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SPACE DOCTRINE FOR THE 21ST CENTURY

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Major Robert D. Newberry

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Acknowledgments

This paper is the synthesis of many people's ideas. Some are my own but most have been around the space community for years. Organizing these ideas into a coherent structure has been an interesting experience and would not have been possible without the help of many people. An advantage of writing a paper while at Air Command and Staff College is the great number of people who are available for consultation on an issue such as space doctrine. I was delighted to find so many people who were willing to review my early drafts and their comments certainly improved the quality of this paper.

I am particularly grateful for the help I received from Colonel Vic Budura, Major Ken Moran, Lieutenant Colonel T.S. Kelso, Mr. John Pike, Lieutenant General Roger DeKok, Lieutenant Colonel Jeff Garner, Major Bruce Deblois, Dr. Dennis Drew, Major Juan Holguin, Major Kevin Elder, Major James Wolf, and Major Jon Kimminau.

Abstract

Today there is virtually no approved space doctrine to guide the development and employment of space forces. The supporting strategies for organizing, training, equipping, and employing space forces do not exist. There is no discussion of the tenets of space power or the operational art of employing space forces.

Space policy has emerged to fill the doctrinal void. Policy is the major influence on the organization, training, equipping, and employment of U.S. space forces. The preeminence of policy and absence of doctrine has caused military effectiveness to be muted in the debates over space forces.

Without a clear vision of what space forces should do, the Air Force has been left to build space forces in an ad hoc manner. There is no doctrinal guidance for how to achieve the offensive and defensive mix of forces called for in the national space policy and there is no approved process from which the needed doctrine can be developed. Although doctrine development follows a proscribed bureaucratic process, little consideration is given to the underlying thought process.

This paper attempts to define a doctrine development process and use it to formulate a space doctrine. This doctrine includes the tenets of space power, the operational art of space warfare, and implementation strategies for space forces. This doctrine can be immediately applied to ongoing space operations.

Chapter 1

The Space Doctrine Problem

U.S. space forces are vulnerable to attack and some missions could be "driven from space" in future conflicts.[1] This vulnerability is not based on a single peer competitor like the Former Soviet Union. Rather, it is based on the availability of many attack options such as, jammers, deception, attacks on ground stations, kinetic weapons, space mines, and directed energy weapons.[2] Most of the technologies needed to employ these weapons are readily available to anyone with a desire to acquire them.[3] Technical sophistication is no longer a barrier to launching space attacks, instead, the U.S. must rely on deterrence and the goodwill of others to safeguard its space forces from attack.

What would happen if deterrence and goodwill broke down and U.S. space forces were subjected to attack? The answer goes beyond an analysis of the defensive measures for each space system and calls into question the underlying doctrine that ties space operations together. Should these operations have to respond to a direct attack, space doctrine must be at work guiding the development and employment of space forces to ensure their success in battle.

Unfortunately, there is virtually no approved space doctrine. This is true for both joint and service doctrine. Despite its importance to the success of the joint team, there is almost no mention of space forces in the joint capstone and keystone doctrine publications. In addition, the Joint Tactics, Techniques, and Procedures (JTTP) for space operations is still in draft after many years of development. Air Force doctrine is not much farther along. Space is included in Air Force basic doctrine only because aerospace is taken to mean both air and space. This is highlighted by the fact that Air Force basic doctrine has very little to say about the organization, training, equipping, and employment of space forces. In addition, the Air Force does not have any operational space doctrine, since the only publication of its kind was rescinded in 1991. There is no discussion of the tenets of space power or the operational art of employing space forces. No one seems sure what the tenets of space power are. In the absence of doctrine, coherent strategies for organizing, training, equipping, and employing space forces have not evolved.

Space policy has emerged to fill the doctrinal void. Policy now controls almost every aspect of the military space program. It determines what programs are developed, how many systems are fielded and how they are employed. There are few checks and balances to weigh military effectiveness against cost or policy constraints.

Without a clear vision of what space forces should do, the Air Force has been left to build space forces in an ad hoc manner. National space policy calls for the Air Force to field a space force composed of offensive and defensive weapons, but no master plan exists to set priorities. Therefore, the formulation and implementation of each weapon system is undertaken in a piecemeal fashion. With this kind of disjointed approach, there is no way to determine if the current weapons suite is properly balanced. This is alarming since the balance between missions and force size is crucial to fielding a militarily effective space force. Clearly the current ad hoc approach is flawed.

Given the absence of doctrine, but its obvious criticality, what must be done? Unfortunately, there is no approved process from which the needed doctrine can be developed. It is also very difficult to discern how the Air Force develops its doctrine. For example, although doctrine development follows a proscribed bureaucratic process, little consideration is given to the underlying thought process. Therefore, in order to construct space doctrine a process is needed that logically ties space power theory, policy, and strategy together.

This paper attempts to define a doctrine development process and use it to formulate a space doctrine. The discussion begins with a review of existing doctrinal publications and their treatment of space power. It proceeds with a review of space policy and shows how policy has been substituting for doctrine. Next, a doctrine development process is recommended which highlights the absence of a space power theory. Finally, a space power theory is proposed and used to derive doctrine including: the tenets of space power, the operational art of space warfare, and implementation strategies for space forces. This doctrine can be immediately applied to ongoing space operations.

Notes

[1]Carter, Ashton B., "The Current and Future Military Uses of Space." In *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime*, (Lanham, MD, University Press of America), edited by Nye, Joseph S., and James A. Schear, 1987, pp. 57-64.

[2]Ibid.

[3]Lambakis, Steven, "The United States in Lilliput: The Tragedy of Fleeting Space Power," Strategic Review, Winter 1995, pp. 35-36.

Chapter 2

Current Space Doctrine

> *At the very heart of war lies doctrine. It represents the central beliefs for waging war in order to achieve victory. Doctrine is of the mind, a network of faith and knowledge reinforced by experience which lays the pattern for the utilization of men, equipment, and tactics. It is fundamental to sound judgment.*
>
> —General Curtis E. Lemay, USAF, 1968

The Role of Doctrine

There are many historical examples of political leadership directing force development and force employment via policy directives. History also highlights the perils associated with such an approach. French reliance on the Maginot Line after World War I illustrates how politically-driven military strategies and force structures can imperil a nation. It is imperative U.S. space forces give careful consideration to space doctrine lest they leave themselves open to disaster.

Joint Publication 1, *Joint Warfare of the Armed Forces of the United States*, describes how doctrine is a key determinant for force employment.

> Doctrine facilitates clear thinking and assists a commander in determining proper course of action under the circumstances prevailing at the time of decision. Though neither policy or strategy, joint doctrine deals with the fundamental issue of how best to employ the national military power to achieve strategic ends.[1]

Strategic objectives are defined by the country's political leadership. They define what national interests are at stake and what the military instrument of power is intended to accomplish. Strategic objectives are often expressed as national policy. Samuel P. Huntington noted "the fundamental element of a military service is its purpose or role in implementing national policy."[2] Therefore, doctrine is also a tool to translate national policy into military forces and employment strategies.

These relationships can be illustrated graphically as shown in figure 1.

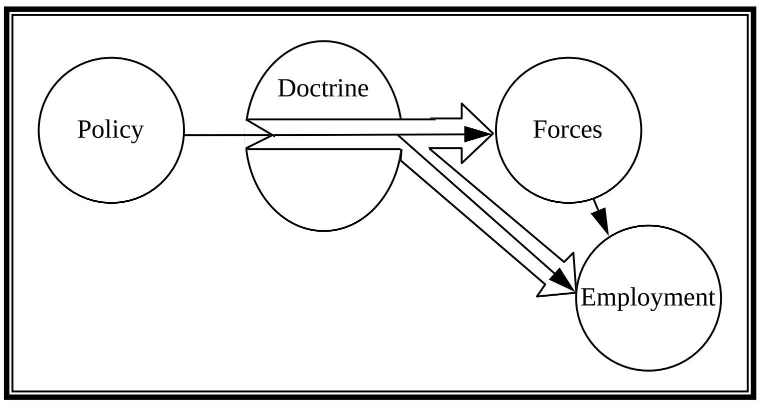

Figure 1. Key Relationships

Figure 1 depicts the central role of doctrine to augment policy as it guides force development and employment. Consider this hypothetical example of how doctrine translates policy into forces. Policy could direct the creation of a new space mission for space-based radar. The directive would be more concerned with what needs to be done rather than how to go about it. Doctrine is needed to fill in the gaps to guide how the new space-based radar forces would be organized, trained, equipped, and employed. However, there is nothing sacred that says a military service must have doctrine. Figure 2 shows how policy can substitute for doctrine by guiding force development and employment directly.

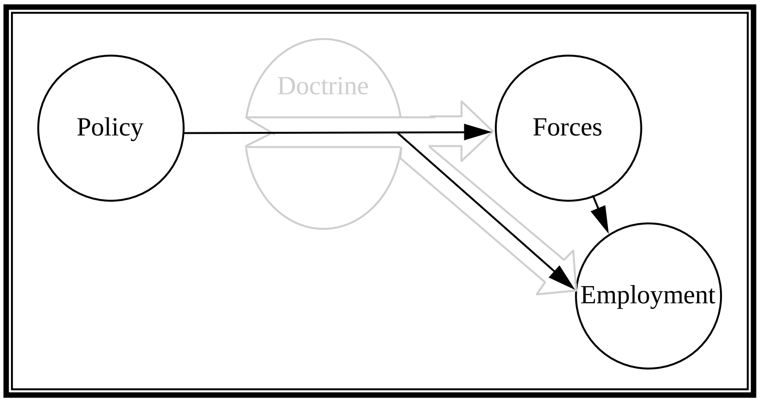

Figure 2. Policy in the Absence of Doctrine

Space Doctrine

Doctrine comes from many places and exists for different purposes. Doctrine also carries different levels of authority based on who promulgated it. Figure 3 illustrates some of the most common types of doctrine.

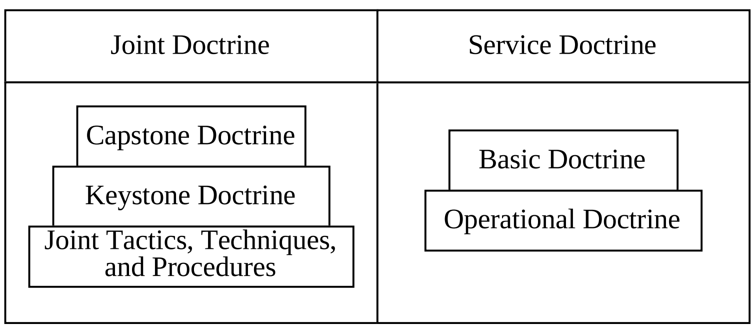

Figure 3. Types of Doctrine

Joint Doctrine

Joint doctrine is tied together under the capstone publications of Joint Publication 1, *Joint Warfare of the Armed Forces of the United States*, and Joint Publication 0-2, *Unified Action Armed Forces*.[3] They lay the foundation for conducting joint operations. The main concern of capstone doctrine is to integrate all military services and instruments of national power in a joint warfighting environment.[4] Since there is not an independent space service, space power is not specifically addressed.

Keystone doctrine links together families of warfighting doctrine and procedural publications.[5] Joint Publication 3-0, *Doctrine for Joint Operations*, is the keystone doctrine for space operations. It only tangentially incorporates space forces by discussing force enhancement and space control and only superficially discusses how the synergistic effect of space forces can contribute to dominance on the battlefield.[6]

Joint Tactics, Techniques, and Procedures (JTTP) 3-14, *Space Operations*, is earmarked to be the joint-level space doctrine. Unfortunately, this publication is still in draft after several years of development. Therefore, there is essentially no joint space doctrine at this time.

Service Doctrine

The Air Force included space in its doctrine starting in 1959. Appendix A provides a review of the history of space operations in Air Force doctrine. As figure 3 indicates, service doctrine can be either basic or operational.

> *Basic Doctrine.* Basic doctrine is comprised of the fundamental principles for the employment of aerospace forces in support of US national objectives in peacetime and during periods of conflict.[7]

The basic doctrine of the Air Force makes prominent mention of space operations. It does so by including space in its definition of "aerospace."[8] References to space as a unique environment were avoided and aerospace was used when either air operations, space operations, or both air and space operations were appropriate. Even though the term "space" was avoided, some references proved to be inescapable. These include references to unique space missions such as counterspace, spacelift, and on-orbit support.[9] Unfortunately, the general lack of distinction between air and space inhibits the understanding of how the Air Force intends to implement its space missions.

The Air Force is moving away from the term aerospace and replacing it with air and space. This is seen in the recent publication of *Global Engagement: A Vision for the 21st Century Air Force* where air and space superiority is now listed as a core competency.[10] Although the idea of space warfare is becoming prominent in Air Force thinking, little effort has been made to flesh out what it means. One would expect Air Force operational doctrine to provide a cogent discussion of the operational art of space warfare as seen in the definition of operational doctrine.

> *Operational Doctrine.* Operational doctrine is comprised of the principles and rules governing the organization, direction, and employment of aerospace forces in the accomplishment of major operational tasks.[11]

The Air Force had operational space doctrine in the form of Air Force Manual (AFM) 1-6, *Military Space Doctrine*, from 1982 until 1991 when it was rescinded. Unfortunately, no replacement doctrine has been approved.

Notes

[1]Joint Publication 1, *Joint Warfare of the Armed Forces of the United States*, 10 January 1995, p. vi.

[2]Huntington, Samuel P., "National Policy and the Transoceanic Navy," *Proceedings*, May 1954, p. 483.

[3]Joint Publication 1-01.1, *Compendium of Joint Publications*, 25 April 1995, p. A-4.

[4]Joint Publication 1-01, *Joint Publication System Joint Doctrine and Joint Tactics, Techniques, and Procedures Development Program*, p. 39.

[5]Ibid.

[6]Joint Publication 3-0, *Doctrine for Joint Operations*, 1 February 1995, pp. IV-3, IV-5, and III-9 through III-10.

