The Fairchild Papers are monograph-length essays of value to the Air Force. The series is named in honor of Muir S. Fairchild, the first commander of Air University and the university's conceptual father. General Fairchild was part visionary, part keen taskmaster, and “Air Force to the core.” His legacy is one of confidence about the future of the Air Force and the central role of Air University in that future.

Whither Space Power?

Forging a Strategy for the New Century

SIMON P. WORDEN
Brigadier General, USAF

JOHN E. SHAW
Major, USAF

Fairchild Paper

Air University Press
Maxwell Air Force Base, Alabama 36112-6615

September 2002

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 SEP 2002	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Whither Space Power? Forging a Strategy for the New Century	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air University Maxwell Air Force Base, Alabama**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**156**	

Air University Library Cataloging Data

Worden, Simon P.
Whither space power? Forging a strategy for the new century / Simon P. Worden, John E. Shaw.
p. cm. (Fairchild paper, ISSN 1528-2325)
Includes bibliographical references.
Contents: What has gone before -- Scenarios for the twenty-first century -- Mathematical and physical realities -- Options for the new century -- Threats, limitations, constraints -- The boundless future.
ISBN 1-58566-111-2
1. Astronautics and civilization. 2. Astronautics, Military. 3. Military doctrine -- Unites States. 4. United States. Air Force. 5. Space warfare. 6. Space sciences. I. Shaw, John E. II. Title. III. Series.
358.8/0973--dc21

This Fairchild Paper and others in the series are available electronically at the AU Press Web site http://aupress.maxwell.af.mil and the Air University Research Web site http://research.maxwell.af.mil.

Contents

Illustrations

Photo *Page*

Table

Foreword

From the dawn of military history, military strategists have wrestled with an enduring challenge—the challenge to define and prepare effectively for the next war. History is littered with the tragic tales of those armies and nations that failed to meet this challenge and paid the price—on the battlefield, on the seas, or in the skies. One war-fighting medium remains to be exploited, and the challenge facing our nation's military strategists today is the same one that has come down through the ages—to define and prepare for the next inevitable battle—this time, a battle in and for space.

In this book, General Worden and Major Shaw present the building blocks for an all-encompassing strategy and doctrine for space power in the twenty-first century. Their compelling interpretation of the influence of space power over the past 60 years (chap. 1) is mirrored by a captivating vision of the role space power will play in the next 60 (chap. 2). The pictures they paint of potential asymmetric warfare no longer seem as distant as they did prior to 11 September 2001. As we have already tragically witnessed, the adversaries of tomorrow will not necessarily confront us directly, but will certainly challenge our centers of power—and more and more of those centers lie in space.

The succeeding chapters complete the prescription for space power strategy, defining space as the place where the future infrastructure of civilization will reside, and making the case for an aggressive national security policy in space.

The authors' final admonition should not go unheeded: We procrastinate on a strategy for space power at our own risk. If we do not seize the opportunity to control the ultimate high ground, someone else will, and we will then forfeit our role of global leadership in space.

JOHN L. PIOTROWSKI
General, US Air Force (retired)

About the Authors

Brigadier General Simon P. Worden

Brig Gen Simon P. Worden, born 21 October 1949, holds a BS in physics and astronomy from the University of Michigan and a PhD in astronomy from the University of Arizona. He is currently the deputy director for operations, J-3, Headquarters US Space Command, Peterson Air Force Base, Colorado. Throughout the 1980s and early 1990s, he served in every phase of development, international negotiations, and implementation of the Strategic Defense Initiative—a primary component in ending the Cold War. General Worden twice served in the executive office of the president. As the staff officer for initiatives in the National Space Council of the first Bush administration, he spearheaded efforts to revitalize our civil space exploration and earth monitoring programs, and was the architect of the "faster, cheaper, better" approach now adopted throughout the US space program.

General Worden commanded the 50th Space Wing, which encompasses more than 60 Department of Defense satellites and more than 6,000 people at 23 worldwide locations. He then served as deputy director for requirements at Headquarters Air Force Space Command. Prior to assuming his current position, he served as deputy director for operational requirements, then as deputy director for command and control, at Headquarters Air Force.

General Worden has authored or co-authored over 150 scientific technical papers in astrophysics, space sciences, and strategic studies. He was also scientific co-investigator for two NASA space science missions.

Major John E. Shaw

Maj John E. Shaw, born 17 March 1968, holds a BS in astronautical engineering from the United States Air Force Academy (USAFA), an MS in aeronautics and astronautics from the University of Washington, and an MA in organizational management from George Washington University. He is a distinguished graduate of USAFA.

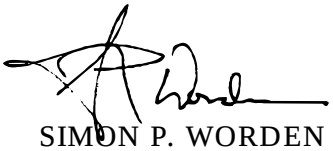
Major Shaw is currently assigned to Headquarters USAF at the Pentagon. His previous assignments have included tours in Air Force Space Command, the National Reconnaissance Office, and United States Air Forces in Europe, as well as internships in the Office of the Deputy Under Secretary of Defense for Space and in SAF/AQ, Space and Nuclear Deterrence Directorate. Major Shaw has authored several papers on aerospace issues, including "The Influence of Space Power upon History," which won the 1998 USAF/Royal Air Force "Two Air Forces" award for writing in history.

Acknowledgments

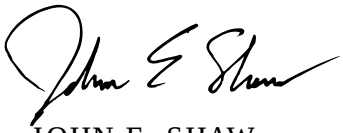
We would like to acknowledge the contributions of many military space colleagues, each of whom greatly shaped this work. These are the officers who will forge the United States' twenty-first century space-oriented national security strategy.

We also want to take this opportunity to acknowledge and honor Lieutenant Commander David L. Williams and our other comrades in arms who perished in the Pentagon on 11 September 2001. They were among the first casualties in the wars of the twenty-first century—and it is the objective of this work to ensure the United States is prepared to fight and win those wars decisively. We will not forget their service and sacrifice.

Finally, we'd like to particularly thank our ultimate mentor, Gen Bernard A. Schriever, who has done so much to move our country forward in using space to guarantee our freedom and security. To you, Sir, we dedicate this work and commit our very best effort to move your vision forward.



SIMON P. WORDEN
Brigadier General, USAF



JOHN E. SHAW
Major, USAF

Abstract

The influence of space power pervades almost every sphere and level of human existence, from politics to military affairs to commercial activities to cultural mindsets. Yet there is little to be found today in the way of coherent space power doctrine and strategy, particularly in national security circles. To what extent do our national interests rely on space? How shall we defend our interests in space and, in times of conflict, how shall we deny our adversaries the benefits of space power? How can we control and exploit the space environment? How can we effectively wield space power against the full spectrum of threats—from the lone terrorist to global peer competitors? What should be our long-range strategy and objectives if our goal is to achieve and maintain long-term space superiority? The purpose of this Fairchild Paper is twofold: first, to illuminate the historical and ever-increasing importance of space in modern society; and second, to prescribe, in view of this importance, the foundations of a strategy for achieving lasting space superiority and ensuring national and world security.

Introduction

Space power is intricately woven into the tapestry of modern civilization. Its influence is everywhere. In the few short decades since humankind first began to wield it, space power has played a fundamental role in the spheres of politics, military affairs, commercial activities, and cultural mindsets. It has often dominated political agendas, been used to champion ideological superiority, been the focus of multinational cooperation, and more. It is central, if not dominant, among the national security issues of our time—from providing strategic deterrence to countering weapons of mass destruction to maintaining constant global surveillance to ensuring the security of global networks and utilities. One can hardly venture anywhere in modern society without stumbling into its grasp. Its omnipresence in everyday life—through television, Internet, personal communication, navigation, weather, power distribution—demonstrates a significance that is, strangely, neither widely recognized nor greatly appreciated.

Equally strange, despite this pervading influence and compelling importance, there is little to be found today in the way of coherent space power doctrine and strategy, particularly in national security circles. To what extent do our national interests rely on space? How shall we defend our interests in space, and, in times of conflict, how shall we deny our adversaries the benefits of space power? How can we control and exploit the space environment? How can we effectively wield space power against the full spectrum of threats—from the lone terrorist to global peer competitors? If our goal is to achieve and maintain space superiority in the long term, what long-range strategy should we employ? How should we establish the objectives necessary to achieve our goal? What should those objectives be?

The ever-growing field of literature on space power is full of excellent works that either present a thorough history of space power or provide a comprehensive review of the current space policy debate. Less common are more prescriptive, visionary approaches to space power and strategy—those that provide answers to the questions above. The purpose of this paper is twofold: 1) to illuminate the historical and ever-increasing

importance of space in modern society, and 2) to prescribe the foundations of a strategy for achieving lasting space superiority and ensuring homeland and world security.

In chapter 1, we briefly review the history of space power and examine its influence on the unfolding history of humankind. We do this through the four-faceted lens of space sectors: space exploration, national security, space reconnaissance, and commercial ventures. Our historical review culminates with our conclusion that the Cold War, which consumed the second half of the twentieth century, could be recast as "The Great 50-Year Space War." This was a war where US dominance across the four space sectors—from the ideology-driven space race to the Moon, to nuclear deterrence, to effective space-based reconnaissance, to the threatened development of space-based strategic defense—significantly contributed to the demise of the Soviet Union. The post-"Great Space War" period, which began with the Gulf War and ended abruptly on 11 September 2001, was marked by significant expansion of the commercial ventures sector. We now stand on the verge of a new, uncharted era—one where the stage is set for the United States to assert space power leadership in the face of a full spectrum of possible adversaries and threats, all springing from different societies and civilizations, and with a wide range of motivations and objectives.

In chapter 2, we continue the "history" of space power with futuristic scenarios to create a vivid picture of the kinds of challenges future wielders of space power will face—and the possible consequences if we fail to develop and implement the kinds of strategies we suggest here. For the skeptic who might find this approach fanciful, we recall the initial reactions to the "fanciful" scenarios presented by Brig Gen Billy Mitchell in the 1920s—of mighty battleships at the mercy of Lilliputian aircraft, and of devastating sneak air attacks on unsuspecting Hawaiian isles. The ultimate purpose of our scenarios (as was Billy Mitchell's purpose regarding air power) is to demonstrate that the need for space power and strategy is not merely doctrinally rhetorical, but militarily real. Space *will* be an arena of military confrontation, adversaries *will* seek to challenge our interests and exploit our vulnerabilities in space, and we delay

addressing these certainties at our great peril. To the extent the scenarios leave the reader with this conviction, chapter 2 may very well be the most important part of this book.

In chapter 3, we examine the realities and constraints of operating in space as dictated by the laws of physics. Today, "easy" movement to and through space is limited by two overarching constraints: 1) a technological limitation on low-cost access to space and, more troublesome, 2) a lack of foreseeable energy resources to make "routine" space travel economically feasible. The logical approach to the first constraint, in the near term, is to encourage reusable spacecraft technologies and other methods that operate within more acceptable engineering (and thus cost-effective) margins. The second approach—more long-term in nature—is to embrace an "open" energy system, realizing that beyond the atmosphere lie energy sources as well as means to transport energy. Viewing space as an open resource system carries with it obvious implications for space power.

In chapter 4, we introduce the important concept of global utilities and explain how such utilities will increasingly depend on space and how space power strategy must evolve to protect them. Despite the constraints described in the previous chapter, space is swiftly becoming the center of gravity for the most important commodity in modern civilization: Information! Video and audio broadcast, personal communications, Internet—all have pathways through space. The Global Positioning System has already emerged as an indispensable global utility, valuable not only for its positioning service, but also for global timing, upon which so many industries depend. We foresee even more such utilities in the near future, including energy storage and transmission. Thus, the infrastructure of modern civilization is moving inexorably into space. With this migration comes the parallel need to protect and defend this infrastructure.

In chapter 5, we discuss the threats, limitations, and constraints to space superiority, and propose what must be done to effectively counter them. Some of these limitations/threats are *natural* in origin: space "weather," comets, asteroids, and so forth. All of these are phenomena of the space environment and represent hazards to the spacefarer (much as storms and

rocky shoals were hazards for the ancient mariner). We explore ways to counter these threats, limitations, and constraints, and even propose ways to exploit them to advantage. Other constraints are *man-made*: treaties and agreements, many of which may have outlived their usefulness. One of these, the Anti-Ballistic Missile Treaty, is even now on the verge of withdrawal. Others may need to follow suit (or at least be interpreted or amended) to allow the United States freedom to pursue those actions necessary to effectively wield space power.

Speaking of the vast oceans surrounding America, historian Bruce Catton has said, "Far from being isolated by the great seas, we are exposed by them . . . our only real defense lies in our ability to make our presence felt far beyond the horizon."[1] These words ring even truer for the vast ocean of space. As more of our national interests and infrastructure move into space, the more we are exposed by it. The United States has a proud history of successfully wielding land, sea, and air power in the protection of our nation and its principles. It is our goal that the United States carry this legacy of success into the medium of space, and the ultimate message of this book is a prescription for doing so. To the extent we have been successful, the following pages will leave the reader convinced that space power will become increasingly important in human affairs and that the need for an effective long-range strategy and vision is greater now than ever before.

Notes

1. Bruce Catton, *Foreword* in Nathan Miller, *The U.S. Navy: An Illustrated History* (Annapolis, Md.: United States Naval Institute Press, 1977), 7.

Chapter 1

What Has Gone Before

As a domain for human endeavors, space is very new. It was not until the late nineteenth century that we found the first "serious" suggestions of space travel, and those came from fantasy writers such as Jules Verne in his novel *From the Earth to the Moon, and A Trip Around It,* or H. G. Wells in his *First Men in the Moon*. Well into the twentieth century, "experts" continued to insist upon the "practical impossibility" of man-made objects traveling through space. Even the *New York Times* supported the "practical impossibility" notion, calling Robert Goddard's groundbreaking rocket experiments in the 1920s "futile." In 1921, an article in the editorial section of that newspaper stated, "That Professor Goddard with his 'chair' at Clark College and the countenancing of the Smithsonian Institution does not know the relation of action and reaction, and the need to have something better than a vacuum against which to react. . . . Of course, he only seems to lack the knowledge ladled out daily in high schools."

The military was even slower to recognize the potential of space as a medium of warfare. Indeed, even on the eve of Pearl Harbor, both the Army and the Navy were still struggling to understand and accept the value of *air*power despite more than two decades of experience flying airplanes in actual battles. The thought of *space*power simply failed to take early root within the US military, even though German engineers such as Wernher von Braun and Eugen Sänger had suggested in the 1930s the possibilities of intercontinental space bombers and missiles. The German engineers then demonstrated some of their ideas with the V-2 rocket during World War II.

The first US proposition for military satellites came only after World War II, in a significant RANN (Research Applied to National Needs, predecessor to today's RAND) Corporation study dated 2 May 1946, entitled "Preliminary Design of an Experimental World-Circling Spaceship." The next decade witnessed modest progress in US space technology, perhaps the

most significant being the development of Intermediate-Range Ballistic Missiles (IRBM) and Intercontinental Ballistic Missiles (ICBM) under the leadership of Maj Gen Bernard Schriever. The pace and importance of space power within US national security circles changed radically, however, with the launching of the first artificial Earth satellite—*Sputnik*—on Friday, 4 October 1957. Stung by the Soviet Union's technological coup, the United States responded with a series of across-the-spectrum major space initiatives. The first successful US satellite—*Explorer I*, launched on 31 January 1958—was actually built upon an ICBM, with a heavy dose of rocket science from Professor Wernher von Braun. Indeed, virtually all of the space launch progress to date, and most of our current launch vehicle inventory, traces its heritage to those ICBM programs.[1]

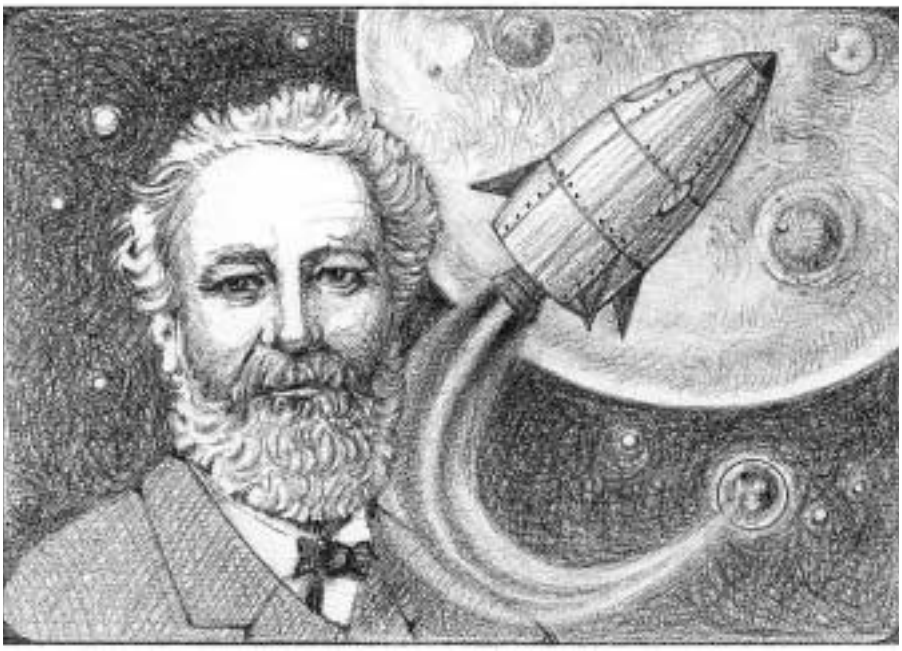


Figure 1. Ready for a Trip to the Moon

Source: AU Press Design Division

The Four Space Sectors

Following *Sputnik*, the late 1950s and early 1960s witnessed an explosion in space mission thinking. This explosion expanded the American vision for space well beyond the military mission of intercontinental strike. It is from these fledgling mission conceptualizations that the four major sectors of our current space infrastructure derive: space exploration; national security; space reconnaissance; and commercial ventures. An understanding of the historical developments and continuing interdependencies between these sectors is vital to successfully applying an all-encompassing space strategy.

Space Exploration

Dozens of volumes have been written on the early development of the civil space program.[2] Far fewer pages have been devoted to explaining how the initial successes in the civil space effort were based on the ICBM programs of the military laboratory system (led by General Schriever) rather than on existing civil technology programs encompassed under the National Advisory Committee on Aeronautics (NACA). This situation, however, was not lost on leaders of that era. Faced with a "crisis" in responding to the Soviet space challenge, the Eisenhower administration considered a variety of alternatives. Recognizing the preeminence of military (particularly Air Force) space technology efforts, President Dwight D. Eisenhower initially believed the nation should build upon these. However, his administration believed that a "civilian" US response to what was evidently a Soviet military effort would be most effective in garnering international sentiment in the ideology-driven Cold War. Thus, on 29 July 1958, President Eisenhower signed H.R. 12575, the National Aeronautics and Space Act (Public Law 85-568). In his statement regarding the Act, the president said, "The present National Advisory Committee for Aeronautics (NACA) with its large and competent staff and well-equipped laboratories will provide the nucleus for NASA. The NACA has an established record of research performance and of cooperation with the armed services. The coordination of space exploration responsibilities with NACA's traditional aeronautical research

functions is a natural evolution . . . [one which] should have an even greater impact on our future." This Act mandated a civilian-led space exploration program under a new National Aeronautics and Space Administration (NASA). Thus, NASA was formulated from pieces of the old NACA and selected military labs (most notably von Braun's Alabama operation), and was soon given the Army's Marshall Center in Alabama and Jet Propulsion Lab in California. NASA began its work over the objection of Air Force space development leaders, including General Schriever.[3]

NASA's efforts proceeded apace, but two years later they were given a new sense of urgency. The new Kennedy administration decided that further Soviet breakthroughs (such as the first man in space in 1961) coupled with political disasters (such as the Bay of Pigs invasion and the shoot-down of Francis Gary Powers' U-2 on a reconnaissance overflight of the Soviet Union on 1 May 1960) demanded a vigorous and focused US response. Relying on rapid analyses by Kennedy's technical advisors, the administration decided to pursue a manned Moon mission within that decade and, over considerable Air Force objections, gave the job to NASA.[4]

NASA, at the time, was hardly ready for a major space program. Still a very small agency, it lacked the necessary technical and managerial expertise. Thus, out of necessity, it turned to the military for assistance. Gen Sam Phillips, USAF, overall Apollo deputy director, led a contingent of about a hundred Air Force technical managers in providing the necessary expertise to NASA. With General Phillips, as well as Department of Defense (DOD) astronauts, launch vehicles, funding, and range support, NASA was then supported sufficiently well to meet the president's challenge.

There is little doubt that the Apollo program was a national security effort, as indeed most space exploration for the past 40 years has been.[5] It was designed to respond to technical, political, and even ideological challenges from the Soviet Union, which was seeking to detach Europe from the United States and win over the rest of the world by demonstrating the superiority of its space capability (and therefore its ideology). As a

response to this Soviet effort, the Apollo program was ultimately a huge success.

Unfortunately, Apollo left in its wake two legacies that, to this day, continue to inhibit the development of effective space power. First, Apollo fostered a radically new perception—that the military had little or no role in exploring and opening up the new frontier of space. The concept of military support for exploration had been otherwise enshrined in US history, from the Lewis and Clark expedition through nineteenth century western expansion and into the twentieth century with the development of aircraft technology in the 1920s and 1930s. The exclusively nonmilitary exploration of space, a politically oriented concept intended to appeal to national and world opinion in the midst of the Cold War, must eventually give way to historical precedent and modern reality; military capabilities and resources should, and will, play a role in future space exploration.

The second unfortunate legacy of Apollo was that the single-minded goal of getting to the Moon, regardless of cost, set US technical development, particularly in the launch vehicle area, on the "one-time spectacular" path rather than in a reliable, sustainable, reusable direction. The echoes of this still reverberate in today's expendable but expensive launch vehicle systems.

National Security

Once *Sputnik* was in orbit, the US military shed its reluctance to embrace space as both superpowers quickly explored the military utility of this new medium. So great was the perceived potential that President John F. Kennedy (then Senator Kennedy) said in his 1960 presidential campaign, "If the Soviets control space they can control the Earth, as in past centuries the nation that controlled the seas dominated the continents. We cannot run second in this vital race. To ensure peace and freedom, we must be first."[6] Interestingly, the Soviets translated this challenge into a doctrinally prescriptive quote cited in the seminal 1962 Soviet strategy book by Marshall Sokolovsky: "Space supremacy is the aim of the next decade. The country that controls space can control the Earth." Spurred on by the traditional military goal of seizing the high ground to achieve battlefield

success, the military now readily saw the potential for space to provide secure global communications. This new perspective led to the launch in 1966 of the first Defense Satellite Communications Systems (DSCS) satellites.

The US Air Force had also developed and launched the Weapons System 117L program in the late 1950s. Growing out of this effort was the Discoverer program, a cover for a covert program, CORONA, which launched dozens of satellites from 1959 onward. Thus began the era of space-based imaging over areas the United States was otherwise denied access to on Earth. When Gary Powers' U-2 was shot down in May 1960, the potential of space imagers to replace no longer invulnerable airborne reconnaissance systems was moved to the very top of the national security agenda, and the intelligence community quickly embraced this mission area. The Air Force deferred control of this vital area when the newly formed National Reconnaissance Office (NRO) began operations in 1961. Spacecraft provided surveillance film used by intelligence analysts to obtain otherwise unavailable information. The spy-thriller nature of the entire NRO program, while rapidly pushing technology frontiers, stifled most other space initiatives by the Air Force or any other national security player. For the remainder of the 1960s, the Air Force was left to focus its less classified efforts on developing support technologies such as launch vehicles.

By the late 1960s, the tide had begun to turn as the Air Force and, to a lesser extent, the Army and Navy, began to focus their space efforts in four basic mission areas, now known singularly as "space force enhancement," using space assets to support traditional military missions. The first of these has been the growing reliance of deployed military forces on space-based systems for communications or, more correctly, command and control (C^2) connectivity. C^2 was quickly followed by global weather observation and data distribution from space, now consolidated in the long-lived Defense Meteorological Satellite Program (DMSP) and merged with civilian weather programs under the Department of Commerce's National Oceanographic and Atmospheric Administration (NOAA). The third military mission area has been surveillance, primarily global early warning

Courtesy of NASA

Aerial Recovery of Film from *Discoverer* Spacecraft

of missile launches (this mission is distinguished from reconnaissance, an intelligence function discussed below). The Air Force developed and launched a series of missile warning satellite programs, beginning with the Missile Launch Detection Alarm System (MIDAS) in the 1960s, and progressing to the immensely successful workhorse, the Defense Support Program (DSP), which is still operating today. The next generation of missile warning satellites, the Space-Based Infrared System (SBIRS), is scheduled for fielding in the next few years. The final military mission area, and arguably the most important, represents the first true global utility: precision navigation, as embodied in the Navstar Global Positioning System (GPS). We will return to this area in much greater depth later in this volume, as it foreshadows the space-based global future within which we must operate.

The other major area of military space focus since the 1960s has been in the mission area of space operations, particularly space launch. Other than the Apollo program boosters, essentially all expendable launch vehicles of the United States have been and continue to be components or modifications of long-range military missiles, generally ICBMs. These have the advantage of being relatively mature technologies, but they also have the disadvantage of being both expensive and of limited operational reliability. To remedy this, NASA embarked on its Space Shuttle program in the 1970s. The resulting "space truck," built within a combination of technical and fiscal limitations, became more of a "space limousine." To make the shuttle cost-competitive against admittedly very expensive expendable boosters required very high launch rates—so much so that the "marginal" cost of the "n plus 1" shuttle flight appeared competitive. NASA succeeded in the early 1980s in persuading the Reagan administration to require US military use of the shuttle to bring the launch rate up to "affordable" levels. However, it rapidly became clear during actual shuttle operations in the early 1980s that the vehicle was simply not capable of meeting the grandiose objectives set for it. Throughout this period, Air Force spokesmen such as then Secretary of the Air Force Edward C. "Pete" Aldridge continued to be vocal advocates of a continued expendable launch option. This foresight was tragically proven correct in the months following the 28 January 1986 *Challenger* accident. The Air Force subsequently sought to restart an expendable program to produce a more affordable launch vehicle. In sequence, an Advanced Launch System, a National Launch System, and now an Evolved Expendable Launch System, were begun to replace the older legacy systems. These new "systems," designed to lower military and US government launch requirements, are struggling to demonstrate the "savings" to justify the investment to produce a new family of expendable launch vehicles. However, growing commercial uses of space may dramatically change this picture. As we will discuss in chapter 3, an affordable and responsive space launch capability must ultimately incorporate some form of reusable launch vehicle technology.

On an organizational front, the Air Force has long believed that space and space operations were important and even crucial for future US national security. The entire Department of Defense has now embraced that belief. Indeed, *Joint Vision 2020* outlines a strategy to use dramatically fewer forces while retaining a superpower-like punch. It views space operations as the key enablers of warfare in the next century.

Two new mission areas are still evolving: space control (the ability to protect our use of space while denying its use to an enemy) and force application (the ability to apply force from space to an enemy in space or on Earth). Both will play central roles in the future of space power, but today must deal with long technological lead times and political sensitivities.

Space Reconnaissance

As noted above, the denial of air access over the Soviet Union in the early 1960s demanded that the essential Cold War function of strategic reconnaissance move into space. The story of this effort is the history of the National Reconnaissance Office. Throughout the Cold War, this remarkable organization executed many of the nation's most secret and most successful operations. Until 1992, the very title of the organization was highly classified.

Founded in 1961, the NRO was created to clarify responsibilities between the Air Force and the Central Intelligence Agency (CIA) with regard to space-based reconnaissance. In many ways, establishment of the NRO was a setback for the Air Force. As discussed above, manned space initiatives had already slipped away from the military. Now the NRO had absorbed another prestigious mission: space reconnaissance. The history of the NRO ever since has been characterized by a tug-of-war between the CIA and the Air Force, the former focused on the need for strategic intelligence for national security, the latter focused on more tactical intelligence for war-fighting application.

The NRO has now declassified its earliest reconnaissance platform, the aforementioned CORONA project. CORONA actually began in 1956 as an Air Force project code-named Sentry/Samos. Its importance was magnified first by the launch of *Sputnik*, then by the shoot-down of Powers' U-2. Though its

method was crude (returning film to Earth via reentry canisters), CORONA fulfilled its mission of photographing areas denied by the Soviet Union and set a completely new standard for intelligence collection. Later platforms would prove more capable and more diverse, collecting not only visual pictures (imagery intelligence, or IMINT), but also signal intelligence (SIGINT) and communications intelligence (COMINT).

Throughout the 1960s, the détente of the 1970s, and the renewed arms race of the 1980s, the NRO remained a top-secret organization. It continued to develop, build, and operate the most advanced space-based intelligence systems.[7] The future of an independent NRO is uncertain, however, given the end of the Cold War and the development of increasingly sophisticated commercial surveillance programs. In accordance with recommendations made by the Rumsfeld-led Space Commission in January 2001, it is likely that the NRO will come into greater alignment with joint war-fighting requirements and operations, while continuing to provide important national security space capabilities.

Commercial Ventures

The use of space for commercial endeavors, particularly communications, was an early entry in the space arena. Indeed, science fiction author Arthur C. Clarke first proposed the positioning of a series of communications satellites in the "geostationary" or GEO orbital positions in 1947. Such satellites are positioned so they orbit Earth's equator once in 24 hours, thus appearing to hang "stationary" over the equator. Accordingly, geodesy satellites (GEOSATS) are visible from most inhabited locations at the same position in the sky and can be used to relay communications signals around the world.

