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AN EVOLVING DOCTRINE: FORCE APPLICATION FROM SPACE

by

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Preface

Having spent my entire career acquiring space systems, my interest in the contributions of space to our nation's warfighting ability is keen. The explosion of interest in space support to the warfighter over the past decade has resulted in substantial attention to various space topics. Relatively limited attention, however, has been afforded the topic of force application from space as an extension of our use of space systems. Many arguments can be made as to the prudence of moving weapons into space, but I believe eventually there will be weapons in space. For this reason, I have chosen to examine the subject and see if an initial operational doctrine may be defined to help guide our thinking on force application from space and on the use of tomorrow's space systems. I hope that my proposed space force application doctrine will begin the process for a full development of our future space capabilities and warfighting doctrine.

If there are some useful facets in this research, it is no doubt due to the thoughtful assistance of three individuals: first, Captain John Grenier of the Air Force's Space Warfare Center who sponsored this topic, allowed me great flexibility in addressing the topic, and provided insights into future space systems; second, Major Jonathan Hines of the Air Force Doctrine Center who helped point the way to several of the key questions that a new doctrine on force application from space need consider; and finally, Lt. Col. Jeffery Garner who provided the guidance necessary to complete the work in a professional, thoughtful, and valuable manner.

Abstract

The Air Force's complete and Joint Staff's draft doctrine for force application from space is currently limited to non-space force used against terrestrial space resources. The doctrinal discussion of space force application is constrained by current national policy. While the other space operation areas of space support, force enhancement, and space control are maturing, force application from space has not progressed commensurately. Only with force application from space can we realize the possibility of Full Spectrum Dominance, as described in *Joint Vision 2010,* and tap into the unique advantages that space systems offer to the warfighter. Bringing about the comprehensive integration of space into the nation's warfighting capabilities is a substantial task and will require doctrine inclusive of force application from space and new space systems able to bring that force to bear. Space-based force application must address military combat operations from space against space, air, and surface targets. As a result of this doctrinal development of space force application, we can move our use of space beyond primarily supporting roles. This paper will first review current doctrinal concepts by way of background. From this will follow an exploration of the uniqueness of the space environment relative to force application and a brief examination of how future space systems could contribute to the combat needs of operational theater commanders. Finally, this paper will conclude with a synthesis of the background and analysis into an initial space force application doctrine that will begin to move the Air Force toward comprehensive integration of future space combat capabilities and ultimately to full spectrum dominance.

Part 1

Introduction

The nature of warfare can be characterized as a continual process of evolution where innovations in technology and innovations in the application of that technology to military operations have combined to provide the opportunity for military advantage. The advent of space concepts and space systems over the last half century have brought with them the next innovation in war, an innovation in which space assets have become critical to success in conflict. We initially witnessed these space innovations in operation DESERT STORM.[1] Space systems provided a significant military advantage by enhancing navigation, communications, weather, intelligence, surveillance, reconnaissance, and early warning.[2] The evolution of space exploitation will not end with these force-enhancing contributions. I believe that combat operations will eventually occur from and within the space medium to both conduct force application operations from space against a variety of targets and protect space-based assets. The use of space-based weapons will become as important to warfighting in the future as space force enhancement systems are to warfighting today.

Space Power

Space is rapidly becoming a vital economic and military center of gravity for the U.S. and others. This reality will put space resources on the target list of adversaries if it hasn't already. The application of our national power will depend in part on space power to protect and exploit

this space center of gravity for our national and military advantage. While space power certainly has military implications, it is important to understand its much broader context.

Space power is "the combination of technology, demographic, economic, industrial, military, national will, and other factors that contribute to the coercive and persuasive ability of a country to politically influence the actions of other states and other kinds of players, or to otherwise achieve national goals through space activity."[3] Air Force doctrine simplifies this broad context into a more focused military framework by describing space power as "the capability to employ space force to achieve national security objectives."[4] Our current military use of space is primarily as a force enhancement tool. Our military space power will eventually expand to include space-based means for force application against land, sea, air, and space-based targets. This expansion will result from our recognition of space as a vital center of gravity and our recognition of the unique combat advantages that forces operating in the space medium can provide to warfighters. In anticipation of this expansion, an exploration of space force application doctrine and of the future systems necessary to conduct space force application operations is appropriate.

Approach to Operational Doctrine

The Air Force and Joint Staff have made initial strides to integrate space concepts into warfighting doctrine. For primarily political reasons these efforts have not explored space-based force application.[5] This paper will examine current doctrinal concepts including the Air Force and draft Joint Staff publications, consider the uniqueness of the space medium with regard to force application, and look briefly at how future space systems can contribute to the combat needs of operational theater commanders. From that perspective, this paper will synthesize an initial space force application doctrine by continuing from where current doctrine ends,

recognizing and applying the unique characteristics of space, and considering how future space systems might apply force from space. The resulting space force application doctrine will begin to move the Air Force and the Department of Defense toward full spectrum dominance that comprehensively integrates future space weapon capabilities.

Notes

[1] James W. Canan, "A Watershed in Space," *Air Force Magazine* 74, August 1991, 32. Lt. Gen. Thomas Moorman's and Mr. Martin Faga's comments quoted in the article support this viewpoint.

[2] Department of Defense, *Final Report to Congress: Conduct of the Persian Gulf War*, (Washington, D.C.: April 1992), 176.

[3] James E. Oberg, *Space Power Theory* (US Air Force Academy, CO: Government Printing Office, March 1999), 10.

[4] Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, 23 August 1998, 1.

[5] The White House, "Fact Sheet: National Space Policy," (Washington, D.C.; National Science and Technology Council, 19 September 1996), 1. National space policy states that the US will ensure the continued exploration and use of outer space for "peaceful purposes" but then goes on to say these purposes allow for defense in pursuit of national security, which serves to introduce some ambiguity.

Part 2

Background

To set the stage, military definitions of doctrine and the Air Force's approach to doctrine development will be reviewed. Thereafter, four prominent space doctrine perspectives will be discussed. Finally, the current Air Force and draft Joint Staff doctrine will be examined with regard to space force application. These steps will help to provide a background upon which we can develop an initial doctrine for space force application.

Doctrine Described

A variety of definitions exist for doctrine. Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, defines doctrine as "fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application."[1] Air Force Doctrine Document 1 (AFDD 1), *Air Force Basic Doctrine*, defines basic air and space doctrine as "a statement of officially sanctioned beliefs and warfighting principles that describe and guide the proper use of air and space forces in military operations."[2] It is important to recognize that while doctrine is typically based on our warfighting and wargaming experiences, it need not be constrained to them. While force application via air, land, and sea and the doctrine for its use have been refined over decades, the use of and doctrine for space-based force application requires we step beyond existing doctrine and go where no experience exists. Doctrine arrived at in this way can then help

to guide the development of space technologies and systems consistent with its principles. This paper will focus on operational level doctrine for space force application. The phrase "space force application" here refers to the use of space-based weapons to achieve specific effects as required by the combatant commander. As the lessons of force application from space are learned in actual conflict, space force application doctrine must continue to evolve.

Doctrinal Concepts for Space Force Application

U.S. space policy has largely dictated doctrine for space force application since the Eisenhower administration's "Open Skies" concept of the 1950's.[3] This policy led to the concept of space as a sanctuary. National policy is beginning to change, however. The growing ballistic missile threat has led to consideration of space-based weapons to protect against this threat. As national policy adapts to the changing geopolitical situation, it is valuable to review the four primary doctrinal concepts of the last half-century. In his book titled *On Space Warfare: A Space Power Doctrine*, Lt. Col. Lupton describes these four perspectives as sanctuary, survivability, high ground, and space control.