[7]Air Force Manual 1-1, *USAF Basic Doctrine*, 28 September 1971, p. 1-1.

[8]Air Force Manual 1-1, Vol. I, *Basic Aerospace Doctrine of the United States Air Force*, March 1992, p. 5.

[9]Ibid., p. 7.

Notes

[10]United States Air Force, *Global Engagement: A Vision for the 21st Century Air Force*, (Washington D.C., Department of the Air Force), December 1996, p. 10.

[11]Air Force Manual 1-1, *USAF Basic Doctrine*, 28 September 1971, p. 1-1.

Chapter 3

Current Space Policy

> *Policy***.** *Any plan or course of action adopted by a government, political party, business organization, or the like, designed to influence and determine decisions, actions, and other matters.*
>
> —The American Heritage Dictionary, 1976

The lack of space doctrine means policy is alone in determining the development and employment of U.S. space forces. It is imperative to examine the national space policy to assess whether or not U.S. space forces are imperiled by such an approach and if the U.S. is relying on the equivalent of a Maginot Line in space.

The process flow shown in figure 1 demonstrates how doctrine complements policy by providing force structure and employment strategies. An understanding of current space policy is needed to understand what space doctrine is seeking to influence.

National Space Policy

The political leadership has clearly articulated the strategic objectives for military space forces in the national space policy dated 19 September 1996. It provides guidance for civil, national security, and commercial space sectors. Specific instructions are provided to the Department of Defense (DOD) within the national security sector guidelines. They include:

1. Maintain a capability to execute the mission areas of space support, force enhancement, space control, and force application.
2. Protect critical space-related technologies and mission aspects.
3. Act as a launch agent for defense and intelligence sectors.
4. Integrate and enhance the robustness of satellite control.
5. Establish requirements for military and national-level intelligence information.
6. Coordinate intelligence gathering with the Director of Central Intelligence.
7. Develop, operate and maintain space control capabilities.
8. Pursue a ballistic missile defense program.[1]

The responsibilities assigned to the DOD are both defensive and offensive in nature. Defensive actions include: (1) maintaining mission capabilities, (2) protecting technologies and missions, (4) enhancing satellite control, and (8) pursuing missile defense. Offensive action is required for (7) developing space control capabilities. The combination of both defensive and offensive capabilities should lead to the attainment of space superiority.

There is an asymmetry between defensive and offensive capabilities. Colin Gray observed "the positive and negative benefits of space power are not identical. To be able to use space does not necessarily imply the ability to deny such use to an enemy, while the ability to deny the use of space to an enemy certainly does not mean that, ipso facto, space can be used by friendly forces."[2] Mark Berkowitz further described the importance of striking a balance between defensive and offensive capabilities when he wrote:

> The United States must continue to mix offensive and defensive measures to ensure freedom of action on-orbit for friendly forces and to prevent enemies from using space for purposes inimical to U.S. interests. The U.S. military can deny access to space solely through offensive action, but the ability to control space to enhance the combat effectiveness of terrestrial forces requires measures to protect U.S. space systems.[3]

Space doctrine will be needed to balance these policy directives.

Policy as a Substitute for Doctrine

Lt Col James Eken observed "the Air Force and the DOD chose to deal with space employment via policy guidance vice specific space doctrine."[4] Space policy certainly addresses many issues normally covered in doctrine, but has it really become a substitute? The different roles policy plays for space forces compared to air forces certainly seems to support Lt Col Eken's statement. Consider the four examples below:

1. The Space Architect's Office and Deputy Under Secretary of Defense (DUSD) for Space were established to provide leadership of the military space program since Congress noted the lack of a "cohesive story" and overall space architecture. DUSD (Space) is charged with consolidating "policy, strategy, and plans."[5] The aircraft community does not have corresponding officials.
2. An interagency panel was needed to recommend development of the evolved, expandable launch vehicle (EELV).[6] The F-22 did not need such policy support since air doctrine clearly calls for the development of an air superiority fighter.
3. Expenditures on protection and survivability measures for space systems are extremely low when they should be integral to a space doctrine. Aircraft survivability continues to be a high priority as seen in the development of defensive countermeasures and stealth technology.
4. Directives to standardize and encrypt spacecraft command and control systems were implemented via policy and never reflected in doctrine.[7]

In the absence of doctrine, policy can drive force development and employment. This process flow presents some interesting problems for space forces. Although policy and doctrine are closely linked, they have separate purposes; moreover, policy is not always an adequate substitute for doctrine. Policy is designed to implement political decisions. Its primary concern is describing what ought to happen. Doctrine describes what military organizations believe to be true concerning operational matters. Doctrine's primary concern is with applying theory and past experiences to maximize the military effectiveness of forces. While policy may or may not concern itself with matters of military effectiveness, doctrine must. Many doctrinal issues are not addressed in policy and policy tends to change more frequently than doctrine. Some of the differences between doctrine and policy are shown in table 1.

Table 1. Policy versus Doctrine

	Policy	Doctrine
Source	Civilian Authorities	Military Leadership
Emphasis	Politically Derived	Military Effectiveness
Responsiveness	Quick	Slow, Incremental
Duration	Short	Long

The different purposes for doctrine and policy can result in conflicting advice about how to organize, train, equip, and employ military forces. The cost of military equipment is one area where policy and doctrine often conflict. Policy may dictate a cost conscious force structure which may not survive the rigors of war. Doctrine is more concerned about military effectiveness and may see advantages to spending more money to have forces which can survive in battle. In these cases, either the policy is modified or the political leadership must accept an increased risk of failure if war occurs. Another area where policy and doctrine can conflict is in determining what quantities of equipment to procure. Policy may again strive to minimize military expenditures and make optimistic assumptions about force attrition. Doctrine tends to be more conservative and assume higher loss rates. The push and pull between policy and doctrine is useful and should result in a superior force structure.

Omitting doctrine from the process eliminates an important check and balance from force development and employment. Policy makers should not fear doctrine since policy takes precedence over doctrine. However, doctrine gives the military leadership a stronger voice in debates over force structure. Doctrine also forces consideration of employment issues which may not otherwise be considered during force development.

Problems With Not Having Doctrine

The absence of military space doctrine has allowed policy to drive how the United States organizes, trains, equips, and employs its military space forces. The advocates of military effectiveness are often ignored in the debate over space system design and implementation. The lack of emphasis on military effectiveness for military space systems is cause for concern.

The lack of space doctrine, so far, has not been catastrophic, as seen in Desert Storm. Some argue that Desert Storm was a space war and the United States and its allies won, so there is no need to fear war in space.[8] This is supposed to allay fears by asserting that space war is not new and U.S. forces are prepared for future space wars. This line of reasoning is dangerous for two reasons. First, the lessons learned from Desert Storm have a narrow application due to the one-sided nature of the space order of battle. The coalition forces had space resources far superior than those of Iraq. Second, there are significant differences between the "space war" and a "war in space." Desert Storm does not tell us much about war in space since Iraq did not attack coalition space forces.

Space Doctrine Is Needed

There is a significant difference between viewing space as a medium from which you can support terrestrial warfare and viewing space as a medium of warfare itself. Doctrine needs to address not only how space systems support terrestrial warfare but how to employ space forces when space becomes the arena of conflict.[9]

If space is no longer a sanctuary from terrestrial conflict, then past and current policy directives do not go far enough to prepare U.S. space forces for battle. In the event of a space attack, military effectiveness will be the dominant concern. Policy directives intended to make space systems cost effective are inadequate to ensure their military effectiveness. An eye on cost effectiveness is warranted, but it should not always dominate over military effectiveness. Future wars will prove that military effectiveness should be the dominant consideration and space doctrine needs to be there to advocate this point. Without credible space doctrine, one can never be sure how space forces will react to an attack. Credible space doctrine is needed to guide the development of future space forces to ensure an ability to effectively fight a war in space.

Notes

[1]National Space Policy Factsheet, The White House, 19 September 1996, p. 5.

[2]Gray, Colin S., "The Influence of Space Power upon History," *Comparative Strategy*, Volume 15, Number 4, 1996, p. 299.

[3]Berkowitz, Marc J., "Future U.S. Security Hinges on Dominant Role in Space," *Signal*, May 1992, p. 71.

[4]Eken, Lt Col James K., *Roles and Missions, Doctrine and Systems Development and Acquisition: Today's Decisions Affect Tomorrow's Space Force Capabilities*, (Air University, Maxwell AFB, AL), April 1995, p. 7.

[5]Scott, William B., "'Architect' to Reshape Defense Space Policy," *Aviation Week & Space Technology*, 20 February 1995, p. 50.

[6]Courtner, Jim, Dave McCurdy, Loren B. Thompson, "Military Space Policy: The Critical Importance of New Launch Technology," *Strategic Review*, Summer 1994, p. 21.

[7]National Space Policy Factsheet, The White House, 19 September 1996, p. 5.

[8]Covault, Craig, "Desert Storm Reinforces Military Space Directions," *Aviation Week and Space Technology*, 8 April 1991, p. 42.

[9]Moore, George M., Vic Budura, and Joan Johnson-Freese, Joint Space Doctrine: "Catapulting into the Future," *Joint Force Quarterly*, Summer 1994, p. 76.

Chapter 4

Doctrine Development Process

> *Therefore, like it or not, space is a new theater of war that must be studied in that regard as thoroughly and carefully as any other lest we suddenly find ourselves confronted by the threat of physical force and violence from others who have taken it quite seriously.*
>
> —G. Harry Stine, 1981

Accepting the argument for better space doctrine doesn't automatically produce it. Space doctrine has to come from somewhere and it generally takes many years to produce. This paper is primarily concerned with the development of space doctrine but it is necessary to define an overall doctrine development process to support this goal since none currently exists. Colonel Drew, in his article, *Inventing a Doctrine Process*, highlights the difference between a bureaucratic doctrine process and an intellectual one. He goes on to conclude that "if the Air Force is to have effective and useful doctrine, it must invent and implement an intellectual process for its development."[1]

Defining a Process

There are many processes available to guide the development of doctrine. The following list shows some possible options.

1. Mimic other doctrinal publications.
2. Create a collage of ideas from subject-matter experts.
3. Define inputs, relationships, and outputs of doctrine to create a doctrine process.

Past doctrine development appears to follow a mix of options 1 and 2. Doctrine format is somewhat standardized since many doctrinal publications mimic a capstone or keystone publication. However, they do not follow a standardized recipe and they can vary significantly over time, organization, and purpose. The collage process is often used to fill in the selected format. A team of subject-matter experts is formed and their drafts are coordinated with all the major stakeholders to create a collage of ideas. AFM 1-1 went so far as to provide the individual essays used to develop the doctrine as an accompanying publication.[2] This kind of process can produce widely varying results and is not suited to rigorous analysis. It is also prone to missing important factors since it is not systematic.

Creating a doctrine development process along the lines of option 3 appears to be best suited to the development of space doctrine. Option 1, mimicking existing doctrine, has proven inadequate to date, as seen in using air doctrine and the term aerospace to describe space operations. Option 2, creating a collage of ideas regarding space operations, would probably confuse more people than it would enlighten, since an underlying theme is not available to build on. The resulting doctrine might be disjointed, have gaps in logic, and miss important points.

Process development "consists of realizing that results come from processes, building a process to produce the desired results, implementing the process so one can later figure out why it produced the results it did, and then feeding this insight back to improve the process next time it is used."[3] Over time, such an approach to writing doctrine should improve the quality of the publications and provide consistency between doctrinal publications.

Observations from Other Doctrine Publications

It is possible to infer a doctrine development process from sampling other doctrinal publications. Joint Publication 1 and AFM 1-1 are good representatives of respected doctrinal publications. Their organization is shown in table 2.

Table 2. Doctrine Organization

Joint Pub 1	AFM 1-1
Chap 1: American Military Power	Chap 1: War and the American Military (includes principles of war)
Chap 2: Values in Joint Warfare	Chap 2: Nature of Aerospace Power (includes tenets of power)
Chap 3: Fundamentals of Joint Warfare (includes principles of war)	Chap 3: Employing Aerospace Forces (includes the operational art)
Chap 4: The Joint Campaign (includes supporting capabilities)	Chap 4: Preparing the Air Forces for War

Both publications follow a similar logical presentation. The principles of war are discussed, followed by the tenets of power and then the operational art of war. This template is shown in figure 4 and can be used to define a doctrine development process.

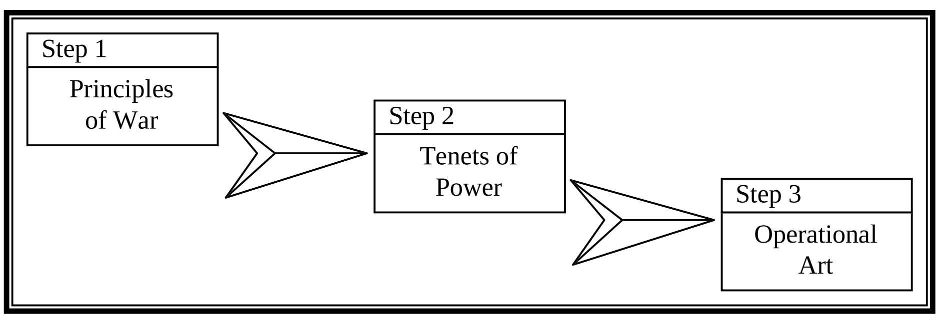

Figure 4. Doctrine Development Steps

Recommended Process

A more thorough review of AFM 1-1 reveals additional information is needed to support the doctrine development process. First, an underlying theory is needed to explain how or why things work. It ensures the resulting doctrine has solid underpinnings and is not strictly self serving for the proponents of the doctrine. Second, the tenets of power are closely tied to the characteristics of the warfighting environment. The environment heavily influences what works or doesn't work under the pressures of war. Appendix C compares the tenets of power for air, land, and sea operations to illustrate this point. Third, operational experience is an important factor in determining the operational art. Doctrine draws heavily on past experience since lessons learned in war are especially credible to military organizations.