On 12 August 1960, NASA's *Echo 1*, the first passive communications satellite, was successfully launched into orbit by a Thor-Delta. It reflected a radio message from the president across the nation, thus demonstrating the feasibility of global radio communications via satellites. The largest and most visible satellite launched to date was the aluminized Mylar-plastic sphere, 100 feet in diameter. A large metallic balloon, it could bounce radio signals across the Atlantic Ocean when in the

right orbital position. Based on this success, considerable interest arose in constructing transatlantic communications systems. Two competing concepts were considered. The first, using systems in low earth orbit (LEO) such as the *Echo* satellite, had the advantage of almost instantaneous communications—but it required many satellites in LEO. The second was to be based on Arthur C. Clarke's concept of GEO relay systems, which suffered from a time delay of several tenths of a second caused by transmitting, at the speed of light, from Earth to the satellite some 40,000 kilometers away, and back to Earth. Another argument ensued over whether the demonstration and subsequent system should be developed by a commercial enterprise (the key company at that time being the AT&T Corporation) or by the government. The resulting compromise was a government-chartered monopoly: the Communications Satellite (COMSAT) Corporation, enabled by Congress in August 1962.

After COMSAT came the international equivalents, International Telecommunications Satellite Consortium (INTELSAT) in August of 1964 and, later, the International Maritime Satellite Organization (INMARSAT) for ocean communications systems. INTELSAT was initially controlled and majority owned by the COMSAT corporation—a cause for later international consternation.

COMSAT was a very successful initiative. By the late 1970s, however, it had become, like most other monopolies, somewhat inefficient. COMSAT thus became a private corporation and soon faced a rapidly proliferating set of communications satellite competitors. Many other nations began to purchase and emplace their own domestic communications systems, all using varying degrees of government control. Some of these systems became commercial competitors of US commercial concerns and international groups such as INTELSAT.

There are two key limitations of GEO communications systems. First, they require relatively high-power uplinks and large "receive" antennas. Second, and more significant, there is limited frequency "bandwidth" (ability of the available electromagnetic spectrum to carry information) as well as limited locations within the GEO belt to avoid interference between different satellites. These two constraints have led to the design

and initial development of distributed LEO constellations. The first of these, the IRIDIUM system, has struggled financially, but is still in service. Relying on many small satellites (the technology for which grew out of the Strategic Defense Initiative [SDI] program) linked via radio cross-links, IRIDIUM provides global "cellular-style" service nearly anywhere on the planet. Follow-on systems will increase the data rates so that the distributed LEO systems can offer a viable alternative to the increasingly crowded GEO belt. The key fact to glean from this expansion in commercial satellite systems is that telecommunications, a key global utility that is worth over $500 billion in annual revenues today, has begun a migration into space. We note here the space communications industry faces stiff competition from advanced terrestrial communications networks (e.g., fiber-optic pathways). However, especially from a national security standpoint, there will always be a requirement for spaceborne communications, as only they provide truly global coverage. The increasing need for bandwidth for the US Navy worldwide, for Air Force unmanned aerial vehicles (UAV), and for communications in remote terrestrial areas (such as Afghanistan) are prime examples of requirements that cannot be met by fiber-optic networks.

Another commercial space development, "global awareness," grew out of NASA's LANDSAT Earth resources system efforts in the 1960s. In the mid-1980s, the LANDSAT program was prematurely transferred to commercial operation as part of the Reagan administration's enthusiasm for divesting the government of (hopefully) commercially viable industries. Although that struggling industry (largely providing low-resolution multispectral images to scientific and Earth resources users) has experienced little development, the subsidized European competitor, SPOT IMAGE, has shown some commercial success. The development of small, affordable satellites is changing the situation once again, however. There are now at least a half-dozen commercial multispectral and hyperspectral imaging systems scheduled for launch in the near future for numerous commercial and government uses.

Perhaps the most important, albeit unrecognized, "space based" businesses are those that rely on new space systems to

do their traditional terrestrial jobs more effectively. To date, most of these have centered on the GPS. This system has been a great boon to such diverse endeavors as precision farming, fleet management, surveying, and myriads more. These applications follow from the existence of a "global space utility"—a concept we'll return to in chapter 4. Such businesses are growing at a 20 percent annual rate. With the expectation that 1,500–1,800 new satellites will be launched in the next 10 years, and with worldwide commercial spending on space outspending military expenditures for the first time in 1996 (53 percent versus 47 percent—a gap that will only continue to widen), the explosion of commercial space bodes both well and ill for military space. Commercial space is beneficial in that it provides greater capability for less DOD investment. It is detrimental to the extent that a potential adversary has greater access to militarily useful information.

The Great 50-Year Space War

As new as space is, it has already played a vital role in the unfolding history of humankind. It is our postulate that "space" capabilities—aggregated across the four sectors discussed above—were the defining national security features of the second half of the twentieth century, and will remain the enabling force for military and economic effectiveness for the first part of the twenty-first century. We could regard the struggle beginning with World War II and US entry into that war in 1941 as the ideological struggle between democracy and various totalitarian "isms." The struggle ended, at least temporarily, in 1991 with the collapse of the Soviet Union.* This period, most of which is known as the Cold War, was so dominated by space activities that it could be better known as *The Great 50-Year Space War*.[8]

The 1940s were a time when space first emerged as a field of conflict. It was also a time when the rapid attack of enemy strategic centers and populations—at that time through air-

*Note that we have already witnessed the rise of new "isms" as serious threats to our national security, most notably terrorism and religious totalitarianism.

power—became the dominant theme of conflict. In the 1950s, space weapons were developed and began to replace air vehicles as the dominant strategic element. Further, this was a time of significant development and perfection of the basic strategic doctrine the United States was to use for the next 30 years. The 1960s was an era during which space capabilities had stalemated either superpower's ability to move forward on strategic or other fronts. However, the 1960s was also a period when the first major space "campaign" was undertaken—the race to put a man on the Moon.

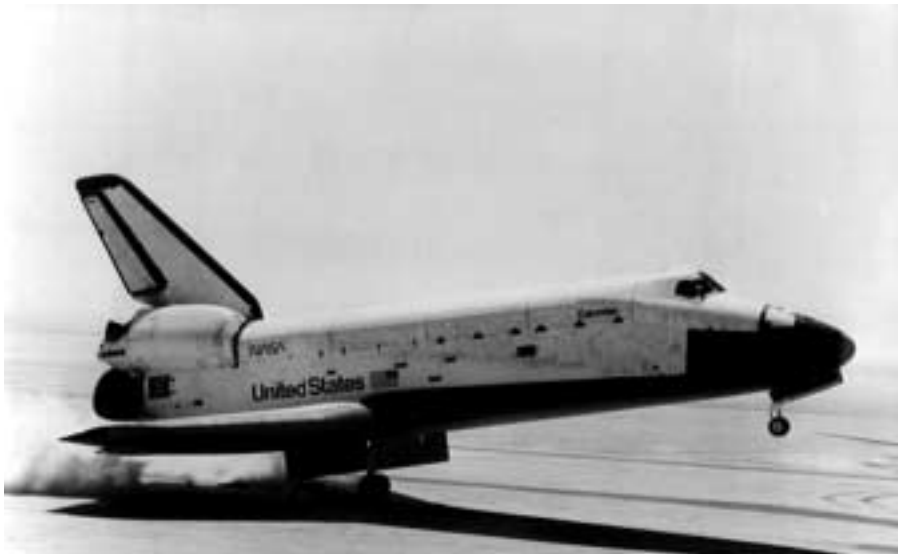
As discussed, this first campaign of the Great Space War began within the sector of space exploration. The "Moon Race" began in a period when numerous strategic thinkers had become convinced that space was the next regime for military competition. President Kennedy's quote earlier in this chapter demonstrates this belief from the American point of view. Throughout the Cold War, the Soviet Union, to an even greater extent than the United States, tended to attribute interest in space domination and competition to its peer competitor. Direct military competition in (and for possession of) space appeared dangerous and confrontational. Thus, Cold War leadership chose "space exploration" as a competition surrogate. It is significant to note that external "exploration," as in sixteenth and seventeenth century British-French competition and nineteenth century Russian-British competition in Central Asia, has often been a surrogate for direct politico-military confrontation. With the landing on the Moon on 20 July 1969, the United States decisively won this first campaign. Although it did little to exploit the advantage, this outcome was very significant—it was the initial blow that set up the eventual victory, for it convinced the Soviets that direct space competition would likely result in their defeat.

Lassitude was dominant in the United States during the 1970s, largely due to its struggles in and eventual withdrawal from Southeast Asia. The Soviets used this period to perfect their strategic theory, to build a dominant "space" offensive capability in ballistic missiles, and to quietly develop the space infrastructure (symbolized by their multiple space stations) necessary for the next major leap. This might be regarded as

the second space campaign of the Cold War—and one initiated by the Soviet Union (in essence, a "counteroffensive"). The Soviets also focused on beefing up ICBM systems: SS-18s, mobile missiles, and multiple independently targeted warhead systems (MIRV). The United States responded initially on Soviet terms with ground-launched cruise missiles, the Pershing 2, Peacekeeper ICBM options, and super-quiet submarines. In addition, the United States continued with plans on the drawing board for new space systems such as GPS and the survivable MILSTAR strategic communications system. The United States also met the Soviets on their own terms when it came to scientific uses of space: space station development and Mars exploration. Though the Soviets seemed to be gaining an upper hand, they soon found themselves mired in a reprise of Vietnam: Afghanistan. This unexpectedly difficult campaign bled their confidence and resources, and also galvanized the US response, which initially took the form of across-the-board US defense expenditure increases under the Reagan administration.

Space assets played a crucial role during this same period—indeed, throughout most of the Cold War—in preserving the existing nuclear deterrence stability. US space-based reconnaissance and surveillance platforms monitored Soviet nuclear missile deployment and numbers, thus facilitating US strategic policy and preventing the Soviets from attaining any "surprise" superiority. Maintaining this stability during a period of US lassitude proved critical, enabling the United States to take the offensive in the third, and last, space campaign of the Cold War.

The 1980s witnessed the third space campaign of the war. Motivated by enthusiasm for defense-dominant strategic theory, the Reagan administration launched the Strategic Defense Initiative (SDI) in 1983. The Soviets, shocked by this US strategic move in space and mindful of the defeat they had suffered in the first space campaign, responded on several fronts. They first sought to exploit their superior space infrastructure, which they had painstakingly built up through the 1970s, by augmenting it with counterspace capabilities. The Soviets, however, lacked the corresponding superiority in electronics



Courtesy of NASA

Space Shuttle *Columbia*

and control, which led to failure for most of the various Soviet space weapons tests in the latter 1980s, including their space-based "death rays" in the form of lasers. Coupled with apparent US successes in the same period, the Soviets concluded they were losing—and would eventually lose decisively—in this campaign.

Their response was twofold. First, they sought to limit US ability to go into space through arms control agreements and other diplomatic initiatives. These tactics met with some success, but were thwarted by nothing other than President Reagan's personal commitment to SDI. Second, Soviet leader Gorbachev sought to strengthen the Soviet economy to better compete with the West, particularly in areas such as SDI. He did this through loosening central control and reducing socialist state planning. This effort backfired, however, as it unleashed the internal dissension that eventually brought down the Soviet Union. Seldom in history has such a modest effort—about one percent of total US defense expenditures during that period—had such a devastating effect on an adversary.

The Strategic Defense Initiative was, arguably, the final significant act of the Cold War. SDI was launched in 1983, in an era when a general view prevailed in the US defense community that the United States, if not losing, was certainly not winning the Cold War. Soviet political agitation, coupled with growing domestic opposition to continued reliance on offensive nuclear weapons, placed the future very much in doubt. Although not specifically formulated as a "space" initiative, but rather as a nonnuclear missile defense initiative, SDI did indeed contribute significantly to ending the Cold War. The key was not the actuality, but the *threat* of space-based defenses. Offering a new and significant strategic counter to ballistic missiles, SDI had a particularly strong effect on the Soviet Union. Confronted with having to begin anew in understanding and developing a new mathematical correlation of forces model, and faced with an economic situation that could not support another round in the arms race, the Soviets found themselves at a significant disadvantage. Despite a coupled effort both to develop capable space weaponry and to use diplomacy and arms control to their advantage, the Soviets failed to stop SDI. Though SDI was, in the end, only one of many factors that ultimately led to the breakup of the Soviet Union and an end to the Cold War, its impact should not be lost on the student of military history.

The fundamental lesson of the "Great Space War" is that the key successful campaigns of the war—Apollo, space-based reconnaissance, and SDI—involved no armed clashes and no actual weapons, relying instead on "political" space competition, effective military space programs, and, in the case of SDI, the psychological deterrence threat of a new decisive space system. It is our contention that future competition, particularly in space, will follow these pathfinders.

Space Power at a Crossroads

We are now at a crossroads in the history of space power. The opening salvo of this continuing history—the Great 50-Year Space War—ended with a victory for the United States. The decade since has witnessed an extraordinary exodus into

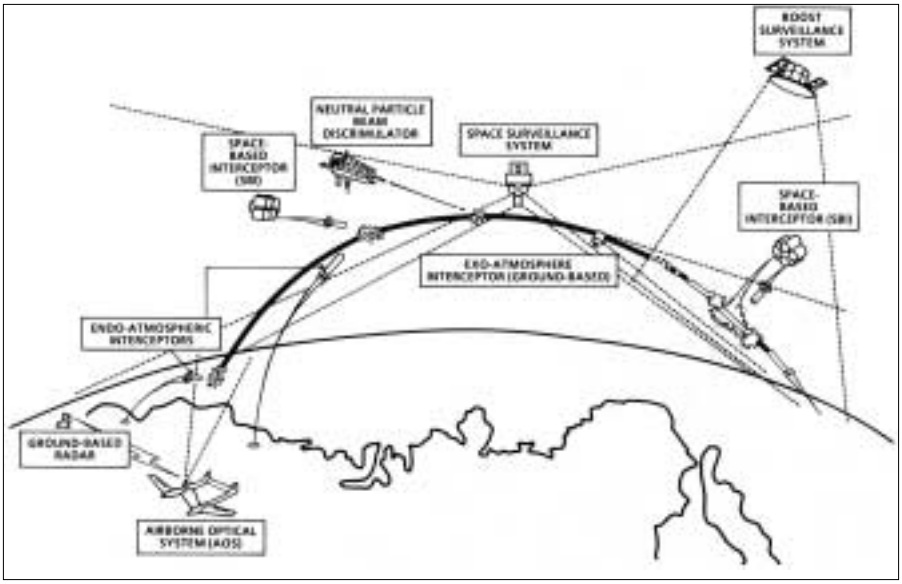


Figure 2. Notional Diagram of Proposed SDI System Architecture

Source: Simon P. Worden, SDI and the Alternatives (National Defense University Press, 1991), 187.

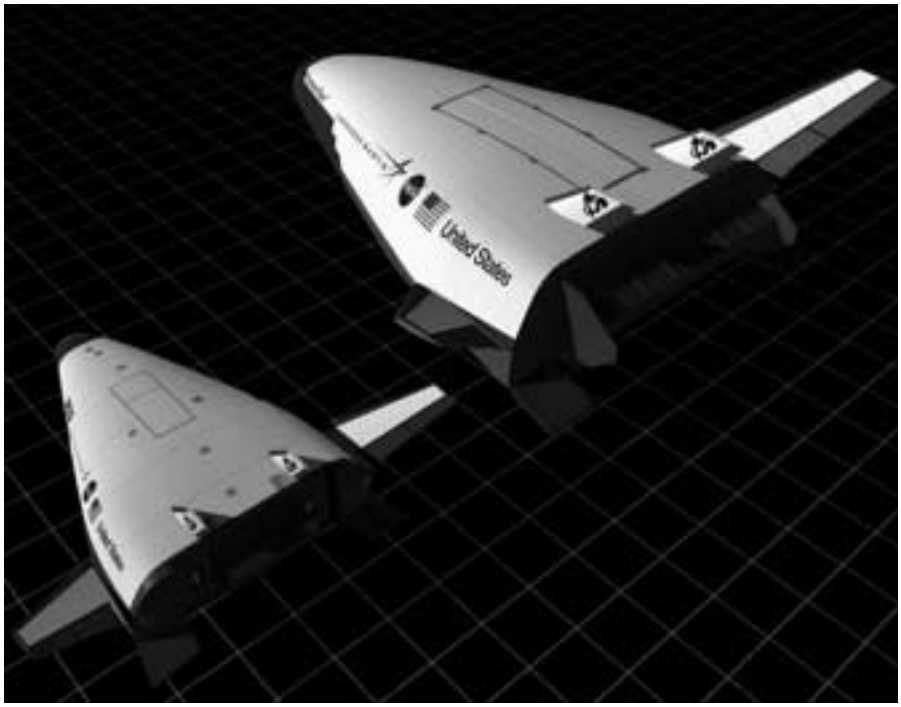
space of commercial programs of every conceivable kind: communications, imagery, Internet, and more. It has also witnessed a revolution in geopolitical affairs, where former adversaries are now allies (even NATO members), and new adversaries and threats, completely unforeseeable a decade ago, have emerged. As we attempt to deal with the realities of this new world order, two more recent events may serve as catalysts for the development of an effective US national security space strategy and policy. The first event was the publication, in January 2001, of the report of the Commission to Assess United States National Security Space Management and Organization (chaired by Donald Rumsfeld before he assumed responsibilities as secretary of defense). This report pointed out many of the shortcomings we attempt to elucidate in this book; for example, the lack of an overarching national security space strategy and the dangerous possibilities of a space "Pearl Harbor"—an attack upon our space systems by a determined

foe, likely using asymmetric means and methods. The Air Force and Department of Defense have made considerable progress in implementing the Commission's recommendations, including enhancing the authority and responsibilities of the under secretary of the Air Force (who also serves as director of the NRO), assigning command of Air Force Space Command to a 4-star space professional, and realigning space acquisition functions. These changes will, hopefully, focus our national security space efforts more effectively, and facilitate the development of a comprehensive space power strategy.

The second event was the act of war inflicted upon the United States on 11 September 2001. The use of such unconventional, asymmetric means to kill thousands of Americans serves as a warning to national security strategists—the wars of the twenty-first century will not be like the wars of the past. The attack also possibly marked the beginning of a new period of global competition—one between multiple societies/civilizations, all with potential for radically different motivations and objectives.[9] To meet the national security demands in this new global environment, we must think anew, especially from a space perspective, not only recognizing our vulnerabilities in the medium of space, but also realizing the strengths to be gained through effective employment of space power.

As before, space power will again play a key role as the history of the twenty-first century unfolds. The question of the moment: How will we respond? Will we allow our space capabilities to languish, or develop passively in response to events and threats? Or will we embrace a visionary space power strategy that anticipates these events and threats, and effectively intertwines space power with national security?

In this chapter, we have reviewed the history of space power and its influence on national security events in the past century. In the next chapter, we will look forward, anticipating some national security challenges that may lie ahead and the role of space power in meeting them. As these scenarios will demonstrate, future adversaries (like the terrorists of 11 September 2001) will employ new and unconventional means to exploit our weaknesses and deprive us of our instruments of power.



Courtesy of NASA

Artist's Concept of X-33 and Reusable Launch Vehicle

Many of those instruments—military, economic, and even the will of the American people—are inextricably linked to space.

Notes

1. David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson Air Force Base, Colo.: Air Force Space Command, 1997).
2. John M. Logsdon and Linda J. Lear, eds., *Exploring the Unknown: Selected Documents in the History of the US Civil Space Program* (Washington, D.C.: NASA, 1995); and Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985).
3. Spires, chap. 2.
4. Ibid., chap. 3.
5. William E. Burrows, *Exploring Space: Voyages in the Solar System and Beyond* (New York: Random House, 1990).
6. Carl Berger, "The Air Force in Space, Fiscal Year 1961," vol. SHO-S-66/142 (Washington, D.C.: USAF Historical Division Liaison Office, April 1966), 2.

7. Gerald K. Haines, *The National Reconnaissance Office: Its Origins, Creation, and Early Years* (Washington, D.C.: National Reconnaissance Office, 1997).

8. John Shaw, "The Influence of Space Power Upon History," *Air Power History*, Winter 1999.

9. Samuel P. Huntington, *The Clash of Civilizations and the Remaking of World Order* (New York: Simon & Schuster, 1996).

Chapter 2

Scenarios for the Twenty-First Century

In his book, *The Age of Heretics*,[1] Art Kleiner describes how a team of planners for the Royal Dutch Shell Oil Company successfully predicted the oil crisis of the 1970s two years before it happened. Accordingly, Shell took measures that other oil companies did not and was able to weather the storm more successfully. So successfully, in fact, that Shell, which had been ranked last by Fortune among the seven major oil companies prior to the crisis, emerged the strongest afterward. The Shell team of planners was unique, for rather than computing a bottom line or "best number," they developed the "heretical" practice of creating scenarios describing different possible futures. These scenarios not only gave Shell's top management vivid pictures of what they might face in the future, but also provided the opportunity to plan for a variety of contingencies rather than a single "bottom line."

This chapter contains four scenarios—four possible conflicts in which the United States could find itself in the next half-century. As with the scenarios of the Royal Dutch Shell planning team, these scenarios are not designed to predict *one* future conflict, but to create a picture of the sorts of issues and challenges the United States might face in that period.

The Rogue State

18 May 2003. Diplomatic Demarche from United Nations Security Council to Foreign Minister, Islamic Republic of Iran:

THE UNITED NATIONS VIEWS WITH EXTREME CONCERN IRANIAN BUILDUP OF ANTISHIP MISSILES THREATENING SEA TRAFFIC IN THE PERSIAN GULF. THE CURRENT LEVELS OF MISSILES ARE SERIOUS DESTABILIZING FACTORS IN THIS REGION. THE UNITED NATIONS STANDS READY TO ENSURE FREE AND OPEN USAGE OF THIS REGION TO ALL NATIONS. IF THESE MISSILES CONTINUE TO CONSTITUTE A THREAT AFTER 1 JUNE 2003, THE UNITED NATIONS HAS AUTHORIZED THE UNITED STATES TO TAKE WHATEVER

MEASURES NECESSARY, INCLUDING "EXTREME MEANS," TO MITIGATE THE THREAT. THE UNITED NATIONS DOES RECOGNIZE THE LEGITIMATE DEFENSE REQUIREMENTS OF IRAN BUT BELIEVES MISSILES IN EXCESS OF 10 UNITS WITHIN STRIKING DISTANCE OF PERSIAN GULF SHIPPING CONSTITUTES AN UNACCEPTABLE OFFENSIVE THREAT.

20 May 2003. From the Revolutionary Council, Islamic Republic of Iran, to The Great Satan:

The Islamic peoples of the world will no longer tolerate imperialist threats. All deployments of Islamic forces are strictly defensive. Attempts to interfere with our legitimate sovereignty will be successfully resisted.

1 June 2003. CNN News Report:

Following the president's repeated insistence that Iran remove its SUNBURN antiship missiles from the missile sites covering the Persian Gulf Straits of Hormuz, and Iran's repeated refusal to comply, the US Sixth Fleet launched 18 cruise missiles one hour ago against four of the six identified sites. These sites were completely destroyed, as seen in these CNN 'sky-eye' photos. In this final video sequence you can see the remarkable precision as the three cruise missiles strike each of the missile subcomplexes two seconds apart. The Pentagon has not yet confirmed destruction of the target sites.

15 June 2003. Minutes of Iranian Revolutionary Council Emergency Session:

Our revered religious leader, the Grand Ayatollah, opened the session to consider responses to the Great Satan's aggression against the people of Iran. He stressed his outrage at the unexpected American response. Much discussion of options ensued.

Immediate martyr actions against America and her Zionist lackeys were the preferred response of many. But the revered leader pointed out that such responses, while earning great merit and satisfying the peoples' immediate outrage, had done little in the past to remove American interference. While assisting the oppressed people of the world to resist their hated

overlords, little long-term benefit has been reached. The oppressor states usually redouble their efforts to deny the legitimate rights of the world's people. Longer-term lessons must be sought.

The progress of our long-strike missile development programs was indeed impressive. However, American missile defense efforts show every promise of responding before we can build sufficient power to overtake the American military advantage.

The revered leader tasked the special revenge group to give much thought and prayer to devising a method for eliminating the American and Zionist threat. Proposed options will be provided to the Revolutionary Council at its October 15 meeting.

The foreign minister was tasked to reiterate with all possible urgency the Iranian peoples' outrage at the corrupt Saudi stewardship of Islam's holy sites. Particularly heinous has been the repeated reports of Zionist women's presence and defilement of the prophet's most revered sites. ALLAH BE PRAISED.

15 October 2003. Report of the Iranian Revenge Group to the Revolutionary Council:

We have been asked to provide our people with effective and lasting neutralization of American interference in our affairs. We have studied deeply in both traditional Islamic learning and the writings of our hated adversary. As we expected, Allah used the mouths of our enemy to show us the path. We found many American musings about the "threat" of "asymmetrical" warfare. One article stood out which we particularly commend to your reading. We have translated and distributed this predictive article by Charles Dunlap, "How We Lost the High-Tech War of 2007."[2] It makes excellent reading. We have also read the Americans' own summaries of their Persian Gulf War against the Iraqi heretics. It is significant that some senior American military leaders called it "the first space war." We believe a five-year program will allow us to eject the Americans from the Persian Gulf. We have attached a detailed plan for your consideration. As you see, it has the added benefit of weakening the heretical and corrupt Saudi hold over our sacred sites and artifacts. The key points for your consideration are, however, few.

The Americans are increasingly enamored with information warfare and information dominance. They will try to use their undoubted superiority in information gathering and distribution to fix and target all enemy forces and plans. Simultaneously, they will try to identify enemy elements of what they call command, control, communications, and intelligence (C^3I) nodes and deny them.

Counter: The Americans do not realize the degree to which their C^3I nodes are located in space and almost wholly commercial. Over 95 percent of their domestic communications are commercial purchases. We, too, can purchase these powers. Conversely, we can use ancient means to defeat modern technology. In addition to using the same commercial means the Americans use—which they will have difficulty in shutting down—we can plan to communicate as our ancestors did. Many of the Americans' intelligence systems, such as the great cameras they use to spy upon us, were designed long ago in an American arrogance that no one could threaten them. These, too, we have found simple means to stop. The Americans have spent little time and effort to protect them from us.

The Americans will have long-term success only if they can rally the easily misled American people. These people can be easily swayed one way or another by images. If startled with initial images of "aggression" on our part, it will be difficult to stop America. Conversely, images of American aggression will result in American vacillation. If a conflict drags on and Americans come to see their soldiers threatened or, more directly, see themselves threatened, the Americans will demand a fast compromise solution.

Counter: We must make sure that Americans are treated to scenes of American atrocities at the initial phases of any conflict. We should exercise care to ensure that our martyr actions are not seen as coming from us. If we can then directly threaten many American lives, we can negotiate a solution to our benefit.

The American military, while touting its readiness for quick action, is in fact very slow to respond. We can count on several weeks before any coordinated military response to our actions can be brought to bear. When they do respond, it is important that many American losses occur so as to discourage the

American people. The more we can disrupt their C^3I systems, the more we can delay their response. ALLAH BE PRAISED.

24 February 2005. Paragraph 6, line item 4. Contract Between Telecosmos International Corporation and the Iranian Communications Company:

6.4: The Iranian Communications Company (ICC) agrees to purchase at least 10 percent of Middle Eastern sector bandwidth from 1 January 2006 through 1 January 2008 at prevailing market rates. The ICC in turn reserves the right to purchase up to 40 percent of this capacity at the same rates for periods not to exceed 30 days with 10 days' advance notice given to Telecosmos International.

19 May 2007. CNN News Report, Mecca:

Large-scale riots erupted in Mecca today, following the commission of one of the most insensitive pranks in recent history. At several points in this most holy city of Islam, groups of pigs—unclean animals to all Moslems—were released. As can be seen in these sky-eye clips, tens of thousands of Moslems rioted in this city and hundreds are dead. Saudi authorities have reacted with outrage, pledging the most severe penalties once the perpetrators are caught. The only group claiming any responsibility has been a hitherto unknown group calling itself the "Christian Defenders."

20 May 2007. CNN News Report, Cairo:

Thousands here are blaming the United States for yesterday's prank in Mecca. Massive anti-American demonstrations are ongoing at the US embassy here, and the scene is being repeated at US embassies throughout the Islamic world. Official US denials that the perpetrators are American or even associated with America are little believed, here or elsewhere.

25 May 2007. CNN News Report, Montgomery, Alabama:

Police here reported today that anti-Islamic literature and numerous other documents found in an office building near

Alabama's capitol have been confiscated. Local officials believe this office building may be the headquarters of the Christian Defenders group, which claimed responsibility for last week's Middle Eastern provocations. No arrests have been made as yet. However, police here say they have several good leads.

6 June 2007. CNN News Report, Riyadh, Saudi Arabia:

In an incident sure to exacerbate tensions in this Middle Eastern kingdom, four local women claim they were raped by "a large number" of US military personnel stationed here. All of those identified by the women are under custody. US military officials here promise swift investigation and action.

7 June 2007. CNN News Report, Riyadh:

Saudi officials here, in an unprecedented request, are demanding that the US servicemen accused of mass rape be turned over to local Islamic courts for justice. Lawyers for the accused have issued statements claiming that the local women were long-standing prostitutes operating within the American military community.

