable shelter with plenty of time to spare. They had just loaded 100 communications satellites into the payload section of their squadron's reusable launch vehicle getting ready to lift off from a remote section of the California coast. He knew the US was also using his sister squadron's expendable launch vehicles from a deployed location on the east coast, and the transatmospheric vehicle (TAV) from Edwards.[71] He was impressed with America's ability to *surge launch* a large number of satellites with tremendous capability in anticipation of, or in response to, a crisis. Not only could we deploy constellations of microsats to be functioning in orbit within hours, but we could launch pieces of larger payloads on separate vehicles to be mated into a whole functioning satellite shortly after launch. Furthermore, we could do all this in a much less vulnerable way than we could years ago. Using deployable systems not requiring extensive launch base support allows us to complicate an adversary's targeting problem. Our small air-launched booster provides outstanding survivability in this manner.

Two days ago, we saw indications of aggression from an Asian nation, the Asian Democratic Republic (ADR). They were positioning themselves to settle an ongoing dispute with a neighbor, the Federated Balkan Republic (FBR), through force. While the diplomats were talking, we were working. Within 24 hours, we had established one new sensor network taking advantage of the latest improvements in remote sensing technology in an orbital constellation tailored to maximize coverage over the region of interest. We also did the same with a new communications network and a new strike network of on-orbit kinetic-impact munitions. Then the ADR's forces starting shooting. They tried to paralyze us with a barrage of directed-energy, kinetic-impact and information weapons. They were partially successful, but our constellations were robust enough to survive their attacks and continue functioning. We struck back, destroying key space force command and control (C2) centers and spacelift facilities. The ADR's attacks on our networks drove CINCSPACE to direct further replenishment of on-orbit forces today. He also suggested the geographic CINC deploy several Unmanned Aerial Vehicles (UAVs) in the region to augment space sensors. The UAVs, high-endurance, high-altitude sensor platforms, had proved their value in previous contingencies by providing backup in the event of space force negation and by providing a closer look than on-orbit forces could provide.

At the same time the ADR was trying to strike our space forces, they were attacking the FBR with surface-to-surface missiles, both cruise and ballistic, long range artillery, and strike aircraft. Their navy even contributed with offshore missile and artillery attacks. The ADR's ground forces simply waited for the enemy to be paralyzed. Our response was to strike at the ADR's key command and control centers first, disrupting the execution of their plans with on-orbit kinetic-impact weapons. For those forces that moved against the FBR, we struck like lightning. Our space-based laser constellations worked smoothly and silently as charred strike aircraft and missiles fell to Earth near the border separating the two adversaries. The ADR naval force turned and headed back to home port after they realized they were next to be struck. They saw the missiles shot down and the splashes from kinetic-impact munitions walking closer and closer to their vessels. Many of the ground troops never got the word to move since they had no satellite communications.

Even commercial carriers wouldn't support them since they knew they would lose their networks if they did. The ground forces' command and control centers were also struck to degrade C2. However, some ground units did get the word since they still had land lines (cable and fiber), line-of-sight radio, and initiative. They were able to move initially, but our space strikes against rails, bridges, roads, and especially fuel depots slowed those ground units that weren't struck in their assembly areas or as they were moving in formation.

The payload NCOIC was proud when the squadron was briefed on the status of the conflict. He knew the birds he and his mates launched the day before were key to our success. He also knew the ones they were about to launch would ensure the ADR would stop their aggression.

At *T-0* smoke and fire poured out of the bottom of their rocket and it lifted off the pad. He and his crew watched the video to see evidence of their hard work on the way into orbit. As the image of the rocket narrowed to a point of light, the speaker in his ear alerted him to a squadron-wide announcement. His commander informed them the ADR had called for a cease-fire and agreed to negotiate.

It had been a busy two days for the United States' space forces. Once again, we demonstrated our ability to strike immediately anywhere on or around the planet in support of world stability and civilization with only a minimum loss of life, especially our own. The aggressor in this case recognized our capability and our willingness to use our space power and ceased hostilities in accordance with the demands of the world community.

Lecture: Destructive Effects

1746Z 7 Nov 2010, Falcon AFB, Colorado. *SMSgt Smith was impressed. This group of students asked good questions, pointed ones, too. His boss wouldn t have liked the students challenge that technology can t solve all problems or replace the human element, but it was true, and important when discussing information effects. Now, he began addressing the* shooters. . .

Our space-based weapons provide an unprecedented capacity to inflict destructive effects to achieve national objectives. Used in concert with the information effects described earlier, space power in 2010 has completely transformed the nature of war.

Fixed Targets. On-orbit hypervelocity kinetic-impact weapons are a key component of our space strike capability. These weapons are deployed in strategic patterns in LEO and highly-eccentric elliptical orbits. They are essentially shaped projectiles attached to microsat controlled mini-propulsion systems. The microsat guidance system is linked into the global satellite sensor network and benefits from the entire system's integrated processing power. As in the case of the WMD guard shack, these kinetic strikes can be engineered to destroy pin-point targets with essentially no collateral damage. A few such *designer* strikes, along with selected information attacks, will frequently suffice to achieve the desired effects.[72]

Defending Friendly Space Systems. We also use the guided kinetic weapon concept to defend against space-based attacks on friendly assets. When an unfriendly spacecraft is detected in a threatening posture, perhaps positioned to conduct an information attack, our sensors direct a hypervelocity kinetic strike with an on-orbit microsat *zone defender*. These kinetic zone defenses complement the mobile target destruction capability of our 20-point orbital laser weapon constellation. These massive directed-energy shooters can strike spaceborne or atmospheric fast moving targets at considerable range. Even unhardened surface targets can be severely damaged by our space laser attacks.

In addition to deploying large laser-weapon satellites, we deploy lasers on smaller, more maneuverable spacecraft. Although less powerful than the 50-ton fixed orbiters, the decreased cost and improved mobility make these *spacecruiser* lasers outstanding ASAT weapons.[73] Similar mini-laser weapon technology has been fitted to the first military models of the transatmospheric vehicle. Although extremely expensive and still impractical on a large scale, their inherent flexibility justifies a small fleet of TAVs to provide contingency space operations support to our expansive commercial and military space infrastructure.

Another class of space weapons combines the destructive power of lasers and kinetic impact for maximum precision and mass. These systems begin destroying the target with a high powered laser, while a precision guided munition slips out of orbital storage, and follows the destructive laser's path to finish off the job. These hybrid weapons are especially effective against high altitude, fast moving targets semi-hardened against a pure laser kill.[74]

SMSgt Smith concluded his lecture and called for a break. Whenever he taught this course it made him wonder what we d think of next.

Scenario: The Future Envisioned From 2010

1726Z 04 Aug 2010, Washington, DC. Maj Jones thought the CJCS-directed operations review, or *hot wash*, for the two-day campaign against the ADR was getting boring. Many of the attendees were simply patting themselves on the back for their success. Nevertheless, there were some lessons learned from this operation.

Several of the belligerent's command and control facilities went unharmed as they had been built in deep underground hardened shelters. We noticed this trend soon after our first demonstrations of what a nation can do with the planet instrumented and the ability to strike the surface from space. Our potential adversaries dug-in to escape our sensors and our strikes. This trend has led some to suggest potential uses of our planetary defense system against surface targets instead of against comets and asteroids. The concept would entail grabbing a near-Earth crossing asteroid with one of our planetary defense units and instead of steering it toward re-entry into our sun, steering it toward impact on top of an adversary's underground facility. Given the potential risks of not hitting the right spot on the surface, we've been proceeding slowly, but a team of scientists and engineers at the Philips Lab recently proposed innovative solutions to the problem, such as using micro-satellite robots to shape the asteroids for more favorable, and predictable, ballistic characteristics. Another potential solution is to use large pieces of rock from the Moon as projectiles with the shaping to be accomplished before launching it toward the Earth. Finally, one might simply use asteroid or Moon dust to fill a large shell which would be driven into the surface in a precise strike. It will probably be a few years before this concept is fully explored and tested, assuming there is continued political support and military need.[75]

Even before we get to the point of using celestial bodies as weapons we have to continue refining our strategy and systems for protecting our interests away from the planet. Just a few weeks ago, an American company reported destruction of a lunar laboratory by an unknown source. While we have a good idea of who made the attack and why, we can't prove it. However, we do know it's time to field the *libration point* defenses we've been developing to guard our Space Lines of Communication (SpLOCs).[76] We need to ensure safe passage for our commerce to and from the Moon and asteroids. We also need to ensure we can intercept and destroy any raiders who may want to slow or exploit our commerce on these bodies. We know it's time to continue *instrumenting* the Moon and perhaps field force application means in its orbit. We must also begin thinking about defending our SpLOCs to Mars, but that's probably a few years away. . . .

"Major Jones!" Oops, he'd been caught daydreaming. The colonel had warned him about his tendency to drift off in meetings.

"Get your mind back on this planet, Major! You spent too much time at that Space Warfare Center in Colorado Springs! This meeting's over. Let's go home."

Lecture: Exploration and Exploitation

1903Z 7 Nov 2010, Falcon AFB, Colorado. *SMSgt Smith began the third and final section of his lecture--exploration and exploitation of other bodies and the implications for space forces.*

We've begun returning to the moon. Commercial development is designed to begin the colonization of the moon. The lunar colony is predicted to have a population of 10,000 residents by the year 2030.[77] Due to continuing population growth and decreasing Earth resources, governments are considering ways to lighten the load on the Earth. However, this first colonization is dedicated to research and exploiting her resources. This *lunar laboratory* is dedicated to the scientific, technical and economic research of the Moon's vast resources of materials and energy.

Microsats for the most part have made this possible. Their small size and limitless capabilities have enabled the US to consider ideas previously regarded as science fiction. Infrastructure development and raw material exploration activities are carried out by preprogrammed robotic probes and by virtual reality vehicles (VRVs). These VRVs allow mining and infrastructure development to be done without concern for loss of human life.

The cost of lunar colonization has been offset by the almost limitless availability of solar energy and mineral resources. Solar energy is not only provided for the lunar colony, but it is also being converted into microwaves and beamed back to Earth for reconversion into electricity,[78] thus reducing reliance on fossil-fuel electricity.

The few approved US multinational development firms currently cultivating the moon are funding research into lunar niche industries involving extremely profitable but environmentally volatile processes. These firms are researching everything from genetic engineering to new chemical developments that only the vacuum of space can facilitate.

The moon has also been developed into a refueling station. Lunar refueling has postponed or eliminated the need for nuclear-fueled rockets.[79] Further, the lunar colony is scheduled to be developed into a jumping-off station to begin the exploration of the whole planetary system. This has heightened the debate over who has rights to the moon and any other planets that may be colonized in the future.

Lunar ventures aside, recent successes in testing microsat-driven deflections of Earth-crossing asteroids have offered the US another space-based weapon. At any given time, over 100 Sun-orbiting bodies, of greater than 10 meters in diameter, lie in the Earth's orbital path. Using the same technology demonstrated in our planetary defense tests, asteroids could be acquired and tugged into a precision-guided collision course against hardened enemy fortifications on the Earth's surface.

The accelerated exploitation of the Moon's resources is expected to serve as a springboard for renewed interest in manned exploration of Mars. The planetary defense technology mentioned above as a potential space-to-Earth weapon, may someday also be applied to induce the heat required to melt the Martian ice-caps. Such a precision-guided asteroid ramming could be the first step in terraforming Mars for future manned exploitation. The deliberate push toward developing lunar, and then later, Martian, outposts is an important and inevitable step in the expansion of US national interests. As we advance beyond 2010, space power theory, doctrine, systems, and organizations will have to continue to evolve as well.

SMSgt Smith dismissed his class for the day. He wondered where space forces would be in 15 years. He was sure glad our leaders of 15 years ago had thought ahead and developed the systems and concepts he taught about today. In the mid-90 s, there were probably some who didn t think it could be done.

Chapter 4: Requirements

Introduction

This chapter enumerates requirements and makes a case for the feasibility of the *Space Power 2010* concepts of operation. The preceding fictional scenarios presented these CONOPS in a context unconstrained by current realities. Now it's time to *back up* to the present to look at a few areas in which this vision suggests the need for progress and change.

Some present-day military theorists perceive the world to have entered a new *revolution in military affairs* (RMA) centered on advanced conventional munitions, non-traditional weapons, and space-based systems.[80] The *Space Power 2010* vision constitutes one possible manifestation of the space systems aspect of this notional RMA. RMA theory proponents characterize RMAs in terms of preconditions, including technological development, doctrinal or operational innovation, and organizational adaptation.[81] This concept provides a framework to discuss the plausibility of the *Space Power 2010* vision.