Figure 5 shows how the basic structure from figure 1 can be expanded to include theory, environmental characteristics, and operational experience.

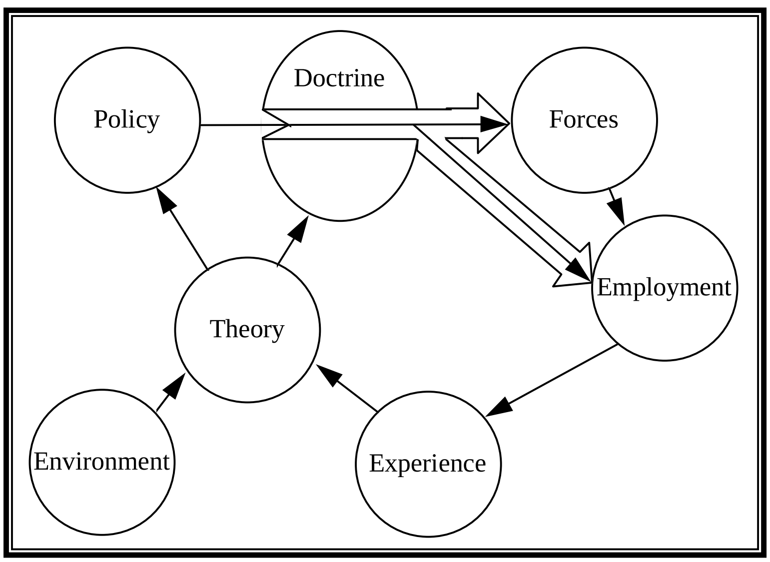

Figure 5. Overall Process

Figure 6 shows how the basic structure from figure 4 can also be expanded to include the contribution of environmental characteristics and operational experience to the doctrine development process.

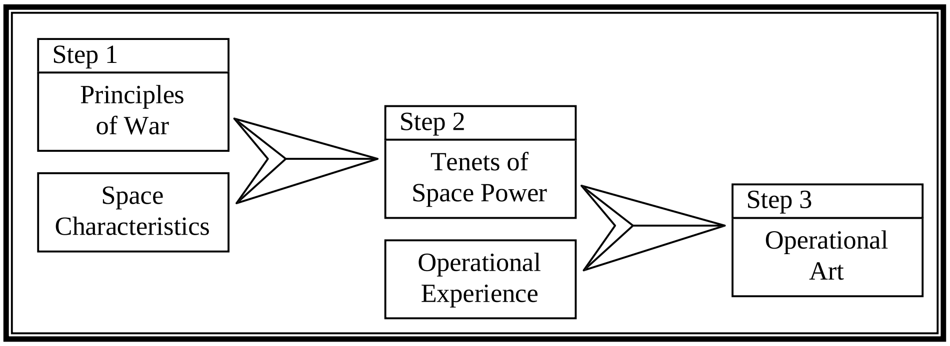

Figure 6. Doctrine Development Process

The one ingredient still missing for the development of a space doctrine is a space power theory. This is the subject of the next chapter.

Notes

[1]Drew, Colonel Dennis M., "Inventing a Doctrine Process," *Airpower Journal*, Winter 1995, p. 42.

[2]See Air Force Manual 1-1, Volume II.

[3]Shiba, Shoji, Alan Graham, and David Walden, *A New American TQM, Four Practical Revolutions in Management*, (Portland, OR, Productivity Press), 1993, pp. 45-46.

Chapter 5

Space Power Theory

> *Man has always sought to expand his domain. In subduing the earth, man moved onto the water, under the water, into the air, and into space as technology allowed. With him, man took war. Man will take war into space. It is not a matter of if; it is merely a matter of when.*
>
> —Lt Col Thomas Eller and Maj Charles Friedenstein, 1981

Carl Builder, in his book, *The Icarus Syndrome*, defined theory as "a supposition or conjecture about the relationships between things. Theories explain *why*."[1] An understanding of why something works makes it possible to predict what needs to be done and how one should go about it. Therefore, theory can structure the way doctrine organizes space power concepts into a coherent whole.

Clearly then, one must begin by questioning why space forces are developed. There are many competing concepts regarding the role of space power and how space forces should be developed and employed. It is impossible to accept every concept since many are mutually exclusive. Therefore, in order to organize the array of space power concepts and coherently guide the development of space doctrine, a space power theory is needed.

Definitions

Before a space theory can be described, a common understanding of terms is needed.

Space System

The first item to consider how to describe a space system. Many publications define a space system as being comprised of space, link, and ground segments where the ground segment includes a control element and user equipment.

Issues with Ground Segment. Grouping the control element and user equipment into a single segment inhibits the understanding of user equipment. User equipment is growing in importance as support to military operations increase for space forces. User equipment is often fielded on airborne or spaceborne platforms and the term ground segment does not adequately convey these applications. Therefore, user equipment should be accorded status as a distinct segment.

Issues with Link Segment. The link segment describes the relationship between the control and space segments. Relationships between segments can be dynamic and take on a variety of forms. Links are usually radio frequency transmissions but they can be accomplished by lasers or canisters. Using the term *link segment* inhibits the understanding of other relationships such as spacecraft-to-spacecraft links and user equipment-to-user equipment links. Mixing relationships and hardware to describe a space system is awkward, at best, and is unnecessary. The system can be adequately defined using only hardware elements and their relationships can be defined on a case-by-case basis.

The following three segments will be used to describe a space system in this paper:

1. Space segment—the actual space vehicle which is also referred to as a spacecraft
2. Control segment—the means of command and control
3. User segment—the equipment which provides users with space services

Regions of Space

The second definition to consider is space or regions of space. It is important to carefully consider what regions are used, since their characteristics will directly influence the development of theory and doctrine. Although space is physically undivided, there are many different regions of space which are readily discernible. It is possible to consider only a single class of orbits, such as geostationary orbits, and develop a doctrine for geosynchronous space. However, such narrowly defined regions of space will probably not be useful to the war fighters since space systems of all orbits types will be needed to support terrestrial operations. A good starting point to define regions of space is to consider the taxonomy John Collins describes in his book *Military Space Forces: the Next 50 Years*. He defined four regions of the space environment as shown in figure 7.[2]

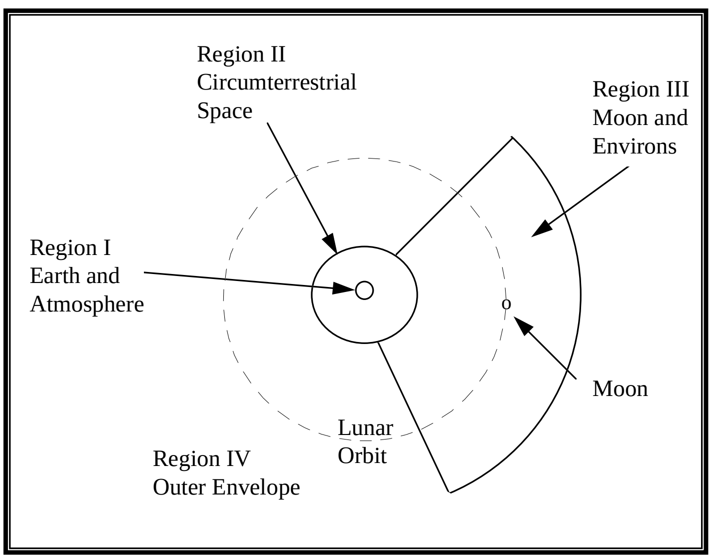

Figure 7. Regions of Space

Although the Air Force now defines aerospace to include the air environment and all of space,[3] it previously used the term to only mean “the region above the earth’s surface, composed of both atmosphere and near-space.”[4] This earlier definition closely matches

Region I which John Collins calls “earth and atmosphere.” In this paper, the term aerospace will be used to describe the region from the surface of the earth up to 60 miles which corresponds to region I. This is where the transition from air to space occurs.

Regions II and III highlight the differences between earth and lunar orbits. For the purposes of this paper, there is not a significant difference between regions II and III and it would be difficult to make a meaningful distinction for doctrine between these two regions. Therefore, they will be combined into a single region called earth orbit. The space power theory put forth in this paper is for the earth orbit environment.

John Collins calls region IV the outer envelope. This includes everything beyond earth orbit. Since outer envelope is not a widely-used term, it will be referred to simply as outer space in this paper.

Using the common frame of reference provided by the above definitions, one can now begin describing the environment and operational experience which are needed to build a space power theory.

Space Characteristics

There are several characteristics of space which define it as a unique arena of military endeavor. There are so many that is often hard to decide which characteristics are important to the development of a space power theory or doctrine. Some interesting characteristics, such as, size or remoteness are not relevant to the development of space power theory or doctrine. Many authors have described the attributes they consider important and a few of them are summarized in table 3.

Table 3. Space Characteristics

AFM 1-6[1]	AFDD 2-2[2]	Lupton[3]	Burke[4]
- Global Coverage - Economy - Effectiveness - Flexibility - Efficiency - Redundancy	- Global Coverage - Flexibility - Economy - Effectiveness - Robustness	- Global Presence - Quasi-Positional Siting - Congregational Tendency - Long-Range Electromagnetic Weapons Effects - Hypervelocity Kill - Infinite Operating Area - Logistical Handicap - Inaccessibility - Lack of Manning - Altitude/Security Trade-off - Legal Overflight - Vehicular Sovereignty - Political Insensitivity	- Size - Remoteness - Openness - Unity - Isolation - Vantage - Harshness - Constancy - Uniformity - Poverty in Resources

[1]AFM 1-6, *Military Space Doctrine*, 15 October 1982, p.
[2]AFDD 4, *Space Operations Doctrine*, unpublished draft, June 1996,
[3]Lupton, Lt Col David E., *On Space Warfare, A Space Power Doctrine*, (Maxwell AFB, AL, Air University Press), June 1988, pp. 19-27.
[4]Burke, 1Lt Roger C., "Basic Space Doctrine." In *Military Space Doctrine -- The Great Frontier: A Book of Readings for the United States Air Force Academy Military Space Doctrine Symposium, 1-3 April 1981, Vol. I*, (Colorado Springs, CO, USAF Academy), compiled by Swan, Major Peter A., 1981, p. 115.

Most of the attributes in table 3 are actually characteristics of individual spacecraft (e.g., effectiveness, flexibility, efficiency, redundancy, robustness), reflect the current state of space technology (e.g., inaccessibility, lack of manning), or are lessons learned (e.g., altitude/security trade-off, economy). Although these types of attributes should be discussed in theory, they should not be incorporated into doctrine since it would force the doctrine to change as the force structure or technology changes. The collection of attributes in table 3 do, however, provide an adequate reservoir to distill out three fundamental characteristics of space: observability, undivided medium, and tie to earth. These attributes incontrovertibly identify the space environment as a unique operating environment separate from the air, land, or sea.

Observability

Observability ties together the ideas of global coverage, high vantage point, and reciprocity. Not only can space forces observe terrestrial forces, but, terrestrial forces can observe space forces. The ability of space forces to observe terrestrial activities is key to their effectiveness, while the ability of other forces to observe space forces poses a significant vulnerability.

Observability is most concerned with the space segment since spacecraft can observe the earth and, in return, be observed and monitored from earth. Space is void of virtually everything, including obscurants. There are no clouds in space, so spacecraft can be observed quite easily. The high vantage point of spacecraft also contributes to the ability to observe their activities. There are some observation limitations depending on the phenomenology employed, such as, sun angles for optical systems and size and distance for radar systems. Additionally, there are latitude limitations for low-inclination orbits and longitude limitations for geosynchronous spacecraft. However, these limitations are small, and, for the most part, anyone can observe spacecraft at any time.

The user segment and control segment are much harder to observe due to their ease of movement (user segment) and worldwide locations (control segment). However, if they radiate energy into space, it is possible to observe their activity, as well.

An element of observability is the predictability of orbital mechanics. Once you know the element set[5] for a spacecraft, you can accurately predict its location in the future. The only way to change the orbit is to expend energy in a velocity changing maneuver (i.e., delta-v) to either accelerate or decelerate the spacecraft. If a delta-v maneuver is observed, then the spacecraft's orbit will still be predictable. In the event the maneuver is not observed, the object will continue to be observed but it may not be apparent that it is the same object since it will be in a different orbit. This is because spacecraft are tracked according to their orbit rather than visual identification. Predictability may change in the future with new spacecraft technologies such as continuously thrusting systems (e.g., ion propulsion). These types of systems may not have predictable orbits and new tracking schemes may have to be employed. Until then, orbits will be predictable.

Another element of observability is low-observable technology and its application to space forces. Low-observable technology can hide specific spacecraft attributes from specific sensors. As sensors either become more sensitive or expand into new observation bands, then spacecraft would have to be redesigned to defeat the new technology. This process would result in a cat-and-mouse game between spacecraft and sensors. There will be periods where the spacecraft have the advantage and others where the sensors have the advantage. It is impossible to predict what the state of the art will be at any time in the future, thus low-observable technology cannot indefinitely overcome the fundamental characteristic of the observability of the space environment. Clearly then, the application of low-observable technologies to spacecraft will have to be considered at the operational art level of space doctrine.

Despite low-observable technology and given the broad implications of global coverage and the potential benefits of the high vantage point, observability is a dominant environmental characteristic that enables space forces to assume war fighting missions. It will drive the need to defend space forces from attack.

Undivided Medium

Earth orbital space is a single, undivided medium. There are no physical barriers to segregate one area from another, unlike the land or sea. There are also no political barriers in space, such as, claims of national sovereignty or exclusion zones for land and air. In contrast, spacecraft are free to transit any region of space at any time given they do not endanger other spacecraft and they have sufficient fuel to make the maneuver. There are natural groupings of spacecraft into similar orbits but these are driven by individual mission objectives. Defining sub-regions of earth orbits, such as geosynchronous or sun-synchronous orbits, is a matter of convenience and does not impact the development of space theory or doctrine for the earth orbit region in general.