Space Sanctuary

The space sanctuary concept was conceived at a time when emerging space capabilities provided a unique means of treaty verification without the risks of aircraft overflight of territorial boundaries.[4] Preservation of this new space-based ability for treaty verification required that the space systems providing the verification not be negated. This led to the concept of space as a zone free of warfighting systems. Since that time, antisatellite weapons have been developed by the U.S., and more aggressively by the former Soviet Union, but not widely fielded.[5] Ballistic missile defense systems have been in the development phase for a couple decades. These

developments, supported by a shifting U.S. national policy on missile defense, are rendering the space sanctuary concept outdated.[6] Growing dependence on space systems is also serving to increase the likelihood of weapons moving into the space realm. The survivability of space-based systems led to the second perspective.

Space Survivability

The space survivability concept treats the space environment itself as a primary limitation on the use of space systems. This concept proposes that space systems are inherently less survivable than terrestrial-based systems for several reasons.[7] First, the harsh environment of space causes degradation to space systems. Second, the physics of orbit adjustments limits space system maneuverability. Third, the electromagnetic pulse of nuclear weapons wreaks havoc on space systems and thereby puts them at risk. These vulnerabilities imply that a military dependence on space systems would be unwise without the ability to protect and maneuver them. Just as air assets provide freedom to attack and freedom from attack today for friendly forces, we can extend this concept to the space environment, which the "high ground" perspective does.

High Ground of Space

The high ground of space concept seeks to extend a key philosophy of air power to space. As expressed by General Thomas White in 1957, "…in the future it is likely that those who have the capability to control space will likewise control the earth's surface." The high ground concept focuses on defensive force from space as a means to restore balance to an otherwise offensive focus characterized by ballistic missiles and antisatellite weapons. The high ground concept sees future wars being "won or lost in space because space systems could overcome any advantages that ground offensive systems possessed."[8] He who can secure control of space, deny an adversary access to space, and defeat weapons moving into or through space may cause an

adversary to capitulate before forces act against each other on the earth.[9] This concept leads to space-based weapons whose primary purpose is counterspace operations. Beyond simply defeating offensive weapons from space, the space control perspective focuses on extending space power to deny adversary use of space and thus ensure friendly forces can engage the enemy on favorable terms.

Space Control

Lt. Col. Lupton's fourth doctrinal concept is that of space control. In this concept, the first priority is securing control of space to protect space lines of communication and deny the adversary similar use of space to aid his terrestrial forces.[10] Space's role is primarily one of securing the environment so that other non-space-based offensive forces can successfully engage the enemy. Continuous space control would not be required but the ability to achieve this control in time of war would serve as a deterrent to aggressive actions by an adversary.[11] The space control and other three perspectives have concepts that may be applicable to a space force application doctrine; however, current doctrine remains tied to space sanctuary thought.

Current Doctrine for Space Operations

The Air Force has made initial strides to integrate space concepts into warfighting doctrine. These efforts resulted in the publication of Air Force Doctrine Document 2-2 (AFDD 2-2), *Space Operations* in August of 1998. The corresponding Joint Publication 3-14 (JP 3-14), *Joint Doctrine: Tactics, Techniques and Procedures (TTP) for Space Operations,* is still in a draft form after nearly 10 years. While all these documents recognize the growing importance of space to warfighting, they do not adequately address the area of force application from space.

Joint Doctrine

Joint doctrine for space operations has been in development for nearly 10 years with initial drafts completed in April 1992, April 1998, and most recently a second draft in January 2000. While these drafts continue to spark considered thought about the application of space to warfighting, they hold little discussion about force application from space. The April 1998 draft simply referred to the possibility that at some future time space systems may be able to strike at terrestrial targets.[12] The most recent draft in January of 2000 falls back onto the current AFDD 2-2 wording and states, “The application of force would consist of attacks against terrestrial-based targets carried out by military weapon systems operating in space. Currently, there are no force application assets operating in space, but technology and national policy could change so that force application missions could be performed from platforms operating in space.”[13] Current national policy states that the United States will "work with other nations to ensure the continued exploration and use of outer space for peaceful purposes."[14] The policy does allow "defense" under the umbrella of "peaceful purposes" if in pursuit of national security goals, but does not elaborate sufficiently on "defense" to provide a firm basis for joint doctrinal development of space force application ideas. Air Force doctrine does not go much further.

Air Force Doctrine

The Air Force’s publication on space operations, AFDD 2-2, supports a seamless integration of space operations with those of air operations into a single aerospace power. AFDD 2-2 captures some of the basic foundations of space power, space characteristics and space systems and asserts that the basic doctrinal principles used to guide air operations also guide space operations.[15] Space is viewed as “the ultimate high ground.”[16] AFDD 2-2 sees space as “a further extension of the medium of air” doctrinally and therefore does not recognize the differences

between aerodynamics and astrodynamics that allow space systems to achieve unique effects, which will be explored in the next part of this paper. AFDD 2-2 addresses other topics relevant to a future space force application doctrine such as unity of command.

Unity of command is strongly endorsed in AFDD 2-2, as is the global nature of space systems.[17] The control afforded the theater commander is described as consisting of "accurate and timely products from space and normally…tactical control over space component equipment and its application *in the area of responsibility*."[18] (emphasis added) Command of space assets would accomplish four primary mission areas. These areas are "controlling the space environment, applying force, conducting enabling and supporting operations for terrestrial-based forces, and supporting space forces."[19] Controlling the space environment and applying force bring with them attacking operations that are central to a doctrine for space force application. AFDD 2-2 briefly references space force application but goes further in discussing space control.

AFDD 2-2 discusses space control as a counterspace mission but limits its accomplishment to non-space based weapons stating, "the principle means of conducting counterspace operations is through the use of terrestrial-based forces as air attacks against space system ground nodes or supporting infrastructure."[20] This misses an opportunity to take advantage of future space-based weapon capabilities. Further, recognizing the need for protection of space assets, AFDD 2-2 urges the nation "be prepared to develop the capability to support multipurpose operations in the space medium and employ such systems as national policy dictates."[21] Presumably, multipurpose operations include targeting space-based weapons against space system targets for the purpose of achieving space control. A space weapon able to conduct space control missions may well be able to expand its missions to include space force application missions.

AFDD 2-2's discussion of force application relative to space systems is significantly limited, although the recognition of future space-based force capabilities is clearly there. AFDD 2-2 states that force application would consist of attacks against terrestrial-based targets by space-based weapons."[22] Absent, however, is any mention of space-based attacks against other space-based targets which may be undertaken for more than space control purposes. Strategic effects may be achievable by targeting space-based systems with space-based weapons. AFDD 2-2 makes two other important points. First, space systems may rely on other space-based systems for a variety of functions including navigation, target acquisition, command and control, etc.[23] This highlights that space force application systems must integrate with other space systems. Second, systems that travel through space may also be important elements of the force application mission. This addresses transatmospheric vehicles rather than ballistic missile systems and ties into possible concepts of operation for future space force application systems.[24] In spite of some valuable points for consideration, both Air Force and draft Joint Staff doctrine leave us wanting for sufficient attention to space force application.