9 June 2007. CNN News Report, The Pentagon:

Citing existing Status of Forces Agreements, the Department of Defense has refused to turn over to local officials the servicemen accused of rape in Saudi Arabia. Among the reasons given in today's press conference was that Islamic punishment for convicted rapists includes clearly unacceptable consequences such as genital removal. Reaction from around the Arab world has been a repeat of several weeks ago, with increasingly violent protests against American embassies and facilities. These protests have not been limited to Islamic capitals. Several thousand people gathered outside the Pentagon this afternoon to protest what they say is recent American insensitivity to Islamic sensibilities. The following statement, given in response to a CNN reporter's question, typifies the protesters' thinking:

> I am an American of Middle Eastern extraction. I was born in the United States and consider myself to be 100 percent American. But now I'm not

> so sure. My fellow citizens have committed sacrilege in sacred religious shrines and shamelessly deflowered women they were sent to protect. I am disgusted.

Not all of these protesters were here to protest affronts against Islam, however. Numerous women's groups were present, protesting the debasement of women, whether Moslem, Jew, Christian, or other. Esther Ford, spokeswoman of the World Institute for Women, issued the following statement outside the Pentagon:

> It's time we bring our ill-trained American troops home. The past 15 years have repeatedly shown that our so-called men cannot keep their hands to themselves. I remind you that this is not an isolated incident, but that we have documented 14 rape and abuse cases promulgated by our Middle Eastern "peacekeeping" forces.

12 June 2007. Associated Press (AP) Report Summary, Riyadh:

After a marathon eight-hour negotiating session here in Riyadh, US Defense Secretary Bryan issued a joint communiqué with the Saudi government. It appears to do little to solve the ongoing crisis, however. The United States has agreed to phase out its presence in return for increased pledges of self-defense on the part of the Saudis. In the emotional issue of the accused rapists, the United States and Saudi Arabia have agreed to disagree. For now, the eight men will remain under US custody here in the US military compound.

16 June 2007. News Item, *Space News*:

In its largest overseas sale to date, World Image has sold exclusive rights to daily images covering over one million square kilometers of Middle Eastern territory. The Middle Eastern shipping consortium, Gulf Trade, plans to use this imagery, which will begin delivery on 1 July, for unspecified resource planning purposes. The proposal was approved in a routine action by the US Department of Commerce—which has sped up action on such requests, finalizing eight such requests in the last 90 days.

22 June 2007. Associated Press Report Headline:

LARGE-SCALE ANTI-AMERICAN PROTESTS SPREAD TO WORLD CAPITALS. US INACTION SEEN AS ANOTHER EXAMPLE OF AMERICAN INSENSITIVITY

25 June 2007. *Washington Post* Headline:

CONGRESS BEGINS HEARINGS ON "ADMINISTRATION MISMANAGEMENT OF MIDDLE EASTERN CRISIS." WHITE HOUSE DECLINES OPPORTUNITY TO TESTIFY

1 July 2007. Viewgraph 4, Morning Intelligence Briefing to the President:

- Imagery intelligence (IMINT) of Iranian army sites shows enhanced activity.
- Iranian region signal intelligence (SIGINT) shows no unusual command and control traffic.
- CONCLUSION: Routine redeployment activities are likely cause of Iranian activity.

3 July 2007 (2300Z). Air Force Space Command Space Operations Center OPREP:

DSP FLIGHT Z-5, SENSOR ANOMALY REPORT, MISSION SENSOR OPSCAP* RED, SATELLITE OPSCAP GREEN, OVERALL WARNING MISSION OPSCAP YELLOW. ANOMALY TEAM ACTIVATED.

3 July 2007 (2318Z). National Reconnaissance Office (NRO) Operations Center Report:

IMINT FLT BLUE-37 SENSOR ANOMALY REPORT. OPTICAL SUBSYSTEM OVERHEATING, SATELLITE IN SAFE MODE.

3 July 2007 (2322Z). Air Force Space and Missile Center Test Detachment Message:

---

* OPSCAP: "Operations Capability." "Green" meaning operationally effective, "Yellow" denoting degraded performance, "Red" denoting a failure. In this report, the satellite, or support spacecraft, is "Green"; but the sensor (payload) is "Red" and malfunctioning.

SBIRS FLT A-1. MAJOR ANOMALY, EARTH LOCK LOST, SATELLITE PLACED IN SAFE MODE, TEST TEAM RECALLED FROM LEAVE.

3 July 2007 (2337Z). Air Force Space Command Space Operations Center OPREP:

DSP FLT Z-4, SENSOR ANOMALY REPORT, MISSION SENSOR OPSCAP RED, SATELLITE OPSCAP GREEN, OVERALL WARNING MISSION OPSCAP YELLOW. ANOMALY TEAM ACTIVATED.

3 July 2007 (2348Z). Air Force Space Command Space Operations Center OPREP:

DSP FLT Z-3, SENSOR ANOMALY REPORT, MISSION SENSOR OPSCAP RED, SATELLITE OPSCAP GREEN, OVERALL WARNING MISSION OPSCAP RED FOR EASTERN HEMISPHERE. ANOMALY TEAM ACTIVATED.

3 July 2007 (2356Z). CINCSPACE Message to CJCS and SECDEF:

POSSIBLE SPACE SYSTEM ATTACK MESSAGE, IMINT FLT BLUE-37, POSSIBLE LASER ATTACK. FOLLOW-UP ACTIONS INITIATED.

4 July 2007 (0012Z). CINCSPACE Message to CJCS and SECDEF:

PROBABLE SPACE SYSTEM ATTACK MESSAGE, IMINT FLT BLUE-37, LASER ATTACK SENSORS CONFIRM LASER ILLUMINATION. LIKELY SOURCE WITHIN NATIONAL TERRITORY OF IRAN. EASTERN HEMISPHERE IMINT OPSCAP YELLOW. CINCSPACE DECLARES DEFCON 3 FOR ALL CINCSPACE COMPONENTS.

4 July 2007 (0126Z). CINCCENT Message to CJCS and SECDEF:

APPARENT WIDESPREAD NAVAL ACTIVITY IN NORTHERN PERSIAN GULF. SCATTERED REPORTS OF AMPHIBIOUS

LANDINGS ON SAUDI TERRITORY. CINCCENT DECLARES DEFCON 3 FOR PERSIAN GULF REGION.

4 July 2007 (0330Z). CINCCENT Message to CJCS and SECDEF:

WIDELY SCATTERED REPORTS OF FAST-MOVING LIGHT TROOP TRANSPORTS MOVING SOUTHWEST FROM SAUDI PERSIAN GULF COAST IN DIRECTION OF SAUDI CAPITAL OF RIYADH. UNABLE TO VERIFY STATUS OF SAUDI RESISTANCE.

USS *PHILLIPS*, MINESWEEPER, STRUCK WITH UNKNOWN WEAPON. SHIP SINKING WITH MODERATE REPORTED CASUALTIES.

4 July 2007 (1100Z). Minutes of Emergency National Security Council Meeting:

Defense Secretary Bryan briefed the status of the current Southwest Asia military actions.

An apparent large-scale Iranian invasion of Saudi Arabia is underway. Riyadh is the likely objective. Saudi leaders are aware of the situation and have vowed to engage the Iranians. They have requested all available US assistance in cutting off Iranian support and forces prior to their reaching Saudi territory but that US forces remain disengaged within Saudi territory.

It appears that the Iranians have engaged our overhead imagery and early warning satellites with some sort of laser weapon. We have temporarily lost all missile early warning assets capable of covering this region. Other assets are being moved into position, but early warning capability will not be restored for another 36 hours. Overall IMINT systems have been degraded by 50 percent. Synthetic aperture radar imaging capabilities are at 100 percent.

It appears that one US ship, the USS *Phillips*, has sunk, losing 36 sailors. The weapon used in this action is unknown and we cannot confirm at this time that it was part of the overall Iranian attack.

US Naval forces are at full readiness and are capable of mounting air and cruise missile strikes within four hours. US

and European land-based aircraft have been alerted and will be able to mount additional strikes commencing within 12 hours.

Secretary of State Smyth briefed the current diplomatic situation.

Opportunities for United Nations (UN) action to stem the Iranian attack appear low due to recent Chinese support for Iranian views. Chinese UN Security Council veto would stymie any US-proposed action. Most likely outcome would be a UN resolution calling for "return to normalcy."

Prospects for concerted Middle Eastern response are also unlikely due to recent Arab outrage over perceived US insensitivity to Islamic interests. European assistance might be forthcoming, but is unlikely to materialize for several weeks. If the situation can be stabilized, prospects will increase.

The president reviewed Department of Defense options for unilateral action. After considerable discussion, consensus was reached to conduct an immediate US strike on Iranian command and control centers, followed by intensive naval actions in the Persian Gulf to cut off logistics flow to Iranian invasion forces. US forces sufficient to eject Iranian forces from Saudi Arabia would begin mobilization, and would transport to forward NATO marshaling points. The president expressed his intent to immediately take this aggression to Congress and the American people.

4 July 2007 (0900 EST). CNN News Special Report:

Once again it appears that the United States is engaged in armed hostilities—for the fourth time in as many years, this time disrupting our Independence Day celebrations. In the president's very short remarks a few minutes ago, he outlined the current situation. Units of Iranian Revolutionary Guards staged an amphibious assault last night across the Persian Gulf and into Saudi territory. The president vowed to assist the Saudis in both repulsing this aggression and restoring a stable situation. The Iranian government issued a communiqué about an hour ago, stating their intent to "redress repeated American outrages against Islam" and warning against American interference in an internal Islamic issue. The Department of Defense has issued very little concrete information on this

engagement so far. CNN has learned, however, that one or more US Navy ships in the Persian Gulf have been hit and there are American military casualties.

In this sky-eye sequence taken earlier today, units of the Iranian Revolutionary Guard are seen converging on the vital crossroads of Al Huluf. We now take you live to our reporter in this town. "Al, what is the situation there?"

"Well, Mary, it's hard to know what is going on. Saudi radio has alternated between Islamic cultural programming and exhortations to the people to block the invaders—with their bodies if necessary. Few Saudi forces are seen in this town. A few minutes ago, a large Saudi armored column headed toward the capital city of Riyadh. This is somewhat surprising as the Iranian invasion is converging from the opposite direction. The people here seem remarkably unconcerned and little inclined to throw their bodies in front of any force. Of course, we must remember that the populace in this part of Saudi Arabia is overwhelmingly pro-Iranian Shiite."

4 July 2007 (1312Z). CINCNORAD Message to US and Canadian National Leadership:

POSSIBLE NORTH AMERICAN ATTACK DETECTED AT 1307Z. OTIS EARLY WARNING RADAR HAS DETECTED FOUR PROBABLE THREATENING OBJECTS INCOMING FROM THE PERSIAN GULF REGION ON AN INTERCONTINENTAL BALLISTIC MISSILE (ICBM) TRAJECTORY. SPACE EARLY WARNING SYSTEM OUTAGES PREVENT CONFIRMATION OF LAUNCH SOURCE AT THIS TIME—LOSS OF SPACE SYSTEMS PREVENTS DUAL PHENOMENOLOGY VERIFICATION. PROBABLE IMPACT: EASTERN PENNSYLVANIA.

4 July 2007 (1100 EST). CNN News Report:

This will certainly go down as one of America's more eventful Independence Days. We have received little news from the Persian Gulf, but are receiving a large number of reports of strange occurrences in eastern Pennsylvania. Shortly after 9 A.M. this morning, residents in several towns near Lancaster, Pennsylvania, reported several bright streaks in the sky followed

by sonic booms. We have also received several reports of "brightly colored parachutes" floating down from the sky. We do not know if these occurrences have anything to do with the current Persian Gulf hostilities. The Pentagon has issued a brief statement, which only admits, "incidents in eastern Pennsylvania are under study."

4 July 2007 (1620 EST). CNN News Report:

A press conference is under way here at the Pentagon. We will repeat the opening statement by the secretary of defense in a moment. He has confirmed that long-range missiles have been fired at the United States from the Persian Gulf. At least one of those missiles seems to have delivered a series of small, parachute-borne packages. The Pentagon has cautioned that anyone sighting one of those packages should immediately evacuate the area and contact local civil defense officials. We now take you live to the press conference with the secretary of defense.

5 July 2007 (0630 EST). White House Situation Room, Summary of Secretary of Defense Presentation:

The secretary of defense briefed the current Persian Gulf situation. We have executed 24 manned sorties against coastal Iranian command and control (C^2) sites with no aircraft losses. Eighty-six cruise missile sorties have been flown against internal C^2 targets. Due to limited overhead assets and insufficient numbers of unmanned aerial vehicles available for tasking, we are having very great difficulty in getting bomb-damage assessment (BDA) of strike effectiveness.

- The Iranian naval forces, consisting primarily of small, fast "motorboats," have been very difficult to interdict. Visual and optical surveillance of the Gulf has been of poor quality due to the very dusty atmospheric conditions typical at this time of year in the Persian Gulf region. The Iranians have scattered numerous small radar "corner reflectors" on rafts throughout the engagement region, making radar surveillance extremely difficult.
- Our communications connectivity has been extremely poor. It appears that many of our forces have been unable

to use commercial communications connectivity. We are working with the civilian contractors to establish workarounds.

- It appears that the Iranians have mined the northern Persian Gulf. We have had two destroyers damaged by mine strikes. It will be at least a week before we can begin mine-clearing operations due to the loss of our on-station minesweeper.
- The Saudi defense forces appear to have largely abandoned attempts to slow the Iranian advance in order to concentrate forces in defense of Riyadh. Consequently, lead elements of the Iranian forces now appear to have penetrated over 50 miles into Saudi territory in the first day of their assault.

The director for Central Intelligence added the following points:

Surveillance of Iranian C^2 traffic has been extremely confusing. Neither before nor even during the assault has there been any significant change in type and nodes for military C^2. Radar imagery has been singularly ineffective. The Iranians have scattered simple but effective "corner cubes," which produce very "bright" radar noise. As defense has pointed out, this noise has made it very difficult to track naval activities as well as land movements by radar.

6 July 2007 (1800Z). CINCCENT Message to NCA:

PRELIMINARY BDA OF THE C^2 TARGETS IN IRAN REVEAL ONLY SEVEN PERCENT FULLY SUCCESSFUL STRIKES. THE RECENT LOSS OF FOUR F-18 AND TWO F-22 AIRCRAFT HAS CAUSED US TO RETHINK FURTHER STRIKES AND ADDRESS NEED TO SUPPRESS ENEMY AIR DEFENSES. REQUEST GUIDANCE ON FURTHER STRIKES OF C^2 SITES AND OTHER POTENTIAL TARGETS.

7 July 2007 (0630 EST). White House Situation Room, Summary of Report to the President by the Secretary of Defense:

The Iranians have apparently succeeded in jamming Global Positioning System (GPS) signals during almost all of our

strikes. The precision munitions we have been using have backup inertial guidance. However, without GPS updates, they suffer lower accuracy to approximately a factor of three. This translates into only 10 percent of the effectiveness of a GPS-assisted guidance system.

Iranian forces have surrounded Riyadh. Saudi defense forces have put up stiff resistance but appear to be outnumbered and crumbling. Their most effective action to date was last night's evacuation of the royal family southeast to the town of Halaban on the road to Mecca. No direct attacks have been made on US compounds in Riyadh, but Iranian forces now surround over four thousand American troops and citizens. We have recommended an immediate evacuation and have begun this activity. However, it will take more than 48 hours to extract the bulk of our forces.

7 July 2007 (1800 EST). CNN News Report, Teheran, Iran:

The Iranian government today revealed that recent American strikes on Iran in retaliation for the Iranian incursion into Saudi Arabia were targeted against civilian population centers. We are standing here outside a hospital on the outskirts of Teheran. The building has obviously been largely destroyed. Those stretchers you see behind me, which seem to number in the hundreds, are all casualties. Iranian leader Ayatolloh Mhamadhi stated that these terrorist acts against the Iranian people will be swiftly avenged and will have no impact on the resolve of the people to see the American terrorists ejected from further interference in Islamic affairs. Government spokesmen also revealed two other targets with massive civilian casualties. This sky-eye view of a destroyed school near Shiraz lends considerable legitimacy to the Iranian claims. The several dozen white dots that are plainly visible outside the destroyed wing of the building on the left are apparent casualties. Back to you in Washington, Bill.

The Department of Defense had little response to our questions about these attacks on civilian targets, issuing only a terse statement that the United States does not deliberately target civilian populations.

8 July 2007 (0900 EST). Emergency National Security Council Meeting, White House Situation Room, Summary Notes:

The secretary of defense reported that two C-17s have been lost to heavy ground fire, with at least four hundred casualties, in attempts to evacuate American personnel from the three US compounds in Riyadh. Further evacuation attempts have been halted. Although US forces have engaged the Iranian attackers, it appears that the perimeters at all three compounds have collapsed. We lost all contact with our command posts there about 20 minutes ago, due to heavy radio interference. At least twenty-five hundred US personnel remain in these compounds.

The director of Central Intelligence reports that apparent Iranian laser blinders have neutralized all remaining overhead imagery systems. We have been unable to locate these systems by either electronic or radar imagery means. Other than the commercial news imagery, we have no way to confirm the reality of the Iranian claims of strikes against civilians. However, we can confirm that the buildings shown are in the general vicinity of C^2 nodes targeted by our strikes earlier this week.

The secretary of state reported that the UN has been singularly unhelpful. We were able to get only a weak call on all parties to cease hostilities. The general assembly passed a rather pointed request for all external influences to leave the Persian Gulf, but we were able to stop action on this statement. All of our allies in Europe and the Middle East have sent requests for additional information on the alleged targeting of Iranian civilians. All except the Brits have told us that, if there is any truth to this charge, it will be impossible to marshal support for any assistance to us.

8 July 2007 (1800 EST) CBS Evening News:

“This mob scene outside Philadelphia General Hospital is being repeated throughout the Northeast today. Thousands of people are besieging local medical treatment facilities demanding a counter to the AIDS virus they believe they have been exposed to. We bring you this word from our medical correspondent, Dr. Melvin LaForge, of the University of Michigan Medical

Center. “Dr. LaForge, do these people have anything to worry about, and is there anything that can be prescribed for them?” “Well, Joe, I know the surgeon general has issued a statement that you can’t catch AIDS from airborne contact with the virus. But I have to tell you Joe, I’m not so sure. I think most of us have significant skepticism about US government claims after last decade’s fiasco over the Persian Gulf syndrome, and the more recent bumbling in reaction to the anthrax attacks six years ago. We now know that those Gulf War illnesses were directly related to the twin exposure of chemical agents and a normally benign virus. Yet it wasn’t until four years ago—almost 12 years after the first symptoms—that the US government acknowledged the problem and devoted enough resources to devise effective treatments. And we all remember the confusion over the anthrax attacks in 2001, and the mixed messages the government delivered on the dangers at the time. Remember how everyone was clamoring for antibiotics? Until we can complete a thorough genetic deconstruction of the material in the canisters, no one can say whether this is the standard AIDS virus or some form modified for airborne transmission. I know that I would recommend that anyone in that region of the country begin an immediate treatment of our most effective AIDS regimen. You have to ask yourself why the Iranians would have gone to all the trouble to deliver a biological agent that was ineffective. Further, I would suspect that, if effective, they probably know something about countering it as well.”

10 July 2007 (1800Z). CINCCENT Status Report to CJCS and SECDEF:

1. ALL AMERICAN FORCES IN THE VICINITY OF RIYADH HAVE APPARENTLY BEEN CAPTURED. WE ESTIMATE APPROXIMATELY TWO THOUSAND US PERSONNEL ARE IN IRANIAN CUSTODY. WITHOUT OVERHEAD CAPABILITIES, OUR AIRBORNE RECONNAISSANCE HAS BEEN UNABLE TO LOCATE THEIR WHEREABOUTS. WE HAVE BEEN ABLE TO SUCCESSFULLY INTERDICT AN ESTIMATED 90 PERCENT OF IRANIAN LOGISTICAL SUPPORT TRAFFIC ACROSS THE PERSIAN GULF. WE HAVE STOOD DOWN FURTHER ATTACKS WITHIN IRAN PROPER, FOLLOWING SECDEF DIRECTION.

WE BELIEVE WE COULD CONSIDERABLY ATTRIT IRANIAN FORCES IN SAUDI ARABIA, WHICH WE ESTIMATE AT APPROXIMATELY THREE LIGHT MOBILE DIVISIONS, WITH FOCUSED AIR STRIKES FROM CARRIER AND AIR EXPEDITIONARY FORCES. REQUEST NCA APPROVAL FOR SUCH STRIKES.
2. PRELIMINARY ANALYSIS BY CINCCENT STAFF IN CONCERT WITH JOINT STAFF HAS BEEN CONCLUDED WITH A GENERAL PLAN TO RECAPTURE OCCUPIED PARTS OF SAUDI ARABIA FROM THE IRANIANS. IT WILL REQUIRE SIX CARRIER BATTLE GROUPS AND APPROXIMATELY EIGHTY THOUSAND AMPHIBIOUS TROOPS. ESTIMATED D DAY, 25 OCTOBER 2007. REQUEST GUIDANCE.

12 July 2007 (1400 EST). CNN News Report, Washington, D.C.:

Senator Strockbridge has just completed a speech on the Senate floor, which we will broadcast in its entirety momentarily. In it he makes it clear that Congress wants an immediate end to US involvement in what the senator called the biggest fiasco in American military history. He has also called for an immediate focus on treatment for the millions who may have been infected by what's being called Teheran AIDS. The senator has made it clear that he has overwhelming bipartisan support for activating the War Powers Act for the first time and has scheduled a vote for two days from now.

14 July 2007 (1000 EST). CNN News Report, Halaban, Saudi Arabia:

Saudi high command one-half hour ago announced a cease-fire with the invading Iranian forces. They have agreed to begin negotiations with the Iranians on the "protection of Islamic holy sites and a new security arrangement for the Persian Gulf region."

15 July 2007 (0800Z). Iranian Government Official Statement:

IRAN WELCOMES THE PARTICIPATION OF THE SAUDI GOVERNMENT IN DEFINING A NEW ERA OF ISLAMIC LIFE IN OUR REGION. WE SEEK NO LAND, ONLY A SECURE AND SACRED ENVIRONMENT FOR ISLAMIC PEOPLE

EVERYWHERE TO PURSUE OUR OWN CULTURE FREE FROM WESTERN INTERFERENCE. AS FOR THE AMERICANS, WE HOLD NO ANIMOSITY FOR THE AMERICAN PEOPLE BUT MUST LET BOTH THOSE PEOPLE AND THEIR CORRUPT GOVERNMENT KNOW THAT THE IRANIAN PEOPLE HAVE SUFFERED ENOUGH AT THEIR HANDS. WE WILL MATCH YOUR ATROCITIES WITH FEARLESS RESOLVE AND EXTRACT HOLY VENGEANCE AS WE HAVE BEGUN TO DO ALREADY FOR EACH OUTRAGE. WE WILL HOLD YOUR DECADENT SOLDIERS RESPONSIBLE FOR THEIR ACTIONS. WE WILL PROVIDE A BEACON TO A NEW WORLD ORDER FREE FROM YOUR INTERFERENCE.

21 July 2007 (1400 EST). Summary of National Security Council Meeting, White House:

The secretary of defense reported that three carrier battle groups are now in place with two more to arrive by 25 July. Two wings of forward-based strike aircraft have been moved to Diego Garcia. At the request of North Atlantic Treaty Organization (NATO) governments, no strikes or overflights will be used from European or Mediterranean locations. Full buildup with necessary amphibious forces remains on-schedule for 25 Oct D day. Lack of land-based access in the Middle East will seriously hamper operations.

The secretary of state reported that Saudi officials have agreed to allow US representatives into the cease-fire talks with the Iranians. They report that Iranian officials have agreed to this presence. The Saudis continue to request no US actions within their territory and believe they may be able to negotiate a peaceful settlement to the conflict.

The attorney general reports that large-scale riots over the unavailability of AIDS treatment have spread to the west coast, with thousands rushing to hospitals in Seattle, San Francisco, and Portland. The surgeon general, attending this NSC meeting by special invitation, reports that there is absolutely no reason to believe the airborne AIDS virus is contagious. Samples of the Iranian-delivered virus are identical with the known virus. However, the nationally televised messages from the surgeon general's office seem to have had a counter effect, leading to numerous denunciations of the US government's opinions by noted medical personnel—many who should have known better. Efforts to increase supplies of anti-AIDS

treatments are not expected to significantly increase supplies until early autumn.

Four different congressional resolutions demanding an immediate cutoff of funds for continued Middle East operations have been introduced. All are expected to pass within the next three days with overwhelming majorities.

4 August 2007 (1800 EST). CBS Evening News:

The video recording you are about to see was released by the Iranian government earlier today. We warn viewers that the scenes shown are both graphic and disturbing. You will recall that the Iranian forces occupying Riyadh announced last week the "convictions" for rape of 47 US troops in their custody. They further announced that "swift Islamic punishment" would soon follow the convictions. The first of those punishments, surgical castration, was conducted earlier today and is shown in its entirety on the following tape. The US military individual shown in these tapes has been identified as Air Force 1st Lt Timothy Wells, of Denver, Colorado. Although apparently conducted under sanitary surgical conditions, it also appears that no anesthetic was administered. The Iranian government also announced that the remainder of the punishments would be carried out "soon."

14 September 2007 (1800Z). CNN News Report, Riyadh:

In a joint communiqué issued by the Saudi and Iranian governments, the two parties to the current Middle Eastern conflict announced a negotiated settlement. Iranian forces have agreed to withdraw immediately from Riyadh. This withdrawal appears to be largely on Saudi terms, with Iran getting only an agreement that a joint Saudi-Iranian commission will henceforward administer the Islamic holy sites in Medina and Mecca. No Iranian forces will remain on Saudi territory.

15 September 2007 (1400 EST). CNN News Report, The Pentagon:

The secretary of defense announced a few minutes ago that, as part of the negotiated Saudi Arabia–Iran settlement, all US

personnel under Iranian control will be returning home immediately. He also said that a joint Arab-Iranian task force would henceforward patrol the Persian Gulf. On a note of great personal interest to Americans, the Iranian government has agreed to pay $2 million to Lt Timothy Wells, subject to US agreement to try him and his fellow accused colleagues in US military court for the alleged rape charges.

14 May 2008. Executive Summary of Joint Congressional Report on the Iran–Saudi Arabia Conflict of 2005:

In the course of thousands of hours of hearings and millions of pages of documents, the US Congress cannot help but conclude that the United States and its interests suffered a major defeat in the Persian Gulf War of 2005. The coup, which toppled the Saudi royal family from power in January and replaced it with a pro-Iran Shiite Junta, underscores the complete victory achieved by Iran in this conflict.

From the start, US forces in the Persian Gulf, as well as our entire intelligence apparatus, completely failed to recognize the true state of events. Our problems stemmed from both a complete reliance on space-based overhead intelligence gathering systems and our misunderstanding of the degree to which Iran recognized this fact and knew how to use it to their advantage.

Most telling was our reliance on signals and communications intelligence to provide strategic warning of the impending attack. It was significant that no increase in C^2 traffic was detected in the weeks leading up to the military action. The Iranians both understood and made use of US dependence on space systems. It is quite possible to use nonelectronic means of communications to conduct complex military operations. Armies have done so for thousands of years. Through constant training, and by using couriers and even signaling with small mirrors to reflect sunlight, the Iranian Army was able to prepare and strike, giving away little of their positions or intentions.

The Iranians also successfully confused and frustrated US capabilities that rely on sophisticated electronic and space systems. By mounting simple industrial lasers on trucks, they were able to dazzle and blind both our early warning and optical

imaging systems. Similarly, Iranian use of simple "corner reflectors" scattered both at sea and on land, made it impossible for our air- and space-borne radar imaging systems to get an accurate picture of enemy formations. Perhaps most effective was the Iranian approach to denying US Global Positioning System (GPS) signals. By "detuning" their television broadcasts, they were able to jam effectively our use of the system. Since we relied almost exclusively on precision-guided munitions that use GPS, the large-scale denial of GPS ruined those weapons' effectiveness. While the US military correctly pointed out that our weapons have other means of guidance, such as inertial reference systems, these are invariably less accurate. Thus, our strikes with precision-guided weapons were not only ineffective, but inadvertently gave the Iranians one of their most effective propaganda weapons—the unforeseen destruction of civilian sites with large, highly visible loss of life. Moreover, as noted above, even an effective interdiction of Iranian C^2 nodes would have little effect on the enemy's military progress as they had worked hard to largely eliminate their reliance on "high-tech" communications.

We should not conclude, however, that the Iranians did not make very effective use of high technology and space systems for themselves. Recognizing that commercial space systems are widely available, they used them and, in many cases, actually denied our own use of commercial space systems. Their commercial imaging purchases enabled them to locate and destroy our one and only minesweeper in the Gulf. This was the one most crucial loss that led to most of our military casualties in this conflict. Similarly, their purchase of commercial cellular telephone service not only gave them an effective back-up and supplement to their nonelectronic C^2—it denied that same usage to our forces. Quite simply, we did not realize the degree to which US military forces had purchased and relied upon wholly commercial communications systems, usually without any central coordination. This too, contributed greatly to the confusion and prevented virtually any effective counterstrike in the early days of the conflict.

The Iranians' most effective use of high-technology commercial systems was in their exceedingly effective psychological

warfare campaign. From rapid broadcast of "US atrocities" to the chillingly effective spectacle of a US soldier's castration, the Iranians manipulated US and world public opinion to their advantage. Once again, the Iranians knew that a large number of US hostages—especially when those hostages are threatened with serious physical harm—would have an amazing impact on US public opinion. Similarly, the by now universally agreed-upon sham charge of blasphemy against Islam was clearly the result of well-thought-out Iranian psychological warfare actions. Without the negative world opinion these prewar actions generated, the United States might have been able to generate an effective international counter to the initial Iranian attack.