Tie to Earth

Earth orbiting spacecraft are inherently tied to terrestrial activities. At the most basic level, they are bound by the earth's gravity until they reach escape velocity. Space forces in earth orbit will assume roles and missions which will, in some way, influence activities on earth as well as be influenced by those activities. Most people recognize that orbiting spacecraft are in view of the earth and can be viewed from the earth. Their influence need not be so passive, however. Terrestrial systems can project energy and/or matter up to orbiting spacecraft at virtually any time. While the ability of terrestrial forces to attack space forces is limited by the relative geometry of the weapon system, ground mobile or airborne weapons can overcome these limitations and attack space forces at virtually any time or place. Every space system is vulnerable to attack whether or not its operator wants it to be.

Operational Experience

The United States Air Force has been operating spacecraft for almost forty years. This operational experience has taught us much about military space operations. One of the most important events to demonstrate the importance of military space power was Operation Desert Storm during the Gulf War. Sir Peter Anson and Dennis Cummings observed the following lessons from Desert Storm:

1. The user segment needs to be more flexible to exploit space capabilities.
2. The distinction between military and civil systems is blurred.
3. Space systems will be increasingly in demand.[6]

Similarly, Vice Admiral William Dougherty cited these lessons from Desert Storm in his article titled *Storm from Space*:

1. Space plays a broad role to support both tactical and strategic operations.
2. Dependence on space systems will continue to grow.
3. Improved space systems are needed, for:
    - More immediate support to troops and assembled forces
    - Upgrades to early warning systems
    - Responsive space launch capability
    - Space-based wide area surveillance
    - An ability to protect U.S. space assets and selectively deny adversary space use[7]

Not all of these observations are general principles of space operations. However, three generalized statements of operational experience can be made using these observations.

Useful to Many

The clientele for space-derived information is impressive and growing. Every time a new space mission is undertaken, it quickly becomes indispensable to military, political, and economic operations. Satellite navigation aids, missile warning, and weather systems are familiar examples of how the simplest space service can spawn entire new industries and enhance military weaponry. The U.S. armed forces already have a considerable reliance on space data and this is crossing over to the domestic civilian population and spreading worldwide. The increasing sophistication of civilian space systems blurs the distinction between military and civilian space capabilities and increases the probability civilian space systems will be used for military purposes.[8] Sir Anson observed "[Desert Storm] revealed the military potential of commercial communications and earth observation systems and narrowed the gap between military and commercial space ground equipment."[9] Reliance on space systems should continue to grow for both military and civil users.

Fight on Demand

Space forces support military operations 24 hours a day, every day. They play a prominent role in peacetime military operations and support a high operations tempo. Space forces must be constantly available to support surges in military operations whether for war or military operations other than war (MOOTW).[10] This has blurred the distinction between peace and war in space.

The transition from peace to war may happen unexpectedly and space systems will be among the first to respond. An attack on space-based early warning or communications systems could proceed fighting between terrestrial forces. A space force's ability to withstand such an attack could be crucial to preventing an escalation in hostilities or concluding them quickly. Therefore, space forces must be able to fight on demand, even if the timing is dictated by the adversary.

Always Vulnerable

Space is a sanctuary only as long as no one shoots at another's space forces. The nature of the space environment (observability and tie to earth) makes spacecraft vulnerable to a wide variety of threats. In addition, it may be difficult to perceive an adversary's actions for what they are. Space attacks could easily be mistaken as unintentional interference since space forces can come under attack with little or no warning. Even if there is overwhelming evidence of harmful interference, it may not be possible to pinpoint the culprit or go public with it for fear of revealing the capabilities or limitations of space forces. This concern encompasses more than just the space segment. The user and control segments also have many vulnerabilities of their own.

It is unreasonable to expect a country to have sufficient information about the threat or the political resolve to conduct preemptive strikes to protect its space forces. Although the claim of national sovereignty for spacecraft is a strong deterrent to taking preemptive action, many treaty provisions that are intended to protect U.S. space forces make it harder to actively defend against space attack. An adversary may routinely probe another's forces just to see what happens or if they even notice. The "attack" may not be an attack at all but rather unintentional interference which is not worth risking a war for. Since the U.S. has the most to lose from a war in space, it will be reluctant to make the first strike against the space forces of a nation with the means to retaliate. This reluctance almost guarantees the U.S. will continue to be vulnerable to a first strike in space.

Space Power Theory

A space power theory can be developed using the information presented above to conjecture about how and why space forces will shape the future of national power. Space forces have already assumed important national security roles and all indications are for their importance to grow.

Trends

There are many trends that indicate a prominent future for space power, however, two in particular bear mentioning.

Continuous Awareness. The first trend is toward space forces that provide continuous awareness of terrestrial events. The observability characteristic of the space environment has allowed space forces to monitor important world events and situations. Early missions were to monitor strategic forces and to verify treaty compliance. Other missions developed to continuously monitor the earth for missile launches and weather patterns.[11] For all of these missions, the emphasis has been to lessen the time from sensing an event to reporting it. Relay satellites have been employed to allow space forces to operate in a near real-time mode. The trend is taking space forces toward an ability to provide continuous awareness of terrestrial events.

Vital to All. The second trend is the transition of space forces from being important to many, to being vital to all. Space power has become increasingly important to political, economic and military power. Terrestrial military forces in particular are becoming increasingly dependent on space power in the conduct of their operations.[12] The time compression caused by continuous awareness gives organizations less time to react to crises. This has elevated the importance of space power for state and non-state actors alike (e.g., businesses, private volunteer organizations, and potentially terrorist groups). The trend is for space power to become a concern of all organizations, regardless of their technical sophistication. General Herres put it well when he forecast that "no nation will be fully able to control its own destiny without significant space capabilities."[13]

Conjectures

The two trends discussed above can support many different conjectures about space power in the future. Some are found in Lt Col Mantz's booklet titled, *The New Sword, A Theory of Space Combat Power* where he lists the following "axioms of space combat power":

1. Space strike systems can be decisive by striking earth forces.
2. Space strike systems can be decisive when an enemy's essential means for waging war are vulnerable to space attack.
3. Space strike systems can be decisive by striking enemy decision-making structures.
4. Space strike systems can deter hostile actions by holding the enemy at risk.
5. Space denial systems can be decisive by denying enemy access to space-derived data.
6. Space denial systems can be decisive by physically denying enemy access to space.
7. Space protection systems can assure friendly access to space.
8. Total space control is neither achievable nor necessary.
9. Space combat power must be centrally and independently controlled.
10. Space power is not intrinsically linked to air power.[14]

These conjectures are more exhaustive than is desired for this paper. While a comprehensive space power theory needs to discuss space power at this level of detail, the need here is to summarize the fundamental conjecture about the future of space power.

The conjecture offered here is that *space power is a precondition to control the sea, land, or air.*[15] This conjecture is supported by the two trends stated above and breaks down into four supporting conjectures.

Space forces are necessary to enhance war fighting capabilities.[16] This conjecture is based on the positive benefits gained from exploiting the space medium, operational experience using these capabilities, and the trend toward greater reliance on space forces. The mission area undertaken to enhance war fighting capabilities is force enhancement.

Space forces can target sea, land, and air forces.[17] Space forces can target terrestrial forces in one of two ways. First, they can enhance the lethality of terrestrial forces as stated above. This added lethality makes it possible for terrestrial forces to more quickly engage opposing forces once they are detected by space forces. The second means is for space forces to directly engage terrestrial forces through space-to-ground or ground-to-space-to-ground weapons. The mission area to target terrestrial forces is force application.

Adversaries must be deprived access to space to gain a decisive advantage.[18] This conjecture starts with the assumption that other nations will follow the U.S.'s lead in relying more on space power in the future. Indeed, the European viewpoint of lessons learned from Desert Storm indicates this to be the case.[19] A more conventional way to prove this point is to produce intelligence estimates which demonstrate foreign utility and dependency on space systems. This option may not be possible since it is difficult to project foreign space developments much beyond a few years and intelligence estimates are generally classified. The mission area to deprive others access to space is space control.

Space power is perishable and must be protected.[20] This conjecture is based on a demonstrated or a reasonably plausible threat to friendly space forces. The threat discussion provided in chapter 1 was cursory but adequately supports this argument for now. Operational experiences demonstrate how quickly a country can target the space forces of an adversary. The mission area to protect friendly space forces was once called space defense but it is now included as an element of space control.

Roles and Missions

The proposed space power theory identified the force enhancement, force application, and space control mission areas. AFM 1-1 and the national space policy complement this list by adding space support. The list of mission areas and supporting missions include:

1. Space Support
   - Launch
   - Satellite Operations
2. Force Enhancement
   - Surveillance and Reconnaissance
   - Navigation
   - Communication
   - Weather
3. Space Control
   - Space Surveillance
   - Counterspace
   - Missile Defense
4. Force Application
   - Ground Based Nuclear Deterrence
   - Conventional Strike

Armed with an understanding of the space environment, past operational experience, and a space power theory, it is now possible to develop space doctrine.

Notes

[1]Builder, Carl H., *The Icarus Syndrome*, (New Brunswick, Transaction Publishers), 1994, p. 206.

[2]Collins, John M., *Military Space Forces: the Next 50 Years*, (New York, NY, Pergamon-Brassey), 1989, pp. 6-7.

[3]Air Force Manual 1-1, Vol. I, *Basic Aerospace Doctrine of the United States Air Force*, March 1992, p. 5.

[4]Air Force Manual 1-1, *United States Air Force Basic Doctrine*, 14 August 1964, p. 2-1.

[5]An element set provides data to determine a spacecraft's orbit.

[6]Anson, Sir Peter and Dennis Cummings, "The First Space War: The Contribution of Satellites to the Gulf War," *RUSI Journal*, Winter 1991, p. 53.

[7]Dougherty, VAdm William A., "Storm from Space," *Proceedings*, August 1992, pp. 48-52.

[8]Lee, Major James G., *Counterspace Operations for Information Dominance*, (Maxwell AFB, AL, Air University Press), October 1994, p. 13.

[9]Ibid.

[10]Herres, General Robert T., "Space-Based Support," *Defense 88*, November/ December 1988, p. 8.

[11]Herres, p. 9.

[12]Ibid.

[13]Ibid.

[14]Mantz, Lt Col Michael R., *The New Sword: A Theory of Space Combat Power*, (Maxwell AFB, AL, Air University Press), May 1995, p.74.

[15]See Colin Gray's article, "Space Warfare, Part I, The Need for Doctrine," *National Defense*, January 1988, pp. 25-26. He arrives at the same conclusion although in a somewhat different manner since he includes the delivery of nuclear weapons through space on ICBMs.

[16]Herres, p. 7.

[17]Mantz, pp. 31- 33.

[18]Berkowitz, Marc J., "Future U.S. Security Hinges On Dominant Role in Space," *Signal*, May 1992, p. 71.

[19]Anson and Cummings, p. 53.

[20]Carter, Ashton B., "The Current and Future Military Uses of Space." In *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime*, (Lanham, MD, University Press of America), edited by Nye, Joseph S., and James A. Schear, 1987, pp. 63-64.

Chapter 6

Warfare in the Space Environment

Future military space operations must be treated with the same 'developed-for-war' approach that today is applied to operations on the land, sea, and in the air.

—General John L. Piotrowski, USAF, 1989

The pieces to the doctrine process discussed in chapter 4 are now ready to be put together. Chapter 5 provided supporting information concerning space characteristics and operational experience as it relates to space power theory. The principles of war and their application to the space environment are provided in Appendix B. The completed pieces of the space doctrine process are shown in the gray boxes below.

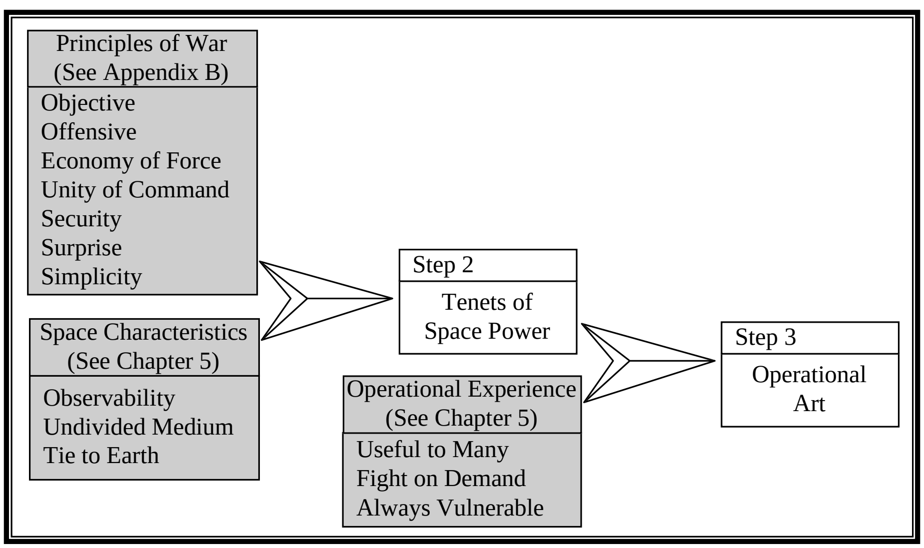

Figure 8. Completed Pieces

Tenets of Space Power

Codifying the tenets of space power is the next step in the doctrine development process. Tenets describe how “power can be used to achieve military objectives.”[1] They are the operational strategies that harmonize environmental constraints and the principles of war. The following checklist lays out the process used to compare the principles of war to the environment characteristics.

1. Make a one-to-one comparison of the principles of war to the environmental characteristics.
2. Consider whether or not the environment enables or impedes employment of forces in a manner called for by the principles of war.
3. If the environment enables such operations, then no tenet of power will result since all forces will enjoy that advantage.
4. If the environment impedes such operations, then a tenet of power should result to describe what characteristic forces need to overcome the impediment.