Both the approved Air Force and the latest draft Joint publications provide little guidance on space force application. Their brief attention is consistent with current national space policy emphasizing "peaceful purposes" and reflecting primarily the space sanctuary concept. However, we can also see a blend of some high ground and space control concepts. Survivability issues are not raised and presumably are left as technology challenges for future space force application systems. Should national policy constraints be relieved to allow force application from space, published military doctrine will expand. These constraints can be lifted in the academic arena to continue thoughtful discussion and development of an operational space force application doctrine.

Notes

[1] Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms,* 23 March 1994 as amended through 10 January 2000, 142.

[2] Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*, September 1997, 1.

[3] Michael J. Muolo, *Space Handbook: A War Fighter's Guide to Space*, vol. 1 (Maxwell AFB, AL: Air University Press, December 1993), 4.

[4] Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press, June 1988), 35.

[5] David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Air Force Space Command with Air University Press, 1998), 188-191.

[6] *National Missile Defense Act of 1999*, Public Law 106-38, 106th Cong., (22 July 1999), sec. 2.

[7] Lupton, 67.

[8] Air University, *Space Reference Guide,* Second Edition, Maxwell AFB, AL: August 1999, 17-17.

[9] Lupton, 38.

[10] Lupton, 41-42.

[11] Lupton, 40.

[12] Joint Publication 3-14, *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) for Space Operations*, First Draft, V1.0, April 1998, III-4, III-5.

[13] Joint Publication 3-14, *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) for Space Operations*, Second Draft, 20 January 2000, III-23.

[14] The White House, *Fact Sheet: National Space Policy*, (Washington, D.C.; National Science and Technology Council, 19 September 1996), 1.

[15] Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, August 1998, 1.

[16] Ibid., v.

[17] Ibid., 5.

[18] Ibid.

[19] Ibid., 7.

[20] Ibid., 8.

[21] Ibid.

[22] Ibid., 11.

[23] Ibid.

[24] Ibid.

Part 3

Considerations for a Space Force Application Doctrine

Space force application is relevant only if it can provide unique advantages to the warfighter. A doctrine for space force application must therefore consider the uniqueness that forces operating in the space medium offer to the operational commander over those forces on land, in air, or at sea. To apply these unique characteristics, space force application systems will need to be organized to support warfighting operations. The unique characteristics of space also bring some inherent risks that must be understood to avoid doctrinal or operational pitfalls. By considering these three areas, we can understand the relevance of space force application to the warfighter and the factors that a space force application doctrine must incorporate.

Harnessing the Uniqueness of Force Application from Space

The former Air Force Chief of Staff, Gen. Ronald Fogleman stated that "in the first quarter of the 21st century it will become possible to find, fix or track and target anything that moves on the surface of the earth."[1] This statement can be expanded to form a vision in which anything of political or military value can be found, identified, tracked (if moving), targeted, engaged, assessed, and re-engaged as required anywhere in near real time. Such a vision recognizes the fast-paced nature of future conflict, the need for instantaneous action, the requirement for feedback and assessments, and therefore helps us focus on the contributions that the unique advantages of the space medium offer. When these advantages are coupled with systems able to

exploit them, the Full Spectrum Dominance inherent in this vision and in *Joint Vision 2010* can be achieved. Space systems are not a panacea for every force application job but are absolutely critical to realize such a vision. Several unique aspects of the space medium are noteworthy.

Global Presence

Perhaps the most significant attribute of space systems is their ability to provide continuous global presence. Systems in the space medium achieve this capability differently from those in the air. Proper tradeoffs among orbital altitude, inclination, and constellation size can provide continuous global coverage. Limitations are driven primarily by mission requirements, available technologies, and fiscal constraints. As technologies mature, particularly in the force application arena, our Expeditionary Aerospace Force can be permanently on station at every location around the globe without the limitations placed on other forces such as basing, transit times, and overflight restrictions.

The fact that space systems can be permanently on station over every point on the earth does not necessarily equate to instantaneous application of force against any location on earth at any time, but it could. The characteristics of both the target and the space weapon will drive the timeliness of attack based on physics. Target susceptibility to electromagnetic weapons could render nearly instantaneous attack possible while limiting issues of collateral damage and force economies. Other targets may be more vulnerable to kinetic attack where the impact of a mass against the target is necessary to achieve the desired effect. In this case, the space-based weapon will have to travel distances from hundreds to tens of thousands of miles from their orbits to reach their intended targets. The greater the distance, the greater the time to arrive on target. At a distance of 900 kilometers the kinetic weapon could reach its target in under 12 minutes while a weapon orbiting at 40,000 kilometers would take about 5 hours to arrive at its target.[2]

Nevertheless, the continuing reduction of military forces and the resulting loss of forward presence can be offset in part by the continuous global presence of space based force application systems and, because of this presence, their ability for persistent action.

The global presence of space systems gives them a unique ability to apply the U.S. Air Force's tenet of persistence.[3] The predictable orbit of satellites, their collective or individual ability to provide continuous coverage over any target area, and their ability to remain in such an orbit for an extended period, often years in duration, provides space weapons the ability to re-engage a target as necessary to achieve the desired effects. Global presence and the resulting persistence are relevant only to the degree they can achieve effects against a particular target.

Target Access

Space force application must be capable of achieving the desired effects, particularly where or when other force application assets cannot. This uniqueness comes from the space weapon's characteristics (kinetic, electromagnetic, etc.) and from space's ability to achieve surprise and persistence. As technology and engineering advance, the feasibility and effectiveness of future space-based weapons will improve. Additionally, space force application systems can strike targets essentially impervious to or restricted from attack by air, ground, and sea-based attack.

Deeply Buried/Isolated Targets. As we found in DESERT STORM, many Iraqi command centers were deeply buried and proved a difficult target for air power weapons.[4] These type targets are susceptible to kinetic energy weapons from space. Space delivered weapons offer the ability to penetrate concrete targets to depths of 40 feet[5] and penetrate earth hundreds of feet.[6] In addition to deeply buried targets, available and advancing technology enables space-based systems and space transiting vehicles to be launched against targets located in remote regions

such as the open ocean or a large land mass. Such capabilities may not be completely unique to space systems but do present a substantial flexibility for the combatant commander.

Space and Other Forces. The increasing economic, informational, political, and military dependence on space makes space capabilities an attractive target to our adversaries. Ground stations and satellite links are targetable elements of space systems. Disabling the satellites themselves is also a viable option. Space-based weapons can be targeted against other space forces as well as against surface and air forces. The versatility of space-based weapon systems to achieve effects across all levels of war and execute a wide array of functions including counterland, countersea, counterair, counterspace, and strategic attack gives them unique opportunities to expand the options available to the operational commander for synergistic use of all his forces. It also offers the option of precision force application when risks to human life are too great to employ other air, land, and sea-based weapons.

Human Risks

The military has always understood that our profession of arms brings with it risks to life. Recent operations have highlighted that when U.S. service members are injured, captured, or killed, the U.S. population's will to fight may change dramatically. The ability to implement national power militarily is limited by the willingness of the U.S. population to tolerate losses particularly where vital national interests are not at stake. Space power provides opportunities to greatly reduce the risk to personnel and national treasure by removing military personnel and equipment from the threat environment while still achieving the desired effects.

Uninhabited Systems. The ability to remove personnel from a threat area while still achieving military effects is a desired capability. This is evident in our increasing development of standoff weapons and uninhabited aerial vehicles. Space systems offer the ultimate in standoff

weapons. Attack of an uninhabited space-based system would not create the emotional reaction that an attack resulting in the loss of U.S. lives would. While DoD space policy considers an attack on our space systems as an attack on our sovereignty,[7] the loss of space systems to hostile action would not shake U.S. public resolve to continue military operations to the degree that the loss of life does today. It is certainly possible that future military space systems may be inhabited and therefore limit this consideration. Nevertheless, the possible use of chemical or biological agents presents a threat to military personnel that space force application assets can mitigate.