Perhaps the most effective Iranian action of all was the completely nonthreatening ICBM attack on the United States. In retrospect, it would appear that we adhered too long to the former ABM Treaty, for our developing missile defense capabilities were not yet mature or responsive enough to intercept even the two attacking missiles. This problem was compounded by the Iranians' effective blinding of our space-based early warning system. The fact that we were not able to provide the public with any credible information for 48 hours was the prime reason the people would not believe anything we claimed later. Had we not postponed an updated and distributed early warning system, "SBIRS Low," we might have at least been able to warn of the attack. The addition of a completely harmless, but universally feared, "AIDS" payload was a stroke of pure genius. The US government was put into the awkward position of trying to retaliate against something we claimed was harmless. Not only did our people not believe their government, but the world would also have regarded it as hypocrisy to administer a deadly counterstrike to a harmless first move.

The Congress concludes that we have lost a major battle for the vital Middle Eastern region. We are now effectively expelled from the entire Persian Gulf region, which seems to have been the Iranians' primary purpose in the first place. While Congress must bear some of the blame for responding precipitously to public opinion, the administration and particularly

the Department of Defense must bear the bulk of the blame for once again preparing for the next war based on our experiences in the past. Confident that our high-technology systems and our space-based systems would operate as effectively as they had in the 1991 Persian Gulf War and the 1999 Kosovo campaign, we did not anticipate that others would learn from those wars and devise effective counters, as the Iranians indeed have done. We were also deceived by our more recent experiences in Afghanistan and Iraq, where we fought an enemy not bold enough to directly challenge our spaceborne assets. The Iranians were far bolder.

Congress believes we must learn several lessons and take several actions. We do not believe the United States should abandon its efforts to gain and maintain a high-technology advantage. We quite simply cannot afford the manpower, and our people will not tolerate the ruthlessness necessary, to match the approach taken by the Iranians. However, we must constantly strive to understand how a determined enemy will try to deceive and counter our technology. We can and must continue to use space and other high-technology capabilities, but we should also have both alternate space-based means and Earth-based means for gathering and distributing critical military information.

We cannot ignore the fact that commercially supplied space services are available to everyone. We cannot afford to avoid use of those services for ourselves. However, we must understand how to protect those commercial services for ourselves and deny them to a potential adversary.

The Battle for Global Utilities

Sun Tzu Rebutted

Remarks

by

Lt Gen Maria Barbicane

Deputy Chief of Staff for Air and Space Operations

United States Air and Space Force
at the
Graduation Ceremony
Class of 2018
Air and Space War College
1 June 2018

It is indeed a great honor for me to address you today—you who are soon to enter senior leadership positions in the most effective force the world has ever known. It's been only a few short months since our Service virtually single-handedly wielded the keys to victory. In just 10 years from the disastrous Persian Gulf fiasco—one in which everyone declared the era of high technology warfare was over, we reconstituted ourselves into the instrument of victory in Southeast Asia. Let me recount the few short weeks of the recent Vietnam conflict. The momentous victory of our Vietnamese allies over the Chinese aggressor shows all of those naysayers of the past decade that we are not only the last superpower, but destined to remain so for not only our own lives, but those of our children as well. And, as you can plainly see by my condition, my mind, as well as some other parts of me, is very much concerned with those children. (audience laughter)

A decade ago, the naysayers claimed our investment in space had been proven futile. They said we could not rely on space for any critical military function. They said it was impossible to count on space for navigation, intelligence, or C^2. They were wrong, as we so vividly saw a few months ago. Perhaps most important, they did not foresee that we were on the verge of wielding true "fire from heaven" to confound and defeat our enemies. In this war, we returned at last to our true calling of "killing people and breaking their stuff" (pause for applause). Now we can do it almost instantly from space—HUA! (pause for more applause).

We now know that the large-scale Chinese attack on Vietnam was intended to drive south in a lightning strike. They had hoped to capture not only the Vietnamese capital of Hanoi, but also our own naval base at Cam Ranh Bay much

further south. In short, the 35 attacking Chinese divisions, the largest land-army action since last century's World War II, hoped to capture 20,000 American troops and repeat on a very large scale the Iranian accomplishment of a decade ago. They were foiled, and you foiled them.

We knew what the Chinese were up to weeks in advance. Although still in the process of deployment, the new *Space Star* radar system was the key. Any electronic eavesdropping system can be fooled. A point image surveillance system, such as the old optical systems we've had for almost 50 years can be spoofed by moving when they are not there or aren't looking. The only way to know what an enemy is up to is to have a large-scale surveillance system that covers essentially his entire territory continuously. Although we only had 16 of the 24 satellite Space Star radar constellations in place this January, it was enough for us to detect the large-scale movement of ground forces two weeks before the 26 January attack on Vietnam. This allowed us to give our Vietnamese allies two weeks of vital warning, and it gave us time to both move carrier-based aviation into place and begin activating US-based air and space forces.

But it was the activities that followed Chinese entry into Vietnam that allowed us to really "strut our stuff." Both sides tried to use air and space forces to find, fix, and track enemy forces. Both sides soon found that airborne sensors simply could not survive in a modern battlefield and quickly established an impenetrable dome over their forces. After we lost 18 carrier-based aircraft in attempts to penetrate behind the enemy's front lines, we—and we soon found out they—turned to space. Perhaps our biggest surprise was that long-vaunted stealth aircraft aren't so invisible, particularly when each side has space-based infrared detectors.

Another great surprise of the conflict was the ineffectiveness of missile attacks. Neither the Vietnamese nor the Chinese were able to get ballistic missiles to their targets. Our Airborne Laser (ABL) Wing arrived just in time. Not a single Chinese missile reached its target. However, we were surprised to find that the less sophisticated but extremely effective Chinese surface-to-air missile (SAM) system almost invariably found

its target. The space-based infrared systems of both sides were effective in picking up missiles soon after their launch.

Within two weeks of conflict, it appeared that we might have gone back a century in time—to World War I. After penetrating some one hundred miles into Vietnam, Chinese forces simply bogged down into static warfare. Dug in to a level and depth that would have amazed World War I soldiers—sometimes at depths up to one hundred feet below ground—it appeared that we were in for a long fight. We estimate that the Chinese lost 450,000 troops in the first week of futile efforts to dislodge the Vietnamese line. Although less wasteful of manpower, Vietnamese counterattacks were equally ineffective. Our air support to any troop advance simply could not get to the front. But it was not to remain World War I redux.

It was clear that we had to help the Vietnamese crack the Chinese "dome of impenetrability." This is where the battle became ours to win, and this is where I came in. As commander of the Fourteenth Space Force, my forces were chopped to CINCPAC. I had to remove the space-generated dome over the Chinese forces. At the same time, I had to stop them from doing the same to us. And believe me, although this seems easy from our current perspective, it looked real hard at that time. The campaign for space took six weeks. Our task was to figure out what systems the Chinese were using and how to deny them those uses. What I soon found out was that my Chinese counterpart was trying to do the same thing to me—and he came a lot closer to succeeding than you heard about from the public media.

Our task was to dismantle the interlocked air and space net upon which his defenses rested. We quickly discovered the incredible degree to which the Chinese military was relying on space systems. Indeed, they depended on these systems almost as much as we did. It took us approximately two weeks to piece together their space order of battle and devise strategies to dismantle their use of space. First and foremost, we discovered that every Chinese system was operating on time coordination provided by the Russian NOVI-GLONASS and United States GPS. With time accuracies of four nanoseconds, Chinese forces were using small interlocked

computers to give them a truly distributed C^2 system. In short, there were no nodes for us to attack. They used these signals for geolocation of both their own forces and enemy targets, as did the allied forces. So our first objective was to deny or degrade their use of these signals.

Fortunately, we had the fully upgraded GPS Block IIIB Constellation 85 percent deployed. The new system gives us the ability to pinpoint-deny hostile use of both GPS and NOVI-GLONASS signals. This we did at once. Much to our surprise, the Chinese unveiled their own formidable capability. Their 32-satellite low-earth constellation of optical sensor satellites proved to have a "special" payload onboard. It not only provided a "pseudo" navigation and timing signal to the Chinese, it successfully denied our use as well. But we had a few surprises too, and were able to boost power and go to alternate frequencies over the theater of conflict. The first round of the space campaign was a draw.

We were at a loss to understand how the Chinese picked up our incoming aircraft—even stealthy ones—so far out that they were able to pinpoint-attack these assets before they got anywhere near the front lines. What we discovered was that they were using the raw signal of our radar satellites as a bistatic source for passive tracking of incoming aircraft and missiles. It took us about 10 days to figure that out and rephase the radar satellite transmitters to confuse the Chinese systems. This is when we found that some of those "optical sensor satellites" also had a small but powerful and effective radar transmitter. We had wondered why the Chinese satellites were so large. The intelligence community had assured us that it was only "poor and outdated Chinese technology." No wonder they say "military intelligence is a contradiction in terms." (wait for laughter) Round two of the space war was also a draw.

The prime objective of our initial space engagements was to degrade Chinese C^2. I've already noted that the Chinese used such a simple but sophisticated distributed computing and communications network that there were few, if any, C^2 nodes we could have attacked—even if we could penetrate the Chinese air defenses. What we could affect, however, was the

space-based communications satellite nodes. We used large-scale electronic and information warfare attacks against the Chinese space communications systems. To no one's surprise, they did the same thing to us. However, we had learned not to rely so heavily on commercial systems and to protect our space communications systems from such attacks; the Chinese had taken an opposite tack. They had purchased multiple accesses to a number of low-altitude Internet carriers. As I'll describe below, we eventually were able to handle the dilemma of how to deny them access to these systems, but that took considerably more time. Round three of the space war was a draw five weeks into the war.

It was becoming increasingly clear that we had a space war on our hands. We had been unable to deny the Chinese access to their space-produced services through ground-based means. Conversely, they had failed in their attempt to do the same to us. The next round of our space war was to get interesting. Although it took a lot of persuading, we finally got the president to authorize going after the Chinese space infrastructure. Initially, the rules of engagement (ROE) were to use only ground-based means. Thus, we activated our White Sands laser facility and retargeted the Aegis missile defense system for space intercept. We quickly found that the Chinese satellites were very hard to kill with either weapon by itself. It seems those multipurpose satellites had both a laser shield and a decoy-maneuver system so that they could take a direct laser hit and evade the interceptor missiles. After three days and the expenditure of 40 percent of our interceptor ammunition—with no confirmed satellite kill—we developed an effective, albeit slow and expensive tactic. By bringing the Aegis ships literally into our ports in Texas and California, we could just target an enemy satellite while it was in view of the White Sands laser. Thus, as the laser forced the satellite to "blink," we fired an interceptor at the same satellite. We found that the satellites could not simultaneously remain buttoned up and evade the interceptors. WHAM! One by one we were able to take out their satellites—but ever so slowly, only about one per day. But we were beginning to kill Chinese space forces.

Alas, our joy was short-lived. We soon saw that the Chinese were able to put new satellites up just about as fast as we could deplete them. Worse yet, we were running out of interceptors with little likelihood of new rounds coming off the assembly line in time. We needed to kill the enemy forces faster! Worse, the Chinese were beginning to score a few hits on our birds. While they had nothing as effective as our laser-interceptor one-two punch, they did manage an occasional lucky shot with their own interceptors. While they were killing our assets much slower than we were getting theirs, we were also much slower in launching new birds. We simply had to accelerate our offensive activities.

We turned to the 330th Spaceplane Squadron (interim), our newest war-fighting tool, just declaring IOC with four SF-1 spaceplanes. Although its full strength was not scheduled for two more years at 12 SF-1s, we pressed it into service as soon as we could. We had 48 Schriever II space rendezvous vehicles on hand and were producing more at five per week. Each spaceplane could do one sortie per day and carry four *Clem IV*s. I'll tell you, it was one hell of an argument to get the White House to give me release authority. I suspect it was the mounting losses of US pilots that finally persuaded the president to grant authority to conduct the world's first space-to-space battle. And it was glorious!

We launched at dawn, 18 March. Fifteen minutes apart, four spaceplanes leapt into space from southern California. Each deployed four Schriever IIs into four of the eight sensor planes occupied by the Chinese sensor system. Within six hours, the bad guys were 12 satellites lighter; in one day, we had taken out a third of their eyes. The next day, we launched again but weren't so lucky. One SF-1 blew up on launch and another had to abort before we got the Schriever IIs deployed. But the Chinese were seven satellites poorer—only one Schriever II missed, which was better than the four misses the day before. The Chinese launched three more birds, but we had them on the run!

The Chinese then did what we thought they would. They turned almost wholly to commercial sources for their data. Most of the global commercial communications and imagery

suppliers were persuaded through a combination of patriotism and money to deny access to the Chinese. But it took a demonstration of Schriever IIs flying in formation around two of Mr. Kates' commercial birds to persuade the world's richest man to assist us in return for our assisting him to get even richer.

With the loss of much of the Chinese forces' external eyes and brains, we hoped for a swift and effective counterattack by our allies to expel the Chinese. We were now free to assist them with air support essentially unhampered by ground defenses. However, after two weeks of heavy fighting and even heavier losses, allied forces had advanced only a few miles at most, and in some cases only a few hundred feet. It looked like we were in for a long war of attrition, and I don't need to remind you that the Chinese had lots more forces than our allies. We simply had to interdict the interlocked and mostly underground C^2 and supply channels that were supporting the Chinese front lines.

Our air-delivered munitions simply couldn't go deep enough to hit the underground Chinese nodes. So the commander in chief (CINC) turned to my sister space force, the Twentieth NSF. My good friend, and soon to be my daughter's godmother, Gen Pam Acuna, had an answer. Ironically, she didn't have as much trouble persuading the White House as I did—guess it's better to be second. They issued the coup de grâce to the Chinese. Four days of bombardment by the Minuteman IV's deep-target munitions threw the Chinese front line into disarray. Chinese forces had been all but expelled from Vietnam by 15 April, and lead allied elements had actually entered Chinese territory.

The rest is history, as they say. Although I personally would have liked to have a victory parade in Beijing, I doubt if the American people or our allies could have spent the manpower necessary to deliver such a victory. Besides, our civilian leadership has a negotiated settlement that will keep the Chinese dragon licking its wounds for an awfully long time.

There are a few lessons I need to foot-stomp before I get off this stage. First and foremost is that he who controls space and has the will to exploit it will win. It's that simple. Second—and

this is really important—you can't control space from the ground, you just gotta be in space. You know, this is an old argument for those of you who can remember the last century—which I unfortunately do. From the First World War on, lots of people argued that heavy firepower from the ground could control the air. Others, with names like Mitchell, Arnold, Eaker, and so on, knew you had to be up there to own the air. Well, this little space war just proved that adage in spades. We will not be able to control space unless we are in it! Finally, and this is the shape of things to come, weapons delivered through space, and soon *from* space as we deploy defensible lasers, are the final element of victory.

The reason I'm emphasizing these points is that I fear our civilian masters are ignoring them. Just two days after last week's victory parade the president asked, and Congress agreed, to limit our SF-1 buy to two squadrons. I know that this was perceived as a small price to get Chinese agreement on an admittedly very bad peace treaty from their perspective. But I can't help but believe that we will live to regret putting so much trust in paper when hard steel is to be had—or at least hard titanium and depleted uranium!

I just want to leave you with my best wishes for the world's very best and undoubted champion space warriors. HUA!!

The Pan-Asian Federation Strikes Back

Inaugural Issue

Journal of the Chinese Space Forces

Table of Contents

1 October 2020

(UNOFFICIAL TRANSLATION, TREAT AS "DEFINITELY SECRET" MATERIAL—NOT TO BE RELEASED OUTSIDE US/VIETNAM AUTHORIZED CHANNELS)

Invincibility Lies in the Defense; the Possibility of Victory Lies in the Attack—Applying Sun Tzu to Problems of Space Conflict, CSF Gen Wu Lao, 1–43.

The Importance of Medium-Earth Orbit—A Strategy for the Middle Kingdom, CSF Col Wang Ling, 44–58.

Striking Swift and Sure in Space, Avoiding Protracted Space War, CSF Chief Marshall Tu Yu, 59–65.

Imperialist Space Strategy—70 Years of American Aggression from Above and Thoughts on How to Defeat It, CSF Gen Li Chaun, 66–74.

Allies and Enemies in Space—Natural Alliances With Islamic States, CSF Lt Col Wang Hsi, 74–80.

Japanese Dependence on Space Commerce, CSF Maj Tu Mu, 81–89.

When You Make a Mistake, Do Not Be Afraid of Mending Your Ways, Confucian Lessons for Confounding Imperialist Designs, CSF Col Tzu Kung, 90–105.

Learning From The Enemy, "Always Have a Plan 'B' ", CSF Col Chang Yu, 106–16.

Strategies and Tactics for Engaging Spaceplanes, CSF Capt Ho Lu, 107–25.

Vulnerabilities of Naval Vessels, CN RADM Liu Yuan, 126–33.

15 May 2023, *London Times* Flash Note Holographic Service, Voice Narration of Holographic Clip:

Wow! What a show! The Chinese government released this test holoclip a few minutes ago and I know all of you can feel this baby fly. The Chinese are offering their new space cruiser as an alternative to what they claim is an unfair monopoly of American space launch services. But I have to tell you that this baby looks like she can fly rings around anything the Americans have. On a sour note, the US news service has

raised American concerns that this capability may violate the 2015 Vietnam accords limiting spaceplanes.

24 September 2024, *Wall Street Journal* News Item:

New York. Recently retired Air and Space Force Chief of Staff, Gen Maria Barbicane, and 12 of her former military colleagues announced the formation of their new company, CISLUNE Corporation yesterday. General Barbicane said during her brief press conference that the firm would focus on developing space resources. Unlike most start-up corporations in the space business, the *Journal* has learned that CISLUNE is very well capitalized, with over $1 billion in initial cash on-hand. Initial stock offerings in CISLUNE opened today at 85 dollars per share. Interestingly, General Barbicane made no mention of her dispute with the president over the administration's decision to cap SF-1 spaceplane deployments at 24 vehicles per the 2017 Vietnam accords. It has been widely speculated that it was this decision that led to the general's earlier than expected retirement.

6 February 2027, *London Times* Flash Note Holographic Service, Voice Narration of Holographic Clip:

We're here at the reception in Teheran following the signing a few minutes ago of the Islamic Federation–Asian Hegemony Treaty of Peaceful Principles and Eternal Friendship. Although specific details have not been released, it appears that long-standing border disputes between the Islamic world and the Chinese, who now call themselves the "Asian Hegemony," have been resolved. That noise you hear outside is the start of what's been promised as the "mother of all military parades." If the flyby of the four Asian spaceplane squadrons was any indication, it'll live up to its billing.

Sun Tzu Vindicated

Remarks

by

Chief Space Marshall Tu Yu
Space Forces of the Asian Hegemony
Festival of Glorious Victory
Great Hall of the People
Beijing, Asian Hegemony
7 December 2032

Over 25 centuries ago, our ancestors invented rockets. For centuries, these honored forefathers developed these magnificent devices for peace and security. Six centuries ago, we had developed the most wonderful fleets of ships for exploring the unknown. We set out not to enslave peoples or capture trading markets, but to spread awareness of the beautiful culture our ancestors had developed. Sharing the benefits of progress has been our longest and greatest heritage.

But there were those who took these gifts and perverted them. They took the magical powder we used in our rockets and forged terrible weapons from it. They used the technology we exhibited in our ships to build fearsome warships. With these weapons, the foreign devils set out on a many-century quest to dominate all before them. They made each century bloodier than the past. Cultures that had stood for millennia fell before their onslaughts. Peaceful peoples felt the yoke of imperialism and slavery. Even our own ancestors were forced to bow to the seemingly unstoppable war machines the enemy wielded. The culture of death and power reached its awful peak in the last century—untold millions perished in war after war, fueled by an insatiable imperialist appetite. As this century dawned, these imperialists had already turned their greedy eyes to the heavens. This could not be allowed to come to fruition.

In the wars of the last century, great men emerged from our Asian cultural tradition. Men like Mao Tse Tung taught us how to first cast the forces of imperialism out from our own country—but those great ones could only dream of days when the world would be safe from imperialistic grasping. In the past few decades, we've begun to make those dreams real. One

year ago today, we achieved the greatest victory yet in this noble struggle.

The details of this glorious victory are well known to our long-standing citizens. But as we welcome today our new partners in the Asian Hegemony—Japan, Vietnam, and Korea—it is suitable to recount the careful planning and flawless execution that led us to this great day of celebration.

In 2017 we began efforts to liberate our Vietnamese friends from imperialist domination—an effort they had themselves largely achieved in the middle of the last century—only to later fall victim to insidious economic imperialism. We learned that, although our troops were brave and our weapons keen, the imperialists had shrewdly militarized space. In the attempted 2017 liberation, the forces of imperialism callously attacked systems designed to better our peoples' lives from space. They used their control of the international financial community to deny our access to services that were allegedly for sale to all. Then they used space to attack our liberation forces directly. These war-mongering moves were effective on the short term, but Asian minds and Asian creativity learned these lessons well; in our next encounter, *we* were the teachers!

We studied the adversary's forces for over a decade. We read their writings. We learned their systems. We built our capabilities. We planned our revenge. For as Sun Tzu said, "a victorious army wins its victories before seeking battle; an army destined for defeat fights in the hope of winning."[3] It was obvious from the 2017 conflict that the enemy had come to rely totally on space—but to a degree that even he did not know. Wall Street controlled their space capabilities more than their War Room. This meant we could impact them as much by attacking in the financial "bottom line" as by attacking in the battlefield. If we could threaten commercial investments, they would lose much of their stomach for fighting. We understood, too, that space had long been militarized. Applying force from space-to-space and space-to-ground was and will continue to be the highest priority in military conflict.

Perhaps most important of all, we understood that warfare was the battle of perceptions and nuances. We had to force the enemy to fight on our terms and on our ground. The war never

stopped in 2017. Our first objective was to encourage the uniquely Western idea that the absence of war is peace. What we lost in battle, we won in negotiations. We have followed our ancient master, General Sun Tzu, who wrote, "When the enemy's envoys speak in humble terms, but he continues his preparations, he will advance."[4] The Americans have paid Sun Tzu scant attention, and we succeeded in stopping them from building the very systems that so threatened our forces in the past through a smiling demeanor and peaceful exterior. We built our own forces under the guise of peaceful intent. We thus entered this decade with an overwhelming advantage in forces-in-being.

From studying past conflicts, we also understood that the masses toiling to support the imperialists want their masters' adventures to be bloodless. We knew these misled people would rise up to demand an end to further expansion if we could convince them that they would eventually pay in blood for their masters' adventures.

Finally, we knew we had to find and engage allies who would bring different and complementary capabilities to our cause. This was easy, as the imperialists had left a centuries-long bloody trail of trampled peoples in their wake. Our Islamic brethren were well prepared to assist us. Their contribution was the key to our glorious victory—a victory in fact for all the peoples of Earth.

A year ago today, exactly 90 years after some of our Japanese ancestors showed the way to begin a conflict with imperialists, we struck a fatal wound to the enemy's black heart. We had four objectives when we opened that glorious day. First, we needed to strike fast and hard to destroy his eyes, ears, and central nervous system. This we hoped to do by swiftly striking and removing all his space-based sensors, communications, and C^2 systems. Since we recognized that the so-called commercial systems were part of his means to accomplish these tasks, we did not plan to spare these systems. Second, we needed to remove his means to project power, primarily by removing his long-range space strike forces. Third, we needed to inflict devastating human losses on his forward-based forces. Finally, we took a cue from our Islamic allies

and endeavored to capture imperialist territory along with imperialist forces, which could be used to negotiate a favorable capitulation. We heeded Master Sun Tzu's admonition well: "Do not thwart an enemy returning homewards—to a surrounded enemy you must leave a way of escape."[5] It was not Armageddon we sought, but a world free of the enslavement and coercion of corrupt Western values.

To accomplish our first task, we needed to strike the enemy's vulnerable nodes for his eyes, ears, and brains. This was a significant task: There were almost 3,000 satellites carrying the world's imperialist traffic and war orders. In addition, this information was gathered and disseminated in thousands of critical interstices on the ground. Most of these lay deep within the territory of our enemy. Here, we planned a coordinated attack with our Islamic allies. While we prepared a comprehensive strike with the goal of destroying 50 percent of the enemy's space systems within 24 hours, we also planned a massive strike against his key surface nodes. The latter mission would employ martyr attacks, sabotage, and a variety of sophisticated cyber attacks perfected by our allies. Again, we aimed for a 50 percent reduction in enemy information flow. At the same time, we had worked hard to free much of our government and industrial infrastructure from reliance on imperialist-controlled systems.

Our D day strike was phenomenally successful. We used both ground- and space-based weapons to destroy over 1,900 satellites, nearly 70 percent of the adversary's space infrastructure, in that first day. Everything worked! Particularly easy were the so-called commercial systems, which our enemy used for spying and for carrying financial and war plans. The imperialists had little thought that anyone would attack these "commercial" systems because they believed we all relied on them. Yet we had a capability in each case—often using alternate means not in space—for carrying out critical sensor, communications, surveillance, and timing functions. We found that even very weak directed-energy attacks could quickly silence the enemy's space systems. Further, our allies' attacks proved swift and sure. The imperialist war machine and the economy that fed it were brought down in a few short hours.

Particularly important for us to neutralize in those first few hours was the enemy's formidable space strike force—residing primarily in his constellation of 12 laser battle stations and two squadrons of intercontinental-attack spaceplanes. If these weapons had been left active, the ultimate outcome of our campaign would have been very much in doubt. Thus, we devoted the first few hours of our preemptive strike to locating and destroying the enemy's ability to use these assets. As good fortune would have it, both spaceplane squadrons had been drawn up for display in the enemy's celebration of "Pearl Harbor" day. Our spaceplane strike on these two squadrons destroyed 80 percent of the enemy's war machines. Moreover, our allies' martyr attacks got most of the remaining assets—in addition to the spaceplane production facilities in California. Not only had we virtually eliminated his forces-in-being, we had removed his ability to reconstitute these forces for a very long time. The laser platforms proved even easier to destroy. While our heroic spaceplane pilots would have no doubt gloried in a personal attack on the laser battle stations, we noted that the imperialists had anticipated just such a strike. As we learned in 2017, a laser weapon was the last place one wished to hit with a direct air or space attack; the closer one gets, the more formidable the laser becomes. However, 12 loads of simple ball bearings delivered into the laser platforms' paths proved successful in quickly removing that threat to our operations.

After a mere 24 hours, Western economies and armed forces were in disarray. It was now our task to use our space superiority to wipe the Western devils from the seas, which they had dominated for five centuries. With unhindered space reconnaissance, we had quickly fixed all of their surface ships and most of their underwater assets. In the second 24 hours of the conflict, we had sunk 89 of the enemy's vessels, including four aircraft carriers and 15 submarines. Although we were saddened by the great loss of life this entailed, it was a small repayment for centuries of Asian blood extracted to satisfy western greed.

The second week in December saw our victory become complete. As our forces flowed south to complete the task of 2017, we swept the futile efforts of the imperialist lackeys in Vietnam

aside. With no support from above, they knew not where we were or what we were about. The confusion sown in the adversary's inner working prevented him from even attempting to withdraw his forces from Vietnam until we had surrounded them. A swift surrender and 40,000 captives resulted. The story was the same in Korea. There, too, we were able to sweep all opposition away with no more effort than was needed to remove an annoying fly. As our victory grew near, those forces the enemy had counted on came over to our side—the Asian side—swiftly. We welcome their addition into the Greater Asian Hegemony today.

Some of you may wonder why we did not continue our success and wipe the imperialist adversary from the face of the Earth. I must remind you again that a cornered rat fights to its last extreme ability. We know that the imperialists retain horrid weapons of mass destruction and would have been only too happy to unleash them upon the innocent peoples of the world. This we could not allow. It is our task to return the world to a time where a thousand blossoms of beauty can bloom forth. To allow the adversary to unleash mass death—even had we punished him in the end—would have been to succumb to the very methods used against us for hundreds of years. We opted instead to make a new beginning.

We chose to complete the international efforts started so long ago. In the new United Nations charter that we are now finalizing, all people will have their voice—not as in the past with the richest dictating to all, but with each voice heard in proportion to the numbers shouting the same message. We have placed the United Nations under Asian protection. And it will be a peaceful Asian dream that the new United Nations will work toward from UN headquarters in Beijing.

Our work is just beginning. The Space Peace Treaty just completed by our negotiating teams in Sydney is a major step forward. It will forever ban imperialist monopoly of space. It will ensure the great resources to be had there will be shared equally by all people. It will deny future imperialists the ability to militarize space in order to threaten the people of Earth.

We have won a great victory—a victory our people have waited five centuries to enjoy. We are on our way to making

this millennium the Asian millennium. It will be a time of collective prosperity and collective wisdom—a time for respect for the cultures of the past and continuity into a culturally rich future. The wisdom of our leaders, past and present, has made this great future possible. It is up to you to build it!

Text of the United Nations International Peace Treaty and Agreement on Outer Space 2032

Preamble

The states signatory, recognizing that the imperialist aspirations of certain states have, for centuries, driven the world to war and its associated death, destruction, and suffering, do hereby complete this treaty, thereby ending the imperialist era. Recognizing that these same imperialist aspirants have attempted to expand their grasp into the cosmos, the parties complete this agreement to ensure that the fruits of human expansion into space are gathered for the benefit of all mankind. The attempts of imperialist forces to further dominate human life and expand their sway into the cosmos having resulted in armed conflict in the recent past, the states signatory hereby declare that the provisions contained herein do constitute a permanent end to these hostilities.