This chapter first considers various areas of technological development, implicitly or explicitly suggested by the *Space Power 2010* concepts of operations. These requisite areas include spacelift, satellite miniaturization, information systems, space weapons, robotics and virtual reality. The technology survey then yields to the consideration of relevant contextual, organizational, and doctrinal issues. The discussion addresses what the US can do to facilitate the necessary progress. The treatment of requirements is far from exhaustive. The chapter serves only to sketch elements of an argument for how the US might achieve desirable military space power in the future.

Technological Development

In the winter 1992 edition of *Daedalus,* W. Daniel Hillis discusses the amazing potential of massively parallel computing, one of the particularly promising technological areas to be addressed later. In his introductory comments Hillis says,

> By the end of this article I will be writing about strange and unlikely sounding things . . . because significant technical advances . . . generally have surprising consequences. It is always easiest to believe in a future that is a minor extrapolation of current-day trends. Such an extrapolated present is unlikely to happen in a time of rapid technological change.[82]

Hillis goes on to say,

> Massively parallel computing transforms both the economies and the absolute capabilities of information processing. All that can be said for certain is that this is bound to cause changes and that change is difficult to think about. I am confident that once again reality will go beyond our imagination.[83]

For at least some readers, the preceding fictitious view of military space operations in 2010 depicts some "strange and unlikely sounding things." But this future view clearly does not go "beyond our imagination."

A variety of current technical advances support the presented view of space power in 2010. For example, steady progress in spacelift technology could provide the necessary systems for deploying networks of thousands of sensing and shooting spacecraft. The continuing trend of satellite miniaturization should help ease the requirements of this significant spacelift burden. Future developers might exploit orders-of-magnitude size reduction in powerful computer electronics, as well as advances in lightweight structural materials, to mass produce microsats deployed by the tens or hundreds, rather than by ones or twos. Users and other space systems can then exploit the informational advantages of these massively proliferated and networked microsat constellations.

The many individual sensing nodes of these orbital super-constellations would be fortified by the latest results of continuing advances in remote sensing technology. Each node would also benefit from the powerful *resonance* of sharing the sensor data collected by every other node in the space network. Continued strides in digital communication technology, including laser satellite crosslinks, could facilitate this massive overhead information exchange. The resulting super information infrastructure might help solve the many targeting and guidance complexities of the proposed spaceborne weapons systems. This would assist developers, who will continue to make steady advances in the lethality and effectiveness of space-based kinetic-energy and directed-energy weapons. Today's technological trends, sustained and carried through to their logical conclusions, could guide the US to revolutionary progress in space power over the next 15 years. The following sections explore in greater detail some of the technology trends and requirements just outlined. Furthermore, the technologies detailed in these sections directly enable the *Space Power 2010* concepts of operations (see table 2).

Table 2. Advancing Technologies Support Space Power 2010 Requirements

CONOPS technologies	space strike	info blockade	space denial	omniscience/ omnipresence	operational spacelift	proliferated & networked microsats
quick launch spacelift					✓	
satellite miniaturization					✓	✓
laser crosslinks				✓		✓
advanced sensors				✓		
kinetic-energy weapons	✓	✓	✓			
directed-energy weapons	✓	✓	✓			
robotics/virtual reality				✓	✓	

"✓" indicates that the technology specified on the left supports the 2010 CONOPS indicated on top

Spacelift

All the launch capabilities required to make the space power vision possible by 2010 are available, in progress, or achievable. This section looks at just some of the progress toward more operational and efficient spacelift systems. This brief survey also points out the momentum building in commercial spacelift technology.

Quick launch of payloads is a vital requirement to the authors' space power concepts of operations. For spacelift, quickness is a function of several factors. These include the degree of dependence on tailored launch facilities. Spacelift vehicles dependent on extensive launch facilities usually require several months of buildup and preparation to launch. Such delays would not be acceptable for a future of space power demanding the ability to employ, deploy, and sustain space forces. Two of the most promising quick launch vehicles are Pegasus and Taurus. Currently, Pegasus can carry a 700-pound payload into low-Earth orbit and Taurus can carry a 3000-pound payload into LEO or 860 pounds to geosynchronous transfer orbit (GTO). The larger enhanced version of the Taurus XL/S will be capable of 4,300 pounds to LEO and 1515 pounds to GTO.[84] Pegasus is launched from an airborne platform while Taurus is launched from a concrete pad. Taurus is designed for build-up from storage to launch in five days, while Pegasus could be launched within two days.[85] Both of these systems are currently available and under continuous improvement to help better support the future concept of space power. This developmental trend in spacelift systems must continue in order to make quick launch operations commonplace instead of just a novelty event.

A key adjunct to quick launch lift systems is the requirement that satellites be available for use immediately upon attaining orbit, with virtually no on-orbit checkout time needed. This degree of spacecraft reliability could be realized by 2010 with continued progress in manufacturing quality and the enabling features of the information advances discussed later in this chapter. Greatly enhanced manufacturing quality might come, in part, from the mass production of satellites. Programs for satellite mass production are already under way in the commercial sector. The largest example is the Iridium global cellular communications system.[86] “We are changing the whole paradigm,” said John Windolph, spokesman for Iridium Incorporated of Washington. “Under the traditional setup, you would typically build two satellites at the same time; now we are going to build 60 or 70 in an assembly line process.”[87] Orbital Sciences Corporation is attempting something similar in the assembly line construction and launch of 26 Orbcomm satellites by 1996. The same mass production effort could be done for small military satellites.

How will this quick launch capability support space power? If satellite payloads were built up with the appropriate quick launch system, then stored for contingency use, the satellites could be placed into useful orbit in a matter of hours. Use of this contingency quick launch capability will make tactical satellites available for operations at the moment it appears that conflict could be brewing. Satellites could be launched to observe or help prevent hostilities, as well as to bolster space forces during hostilities. An historical example demonstrates operational quick launch surge in practice--the Soviets conducted 29 satellite launches within 69 days during the Falklands War.[88] Although current US capabilities could not come close to this, the decade-old example proves the concept of operationally responsive spacelift systems.

The US must also develop the capability to more efficiently launch larger payloads into orbit before 2010. Fifty-ton space-based weapon systems, such as powerful on-orbit lasers, will require this heavy lift capability. Developers can consider both reusable and expendable vehicles. Several reusable launch vehicles are under consideration or development currently as part of the X-33 program. The X-33 program will be a vehicle to demonstrate single-stage-to-orbit (SSTO) technology and operational efficiencies that could drastically lower the cost of a future space transportation system. The mission requirements for the SSTO include the capability to lift a 25,000-pound (mass) payload to a 220 nautical mile/51.6-degree inclination orbit.[89] The X-33 should pave the way for more reliable, cheaper reusable launch vehicles.[90] McDonnell's DC-X subscale flight demonstrator of a SSTO vehicle performed five successful flight tests in 1993-94 and shows promise that such capability is achievable.[91] Such a vehicle will permit missions to send vehicles onward to the moon, to resupply space stations, and deploy large space-based weapons more efficiently. A reusable, advanced technology SSTO rocket launch vehicle has the potential to reduce the cost of space transportation to a commercial level.[92] In addition, several existing Cold War technologies that have never been incorporated into operational systems could be used to develop an SSTO vehicle, according to David Urie, director of space and high speed systems at the *Skunk Works*.[93] He claims that Lockheed has a plan for a single-stage rocket that could deliver up to 40,000 pounds to LEO with a development cost of $5 billion.[94]

Another viable option for placing large, time-critical payloads into orbit quickly is to launch the satellite and upper stage separately on small launch vehicles, mate them together in orbit, then transfer to a higher orbit by burning the upper stage.[95] This system design would take advantage of the quicker launch capability of Pegasus- and Taurus-type lighter launch vehicles if quick-launch heavy capability is not available. In the same manner, a very large spacecraft could be placed into orbit as smaller pieces which could be joined in space to produce a very large and capable satellite. As an aside, this type of satellite construction could be adapted for providing on-orbit logistics. This would allow for the capability to upgrade an existing satellite by launching another module for attachment at any time. Likewise, additional fuel could be transported to the satellite to facilitate orbital changes.

Satellite Miniaturization: From Lightsats To Microsats

Smaller lightweight satellites (lightsats) should be able to accomplish as much as or more than a current heavy satellite by the year 2010. Generally, lightsats are spacecraft under 500 kilograms (1,100 pounds).[96] Dozens of such spacecraft have been launched in the last few years as technology demonstrators and as useable satellites. These pioneering lightsats include the Air Force Space Test Experiment Platform, DARPASAT, and Clementine. Throughout the last two decades, miniaturization has continually made electronic items both smaller and more capable. Further electronic miniaturization should continue to make satellites smaller and thus cheaper to launch and maneuver, and even more stealthy.

Are powerful microsats, satellites about the size of a basketball,[97] possible by 2010? NASA thinks so with its New Millennium initiative that will seek cutting-edge technologies that shrink spacecraft size and cost while increasing their performance.[98] "Ultimately, we hope that in the 21st century we can get things down to a size that you can hold in your hand" says Ellen Stofan, the New Millennium initiative program scientist at JPL.[99] By looking at some of the communication satellites currently under construction, like Iridium and Orbcomm, we can already see dramatic progress in size reduction.

Even more promise is demonstrated by the microsat project *Bitsy* developed by AeroAstro. This three-pound satellite with only $80,000 in development costs measures 19 inches from tip to tip. Bitsy, using primarily the same off-the-shelf electronics found in today's portable computers and cellular telephones, consists of a circuit board in a protective housing, with solar panels to provide power, and a tiny propulsion system for keeping the satellite in proper orbit.[100] Such a microsat could be attached to a payload as the prepackaged modular *brains* to control the system.[101] Rick Fleeter, AeroAstro's president, who sees the ultimate goal as reduction of a satellite's electronic functions to a single integrated circuit, predicts "a $100,000 satellite-on-a-chip . . . could be available by the end of the decade and would cost less than $50 million to develop."[102] Developers envision various military applications for such tiny satellites, such as launching them by the dozens into low orbits to quickly set up wireless regional communications networks in wartime, gathering battlefield intelligence, or ramming enemy satellites.[103] In some applications, "buying swarms of microsats might be more cost effective than building and launching one or two leviathans."[104]

Many technological advances have made powerful microsats more attainable. These include graphite composite structures, advanced star trackers, magnetic suspension, solar cell improvements, and advanced processors (see table 3).

Table 3. Microsat Technologies

SUBSYSTEM	TECHNOLOGY	BENEFITS
Structure	Graphite-Composite vs. Aluminum	25% weight savings
Attitude Control	Advanced Star Tracker vs. Conventional	2-5 times lighter weight
	Stellar Reference Units	>50% decrease in power
	Magnetically Suspended Reaction Wheels	2-3 times increase in operating life
Electrical Power	Gallium Arsenide Solar Cells vs Silicon Cells	15-25% weight savings
	Nickel Hydrogen Battery vs Nickel Cadmium	10-50% weight savings
Command and Data Handling	Advanced Spacecraft Processors	>50% decrease in size, weight, power >5 times increased throughput
Thermal	High Conductivity Structural Materials	Passive thermal control reduces complexity, weight
Propulsion	Overwrapped Tanks vs. Titanium	>50% weight savings >50% cost savings

Source: "Lightsats: the Coming Revolution," *Aerospace America,* Feb 1994.

Other extremely promising technology will reduce the size and weight of satellites, including microelectromechanical systems (MEMs). Such devices are already in use in automobile airbag systems. Within a few years, engineers could begin replacing large mechanical systems with chip-sized gyroscopes, accelerometers, inertial guidance systems, air data systems, and a host of other sensors.[105] Experts also expect big things from silicon chips populated with microscopically small moving parts. Such devices could equip basketball-sized microsatellites for low-Earth observation and telecommunications, and lead to even smaller disposable nanosatellites (less than 100 grams) for specialized tasks.[106] Today's satellite miniaturization trends appear to strongly support the microsat requirements of the *Space Power 2010* vision.

Information Technology

The space power vision of 2010 assumes great strides in information transfer and processing technology. An engineer grappling with current computational and bandwidth limitations might sneer at the phenomenal technological demands of a completely *instrumented planet*. However, the explosion of information science and technology makes the seemingly unimaginable very possible, very soon. Huge leaps in space-based informational exploitation might be achieved through the synergistic combination of current advanced technology, such as smart sensors and laser communication, along with the scores of similar innovations certain to be looming on the immediate scientific horizon. Cited below are a few examples of the current technological developments that might combine to satisfy the dramatic informational requirements of the *Space Power 2010* concepts of operations.