Chemical/Biological Warfare. A complicating factor to land, sea, and air engagement is the threat of chemical and biological weapons. Applying space-based force against targets within a contaminated area avoids the risks to personnel. Space-based systems can operate largely outside the threat areas of chemical and biological weapons. Nuclear weapons do, however, present a risk to satellites much as they would to surface and air forces. In addition to balancing specific weapon systems against human risks, future commanders will need to prioritize requirements and balance the use of limited space force application assets.

Balance and Priority

Space-based systems present a challenge from both a balance and priority perspective. The application of space weapons can concentrate combat power to achieve tremendous effects and will therefore be a high demand resource by theater commanders. However, these weapons are likely to be in short supply based on cost, initial technologies and system design, and space lift limitations. The number of weapons on board each spacecraft, the number of spacecraft in orbit, and the orbital inclination of the satellites will limit use of kinetic energy weapons. The number of lazes available without chemical resupply may similarly limit laser weapons. Electromagnetic weapons may be more robust in the resupply arena as they may have the ability to regenerate

over time using solar power. However, this time factor may limit their use in a combat environment. In each case, the weapon's availability to the commander will be constrained and, therefore, demand that the commander carefully prioritize his objectives and balance his use of space force application systems with those forces operating in other environments. Future commanders will likely choose to use space force application assets early in a conflict because the global presence of space weapons allows them to surprise an enemy and seize the initiative.

Surprise

Space systems offer the element of surprise to the operational commander. Our search for more stealthy weapons is an effort in part to surprise the enemy. Force application systems from space offer a new approach to surprise by being omnipresent overhead. Enemies may seek to avoid surprise by tracking all military space force application systems and calculating when they may be invulnerable to attack. This window of invulnerability can be closed by either providing a space architecture with enough properly placed operational spacecraft to fill coverage gaps or by augmenting orbiting space weapons with transatmospheric weapons that can launch directly into a target trajectory. Force application from space will not require suppression or destruction of enemy air defense systems prior to the onset of an attack. Attack from space need not be preceded by the warning signs visible when using some other forces. In addition to surprise, space force application systems can provide great versatility and flexibility.

Versatility and Flexibility

A single space force application asset has the ability to support strategic, operational, and tactical objectives. It can be retargeted to a different objective at any point prior to weapons release and, based on the weapon employed, even thereafter. The use of a space force asset must be balanced against the priority of the target given the limitations of space force application

systems. This may constrain the operational versatility of space force assets and preclude their frequent use against tactical targets. With current technology and systems, a primary physical limitation on flexibility is the tremendous amount of energy required for a spacecraft to change its orbital inclination. This maneuvering limitation can be resolved by locating spacecraft in various orbits, launching directly into needed orbits, or by using space-maneuvering systems. Current launch capabilities are also a significant limitation in that prompt launch may be required to satisfy operational requirements.

The versatility of space weapons can be exploited by parallel attack from space weapons alone or in combination with non-space weapons where the capabilities of each are tailored to the target. The combined arms approach to military operations must not be lost by a focus on space weapons alone as a panacea for offensive operations particularly given the broad spectrum of military operations. Integration of all offensive military systems with supporting command and control and intelligence systems can achieve great synergy.

Network Centric Warfare

The proper integration of all sensors and all shooters into a single picture for the operational commander with the ability to then optimize the weapon to the target must include space systems, both sensors and future force application systems. Current space thinking is often platform centric. The navigation constellation, the early warning constellation, the weather constellation, the imagery constellation, and so on must be integrated into a total network of sensors, processors, and ultimately shooters, all operating in the medium of space. Only through this synergy of space constellations working together as a single space architecture can network centric operations take the next revolutionary step. That step will link air, land, sea, and space-based sensors, processors, and command & control systems with space force application systems

to provide a fundamentally new capability. In fact, only through the space medium can global network centric operations be undertaken. With space-based network centric warfare, we can reach the vision of finding, fixing, tracking, targeting, engaging, assessing, and re-engaging any target of military or political interest anywhere in near real-time.

Achievement of this vision requires that we harness the unique global presence, target access, surprise, versatility and flexibility of future space force application systems and combine their use with other forces available to the operational commander to achieve the desired effects. The commander must also balance the use of space force application systems in terms of priority and human risks. This requires that space force application systems be organizationally employed to apply the operational art of space in support of joint force commanders' objectives.

Organizationally Employing Space Force Application Assets

The operational command of future space systems, and in particular those that can apply force, is an important doctrinal consideration for several reasons. First they will play an increasing role in nearly every aspect of military and non-military operations in times of peace through times of war. Second, the commercial, civil, and military organizations that have ownership or influence over space-based systems will continue to be large and frequently outside the direct control of the Department of Defense and even outside the control of the United Stated government. Finally, space systems have unique properties over systems operating in the environments of air, land, and sea. In terms of operational employment then, what does the Joint Force Commander (JFC), and more specifically the Joint Force Air Component Commander (JFACC), command?

Essentially, the JFACC commands those aerospace power assets located in theater that are available after naval and marine force needs are satisfied, subject to modification and allocation

of assets by the JFC. The JFACC typically has operational command, might also have tactical command, and sometimes has administrative command. This is done in order to centralize command of limited air assets and bring functional expertise, “airmindedness,” to bear in making command decisions on the best use of limited air forces and ensure proper coordination with other component commanders to achieve the JFC’s desired effect. While some ground elements of space systems can be physically moved into theater and therefore be operationally commanded by a component commander, the vast majority of space system elements reside outside the theater and have effects beyond an individual theater. Many space systems are outside the realm of U.S. military control including those controlled by the National Reconnaissance Office, NASA, and a host of commercial endeavors and are not under the command of the JFC or JFACC. However, based on DoD’s responsibility for national defense, future space systems capable of applying force should fall under military command. So how should these be commanded?

Weapons from space will have, at least initially, a tremendous political and strategic effect on diplomatic and military operations. Thus, National Command Authorities (NCA) will likely maintain overall control for the use of space-based weapons. Once authorized by the NCA for use, combatant commanders can employ space weapons. The effective use of space assets, and in particular space force application assets, requires a commander able to recognize the unique and synergistic opportunities they bring to achieve desired military effects. Further, multiple theater commanders attempting to command a single, globally capable space force application system violates the "unity of command" tenet of air and space power. It’s possible that some future space force application system may be deployed specifically to support a single JFC. In this case operational command by the JFACC in theater, or a future Joint Forces Space Component

Commander (JFSCC) subordinate to the JFC,[8] would be appropriate. In all other cases, operational command of space force application systems should remain with USCINCSPACE and his component commanders. USCINCSPACE can apply functional space expertise, "space-mindedness," to determine how best to employ the unique capabilities and limited resources of space force application systems to achieve the effects desired by the NCA, the various regional and functional Commanders-in-Chief (CINC), and other joint force commanders.