A good way to explain this process is to demonstrate it by applying it to a familiar topic as shown in table 4. The following example from air doctrine is illustrative only. It is unlikely this process was used by the authors of AFM 1-1.

Table 4. Tenets of Air Power Analysis

Principles of War	Aerospace Characteristics[1]		
	Dispersed Capabilities	Many Targets/ Hard Targets	Lethal Environment
Objective	central control	**persistence**	
Offensive	flexibility	concentration	
Economy of Force	synergy	priority	balance

[1]Extracted from discussion of aerospace power tenets, AFM 1-1, Vol. I, March 1992, p. 8.

Table 4 shows how the seven tenets of air power can be described using the first three principles of war and the most elementary aerospace characteristics. The combination of objective and many targets leads to a need for persistence. AFM 1-1 states that "destroyed targets may be rebuilt by resourceful enemies" (environment characteristic). The principles of war call for military forces to achieve objectives. Therefore, "air planners should plan for restrikes against important targets." In other words—persistence.[2]

This same analysis process should reveal the tenets of space power. The tenets of space power analysis are shown in table 5.

Table 5. Tenets of Space Power Analysis

Principles of War	Space Characteristics		
	Observability	Undivided Medium	Tie to Earth
Objective	initiative	N/A	synergy/sustain
Offensive	initiative	N/A	N/A
Economy of Force	N/A	N/A	sustain
Unity of Command	initiative	N/A	synergy
Security	initiative	agility	N/A
Surprise	initiative	N/A	N/A
Simplicity	N/A	N/A	sustain
Note: N/A means no tenet was derived from this analysis.			

A brief description is provided for each tenet of space power in the following paragraphs.

Initiative

Table 5 shows that the observability of space forces leads to the tenet of initiative.

> *Initiative.* Initiative sets or changes the terms of battle by action and implies an offensive spirit in the conduct of all operations. Applied to the force as a whole, initiative requires constant effort to force the enemy to conform to commanders' operational purposes and tempos, while retaining freedom of action. It means depleting the enemy's options, while still having options of their own.[3]

Initiative is required of space forces to: (1) achieve objectives, (2) take the offensive, (3) achieve unity of command, (4) maintain security, and (5) surprise the adversary.

Another way of looking at this is to consider what may happen if space operators fail to take the initiative. They will be unable to achieve any new objectives other than continue current operations. They will be in a defensive posture and unable to take the offensive. Unity of command may not be achieved and some assets may be beyond the commander's control. The security of the systems may be threatened by an adversary who has found key vulnerabilities. And, finally, the adversary will never be surprised or forced to react to the space forces.

Initiative is needed to ensure the safety of friendly spacecraft, as well as put the adversary on the defensive. By forcing the adversary to react instead of act, the likelihood of success increases. This tenet applies to the user and control segments, as well as the space segment.

Agility

The tenet of agility arises primarily from concerns over the security of space systems.

> *Agility*. Agility is the ability of friendly forces to react faster than the enemy and is a prerequisite for seizing and holding the initiative. It is as much a mental as a physical quality.[4]

Agility can be both physical and virtual. Physical agility is the ability to move space forces or use alternate equipment in reaction to adversary actions. Virtual agility is the ability to change operating characteristics without moving or changing equipment. Agility is the linchpin for the protection and preservation of space forces during hostilities, and without it, a space-faring nation risks losing its space assets during war. Agility includes two sub-elements. First, it is necessary to maintain a situational awareness to detect threats to space systems. Second, space operators must be prepared to react to threats as they arise. Contingency plans need to be well understood and exercised.

Synergy

The tenet of synergy arises from the tie between space and terrestrial forces.

> *Synergy.* Synergy is the ability to "produce effects well beyond the proportion of each mission's individual contribution to the campaign."[5]

Space forces are inextricably linked to the earth and their operations provide a force multiplier to achieve desired objectives. The force multiplier effect of spacecraft providing information superiority is so well known it is almost taken for granted (e.g., the role of the Global Positioning System in precision-guided munitions). Unity of command also has implications for synergy since some centralized control is needed to ensure compatibility and to not overwhelm the user with unnecessary information. If space forces operate in an uncoordinated manner, it can cause information overload and become a detriment to the combatant commander. Space systems work best when they are operated cooperatively rather than competitively.

Sustain Operations

Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms,* defines sustainment as:

> *Sustainment.* The provision of personnel, logistic, and other support required to maintain and prolong operations or combat until successful accomplishment or revision of the mission or national objectives.[6]

AFM 1-6 stated that "an integral responsibility to deploying a space force is maintaining it and ensuring it has an enduring capability."[7] Once space systems are included into operational war plans, every effort must be made to sustain their operations.

It may be more important to the commander to continue receiving space support he is familiar with than testing something new in the heat of battle. Space forces must be used wisely so they will be available throughout the conflict. Sustaining space operations will reduce the fog and friction of war for U.S. forces. Sustainment operations include defensive operations, replenishment strategies, and maintaining reserve capabilities.

A comparison of the tenets of power for land, sea, air, and space operations is provided in Appendix C.

Operational Art

The tenets of space power can now be used to develop the operational art for space forces. Joint Publication 1-02 defines operational art as:

> *Operational Art.* The employment of military forces to attain strategic and/or operational objectives through the design, organization, integration, and conduct of strategies, campaigns, major operations, and battles.[8]

The operational art is the heart and soul of military doctrine. It calls for careful consideration about what strategies and capabilities will lead to mission success. Operational art is comprised of the capabilities or techniques military organizations develop to maximize the effectiveness of their forces. It is rooted in operational experience and seeks to animate the tenets of power in a given medium. Operational art elements can be either backward-looking or forward-looking based on what experiences are considered most important to the organization. The attempt here is to articulate a forward-looking doctrine and prescribe what should work in the future to make U.S. space forces as effective as possible.

The mechanics of developing the operational art is similar to that used for the tenets of power analysis. The following checklist was used to conduct this analysis.

1. Make a one-to-one comparison of the tenets of power to operational experience.
2. Consider what the operational experience reveals concerning the tenet of power.
3. If the operational experience if favorable, then record what capabilities or techniques were the cause for success.
4. If the operational experience is negative, then record what new capabilities or techniques may be needed to ensure success in the future.

Several operational art concepts can fit into many places in the analysis, however, the matrix below only lists the best match to reduce repetitiveness.

Table 6. Operational Art Analysis

Tenets of Power	Operational Experience		
	Useful to Many	Fight on Demand	Always Vulnerable
Initiative	encryption	observation management	maneuver
Agility	N/A	autonomy training	attack detection space surveillance
Synergy	standard products interoperability	exploit others	data fusion
Sustain	exploit others	launch on demand reserve modes	robustness

The explanation and discussion of each of these capabilities requires more attention than can be devoted here. Appendix D provides a definition, examples, and a discussion of all fourteen operational art elements. They are also summarized in table 7 below.

Table 7. Operational Art Summary

Operational Art	Description	Examples
Encryption	Stop intruders and pirates	Crypto boxes, on-board processing
Observation Management	Control what is revealed	Decoys, debris, LPI links
Maneuver	Change orbits or locations	Thrusters, mobile ground segments
Autonomy	Automate counter measures	Safe mode, back-up frequencies
Training	Train as you fight	Exercises, simulation, planning
Attack Detection	Characterize attacks	Attack warning, direction finding
Space Surveillance	Maintain situational awareness	Radar & optical tracking, listening
Standard Interfaces	Facilitate data sharing	Commercial standards and formats
Interoperability	Modular and standard designs	SGLS, standard/modular designs
Exploit Others	Use non-military systems	CRSF, commercial GPS receivers
Data Fusion	All-sensor view of the battlefield	All source intelligence reports
Launch on Demand	Deploy spacecraft when needed	Space plane, ICBMs
Reserve Modes	Overcome problems or attacks	Alternate power settings, back-ups
Robustness	Be hard to kill	Milstar waveform, hardening

Notes

[1]Air Force Manual 1-1, Vol. I, *Basic Aerospace Doctrine of the United States Air Force*, March 1992, p. 8.

[2]Ibid.

[3]Field Manual 100-5, *Operations*, June 1993, p. 2-6.

[4]Ibid., p. 2-7.

[5]AFM 1-1, p. 8.

[6]Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 23 March 1994.

[7]Air Force Manual 1-6, *Military Space Operations*, 15 October 1982, p. 10.

[8]Joint Publication 1-02.

Chapter 7

Applying the Operational Art

Doctrine is intended to guide the organization, training, equipping, and employment of military forces. Doctrine guides these activities by codifying military judgment in a form that is usable by developers and planners. A readily usable form of doctrine is found in implementation strategies to guide acquisition and employment activities. These strategies assist in the translation of policy directives into force structure and employment concepts. Implementation strategies can be categorized as either force-development or force-employment oriented. Both types of strategies should reflect the application of the operational art to space missions.

Force-Development Strategies

Force-development strategies should address issues related to the acquisition of space forces. Many important characteristics of space forces are determined during the acquisition phase because follow-on operational innovations will be significantly constrained by the design of the space system. Force-development strategies are intended to describe general capabilities space forces need rather than mission- or design-unique characteristics. The proceeding list of operational art elements contain two readily apparent force development strategies.

Modular Design

Modular design is the ability to mix and match different payloads between different types of space systems. It applies equally to the space, control, and user segments, although the emphasis is often placed on the space segment since it is more difficult to change once it is launched.

Modular design is also concerned with adding ancillary payloads to spacecraft. Many of the operational art elements advocate equipping all spacecraft with multiple sub-payloads. This idea was prominent in AFM 1-6 and was referred to as a multi-mission capability. AFM 1-6 envisioned a capability to: "defend friendly space systems by avoiding or surviving attack and to promote deterrence by having the ability to detect, identify, and neutralize threatening enemy systems."[1] These same ideas are expressed in this paper in the operational art elements of:

1. Attack Detection
2. Space Surveillance
3. Standard Interfaces
4. Interoperability
5. Reserve Modes

The term multi-mission was not used here since it now carries a different connotation. Multi-mission is often taken to mean combining primary spacecraft payloads such as adding an imagery mission to a missile warning spacecraft. This may be a good idea under certain circumstances, but it is not generalizable to all space forces. Modular design on the other hand emphasizes the ability to add general warfighting capabilities as an adjunct to primary spacecraft mission(s). It is reasonable to consider all spacecraft as candidates for implementing one or more of the capabilities listed above.

Commercial Standards

Many of the functions required of military space forces are common to commercial users and there is often no reason to have unique military standards. This idea has been around for some time and was the subject of an acquisition reform. In 1994, Secretary of Defense Perry issued a policy memorandum stating "the use of military specifications and standards is authorized only as a last resort, with an appropriate waiver."[2]

While commercial standards are being pursued by the acquisition community for the potential cost savings involved, this strategy also offers many force employment benefits. Adopting commercial standards should make space forces more responsive in implementing these operational art elements:

1. Standard Interfaces
2. Interoperability
3. Exploit Others
4. Data Fusion

Fielding space forces in this manner will facilitate the integration of space forces into theater operations and theater Battle Management, Command, Control and Communication (BMC3) systems. It will make space forces more flexible to operational demands by allowing greater interoperability between service components and commercial user equipment. It should also facilitate rapid dissemination of space-derived information to terrestrial forces.

Force-Employment Strategies

Force-employment strategies differ from force-development strategies in that they arise from use of the forces rather than their design. For example, a space system can be designed to be maneuverable, but if an attack warning is never received, the spacecraft will not respond to defeat the threat. Employment strategies can also allow space operators to possess capabilities not originally considered when the space system was designed.

Operational Security

Operational security, or OPSEC, has been a prominent feature of U.S. space forces. Most space systems are cloaked in a veil of secrecy and OPSEC is almost synonymous with program security classification guides. A too narrow mindset, however, can blind space operators to the full range of OPSEC strategies and measures. OPSEC is supported by these operational art elements to create uncertainty in the mind of the adversary:

Table 8. OPSEC and Uncertainty

Operational Art Element	Adversary's Uncertainty
1. Encryption	I don't know what they are doing.
2. Observation Management	Can I believe what I see?
3. Training	They seem to anticipate my moves.
4. Interoperability	What are the connections?
5. Data Fusion	Can I have a meaningful effect?
6. Launch on Demand	Should I expect more?

A comprehensive OPSEC plan can help prevent attacks on U.S. space forces by making it more difficult for an adversary to launch an attack. It can create uncertainty as to the true nature of U.S. space operations and deny the adversary needed targeting data. Although the benefit to some space systems may be negligible, OPSEC can be particularly effective in protecting high-value assets.

Instant Awareness

Instant awareness is concerned with maintaining the commander's situational awareness of space and enabling him to respond effectively to an adversary's actions. Most attacks on space forces can occur in a few minutes to hours.[3] These short warning times make it imperative to detect and respond to an attack as early as possible. Even if it is not possible to protect the first system attacked, countermeasures can be implemented to protect likely follow-on targets. Instant awareness is supported by these two operational art elements:

1. Attack Detection
2. Space Surveillance

The main benefit of instant awareness is it increases the ability of the commander to defeat an enemy attack on U.S. space forces.

Decisive Action

Decisive action is the ability to expand space operations to meet increased demand, sustain space operations in the face of attack, and to retaliate against an adversary's actions in space. Decisive action is supported by these operational art elements:

1. Maneuver
2. Autonomy
3. Training
4. Interoperability
5. Exploit Others
6. Launch on Demand
7. Reserve Modes

Expanding Operations. Operational demands may require space forces to support more users than originally envisioned. An ability to exploit civil, commercial, and/or coalition space systems may be vital to providing these capabilities quickly.[4] A launch on demand capability may be equally important to expand space services by either deploying additional or new forces. Regardless of the technique chosen, space forces must be able to satisfy surges in user demand.