Massively Parallel Computing. The introduction to these technology sections presented a perspective on the amazing potential of massively parallel computing. This great potential derives from the synergy of many powerful processors interacting cooperatively. With this in mind, consider the power of this technology made available in space. Consider orbiting, massively parallel computing nodes linked to thousands of microsats in an integrated constellation. Or perhaps each of the microsats themselves will employ the astonishing processing capacity of massively parallel design. This idea may be a little hard for the knowledgeable computer scientist to swallow. Massively parallel machines are incredibly powerful, but right now they're also big and heavy. For example, the Connection Machine contains 65,536 processors and associated memory (massively parallel!) in a five-foot cube.[107] That's not exactly lightweight, microsat material. But remember, this is recently emerging technology and it will scale down quickly, perhaps "beyond our imagination." Even with present-day scales, much of the leverage of massively parallel design might be achieved *remotely* by large-scale integration of our heavily populated microsat constellations.

Data Transmission. The kind of large-scale information exploitation envisioned for space will require tremendous communication bandwidths and extremely high-data-rates. Raging rivers of data will enable the *virtual massively parallel design* as well as deliver basic space system informational functionality. The important breakthroughs in the related technologies are being marketed today for surface applications. *Wireless internetworking* products are now on the market, featuring microwave, spread spectrum, and laser transmission technology.[108] Of these, laser-based products offer the highest data rates. Fortunately, the line of sight and atmospheric limitations inherent in laser communications on land are greatly reduced in a space-based network.

Laser crosslinks will facilitate the exchange of huge quantities of data among the microsat nodes of a space-based parallel processing system. As the Air University Press *Space Handbook* explains, "Because of the extremely high frequencies generated by lasers, they have an enormous potential capacity as transmitters of information."[109] A single laser's information bandwidth is several orders of magnitude wider than the total radio frequency spectrum. Another significant advantage is the coherence (narrowly intense concentration) of the laser beam, which allows high antenna gains and permits high-data-rate communications over vast distances. Laser techniques have matured sufficiently to carry real-time television pictures at interplanetary distances.[110] With modest technological advances to simplify the challenging problems of laser pointing and receiver inefficiency, this form of inter-satellite crosslink would provide enormous capacity.

Complementing breakthroughs in high-data-rate communications, advances in data compression will contribute to the envisioned continuous imagery coverage of the Earth's surface. Graphic images can be many megabytes in size and can therefore take a long time to transmit.[111] One partial solution is to squeeze the image information into a much smaller data stream without any loss of detail. Brute force data compression techniques have been around for years, providing marginal data transmission relief at a cost of processing time. However, recent applications of new, exotic mathematical sciences are offering the promise of significantly greater reductions. Pioneers in fractal compression of digital images have claimed compression ratios of up to 2,500:1 within just five years of discovering this powerful processing technique.[112]

Sensors. Rapid advances in sensor technology can also contribute to space-based informational dominance in 2010. The current generation of imagery sensors are already extremely powerful. Looking at the increasing resolution of commercial remote-sensing satellites offers some insight into the advancing state-of-the-art. Exercising its licensing authority over commercial imagery ventures, the Commerce Department has recently granted three firms permission to launch satellite systems sharp enough to detect objects one-meter across.[113] This marks a significant improvement over today's best commercial systems featuring 10-meter resolution.

Developers are pushing future sensor capability rapidly with innovative integration of sensor components with microprocessor and expert systems technology. For example, a March 1994 *R&D Magazine* article describes recent progress in "smart sensor" instrumentation:

> Combining silicon-based sensors and ICs [integrated circuits] on the same chip to produce a smart sensor has been a natural evolution. . . . Researchers at the Georgia Institute of Technology, Atlanta, [are] developing smart sensors . . . using analog VLSI [very large scale integrated] circuits to integrate arrays of silicon photodetectors and processors to model the human eye. Each of the photodetectors for [the] imaging array feeds directly into local circuitry. "With analog VLSI circuits and parallel focal-plane architecture, we can create systems which process visual information in real time."[114]

Along similar lines, recent applications of mathematical wavelet analysis are dramatically improving "the ability of military radar systems to distinguish between, say, an ambulance and a tank."[115]

As the following *Space Handbook* extract suggests, advancements in laser radar and surveillance systems will contribute significantly to the *instrumentation of the planet:*

> The highly collimated laser beam permits range measurements in environments where conventional radars fail. . . . In a space-tracking role near the Earth, conventional radar can determine range to an accuracy of approximately 100 feet; the laser narrows the error to approximately 25 feet. With cooperative satellites equipped with special mirrored corner reflectors, accuracies are better than 10 feet. . . . Because of the narrow beam, present target azimuth and elevation angle resolution show an improvement of at least an order of magnitude over conventional radars. . . . Laser systems offer better resolution than passive infrared and side-looking radar and cover more night operation than conventional photography.[116]

Although space-based laser and surveillance systems do suffer weather and target acquisition limitations, this class of sensor offers tremendous potential for future systems.

Combined Information Technologies. The given sample of the emerging technologies may enable the tremendous informational space power envisioned for 2010. Each example considered separately offers exciting promise for the near future. Considered together, we could have smart sensors feeding real-time information via super high-data-rate laser links throughout a globe-encircling distributed network employing massively parallel computing architecture. These orbiting super networks would yield global omniscience and omnipresence, and could form the backbone of the *purple cloud* (a conceptual joint military command, control, communications, computer, and intelligence architecture for the future) discussed in the information dominance portion of *CONOPS 2010*. And, of course, all this is just "an extrapolated present," not a wild future vision beyond our imagination. Contemplating present realities in this manner makes the concept of the complete instrumentation of the planet seem much less fanciful.

Space-Based Weapons

The space power vision departs from the military status quo perhaps most dramatically in the extensive deployment of space-based weapons for both space control and force application. However, these weapons concepts themselves are not new. Such weapons have been intensely researched as potential components of the proposed US nuclear umbrella program called the Strategic Defense Initiative. Although the end of the Cold War virtually eliminated the strategic defense imperative behind the controversial SDI program, a decade of well-funded SDI research accelerated general progress in space weapons development. In *Space and Nuclear Weaponry in the 1990s,* Dietrich Schroeer suggests SDI will have an impact even though it will not likely be deployed for its original purpose of nuclear strategic defense.[117] "It produce[d] advanced technologies that may be very useful for such military purposes as anti-satellite activities and defenses against tactical missiles."[118] Later, Schroeer emphasizes this point,

> The strategic-defense community has been particularly interested in the use of SDI technologies as ASAT weaponry. This interest acknowledges the obvious: the technological requirements for ASAT weaponry are much lower than those for strategic defense.[119]

This is precisely the spirit behind the space warfare portion of the *Space Power 2010* vision. In considering space strike technology requirements, this section explores the present status and feasibility of the two general space-based weapons concepts, kinetic energy and directed energy.

Kinetic-energy Weapons. Kinetic-energy weapons are systems that derive their destructive power from impact of the weapon's mass with, or by explosion near, another object traveling in its path.[120] According to Schroeer, the SDI-induced improvements in target-seeking technologies have led to the proposals of space-based kinetic-energy weapons "either as space-based interceptors (SBIs) or as so-called Brilliant Pebbles (BPs)."[121] The massive proliferation and miniaturization concepts at the heart of the *Space Power 2010* thesis are most closely aligned with the Brilliant Pebbles concept. Brilliant Pebbles are satellites designed to shed their housing, or *life jacket*, and release an interceptor into the flight path of a missile.[122] Two defense industry teams, Martin Marietta and TRW, have worked toward developing Brilliant Pebble vehicles. The Martin Marietta team focused on "miniaturizing structures, inertial measurement units and sensor suites. The objective is a lighter weight, more agile kill vehicle that has discrimination and processing capabilities."[123] Additionally, TRW technology contributes special circuitry designed to reduce the size and weight of radio communications equipment.[124] Clearly, consistent with one key *Space Power 2010* theme, satellite miniaturization is a driving principle behind the Brilliant Pebbles concept. As Dietrich Schroeer notes,

> The current model of BPs [Brilliant Pebbles] is projected to have a mass of 155 kg each, although the originator of the BP concept, Lowell Wood, confidently expects considerable improvements as industry turns his ideas into mass-produced reality.[125]

In addition to ongoing miniaturization, Brilliant Pebbles developers have struggled with complicated data processing or *battle management* problems. The biggest technical challenge has been to develop algorithms to process vast quantities of sensor data in orbit.[126] Martin Marietta is meeting this challenge by "adapting its Geometric Arithmetic Parallel Processor (a massively parallel processor which is capable of several billion operations per second) for spacecraft use."[127] The continued revolution in information technology discussed earlier in this chapter should lead to other dramatic solutions to these battle management issues.

Although Brilliant Pebbles technology very closely parallels the kinetic-energy space strike weapons described in our space power concepts of operations, it's important to emphasize how significantly they differ in function and purpose. Brilliant Pebbles was designed as a defense against nuclear-armed ICBMs vice the space, air, and surface strike kinetic-energy weapons envisioned as a lethal component of space power in 2010.

Directed-energy Weapons. Space-based directed-energy weapons constitute the other space strike component of the *Space Power 2010* concepts of operations. Directed-energy weapons produce destructive effects through the intense concentration of electromagnetic wave or particle beam energy, rather than through the physical impact of solid masses. The Air University *Space Handbook* provides a more precise textbook explanation of how directed energy can be used to destroy targets:

> Since light travels at a speed of 186,000 miles per second, the lethal fluxes would arrive at targets almost instantaneously, and there would be no requirement to lead the targets unless they were located very great distances from the weapons. In general, directed-energy weapons strike capability results in the overheating of the target surface and internal equipment. The military could use laser weapons for selective engagements of single targets in the midst of numerous friendly vehicles. Unlike nuclear weapons, laser weapons would not disturb large segments of airspace and would not destroy indiscriminately all vehicles within their lethal range. Chemical lasers hold the most promise of all the directed-energy weapons.[128]

Chemical lasers, in which hydrogen and fluorine react to produce excited hydrogen fluoride molecules, emit infrared light at wavelengths of 2.5 to 3 micrometers. Because they're powered by chemical fuels, these lasers require virtually no electricity to generate their deadly light beams. This is an important feature in space, where electric power is at a premium.[129] The MIRACL and Alpha, both chemical lasers, are the two best known US directed-energy weapons research projects. In a spectacular demonstration, the MIRACL laser destroyed the second stage of a Titan-2 ICBM, providing proof of the destructive potential of directed-energy weapons.[130]

As of December 1994, the Alpha laser had been test-fired 11 times, most recently in August [1994].[131] Project contractors say "the energy intensity at the core of the laser is several times that of the surface of the sun."[132] Those most familiar with the Alpha can accurately predict the design requirements for long-range laser strikes:

> A 10-megawatt laser with a 6-meter telescope should be able to put roughly 500 watts/sq cm on a target 1,000 km away, and deposit 2,000 joules/sq cm of energy over several seconds. . . . An Army test showed

> 1,000 joules/sq cm could destroy a Minuteman missile under boost conditions.[133]

Given these successes with chemical laser research, efforts have already focused on developing space-deployable versions. This requires substantial size reduction without sacrificing power. Examples of size and weight reduction progress include improved mirror reflective surfaces to eliminate cooling requirements[134] and largely aluminum support structures.[135] The Star Lite chemical laser program was originally scheduled for test in space against missiles in 1997,[136] and the Zenith-Star space-based laser weapon test was delayed until 1998.[137] Although fiscal constraints and changes in priorities continue to delay program milestones, the deployment of space-based laser weapons could be achieved now and seems inevitable in the near future.

As was noted with the Brilliant Pebbles example, the *Space Power 2010* vision calls for space-based directed-energy weapons for a more general strike capability than the SDI-style programs mentioned here. Although, as already mentioned, the ASAT task is technologically easier than strategic missile defense, the *space-to-Earth* strike concept appears to be technologically much harder. In the case of both kinetic-energy and directed-energy weapons, distance and atmospheric density at low altitude present a formidable barrier for space-to-Earth strike concepts.[138] This technological challenge will have to be attacked more vigorously to achieve the full range of space strike effects described in chapter 3.

Robotics and Virtual Reality.

Building and sustaining the 2010 vision will demand a variety of complicated space operations and logistics. These requirements can be supported through extensive exploitation of the exotic technologies of virtual reality and remotely operated space robots.