Article 1

All signatories hereby forever ban any and all claims on territory outside of their currently constituted and United Nations-recognized borders. Changes to future borders or mergers between states will henceforth be accomplished by mutual agreements overseen by the UN High Commission on Borders. The Asian Hegemony will chair this commission, which will consist of representatives from no fewer than five nonimperialist states.

Article 2

The United States of America assumes full responsibility for the war of 2031 and admits to having served as the primary instrument of imperialist expansion in the twenty-first century. The United States of America agrees to pay the United Nations five trillion dollars in reparations to be spread equally over the next 10 years and to be used in reconstructing damaged states and redressing past imperialist damages to oppressed peoples. The Asian Hegemony will ensure that all combatants are expeditiously returned to their respective homelands.

Article 3

The United States of America agrees to withdraw all forces to within 200 miles of its current borders and declares that it will maintain only those forces necessary for internal security. The United States of America will forever refrain from placing any military weapon, supporting device, or forces in space. All signatories agree that outer space will be forever demilitarized. Peaceful uses of outer space will be enforced by the UN High Commission on Outer Space, which will be chaired by the Asian Hegemony and will consist of representatives from no fewer than five nonimperialist member states. To ensure compliance with these provisions, the High Commission may authorize and finance multinational space peacekeeping forces.

Article 4

All states agree that the fruits of space development will be distributed equitably to all the world's people. Development and exploitation of space by private parties will be allowed only under supervision by the UN High Commission on Outer Space and only under the condition that 90 percent of any products or returns be distributed equitably to the world's people through the United Nations High Commission on Outer Space.

Ratified:

24 January 2033, Beijing, Asian Hegemony

8 February 2033, Washington, D.C., United States of America
15 February 2033, Teheran, Islamic Alliance
15 February 2033, Brussels, European Community
22 February 2033, Moscow, Russian Republic
15 May 2033, Delhi, Republic of India
5 June 2033, Brasilia, Republic of Brazil

Seizing the Solar System

22 August 2038, Wall Street Journal NetNews Item:

The CISLUNE Corporation has been granted a license from the UN High Commission on Outer Space to utilize location 54 at the lunar South Pole for automated bio products development. Together with their successful application last year for a solar-power satellite grid slot allocation, this marks CISLUNE as the only American-chartered company to be granted space development rights. Financial analysts are not optimistic, however, that CISLUNE will be able to successfully compete with the government-subsidized Asian groups currently in the space development business.

2075, Peoria, Illinois, United States of North America:

CISLUNE Home Suite on the World Wide HoloWeb (hololink)

Welcome New Employee,

Congratulations on joining CISLUNE! You are now a member of the number one team on Earth or above it. We have a proud tradition of service to our customer, service to our nation, and service to the world. And above all that, we have always been profitable. You may have heard about our outstanding employee ownership and profit-sharing plan. The attached holochip should answer all of your questions.

As a new employee, we also hope you will find great pride in our rather unique history, as we all do. My mother was one of the original corporation founders, and was the visionary behind our success in exploiting space. We all also take pride in the role our corporation has played in assisting our great nation to recover from the terrible setbacks earlier in this century. I think you will find the brief history we've prepared to be inspirational.

Always remember—when you join the CISLUNE space development corporation, opportunities are as endless as the environment in which we work!

Harvey Barbicane

CEO, CISLUNE Corporation

Do you want to know more?.....

About Cislune (hololink)

CISLUNE is the global leader in space development. We are proud to cite our position as number one global energy supplier. Over 14 percent of planetary energy usage is supplied via CISLUNE-built and CISLUNE-operated systems. Thirty-two percent of products manufactured off-world carry a CISLUNE label. We are the world leader in pharmaceuticals, electromechanical components, electro-optical components, and nuclear technology. We have subsidiaries in every nation on Earth. But perhaps our most exciting endeavor is our pioneering efforts on Mars. The corporation now has over five thousand people living in our Mars facility. We believe the coming decades will see an explosion in Mars products. We hope you will be a part of this great endeavor.

How Did We Get Where We Are? (hololink)

CISLUNE was formed in 2023 by a group of former senior US Air and Space Force officers. Headed by former Aerospace Force Chief of Staff General Maria Barbicane, the group established the firm out of both a shared vision and a shared frustration with US government inaction on the space front. Maria

and her colleagues, however, were assisted by a group of visionary businessmen and, as can now be told, by special US government funding. Throughout the early part of this century, it became increasingly clear that governments had their hands tied when it came to space development.

Although the government intended well, and the space contribution to the economy had reached the $500 billion per annum level by 2020, efforts to expand this base were undercapitalized. Moreover, most of the business was in supporting government-sponsored and government-regulated utilities such as global timing, navigational positions, moving target tracking, and communications. Governments were increasingly indifferent to space development and were further hamstrung by international treaties, which declared space a "common" preserve—much like the Antarctic continent. Thus, nations could not "own" space resources such as lunar or asteroid territory. No one was going to invest in or make money off things they could not own. Furthermore, our founder, Dr. Barbicane, knew that true space development would not occur until there was money to be made from space products—not just services back on Earth. To put this in a different perspective, people early in the century were using space only for things they were already getting via other means. For example, one could communicate without space systems, navigate without them, and take Earth resources pictures—all without using space. Space made it possible to do the job better, and sometimes cheaper—but nothing was produced in space. Maria Barbicane and her colleagues wanted to change that.

Our founders were not unique in desiring to use space for producing products. Since the mid-twentieth century, hundreds of visionaries had proposed using space for producing energy, electronics, and pharmaceuticals. Where our founders differed was in their ability to marshal capital to make the dreams real. As virtually the entire senior leadership of the recently victorious US Aerospace Force, the executives of CISLUNE had the credibility to attract big investors. What could not be told until recently was that some—indeed a very large initial percentage—of the investment was US government funds covertly channeled to the new CISLUNE Corporation.

CISLUNE's first product was, alas, a service. It was one that could only be done in space, however: repairing and servicing on-orbit commercial satellite systems. We purchased three "surplus" SF-1 spaceplanes—conveniently excess since the Aerospace Force had canceled their full buy. We had these modified and went into the space servicing business. Since there were about 3,000 commercial satellites, most of them in low earth orbit with no affordable way to service them one at a time, we had a big customer base. Ironically, the second Asian Space War became quite a windfall for us despite being a disaster for the United States. Since we were an international company that had remained scrupulously neutral during the conflict, we were not banned from space, as were most of the wholly American companies. Moreover, the damage done to thousands of commercial satellites by the Asian Hegemony gave us a vastly increased market. With a few judiciously applied "investments" in Asian concerns, we were able to win approval from the Asian-controlled UN High Commissions to acquire the few undamaged US spaceplane assets that survived the war—and at quite a cut rate. By the mid-2030s, we had built an enormous investment account and were ready to begin true space commercial development.

Our first task was to win exclusive access and license to develop space resources. Once again we had to persuade the Asian "guardians" of space that we were, despite our American heritage, true internationalists interested only in the welfare of our entire planet. Fortunately for the company, very few Asian leaders actually believed the propaganda that all Western-origin firms were tools of imperialism. Fortunately too, those leaders were also receptive to profitable partnerships with successful commercial endeavors. We were thus granted slots for future solar-power satellites and a portion of the very promising lunar South Pole territory for commercial development.

The first half of this century, as we all recall, was a time of environmental paranoia. Any process or procedure, particularly bioengineering research—even if it was directed at producing life-saving pharmaceuticals—was impossible to conduct on Earth. The UN Environmental Control Organization, backed up by Asian military might, was a very effective enforcer on Earth. Not so on the Moon. Unfortunately, most of the Moon lacked crit-

ical resources to support research or manufacturing. But with the 1994 discovery of ice at the lunar South Pole, we had the "volatile" resources such as water and hydrocarbons to make a go of it. By placing an automated bioengineering research and production facility on the permanently sunlit rim of the lunar South Pole crater for solar energy and using the volatiles from the crater floor, we had an effective opportunity to produce profitable products. The UN license gave us the charter, and we were off. Our 2041 release of lunar-produced NEVERAGE, which extended the average life span for the elderly user by 10 years, made us an enormous profit—even after we paid the 90 percent UN "human development tax" mandated in the 2032 Space Treaty.

Our next product took a bit longer to develop. When the Islamic Federation began the space-based energy transfer net in 2029 to better market their energy resources and distribute them to far-flung spots on the globe, they had little idea of the system's ultimate use or potential. However, as the contracted service organization for this net, CISLUNE did. Most experts laughed at us when we purchased the solar-power slots in 2036, because there were no such satellites at the time. But once the Islamic power grid was complete, we had the means to market space-produced solar power. Although our first solar-power satellite was a net loss, largely due to the UN tax and Islamic Federation fees, the situation was soon to change. When the Kazakhstan oil fields depleted considerably ahead of predictions, the Islamic Federation found itself in the position of going to CISLUNE to purchase power to meet their market obligations. By 2052, we owned 14 solar-power satellites—all highly profitable despite the various "taxes and fees" we had to pay.

Our biggest crisis and most glorious moment came in 2056. With the global recession, the Asian Hegemony met the first real crisis in its short history. Initially they sought to increase the "people's tax" on space activities of firms such as CISLUNE. This was particularly appealing to them because essentially all space development had become the province of Western companies. State-controlled monopolies simply aren't efficient at developing new resources. Given the overwhelming power of the Asian Space Forces, we complied. But as the recession wors-

ened, Asian demands grew. The next move of the Asian Hege-Mony and their allies was to begin making demands of the western democracies, particularly the United States. Initially, the US government and its partners complied. But by 2059, the demands had gotten out of hand.

Rapidly escalating taxes drove the people to open revolt in many places. The firebomb attack on the White House on 2 August 2059 was the defining moment. Although not officially invited, Asian forces stepped in to "restore order" in a number of European, American, and Russian cities. At the same time, the Hegemony announced it was assuming control of all "Western" space companies. As head of the largest space corporation, Dr. Barbicane, then over 80 years old, took the lead in formulating a response. Meeting surreptitiously with the Joint Chiefs of Staff of the American Self-Defense Forces, Western space executives decided to seize the high ground. Marshaling over 3,000 space-plane resources, compared to less than 500 obsolete but heavily armed Hegemony war birds, our firms managed to destroy all Hegemony forces in space and those trying to reach space. Most effective was the technique of narrowing the beams of the solar-power satellites to serve as a crude form of directed-energy weapon. The Hegemony responded by seizing all ground-based corporate assets and arresting any corporate or US military official they could lay hands on. Fortunately, we had evacuated key leaders of both the United States and our corporate structure to our lunar base.

Autumn 2059 was an awful time for everyone. Although we knew terrible suffering would result and we also knew the Hegemony would respond in a vicious manner, which they did by beginning public executions of the leaders they had arrested, we cut off all space "utilities": power, communications, timing services, and space-manufactured pharmaceuticals. Although these utilities have grown markedly from what they were 15 years ago, they were still formidable then, with 25 percent of the global energy usage produced or transmitted through space capabilities. The rest was, as they say, "history." With the upheaval that led to the collapse of the Hegemony government in December 2059, we had won.

The company you have just joined is proud of its heritage and its contributions to a free, prosperous, and progressive world. Our future is limitless. Perhaps our most exciting program is our Mars Development Corporation (MDC), operating under official charter to explore this new world. With several hundred people already living on Mars at New Jamestown Outpost, we are developing nuclear and antimatter technology, which will revolutionize life on both Earth and Mars! As CISLUNE owns 45 percent of the MDC, you will have an opportunity to share in the profits earned by MDC. It will be an exciting time to own part of a new planet!

Notes

1. Art Kleiner, *The Age of Heretics* (New York: Doubleday, 1996).
2. Charles J. Dunlap Jr., "How We Lost the High-Tech War Of 2007," *The Weekly Standard,* January 29, 1996, 22.
3. Sun Tzu, *The Art of War,* Trans. and with an Introduction by Samuel B. Griffith (London, Oxford, New York: Oxford University Press, 1963).
4. Ibid.
5. Ibid.

Chapter 3

Mathematical and Physical Realities

We can easily observe how animals move over land, or how a swan moves across the water, or how a fish moves beneath it. We can even conceive of basic aerodynamics by observing a bird in flight. Thus, until the dawn of the space age, humans had natural examples of movement in all mediums from which they could observe and derive man-made means to do the same. The movement of objects in space, however, is neither observable nor, from a biological standpoint, natural. Space is a medium that lies completely outside Earth's biosphere—and outside the realm of direct human observation.

Astrodynamics is not an intuitive science. Even the first-year astronautics student can have difficulty grasping the most basic concepts (to overtake an object in orbit, you must actually slow down—to decrease your orbit radius). An understanding of the fundamental physics of the space environment is essential for anyone who would seek to also understand how to properly use and control space.

Space Environment/Orbits

The basic concept of all space operations is the *orbit*. The realities of space travel and moving around in space differ from all other operations as the branch of physics called *orbital mechanics* totally dominates. On the simplest level, space may be thought of as an empty vacuum occupied by large spherical masses—for the foreseeable future those we are concerned with are the Sun, the Earth, and Earth's Moon, other planets and their natural moons, and small bodies called asteroids. Every mass is attracted to other masses through the force of gravity, which might be represented by an elastic band stretching between the two bodies. The band's attractive power increases as the two bodies come closer together. Suppose the two bodies are moving in a straight line (as all moving bodies in a vacuum do unless acted on by an outside force—one of

Newton's laws) and are moving so as to pass close by one another. As they get closer, their mutual gravity attraction will tend to curve their respective paths toward one another. If they do not collide and if they are moving slowly enough, they will go into an orbit around one another. The force of gravity counterbalances centrifugal force, which tends to swing them apart. Orbits can be elliptical or circular (i.e., the path of one object around the other is either an ellipse or a circle). Since space is not a perfect vacuum, other forces are also operating on these two bodies and other objects "out there." These forces tend, over time, to reduce elliptical orbits into circular ones. Thus, objects that have been orbiting other objects for a long time—such as Earth around the Sun—usually have almost circular orbits. The first objective of space travel is to get into orbit around Earth.

The easiest orbit to get into around Earth is known as low earth orbit, or LEO. This orbit is located just above the atmosphere. One could, of course, orbit Earth within the atmosphere, but one would then need to constantly counteract the effects of air resistance to stay in orbit. For the purposes of our discussion, the differences between a vehicle that can "fly" into LEO and one that can fly to the other side of the planet through space, such as an intercontinental ballistic missile (ICBM), are insignificant. For both, the objectives are: 1) raise the vehicle/payload above Earth's atmosphere; and 2) accelerate the vehicle/payload to "orbital" velocities (to reiterate, where gravitational attraction between Earth and the satellite is exactly balanced by centrifugal force)—about 17,500 miles per hour (mph). To do this, an object at rest on Earth's surface must acquire both "potential energy" by rising in Earth's gravity field several hundred miles and "kinetic energy" by obtaining a velocity of 17,500 mph. This total is a significant amount of energy. A one-pound object in orbit has the equivalent potential and kinetic energy (relative to something at rest on Earth) of about 10 pounds of TNT. This suggests that at least 10 pounds of TNT, or its equivalent, are needed for each pound we want to put into LEO. Space differs from all other fields of human endeavor since it operates in this enormous energy regime.

The essence of space travel and how it differs from ground, sea, and air travel is simple. Traveling via ground, sea, or air does not entail using lots of energy to gain potential and kinetic energy (although air travel approaches this), but simply to overcome friction and air resistance.

A comparison between jet-powered air travel and space travel is useful. In both cases, the means to give kinetic/potential energy to the payload (space) or overcome air resistance/friction (air) is to apply another of Newton's laws—that of equal and opposite reactions. In both cases, the necessary energy comes from chemical reactions. A reactant (fuel) is heated by chemical reactions (burning) to high temperature. The thermal energy of this "working fluid" (kinetic energy of motion in the heated particles) is directed out an exhaust nozzle, transferring momentum and associated energy to the vehicle in the opposite direction. Since aircraft must continually overcome air resistance, the thrust is continuous. There is (almost) no resistance in space, so the thrust need only apply until the payload has gained the necessary potential and kinetic energy to achieve orbit. Chemical energy, however, is not very efficient—it takes the energy from about 10 pounds of chemical fuel (such as TNT, as noted earlier) to get a one-pound payload into LEO. The energy needed to overcome air resistance throughout an aircraft flight across the planet is several times less, and the energy needed to overcome water resistance in sea transport is many times less.

Even the most efficient system for getting a payload to space must burn at least 10 times the weight in chemical fuel as the payload weight we desire in orbit. If all this fuel is carried along from launch onward, the system needed to get to space, which includes the launch vehicle and fuel, is very much larger and heavier than the payload. Conversely, an airplane can have a much larger fraction of its liftoff weight in payload and structure. The weight of the vehicle's fuel compared to its total weight, including payload, is known as "mass fraction." Since an airplane gets some of its chemical reactant (*oxidizer*) from the air, it has an even lower mass fraction—typically 50 percent or less—whereas a space launch vehicle is more than 90 percent fuel. Since much of the remaining weight is the

Courtesy of NASA

A space shuttle main engine being prepared for test firing.

launch vehicle's structure, only two to six percent of liftoff weight actually reaches orbit.

Space launch vehicles are typically *staged* to reduce overhead costs. Following from the prior discussion, most of the size of a space launch vehicle is set by fuel needs, which are enormous for *any* launch vehicle. Once the fuel is exhausted, there's no need to drag along the big empty tanks to orbit, so a space launch vehicle stacks several rockets on top of one another. Each rocket stage falls away when it burns out, reducing the structure that is carried into space.

Most launch vehicles today have a further inefficiency, in that they are designed for one-time use; that is, they are "expendable." The additional complexity and weight, which would be required for designing reuse into the launch vehicle, has been considered cost-ineffective. However, many analysts believe the reusable launch vehicle—eventually a "single stage to

LEO" launch vehicle—is a concept whose time has come. The space shuttle is only a partially reusable and partially successful attempt at achieving this; a truly reusable spacecraft would be significantly different from and significantly more advanced than the shuttle. The military has designated such reusable space vehicles as "spaceplanes."

Getting into LEO is literally only half the task. The easiest orbit to reach is a "LEO equatorial." When a vehicle is launched due east from the equator, Earth's rotation velocity (about 1,000 mph if you are on the equator) is added before it even leaves the surface. As we launch from locations further north (or south) away from the equator, the less benefit we get from Earth's "push." And there is a "coverage" problem in launching due east from a location near the equator: The satellite will overfly only a limited band of territory near the equator.

To cover the entire globe, a polar orbit is required. Earth turns beneath a polar-orbiting satellite, allowing for a different view of the surface with each succeeding orbit. And there is a "special" orbit, called *sun-synchronous*, which puts the satellite over the same locations at more or less the same times each day throughout the year. However, launches in directions other than due east, even on the equator, get less benefit than due east. And north/south launches get no help at all from Earth's rotation.

One might think that once our vehicle is in orbit we could simply do a "plane change" to put it into a more desirable orbit—say from LEO equatorial to polar. We can do this, but it takes nearly the same amount of energy to move a satellite from an equatorial orbit to a polar one as it took to launch it in the first place.

Some of the more useful orbits are higher than LEO. The GPS, for example, orbits every 12 hours at about 10,000 miles altitude in what's called a mid-earth orbit (MEO). Most current communications satellites orbit at 22,000 miles directly over the equator in a geostationary orbit (GEO). At this altitude and in this orbit, the satellite appears to hover over the same point when viewed from the ground. It is thus ideal for communications relays or continuous national security surveillance of a particular portion of Earth.

To get to any of these higher orbits takes more energy than merely getting to LEO. Typically we place a vehicle into LEO that consists mostly of the additional rocket stage required to boost the final payload into GEO. Based on current efficiencies, the same size rocket can place only about one-fourth the useful payload into GEO as LEO.

The Economics of Space Travel

The energy required to put payloads into orbit tells much about the utility of space endeavors to the average business concern or the individual citizen. It is reasonable to define a society's productive capability as the energy used by each citizen multiplied by the number of citizens. This quantity has been slowly increasing for the past several thousand years, especially for people in the most developed societies. With the unlocking of fossil fuels in the nineteenth century, this quantity increased dramatically. And again, the greatest gains have been in the most technologically developed countries. Today, for example, each citizen in the United States uses energy equivalent to 100,000 pounds of TNT per year. This compares to a mean global usage of 20,000 pounds of TNT per person per year. One transcontinental flight uses the equivalent of about 1,000 pounds of TNT in fuel—one percent of an average American's usage, about five percent of Earth's average. It is thus reasonable to transport people and many high-value goods by air.

Space travel is far more expensive in energy usage. The amount of fuel needed to place an object into orbit is 10 times the cost of taking it between continents. If we wish to place an object into more useful GEO or MEO orbits, the energy cost is 40 times the between-continents cost. To take something to the Moon is 100 times the baseline energy usage. Thus, transportation of material to and from space will only be attempted for the highest value products. Today, those products are almost exclusively "weightless" information services. To take a human into even LEO—at 100 percent efficiency for energy usage—requires at least 50 percent of the annual energy requirements of an average Earth inhabitant. Clearly, large-scale

space transportation of people or goods is economically unfeasible at current energy costs.

The cost of the transportation vehicle itself must be added to the costs discussed above. Hardware complexities and costs are about the same for space vehicles and air vehicles. For example, an aircraft that can transport 100,000 pounds at transcontinental distances costs about the same as a space launch vehicle that can transport 10,000 pounds into LEO. The cost for each is about $100 million in US currency. But we cannot buy a ticket to LEO for a mere 10 times the cost of a transcontinental ticket (about $10,000, or two times the cost of fuel), although certain visionaries claim they can approach this low cost with a reusable rocket. In fact, the cost to put a person in orbit is much closer to $10 million, at least 1,000 times more expensive than mere fuel costs alone would indicate. The reason for this is that the rocket is used once, whereas an intercontinental aircraft is used thousands of times before it is discarded. To narrow this gap, the answer would seem to be a “spaceplane” that could be used and repeatedly reused just as an airplane is.

The reusable spaceplane is the focus of much governmental and private development. Development costs should approximate those of developing a new transcontinental aircraft—somewhere between $5 billion and $10 billion. Viewed from a purely energetic standpoint, the spaceplane payload should constitute about 10 percent that of a similarly sized airplane. The required technology appears to be well within hand. It would seem, therefore, that we could be on the verge of developing a large-scale space transportation system. While it would not be as easily developed as an air transportation system, it would appear to be at least within a factor of 10 in feasibility.

There is, however, another challenge. An aircraft usually operates its propulsion systems somewhere near 60 to 80 percent of capacity, whereas a space launch system continuously operates very close to 100 percent of its maximum engine performance. The reason for this is that rocket engines, operating with current fuels, barely have enough output to get into space, whereas jet turbine engines have considerable “excess

thrust" or "margin." Engineers will quickly point out that any mechanical device that operates very close to its margin (the "edge of its envelope") has a limited life. For this reason, it appears that any near-term spaceplane would be "reusable" a few hundred times at best, as compared to a few thousand times for an equivalent aircraft. This additional inefficiency means that any space transportation will "cost" about 100 times more for LEO operations and up to 1,000 times more for operating within the Earth-Moon system than would equivalent air transport.

Most "space visionaries" predict space travel in the next century will be akin to air travel in this century or sea travel in the sixteenth through nineteenth centuries. This is improbable, however, unless at least two things happen. First, technology—particularly propulsion technology—must advance to the state that space launch systems become both fully reusable and operate much farther from their theoretical engineering margins so that a space transportation system can be reused thousands of times while requiring minimal refurbishment and infrastructure maintenance between flights. Second, and far more important, mean per capital usage of energy resources must increase by at least a factor of 10. Such an increase is very unlikely in the current environment; that is, where there is both a very limited supply of fossil fuels and a rapidly increasing global demand for these resources.

The energy usage problem is a serious one for which space itself may prove to be both the solution and the impetus for further space usage. Per capita energy usage in the most advanced societies today has been essentially stagnant for the past half century. Newer terrestrial sources of energy, such as nuclear fission and fusion, do not appear to offer a clear solution to this dilemma, since they seem to produce as much in the way of ancillary problems—nuclear waste—as they supply in additional energy.

As we will return to below, space can solve these limitations by making the terrestrial energy situation an "open" problem vice a "closed" problem. If the current closed energy balance continues, it becomes very difficult to find a "growth" solution where Earth's seven-odd billion people can achieve increasing

energy usage. Even simple problems, such as disposal of waste heat, and by-products, such as radioactive wastes, inhibit any significant growth. However, space can provide both a means of opening the trade-space—by this we mean a way to dispose of excess, and often dangerous, by-products such as radioactive waste—and a source for unlimited energy input. The key to both these problems would appear to be the free-space transmission of energy—in essence, energy in a form that can be "beamed" from one point to another. This power-beaming technology is slowly maturing and appears today to involve coherent microwaves or lasers as the mechanisms for carrying the energy. When this technology matures, it should open an era in which the global power grid resides in space and can receive its energy inputs from space-based sources such as large solar-power satellites.

Thus, the development of a global energy utility, probably decades into the future, is the key to space development. As the price of accessing space falls, the energy resources available to the citizenry will increase. Correspondingly, individuals and groups will find it within their means to access space for continued expansion and development.

Weapon Effectiveness and Space

Space capabilities are the key to effective military operations in the future. As noted in chapter 1, simply the possibility of a massive US investment in space weaponry was a significant factor in ending the Cold War. To understand why, consider traditional measures of military effectiveness. In 1945, noted British strategist Gen J.F.C. Fuller listed the following qualitative parameters as measures of military effectiveness:

1. range of action
2. striking power
3. accuracy of aim
4. volume of fire
5. portability

A 1989 analysis by one of the authors quantified these parameters.[1] The first three can be combined into a parameter

similar to one used today to measure a laser weapon's effectiveness—"brightness." Brightness combines distance, accuracy, and power into a single number. It specifies how much energy the laser weapon puts into a cone; physicists measure this in "joules" (a unit of energy about equivalent to that needed to tap a finger on the table) per "steradian" (a unit of conic volume). One steradian is about the size of an old-fashioned megaphone cone. Although brightness is designed to measure beam weapons, a "pseudo-brightness" can be derived for any weapon system. However, brightness alone is not a complete measure of weapon effectiveness. Firing rate, which combines General Fuller's volume of fire and portability, is also important. Thus, a basic measure of weapon effectiveness could be expressed as:

Effectiveness = Brightness *times* Firing Rate

Table 1 and Figure 3 consider weapons during the past millennia in terms of this parameter and compare results. For space weapons, two different types, "kinetic energy" ("hit-to-kill" interceptors) and directed-energy (laser) weapons, were considered.

Table 1

Weapon Effectiveness

Era (Year AD)	*Weapon*	*Time*[a]	*Brightness (J/Sr)*	*Firing Rate (per sec)*	*Effectiveness (J/Sr/sec)*
1000	Arrows	6 Months	10^{8}	10^{-2}	10^{6}
1500	Bullets	3 Months	10^{9}	10^{-1}	10^{8}
1800	Artillery	1 Month	10^{12}	10^{-1}	10^{11}
1900	Artillery[b]	1 Week	10^{14}	10	10^{14}
1930	Aircraft	1 Day	10^{19}	10^{-1}	10^{18}
1950	Aircraft[c]	1 Day	10^{23}	10^{-2}	10^{21}
1970	ICBM	1 Hour	10^{23}	10^{-1}	10^{22}
2000	SBKKV[d]	1 Hour	10^{23}	10	10^{23}
2020	Laser	5 Min	10^{22}	10^{2}	10^{24}

Source: Simon P. Worden, *SDI and the Alternatives* (Washington, D.C.: National Defense University Press, 1991), 14.

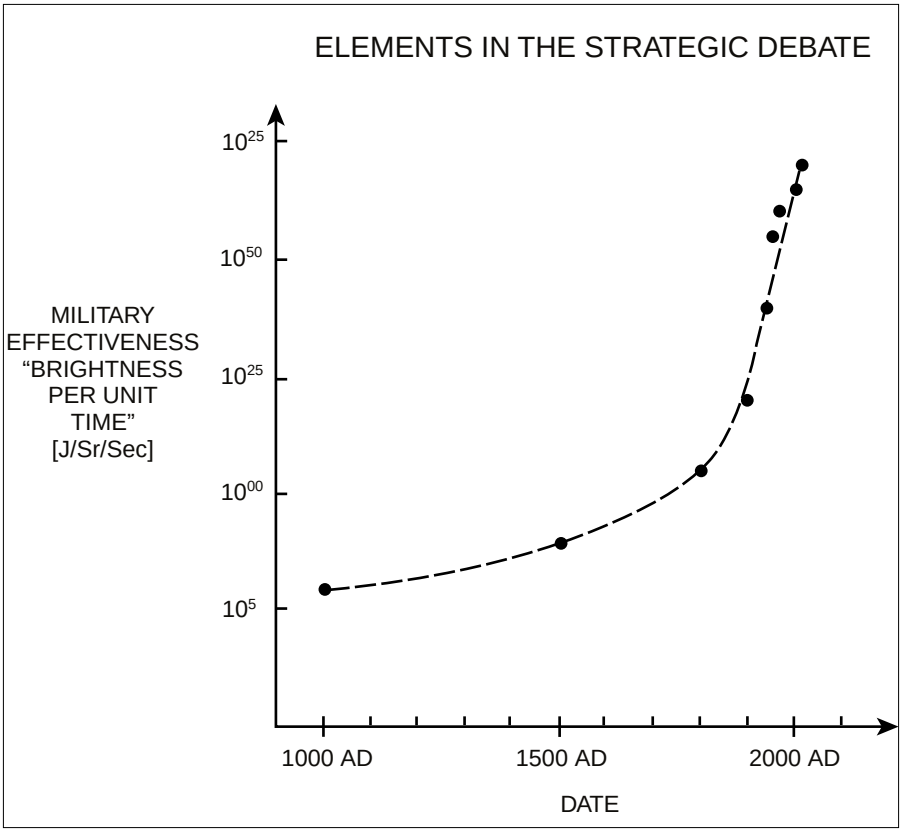


Figure 3. Military Effectiveness

Source: Simon P. Worden, *SDI and the Alternatives* (Washington, D.C.: National Defense University Press, 1991), 14.