USCINCSPACE should determine which space force application assets can be made available for a specific conflict and how best to employ them in concert with other forces to achieve the desired effect of the NCA or supported commander, if not himself. This process is managed through an Aerospace Operations Center (AOC) commanded by 14th Air Force whose focus is on space capabilities.[9] The product of this AOC's efforts, in coordination with the JFACC, is a Space Tasking Order (STO).[10] Once space force application capabilities exist, the STO may be integrated into the Air Tasking Order vice issuing a separate STO. A supported commander can also request a space support team be provided by USCINCSPACE to the theater Joint or Combined AOC to assist in orchestrating this effort.[11] In all cases, the allocated space force capability must be integrated into the theater campaign to achieve synergistic effects with other weapons systems. It is equally important that operational and tactical space commanders communicate in real-time with theater operational commanders. This will ensure that rapid retargeting of allocated space force capability can occur and that any inability of an allocated space force application asset to engage its target can be communicated to theater operational commanders. Poor organizational integration of space force application assets clearly presents a risk to effective employment as do a variety of other risks.

Risks Inherent in a Space Force Application

A sound doctrine for space force application must guard against risks inherent in space force application systems and space systems in general. Several of these risks are discussed below.

Over Dependence

While the idea of space-based force application systems may bring to mind a force so incredible, so lethal that no one would ever again attempt any hostile action against the U.S. or its allies, it is important to avoid the mistakes of the nuclear era. During that era, our fascination with nuclear weapons led to an entire military strategy linked to the use or threat of use of nuclear weapons. Since WWII we have found that such a strategy is woefully insufficient in the face of the broad spectrum of military conflicts from military operations other than war (MOOTW) to major regional engagements. Each circumstance is unique and requires the unique packaging of military capabilities. So too, the options available to the military must continue to be broad even when space force application capabilities arrive. This is true not only because we may chose not to use space force application in some circumstances, but also because when we do, it will be most effective when combined with the other military capabilities.

A combined arms approach to warfare must be retained. This approach expands the achievable effects by the synergistic use of space force application assets in combination with those of air, land, and sea. Every military capability comes with vulnerabilities, space systems are no exception. While vulnerabilities can be minimized and protected, they cannot be eliminated. Total dependence on space force application would be unwise.

A New Strategic Center of Gravity

The dependence on space systems to provide commercial, civil, and military capabilities has created a new strategic center of gravity. This will renew adversaries' efforts to deny us the use

of space-based assets. Thus in addition to having vulnerabilities, space assets will become the focus of specific targeting by adversaries. While the presence of space force application systems may make that interest increase, our dependence on space force enhancement will have long since made space resources on orbit, on the ground, and the links between them targets of enemy action. Unless force application systems become either so ubiquitous that targeting them would be ineffective or so well designed as to present no nodal vulnerabilities, they will be targets. Maintaining a close integration of space force application assets with other military capabilities can help minimize the vulnerability of this new strategic center of gravity.

Integration with Information Systems and other Military Forces

The growing importance of information operations must not be divorced from future space force application capabilities. In fact, only with the close integration of information systems and space force application systems can their combined advantages be fully exploited. Being able to find, fix, track, target, engage, assess and re-engage an adversary's centers of gravity in near real time is only possible with an intricate linkage among sensors, shooters, and controllers. Network centric warfare must extend to and include space-based force application systems not only as shooters but also as sensors. The increasing complexity of warfare and the shortening time available for decisions demand that space force application concepts be completely integrated into command and control, information operations, and other air, land, and sea-based force application concepts. Space force application alone is not a panacea for all future conflicts. In addition to the integration of systems, space force applications require logistics support.

Sustainment

Lines of communication have been a focus of military operations for centuries and for good reason. Our ability to prosecute war is dependent on the continued availability of resources, both

in terms of people and equipment. Space systems are similarly constrained. A formidable space force weapon can be limited by our ability to keep it operational, keep it supplied with ammunition, and get it where we need it. Following the space shuttle *Challenger* accident, we lost our assured access to space. We responded with a renewed focus on expendable launch vehicles and returned our access to space but at substantial cost and with substantial logistic shortfalls. A future space force application capability must be logistically sustainable. More versatile space launch systems are providing some expansion of space logistics capabilities but continued efforts are required. The technologies and design of space force application systems must bear logistical constraints in mind and, therefore, explore on-orbit resupply and maintenance, reduced resupply requirements, employment of interoperable ground systems, and alternative means to rapidly deploy them to all militarily useful orbits. Deployment to space of a force application system may directly challenge current treaty provisions.

Treaties

Perhaps the most obvious limitations to space force application systems are those imposed by treaties and our interpretation of them. Treaties are put in place as a means to serve our national interests. When the time comes that our national interests are more constrained than advanced by existing treaties, those treaties must be modified or abandoned. The current Congress is very focused on force application systems capable of defending against ballistic missiles.[12] This focus has renewed attention on limitations placed on systems that defend against ballistic missile threats. The ability of systems to defensively counter a ballistic missile threat may also give them the ability to apply force from space against other targets for either defensive or offensive purposes. It will not be long before continued compliance with existing treaties

presents real risks to our national interests, risks that space-based force application systems can address. Any treaty decisions will need to address the risk of creating a security dilemma.

Security Dilemma

The ability to implement national power through space power, manifested by the presence of either defensive or offensive space-based weapons, may lead to another space race. This space race will not be based on getting to space but rather on weapons in space. Space-based weapons clearly present a decision point for political leadership. Do the benefits of force application from space outweigh the risks of a security dilemma where even defensive space weapons can cause political instability? This security dilemma along with the legal implications of current treaties has limited development of space force application doctrine. The development of such doctrine must therefore recognize the nature of future space-based weapons as not only an operational and tactical-level tool but also a strategic one. Clearly, space force application brings with it a variety of risks that must be considered in developing a doctrine for its use.

With an understanding of the advantages of the space environment, the proper organizational employment of space force application systems, and the risks inherent in these systems, an initial space force application doctrine is emerging. A brief examination of future space force application and supporting systems can help refine an initial doctrine by considering the operational art that these future systems reveal.

Notes

[1] Gen Ronald R. Fogleman, "Strategic Vision and Core Competencies," address, Air Force Association Symposium, Los Angeles, CA, 18 October 1996.

[2] Maj William L. Spacy II, *"Does the United States Need Space-Based Weapons?"* (Maxwell AFB, AL: Air University Press, September 1999), 26-27.

[3] Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*, September 1997, 25-26.

Notes

[4] Dr. Eliot Cohen, ed., *Gulf War Air Power Survey*, vol. IV, *Part I: Weapons, Tactics, and Training and Space Operations* (Washington, D.C.: U.S. Government Printing Office, 1993), 90, 175, 362.

[5] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 62.

[6] Peter Grier, "Arena of Space," *Air Force Magazine* 79, (September 1996), 46.

[7] William Cohen, Office of the Secretary of Defense, memorandum, subject: Department of Defense Space Policy, 9 July 1999.

[8] Maj Henry D. Baird, Jr., "Is It Time for a Joint Space Component Commander?" (Newport, R.I.: Naval War College, 1992). The paper discusses a variety of reasons for establishing a space component commander under the JFC. The JFSCC would primarily facilitate use and advise the JFC on space issues in Baird's discussion. The future introduction of space force application assets into theater would enhance the argument for such a future position in that there would be theater-dedicated space combat systems to command.

[9] Air Force Doctrine Document (AFDD) 2, *Organization and Employment of Aerospace Power*, 28 September 1998, 67.

[10] Ibid.

[11] Ibid.

[12] *National Missile Defense Act of 1999*, Public Law 106-38, 106th Cong., (22 July 1999), sec. 2. The law states that "it is the policy of the United States to deploy as soon as is technologically possible an effective National Missile Defense System…"

Part 4

Future Space Systems: Individual and Synergistic Uses

The intercontinental ballistic missiles that helped us win the Cold War provided force application through space but not a force application from space. Early efforts by the U.S. and the former Soviet Union to develop antisatellite weapons for force application to space did not lead to the broad fielding of such systems. The current absence of space-based force application systems and the political hesitancy to publicly address such systems has resulted in sparse treatment of space force application. Nevertheless, future space systems have been conceived of that can provide and/or support force application from space.