The Space Exploration Initiative of 1991 examined three types of robots for future space uses. They included structured task robots, the type used in the automotive industry; teleoperated robots, those that are remotely controlled by humans; and surface exploration robots, to perform exploration tasks over various types of terrain. All of these concepts met with considerable acceptance within the scientific community, but the initiative was scrapped because of the immense development costs (estimated at $400 billion over 30 years). Regardless, the chapter 3 discussion of lunar exploration and mining provides an example of how robots could produce wealth and reduce human risks by providing *telepresence* via virtual reality vehicles. Telepresence can be defined as "the creation for the individual user of a realistic, detailed and complete artificial sensory world which makes the user believe he or she is present at a remote location."[139] The technology to accomplish telepresence includes databases, real-time objects or sound, tactile-sensor equipped gloves (gloves that allow you to feel what's in the *virtual-world*), and a head mounted display worn by the user and connected to a computer. Already today, a commercial project is looking to telepresence of the moon for a type of lunar theme park, which will merge lunar rovers with artificial intelligence and cameras to provide a 360-degree panorama of the lunar surface to give audiences on Earth a sense of being on the moon.[140]

Virtual reality systems will require improvements in sensor technology in order to support the space power concepts of operations for 2010 and beyond. Specifically, virtual reality concepts demand better position-sensing technology for head-gear mounted sensors to locate a person or object within an *x, y, and z* virtual-world coordinate system. Virtual systems also need better tactile sensing to allow the human users more genuine *feel* for whatever they are *handling*. Another unsolved challenge is the motion-sickness problem with current virtual reality systems. Virtual reality provides inputs to the eyes indicating motion without the other senses feeling the motion, causing disorientation in some users. This problem is not insurmountable, and can possibly be solved with medication. Finally, positive control of telepresent robots will demand powerful command, control and communications (C3) technology to provide the near real-time connection with the remote human operator. The information technology advances discussed earlier should help satisfy telepresence C3 requirements and make powerful VRVs a reality.

Terraforming

Although not a requirement for the *Space Power 2010* vision, terraforming extraterrestrial environments is a technological concept associated with the human future in space. The concept is briefly mentioned here with the understanding that the 2010 vision is merely a transitional state in space exploitation.

Although terraforming is currently more science fiction than fact, people are discussing how it can be done on both Mars and Venus. Terraforming is the process of building an environment suitable for human habitation on an otherwise unlivable planet. There are those who will insist an *environmental impact statement* be accomplished prior to beginning any type of terraforming activity. The Outer Space Treaty (discussed in more detail later in this chapter) states that parties are obligated to avoid activities that will result in the "harmful contamination" of outer space, including the Moon and other celestial bodies.[141] The most obvious question is what constitutes harm under the treaty.

The treaty, although vague, seems to regard environmental harm as activities that would unduly interfere with exploration and use of celestial bodies by other parties. This is not much of a barrier since terraforming would do a lot to promote the use of a planet.[142] Of course, the prospect of massive environmental change on other planets raises all sorts of questions too extensive for consideration here. Nevertheless, those questions may have to be addressed in order for US space power to extend significantly beyond the Earth-Moon system.

Even before man ventures to Mars or Venus, robot probes will be needed to explore and map these surfaces. Robots will be particularly necessary to construct any permanent base that includes habitats, radiation protection systems, surface power sources, and cargo and space vehicle processing facilities. To establish a fully industrial lunar economy, robotic resource extraction and processing equipment will be needed to generate oxygen, water, rocket fuels, and perhaps other products.[143]

As far as Mars is concerned, David Baker of DAB Engineering in Denver, who along with Bob Zubrin, helped develop *Mars Direct*,[144] believes private enterprise, rather than government interests, will fund missions to Mars. Baker believes that those few individuals who can spend millions on racing yachts will pool their resources to fund the project.[145] It will be like the Queen of Spain funding Columbus to find the westward passage to India. Only these individuals will be funding a mission to Mars, which is high-risk, and as with many risky ventures, has the potential for great gain.

Contextual Elements for US Military Space Power Development

Technological feasibility alone is not likely to bring about revolutionary progress in US military space power. Beyond the vast possibilities of advancing science and engineering, demands for new military capability would drive the realization of the *Space Power 2010* concepts of operations. The following sections first explore evolving global circumstances, including WMD and space technology proliferation, likely to push military space system requirements. Next is a look into the trend toward commercial uses of space, a trend which might advance military space capabilities as well as generate additional military space requirements. This is followed by a survey of several treaties affecting the extension of national space power. The final section enumerates of organizational and doctrinal issues to consider in the advent of the *Space Power 2010* vision.

WMD Proliferation

The issue of weapons of mass destruction proliferation is a very great concern for our nation and the community of civilized nations today. There is no reason to believe it will be mitigated by the year 2010; it will more likely be compounded. According to the most recent national security strategy, "Weapons of mass destruction--nuclear, biological, and chemical--along with their associated delivery systems, pose a major threat to our security and that of our allies and other friendly nations."[146] Our strategy goes on to say, with respect to WMD,

> we will need the capability not only to deter their use against either ourselves or our allies and friends, but also, where necessary and feasible, to prevent it. . . we are placing a high priority on improving our ability to locate, identify and disable arsenals of weapons of mass destruction, production and storage facilities for such weapons, and their delivery systems.[147]

This certainly points to the type of counter-proliferation scenario presented in chapter 3.

Space Technology Proliferation

The rapid proliferation of space technology may also drive the advancement of US space power and may further accelerate the necessity for new military capabilities in space. In 1992, eight nations and one international organization, the European Space Agency, had operational spacelifters.[148] Of the eight, at least three would be considered *developing* nations. Nine more nations were actively engaged in developing a space transportation capability. In 1993, some 26 nations or international organizations had payloads operating in orbit.[149] There is good reason to believe the trend toward increasing proliferation will continue. In fact, the demise of the former Soviet Union may actually serve to encourage proliferation as the former Soviet states desperately look for ways to obtain foreign currency and improve their economies. Furthermore, given numerous and difficult barriers to their entry into the Western commercial space market, the former Soviet states will likely turn to the developing world, thus accelerating proliferation to developing nations.[150]

As for the US, the Gulf War was described as the first "space war."[151] Even a former Chief of Staff of the US Air Force, General McPeak, described the war in these terms.[152] This aspect of the war is illustrated by the fact that "75 percent of all inter- and intra-theater multichannel trunking" was provided by the Defense Satellite Communications System alone by the end of the war.[153] About one-third of the US naval communications were carried over commercial satellite networks.[154] US forces were obviously dependent on other space-based systems in areas such as navigation, weather, and intelligence. As General Thomas S. Moorman, Jr, former commander of Air Force Space Command, wrote in 1992, this dependence is only likely to grow because as

> the Air Force gradually contracts and reduces its presence in Europe and in the Pacific, it will also draw down the forward-deployed, terrestrial support systems which it has counted on over the years . . . many of these support functions will be replaced by space systems.[155]

As US forces take on more of an expeditionary look, they will be increasingly reliant on space systems for support functions and also for crisis warning. Joint publication 3-07, *Joint Doctrine for Military Operations Other Than War*, emphasizes the criticality of intelligence and communications support to military operations other than war (to include contingency operations other than war).[156] This increasing dependence on space forces, to include commercial space systems, by the US military makes protecting our ability to operate in space essential. The growing US reliance on space systems is rapidly becoming a *center of gravity* (COG).[157] In the Gulf War, whether or not the Iraqis recognized this, they could not do much to interfere with US space systems. Given the continuing proliferation of space technology, it seems extremely likely future adversaries will develop means to affect this COG. If so, the requirement to correct current deficiencies in US space power will steadily increase.

Commercialization

One of the strongest assumptions underlying the vision of space power in 2010 is the need for it in the first place. The space power concepts of operations are not driven simply by the requirement to protect our military space forces. The accumulation of private interests in orbit further establishes space as an arena of vital US interests. As the wealth of nations moves above the planet, a nation's security will depend on protecting this wealth through military space power.

The earlier discussion of commercial development of resources on the Moon and asteroids is a very long-term view of commercial space development. One commercial space application we already see today involves information or knowledge. As Alvin and Heidi Toffler forecasted in 1980, we continue to see a knowledge revolution sweep our planet.[158] Increasingly, information itself is a commodity. The dependence on instantaneous international communications is only compounded by the further development of a truly global economy. In this global economy, transmitting information through space is key. In addition, information from space becomes more important. Space presence provides *global view*.[159] Space, or more accurately our constellations of spacecraft orbiting the planet, define the current limit of our *infosphere.* This infosphere is where a large amount of wealth will move or move through by the year 2010. Motorola's proposed Iridium constellation and Orbital Sciences Corporation's Orbcomm illustrate the beginnings of this movement today in the realm of communications. France's SPOT remote sensing system has been demonstrating the profitability of commercial remote sensing for several years. If the US NAVSTAR system weren't already paid for by the government, others would likely pay for it too.

Just as the movement of wealth above the planet will drive the need for military space power, military space power will be facilitated by the commercial development of the space realm. The US Army Air Corps found the practical implementation of its theory of daylight strategic bombing made possible due to great advancements in aircraft technology as a result of the boom in commercial aviation between World War I and World War II. Likewise, the current and anticipated growth in commercial space activity should lead to the great advancements in military space technology discussed earlier in this chapter.[160]

We will likely also find commercialization of space leads to great advancements in the affordability of space technology. According to a report on the future of the US space industrial base prepared for the Vice President's space advisory board, "many studies have been done to show that government programs cost more than corresponding commercial programs (estimates range from 30% to factors of 2 to 3 or more)."[161] One of the great expenses in acquiring military systems in general comes from the small numbers of items produced; that is, economies of scale are not possible.[162] The economies of scale will come with the production of increasing numbers of spacecraft and spacelifters. However, to take advantage of these economies of scale the DoD will have to more eagerly adopt the practice of purchasing commercial systems, subsystems, and components.

Increased DoD dependence on commercial space technology may not be as difficult or dangerous as it seems. First, take spacelifters. The differences between today's *commercial* and *military* spacelifters are really a question of how much government oversight is provided, not a question of hardware. The boosters are the same whether they're launching a NAVSTAR or a commercial communications satellite. Next, consider spacecraft. Some commercial spacecraft may be very nearly identical to those to be acquired and operated for military applications. Communications, weather and remote sensing come to mind. Even those spacecraft types without commercial analogs may at least take advantage of commercially produced subsystems and components.

One drawback to using commercial systems might be the lack of survivability or hardening measures designed into the hardware. However, the massive proliferation of microsat networks, and quick launch reconstitution will provide a sort of *defense in mass* measure of survivability. An adversary has many more targets to hit. And these targets are backed up by a robust, responsive and much less vulnerable spacelift system with which to replenish or replace our constellations.[163] This would give the US a space warfighting capability very similar to that enjoyed by FSU. According to Nicholas Johnson, a prolific writer and respected expert on the FSU space program, the Soviets emphasized "ruggedness, simplicity, relatively low cost of manufacture and operation, mission effectiveness, and proliferation."[164]

Now, how do we (the USAF, DoD and US government) help facilitate this commercialization? A large step forward in space commercialization was taken during the Reagan administration with the passage of the Commercial Space Launch Act of 1984 and the subsequent amendments of 1988.[165] But, as the title of this act implies, this was just for spacelift. A 1992 study sponsored by the Vice President's Space Policy Advisory Board recommended several steps to further commercialization. These steps include increasing "use of commercial business practices and components," removing impediments to the competitiveness of US firms, seeking "procurement opportunities that promote the development of a robust commercial space industry," and encouraging "multiple, small programs in developing space technology and systems in order to encourage innovation and accelerate the translation of ideas into useful products."[166]

Spacelift commercialization has been underway since the Commercial Space Launch Act was first passed. Both USAF spacelift wings, the 45th operating the launch base at Cape Canaveral and the 30th at Vandenberg AFB in California, have commercial advocates on their planning staffs. Both have also entered into agreements with *public-private* groups promoting development of the commercial space industry.[167] At Cape Canaveral, besides allowing commercial spacelift companies to use excess capacity available on *military* launch pads, the AF and US Navy have agreed to allow the Spaceport Florida Authority to use launch complex 46 exclusively for commercial operations with newly developed small commercial boosters such as Orbital Sciences Corporation's Taurus and Lockheed's Lockheed Launch Vehicle. In California, the 30th Space Wing has signed a lease of unused facilities at Vandenberg to include not only launch facilities for the same small commercial boosters to be flown at complex 46, but spacecraft processing facilities as well.