Sustaining Operations. Space operators must anticipate attacks on their space forces during times of increased user demand. This will require defensive measures for all space forces. Military space forces should have a survivability advantage since many of the operational art elements, such as, maneuver, autonomy, and reserve modes will be features of the systems and should enable these forces to defeat or withstand attacks. Civil, commercial and coalition space forces will probably be more vulnerable and defensive measures which can “umbrella” these systems from attack should be employed. Possible examples include: providing attack warning, destroying the attacking platform, and intervening with other space assets to confuse or blunt the attack.

Retaliatory Operations. Retaliatory options are needed to ensure a balance of power can be maintained in space. As space forces become an even greater force multiplier, the temptation to deprive an adversary access to space grows. The U.S. currently would suffer the most from losing its space forces so it is imperative to maintain an ability to retaliate if those forces are attacked. The threat of a decisive U.S. response to space attacks may be a sufficient to deter an attack.

Graceful Degradation

Graceful degradation is the ability of space forces to absorb the loss of space assets in a pre-planned manner and extend the time space services are available to terrestrial forces. It should be a characteristic of both individual space systems and space forces as a whole. The following operational art elements contribute to a graceful degradation capability:

1. Interoperability
2. Exploit Others
3. Data Fusion
4. Reserve Modes
5. Robustness

The emphasis on graceful degradation as an employment strategy is on space forces as a whole. A theater commander is not likely to be concerned with the survival of an individual spacecraft if it is not a single point failure. Space forces should be fielded in such a way that the contributions of individual spacecraft are not readily apparent. The emphasis should be on total mission performance and the loss of individual spacecraft should be noticeable as time delays or lower confidence in the information. Reliance on single platforms to provide highly-specialized information should be avoided.

The force structure and force employment strategies did not evaluate specific space systems or recommend specific changes to space forces. Instead, they laid out a general framework which should lead to the deployment and employment of militarily effective space forces.

Notes

[1]AFM 1-6, p. 6.

[2]Secretary of Defense Policy Memorandum, *Specifications and Standards - A New Way of Doing Business*, 29 June 1994, p. 2.

[3]Giffen, Colonel Robert B., *US Space System Survivability, Strategic Alternatives for the 1990s*, (Fort McNair, Washington DC, National Defense University Press) 1982, p. 38.

[4]Moore, George M., Vic Budura, and Joan Johnson-Freese, "Joint Space Doctrine: Catapulting into the Future," *Joint Force Quarterly*, Summer 1994, p. 76.

Chapter 8

Summary

> *No one can predict with certainty what the ultimate meaning will be of the mastery of space.*
>
> —President John F. Kennedy, 1961

President Bush articulated the need for caring about space power when he observed:

> "Space is the inescapable challenge to all advanced nations of the Earth. Our goal is nothing less than to establish the United States as the preeminent space-faring nation."[1]

To become the preeminent spacefaring nation, the U.S. must organize, train, equip, and employ its space forces around a central, guiding space power theory and doctrine. The need for space doctrine becomes more apparent every day. Day-to-day space operations are conducted in a doctrinal void and this void makes it difficult to predict how well U.S. space forces would react to a surge in mission demands or to an attack. There have been many remedies proposed to solve this problem. Unfortunately, they are generally debated individually and the lack of a common set of principles often makes them ineffectual. What is needed is an overall approach to harmonize the workings of policy, theory, and doctrine.

This paper describes how this harmony can be achieved. Although many of the processes described in this paper are new, they were useful to organize ideas concerning policy, theory, and doctrine in such a way as to allow a coherent strategy to emerge. The approach can be described as a principles-to-strategy analysis and can be thought of as a variant of the strategy-to-task process. The principles of war are compared to the attributes of space to define the tenets of space power. The tenets of space power are then matched with operational experience to describe the operational art of space warfare. Finally, the operational art elements are packaged together into force-development and force-employment strategies. These results are shown in figure 9.

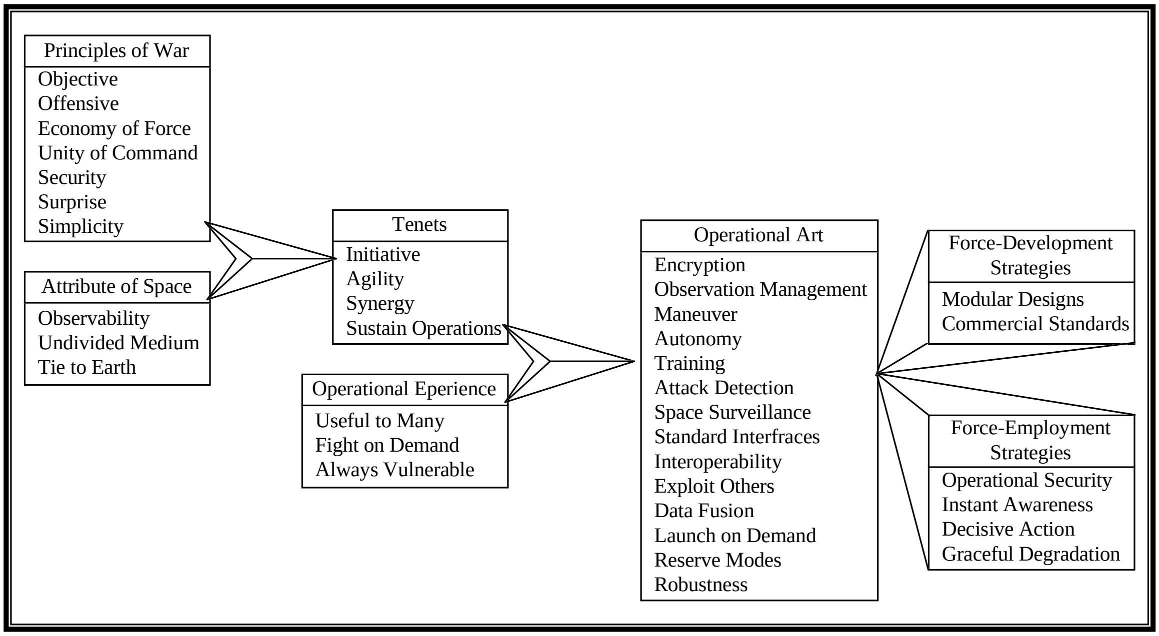

Figure 9. Doctrine Development Process and Results

The figure is probably not completely correct, but that was not the intent. The intent was to get the space doctrine debate into more substantive issues than dealing with the lowest common denominator and semantics. Additional changes will be needed as more people think about these concepts and the understanding of space operations grows.

Some may question whether or not the Air Force should pursue the mastery of space as the national space policy calls for. They believe space is supposed to be a safe haven for the pursuit of peaceful purposes and any military activity should be minimized. History will judge whether or not the United States should have sought the mastery of space but for now, it is the Air Force's challenge to attain it. The question now is whether or not the principles, tenets, operational art, and implementation strategies described in this paper will lead to the mastery of space.

Notes

[1]Bush, President George W., quotation from a speech made on 20 July 1989.

Appendix A

USAF Space Doctrine

Air Force Manual (AFM) 1-2, *USAF Basic Doctrine*, 1959

AFM 1-2 was the USAF basic doctrine publication from 1953 until 1964. The term "aerospace power" replaced "air power" to acknowledge developments in missiles and space systems in the 1959 edition of AFM 1-2.[1] Aerospace was defined as "the total expanse beyond the earth's surface."[2] No further mention of space operations was included.

AFM 1-1, *USAF Basic Doctrine*, 1964

The term aerospace was redefined to only include: "the region above the earth's surface, composed of both atmosphere and near-space."[3] No further mention of space operations was included.

AFM 1-1, *USAF Basic Doctrine*, 1971

The definition of aerospace was expanded back to include: "the region of the earth's surface, composed of both atmosphere and space."[4] A new section titled "The Role of the Air Force in Space" was added. Space forces were described as having these two major roles:

1. Promote space as a place devoted to peaceful purposes.
2. Insure no other nation gains a strategic military advantage through exploitation of space.[5]

AFM 1-1, *USAF Basic Doctrine*, 1975

The definition of aerospace was shortened to be "the region above the earth's surface."[6] The same two roles for space forces described in 1971 were identified.

AFM 1-1, *USAF Basic Doctrine*, 1979

Aerospace was still defined as "the total expanse beyond the earth's surface," however, General Thomas White was quoted as stating "air and space comprise a single continuous operation field."[7] This edition of AFM 1-1 significantly expanded the discussion of space in Air Force basic doctrine and listed three responsibilities for space operations:

1. Protect our use of space
2. Enhance land, sea, and air forces
3. Protect the United States from threats in and from space[8]

In addition, the three types of space operations were listed as:

1. Space support
2. Force enhancement
3. Space defense[9]

AFM 1-6, *Military Space Doctrine*, 1982

In 1977, the CSAF directed the development of the first Air Force doctrine publication devoted to space operations.[10] This new doctrine was assigned the number AFM 1-6 and it was officially approved on 15 October 1982. Its purpose was twofold:

1. Provide a more detailed and updated statement of Air Force beliefs as they pertain to space and Air Force responsibilities, functions, and missions.
2. Provide the foundation for developing detailed operational space doctrine.[11]

AFM 1-6 saw space power as "a natural extension of the evolution of airpower development."[12] It described three roles for space power:

1. Strengthen the security of the United States.
2. Maintain US space leadership.
3. Maintain space as a place where nations could enhance the security and welfare of mankind.[13]

AFM 1-6 listed the following five military objectives for space forces:

1. Maintain freedom to use space.
2. Increase effectiveness, readiness, and survivability of military forces.
3. Protect the nation's resources from threats operating in or through space.
4. Prevent space from being used as a sanctuary for aggressive systems by our adversaries.
5. Exploit space to conduct operations to further military objectives.[14]

AFM 1-6 described two current and three potential missions:

1. Force Enhancement (current mission)
2. Space Support (current mission)
3. Space-based weapons for deterrence (potential mission)
4. Space-to-ground weapons (i.e., force application) (potential mission)
5. Space control and superiority (potential mission)[15]

Several operational art elements were discussed throughout the document although they were not called operational art elements. Most of them were described as desired military capabilities. They are listed in order of appearance.

1. Survivability, endurance, and reconstitution
2. Multi-mission capability
3. Avoid or survive attack
4. Detect, identify, and neutralize threatening enemy systems
5. Deny unauthorized use
6. Reliability, security, and flexibility
7. Quick-reaction launch, short-time regeneration and turnaround for space launches
8. Survivable launch facilities[16]

AFM 1-6 was rescinded in January 1991 to make way for AFM 2-25 which was to be the operational-level doctrine for space.[17] Unfortunately, AFM 2-25 was never published and the core ideas in AFM 1-6 were never expanded as originally envisioned. No further space doctrine has been published by the Air Force other than updates to AFM 1-1.

AFM 1-1, *Basic Aerospace Doctrine of the USAF*, 1984

The definition remained "the total expanse beyond the earth's surface,"[18] however, a new concept for space as a separate region was introduced. Space was now defined as "the outer reaches of the aerospace operational medium."[19] The recognition of space as separate from aerospace was probably the result of AFM 1-6, *Military Space Doctrine*, being published two years earlier.

AFM 1-1, *Basic Aerospace Doctrine of the USAF*, 1992

This edition was a throwback to 1979 and reflected the decision to rescind AFM 1-6 by closing the gap between air forces and space forces. Aerospace was now described as "an indivisible whole" with no absolute boundary between air and space.[20] References to space are made throughout the document but only in parallel to air power concepts. There is no separate mention of space roles but the following space-related missions are identified:

1. Counterspace
2. Spacelift
3. On-orbit support[21]

Air Force Doctrine Document (AFDD) 4, *Space Operations Doctrine*

AFDD 4 was a rough equivalent to the rescinded AFM 1-6. It was to be the basic doctrine of space operations and expand on AFM 1-1 much as AFM 1-6 had. Once AFDD 4 started the coordination process, interest in AFM 2-25 waned to the point that its development was halted. A replacement for AFM 2-25 would be needed later, but the emphasis was to increase to prominence of space in Air Force basic doctrine. When AFDD 4 was presented to the CSAF for approval, he decided an operational-level space doctrine was needed instead of another basic-level doctrine. This new space doctrine was assigned the number AFDD 2-2 and the existing draft of AFDD 4 was simply renumbered.

AFDD 2-2, *Space Operations Doctrine*

AFDD 2-2 is not approved. It is unclear whether the current draft is really suited to be an operational-level doctrine since it was originally written at a basic-doctrine level. Another factor that will influence AFDD 2-2 is the new Air Force Doctrine Center being established at Maxwell AFB, AL in early 1997. There is no way to estimate when AFDD 2-2 will be approved or what it will contain.

Issues with Existing Space Doctrine

There are many issues concerning the adequacy of Air Force space doctrine. The following three arguments capture the essential reasons why an alternative space doctrine should be considered.

Considers Space an Extension of Air Operations. The argument that space operations is an extension of air operations is a doctrinal convenience. The Air Force organized and trained space forces similar to air forces because that was what it was familiar with. Differences in employment and equipment are minimized by using the same operating procedures for space units as for aircraft units. However, the premise that aerospace doctrine encompasses both air and space operations should be looked at with more scrutiny. It can be argued that serious inquiry into the characteristics of the space environment, spacecraft, and, more importantly, space operations will reveal that space is a distinct medium with different tenets of power and a unique operational art.[22]

Lack of Operational Art. Much of the space doctrine to date has concerned itself with a description of roles and missions of space forces. The most vexing omission is the failure to describe an operational art for space. A better understanding of operational art could assist the Air Force in prioritizing force structure decisions and tie budgeting decisions directly to military need rather than the policy process. Policy decisions are more concerned with cost effectiveness than military effectiveness and space doctrine needs to enter the debate as an advocate for military effectiveness.

No Distinction Between Space Regions. Not only is the space environment a distinct medium but it has many naturally occurring divisions within it. Little thought has been given to describing the difference between the earth-moon system and outer space. Space theory and doctrine often confuse these space regions and a better understanding is needed to keep us straight in this area.