Effectiveness is defined as "brightness," or directed (aimed) destructive energy, deliverable on the enemy per unit of time.

Interestingly enough, when these metrics are used, both types of space weapons are more "effective" than the aggregate of Cold War ICBM forces. The reason for this is that space-based weapons can be positioned and brought to bear quickly and accurately. In the case of directed-energy weapons, they can also have very high firing rates. The conclusion is important: *Nonnuclear precision weapons combined with space bas• ing can be more militarily effective than ground-based nuclear*

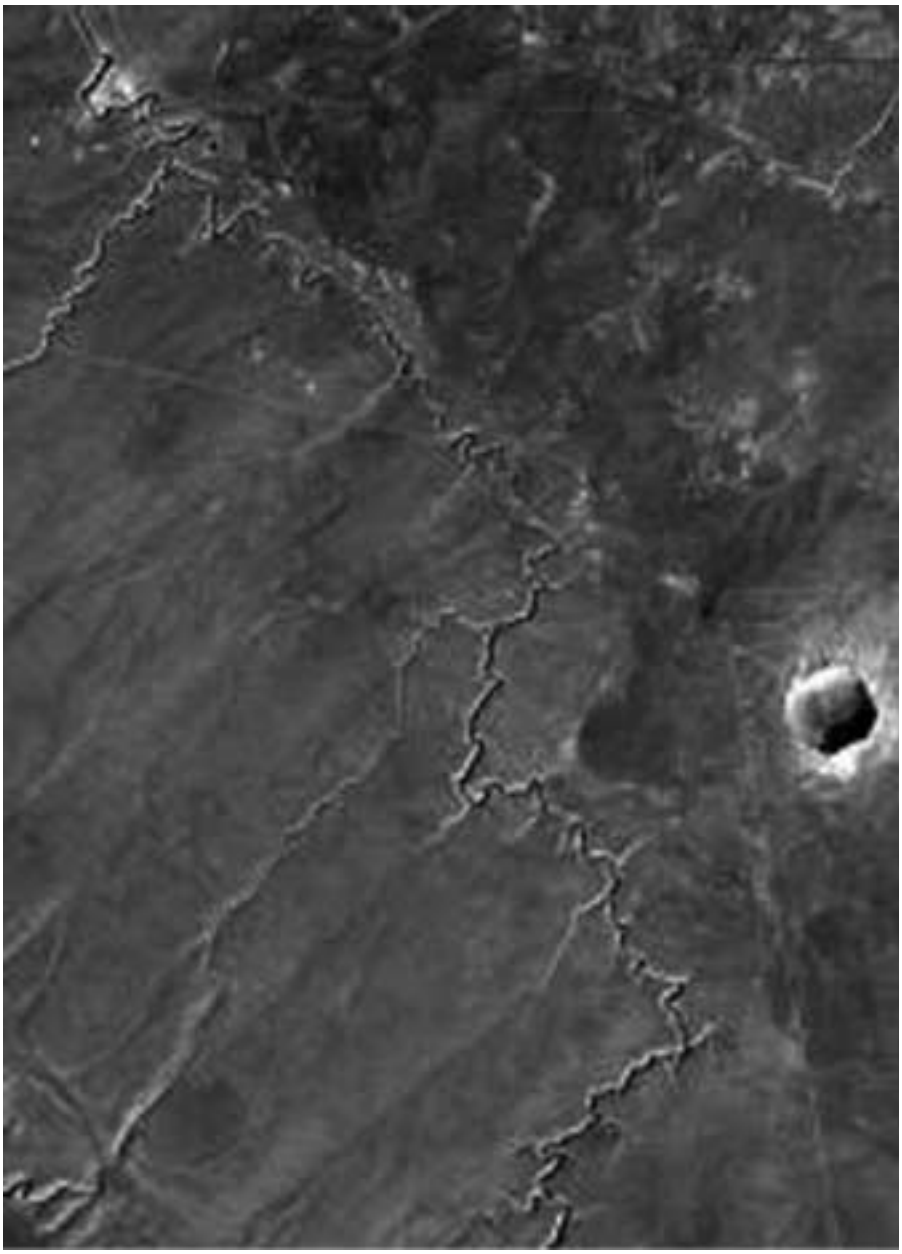
weapons. This potential is even more important today, given the ever-increasing need for precision weaponry with controllable effects.

One additional fact regarding space weapons is important. This is the inherent power in "kinetic energy" weapons. Kinetic energy, as noted above, is the energy carried by an object in motion. An especially important feature of kinetic energy is that the amount contained by a moving object, while increasing proportional to the mass of the object, increases as the square of the velocity. Since objects in space move very fast in comparison to anything that moves on or below Earth's surface, kinetic energy is a dominating feature of objects in space. A typical large satellite in Earth orbit with a mass of 10 tons contains almost a kiloton of kinetic energy—much higher than the amount of energy the satellite would carry if it were a purely high-explosive weapon. Even more significant is that the same satellite in orbit around the Sun, which could have a velocity relative to Earth up to 10 times larger than an Earth-orbiting satellite, would carry kinetic energy comparable to that in a large nuclear weapon—megatons! This is why even a small natural object such as an asteroid about a hundred feet across can cause immense damage. Just such an asteroid created the Barringer Crater, also known as "Meteor Crater," just west of Winslow, Arizona. It appears that a much larger object, probably a few miles across, released billions of megatons 65 million years ago— enough to wipe out most species on Earth, including the dinosaurs.

A testament to the power of kinetic energy, this immense crater was created by a meteor a few hundred feet in diameter.

Range of Interest

Two related distances have defined human spheres of influence, particularly in the military arena. The first distance is that which an individual weapon travels more or less instantaneously; that is, happening too fast for effective reaction. For most of humankind's history, this was the distance one could throw a rock or a spear—about 20 to 30 feet. With the development of "assisted" weapons such as arrows, this range increased



Courtesy of NASA

Barringer Crater

to a few hundred feet. Explosively assisted weapons, such as artillery, increased this range to a few miles, and rocket-propelled weapons (e.g., ICBMs) have raised the range to thousands of miles. This range might be considered to set the size of the "battlefield." The second range of interest is set by the distance one is able to transport an army in a campaign, typically a few weeks' time. On foot, as mankind was for most of his history, this range was a mere few tens of miles. The development of animal-powered transport and sea transport raised this to over 100 miles. Sophisticated wind-driven sea transport raised this to about 1,000 miles, and mechanical-driven ships, including aircraft, made this range essentially global. This range might be thought of as the theater of operations.

The relationship between the battlefield and the theater of operations seems to have remained constant, with about a factor of 1,000 between them. This relationship seems to hold today. With instantaneous weapons operating over ranges of a thousand miles or so, our theater of operations has expanded to encompass several hundred thousand miles into space or into a good bit of the space between Earth and its Moon—referred to as cislunar space.

The range of both weapons, battlefield and theater, will continue to expand. Laser weapons, such as space-based lasers (SBL) with instantaneous ranges of many thousands of miles are under development. Our commercial and military operations already contemplate operations throughout cislunar space. It is likely that beam weapons will continue to expand ranges and our ability to travel in space will expand to a point in the middle of the next century where our theater of operation could encompass much of the inner solar system.

The previous discussion distills to three important points for serious consideration in the development of a far-reaching space power strategy:

1. Space is not yet a regime of human operations comparable to sea or air. It will not become so until mankind expands per-capita energy resources and usage at least an order of magnitude. This will not happen until we begin to use space as both a source of energy and a means of mitigating ever-increasing energy usage problems here on

Earth. A nearer-term requirement to achieve this is the development of reusable spacecraft that operate within more conventional engineering margins (60–80%) rather than at the extreme edges of engineering envelopes.

2. Despite this inability to move about as freely in space as we would wish, space weaponry—in the form of long-range missiles—has already become a vital means of national attack and defense. While nuclear weapons and other technologies remain important, very high-velocity kinetic energy systems that are unique to space and inherent in space operations (i.e., systems that expand the weapons-range/battle space envelope in the tradition of spears, arrows, artillery, and ICBMs) may be the ultimate weapons in the next half-century of warfare. Such weapons will also be extremely *precise*, likely leveraging other space capabilities (or "utilities," as we will discuss in the next chapter) to execute their missions.
3. We already regard space, out to at least GEO, as part of our legitimate military theater of operations. Strategic vision compels us to continually expand our perspective: We will soon need to consider all of cislunar space, and we should begin to think about operations throughout the inner solar system.

Notes

1. Simon P. Worden, *SDI and the Alternatives* (Washington, D.C.: National Defense University Press, 1991).

Chapter 4

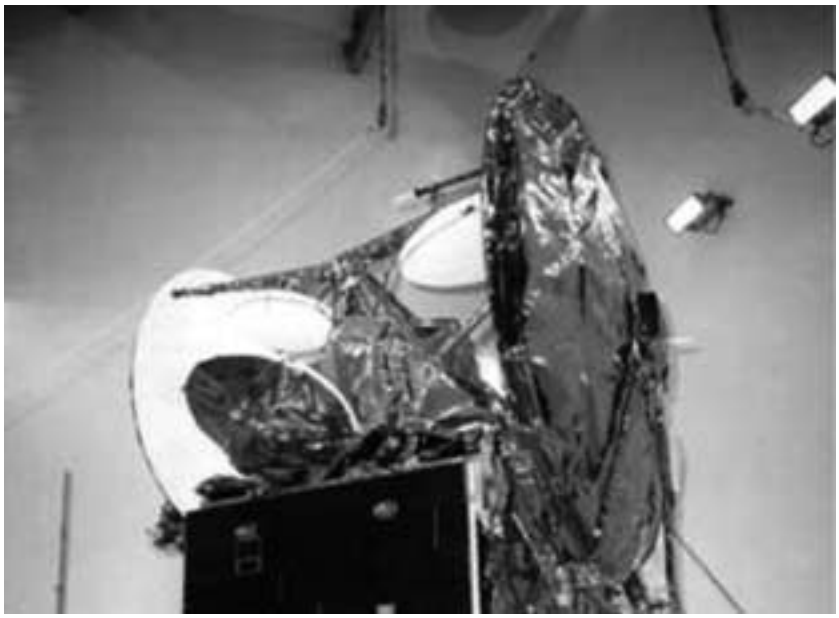
Options for the New Century

The world is entering an era of shared global utilities. These utilities are increasingly based upon space systems. To understand the importance of these utilities, consider an event in California just a few years ago. On 23 October 1997, a power substation in San Francisco shut down unexpectedly. Occurring during rush hour, this power loss plunged the entire city into a four-hour gridlock. Several days later, it was determined that this event had been the result of deliberate sabotage: Someone had broken into the substation and turned off a number of the generators. Whereas this event appeared to have been the result of a single individual, it raised the specter of organized attacks on utilities covering a major portion of the nation. Such attacks would not and could not be adequately addressed by civilian law enforcement agencies. Organized and widespread attacks on utilities systems could very well be part of a concerted attack on the United States in the future.

As global nuclear or conventional strikes on the United States become less likely (for a time, but certainly not forever), attacks against an ever more integrated economic and commercially reliant infrastructure become more likely. To understand how the military itself relies on these commercial utilities, consider that 95 percent of current military communications are carried over commercial circuits. This reliance on commercial circuits prompted the president to charter the National Commission on Critical Infrastructure Protection and the Congress to charter a National Defense Panel to review the Department of Defense. These groups and many others decry the vulnerability of our military infrastructure as well as the lack of national security attention being focused on protecting these services. The Space Commission chaired by Donald Rumsfeld likened US vulnerability to a space “Pearl Harbor.” What all of these reports do not explicitly state is the degree to which these global utilities are increasingly space-based and are already under attack.

Communications

Most people know that global communications are largely reliant on space systems. Many believe that threats to these communications systems will be "cyber attacks" or other forms of "cyber piracy." These are assumed to be computer virus-type attacks inserted in the process flow of communications. For example, a group of teenagers hacked into a number of sensitive DOD and National Aeronautics and Space Administration (NASA) computers in early 1998 (and there have been a number of similar incidents since).[1] With recognition of the threat of cyber attack, many groups, including the US military, are moving to protect themselves by planning and/or implementing various strategies, including having multiple redundant communication systems. Information warfare and its methods, to be sure, will play an ever-increasing role in national security affairs. However, the threat is not limited to just the cyber dimension. The *physical* assets that comprise communications networks—



Courtesy of NASA

Advanced Communication Technology Satellite

whether terrestrial or spaceborne—will also continue to be targets. With increased ease of access to space and the relatively low number of space "nodes" in the form of individual satellites, these assets become increasingly important and are, for now, totally vulnerable.

It is also widely believed that only sophisticated states or groups will be able to mount attacks on global communications, particularly against the space nodes. In fact, this is not true. Consider an incident in 1996 between the states of Tonga and Indonesia—neither highly developed technologically. Both states had claimed a GEO satellite communications slot. When Tonga moved its national communications satellite into this disputed spot, Indonesia protested. However, it appears that Indonesia did more than just protest, for Tongans soon began having difficulties in using their satellite; apparently, it was being jammed. Although it is now widely accepted that Indonesia was deliberately interfering with the Tongan satellite, it took considerable time before any clear idea of what was happening emerged. The lesson here is not that a satellite can be jammed, but that relatively undeveloped nations have both the will and the means to interfere with another state's space-based infrastructure. Add to this the will and determination of not only nation-states, but also nonstate actors such as terrorist groups, and the spectrum of threats becomes very wide indeed.

Global communications will increasingly rely on space for both military and civil uses, especially in those areas not serviceable by terrestrial networks. Direct broadcast television is now being adapted for military use in the "Global Broadcast System" program. We noted in chapter 1 the role being played by distributed low Earth orbit satellite communications systems in constructing the "information superhighway" as it has come to be called. Since virtually all financial transactions—trillions of dollars per day—travel over these networks, an attack can have devastating consequences on national and even global economies.

Even only small decreases in communications capacity can have far-reaching consequences for military or economic endeavors. Consider what some call the "Mother's Day Syndrome."

Anyone attempting to call his or her mother on that holiday knows the frustration of repeatedly getting the recorded phone message, "Due to heavy Mother's Day calling, all circuits are busy; please try your call again later." Imagine trying to conduct a critical business—or worse, a military operation—in the presence of such problems.

Of interest to note here is the military origin for communications capabilities we now rely upon. The Internet was, after all, an initiative of the Defense Advanced Research Projects Agency in the 1960s.

Global Positioning System

Another important global utility that arose out of military requirements is the Global Positioning System, or GPS. This system has become the key to an $8 billion-plus industry. It will soon be the primary, and perhaps sole, means for air traffic management. Its other applications range from entertainment and recreation to agriculture, Earth resources, and exploration. However, its potentially most far-reaching application is in timing. To understand its importance as a timing source, consider an incident that occurred on 17 March 1997. A small manual input error was made in a routine update to one of the constellation's 24 satellites that resulted in a small time error being broadcast on a single satellite for only six seconds. While this would have little impact on those who use GPS as a navigation tool (most GPS receivers will ignore a single out-of-range error), those who use the system for timing purposes will get a time "hack" from the nearest satellite. These time readings have many uses, one of the most important being time-shared circuits—circuits that interweave many different users on the same wires. Cellular telephone systems are just one such time-shared circuit. Thus, the cellular networks in the eastern United States duly picked up the errant time-hack satellite—and 110 of 800 cellular sites in that part of the country failed. Since some of its elements had an incorrect time and other elements had the correct time, the circuits were no longer correctly time-shared. The entire system responded by "crashing" for several hours.

Courtesy of NASA

American Satellite Company (ASC) Communication Satellite

Future GPS upgrades promise time hacks as accurate as one nanosecond (one billionth of a second)—at least 20 times better than today's system. This means properly coordinated systems will be able to time-share even more efficiently. But also the nanosecond timing is very close to the operating cycle-time speed of most modern integrated circuits. What this means is that computers at positions separated by thousands of miles can operate in a coordinated manner. This will, in turn, lead to any given function becoming "distributed" over

many computers operating in concert through the good offices of the GPS timing signal. The efficiency so produced will mean that GPS coordinated circuits will become imbedded in many, if not most, electronic systems. Systems as specialized and diverse as climate control within buildings, water handling, and sewage treatment will become dependent on that simple GPS signal. It is not difficult to conclude that someone interfering with the GPS timing signal can produce a devastating impact on national or even international operations.

More Utilities on the Way

The US national security community continues to pursue efforts to deploy a global space-based system known as Space-Based Radar (SBR). The purpose of such a system would be to supplement and eventually replace the moving target indicators (MTI) currently employed by the airborne Joint Surveillance, Target Attack Radar System (JSTARS) and the Airborne Warning and Control System (AWACS). While this would continue and expand the "revolution in military affairs" whereby the military would be able to "find, fix, track, and target" objects anywhere on the planet, it has even more far-reaching commercial implications. Just as the GPS timing signal acts as an electronic traffic cop, the SBR will serve as a global traffic cop for all things moving on or above the surface (and might eventually be extended even below the surface). It paints a radar picture of the ground much as an AWACS aircraft maps the air. Such a radar platform could migrate to space.

Knowing where everything is and where it's moving to will result in great increases in traffic flow for all types of goods, services, and transportation. Since SBR uses synthetic aperture radar (SAR), we would have not only indications of moving objects but images of them as well.

Since the 1970s, experts have discussed the possibility of supplying electrical power from space. Two concepts emerged: solar-power satellites and fusion-power systems. Solar-power satellites are probably the more near-term of the concepts. The basic idea is to build immense—perhaps kilometers on a side—solar voltaic cell satellites to produce large amounts of

Courtesy of NASA

Airborne Synthetic Aperture Radar (AIRSAR)

solar electrical power. These huge “solar panels” would “beam” this power to Earth using microwave or perhaps laser beams. Many technological problems must be solved before this concept becomes a reality, including efficient ways to convert electrical energy back and forth between sunlight, laser or microwave energy, and electrical power. Another issue at hand is the need for low-cost ways to emplace massive solar-power stations in space—or perhaps to construct them from resources mined on the Moon or on asteroids. These problems are not insurmountable, but experts agree that it will take decades before they are adequately addressed.

Key to solving these problems is the efficient “free space” transmission of energy. Laser or microwave beams appear most likely, and both have been demonstrated—but not with

the necessary degree of efficiency. Related to this transmission problem is the challenge of "downlinking" the power generated in space to a terrestrial location without endangering lives or property. As with laser and microwave beams, plausible approaches to solving this problem have been proposed and progress is being made.

An alternative source of energy from space is nuclear fusion, which proceeds from a "resource" that is present on the Moon but not on Earth. Nuclear fusion is theoretically much cleaner than nuclear fission—our current nuclear power scheme—because it produces much less radioactive by-product. This is particularly true for fusion reactions using a very rare isotope of Helium—Helium Three, or He^3. This isotope is produced in the outer regions of the Sun via nuclear reactions. Because Earth's magnetic field and atmosphere shield it from much of this radiation, little He^3 reaches Earth's surface. The Moon has neither atmosphere nor magnetic field, however, and He^3 from billions of years of exposure has been collected in rocks on the lunar surface. Visionaries have proposed mining the Moon for this ultimate fusion fuel, but we are years away from any reasonable concept for efficient use of nuclear fusion. Moreover, even He^3 fusion is not completely free of radioactive by-product.

Space may, however, provide another answer for nuclear power. Since locations in space, such as the Moon, are "lifeless," far more efficient nuclear power production—as well as other hazardous nuclear processes—could go on there with little or no danger to the terrestrial biosphere or its life. Again, the key to success is the ability to transmit energy efficiently from one place to another.

The effective and safe perfection of power beaming or a similar form of long-distance energy transport will revolutionize this utility, regardless of the initial source of the energy. Much of today's energy costs is in transporting raw material—oil, for example—from its production location to the energy production and use site. As long-distance energy transmission becomes feasible, this physical transport will undoubtedly migrate to space-based transmission systems much as communications systems have done and are continuing to do.

Once this happens, we will have a fundamental global utility in space—and one that modern civilization cannot do without. Once these space-based transmission systems are in place, space-based energy production, through solar-power satellites, space-based fusion reactors, or some other method, will begin to supply increasing quantities of energy to meet Earth's burgeoning demand.*

It is important here to note the synergy between increased access to energy from space and increased access to space. Note the discussion in chapter 3 concerning the mean per capita energy usage of a terrestrial citizen and the energy cost to get to space. Unless per capita energy consumption can increase dramatically, access to space for the average citizen will be very limited. However, a terrestrially closed ecosphere can neither supply nor contain a significant increase in energy consumption. Unlimited expansion of per capita energy usage may be possible, however, if we use space as both a source of energy and, maybe more important, as a repository for energy wastes—making the terrestrial ecosphere an "open" system.

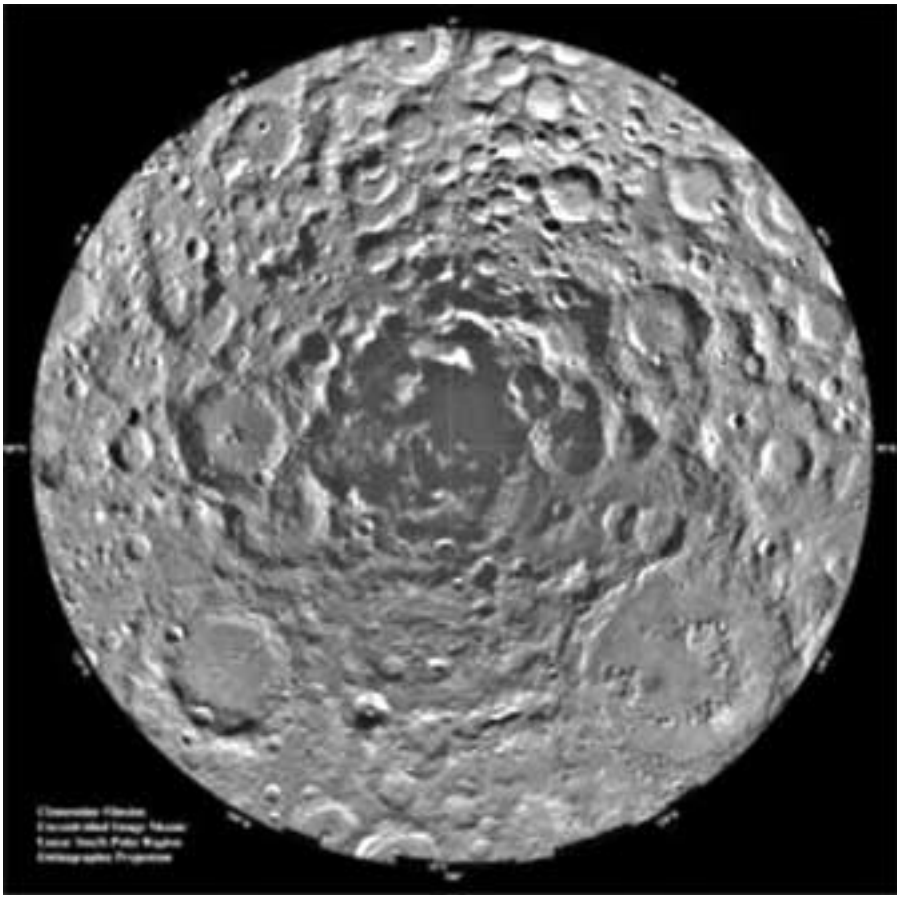
At the same time, this dual use of space could make it much easier for all people to access space. It will be then, perhaps a century or more into the future, when mankind's true expansion into the solar system begins.

Other Space-Based Resources

Although we are again bordering on the realm of science fiction, space does offer unlimited resources. The lunar surface appears to have nothing of great material value other than special resources such as He^3. It even lacks such critical manufacturing material as water and hydrocarbons (with the possible exception of the lunar South Pole, where ice appears to have been discovered a few years ago).

As new products, perhaps from bioengineering technology or nuclear technology, become increasingly promising, concerns

*The greater our ability to exchange "fossil fuels" for "photons" in our society, the more effective will be energy sources from space.



Courtesy of NASA

South Pole Region of the Moon as Seen by *Clementine*

about the processes required to manufacture them also increase. Consider a hypothetical example. Suppose a new bioengineering product that could extend life spans by some significant amount were proposed. Suppose, too, that the process required to produce the product was itself potentially very dangerous. It is unlikely that such a process would be allowed to proceed very far on Earth. Far from Earth and its teeming life, however, this process would be much more acceptable. It thus appears plausible that immensely profitable manufacturing

could begin on the natural isolation ward the Moon represents. It is particularly likely that such manufacturing, most probably automated, would occur in proximity with the very limited lunar water resources at the lunar poles.

Protection and Denial

This brief, highly speculative discussion only tells us that space could very well come to represent a vital and increasingly large share of the global economy. Indeed, space already is an economic engine in some cases. Resources and opportunities are limited at some locations (e.g., GEO communications satellite slots). Immense wealth opportunities, sources of vital infrastructure, and limited resources invariably provide the basis for conflict. As the world returns to its traditional multinational competition, and as threats of global war recede, such conflicts could well escalate.

The potential for increasing conflict in the space arena has not been lost on US national security planners. Numerous reports and recommendations, such as those of presidential commissions (including the Rumsfeld-led Space Commission) and Defense Science Board reports, among others, stress the growing importance of infrastructure protection. However, most do not seem to fully recognize the degree to which these utilities are moving to space. Nor do they consider both the defensive and the offensive aspects of this move.

Imagine that one nation threatens another nation at some future time. The threatening party will undoubtedly rely to some extent on global utilities to conduct all their activities, whether economic, military, or support. No group will be able to conduct any significant international operation in the twenty-first century without access to space-based global support. Thus, just as aggressors will threaten our access to these support systems, we could mitigate the threat they pose by denying such access to them.

How does one deny access to a space-based utility? How does one protect it? There are two strategies that an aggressor may employ to attack a utility. One is to attack the links—cut the “wires.” The other is to attack the “nodes”—generating

stations and switching substations. Furthermore, there are two tactics that can be used: (1) a direct, physical frontal attack on the system; and (2) a cloak-and-dagger operation to sabotage the capability. Both strategies and both tactics are relevant to space-based utilities. Perhaps the best historical analogy is the struggle to protect and control international shipping during the sixteenth through twentieth centuries.

Naval forces grew out of a nation's requirement to protect its trade and, secondarily, to deny trade to an adversary. Only coincidentally were naval forces used to engage other nations' navies—and even more coincidentally to conduct offensive operations against another nation's territory. One had to worry about attacks and defenses of "links" (operations on the high seas) and "nodes" (operations relating to ports, primarily blockades). One had to worry about attack by an enemy navy or rogue pirates as well as sabotage against ports and ships. Sabotage was prevented via good security. To protect against attack at sea, merchant ships sailed in convoys and were accompanied by armed escorts. The same ships could enforce or break blockades—and the same strategies and tactics are relevant for space-based trade.

The newly emerging area of information warfare is the twenty-first century threat analogous to nineteenth century sabotage. Here again, we must be aware of the potential for information warfare to be employed against our global utilities. Putting good security mechanisms in place is the only reliable defense, and devising strategies to circumvent an adversary's security measures is the means for offensive opportunities. However, no major power can successfully rely solely on sabotage and security to effectively protect its own utilities or to deny use of a commercial utility to an enemy. Ultimately, a power must be able to (1) "kill people and break their stuff" and (2) threaten the same.

Perhaps the most effective means to dominate commercial and civil operations is through perception management. Consider the naval analogy. Only seldom does a naval force need to actually strike at a commercial ship to enforce a blockade. The mere threat of lost revenue and revenue-producing ships is almost always sufficient to deter commercial concerns from

trying to run blockades. When shipping has been threatened in mid-ocean by naval forces in the past, the most effective defense has generally been to escort commercial ships with a formidable armed force while simultaneously seeking to engage the threatening enemy before he can get into position. The key in all cases is having armed ships that are fast and flexible.

Let's apply these concepts to space commerce, noting some of the similarities and differences. First, consider the location of nodes. Currently, the equivalent of a "port" is a satellite uplink/downlink site. Another key node is the satellite control center—generally not collocated with the downlink site. However, future space systems are likely headed to a "distributed" architecture in which any location equipped with a cellular-type phone could be used as the up-down link center. Correspondingly, any location, perhaps as far as thousands of miles away, could act as a control center using Internet-type communications links. The satellites themselves could be linked via space-to-space communications nodes. The impact of these changes is that, unlike the naval analogy, "ports" or nodes are proliferating. Another analogy was the Ho Chi Minh Trail in the Vietnam War. It proved utterly impossible to interdict each vehicle moving down the road; it was better to concentrate on key nodes. Similarly, it will become increasingly difficult to target nodes on the ground because there will be so many of them. Moreover, these nodes will generally be deep within the territory of a sovereign state, which may or may not be a party to the hostilities. Unless we are in a large-scale war, physically striking these targets will be problematic. Cyber attacks via computer may prove more promising. However, these types of attacks are most effective when covert. Once revealed, cyber attacks could lose their effectiveness as they could alert the target that it is vulnerable, resulting in increased security measures. Of course, there are also policy issues with launching covert operations against what may very well be an American-owned or partially American-owned (or allies-owned) commercial entity. We must, therefore, look to the nodes and links in space.