These are *first steps* which should be followed by greater strides. These strides might take the USAF and DoD to the point of offering management of the enormously expensive and complex launch bases at the Cape and Vandenberg to a civil government or commercial organization while retaining the right to operate from these locations. This would further encourage commercial development and relieve the USAF and DoD from maintaining the overhead. The USAF would do better to concentrate its spacelift energies on finding ways to use the newly developed small commercial boosters in a more robust and responsive launch system with less vulnerability to attack by an adversary. In other words, the USAF still needs to figure out how to *operationalize* spacelift instead of tolerating minimum *launch on need* times of 40, 60, and 180 days, for its Delta, Atlas, and Titan launch vehicles, respectively.[168]

With respect to spacecraft, one way to encourage commercial development of militarily useful technology and systems may be simply to use commercial systems for military applications when possible. In many cases, the USAF buys rockets and satellites, then flies them itself, when simply purchasing a data stream may suffice. Recent experience provides important examples of when buying a data stream sufficed. These include purchasing LANDSAT multi-spectral imagery to help fight the Gulf War, and buying SPOT imagery to support current military operations.[169] This encourages business to build, market, and operate space systems which provide a service, make a profit, and advance technology. Obviously, there are types of systems business would not build and the military would not want business to operate. Force application systems certainly fall in this category.

The continuing dark fiscal reality faced by the military appears to be forcing the Air Force into pursuing the recommendations discussed above as a cost-saving measure if not for the express purpose of encouraging commercialization. A recent study entitled "Reinventing Air Force Space" proposes to cut military space costs while increasing capability by relying more on commercial systems and practices.[170] The proposals included using industry instead of the Air Force to perform military space launches and satellite control operations, providing a "commercial backup for military satellite communications. . .patterned after the Civil Reserve Air Fleet," and even using systems like Motorola's proposed Iridium constellation for military requirements.[171] According to Brigadier General Roger DeKok, Director of Plans at Air Force Space Command, the "commercial marketplace in many cases is going to be able to satisfy the majority of requirements that are currently on the books for military satellite communications."[172] This would leave scarce military procurement and research dollars to be spent on systems without an analog in the commercial world.

Treaties

The space power concepts of operations have been developed and presented unconstrained by policy or treaty restrictions. However, the following survey of space-related treaties briefly describes current international limitations on space activities. As commercial and military satellite systems proliferate and mature, the US and her allies may wish to reevaluate any artificial barriers to the achievement of genuine US military space power.

The Outer Space Treaty. Although the Outer Space Treaty does limit military and industrial activities in space, it alone does not prohibit the achievement of the space power CONOPS in chapter 3. This agreement entered into force in 1967. In this treaty, most of the world's states agreed not to place any object carrying nuclear weapons or any other weapons of mass destruction in orbit around the Earth, on celestial bodies, or station them in any other manner in outer space. They agreed that outer space and other celestial bodies are not subject to national appropriation, sovereignty, and occupation. They also agreed on general principles of liability, registration and jurisdiction, and established the beginnings of international environmental law for space.

The Outer Space Treaty is regarded as the cornerstone of international space law. The treaty establishes space law by demanding that space activities comply with general international law and the UN Charter.[173] Under its provisions, all parties are required to consult with others before engaging in "potentially harmful interference" with the peaceful use of space.[174] In a contribution to the collaborative work *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime,* Theodore Ralston points out the treaty's provisions for space law-related verification:

> In particular the Outer Space Treaty provides some assistance to verification by establishing a degree of definition of the territory involved and the right of the signatory parties to an opportunity to observe the flight of space vehicles launched by another signatory.[175]

The Anti-Ballistic Missile (ABM) Treaty. The ABM Treaty could limit the deployment of various features of the *Space Power 2010* concepts of operations. However, with the Cold War over, the question is whether the US and the former Soviet Union still want this treaty. This issue will become increasingly salient as the struggle widens against WMD and advanced conventional weapons proliferation.

The ABM Treaty and its Protocol of 1974 prohibit the development, testing, and deployment of sea-, air-, *space*-, and mobile land-based ABM systems and of multiple missile and rapid reload ABM launchers. The treaty prohibits the deployment of a nationwide territorial ABM defense system. This provision was the continuous issue during the Reagan Administration when the Strategic Defense Initiative was proposed using a *broad* interpretation of the treaty. The Clinton Administration has upheld the traditional or *narrow* interpretation of the ABM Treaty, which states that the prohibitions apply regardless of the technology utilized. However, the US is seeking to clarify the distinction between ABM and anti-tactical ballistic missile (ATBM). The signatories to this treaty are only the United States and the Commonwealth of Independent States, all of which have pledged to fulfill the treaty except Azerbaijan. Other nations could develop their own ballistic missile defense system.

The Moon Treaty. This treaty does not limit the development of US space power in any way. However, it does highlight some potential regulatory considerations for the future natural resource rights beyond Earth's surface.

The 1979 Moon Treaty represents the most recent effort to extend the principles governing international space activity beyond those contained in the Outer Space Treaty. The one question the Outer Space Treaty didn't address was the question of when and how individuals, corporations or international organizations could make economic use of outer space resources. The treaty only bans *national appropriation* not private property rights. Although even today many regard the question of Moon-mining as something for the next century, many third world thinkers felt 15 years ago that it represented a real problem. The Moon Treaty was a response to the worries that the third world would be left behind in a race to develop outer space, just as they had been left behind in the economic development of the Western Hemisphere in this century.

The Moon Treaty provided that space resources were part of the *common heritage of mankind* (meaning that they belonged to all nations) and that there would be no exploitation of Lunar resources except through an international authority that would grant less-developed countries a share of the profits. This provision generated substantial opposition from pro-space organizations and other groups, and the Moon Treaty was never ratified by the US Senate. In fact, no space power ratified the treaty. Even though by 1984 the treaty had enough signatories to enter into force, no nation with a credible space program was among them.[176] Obviously, the developed nations understood the impact banning private-enterprise development of Lunar and space resources would have on future space settlement.

However, few interested parties would deny something like a Moon Treaty is needed. No one is going to invest billions of dollars in space enterprises without reasonable assurance that the investment is legal and will be protected. The Gold Rush in the American West might never have occurred had prospectors feared the government would seize their mines.[177] In short, the world community needs a regime that respects property rights, promotes development and encourages competition so as to see the earliest possible industrialization of the Moon. A good set of laws will ensure peaceful and profitable Lunar settlement and development as soon as the technology permits. A bad set of laws could induce violent competition or hold back progress for decades.

Organization and Doctrine

In considering the requirements for the *Space Power 2010* concepts of operation, this chapter has focused primarily on technological development and related contextual elements. However, the realization of the revolutionary space warfare component of military space power will also require substantial doctrinal innovation and organizational adaptation. Revolutionary technological development of space warfare weapons will gain very little without serious consideration of the best way to employ and organize these resources. While prescribing detailed, specific doctrinal or organizational requirements would go well beyond the scope of this effort, the following section enumerates some of the key issues for eventual consideration.

First, the US needs to break away from the divided control of national security space systems. The operation and acquisition of military space systems must be unified under a single authority. The primary separation of authority exists between national-level systems and systems of the military space commands. This outdated schism is a Cold War vestige and a costly barrier to maximizing our national security space resources. In the ongoing DoD roles and missions debate, the USAF has led the charge for a consolidated space management organization to look after all military and intelligence space programs.[178] The USAF is advocating its own space command to serve as the single space authority.

Regardless of how it's accomplished, space management consolidation is vital whether centered in one of the services, the US Space Command, the Office of the Secretary of

Defense, or a separate agency. In an October 1994 *Space News* interview, the Special Assistant to the Air Force Chief of Staff for Roles and Missions, Major General Charles D. Link, said US military space programs have suffered from the lack of consolidated management. He adds that this unacceptable situation is not an indictment of anyone, it's "just what happens when you find yourself in a new frontier."[179] Given the transformation of that new frontier anticipated by the *Space Power 2010* vision, the need for a real organizational solution may grow rapidly in the very near future.

The incoherence of US spacelift procurement policy is one example of the negative effect of the present multi-headed military space authority structure. On the one hand, US Space Command and the service space components have come to favor the development of smaller, cheaper and more operationally responsive spacelift systems. On the other hand, other federal agencies demand the continued development of heavy spacelift systems to support larger payloads. The point here is not to pick sides on the issue. The point is to emphasize how this policy rift disrupts the opportunity to concentrate limited military space development funds in the most effective and purposeful way.

This operational divide has another related, more general effect on the progress of US military space force development. In recent years Air Force space units have focused on establishing standardized and routine procedures for performing military space operations tasks. In fact, one motive for encouraging experienced ICBM missile launch personnel to cross over into the space business was to promote more disciplined and standardized space concepts of operations. In contrast, the national-level agencies continue to embrace the traditional way of doing space business. More specifically, in the traditional research and development approach, it's considered quite natural for the System Program Office

(SPO) to fly *its own* satellite over the entire program life-cycle. This mode of operation seems perfectly natural because each system is unique, specialized, and sensitive. The SPO wouldn't dream of letting some other organization fly *their* satellite. As reasonable as this approach may seem, it runs counter to the establishment of integrated and complementary operational space forces.

A second organizational and doctrinal issue requiring serious consideration is the fallacy of the *aerospace argument* embedded in today's Air Force doctrine. The aerospace argument mistakenly treats space forces as merely high-flying air forces.[180] This line of reasoning incorrectly assigns military space systems the exact characteristics of military aircraft and denies the unique aspects of military space forces.

Today's official US Air Force space doctrine is largely a product of the aerospace argument. The March 1992 version of Air Force Manual (AFM) 1-1, the capstone document of the service publication series, is titled *Basic Aerospace Doctrine of the United States Air Force.* The document maintains its eloquent simplicity partially by treating air and space power as one in the same, and defining the basic terminology of each in parallel. For example, AFM 1-1 lists *counterair* and *counterspace* as typical missions of *aerospace control.*[181] In describing basic Air Force doctrine, AFM 1-1 essentially defines the aerospace argument. For example, paragraph 2-1 states,

> The aerospace environment can be most fully exploited when considered as an indivisible whole. . . . Aerospace consists of the entire expanse above the Earth's surface. . . . Aerospace provides access to all of the Earth's surface.[182]

By applying the aerospace argument, the Air Force has trivialized the task of creating space power doctrine by generalizing eighty years of air power experience to the space environment. In the process, the Air Force has also staked its claim as the appropriate service to control and operate US military space forces.

The aerospace argument is faulty because space forces are distinctively different from air forces. In his book *On Space Warfare: A Space Power Doctrine*, Lt Col David E. Lupton presents the unique space force characteristics to underscore the necessity for a separate space power doctrine.[183] Lupton contrasts some characteristics of air forces--range, speed, and maneuverability[184]--with the characteristics of notional space forces--global presence,[185] quasi-positional siting,[186] congregational tendency,[187] long-range electromagnetic weapons effects,[188] hypervelocity kill,[189] and infinite operating area.[190] To ignore these unique qualities for the convenience of extending air power doctrine to space seriously risks tragedy in future military campaigns.

Contrary to current Air Force doctrine in which the aerospace argument is a deeply embedded assumption, recently established *joint* military space doctrine recognizes space as a unique operating environment. The final draft of Joint Pub 3-14, *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) For Space Operations*, dated 15 April 1992, emphasizes the point,

> Space capabilities can no longer be viewed as simply an extension of Earth-bound systems. Instead, space must be viewed as providing a unique, aggregate capability that offers a tremendous combat advantage to all warfighters.[191]

The aerospace argument is analogous to the pre-World War II dogma that viewed tanks as a mere adjunct to the infantry, or air power as simply over-head artillery. The technological advantages of tanks were not fully realized until military leaders discovered the unique military value of massed armored units. Similarly, the concept of an air force as an independent service is partly a consequence of long-standing arguments for concentrating air power decisively under the authority of a single air commander. The Germans demonstrated the unique characteristics of armored formations as their Panzer corps rolled through the Ardennes and across France in the stunning western Blitzkrieg attack of 1940. Three years later, Germany belatedly rediscovered the value of strategic bombing (independent air power) in the midst of their stalemate on the Russian front. These historical lessons dramatize the potential danger of the hasty aerospace argument. Equating space power to air power is just as erroneous as equating armor to infantry or aircraft to fire-support artillery.

A third organizational and doctrinal requirement for the *Space Power 2010* vision is for the US defense establishment to move beyond Cold War sanctuary or survivability school policies. This will entail more open and vigorous programs for developing and deploying space-based weapons capable of achieving desirable military effects. The 1991 Gulf War demonstrated our military dependence on space systems. Future adversaries, unlike Iraq in Desert Storm, will likely attempt to employ means to degrade or neutralize our military space assets. The US cannot afford to assume treaties or Cold War restraint will continue to protect these resources. The Gulf War also displayed our vulnerability to theater ballistic missile attacks. Space-based missile defenses may still provide the most effective and reliable means to counter such threats. In short, the US should aggressively lead the race to deploy superior offensive and defensive space weaponry necessary to protect our vital national interests.