Notes

[1]Air Force Manual 1-1, *Basic Aerospace Doctrine of the United States Air Force*, 16 March 1984, p. A-3.

[2]AFM 1-2, *United States Air Force Basic Doctrine*, 1 December 1959, p. 6.

[3]AFM 1-1, *United States Air Force Basic Doctrine*, 14 August 1964, p. 2-1.

[4]AFM 1-1, *United States Air Force Basic Doctrine*, 28 September 1971, p. 2-1.

[5]Ibid., p. 2-4.

[6]AFM 1-1, *United States Air Force Basic Doctrine*, 15 January 1975, p. 2-1.

[7]AFM 1-1, *Functions and Basic Doctrine of the United States Air Force*, 14 February 1979, pp. 2-1 and 2-4.

[8]Ibid., p. 2-4.

[9]Ibid., p. 2-8.

[10]Van Inwegen, Colonel Earl S., "The Time is Now: USAF Operations in Space." In *Military Space Doctrine -- The Great Frontier: A Book of Readings for the United States Air Force Academy Military Space Doctrine Symposium, 1-3 April 1981, Vol. I*, (Colorado Springs, CO, USAF Academy), compiled by Swan, Major Peter A., 1981, p. 163.

[11]AFM 1-6, *Military Space Operations*, 15 October 1982, p. iii.

[12]Ibid., p. 1.

[13]Ibid.

[14]Ibid., p. 5.

[15]Ibid., pp. 8-9.

[16]Ibid., pp. 6 and 9.

[17]Wolf, Captain James R., "Toward Operational-Level Doctrine for Space," *Airpower Journal*, Summer 1991, pp. 29 and 33.

[18]AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*, 16 March 1984, p. 2-2.

[19]Ibid.

[20]AFM 1-1, Vol. I, *Basic Aerospace Doctrine of the United States Air Force*, March 1992, p. 5.

[21]Ibid., p. 7.

[22]Eken, Lt Col James K., *Roles and Missions, Doctrine and Systems Development and Acquisition: Today's Decisions Affect Tomorrow's Space Force Capabilities*, (Air University, Maxwell AFB, AL), April 1995, p. 6.

Appendix B

Principles of War

This appendix provides an analysis of the nine principles of war found in Joint Publication 3-0. Most of the principles of war apply equally to space as to the other war fighting environments. However, mass and maneuver were deleted from the list based on the ability of space forces to operate effectively without them. Table 9 summarizes the seven remaining principles of war that apply to space operations.

Table 9. Principles of War Summary

Principles of War	Description
Objective	Direct every military operation toward a clearly defined objective
Offensive	Seize, retain, and exploit the initiative
Economy of Force	Allocate minimum essential combat power to secondary efforts
Unity of Command	Ensure unity of effort under one responsible commander
Security	Never permit the enemy to acquire unexpected advantage
Surprise	Strike the enemy in a way for which he is unprepared
Simplicity	Prepare clear, uncomplicated plans and concise orders

Objective

The purpose of the objective is to direct every military operation toward a clearly defined, decisive, and attainable objective.[1] This principle of war equally applies to space operations as for terrestrial operations. Space systems incorporate this concept to an extent rarely seen in other weapon systems. Once a space system is unable to accomplish its intended objective, it is disposed of.

Offensive

The purpose of an offensive action is to seize, retain, and exploit the initiative.[2] This principle of war has the same meaning for space operations. Space operators should look for ways to seize the initiative from the adversary. Space forces often take the offensive just by fielding spacecraft. The presence of a spacecraft over an adversary's territory may provoke a countermeasure such as denial and deception operations or to attack the spacecraft. The space race with the Soviet Union demonstrated how each side tried to maintain the offensive by fielding more and better spacecraft. The offensive can also be gained by doing the unexpected.

Mass

The purpose of mass is to concentrate the effects of combat power at the place and time to achieve decisive results.[3] The emphasis on mass is to overwhelm the enemy in both a physical and virtual sense. Physically outnumbering an adversary often provides a distinct advantage of superior firepower and being able to saturate enemy defenses. The need for physical mass was driven by the inaccuracy of weapon systems and the need to increase the probability of killing the target. The emergence of precision weapons has lead to the idea of virtual mass where you can concentrate weapon effects without physically outnumbering your adversary. It is now possible for a single weapon operator to "outnumber" an opposing force through precision and information superiority. This is especially true for space operations. Force enhancement systems can provide information superiority to a large number of users and enable them to operate effectively without physical mass. Space control and force application systems can employ a relatively small number of systems to engage multiple targets and achieve the effects of mass through precision and information superiority. Therefore, mass is not a principle of space operations.

Economy of Force

The purpose of economy of force is to allocate minimum essential combat power to secondary efforts.[4] This principle of war has the same meaning for space operations. The most apparent application of this principles is to carefully prioritize space system tasking to ensure the highest priorities are met. This is routinely done for space forces. However, an important extension of this principle is to balance end-of-life considerations. The operational life for many space systems is tied to their usage. Examples include fuel management while repositioning or station-keeping geostationary satellites and power management to balance transmitting power and battery life. The long design life of many space systems causes military planners to look beyond the allocation of space forces for today's conflict and consider long-term economy of force issues.

Maneuver

The purpose of maneuver is to place the enemy in a position of disadvantage through the flexible application of combat power.[5] Maneuver for spacecraft has a different meaning than for land, sea, or air forces. Spacecraft are constantly in motion so maneuver is generally taken to mean a change in a spacecraft's motion rather than the underlying motion itself. Most force enhancement systems are placed into specific orbits which minimize the amount of maneuvering required of them. Also, spacecraft constellations (e.g., navigation) are used to provide continuous user service without maneuvering. The one segment of space systems most amenable to maneuver is the user segment. However, the deployment of user equipment along with terrestrial forces would not be considered a maneuver on the part of the space system. The situation for space control and force application systems is a little different. The spacecraft for these systems may or may not need to maneuver to engage their targets. The need to maneuver will depend not only on constellation size but also system design and attack phenomenology. Maneuver does not appear to be a principle of space operations.

Unity of Command

The purpose of unity of command is to ensure unity of effort under one responsible commander for every objective.[6] Space forces will rarely, if ever, undertake independent actions. The need for space systems is tied to supporting terrestrial forces either through force enhancement, space control, or force application. The synergy between space and terrestrial forces emphasizes the need for unity of effort for space systems. Unfortunately, military planners must anticipate using commercial space systems for which combatant commanders will not have combatant, operational, or tactical control. The National Space Policy stipulates that "U.S. Government agencies shall purchase commercially available space goods and services to the fullest extent feasible."[7] The policy does not advocate the nationalization or militarization of commercial space assets during war so one should not expect to have unity of command over all space assets. Additionally, third parties, or even an adversary, may also be subscribers to these systems. Space doctrine needs to address the issue of how to achieve unity of command for non-military space systems and how to safeguard these systems from attack.

Security

The purpose of security is to never permit the enemy to acquire unexpected advantage.[8] This principle of war has the same meaning for space operations. Space operations should be conducted in a manner which will not give indications and warning of U.S. operations. Simple techniques such as traffic analysis can indicate who is talking to whom and how high-priority orders are executed. Space systems are particularly vulnerable to signals intercept and steps need to be taken to maintain security. A second security issue is having an adversary determine the hierarchy of space system priority so he can attack the most critical nodes first. Operational security measures are needed to safeguard space systems from attack. Security encompasses both physical (e.g., keeping user equipment in secure areas) and virtual (e.g., encryption) measures.

Surprise

The purpose of surprise is to strike the enemy at a time or place or in a manner for which it is unprepared.[9] This principle of war has the same meaning for space operations. Surprise is closely linked to security since security measures are often needed to achieve surprise. Examples of surprise include: having a capability onboard the spacecraft the adversary is unaware of, and, undertaking operations the adversary has never seen before.

Simplicity

The purpose of simplicity is to prepare clear, uncomplicated plans and concise orders to ensure thorough understanding.[10] This principle of war has the same meaning for space operations. The sophistication of space systems is no excuse for complex user equipment or operational plans. Every effort should be made to ensure space operations are clearly understandable to everyone participating in the theater of operations. Space planners must remember that no space system, no matter how sophisticated, becomes irrelevant if the war fighters cannot use or employ them effectively. Simplicity should be considered for all space segments but especially for the user segment.

Notes

[1]Joint Publication 3-0, *Doctrine for Joint Operations*, 1 February 1995, p. A-1.
[2]Ibid.
[3]Ibid.
[4]Ibid.
[5]Ibid., p. A-2.
[6]Ibid.
[7]National Space Policy Factsheet, 19 September 1996, p. 8.
[8]Joint Publication 3-0, p. A-2.
[9]Ibid.
[10]Ibid.

Appendix C

Tenets of Power Comparisons

The space environment is often considered to be analogous to the ocean environment. However, the tenets of space power seem to have more in common with land warfare than with sea or air. This is not surprising since the space tenets are for earth orbit with space in a role of predominantly supporting terrestrial forces. If one were to develop the tenets of space power for outer space using the methodology described in this paper, it should start to more closely resemble sea and/or air power.

Table 10. Tenets of Power

Tenets	Land[1]	Sea[2]	Air[3]	Space
Initiative	✓			✓
Agility	✓			✓
Depth	✓			
Synergy (Synchronization)	✓		✓	✓
Versatility (Flexibility)	✓	✓	✓	
Centralized Command/ Decentralized Execution			✓	
Priority			✓	
Balance			✓	
Concentration			✓	
Persistence			✓	
Sustain Operations		✓		✓
Readiness		✓		
Mobility		✓		

[1]Field Manual 100-5, *Operations*, June 1993, pp. 2-6 through 2-9.
[2]Naval Doctrine Publication 1, *Naval Warfare*, 28 March 1994, pp. 7-12.
[3]AFM 1-1, Vol. I, *Basic Aerospace Doctrine of the USAF*, March 1992, p. 8.

Appendix D

Operational Art Elements

Each operational art element is described using a three-step process. First, a brief definition is given. Second, one or more examples are given which the reader will hopefully be familiar with. Finally, a brief discussion is provided to address issues related to the operational art element.

Encryption

Encryption is to convert plain text into unintelligible forms by means of a crypto system.[1] Encryption protects the content of the information and may protect the fact that information was exchanged. Encryption can be readily applied to communication links by using cryptographic equipment supplied by an intelligence agency. Other forms of encryption include onboard processing of signals so that no correlation can be made between uplink and downlink signals on spacecraft.

Encryption is necessary to protect the content of space signals from unauthorized users and to protect space systems from hackers. Many people are interested in exploiting space systems to gain the same operational advantages the U.S. enjoys. Pirating and hacking are relatively simple ways to gain access to information from unprotected space systems. Policy makers perceived the threat to U.S. space forces if everyone had access to command them and decided to encrypt spacecraft command and control systems.[2] This was incorporated into U.S. space doctrine when AFM 1-6 stated: “our military capability must include provisions to deny unauthorized use of our systems.”[3] This idea has since been lost from U.S. space doctrine. Data encryption isn’t as ubiquitous, with much of the weather and navigation data sent “in the clear” to users worldwide. However, all uniquely-military systems employ encryption techniques.

Observation Management

Observation management is to reveal selected aspects of space operations to potential adversaries and to not reveal important warfighting capabilities. Observation management is comprised of many parts. It has an element of denial and deception to mislead potential adversaries about the true nature of U.S. space forces. It includes use of low probability of intercept (LPI) signals so that adversaries will not detect the signals transmitted to, or emanating from, spacecraft. As Colin Gray observed, it includes ”stealthy design, choice of orbits and of phasing in orbits, (and) look-alike decoys.”[4] Finally, space debris can also be included as a part of observation management.

The observability characteristic of space facilitates and necessitates use of an observation management strategy. An adversary can observe U.S. space forces at virtually any time. This allows for inadvertent disclosures to be staged to look like real operational problems or security leaks. If the potential adversary accepts the credibility of the information, then it may cause him to overlook real vulnerabilities or to target his countermeasures to areas of no concern to the U.S.

Debris offers an excellent opportunity to conduct deception operations in space. While national policy and international agreements call for the minimization of space debris,[5] it is important to understand the military advantage debris can offer. The progress made to keep debris in large pieces that are easily tracked rather than creating many small pieces makes a debris strategy more attractive. The threat of hosting military packages on debris should create uncertainty and confusion in the mind of the adversary which should cause him to generally overestimate U.S. capabilities. Such a threat may deter space attacks or cause adversaries to target the wrong objects.

Debris strategies can also be used against the U.S. by some space competitors and space operators need to be aware of this threat. Maintaining a robust space surveillance network is crucial to minimizing damage from malicious or unintentional debris and employing an offensive debris strategy.

Maneuver

Maneuver is the ability to reposition terrestrial elements and change the orbit of spacecraft. Ground user and control segments maneuvers are generally defensive in nature and designed to minimize their vulnerability to attack. In contrast, spacecraft maneuvers can be offensive or defensive, and tactical or strategic in nature.

Maneuver was deleted as a principle of war for space forces and did not appear as a tenet of power because space forces do not require maneuver to be effective. In fact, maneuver can often be a hindrance to meeting mission objectives. Listing maneuver as an operational art element allows for a more discriminating look at where maneuver can best be applied.

Defensive Maneuvers

Defensive maneuvers protect space forces by making them more difficult to attack and complicating targeting.[6] They are tactical in nature, only work against a portion of space threats, and apply to a subset of spacecraft (e.g., low-altitude systems). Some spacecraft should not maneuver (e.g., communications) since there may not be much chance of success and it could cause a loss of service. Defensive maneuvers are intended to protect the spacecraft from physical damage from threats such as kinetic-kill vehicles or lasers. They generally work against the attacking platform's targeting system to defeat the attack.