The nodes in space are the satellites themselves. By early in the next century, there could be several thousand of these. The links are the radio and, eventually, laser communications

channels between satellites and between the satellites and the ground. Thus, our naval analogy breaks down slightly in space. Satellites are not ships. They are more like mobile transshipping ports. Thus, unlike ports on Earth, these "ports" are constantly moving. The "ships" of space commerce are the communications links; the information they carry is the cargo. Of course, this could change in the future if actual manufactured material is transported through space. But even with energy transmittal systems proposed for the future, the model of mobile ports and speed-of-light links will remain valid.

To control space commerce, then, we must be able to control the activities of the mobile ports—satellites—and/or interrupt and control their crosslinks and downlinks. One approach to interrupting the links is to electronically jam or interfere with the transmission of signals, much like the Tonga-Indonesia incident cited earlier. This is generally difficult to do since radio communications links are increasingly narrow beams. Once satellites begin to communicate with each other and the ground via laser links, they will become even narrower. Thus, to interfere with links, one must be more or less in the line of sight with the nodes between which the communications channels are designed to connect—a very dynamic problem, since everything is moving relative to everything else (except for GEO communications satellites, which move very little in relation to their ground nodes).

The two sets of truly viable targets, then, are the satellites themselves and/or the end user on the ground. It is, of course, possible to focus on denying the receipt of final space products to a user. However, with increasingly flexible and diverse means to transmit information to the user—many not involving any space asset—we are being driven to move even closer to the user we are trying to influence. This task is difficult, expensive, and, in many cases, politically and physically risky. We turn back, therefore, to the nodes in the great "common" of space—the satellites.

Regarding satellites, we might wish to accomplish one or more of the following four objectives.

1. Deny its use to an enemy.
2. Degrade its performance.

3. Disrupt its operation.
4. Destroy it.

The first two are more appealing because they are aimed at temporary effects. Temporary, reversible effects on satellites are much like intercepting a ship at sea during a blockade and turning it. The ship, or satellite, is still available for use by other groups or by a targeted group at a future time when the issue at hand has been resolved.

A brief digression is in order here. US history reveals a significant distinction between offensive and defensive military activities. In the eighteenth century, European monarchs conducted offensive military activities for their own benefit. These activities were characterized by armed intervention in the affairs of another state and, in naval terms, physical attacks on an enemy's ships and ports. The founding fathers of the United States, wishing to avoid an imperial executive, gave the power to conduct offensive operations, or declare war, to the people through their Congress. Defensive actions taken solely to protect American sovereignty and defend fielded forces were allowed to the executive at his own discretion. Thus, America has a long tradition of considering defensive acts far more favorably—the very name, "Defense Department," is a clear legacy of this tradition.

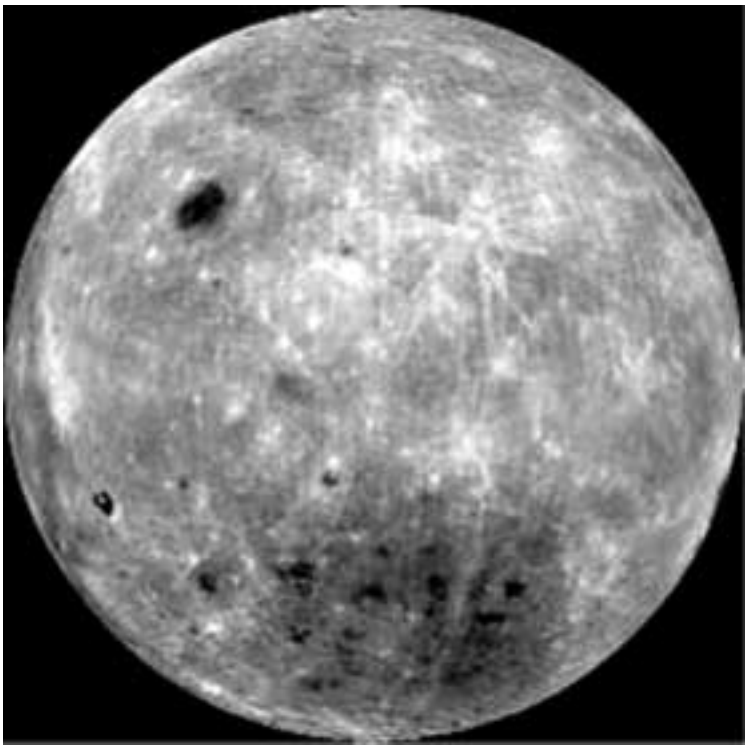
What, then, is an acceptable defensive operation against a satellite—particularly a commercial one? Clearly, destroying a satellite in space, or permanently damaging it, is akin to open naval warfare in the eighteenth century. It would appear to come under the heading of *offensive operations* unless the targeted satellite had already taken some hostile initiative. However, blockading the satellite could be looked at much differently. Indeed, in a landmark 1863 Supreme Court decision, blockades of Southern ports to neutral shipping were deemed *defensive* and, thus, under presidential executive prerogative. To underscore the acceptability of blockades, one must note that blockades and embargoes of various states have been the primary diplomatic tool used in recent years to further US national security interests.

How would one create a space blockade? Clearly, space circumstances are not like naval circumstances, which are

fundamentally (or at least relatively) static. Spacecraft move quickly. A space service will be delivered by a distributed constellation. The satellite that is providing a service now will not provide the same service to the same customer 15 minutes from now. If we develop the means to deal with one satellite, we must either be able to redirect those means to another quickly, or make the capability so cheap that it may be proliferated to handle many target systems simultaneously. These requirements argue for a highly maneuverable space infrastructure at very low cost.

Today's space systems are inflexible and barely maneuverable. Spacecraft are generally not launched without a lengthy preparation and checkout process—from weeks to months. Moreover, once in place, today's satellites are unable to change their orbit by very much. The reason for this is that it takes almost as much energy to move an orbit plane 90 degrees as it did to initially place the satellite into space. Satellites today are mostly hardware, with only a very small amount of fuel to maintain a precise position and make minor orbit adjustments. If we were to get "up-close and personal" to any satellite, it would be difficult to do the same for satellites in any other orbital plane. A word of clarification here—since all GEO satellites are in more or less the same orbital plane, and it takes relatively little fuel to "drift" along an orbital plane, GEO birds can slowly (in weeks) move to other positions within that plane. However, the new LEO communications systems, and other systems currently being emplaced, reside in up to 10 or more different orbital planes.

Researchers are developing means to remedy this inability to either get to space quickly or move around rapidly from one orbital plane or orbital altitude to another. The key to this revolution is in the ever-decreasing size of satellites and their increasing capability. It is possible to make large orbital changes by making the payload and support structure of a satellite small and increasing its fuel capacity. Satellites a decade ago weighed between 5,000 and 20,000 pounds. Due largely to the push in technology during the 1980s' Strategic Defense Initiative (SDI), satellite sizes decreased about one order of magnitude. The satellites now being deployed in LEO, and soon to other



Courtesy of NASA

Farside View of Earth's Moon as Seen by *Clementine*

orbits, weigh between 500 and 2,000 pounds. It is still expensive to frequently move these satellites around, however, and some experts believe it is unlikely that satellites will get much smaller due to the power required for transmitting a signal to and from the ground or another satellite. To get enough power, the solar panels need to have relatively large surface areas, which would make the satellite large and heavy. The authors believe this, too, may change as much less power-hungry laser communications systems come to the fore. Moreover, compact energy sources such as nuclear power were once on a trajectory to very small, very powerful units. Whereas political concern initially stopped this development, it is less likely that the new technology, with small, relatively nonradioactive systems, will

encounter the same resistance. NASA is, even now, considering resuming development of such technology to power its deeper space probes.

Creative techniques for conserving energy in satellites may also prove valuable. NASA's *Wind* satellite, which provides plasma, energetic particle, and magnetic field input for magnetospheric and ionospheric studies, completed a previously theoretical backflip maneuver in April 1999. Achieving the same orbital changes with propulsive maneuvers alone would require more fuel than the entire mission's fuel budget at launch. Several small maneuvers at strategic locations accomplished the objective at a tiny fraction of propulsive maneuver cost.

Very capable satellites weighing 50 pounds or less are now under development. Some such spacecraft, known as "microsats," have designs that weigh in this range *and* have a two to five kilometers-per-second maneuvering capability (enough to change orbit planes by 30 degrees or more). The cost per satellite of this type is also correspondingly lower—already being in the range of a few million dollars per bird.

The second revolution in space operations is the development of reusable launch vehicles. Although currently driven by NASA's efforts to affordably service the new international space station, the emergence of hundreds—and soon thousands—of commercial satellites will drive the development of small, low-cost, reusable launch vehicles. These vehicles will have the capability to launch up to several thousand pounds into LEO at a cost of a few million dollars or less.

Commercial concerns will not push for highly maneuverable or very responsive launch vehicles for the foreseeable future. Just as commercial ocean-shipping systems, or air systems for that matter, are not very small or fast, those capabilities are likely to remain uniquely military attributes. It is our contention that the military should adapt the new commercial technologies to build an infrastructure of very small spaceplanes capable of launching within hours payloads of up to 1,000 pounds into any orbit and changing the insertion plane of those payloads on short notice. The payload itself would

Courtesy of NASA

Artist's Impression of *Wind* and the Sun-Earth Environment

consist of several small, highly maneuverable "microsats," each weighing less than 100 pounds.

How might we use these capabilities to control and leverage space commerce? One possibility might involve placing mi-

crosats in the vicinity of targeted space systems. In some sense these escorting microsats would be analogous to naval destroyers. All satellites in a targeted constellation need not be "escorted." It is possible to narrow the target to a subset of a constellation that is needed to provide service to a given area, particularly if there is only a limited time period during which we would intend to manage use of that asset. Once in place, the escorting microsat could passively interfere with the satellites' operation. It could physically or electronically block crosslinks. It could obstruct optical or radar imaging apertures. It could even "shade" the solar panels to cause power deficit shutdowns. Clearly, the possibilities are limited only by engineering capabilities and the system designer's imagination.

We can see how these tools might lead to effective denial of an adversary's access to commercial or other space-based service. One might expect a global multinational corporation providing space-based services to be reluctant to follow the US government's dictates on denying service. This might be particularly so if the protagonist was part owner of the corporation. This is analogous to declaring an embargo on seaborne or airborne goods and services. Initially, the corporation may try to ignore the embargo. That's when the United States could begin to deny service—perhaps by shading sequentially the solar-power resources on critical satellites, forcing a time-consuming and revenue-losing shutdown, recovery from which might take weeks on each failed spacecraft. As the targeted corporation sees increasing percentages of its revenue-producing assets turned off, it becomes ever more likely that the corporation would voluntarily deny service to the targeted party. After an initial few demonstrations of US capability and commitment, the mere presence of a few microsats escorting commercial satellites could be sufficient to establish and maintain embargoes in future crises.

Over time, it is likely that other powers would seek to match or circumvent US ability to deny access to commercial capabilities. In such cases, these escort assets would serve in a wholly defensive capacity. Should an adversary try to deny US or US-supported parties access to space services, we could use escort satellites to block or even destroy the attacker. These

functions are exactly analogous to naval and air escort. In no case does the escort have to be 100 percent effective in establishing embargoes or protecting friendly assets from enemy embargoes. The goal is simply to have more and better capabilities to outperform both commercial targets and hostile powers.

It is unlikely that commercial concerns would add substantial and expensive maneuver and counterforce capability to their satellites. Merchant ships did initially provide their own protection, in the form of cannons, convoys, or mercenary marines. Eventually, however, building a navy to provide for their common defense proved more cost-effective than each company trying to do it individually. This would particularly be true to the degree that the United States continues the historical US and British policy of open and free trade on the seas (space). In that case, the only embargoes enforced would be as they had been—on aggressive states and combatants. It is likely that aggressors would seek to counter us through symmetric or asymmetric means. This is due, quite simply, to the very high leverage they would accrue by denying space service to adversaries and preserving it for themselves. As much as we might like to have space declared a "peaceful and demilitarized zone," its importance to any future crisis or conflict mandates that it will be, as it already is, an arena for confrontation. It may even be the initial theater of struggle. If we intend to preserve the free and open use of space, we must be prepared to enforce it.

If we are to control space effectively, we must recognize that continuous real-time surveillance and tracking of all targets is essential. Superior situational awareness, the basis of America's overwhelming air and sea superiority today, will be necessary if we are to achieve space dominance tomorrow. However, the United States has invested little in real-time awareness in space, focusing only on tracking objects whose locations we already know. The first step in establishing space superiority is to develop the ability to search all of space in a short time—probably through ground- and space-based wide-field optical sensors supplemented with ground-based radar "fences" that detect anything that passes through them. As we, and our potential adversaries, develop the means outlined above

Courtesy of NASA

Earth Station Antenna at Johnson Space Center

to move things around in space, and to put them there equally rapidly, we must increase our ”space vigilance” capabilities.

Seizing the Solar System

Currently, NASA is the agent for US space exploration. This is counter to traditional American approaches to exploring and exploiting new territory. It is also counter to common sense. NASA is a research and technology organization. It has little incentive to develop, open, and protect new areas for commercial exploitation.

Since the era of Lewis and Clark, the United States military has played a unique and central role in US-sponsored exploration. Throughout the nineteenth century, the primary purpose of peacetime military forces was to explore, map, and protect exploitation of the unknown portions of the North American continent. Captains Meriweather Lewis and Rogers Clark led the first of these expeditions and were the prototype

for many who followed. Officially designed to map newly acquired territory, the Lewis and Clark expedition had several related objectives that were clearly expansionist, scientific, commercial, and military. First and foremost, the military expedition was designed to show US presence in the newly acquired Louisiana Territory, particularly in areas where actual ownership between Spain, Britain, and the new United States was unclear. Its scientific character was high in official priority, due in part to public interest but due also to the scientific curiosity of President Thomas Jefferson, whose brainchild it was. But its real priority was to open a vast new area for commercial development—at the time thought mostly to be the lucrative fur trade. The expedition was military for a number of reasons, including the military's tradition of operating in unknown environments that were often hostile. The military also had a long tradition of retaining focus on government rather than personal objectives. Finally, it was likely that other expanding powers might confront such an expedition with military forces of their own—and so it was throughout the nineteenth century. Military expeditions charted the unknown, mostly to map and provide access to commercial assets and to protect those assets, as well as those using them, from hostile intervention. Indeed, the primary peacetime occupation of the US military was just this function, which also served to keep the vital nucleus of a fighting force ready in time of national emergency: "keeping the powder dry."

Until the late 1950s, exploration of the unknown remained primarily a military function. As the frontiers grew "up" into the atmosphere and space rather than "out" across the prairies and mountains, American exploration retained a military character. Throughout the first half of this century, the US Army and Navy were heavily involved in and supportive of manned balloon flights into the upper atmosphere. Into the 1950s, manned rocket-plane development in the X-series vehicles was largely a military effort. As noted in chapter 1, it was precisely when the competition for space exploration became "symbolic," as a contest between competing ideologies in the Apollo Program and the events that led up to it, that military participation in space exploration was deliberately suppressed.

Courtesy of NASA

X-15 with B-52 Mothership Flyover

Although the "space race" of the 1960s was part of the Cold War competition with the Soviet Union, with undeniably military overtones, it was deliberately a civilian operation. So much so that US President Richard M. Nixon shuffled the *Apollo 11* lunar excursion so that a civilian, Neil A. Armstrong, would be the first man to step on the Moon rather than the military officer, Air Force colonel Buzz Aldrin. Precisely because there was nothing of direct value perceived in space—particularly deep space such as the Moon—the "perception value" of the US program being "peaceful" and "civilian" took precedence. Military involvement was not only submerged, it was deliberately downplayed.

The Cold War is over, but its perceptions live on. Military personnel make up a large percentage of NASA's astronaut corps, but military uniforms and titles are seldom shown. NASA's leadership bears a striking legacy of military background in that

a very high number of former and retired military personnel are on the team. Nevertheless, the pretense remains that our space exploration effort is overwhelmingly civilian.

In 1989, one of the authors was a staff officer at the White House National Space Council responsible for staff work on President George H. W. Bush's Space Exploration Initiative (SEI). Occurring as this initiative did in the closing years of the Cold War, it offered an opportunity to rethink the role of the military in space exploration. There were, at the time, compelling arguments to reintegrate the national space effort. Not the least of these arguments was financial. The cost of duplicative research and space operations facilities alone was prohibitive. Moreover, due to huge investments in SDI technology within the Departments of Defense and Energy at the time, much of the most promising space technology and expertise resided in the national security sector and not in the civil (NASA) programs. Finally, there was a realization that, with the Cold War subsiding but the world remaining a dangerous place, it would be desirable to preserve and continue the development of military space prowess—which won the Cold War—in a combined civil-military space exploration effort. In the case of SEI, a revitalized manned exploration of the Moon and Mars was to involve both NASA and its national security partners in the Department of Energy (DOE) and DOD. A presidential directive so stating was signed in 1990 and a combined NASA-DOE-DOD team was constituted under *Apollo 10* astronaut and retired Air Force lieutenant general Tom Stafford to chart the program.

The SEI failed to take root for a variety of reasons, the burgeoning federal deficit at that time being most serious. "Peace dividends" from reduced military requirements went to deficit reduction rather than ill-defined space adventures. Also, public support for something that neither made America rich nor protected it from threats was confined to the relatively small "Star Trek" segment of society. Further, many in Congress had little interest in increasing expenditures on space. They and others resisted nurturing an expanding military role in space exploration.

The *Clementine* Program—the successful *Clementine I* and the canceled *Clementine II*—was an example of an important new direction in US space development and exploitation. *Clementine I* was conceived in late 1989 by one of the authors and a colleague on the National Space Council staff as a means to (1) transfer new DOD, low-cost technology into NASA culture; (2) conduct meaningful space exploration of the Moon and asteroids, focused on both the potential threat of asteroids and the appeal of financial gain in surveying potentially useful resources on the Moon and asteroids; and (3) demonstrate space-based Brilliant Pebbles interceptor technology in an ABM Treaty-compliant and politically acceptable scientific mission. The program got underway in 1991. With only two years and a development cost of $80 million, *Clementine I* was launched in January 1994. The whole program had a very "counterculture" approach and reveled in its "underground" success. With the change of administration and policy toward space-based missile defenses in 1993, the program's advocates moved on to other duties—but not before *Clementine I* was launched.

Clementine I produced the first full, multicolor map of the Moon and proved that new low-cost technology, which might be used in space-based missile defenses, was feasible. And, in its most far-reaching potential implication, it detected what may be modest deposits of ice at the lunar South Pole. This ice, confirmed at both poles by the *Lunar Prospector* in 1998, is probably the remnant of billions of years of bombardment of the Moon by ice-bearing comets—the vaporized ice being trapped in deep craters near the lunar South Pole where sunlight never penetrates and cannot melt the deposits. Unfortunately, software errors prevented *Clementine I* from completing its mission with a flyby of an asteroid. It did, however, change the NASA "culture," which now enthusiastically embraces its "faster, cheaper, better" philosophy in virtually every area of NASA endeavor. Whether this cultural change is real, however, remains to be seen.

Advocates of space-based missile defenses and space control missions with Congress demanded and provided funds for a *Clementine II* mission to be directed at completing its prede-

Courtesy of NASA

The Moon, Solar Corona, and Venus, as Seen by *Clementine*

cessor's reconnaissance of an asteroid. This mission, to have been launched about the year 2000, was more ambitious—it was to fire an impact probe or interceptor to strike one or more Earth-crossing asteroids. The successful completion of *Clementine II* would have proved the technology necessary for detailed space control and missile defense as well as "planetary defense" of Earth against asteroids—a topic to be discussed in more detail below. In addition, it would have provided the first "assay" of asteroid composition—necessary for any commercial exploitation of asteroid resources. Truly, *Clementines I* and *II* earned their names as the "Miner's Daughters." However, the program was line-item-vetoed in October 1997. Nevertheless, the defense establishment's foray into space exploration is only beginning, not ending. Strictly "scientific" exploration of space or any other new area is quite acceptable as long as nothing of value is seen in it and no threat can emerge from the new territory. This was the case for the Antarctic continent and has certainly been the case for objects beyond GEO orbits. However, just as the global economy is migrating to increased reliance on LEO-, MEO-, and GEO-based global utilities, so there will be both potential threats to them and economic resources to protect. The same will inevitably occur with the Moon, asteroids, and other objects in the solar system. This could happen much sooner than has been thought, given the promise of lunar and asteroid resource utilization and potential large-scale energy production and distribution in space. The military services will inevitably return to their traditional roles: protect commerce, deny access to adversaries, and discover new resources. It would be a good thing if sufficient forethought and investment were made in this new mission.

Notes

1. "'Rites of Youth': Hacking in the 1990s," *Washington Post,* 21 March 1998, 15.

Chapter 5

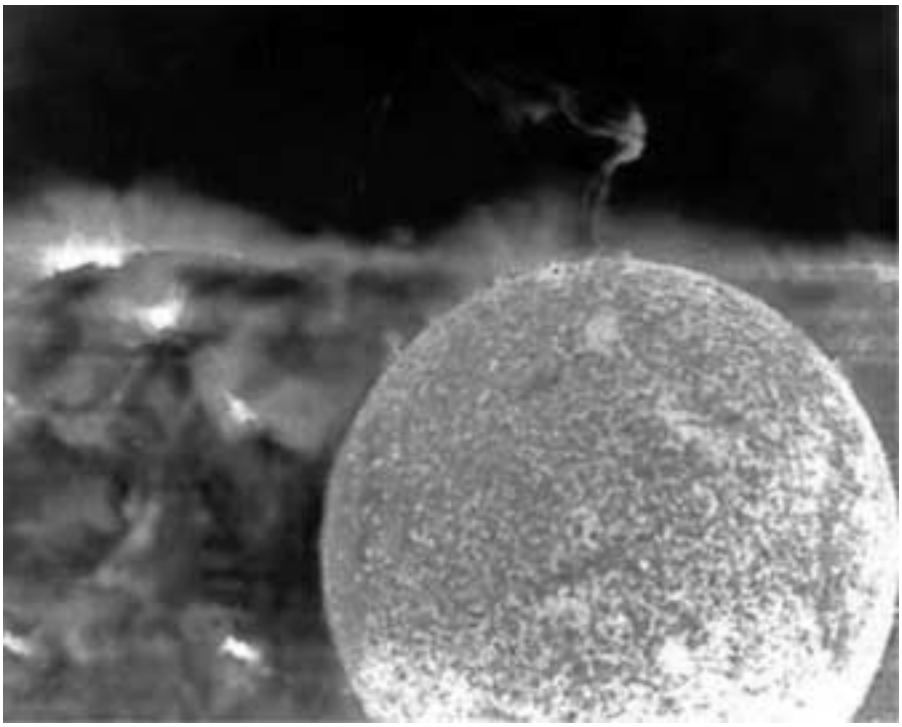
Threats, Limitations, Constraints

In chapter 3, we discussed the physical constraints involved in getting to space, primarily focusing on energy requirements. Once there, however, space provides a number of natural limitations, and even threats, that must be understood. Sun Tzu, the strategist of ancient China, said, "know the ground, know the weather; your victory will then be total." We must understand that space is not empty. It holds many natural barriers. In this chapter, we will briefly review those realities and how they can be mitigated.

Natural Barriers

In addition to the energy, expense, and difficulty involved in getting into space, there are natural barriers to be reckoned with. The environment there is far from benign. To use once again the seafaring analogy, there exist in space the equivalents of thunderstorms and typhoons.

Space "weather" in our solar system has the Sun as its source. The Sun has at its core a giant fusion energy generator. The fusion energy released in converting hydrogen to helium has powered the Sun for over four billion years and should continue to do so for at least that much longer. However, the outer part of the Sun is a boiling sea of electrically charged "plasma." Imbedded in this plasma are magnetic fields. As the solar energy boils its way to the surface, these magnetic fields are twisted and enhanced. At some point, the magnetic fields burst through to what we see as the Sun's visible surface—the "photosphere." Where the magnetic fields are particularly strong, they cause a cooler, dark region to form. We call this dark region a sunspot. The photosphere is nearly the coolest part of the Sun—at *only* about 10,000 degrees Fahrenheit. However, the magnetic fields arch above the photosphere into tenuous regions—the solar chromosphere and corona—that we can only see with specialized instruments.



Courtesy of NASA

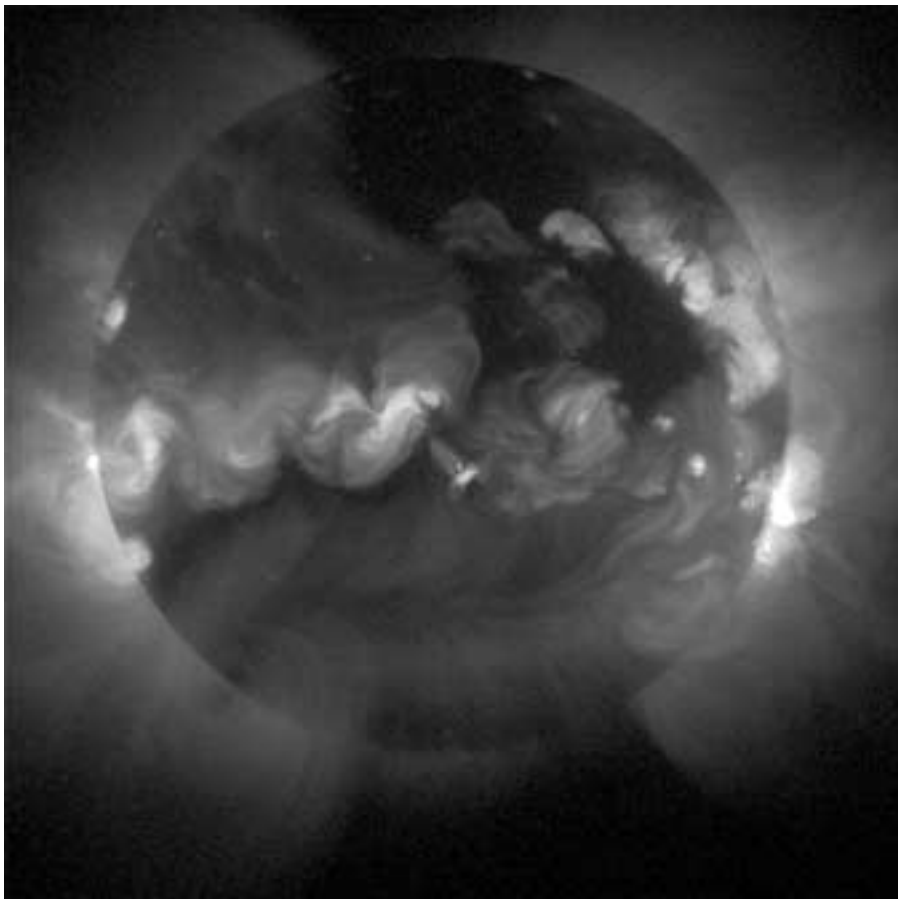
Sun – Solar Flare – Corona and Large Solar Eruption

The fields carry energy with them and actually heat the corona to temperatures of millions of degrees. Sometimes the magnetic fields "snap," much as a rubber band that has been wound too tightly, and violently release energy over an area many times the size of Earth. This violent energy release can heat the corona to over 100 million degrees and is known as a flare. It is the flare that causes storms in space near Earth.

A solar flare has the effect of a giant nuclear explosion in the Sun's corona. It sends out three kinds of radiation, each of which can affect events in space near Earth. The very high temperatures in the flare produce an intense pulse of gamma and x-radiation—a "shock wave." Traveling at the speed of light, this shock reaches Earth about eight minutes after the flare occurs. Although this radiation doesn't greatly damage

satellites, it does heat the outer layers of Earth's atmosphere—the ionosphere. The changes produced in the ionosphere cause it to rise higher into space, generating increased drag to satellites in LEO. It also affects the ionosphere's response to radio waves, which can cause blackouts of satellite communications and errors in Global Positioning System satellite positions. The solar flare also produces high-energy particles—protons and atomic nuclei—that travel at a sizable fraction of the speed of light and reach Earth within an hour or two after the flare. These high-energy particles can penetrate deep inside a satellite to disrupt sensitive electronics. Whereas military satellites are hardened against these effects, increasingly sophisticated and electronically integrated civil and commercial satellites are more vulnerable. The final products of a flare are large clouds of electrically charged particles—in essence, they are pieces of the solar corona lifted away from the Sun and flung into space. These particles are the most unpredictable and potentially the most damaging of Sun flare's products.

It is the charged particle cloud, which can take several days to get to Earth, that constitutes the solar storm. Unlike the direct radiation, the particle clouds wend their way to Earth in a most circuitous path, as do some of the higher-energy particles. The space between Earth and Sun is filled with a weak but chaotic magnetic field that channels the particle storm clouds in unpredictable directions. A given cloud may or may not hit Earth. Earth's magnetic field is another factor that affects the storm's impact. It stretches deep into space, connecting the north and south magnetic poles. The region affected by these fields, referred to as the magnetosphere, stretches out beyond GEO orbit. The electronic solar storm compresses and distorts the magnetosphere when it strikes. Huge sheets of electronic particles can sweep back and forth across GEO satellites and deposit large electrical charges on the satellites' surfaces. These electrical charges can short out vital satellite components. Deeper in toward Earth, some of the storm particles get trapped into belts of intense radiation—the Van Allen belts. MEO satellites, such as the Global Positioning System, orbit there and can feel the storm's effects. Even some satellites in LEO can be damaged. Earth's



Courtesy of NASA

Solar Flare

magnetic fields channel some particles down over the magnetic poles. When these particles strike the atmosphere, the Aurora Borealis or “northern lights” phenomenon develops. Satellites or manned space missions in polar orbits can also be affected by these particles.