Lt Col Michael E. Baum, USAF, warns of the potential military disaster of adhering dogmatically to the outdated doctrine of space as a sanctuary for only peaceful activity. In his Spring 1994 *Airpower Journal* article "Defiling the Altar: The Weaponization of Space,"[192] Lt Col Baum narrates a chilling fictional account of a Chinese military victory over the US in the year 2011. In Baum's story, General Smith, the Chairman of the Joint Chiefs of Staff, testifies before Congress, explaining that the successful Chinese attack resulted from their weaponization of space and the lack of space weaponization by the US. General Smith pins the problem on the US failure to develop space superiority weapons starting in the late 1990s. We had learned the wrong lesson about space from our victory in Desert Storm. Our potential adversaries had not.

Fourth, the US should consider divestiture of government control over costly space functions. For example, commercial organizations might operate large space launch bases more efficiently than the military or NASA. As detailed earlier, growing market forces in the space industry, if properly nurtured, might help provide new and affordable technology required for future space power.

A fifth organizational and doctrinal requirement is to resolve the devilish details of command and control of space power systems. Given the deployment of ASATs and space strike weapons, who controls them? Who pulls the trigger? Who makes targeting decisions? Should space weapons be massed for effect, or should they be parceled out to support air, land and sea forces? Should space assets providing theater support be coordinated through the Joint Force Air Component Commander (JFACC), as the aerospace argument would imply? Or should the US add a Joint Force Space Component Commander (JFSCC) to the theater warfighting structure?[193] Who has combatant command (COCOM) authority, operational control (OPCON) authority, or tactical control (TACON) authority over US military space systems? Who will coordinate all the satellite command and control, launch requirements, space control, and force application missions in real-time?

Attempting to answer these questions within the limited scope of this paper would only trivialize such a huge and vital task. These issues must be probed deeply in the context of a concerted national program to develop future US military space power. With the development of fully capable space forces, the US must build innovative doctrine and a winning organizational structure. The specific solutions should be consistent with joint warfighting doctrine, while fully exploiting the unique characteristics of military space forces.

Conclusion

The preceding survey of present-day technology shows the *Space Power 2010* vision to be quite feasible. Technological requirements can be filled by existing or emerging advances in spacelift, satellite miniaturization, information systems, space weapons, robotics and virtual reality. To complement advancing technologies, the US will require properly focused policy. Specifically, WMD and space technology proliferation may motivate policies to accelerate development of US military space power. Likewise, the US space power future calls for policies to facilitate commercial space activities, introduce possible treaty modifications or reinterpretations, and initiate organizational and doctrinal innovation.

Chapter 5: Conclusions

Today's US military space power is clearly deficient. US space forces have no force application capability, and no ASAT weapons to support a viable space control capability. Furthermore, the US ability to deploy and sustain space systems is seriously impaired, and its force enhancement capabilities need some improvements. The US military must recognize and correct these deficiencies in order to remain a top space power. These deficiencies can be corrected with existing or emerging technology, especially with the aid of official policies focused to encourage growth in commercial space activities. Additionally, organizational and doctrinal progress will help the US achieve fully effective military space power.

A theoretical lexicon assists in the process of analyzing current US space power and in efforts to contrive a desirable vision for its future. The authors first derived a working definition of *military space power* by drawing on scholarly interpretations of the notions of *space* and *power.* The derivation process led to military space power being defined as the ability of an actor's military space forces to successfully contribute to achieving the actor's goals and objectives in the presence of other actors on the world stage through control and exploitation of the space environment. This concept breaks down further into five elements of military space power. These elements comprise forces deployed, the ability to deploy them, the ability to employ them, the ability to sustain them, and the ability to deny an adversary space control and exploitation. The five elements must be supported by a capable industrial base and a cadre of military space professionals (*spacemen*).

The brief history of US military space power is dominated by the demands and limitations of the Cold War. The Cold War paradigm shaped virtually every aspect of our existing space systems, as well as the various doctrinal views of space warfare. With the Cold War over, market forces and more conventional military requirements are just beginning to shape the space systems of the future. As commercial space activities grow, the required technologies should become much cheaper and more capable. This could very quickly create new possibilities for a revolution in space power.

Space Power 2010

Guided by the formal concept of military space power and its elements, the authors presented six basic *Space Power 2010* concepts of operations. These six CONOPS are *space strike, information blockade, space denial, omniscience/omnipresence, operational spacelift,* and *massively proliferated and networked microsat constellations.*

The first step toward the authors' vision of space power is the complete instrumentation of the planet. This would be achieved by massively parallel orbital networks of sensor-equipped microsats. These super networks would yield global omniscience and omnipresence, and could form the backbone of the *purple cloud* discussed in the information dominance portion of *CONOPS 2010.*

In addition to the obvious intelligence value, this informational infrastructure could solve many of the technological complexities and costs associated with space-based weapons. The resulting deployment of various orbiting kinetic and directed-energy weapons would provide the capability to strike targets on the surface, in the air, or in space.

Both the informational and shooting components of this space warfare structure would be deployed and rapidly reconstituted by much more operationally oriented military spacelift systems than those we have today. Many of the costs and limitations associated with present-day space systems would be solved by the synergism of satellite miniaturization, massively parallel networking, and operationally routine spacelift. The huge scale of resultant space exploitation constitutes increased vital national interests in space and also provides the space power means to protect those interests. Finally, if the US does achieve this degree of space power in the next fifteen years, it would likely be only a transitional state. From this future vantage point one can foresee, in the much more distant future, the eventual exploitation of Lunar, Martian, and near-Earth crossing asteroid resources enroute to space power expansion throughout the solar system and beyond.

Is Space Power 2010 Feasible?

A brief survey of present-day technology shows the space power vision to be quite feasible. Recently developed launch vehicles are making incremental progress toward more routine spacelift operations. Great leaps in computer processor miniaturization and advanced materials development promise orders of magnitude reduction in satellite size and weight. Advances in massively parallel computing, digital data transmission, and remote-sensor design indicate accelerated progress toward a fully instrumented planet. The command and control leverage inherent in this space-based information dominance, combined with continued steady progress in directed and kinetic-energy weapons technology, could solve many of the engineering and logistical obstacles to routine deployment of advanced space weapons. Even the space power advances anticipated far beyond 2010, such as Lunar, Martian, and asteroid mining and settlement, are topics of serious consideration in today's scientific community.

Is Space Power Really Necessary?

As the US continues to draw down forces from the Cold War peak, a new and increasingly complex array of hazards is poised to threaten global peace and national interests. These challenges include more developing nations acquiring weapons of mass destruction, space technology proliferation, and emerging threats to the accumulation of space wealth. US space power is needed in order to face these complex military problems.

How Do We Get There?

In order to achieve genuine space power the US must act to encourage the commercialization of space and then exploit the resulting technological advances and economic advantages. This requires striking a delicate balance between stirring the industrial pot and staying out of the way. Specifically, this entails encouraging commercial space activities by removing impediments to the competitiveness of US firms. For instance, commercial spacelift companies should be allowed greater access to, and perhaps control of, government launch and satellite processing facilities. Finally, the US should stimulate new commercial space business through increased use of commercial space systems and services to fulfill military space requirements. These initiatives should be combined with aggressive government-led development of the few uniquely military space technologies, doctrinal innovation and organizational adaptation. This would put the nation on course to be the top military space power in the year 2010.

New Technology, New Environment, Same Old Story

Not until after fighting her first war as a great nation in 1898 did the US heed the advice of A. T. Mahan to build a modern navy and achieve real sea power. An established merchant ship-building industry provided a commercial infrastructure for military ship construction. Similarly, not until some time after fighting her first war with powered aircraft in 1918 did the US develop a modern air force and achieve real air power. Again, an emerging passenger aircraft industry provided a commercial environment in which to manufacture long range bombers. Today, following her first war significantly employing space systems in 1991, the US faces the need to develop space forces and achieve real space power. Clearly, we should follow the lessons of history and look to a growing commercial space industry to provide the foundation for the military space power of tomorrow.

NOTES

[1] For a general introduction to the subject see Adolf A. Berle, *Power* (New York: Harcourt, Brace & World, Inc., 1969) and Thomas E. Wartenburg, *The Forms of Power* (Philadelphia: Temple University Press, 1990).

[2] See Jack H. Nagel, *The Descriptive Analysis of Power* (New Haven: Yale University Press, 1975) for a mathematical approach to defining, describing, and measuring power.

[3] See Kenneth E. Boulding, *Three Faces of Power* (London: Sage Publications, 1990) for a discussion of destructive (threat), productive (exchange), and integrative (love) power and how he relates these to political-military, economic, and social power, respectively. See John Kenneth Galbraith, *The Anatomy of Power* (Boston: Houghton Mifflin Company, 1983) for a discussion of condign, compensatory, and conditioned power. See Terrence L. Moore, *The Nature and Evaluation of Terrorism*. Ph.D. dissertation. University of Pittsburgh, Pittsburgh PA, 1987, 75-103, for his definitions and discussion of power, power relationships, power resources, and power strategy.

[4] Notice this definition does not require a competitive or antagonistic relationship between actors, nor does it require actors to act on each other. As Boulding described, there can be a positive type of power (integrative) used by an actor or actors to further a common good, perhaps even at their own expense. As Moore described, simply the state-of-being of an actor can influence the behavior or state-of-being of another actor. These possibilities were certainly not accounted for by previous authors. Hirshleifer said "Power is the ability to achieve one's ends in the presence of rivals." (See Jack Hirshleifer, *The Dimensions of Power as Illustrated in a Steady-State Model of Conflict* (Santa Monica CA: The RAND Corporation, 1989), v (N-2889-PCT)). As used here, the term *non-state actor* refers to entities such as international governmental organizations, non-governmental organizations and multi-national corporations.

[5] A brief and unscientific dictionary review reveals no definitions for the term space, but only for outer space. The term outer space is defined as "space beyond the atmosphere of the Earth" in David B. Guralnik, ed., *Webster s New World Dictionary of the American Language* (William Collins and World Publishing Company, Inc., 1978), 1009, and as "space beyond the extreme limits of the Earth's atmosphere" in Sidney I. Landau, ed., *The Reader s Digest Great Encyclopedic Dictionary* (Pleasantville NY: The Reader's Digest Association, Inc., 1977), 958.

[6] Both the US and USSR preferred to avoid defining the term space and where it began, instead opting for a functional definition stating that whatever is in orbit is in space. According to McDougall in Walter A. McDougall, . . . *the Heavens and the Earth: A Political History of the Space Age* (New York, Basic Books, Inc., 1985), 180 and 259, the two powers wanted to avoid too explicit an environmental definition for fear of constraining their freedom in this new arena. Gen Thomas D. White also intentionally

avoids defining space as a separate environment, preferring to claim the entire environment above the Earth's surface for the US Air Force in Gen Thomas D. White, USAF, "Air and Space Are Indivisible," *Air Force*, March 1958, 40-41. Current US Air Force doctrine continues this idea. Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force*, Volume II, March 1992, 63-69 and 269-308, provides no definition for space in the glossary and explicitly denies the uniqueness of space as a separate environment in the essay on the aerospace environment.

[7] A brief summary of various definitions of space is provided in Captain Carol Laymance, "Science of Space," in *Space and Missile Orientation Course* (Vandenberg Air Force Base CA: 30th Operations Support Squadron, 1993), 1-3. If trying to define where space begins for biological reasons, one might choose 9 miles above the Earth since above this point a pressure suit is required. If concerned with propulsion, 28 miles is important since this is the limit of air-breathing engines. For administrative purposes, one might find it important that US astronaut wings may be earned above 50 miles. An aeronautical engineer might define space as starting at 62 miles above the Earth's surface since this is where aerodynamic controls become ineffective. Conventional and customary law defines the lower boundary of space as the lowest perigee of orbiting space vehicles, about 93 miles. Sellers, in Jerry Jon Sellers, *Understanding Space, An Introduction to Astronautics* (New York: McGraw-Hill, Inc., 1994), 60, says "space begins where satellites can maintain orbit--about 130 km (81 miles)."

[8] This definition is chosen primarily to recognize when the environment differs from air as to require vehicles having operating characteristics distinct from aircraft, i.e., spacecraft. Some might say this is a poor choice since a satellite cannot maintain an orbit that low, it must be at least 81 miles high. However, the authors do not wish to allow current technology to drive a definition of where the space environment begins.