Offensive Maneuvers

Offensive maneuvers are intended to force the adversary to react rather than act. They can be tactical or strategic. Offensive maneuvers are limited to spacecraft that interact with an adversary's forces, such as, imagery systems. Tactical offensive maneuvers can be used for rendezvous operations, changing orbital parameters, or deploying sub-packages. They can be used to target the adversary's spacecraft or to de-orbit objects into the battle area. Strategic offensive maneuvers can be used for many of the purposes listed above but over a longer time. These maneuvers are useful to change arrival time of the spacecraft over the battle area or cause it to appear in an unexpected location. They can compromise denial and deception activities by forcing the adversary to react at a time for which he is unprepared. An orchestrated plan of secondary maneuvers, made by other spacecraft, can be used to further confuse an adversary who has the technical means to observe them.

Autonomy

Autonomy is agility under computer control. Examples of autonomy include "safe modes" where the satellite attempts to preserve mission functions after an attack or losing contact with the control segment. Switching to back-up frequencies to re-establish contact is another form of autonomy.

Autonomy is needed because spacecraft can come under attack before a human in the loop can react. It is important for spacecraft to be able to conduct basic defensive operations without receiving instructions from the ground. Entering safe mode or using backup frequencies to re-establish contact are examples of useful autonomous operations.

Training

Training is to "make proficient with specialized instruction and practice."[7] Examples include participating in exercises, conducting simulations, and planning. Each of these activities is designed to hone the skills of the space operator so that he will be able to respond effectively to space threats.

The need for training is tied to operational effectiveness. Military forces only fight as well as they train. For space operators to be able to plan and execute defensive and offensive operations, they must be trained to do so. Training should include responses to every type of threat from jamming of user equipment and control segments to attacks on spacecraft. There are many opportunities for space operators to participate in war games. A very simple one would be to treat each spacecraft malfunction as the result of a hostile attack so the crews can gain experience needed for wartime. Joint and multi-command exercises could include satellite jamming to better simulate wartime conditions. Such a training program should increase threat awareness and operational readiness.

Attack Detection

Attack detection is the ability to detect that an attack occurred and determine when, where, and how it happened. Examples include light sensors to detect laser attack, low power radars to detect space mines, and RF sensors to detect spoofing and jamming.

Attack detection is the first step in obtaining agility since most defensive capabilities require some sort of queuing for them to be employed effectively. The need for attack detection is not solely based on a capability to defend the spacecraft. Ashton Carter observed that "the ability to detect attack can be a deterrent even if the attack cannot be prevented."[8] Also, an attack warning system would provide conclusive information about who conducted the attack which may be diplomatically useful in imposing sanctions against the perpetrator. Finally, correlating attacks to spacecraft anomalies can enable threat systems to be better characterized and the development of new defensive capabilities.

Space Surveillance

Space surveillance includes the detection, tracking, monitoring, and investigation of spacecraft, space debris, and launch vehicles. Examples include radar and optical sensors to track spacecraft orbits. Some optical sensors can also be used to take pictures of space objects to better discern their capabilities. Space surveillance also includes passive measures such the ability to listen to foreign spacecraft.

While space surveillance has status as a mission, it also is prominent as an operational art. Space surveillance is crucial to having an effective space force and its importance is hard to overstate. Space surveillance allows the U.S. to "detect, to interpret, and to react quickly to threatening events."[9] Another function of space surveillance is to provide indications and warning of pending space attacks and extend the amount of time available to react.[10] Space surveillance is the principal means for the commander to maintain his situational awareness of space and interact in the space environment.

Improved space surveillance capabilities can pay for itself by lowering the need for other defensive measures. To realize this savings, space operators need to be integrated into a battle management plan and be able to react instantly to threats detected by the space surveillance system, as well as, have realistic responses pre-planned. Space surveillance should also include an ability to "examine and characterize foreign spacecraft" to determine the space capabilities of other nations. In particular, it should look for hidden offensive capabilities onboard foreign spacecraft.[11]

Standard Interfaces

Standard interfaces deals with making space-derived information portable between different platforms. It does not include the interconnection between space segments or the standardization of internal connections. An example of a standard interface is the use of commercial standards and formats so that space derived information can be used in its original form by multiple users. It is more than a common data format. Anyone who has tried transporting software between Macintosh and IBM computers realizes the information interface is vitally important.

Employing standard interfaces facilitates synergy. It is needed to ensure "rapid dissemination of mission data to supported operational forces."[12] Many weapon systems use awkward or one-of-a-kind data formats and space systems are no exception. This has been a chronic problem for the military space program and has been tolerated for reasons such as security classification and a small pool of specialized users. The commercialization of space is bringing some standardization but profit incentives still motivate companies to use non-standard formats and interfaces. It is important to adopt standard formats and interfaces so more military users can benefit from space-derived products. It will allow space forces to be more quickly integrated into the warfighter's battle management, command, control, and communication (BMC3) system. Integrating space forces more deeply into joint warfighting will also facilitate data sharing and data fusion and expand space support into new war-fighting arenas such as military operations other than war.

Interoperability

Interoperability is the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.[13] Interoperability is closely related to standard interfaces but it is more about mixing space segments rather than products. The space-to-ground link system (SGLS) made all military spacecraft interoperable with the Air Force Satellite Control Network (AFSCN). This increased the control segment's effectiveness and flexibility since interoperability allows the system to quickly accommodate the loss of a commanding site or command a spacecraft on a priority basis. Although this capability has been adopted for a long time as a matter of policy,[14] it is a doctrinally sound approach to military space operations. Similar interoperability initiatives are needed for user segment (e.g., modular equipment) and space segment (e.g., standard spacecraft designs).

Exploit Others

Exploiting others is the ability to effectively combine civil, commercial, and coalition space systems into an overall space force. Desert Storm provides a familiar example of exploiting others when commercial GPS receivers were sent to soldiers in the Gulf. The Air Force was similarly able to use French SPOT satellites to get imagery of Iraq.

Exploiting commercial and coalition space systems has become accepted and enshrined in policy. The concept of using these "gray space" assets in time of war, much like the civil reserve air fleet (CRAF), is becoming more accepted. Such a "commercial reserve space fleet" offers significant cost savings over operating a dedicated military system. Commercial communication and earth resources systems in particular may offer needed capabilities which U.S. forces may need during war.[15]

The operational art of exploiting others deals with three issues. First, adequate command relationships must be in place to ensure unity of command and integrate the assets into the overall space plan. Second, it can put an adversary at a bigger disadvantage by depriving him the use of the systems, presenting him with a larger space threat, and threaten an escalation of hostilities should he attack non-U.S. spacecraft. Third, a strategy of leasing commercial space assets during war may effectively negate an adversary's ability to use space. If an adversary relies on commercially available space systems to communicate and conduct reconnaissance, then these systems may be denied to him if the U.S. leases the assets from their owner.

Data Fusion

Data fusion is the ability to combine information from several different source to create an overall picture of the battlefield. It is also a useful way to disseminate information so that the original source is not revealed. Constant Source is a good example of data fusion.

Data fusion jumps out as an operational art because it provides a mechanism to gracefully degrade space products as individual systems are degraded or become unavailable. Space systems are often used to corroborate events detected by terrestrial sensors and often more than one spacecraft will observe an event of interest. By providing fused products, it is possible to maintain the security of space operations and make it transparent to the end user when some space assets are lost. Data fusion will also be particularly important in creating the all-sensor view of the battlefield the joint force commander needs to maintain his situational awareness. It is important to note that the employment of other operational art elements such as standard interfaces are needed to facilitate data fusion.

Launch on Demand

Launch on Demand is the ability to rapidly deploy spacecraft. Examples include transatmospheric systems such as a spaceplane and rocket systems such as ICBMs.

Launch on demand is *the* most important sustainment concept. AFM 1-6 stated that "the Air Force must continue to prepare for quick reaction launch and short-time regeneration and turnaround for space launches from more survivable facilities."[16] Contracting for commercial space services may work for some missions but there will be an enduring need for a dedicated, responsive military launch capability. Spacecraft replenishment is a high priority national security concern during peacetime and is even more critical during war. During war, U.S. space systems are likely to be overtasked or even attacked. It is important to be able to expand or replenish the space order of battle in very little time. This has clear implications for launch systems as well as for space and user segments. User equipment must to be able to meet increased user demand and reserve spacecraft need to be ready for call-up. Also, the initial on-orbit checkout period needs to be reduced to hours rather than months. (On-orbit checkout is the time it takes to confirm the spacecraft is functioning properly and then turn it over for operational use.)

There are compelling operational advantages from a launch on demand capability. First, it enhances the security and survivability of space forces by garrisoning them on the ground rather than in space.[17] Second, an adversary could not be certain what space forces would be employed against him and could not effectively plan countermeasures. Third, spacecraft with politically sensitive missions could maintain operational readiness while still on the ground. It almost creates a virtual space force rather than focusing on a "force in being."

The risky nature of space launch makes launch on demand seem like an impossible task, however, if it was possible to keep a thousand intercontinental ballistic missiles (ICBMs) on alert and ready for launch for twenty years, then a less ambitious launch on demand system is possible, too. A launch-on-demand system would require verification launches for training and exercises and to build confidence in its reliability.

Reserve Modes

Reserve modes are space system capabilities which are not used during routine operations. They are specialized design features to mitigate the effects of malfunctions or attacks. Examples of reserve modes include alternate power settings to overcome jamming and back-ups to reroute signals past malfunctioning components.

Reserve modes have been employed on spacecraft since the beginning of the space program. An original use of reserve modes was to have an alternate commanding frequency for spacecraft should the primary system fail. Reserve modes enhance the likelihood of mission success by reducing the number of things that can cause a failure. Reserve modes can also be used to ensure all segments degrade gracefully if attacked and are able to prolong operations as long as possible.[18]

The use of reserve modes must be integrated with other operational strategies. First, the use of reserve modes should be balanced against other sustainment strategies. Reserve modes may be able to completely frustrate certain types of attack and eliminate the need for other backup systems. There are limits to reserve modes and it is unlikely to develop a reserve capability to mitigate a kinetic energy attack. If a launch-on-demand system is fielded, then it may be better to forego reserve modes and simply replace failed spacecraft. Second, there is an inherent risk of compromising reserve modes when exercising them. Although many potential adversaries lack the sophistication to detect them, it would be foolish to needlessly expose reserve modes. Exercises should include hypothetical spacecraft attacks and it may be possible to occasionally test reserve modes unnoticed. Finally, reserve modes made be used in concert with an observation management strategy to create uncertainty. They may be able to make the adversary hesitant about attacking U.S. space forces and divert his attention from real vulnerabilities.

Robustness

Robustness is the ability to withstand attack and continue functioning. Robustness also calls for space forces to raise the difficulty of attack even if there is no hope of defending against it. Robustness can be both physical and virtual. An example of physical robustness is to harden a space segment against laser or nuclear attack. An example of virtual robustness is to employ a signal that is difficult to jam like the Milstar waveform.

Every spacecraft needs to be able to survive both the rigors of space and harmful interference. Survivability measures "may play a more decisive role in deterring attacks on our satellites than would the availability of an ASAT to retaliate against the other side's first use."[19] There are degrees of robustness and at some point it becomes more cost effective to throw away spacecraft rather than make them bulletproof. However, one should not be too vulnerable to attack or one may invite it.

Notes

[1]Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 23 March 1994.

[2]The advocacy for encryption is still evident in policy today since it still calls for the protection of critical "mission aspects." National Space Policy Factsheet, The White House, September 19, 1986, p. 5.

[3]AFM 1-6, *Military Space Operations*, 15 October 1982, p. 6.

[4]Gray, Colin S., "Space Warfare Part II: Principles, Weapons and Tactics," *National Defense*, February 1988, p. 42.

[5]Ibid., p. 12.

[6]Nye, Joseph S. and James Schear, editors, *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime*, (Lanham, MD, University Press of America), 1987, p. 13.

[7]The American Heritage Dictionary, 1976.

[8]Carter, Ashton B., "The Current and Future Military Uses of Space." In *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime*, (Lanham, MD, University Press of America), edited by Nye, Joseph S., and James A. Schear, 1987, p. 64.

[9]Nye and Schear, p. 26.

[10]Carter, p. 65.

[11]Ibid., p. 66.

[12]Herres, General Robert T., "Space-Based Support," *Defense 88*, November/ December 1988, p. 11.

[13]Joint Publication 1-02.

[14]The national space policy still calls for "interoperability of satellite control for all governmental space activities." National Space Policy Factsheet, The White House, September 19, 1986, p. 5.

[15]Moore, George M., Vic Budura, and Joan Johnson-Freese, "Joint Space Doctrine: Catapulting into the Future," *Joint Force Quarterly*, Summer 1994, p. 76.

[16]AFM 1-6, p. 9.

[17]Caton, Major Jeffery L., *Rapid Space Force Reconstitution*, *Mandate for United States Security*, (Maxwell AFB, AL, Air University Press), December 1994, p. 14.

[18]Berkowitz, Marc J., "Future U.S. Security Hinges on Dominant Role in Space," *Signal*, May 1992, p. 73.

[19]Nye and Schear, p. 14.

Glossary

ACSC	Air Command and Staff College
AFB	Air Force Base
AFDD	Air Force Doctrine Document
AFM	Air Force Manual
AFSCN	Air Force Satellite Control Network
ASAT	Anti-Satellite
BMC3	Battle Management, Command, Control, and Communications
CRAF	Civil Reserve Air Fleet
CRSF	Civil Reserve Space Fleet
CSAF	Chief of Staff of the Air Force
DOD	Department of Defense
DSAT	Defensive Anti-Satellite
DUSD	Deputy Under Secretary of Defense
EELV	Evolved, Expandable Launch Vehicle
GPS	Global Positioning System
ICBM	Intercontinental Ballistic Missile
JTTP	Joint Tactic and Techniques
LPI	Low Probability of Intercept
MOOTW	Military Operations Other Than War
OPSEC	Operational Security
RF	Radio Frequency
SGLS	Space-Ground Link System
USAF	United States Air Force
USAFA	United States Air Force Academy

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Air Command and Staff College
Maxwell AFB, Al 36112