Space-based force application will harness the uniqueness of space. Space offers unprecedented global presence, target access, freedom from risk to the user, surprise, versatility and flexibility, and integration within network centric warfare. Naturally, space imposes limitations driven by physical, technical, fiscal, political, and logistical considerations. The fundamental advantages offered by several future systems are nonetheless worthy of note, specifically the Space Based Laser (SBL), Ground Based Laser (GBL), Common Aerospace Vehicle (CAV), Space Orbiting Vehicle (SOV), and Space Maneuver Vehicle (SMV). Some details on their description and concepts of operations are provided in the appendices.

The space force weapon can take on many forms. The SBL and GBL have the ability to strike at the speed of light. Although the SBL's current concept of operation is defensive in

nature and focused on destroying ascending ballistic missiles in powered flight,[1] it could be applied against space, air, land, and sea-based targets to achieve a variety of lethal and non-lethal effects. Heating, energy overloads, system degradation, and visual degradation of combatant personnel are all possible applications that provide potentially valuable warfighting effects. In addition to ballistic missiles in ascent, destruction of ground targets may follow as technology matures. The fielding of the SBL is subject to a variety of technical, fiscal, and political constraints.[2] It may, however, be the first system to provide force application capabilities from space.[3]

Similarly, the ground-based laser (GBL) offers the same effects as the SBL but has its own limitations such as its cooling, target opportunity, weather, and optics.[4] Resupply of the GBL would be simple relative to the task of providing on-orbit resupply of the SBL's chemical ammunition. While the GBL suffers from similar physics constraints as the SBL in terms of power, range, and atmospheric effects, it does not take advantage of the global presence of space-based lasers. This GBL limitation can be resolved by locating reflective mirrors in space subject to their launch and control challenges.[5] This approach requires the GBL to twice overcome distance and atmospheric effects to target distant air, land, and sea-based targets. Strategic attack of an adversary's on-orbit space capability could be accomplished by a GBL based in the continental U.S. without the risks the SBL may face. In addition to lasers, electromagnetic and kinetic energy offer another tool for space-based force application.

The common aerospace vehicle (CAV) addresses this challenge by providing the ability to deliver precision guided weapons from or through space with tremendous physically destructive power to any location in the air or on the earth when coupled with the Space Orbiting Vehicle.[6] This space-based platform is a tremendous standoff weapon. It can deliver weapons to destroy

more deeply buried targets, operate against targets located within a chemically/biologically contaminated theater, and carry various ordnance types to provide sensor-fused targeting abilities.[7] However, every deeply buried target is not vulnerable to attack from space based on current technologies. A further limitation on the use of these space-based weapon systems can be the systems that deliver them to orbit and maneuver them once in space.

The Space Operating Vehicle (SOV) and the Space Maneuver Vehicle (SMV) provide answers to these challenges by providing our future space lines of communication both into and within the space environment. In the future, the SOV will improve our core competence of global mobility into the space medium. It will provide responsive and robust space lift capability with rapid turn-around times more akin to today's aircraft than our current space lifters.[8] As our future space lifter, the SOV can provide a host of functions such as a space mine laying, decoy drop-off, autonomous space surveillance platform, microsatellite deployment, and CAV or SMV delivery vehicle among many others. The SOV's ability to deliver CAVs into transatmospheric trajectories may even result in a reevaluation of ballistic missile use. From the SOV's lift capabilities follows the SMV's maneuver capabilities. The SMV can provide orbital maneuver to various on-orbit payloads within its 1200 pound, 4 ft. by 4 ft. by 7 ft. payload capability.[9] Recovery and repair of damaged spacecraft, chemical resupply of an SBL, redeployment of a satellite to a new orbit particularly a new orbital plane, and maneuver of spacecraft to avoid hostile action, are but a few of the possible capabilities of the future SMV as a support to force application systems.

A host of space force application systems can be envisioned that would provide operational commanders with the ability to achieve objectives set forth by the NCA. By applying the operational space art, we can combine various space weapons with space access,

maneuverability, and logistical support and begin to move toward a fundamentally new capability for warfare. In certain circumstances, future space force application capabilities may be able to achieve unilaterally desired military effects previously dependent on air, land, or sea-based forces. Even so, the benefits of a broad family of military capabilities operating in all environments are significant. These benefits are greatly expanded by a combined arms approach that integrates future space force application systems with other instruments of power. By synthesizing the insights revealed by examining the above possible future space force application systems with the earlier considerations of this paper, we can conclude with a proposed space force application doctrine.

Notes

[1] Maj Rick Walker, "Future Space Capabilities for Fire Control," (paper, Space Warfare Center, 1999), 16.

[2] Lt Col William H. Possel, "Lasers and Missile Defense: New Concepts for Space-Based and Ground-Based Laser Weapons," (Maxwell AFB, AL: Center for Strategy and Technology, Air War College, July 1998), 15-16.

[3] Walker, "Fire Control," 17.

[4] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 86.

[5] Possel, 18-19.

[6] Walker, "Fire Control," 16.

[7] Walker, "Future Space Systems 2000 - 2030," 62.

[8] Ibid., 14.

[9] Ibid., 41.

Part 5

Conclusion

A Space Force Application Doctrine

Having examined the current doctrinal concepts for space force application, described some of the unique advantages and capabilities inherent in the space medium, and explored how some selected future space systems may contribute to the operational needs of combatant commanders, some conclusions and an initial doctrine for space force application can be proposed.

A wide variety of conclusions result from an examination of force application from space. I offer these based on my own consideration of space force application. First, space systems can offer unique force application options beyond current doctrinal limitations of force enhancement. Second, space has become a critical center of gravity given our military, economic, informational, and political dependence on it. The eventual inclusion of weapons in space will make space an even more important center of gravity. Combat has always followed where national interests and centers of gravity have existed, and space will be no exception. Third, our ability to use space and deny that use to an adversary will require space superiority. Space superiority will be as important to future military operations as air superiority is today. Fourth, only the space medium offers the ability to achieve the vision of finding, fixing, tracking, targeting, engaging, assessing, and re-engaging significant military and political targets in near real time. The future architecture of space systems must therefore avoid platform or constellation

centric views. Instead, it must integrate all of space systems into a single, interoperable architecture capable of achieving this vision. This requires the close coordination of air and space operations, air and space research and development, and air, space, information (electronic), and armament acquisition centers. Fifth, space-based force application can operate simultaneously at the strategic, operational, and tactical level; however, it will likely be reserved for strategic and operational effects initially. Sixth, space force application systems can conduct or contribute to many aerospace functions currently undertaken by airpower including counterland, countersea, counterair, counterspace, and strategic attack across the complete spectrum of military operations. Seventh, space force application is not a panacea for offensive capability, but rather another tool to achieve the effects desired by military commanders and their political masters. A combined arms approach to military capability must be preserved. Eighth, space weapons have advantages over other surface and air-based weapon systems in that space weapons can have global visibility and access, be applied against targets not accessible to other weapons, engage with lethal or non-lethal force, and be used when risks to human life are great as from chemical and/or biological hazards.

From these conclusions, the following specific doctrinal statements for the application of force from space are proposed:

Space superiority is the first priority. Our ability to conduct successful military operations in the future will be inextricably linked with our access to space capabilities including space-based information capabilities. Space superiority enables the use of space and therefore of space weapons for force application.