[9] Notice this definition allows for space power to be held by actors other than nation-states. Today, organizations like the European Space Agency might illustrate this concept. In the future, it is conceivable multi-national corporations will have space power. Additionally, notice space power is defined not only in terms of exploiting the space environment, but also in terms of controlling it. Lupton, in Lt Col David E. Lupton, USAF, *On Space Warfare: A Space Power Doctrine* (Maxwell Air Force Base AL: Airpower Research Institute, 1988), 6-7, does an excellent job of defining and describing space power, but neglects to acknowledge that space power may be held by other than nation-states and neglects to acknowledge that space power should also include the ability to control the environment. An actor may be said to possess space power if it can exploit space without the ability to control the environment, but, all other things equal, it will not be as powerful as an actor that can control as well as exploit space. Again, current US Air Force doctrine provides no help in defining space power. AFM 1-1, Vol II, 300, simply describes space power as "That portion of aerospace power that exploits the space environment for the enhancement of terrestrial forces and for the projection of combat power. . .to influence terrestrial conflict." It is interesting to note AFM 1-1 uses "space environment" in this definition, but fails to define this term. It is also interesting to note space power is defined solely in terms of enhancing and influencing terrestrial forces and

conflict. Air Force Doctrine Directive (AFDD) 4, as quoted in Lt Col Michael R. Mantz, *The New Sword: A Theory of Space Combat Power* (Unpublished draft prepared for the Airpower Research Institute, Maxwell Air Force Base AL, July 1994), A-3, defines space power as "That portion of the nation's aerospace power that seeks to control and exploit space to accomplish national goals and objectives."

[10] Lupton, 6. Of course, this concept is disputed by current US Air Force doctrine in AFM 1-1, Vol II, 63-70.

[11] Hap Arnold, quoted in AFM 1-1, Vol II, 272, described air power as "The total aviation activity, civilian and military, commercial and private, potential as well as existing." Mahan said, "sea power, in the broad sense includes not only the military strength afloat, that rules the sea or any part of it by force of arms, but also the peaceful commerce and shipping. . .on which it securely rests" in Adm A. T. Mahan, *The Influence of Sea Power Upon History* (New York: Dover Publications, Inc., 1987), 28. As previously quoted, Lupton describes space power as "the entire astronautical capabilities of the nation."

[12] See *The Relationship Between National Power and National Objectives*, US Army War College, Carlisle Barracks PA, September, 1957, 1E-2, for a discussion of geographic, political, economic, psycho-sociological, and military elements of national power. Hughes, in Barry B. Hughes, *Continuity and Change in World Politics* (Englewood Cliffs NJ: Prentice Hall, 1994), 80-92, identifies military strength, demographic size, economic production, resource bases, and geographic position as the source of state's power and discusses several methods of measuring power. For an introduction to much more sophisticated and complex methods of analyzing and comparing nation-state power, see Michael P. Sullivan, *Power In Contemporary International Politics* (Columbia SC: University of South Carolina Press, 1990).

[13] Theresa Foley, "How Ariane Does It," *Air Force*, February 1995, 66.

[14] Sheila E. Widnall, "State of the Air Force," *Airman*, March 1995, 10-11.

[15] These four functions are drawn from AFM 1-1, Vol II, 103-111, the essay on aerospace power roles and missions and Joint Pub 3-14, *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) For Space Operations* (Washington DC: Government Printing Office, 1992), I-15.

[16] AFDD 4, quoted in Mantz, A-2, defines military space power as "That portion of a nation's space power that seeks to control and exploit space to accomplish military goals and objectives."

[17] Mantz, 2-4.

[18] Joint Pub 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington DC: Government Printing Office, 1994), 238, defines military capability as "the ability to achieve a specified wartime objective" and identifies four major components: force structure, modernization, readiness, and sustainability. Lupton, 127, emphasizes five pillars of his space control doctrine: logistics, the human being, a space surveillance system, control weapons, and the proper organizational doctrine.

[19] The term *spacemen* is used here as one might use the terms *airmen* and *seamen.* See Lupton, 144-145. Perhaps a gender neutral term (like soldier, sailor, marine, or astronaut) should be devised.

[20] Dr Joan Johnson-Freese, "US Space Policy: An Anomaly Wrapped in an Enigma," in *Space Forces* (Maxwell Air Force Base AL: Department of Regional and Warfare Studies, 1994), 8-9. Dr Johnson-Freese makes the case that the US military space program is in position analogous to NASA after the Apollo program. The US military must develop a new space policy "aimed at optimizing what is possible within the stringent budget conditions imposed, rather than merely moving incrementally forward, building what is possible because it is possible."

[21] The White House, *A National Security Strategy of Enlargement and Engagement* (Washington DC: Government Printing Office, February 1995), i.

[22] W. H. Pickering, "Reflections on Space Research: The Challenges and the Triumphs," *Space Times*, July-August 1994, 9.

[23] Walter A. McDougall, . . . *the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., 1985), 4-9. One of the major themes of McDougall's work is how the US was transformed into what he calls a technocracy by the dawn of the space age.

[24] Quoted in Russell F. Weigley, *The American Way of War: A History of United States Military Strategy and Policy* (Bloomington: Indiana University Press, 1977), 379.

[25] McDougall, 117.

[26] Weigley, 427.

[27] McDougall, 176.

[28] Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB AL, Airpower Research Institute, 1988), 35.

[29] Paul B. Stares, *The Militarization of Space: US Policy: 1945-1984* (Ithaca NY: Cornell University Press, 1985) 65.

[30] McDougall, 191 and Stares, 63.

[31] McDougall, 221-224.

[32] Charles W. Bostian and Timothy Pratt, *Satellite Communications* (New York: John Wiley and Sons, 1986), 2.

[33] Sir Peter Anson and Dennis Cummings, "The First Space War," in Alan D. Campen, ed., *The First Information War* (Fairfax VA: AFCEA International Press, 1992), 123.

[34] Ibid.

[35] Stares, 111.

[36] Lupton, 91.

[37] Col Simon P. Worden, 50th Space Wing Commander, interview with authors, 12 January 1995.

[38] Stares, 109.

[39] Ibid., 119.

[40] Ibid., 123.

[41] Ibid., 135.

[42] Ibid., 184.

[43] Ibid., 140 and 180-184.

[44] Major Steven R. Peterson, *Space Control and the Role of Antisatellite Weapons* (Maxwell Air Force Base AL: Air University Press, 1991), 8.

[45] Ibid., 131-134.

[46] McDougall, 128.

[47] Characterizing today's spacelift systems and operations as "non-operational" is not intended to criticize or ignore the tremendous work of the thousands of contractor and military personnel who spare no effort to ensure safe and successful launches, but the system is none the less expensive and unresponsive. It is the experience of one of the authors, Maj Rampino, that even trying to impose standard operating procedures is an enormously difficult task at our launch bases. It is tough if for no other reason than the culture that says "every launch is unique." For example, Maj Rampino, acting as observer inside the complex-36 block house for an Atlas launch, heard the contractor directing operations exclaim "great *test* tonight, guys" after the successful operation. This opinion is based on lessons learned during a tenure as the chief of standardization and evaluation for the 45th Operations Group, the Air Force unit responsible for military spacelift and range operations at Cape Canaveral.

[48] Lt Col John R. London III, *LEO On The Cheap, Methods for Achieving Drastic Reductions in Space Launch Costs* (Maxwell Air Force Base AL: Air University Press, 1994), 203.

[49] Major Jeffrey L. Caton, *Rapid Space Force Reconstitution, Mandate For United States Security* (Maxwell Air Force Base AL: Air University Press, 1994), 17.

[50] Ibid., 18.

[51] Lupton, 35-44.

[52] Ibid., 36-44.

[53] See Lupton, 37-45, for source of this information about the control school. The "aerospace argument" refers to the belief the entire environment extending up from the surface of the Earth should be the Air Force's responsibility. This argument suggests a continuous medium including air and space rather than emphasizing air and space as separate and unique operating environments. See Major Grover E. Myers, *Aerospace*

Power: The Case for Indivisible Application (Maxwell Air Force Base AL: Air University Press, 1986) for an introduction to this argument.

[54] Lupton, 36-45.

[55] Stares, 44.

[56] Ibid., 34.

[57] Ibid., 43.

[58] Ibid., 43.

[59] Lt Col Paul Keller, USAF Doctrine Center, telephone interview with author, 28 March 1995.

[60] Caton, 17.

[61] Stares, 205.

[62] Ibid., 241.

[63] See Lt Gen Daniel O. Graham, "Space Policy 2000--Double Prime," *Journal of Practical Applications in Space*, Vol IV, No 4, Summer 1994, 231-249, Mark R. Whittington, "Stifled By Political Correctness," *Space News,* April 25-May 1, 1994, 15, and McDougall, 4-9.

[64] Bostian, *Satellite Communications,* 3.

[65] Alvin Toffler and Heidi Toffler, *The Third Wave* (New York: Bantam, 1980) and *War and Anti-War: Survival at the Dawn of the 21st Century* (Boston: Little, Brown and Company, 1993) for background on their waves of change theory.

[66] The term *knowledge supremacy* is coined here to describe the omniscience and omnipresence achieved through instrumenting the planet.

[67] This concept of instrumenting the planet across the entire spectrum is derived from a 12 Jan 95 personal interview with Colonel Simon P. Worden, 50th Space Wing Commander, at Air Command and Staff College, Maxwell Air Force Base AL. Also see *SPACECAST 2020, Vol I, Global View White Papers*, Air University, Maxwell Air Force Base AL, Jun 94 for description of a similar concept.

[68] Worden interview, 12 Jan 95.

[69] Ibid.

[70] Ibid.

[71] For description of such a TAV, see *SPACECAST 2020, Vol I, Spacelift: Suborbital, Earth to Orbit and On-Orbit*, Air University, Maxwell Air Force Base AL, June 1994.

[72] Worden interview, 12 Jan 95.

[73] Lupton, *Space Warfare,* 140.

[74] Worden interview, 12 Jan 95.

[75] Worden first suggested this potential use of asteroids to the authors. Maj Larry Bell, et al, helped explain the technical possibilities and suggested the concept of using a large shell containing *dust* from asteroids or the Moon. See Natural Space Debris study by Bell, et al, ACSC Research paper, 1995.

[76] The term *SpLOCs* was first documented in, Major Henry G. Franke III, *An Evolving Joint Space Campaign and the Army s Role*, (Fort Leavenworth: School of Advanced Military Studies, US Army Command and General Staff College, 1992), 21. Libration points, also called *LaGrange* points, are "the five points such that an object placed at one of them will remain there indefinitely." For more details, see Wiley J. Larson and James R. Wertz, *Space Mission Analysis and Design* 2nd Edition (Torrance CA: Microcosm, Inc., 1992), 185 and John M. Collins, *Military Space Forces: The Next 50 Years* (Washington: International Defense Publishers, Inc., 1989), 7, 20-25, and 47.

[77] Edward Teller, *Better a Shield Than a Sword* (New York: Free Press, 1987), 188.

[78] Ibid., 182.

[79] Ibid., 183.

[80] Mary C. FitzGerald, *The New Revolution in Russian Military Affairs* (London: Royal United Services Institute for Defense Studies, 1994), 3.

[81] Commanders James R. FitzSimonds and Jan M. van Tol, "Revolutions in Military Affairs," Joint Forces Quarterly, no. 4 (Spring 1994), 25-26.

[82] W. Daniel Hillis, "What Is Massively Parallel Computing, and Why Is It Important?," *Daedalus*, Winter 1992, 1.

[83] Ibid., 14.

[84] James R. Asker, "Quick Response Key to Next US Launcher," *Aviation Week and Space Technology*, 28 September 1992, 44.

[85] Air University, *SPACECAST 2020*, vol. I, I-13.

[86] *Iridium* is Motorola's low altitude satellite cellular telephone communications system originally consisting of a constellation of 77, now 66, satellites. The system is named after the chemical element Iridium which has an atomic number of 77.

[87] Patrick Seitz, "Space Companies Streamline Satellite Assembly," *Space News*, 23-29 January 1995, 8.

[88] Air University, *SPACECAST 2020*, vol. I, J-3.

[89] Robert E. Austin and Stephen A. Cook, "SSTO rockets: Streamlining access to space," *Aerospace America*, November 1994, 35.

[90] James R. Asker and Jeffrey M. Lenorovitz, "Team Formed for X-33 Bid," *Aviation Week and Space Technology*, 5 December 1994, 19.

[91] Ibid., 20.

[92] Austin, 38.

[93] *Skunk Works* is the nickname for the Lockheed Advanced Development Company, known for state-of-the-art aerospace development.

[94] Ben Iannotta, "New Launcher Plan Unsettles," *Space News*, 21 November-4 December 1994, 29.

[95] Bob Parkinson, "Strategy for a Future Launch System," *Spaceflight*, December 1994, 400.

[96] James R. Asker, "Technology Spurs Lightsat Activity in Science, Commercial, Military Sectors," *Aviation Week and Space Technology*, 30 July 1990, 78.