These solar storms can even have a dramatic effect on terrestrial conditions. Solar storm particles striking Earth’s upper atmosphere can produce immense electrical currents in terrestrial power grids. Large surges caused by solar storms

have been known to burn out nodes in power grids. In fact, such surges are responsible for some of the largest power outages in recent decades.

Solar flares and associated storms do not occur randomly. The Sun has a well-known 11-year sunspot cycle. At solar minimum, very few sunspots occur and there are few serious storms as well. Conversely, we have periods of the largest and most damaging storms just before and just after sunspot maximum. This can be considered the space version of El Niño, as it has the same potential for unpredictable damage and impact. Thus, solar activity and its effects on space operations are important for military operations. While many experts argue that space systems can be designed to handle any space environmental problem, the cost for such systems can become prohibitive even if it were possible to build them. Moreover, there is always the effect one hasn't anticipated. While an adversary who is better able to cope with or predict periods of adverse weather will have an advantage in any area of conflict or confrontation, this will be particularly true in space. Because the space environment is very sensitive, the addition of relatively small amounts of material or energy could change the way it responds to solar storms. For example, small amounts of charged particles injected into the space environment from a space-based particle accelerator could mimic the effects of a large solar storm on another satellite thousands of miles away. Since military forces must be ready to act, often at a time and place not of their choosing, they must be prepared not only to act in adverse conditions but to force an adversary to put up with even worse conditions. It is in the interests of the United States, therefore, to have the best knowledge of space environment conditions possible, based on both *in situ* measurements and an in-depth understanding from which we can accurately predict future conditions. Such knowledge could be a decisive advantage.

"Icebergs" in Space

A dominant theme in the story of humankind has been its struggle against the destructive forces of nature. The tragedy

of White Star Line's *Titanic* on that cold, still April night in 1912 still haunts us. What makes the story of *Titanic* so dramatic is the irony of its fate: the assumption by so many that this great monument to man's achievement was invincible, that nothing so simple as an iceberg from Mother Nature could seal its fate. The chance that *Titanic* would founder upon an iceberg, deemed so remote, was tragically underestimated.

The lives lost in *Titanic*'s chance encounter with a natural obstacle numbered more than 1,500. But how much greater are the stakes for our entire planet as we risk a similar chance encounter with nature's cosmic threats? We need look no further than the example provided by the Shoemaker-Levy 9 comet in July 1994 when it plunged into the planet Jupiter. As it struck the "Giant Planet," the comet's destructive force exceeded by more than six times the entire destructive force of all the nuclear arsenals on the globe.

When our solar system was formed some 4.5 billion years ago, the Sun, containing most of the mass, coalesced first. The

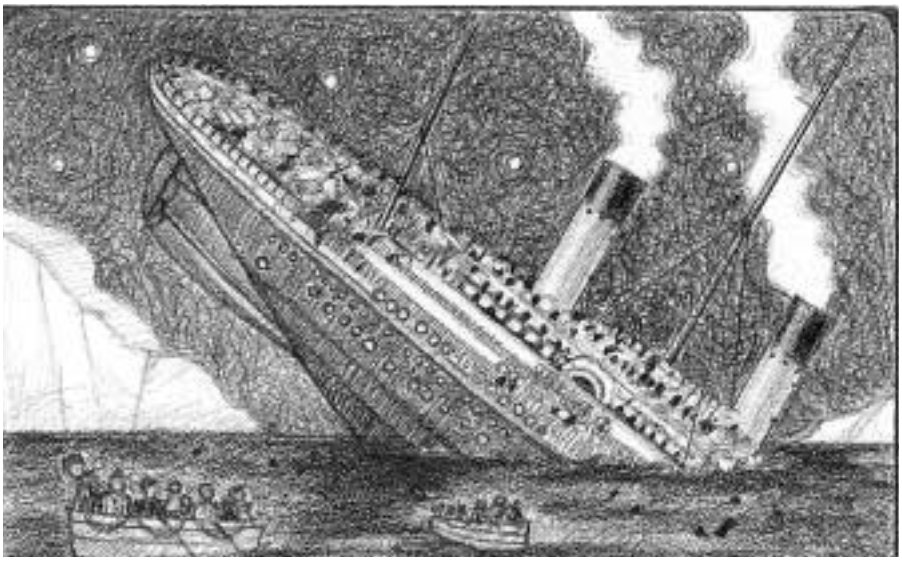


Figure 4. Sinking of the *Titanic*, April 1912

Source: AU Press Design Division

rest of the material swirled around, comprising a flat "pancake" about 10 billion miles wide. Soon, small bodies—planetesimals, a few miles to a few hundred miles wide—coalesced within this pancake. These planetesimals, composed of heavier elements and compounds like rocks and metals, were closer to the Sun and at correspondingly higher temperatures than were the lighter elements. The lighter elements (hydrogen and hydrogen compound ices) were further out. Over time, the planetesimals collided and merged to form planets. In two regions, however, there were not enough planetesimals to form a single planet. The remnants of the inner rock and metal objects now orbit as the asteroid belt, mostly between Jupiter and Mars. The remaining ice objects move in what's known as the Oort cloud, out beyond the orbit of planet Pluto. But these objects do not stay in these locations. Complex interactions with the gravity fields of the Sun, the planets, and even nearby stars, perturb some objects and allow them to fall toward the Sun. Ice balls begin to melt when they approach the Sun. As they melt, they throw off gas and dust, which stream away from the Sun in the solar wind. These streamers are comets. The nearer-in asteroids are generally only seen when they get close to Earth, at which time they are known as near earth objects (NEO).

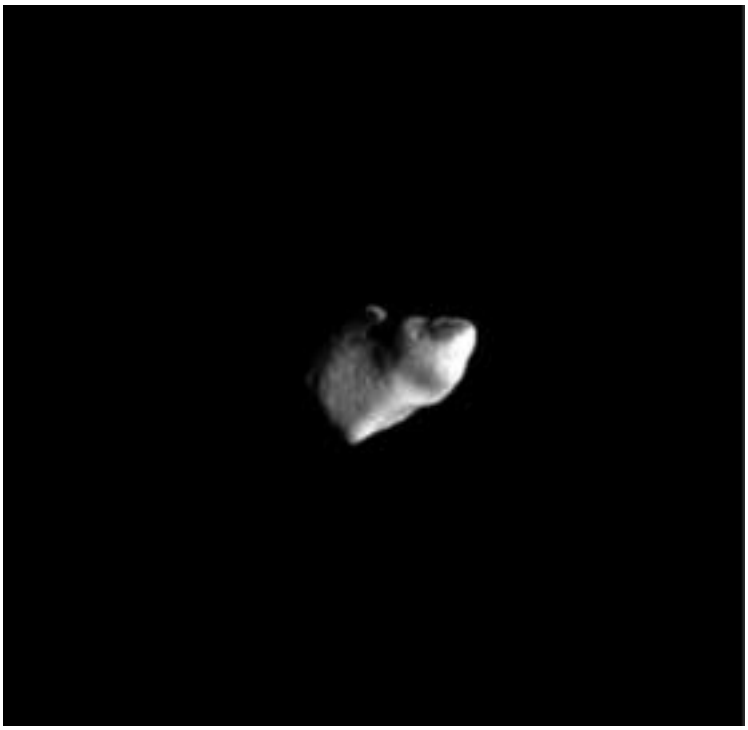
After a few dozen passes by the Sun, the comets lose all of the ice from their surface layers and look little different from NEO asteroids. We have tracked a few hundred of the NEOs but know there are probably several thousand that are larger than a mile across and up to a million that are 100 feet or more across. These objects, "icebergs" in space, represent a serious hazard as well as a potential economic opportunity.

About 65 million years ago, it appears, a particularly large NEO—probably almost 10 miles wide—plummeted through the Cretaceous sky and struck the ground near what is now the Yucatan peninsula. Within seconds, a glowing hole 20 miles or more deep had been punched into Earth's crust and 500 million megatons of kinetic energy had been released. Billions of tons of Earth's crust were flung back in space. In the next hour, a mile-high tidal wave likely inundated the exposed coasts of what is now eastern North America. The very crust of Earth heaved and fell for thousands of miles in every direction.

Courtesy of NASA

Nucleus of Comet Halley, taken by the *Giotto* Spacecraft

Most of what is now the United States experienced a sudden upward thrust almost a thousand feet into the atmosphere, followed by an equivalent fall. Within the next half hour, the material thrown into space began to reenter the atmosphere.



Courtesy of NASA

Asteroid: An “Iceberg” in Space

Like most people, you probably have seen single meteor trails—imagine 100 billion of them per second! The heat from these burning meteorites raised the surface temperature to about 800 degrees Fahrenheit everywhere on the planet. Every forest and grassland burst into flames. The ashes of the global fires are still visible today in 65-million-year-old rock strata found throughout the planet. The smoke-filled atmosphere blocked sunlight for months. Plants and animals that survived the tidal waves, fires, and shock waves soon perished from cold and starvation. The catastrophic effects on the planetary environment took centuries, if not millennia, to fade away. When all was stable once more, over 95 percent of all plant and animal species had perished.

But an event such as this is not limited solely to prehistoric times. On 8 June 1908, a pale blue globe appeared in the Siberian sky, moving rapidly northward. It exploded about four miles above the forest, with a force of at least 10 megatons, at a place known as Tunguska. Over 1,000 square miles of forest and tundra were devastated. Astronomers now believe the Tunguska explosion was caused by the strike of a small comet several hundred feet in diameter. Tunguska was not a singular event. Our early warning satellites see about 30 explosions in Earth's upper atmosphere every year, each releasing at least one kiloton of energy from a small asteroid or comet strike. A large strike, probably releasing more than 100 kilotons, occurred over southern Greenland in November 1997. More recently, on 18 January 2000, a small meteor of several kilograms entered Earth's atmosphere and exploded at an altitude of about 25 kilometers over Canada's Yukon Territory. This last event appeared to have produced some kind of electromagnetic pulse or interference, for the Yukon power grid noted some fluctuations at the time of the event.[1]

Many of these strikes yield over a megaton of force, and several cause significant damage on the ground every century. All told, one's chances of dying from an asteroid or comet strike are about the same as one's chances of dying in an aircraft accident or a flood. Whereas asteroids and comets represent a real, if not immediate, threat to life and property on Earth, they may be a more serious hazard to space commerce. A strike the size of the Tunguska explosion is large enough to throw considerable amounts of asteroid or comet debris, as well as gases from Earth's atmosphere, back into space. This debris remains in LEO for hours—even days—and can easily represent a serious hazard for LEO satellites. But perhaps the most serious threat is from "dead" comets.

As comets repeatedly pass close to the Sun, their surface layers melt and are driven off into space. This would not be a significant problem if comets were made of ice only. But they are more like a "dirty" snowball, with particles of sand and rock imbedded in the ice. This "dust" is also driven off into space as the comet melts. After many passes, a "crust" of this dust forms, shielding the comet and insulating its core from further solar

Courtesy of NASA

Computer-Generated View of Earth as Seen from an Asteroid

melting. At this point, it looks much like an asteroid NEO. The dust clouds it had previously thrown off remain, however, tailing the dead comet in its orbit. These dust clouds are hazardous.

When Earth travels through the dust clouds that follow a dead comet, the tiny dust grains strike the atmosphere in great numbers. They are visible as a spectacular meteor shower—all the meteor trails radiating from the same point in the sky. Typical meteor showers will have up to three or four meteor trails per minute. The showers are named for the constellation they appear to radiate from. Occasionally, these showers intensify so that thousands of meteors are seen per minute. These meteor storms are unpredictable, but seem to be most likely when Earth passes just behind a dead comet, presumably where the thickest dust clouds are to be found.

The largest meteor storms in recent years have been the Leonid storms, which have produced up to 10,000 meteor

trails per minute for several hours. The Leonids follow in the wake of the extinct comet Tempel-Tuttle, which has a 33-year orbital period around the Sun.

What kind of threat does cosmic dust represent? Since the dust is traveling at about 50 miles per second relative to Earth, it has considerable impact on any Earth target. At this speed, even a dust grain carries the wallop of a rifle bullet! An unpredicted meteor storm in 1992 appears to have put a Canadian satellite, *Olympus*, out of commission. During a large storm, such as the Leonids shower, many or even most satellites could be hit. Even if not hit by large sand grains, the tiniest dust can strike the satellite so hard that a huge electrical charge will result. Such an electrical charge could short out critical satellite components. Space is, indeed, filled with hazards.

What is the reality of these threats, and what should the military's role be? There are three related aspects—awareness and surveillance, mitigation, and exploitation.

A fundamental requirement for controlling any field of confrontation or endeavor is "battle space awareness." Today, we track several thousand objects in space through a network of US military tracking telescopes and radars. However, we have little ability to find objects; that is, to search the sky for things we don't already know are there. The small number of asteroids and comets we do know are there have mostly been found by a few astronomers and amateur sky watchers.

What if we did have the ability to search and track all objects in space? Would it be prohibitively expensive? In fact, a rather modest upgrade of modern wide-field electronic (CCD) cameras installed on existing Air Force satellite-tracking telescopes would enable us to search the entire sky in a few days to locate essentially all satellites in Earth's orbit. In addition, any NEO approaching Earth would be detected. Experts suggest that this method would detect, in about a decade, most NEO asteroids and plot the orbits of those objects that could approach and threaten Earth in the centuries ahead. In addition, comets, which have very long orbital periods—many decades to many centuries—would be spotted months or even years before they become threats. The initial ground-based

space tracking system could be followed by simple upgrades to an already planned missile tracking system, the Space-Based Infrared System (SBIRS-Low), in LEO orbit.

A comprehensive space- and ground-based space search and surveillance capability would enable us to detect any aggressive move by an adversary against friendly space systems. But there is a direct military advantage for tracking incoming NEOs as well. Imagine if an explosion such as the 100-plus-kiloton Greenland strike in November 1997 occurred over the crisis-poised Middle East. The bright flash and loud boom, and perhaps even blast damage on the ground, would look just like a nuclear detonation. This could be just the match to set off a Middle Eastern tinderbox situation. It would thus be very much to our advantage to have full awareness and warning of such incoming objects. This same awareness could also enable us to predict future meteor storms by maintaining tracks on extinct comet nuclei that spawn the storms.

An additional concern about tracking NEOs is that if the United States does not use its current assets to perform this function, others will—for scientific reasons if nothing else. Indeed, international scientific organizations have repeatedly called for an international network to monitor NEOs. Just as a military surveillance system can pick up NEOs, a civil system to monitor NEOs will pick up military and commercial satellites. This "battle space awareness" is a decisive advantage. It could be in the United States' interest to deter others from constructing such an "open-to-all" database by modifying our own system and making the militarily insensitive but scientifically invaluable data available to all.

The second major aspect of NEO relevance is mitigation. Should an NEO be found on a collision course, whose job should it be to divert the threat, and how? It is our view that an organization the people have placed their lives in the hands of for the past several centuries—the US military—is best suited to provide protection from either natural or man-made threats. Little capability against such a natural threat exists today, but it is a mission that should attract increased attention as we expand our ability to control space.

A third, and perhaps the most important, aspect of NEO study is the potential eventual exploitation of these objects as a natural resource. Asteroids and comets have a wide variety of compositions. This is known from both remote study and analysis of asteroid fragments (meteorites) that have reached Earth's surface. Most contain far more volatiles—water among these—than the virtually dry Moon (except for the likely ice deposits at the lunar south pole discussed earlier). In addition, some are made wholly of metal and may contain very high quantities of platinum group metals. Although this explanation lies decades into the future, asteroids may prove to be extremely appealing sources of raw materials for true space manufacturing. For example, asteroids may provide more and better raw materials for space-based equipment, such as solar power satellites, than any other source. Indeed, some small asteroids may be nudged, through the simple kinetic means outlined above, into stable orbits around Earth. From such positions, the asteroid substance could be the raw material of large-scale space industrialization in coming centuries.

International Treaties and Policies

The barriers are not only physical, but also political. International treaties and other agreements can influence the development and execution of space power strategy. When these agreements are mutually beneficial to all parties, they are appropriate instruments for governing international conduct in space. However, it is necessary for signatories to constantly review these agreements to ensure they have not outlived their usefulness and unnecessarily (or unfairly) restrict policy and capability development.

Perhaps the most encompassing treaty, and potentially most troublesome, is the Outer Space Treaty of 1967. It banned national ownership and expropriation of any heavenly body, specifically including the Moon. In addition, it banned the stationing thereon of weapons of mass destruction, to include nuclear weapons and "any other kind of weapon of mass destruction." It also prohibited the construction of military bases on any heavenly body. It would seem, on the surface,

that the Outer Space Treaty effectively banned national competition and military activities from space. It did not in fact do so, however.

The Outer Space Treaty does not ban military activities or weapons in space: "The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited." It goes on to add that use of any facility or equipment for "peaceful purposes" is allowed. The only weapons banned are those of mass destruction and those stationed on the Moon or other heavenly bodies. The key to all these activities is the meaning of the phrase, "peaceful purposes." In fact, this phrase encompasses defensive military activities as discussed under the UN Charter. Thus, all of our military space programs today are fully compliant with the Outer Space Treaty, including future ones that could involve weapons. We have already noted that the US Supreme Court defined the blockade of goods and services as a permissible defensive activity in 1863. We have also noted that the development of space weapons will most likely follow the highly kinetic high-precision route, rather than mass destruction path.

Neither does the Outer Space Treaty ban commercial, or even national, exploitation of space resources. There have been attempts to address commercial exploitation of "common" resources such as the seabed and the Moon. In the case of the Moon, however, where a negotiated "Moon Treaty" would ban all exploitation that does not return the resources for the common good, the United States has neither signed nor ratified the proposed treaty. Moreover, a case may be made that the Outer Space Treaty allows what it doesn't prohibit; for example, private ownership of space resources. Should such private ownership occur, it would follow that military protection of privately owned assets would be defensive and, as such, allowed under the treaty's provisions.

Finally, a major criticism of the Outer Space Treaty is that it, unlike any other "arms control" treaty, lacks any discussion of, or mechanism for, enforcement of compliance with the treaty's provisions. We have no way to detect violations, no way to adjudicate alleged violations, and no way to enforce sanctions.

The other treaty of interest to military leaders on space power employment is the Antiballistic Missile (ABM) Treaty of 1972. At the time of this writing, it is undergoing intense scrutiny by both the United States and Russia, and the United States has already given the required six-month notice of its intention to withdraw. This treaty attempted to ensure the stability of mutual assured destruction (MAD), a bipolar strategy peculiar to the Cold War. MAD required each side to remain absolutely vulnerable to the other's nuclear weapons—thus, the treaty attempted to ban most defensive measures against the premier nuclear weapon of the time—ballistic missiles. The treaty took into account neither changing strategic realities and world situations nor technological advances (even its architect, Henry Kissinger, acknowledges the agreement was more ad hoc than carefully planned to stand the test of time). Today's world is a multipolar one, with many nations possessing long-range missiles—and today's technology has given us effective defenses against these weapons. The ABM Treaty (as voiced in the current debate) is thus a questionably relevant document that hinders opportunities to further define space power. It appears that the stage is now set for US and Russian withdrawal from the ABM treaty—a move that will better position the United States to exploit space in the interests of national security.

What we have reviewed, then, is the "physical" as well as political terrain the space power strategist will encounter. The principles to draw from this discussion include:

1. Space, like any other medium, has its unique "weather," natural obstacles and threats, and "terrain." These should be understood and accounted for as any terrestrial strategist would do for similar phenomena in the environment of regard.
2. As in any human endeavor, there are, regarding space, agreements for the conduct within and use of that medium. Such agreements are meaningful only to the extent they are mutually beneficial, and do not inhibit necessary development of national security capabilities.

Notes

1. Martin E. B. France, “Planetary Defense: Eliminating the Giggle Factor,” *Aerospace Power Chronicles*, 2000 (http://www.airpower.maxwell.af.mil/airchronicles/cc/france2.html).

Chapter 6

The Boundless Future

Our initial precept has been the acknowledgment that space is a far more pervasive aspect of our recent national security history than is generally recognized. Space systems, in the form of nuclear-armed missiles, were the defining elements of most of the Cold War. A space competition (the race to the Moon) became the premier conflict surrogate during the height of the Cold War. Just as the missile "space weapon" was the key offensive weapon of that conflict, space-based sensors in the form of "national technical means" of strategic reconnaissance and treaty verification became the key defensive element. And it was the beginnings of a true military race for the control and weaponization of space that marked the end of the Cold War and the emergence of a decisive victor. If space was the unrecognized national security actor in past decades, it is about to become, as our scenarios were meant to portray, the central focus of all security—and economic—competition in the near future.

Most immediate and visible is the necessity for space power in fighting modern war effectively. The expanding power of space capabilities in military engagements points to an increasingly visible reality: Space capabilities are an integral part of a modern war-fighting force. With this reality comes an admonition: We cannot, and must not, take our space capabilities for granted; nor can we ignore the increasing role space capabilities will take in the war-making efforts of our adversaries. With our amazing space war-fighting capabilities—all kinds of intelligence collection, force navigation and weapons delivery precision, worldwide communication and transmission of information—we have been paving the road of 21st century warfare. Others will soon follow as potential adversaries seek to develop and leverage these same capabilities. In fact, they are doing it right now.

It has been noted before that we have not lost an American to enemy air attack in 50 years. It has been our ability to

maintain air supremacy in every hostile environment we have entered that has produced this amazing and proud legacy. We have kept air supremacy because we have a very rigorous and aggressive doctrine: Control of the air! The first thing we do in any military campaign or combat operation is to gain mastery of the skies and deny the skies to our adversary.

We need to do the same in space. When American lives are put at risk because an adversary uses spaceborne imagery collectors to identify and target American forces, or leverages the global positioning system (or the Galileo constellation) to attack American forces with precision, we will need to aggressively counter that threat. Space capabilities will only become more and more a part of an adversary's war-making capacity. Thus, it will not lie outside our war-fighting responsibilities to deprive adversaries of their benefit. In addition to space denial, an equally important facet of space supremacy is space protection. If adversaries recognize the value of space capabilities in modern warfare, they will not only seek to use them themselves, but they will also seek to deprive us of ours.

But beyond the necessity for space power in fighting twenty-first century wars is the realization that the centers of gravity, the very infrastructure of our society, are migrating towards space. Right now, the factors limiting future use of space, whether military or economic, are the cost and the ease of access. There does not appear to be a "magic bullet" for cheap and easy space access. It simply requires a lot of energy—the equivalent annual usage of hundreds to thousands of people—to get even a modest payload into a useful space location. This does not mean that we will not experience increased commerce in space, merely that "explosive" development of space, analogous to development of the New World five centuries ago, must await (but will also be spurred by) greatly increased access to (and demand for) sources of energy. Ironically, the most likely source of that energy is to be found in space, along with the means to efficiently transmit energy over very large distances. Once this self-reinforcing trend begins, humankind's true expansion into space can and will begin. From this perspective, the current enthusiasm for lowering national and individual use of energy would appear counterproductive,

particularly in light of the fact that energy input and adjustment from space may be precisely the means to provide ecologically benign growth in global energy usage.

In the meantime, we should expect an increasing use of space for "global utilities." These utilities warrant the term in its fullest sense. Access to high-data-rate, space-based, global access communications (complemented by effective but not ubiquitous terrestrial networks) is increasing and will likely see continued deployment of the so-called big LEO constellations of small communications satellites. The Internet is also going to space. The next utility, the global positioning system (GPS), has been less recognized but is more encompassing. It already precisely locates goods, services, and people. However, as the GPS becomes the mainspring of an increasingly accurate global clock, commerce will depend on it in invisible ways. As the means to provide nanosecond global accuracy, power and communications channels will come to depend on it implicitly in order to work. Other utilities, such as global traffic management via space-based radar, are on the horizon. And, as noted above, we can look for energy grids to migrate to space in the next century.

Without access to these global utilities, it will not be possible for a modern state to operate in the twenty-first century. Increasing portions of global wealth will be tied up in, and most certainly dependent on, smooth functioning of these utilities. For these reasons, the utilities will eventually be the focus of controversy, confrontation, and, no doubt, conflict. It is our belief that future conflicts will revolve around the ability of one set of international actors, which may or may not be traditional nation-states, to protect their own use of these space-based utilities, and to deny similar access to those who would challenge national and global security.

It appears that future security concerns will center on how to protect, and/or deny access to, global utilities. No doubt many of the approaches and methods taken by future protagonists will focus on controlling access to these utilities through terrestrial-based means. However, with critical satellite nodes in the great "common" of outer space, attention will shift to protecting and denying those capabilities in space itself. It would appear,

then, that many of the lessons learned in past centuries concerning protection and/or denial of seaborne commerce might profitably be applied to spaceborne commerce.

We advocate developing the means to operate in space in a manner analogous to establishing and maintaining blockades at sea. If our nation has the ability to physically confront—or prevent adversaries from confronting—a space system in space, it will intrinsically have the ability to regulate use of that asset. These means are straightforward—being able to get to a location in space when necessary, and moving to another location as rapidly as possible, all within reasonable cost. Currently, this would seem to mandate development of small, reusable launch vehicles equipped with even smaller space-maneuvering elements. These capabilities would enable us to protect our space assets and deny their use to adversaries through either nondestructive or destructive means, as necessary.

In addition to developing affordable means and tactics to control space commerce, we should also develop a national understanding of the space environment and the resources and threats we may find there. A mission to chart and warn of natural and man-made hazards as well as to locate and explore regions of possible future resource utilization, in addition to controlling and protecting space commerce, would be logical. Thus, missions to explore the Moon and asteroids for potential resources, and to develop the means to divert potentially dangerous asteroid hazards, should be part of our overall national security mission. As we mentioned at the start, two recent events: the report of the Space Commission and 11 September 2001—will serve as important catalysts for the development of space power.

The Space Commission implementation—currently in progress—will hopefully produce stronger leadership and organization for national security space efforts, especially in the acquisition arena. Such leadership will be critical to forming the long-range strategy for obtaining and sustaining the capabilities of space power we have described.

The ongoing war against terrorism has already proven the critical need for space capabilities in the mountains of Afghanistan, where B-52s using GPS have served as close air

support aircraft, and Special Operations forces on horseback have downloaded imagery and other intelligence onto laptop computers via communications satellites while navigating by GPS. We can only begin to imagine, as our scenarios suggest, the endless ways space capabilities will be critical to war fighting in the years to come.

The future will undoubtedly differ considerably from any conjectures we can make. However, groups and nations that have seized opportunities in the unknown have invariably prospered far more than those who leave such exploitation and development to others. The United States has a good start in space. We need to maintain and expand our capabilities to ensure global security and prosperity for the benefit of countless future generations.

Bibliography

Books

Burrows, William E. *Deep Black: Space Espionage and National Security*. New York: Random House, 1986.

Burrows, William E. *Exploring Space: Voyages in the Solar System and Beyond*. New York: Random House, 1990.

Friedman, George, and Meredith Friedman. *The Future of War*. New York: Crown Publishers, 1996.

Fuller, J. F. C. *Armament and History*. New York: Scribners, 1945.

Graham, Daniel O. *Confessions of a Cold Warrior*. New York: Preview Press, 1995.

Haines, Gerald K. *The National Reconnaissance Office: Its Origins, Creation, and Early Years*. Washington D.C.: Official NRO publication, 1997.

Kahn, Herman. *On Thermonuclear War*. Princeton: Princeton University Press, 1960.

Kleiner, Art. *The Age of Heretics*. New York: Doubleday, 1996.

Logsdon, John M., ed. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*. Volume I: *Organizing for Exploration*. Washington, D.C.: NASA History Office, 1995.

Logsdon, John M., ed. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*. Volume II: *External Relationships*. Washington D.C.: NASA History Office, 1996.

McDougall, Walter A. *The Heavens and the Earth: A Political History of the Space Age*. Baltimore: Johns Hopkins University Press, 1985.

Peebles, Curtis. "High Frontier: The United States Air Force and the Military Space Program." Washington, D.C.: Air Force History and Museums Program, 1996.

Project RAND. *Preliminary Design of an Experimental World-Circling Spaceship*. Santa Monica, Calif.: Douglas Aircraft Co., 1946.

Schriever, Bernard A. *Reflections on Research and Development in the United States Air Force*. Edited by Jacob Neufeld. Washington, D.C.: Center for Air Force History, 1993.

Spires, David N. *Beyond Horizons: A Half Century of Air Force Space Leadership*. Peterson Air Force Base, Colo.: Government Printing Office, 1997.

Sun Tzu. *The Art of War*. Translated and with an Introduction by Samuel B. Griffith. London, Oxford, New York: Oxford University Press, 1963.

Toffler, Alvin, and Heidi Toffler. *War and Anti-War*. New York: Warner Books, 1993.

Worden, Simon P. *SDI and the Alternatives*. Washington, D.C.: National Defense University Press, 1991.

Periodicals

Dunlap, Charles J. Jr. "How We Lost the High-Tech War Of 2007." *The Weekly Standard*, January 29, 1996, 22.

Shaw, John E. "The Influence of Space Power Upon History 1944–1998." *Air Power History Magazine*, Winter 1999.

Index

Whither Space Power?

Forging a Strategy for the New Century

Air University Press Team

Chief Editor
Preston Bryant

Copy Editor
Sherry C. Terrell

Book Design and Cover Art
Daniel M. Armstrong

Illustrations
L. Susan Fair

Composition and
Prepress Production
Vivian D. O'Neal