Space force application is the direct and/or indirect application of force against air, land, sea, and *space* targets from systems operating in space. It **must not be constrained doctrinally**

to address only air, land, and sea targets. Space targets should be included as well when attack of such is for the purpose of achieving strategic effects.

NCA authorization for use will be required for space force application systems, which must then be centrally controlled by space-minded professionals.

Space-based force application must be **integrated with other force application systems and with information operations** into the warfighting command structure, not be divorced from air, land, or sea-based force application options.

Space force application weapons should be **used when uniquely advantageous** and **in concert with other force systems** to produce synergistic effects via a combined arms approach.

Priority and balance must be considered when using space force application. These resources will be required and demanded by all combatant commanders and will be expensive and quantity-limited initially. Combatant commanders must remain actively engaged in the requirements and acquisition processes to ensure their force application requirements are stated, validated, and satisfied.

Recommendations

A more comprehensive discussion of space force application is required. Such a discussion can serve to expand military doctrine to address force application from space and guide the acquisition of future weapon systems able to bring about this addition to warfighting capabilities. Space force application must be given more prominent consideration as Joint Publication 3-14 goes into final coordination, as progression on Air Force doctrine continues, as future concepts are explored, as requirements are defined and acquisitions begun, and as wargaming exercises are conducted. The operational space force application doctrine proposed above can provide a useful point of departure in an evolving doctrine for force application from space.

Epilogue

At the time of this writing, Joint Publication 3-14 *Joint Doctrine; Tactics, Techniques, and Procedures (TTP) for Space Operations* is still in draft form. This paper has been provided to the Air Force Doctrine Center for their consideration within the formal coordination process. I hope the final version of Joint Publication 3-14 will fully recognize the necessity of complete integration of space systems into the operational warfighting arena and expand the treatment of the force application from space-based systems.

Appendix A

Space Based Laser (SBL): Facts and Uses

Basic Description:[1]
- High-power, chemical fueled laser based in space and weighing an estimated 75,000 pounds.
- SBL consists of several subsystems including the laser subsystem; the acquisition, tracking, and pointing subsystem; the optics and beam control subsystem; and the spacecraft bus.

Benefits/limitations as a space force application asset:
Benefits:
- Technology to apply sufficient power against a target to destroy it has been demonstrated.[2]
- Targets ballistic missile systems that can deliver conventional and unconventional munitions such as weapons of mass destruction destroying them over enemy territory.[3]
- SBL can target space-based objects to degrade or destroy them while limiting space debris.
- Defensive capabilities can easily be turned to offensive purposes.
- SBL can provide militarily useful intelligence and reconnaissance on targets using its acquisition and tracking subsystems.
- SBL can contribute to a space-based vision by "finding, fixing, tracking, and targeting" a variety of objects possessing a bright infrared signature.

Limitations:
- SBL's ability to kill a target is limited by laser spot size, laser dwell time on the target, laser energy per unit area, range to the target, and target vulnerability.[4]
- Projected SBL weight exceeds the capabilities of planned launch systems by nearly twofold.
  - SBL requires either a significantly more capable launch system or an assembly-on-orbit construction approach.
  - It may be necessary to locate SBLs in a variety of orbits to provide adequate space and earthen coverage within its effective range.
- Chemical fuel for the SBL's laser cannot be reconstituted once expended.
- Deployment will require modification or abrogation of Antiballistic Missile Treaty.[5]

Primary Concept of Operation:
- Ballistic missile launch is detected and trajectory forwarded to the SBL.
- SBL acquires and tracks the rising ballistic missile using its tracking laser.
- SBL focuses its powerful chemical laser beam on a small area of the ballistic missile.
- The beam weakens the missile's structure sufficiently to cause catastrophic failure before the missile completes its propulsive phase of flight.

Expanded Concepts of Operation:

- Apply chemical laser beam to other land, sea, or air based targets to produce militarily useful effects such as:
  - Non-destructive engagement of an otherwise restricted target such as a historical or religiously significant building that houses adversary's leadership. This is accomplished by lazing the building to overload its heating systems thus rendering it uninhabitable.
  - Blinding or heat overloading sensors or occupants of an aircraft in flight.
- Integrate SBL's sensor suite into the larger intelligence gathering architecture thereby improving overall situational awareness.
  - Would enable network centric operations by cueing other sensor platforms or even directly cueing another force application system.
  - May require expanded on-board processing, connectivity to other systems (space, air, land, or sea-based), and interoperability with those systems.
- Integration of space-based sensors, command and control, and shooting systems into a single architecture capable of finding, fixing, tracking, targeting, assessing and re-engaging any target or military significance anywhere.
  - The greatest possible satellite-to-satellite cross-linking will be required for this and other space-based systems to interact in this fashion.
  - Such capability can help diverse satellite constellations such as weather, navigation, sensing, communicating, and shooting systems to pass vital information when some paths are jammed or otherwise nonfunctional.
  - Would require increased satellite autonomy and improved robustness that together could help mitigate adversary attacks against military and supporting space systems.
  - Enable network centric operations to move more readily into the space environment.
- Logistical resupply of chemicals to fuel the laser would be necessary unless the SBL was inexpensive enough to be considered a "disposable" weapon system.
  - Logistical resupply of chemicals (space refueling essentially) would require space superiority sufficient to provide continued access to space.
  - Space refueling could be achieved with pre-positioned chemicals located at on-orbit fuel depots. Fuel cells could be moved into a co-orbital rendezvous with the SBL. Unless the depot was in the same or near same orbital plane, a space-maneuvering vehicle may be needed to move fuel to spacecraft. Depending on the SBL constellation architecture, depots may be needed in several orbital planes each coincident with that of the SBL spacecraft. Obviously, the SBL would need to be designed for such a concept.

Relevant Doctrinal Principles for Space Force Application:

- Provides counterair, counterland, countersea, and counterspace capabilities
- Counterspace role may be either offensive or defensive and serve as a means to provide or support space control and space superiority.

Notes

[1] Maj Rick Walker, "Future Space Capabilities for Fire Control," (paper, Space Warfare Center, 1999), 17.

Notes

[2] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 76.

[3] Walker, " Fire Control," 16.

[4] Walker, "Future Space Systems 2000 - 2030," 68-72.

[5] Walker, " Fire Control," 16.

Appendix B

Ground Based Laser (GBL): Facts and Uses

Basic Description:[1]
- High-energy, ground-based lasers located in different regions around the country.
- Five different locations sited for good weather, each with its supporting infrastructure.
- Four geosynchronous orbiting mirrors provide redirection of the laser beam to the target.

Benefits/Limitation as a Space Force Application Asset:
Benefits:
- No on-orbit maintenance or fuel resupply constraints.
- Continental U.S. basing will limit GBL vulnerabilities to enemy attack.
- Not constrained in size to fit within the launch capability of current or future space lifters.

Limitations:
- Atmospheric effects worse for GBL than for SBL due to proximity to atmosphere and possibility of traversing atmosphere twice in some concepts of operation.[2]
- Air, land, and sea targets are not in direct field of regard without use of space-based reflector.
- Use of such a reflector system would result in extremely long distances to targets, which presents laser effectiveness problems.
- Without mirror system, GBL must wait for space targets to orbit within the field of regard of the GBL, which can result in target access constraints.[3]
- Limited by local weather over regional GBL ground sites.[4]
- GBL has longer cooling times than SBL, which limits the GBL's frequency of lazes.[5]

Primary Concept of Operation:
- The GBL fires its laser onto a space-based reflector that then redirects the beam to the intended air, land, sea, or space-based target.
- Alternately, the GBL waits for a space target to pass within its field of regard and then lazes the target to degrade or destroy it.