[97] Alan S. Brown, "MEMs: Macro growth for micro systems," *Aerospace America*, October 1994, 32.

[98] Leonard David, "NASA Aims for Radical Changes in Spacecraft," *Space News*, 13-19 February 1995, 3.

[99] Ibid., 3.

[100] Theresa Foley, "Tiny Satellites Aim to Please the Bean Counters," *New York Times*, Sunday, 5 March 1995, 10F.

[101] Brian Giblin, Director of Finance and Marketing, AeroAstro, Herndon VA, telephone interview, 13 March 1995.

[102] Foley, 10F.

[103] Ibid.

[104] Ibid.

[105] Brown, 32.

[106] Ibid.

[107] Hillis, 6.

[108] David Newman and Kelly Tolly, "Wireless Internetworking," *Data Communications,* 21 November 1993, 60.

[109] *Space Handbook: An Analyst s Guide*, Volume Two, AU-18, (Maxwell AFB AL, Air University Press, December 1993, 257.

[110] Ibid.

[111] W. Wayt Gibbs, "Practical Fractal: Mandelbrot's Equations Compress Digital Images," *Scientific American*, July 1993, 107.

[112] Ibid., 108

[113] Warren Ferster, "Imagery Firms Say Spying is Minor Factor in Market," *Space News,* 31 Oct-6 Nov 1994, 1.

[114] Tim Studt, "Smart Sensors Widen Views on Measuring Data," *R&D Magazine,* March 1994, 20.

[115] W. Wayt Gibbs, "Making Wavelets: New Math Resurrects Brahms and Compacts Computer Data," *Scientific American*, June 1993, 137-138.

[116] *Space Handbook: An Analyst s Guide*, Volume Two, 258-259.

[117] Dietrich Schroeer (Edited by Carlo Schaerf, Giuseppe Longo, and David Carlton), *Space and Nuclear Weaponry in the 1990 s* (Worchester Great Britain: Billing and Sons Ltd, 1992), 3.

[118] Ibid.

[119] Ibid., 30.

[120] Alves P. Gasparini, "Prevention of an Arms Race in Outer Space: A Guide to the Discussions in the Conference on Disarmament," (United Nations, New York 1991), Part I: 29-30.

[121] Schroeer, 6.

[122] William J. Broad, "From Fantasy to Fact: Space-Based Laser Nearly Ready to Fly," *New York Times*, 6 December 1994, sec. C.

[123] William B. Scott, "Brilliant Pebbles Development to Change Building of Spacecraft," *Aviation Week and Space Technology*, 4 May 1992, 76.

[124] Ibid., 78.

[125] Schroeer, 8.

[126] Scott, 78.

[127] Ibid.

[128] *Space Handbook, An Analyst s Guide, Volume Two,* 260.

[129] Jeff Hecht, "Blinded by the light," *New Scientist*, 20 Mar 1993, 29.

[130] Schroeer, 8.

[131] Broad, sec. C.

[132] Ibid.

[133] Michael A. Dornheim, "Alpha Chemical Laser Tests Affirm Design of Space-Based Weapon," *Aviation Week and Space Technology*, 1 Jul 1991, 26.

[134] Broad, sec. C.

[135] Ibid.

[136] Hecht, 29.

[137] Schroeer, 8.

[138] FitzGerald, 32-33.

[139] David Criswell., D. Gonzales, Ewald Heer, *Automation and Robotics for the Space Exploration Initiative: Results from Project Outreach*, Prepared for the United States Air Force and NASA by the RAND Corporation, (Santa Monica CA, 1991): viii.

[140] Leonard David, "Robot Projects Link NASA, Universities", *Space News*, (19-25 December 1994): 18.

[141] Glenn H. Reynolds, "What about the Environmental Impact Statement?", *Ad Astra*, (September/October 1992): 42.

[142] Ibid.

[143] Criswell, 9.

[144] "Mars Direct" is a project that evolved from the 1991 SEI, which has a strategy for astronauts bound for Mars won't have to bring oxygen and propellant with them for the journey. The vehicle that will bring them back to Earth, sent to Mars in advance of the people, will have its own factory to manufacture fuel and oxygen from the chemicals in the Martian atmosphere.

[145] Lance Frazer, "Mars Direct," *Air & Space Smithsonian*, (April/May 1994): 65.

[146] The White House, *A National Security Strategy of Engagement and Enlargement,* (Washington DC: Government Printing Office, February 1995), 13.

[147] Ibid., 14-15.

[148] Donald Blersch and Robert Usher, *Decision Maker s Guide to International Space* (Arlington VA: Anser, 1992), 176-177.

[149] John T. Correll, "Fogbound in Space," *Air Force*, January 1994, 24.

[150] Lt Col Gregory A. Keethler, "The Impact of the Soviet Union's Demise on the US Military Space Program" (Research report submitted to the faculty in fulfillment of the curriculum requirement, Air War College, 1993), 13-15.

[151] Anson and Cummings, 121-134.

[152] Quoted in Lt Gen Thomas S. Moorman, "Space a New Strategic Frontier," in *The Future of Airpower*, ed. Richard H. Schultz, Jr. and Robert L. Pfaltzgraff, Jr. (Maxwell Air Force Base AL: Air University Press, 1992), 241.

[153] Alan D. Campen, "Silent Space Warriors," in *The First Information War*, ed. Alan D. Campen (Fairfax VA: AFCEA International Press, 1992), 138.

[154] Anson, 124.

[155] Moorman, "Space a New Strategic Frontier," 240.

[156] Joint Publication 3-07, (draft final pub), *Joint Doctrine for Military Operations Other Than War*, 12 November 1993, V-3 - V-5.

[157] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton NJ: Princeton University Press, 1984).

[158] Alvin Toffler and Heidi Toffler, *The Third Wave* (New York: Bantam, 1980) and *War and Anti-War: Survival at the Dawn of the 21st Century* (Boston: Little, Brown and Company, 1993).

[159] The *SPACECAST 2020,* Air University, 1994, summary report describes global presence as a prerequisite for global view and global view as a prerequisite for global awareness and knowledge. In this context the *SPACECAST* focus was the warfighting power of space. However, many examples of the non-warfighting power of global view suggests this concept extends beyond warfighting. These examples include weather observation and forecasting, agricultural analysis, oceanographic and geologic surveys, and so on. Many of these non-warfighting global view applications have commercial (wealth producing) possibilities.

[160] See Robert T. Finney, *History of the Air Corps Tactical School, 1920-1940*, USAF Historical Study 100 (Maxwell Air Force Base AL: USAF Historical Division, Air University, 1955), 59 and Maj Anthony C. Cain, "The Military Technical Revolution in the Interwar Years: Strategic Bombardment" (Paper included in the curriculum of the War Theory course, Air Command and Staff College, 1994), 335-336.

[161] Vice President's Space Policy Advisory Board, *The Future of the US Space Industrial Base*, (Washington DC: Vice President of the United States, 1992), *x*.

[162] Jacques S. Gansler, *Affording Defense* (Cambridge MA: The MIT Press, 1989), 232, 334, 341.

[163] Our argument of survivability through (commercially induced) proliferation begs the question, *What s to stop a potential enemy from defeating this means of survivability through mass quantities of smaller, cheaper, and more effective ASATs?* The question of infinite escalation of the offensive and then defensive, countermeasure and then counter-countermeasure, is a very complicated argument and falls beyond the scope of our research. However, intuitively, the offensive and defensive space weapons we foresee are enabled by the much more massive informational networks. A nation without access to a planetary instrumentation infrastructure of this degree would not have an equivalent capacity for spaceborne lethality. (A stand-alone system of ASATs would not compete against our information dominance/space weapons nexus.) Given the commercial push we anticipate as a precondition to a nation's establishment of similar space power, a peer space power competitor would likely be a major trading partner in the global economy. This element of major international trade association as a defacto *membership requirement* for aspiring space powers induces a stability on the top rung of the space warfare club (ideally a club of one). Given this stability, our space forces serve primarily as a deterrent to peer nations, as a shield from assaults from lessor spacefaring nations, and as a tremendous source of offensive force. Of course this argument is not completely adequate because it assumes away enemy capabilities and intentions. It is however consistent with our commercialization thesis.

[164] Quoted in Keethler, "Impact of the Soviet Union's Demise," 4.

[165] Air Force Space Command, *Commercial Space Launch Act (CSLA) Implementation Handout*, (Peterson Air Force Base CO: HQ AFSPC/DOPP, 1993).

[166] Vice President's Space Policy Advisory Board, 43-45.

[167] David J. Lynch, "The Air Force Takes Stock," *Air Force*, February 1995, 29. One of the authors, Maj Rampino, has personal experience with commercialization at both launch bases having been chief of requirements for the 45th Space Wing and supervising the activities of the commercial space advocate for the eastern launch base.

[168] 45th Space Wing and 30th Space Wing, *Concept of Employment for Spacelift*, unpublished draft.

[169] Correll, 28-29.

[170] Steve Weber, "Air Force Rethinks Role for Commercial Space," *Space News*, October 31-November 6, 1994, 6.

[171] Ibid.

[172] Ibid.

[173] Donald L. Hafner, "Negotiating Restraints on Anti-Satellite Weapons: Options and Impact," in *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime,* ed. Joseph S. Nye, Jr. and James A. Shear (Lanham MD: Aspen Strategy Group and University Press of America, 1987), 93.

[174] Ibid.

[175] Thomas J. Ralston, "Verifying Limits on Anti-Satellite Weapons," in *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime,* ed. Joseph S. Nye, Jr. and James A. Shear (Lanham MD: Aspen Strategy Group and University Press of America, 1987), 128.

[176] Glenn Harlan Reynolds, "Return of the Moon Treaty", *Ad Astra*, (May/June 1994): 28.

[177] Ibid.

[178] Newsmaker Forum Q&A Interview with Major General Charles D. Link, USAF, *Space News,* October 3-9, 1994, 22.

[179] Ibid.

[180] Lupton, 17.

[181] Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force* (Washington DC, Department of the Air Force, March 1992), 7. Figure 2-1.

[182] Ibid., 5.

[183] Lupton, 17.

[184] Ibid.

[185] Lupton, 19. This characteristic stems from several factors. First, space surrounds the other environments. Second, space vehicles operate with a high-altitude vantage that provides line-of-sight view of large portions of the Earth. Third, space forces, once in orbit, can sustain altitude without expending fuel.

[186] Lupton, 20. Unpowered space forces have more of the attributes of fixed fortifications whose position is known than of maneuvering forces whose future position is in the mind of the commander.

[187] Lupton, 20. For example, the geostationary, sun-synchronous, and Molniya orbits are places where satellites tend to be deployed, due to operational requirements.

[188] Lupton, 21. Directed-energy weapons, if operationally feasible, will transmit their killing power at the speed of light over greater ranges than are possible with atmospheric use.

[189] Lupton, 22. The absence of atmospheric drag permits movements at speeds not attainable in the atmosphere. At these speeds, even small masses have enormous kinetic energies that can be used as kill mechanisms for space-to-space weapons.

[190] Lupton, 22.

[191] Joint Pub 3-14, I-1

[192] Lt Col Michael E. Baum, "Defiling the Altar: The Weaponization of Space," *Airpower Journal*, Spring 1994, 52-62.

[193] Henry D. Baird, *Is it time for a Joint Space Component Commander?*, Newport RI, Naval War College, 19 June 1992.

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VITAE

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Major Michael A. Rampino earned a bachelor of science degree in economics and received his commission from the United States Air Force Academy in 1983. He earned a master of science in space operations from the Air Force Institute of Technology in 1987. He served two assignments in intelligence and two in space operations. His most recent assignment was with the 45th Space Wing at Patrick Air Force Base, Florida as chief of requirements and, later, as chief of standardization and evaluation. He published a paper based on his master's thesis research in the proceedings of the 25th Space Congress. Following graduation from Air Command and Staff College in June 1995, Maj Rampino will be a student at the School of Advanced Airpower Studies in Montgomery, Alabama.

Major Ronald R. Ricchi, Jr, was commissioned in 1982 via ROTC at Syracuse University. He graduated from Undergraduate Navigator Training in April 1983 and Electronic Warfare Officer (EWO) Training in October 1983. Maj Ricchi has flown on B-52Gs and B-1Bs at Loring Air Force Base, Maine and Dyess Air Force Base, Texas, respectively. During these assignments, he served as senior standardization and evaluation EWO and as chief, standardization flight. He taught at the United States Air Force Academy from April 1992 to August 1994, where he was the assistant operations officer, 50th Airmanship Training Squadron. Following graduation from Air Command and Staff College in June 1995, Major Ricchi will serve in a joint assignment at the United States Space Command in Colorado Springs, Colorado.

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