Expanded Concepts of Operation:
- Possible ability to provide some limited measure of self defense using its laser to engage an attacker.

Relevant Doctrinal Principles for Space Force Application:

- Force application only as a strategic attack against space systems or, via space-based reflectors, against air, land, sea, and space-based targets.
- Space superiority through space control functions.

Notes

[1] Lt Col William H. Possel, "Lasers and Missile Defense: New Concepts for Space-Based and Ground-Based Laser Weapons," (Maxwell AFB, AL: Center for Strategy and Technology, Air War College, July 1998), 18-20.

[2] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 84-84.

[3] Walker, 86.

[4] Ibid.

[5] Ibid.

Appendix C

Common Aerospace Vehicle (CAV): Facts and Uses

Basic Description:
- A 12 – 16 foot long weapons delivery platform (reentry vehicle) with global range weighing less than one ton.[1]
- Capable of carrying up to 800 pounds of weapons.[2]
- Launched into either a suborbital trajectory or an orbital trajectory with deorbit as required.[3]

Benefits/Limitation as a Space Force Application Asset:
Benefits:
- Ultimate in standoff capability—able to precisely attack any location from either a continental United States (CONUS) or orbital basing location.[4]
- Can be sortied to a global target in less than 90 minutes.[5]
- Can deliver a variety of precision weapon types tailored to the target.[6]
  - Small smart bombs, deep penetrators, or precision anti-armor weapons.[7]
- No human risks to attacker given standoff release point in CONUS or space.[8]
- No overflight restrictions typical of aircraft platforms.[9]
- Rapid reaction with weapon on target within 90 minutes.[10]
- Stationed on-orbit or launched on the SOV on short notice.
- Bypasses adversary's air defense systems.
- CAV weapon load can be tailored to theater commander's target requirements.

Limitations:
- Requires precise knowledge of target location.
- Physics and precision weapon type still make some deeply buried targets difficult.
- Instantaneous engagement not possible since weapon must physically travel from its orbital location.

Primary Concept of Operation:
- CAV is launched aboard an SOV into either orbit or a suborbital trajectory.
- If inserted into orbit, it remains there until called upon to deorbit and release its weapons against a specific target.
- CAV has the ability to carry a variety of precision, conventional ordnance types.

Expanded Concepts of Operation:
- Dedicated deployment in mass to support a specific theater commander's requirements.

- Rapid launch of CAVs into orbit as a deterrent show of force.

Relevant Doctrinal Principles for Space Force Application:
- Would require commander to employ tenets of balance, priority, and versatility & flexibility.

Notes

[1] Lt Col Ken Verderame, "MS-1A Military Spaceplane: Mission/Capabilities (SWC Tactics Day)," (briefing, Air Force Research Laboratory, 1 October 1999), 10.

[2] Ibid.

[3] Maj Rick Walker, "Future Space Capabilities for Fire Control," (paper, Space Warfare Center, 1999), 15.

[4] Verderame, 10.

[5] Walker, "Fire Control," 16.

[6] Ibid.

[7] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 62.

[8] Verderame, 10.

[9] Ibid.

[10] Ibid.

Appendix D

Space Operating Vehicle (SOV): Facts and Uses

Basic Description:
- Reusable space launch system.[1]
- Launch-on-demand capability.
- CONUS based or dispersed locations for SOV launch and recovery.

Benefits/Limitation as a Space Force Application Asset:
Benefits:
- Delivers payloads to all orbital inclinations.[2]
- Rapid launch turnaround times: 7 hours nominally, 3.5 hours in an emergency.[3]
- Reduces launch costs for satellites to low earth orbits initially by factor of 10^4 moving to a factor of 100.[5]

Limitations:
- Primarily a low earth orbit delivery system akin to the space shuttle.
- Unable to lift the weight of the Space Based Laser (maximum SOV payload is 50,000 pounds).

Primary Concept of Operation:
- Vertical liftoff and vertical or horizontal landing depending on design selected.
- Drop off payload in orbit or to suborbital trajectory.
- Returns to earth for refurbishment and reflight.

Expanded Concepts of Operation:
- Emergency deployment to recovery astronauts.

Relevant Doctrinal Principles for Space Force Application:
- Can help provide space superiority by assuring access to space in time of conflict.
- Key space support capability that must be integrated within the larger system of systems.

Notes

[1] Lt Col Ken Verderame, "MS-1A Military Spaceplane: Mission/Capabilities (SWC Tactics Day)," (briefing, Air Force Research Laboratory, 1 October 1999), 3.

Notes

[2] Verderame, 4.

[3] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 14.

[4] Maj Rick Walker, "Future Space Capabilities for Fire Control," (paper, Space Warfare Center, 1999), 4-5.

[5] Walker, "Future Space Systems 2000 - 2030," 14.

Appendix E

Space Maneuvering Vehicle (SMV): Facts and Uses

Basic Description:
- Reusable, uninhabited upper stage to maneuver assets into final orbit or between orbits.

Benefits/Limitation as a Space Force Application Asset:
Benefits:
- Able to provide a 20-degree orbital inclination change for a 1200-pound payload.[1]
  - Orbital changes reduce vulnerability by moving out of harms way or making tracking difficult for an adversary.[2]
- Turnaround time of 72 hours.[3]
- Can respond to short notice tasking and launch on demand.[4]
- Ability to change orbital plane provides substantial survivability for itself and payload.
- Can fly-by spacecraft in medium to high altitude orbits.[5]

Limitations:
- Small payload bay of 4 ft by 4 ft by 7 ft.[6]
- Can only dock with spacecraft out to a 10,000 nautical mile orbit.[7]

Primary Concept of Operation:
- Launched aboard the SOV, Evolved Expendable Launch Vehicle, Space Shuttle, or Peacekeeper.[8]
- Maneuver its payload to its desired orbit or remain on orbit for up to 18 months awaiting requirement to perform a fly-by of another space object or dock with another satellite.[9]
- Autonomous, aircraft-like landing on earth.

Expanded Concepts of Operation:
- Provide global space mobility for payloads within its interface and maneuver capabilities.
- Serve as a space refueler, space minelayer, space minesweeper, microsatellite or decoy delivery platform, or ISR platform for space object identification or battle damage assessment.
- Can provide on orbit maintenance, resupply, or recovery of space systems.

Relevant Doctrinal Principles for Space Force Application:
- Supports space superiority and space control through dominant space maneuver.

- Deploys, resupplys, or logistically supports space force application satellites as well as other space systems.
- Must be integrated into family of space systems in terms of payload interfaces and infrastructure requirements.

Notes

[1] Maj Rick Walker, "Future Space Capabilities for Fire Control," (paper, Space Warfare Center, 1999), 9.

[2] Walker, "Fire Control," 9.

[3] Lt Col Rick Walker, "Future Space Systems 2000 - 2030," (briefing, Space Warfare Center, 29 June 1999), 41.

[4] Lt Col Ken Verderame, "MS-1A Military Spaceplane: Mission/Capabilities (SWC Tactics Day)," (briefing, Air Force Research Laboratory, 1 October 1999), 9.

[5] Walker, "Fire Control," 9.

[6] Walker, "Future Space Systems 2000 - 2030," 41.

[7] Ibid.

[8] Ibid., 38.

[9] Ibid.

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