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SPACEPOWER AS A COERCIVE FORCE

by

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Abstract

Much has been written about the possibilities and characteristics of spacepower. However, one issue that continues to inhibit the development of space forces is the lack of a holistic spacepower theory. The concept of spacepower needs to be expanded beyond that of an information service. Failure to do so will leave space forces adrift as simply a force enhancement capability, marginalized in national security planning, and impede the access to resources needed for force development.

The purpose of this paper is to propose a spacepower theory and explore the implications of such a theory on future space operations and force structure. Air concepts are considered for what insights they provide to the logic process and operational concepts. This paper emulates the logical process for the development of air concepts while avoiding many contentious issues regarding the relationship between air and space forces. Issues such as a separate space service, air and space integration, and the concept of aerospace forces are not addressed.

Introduction: The Spacepower Problem

The US has operated space systems for the past 45 years. Both the civil and military space programs have been hugely successful and the American public has embraced space-based services and support into many aspects of their everyday lives. Space systems contribute many billions of dollars annually to the national and global economies.[1] One could conclude from the size and pervasiveness of the US space program that we must have a well-developed concept of spacepower. A closer examination of the nature and substance of the US military space program actually reveals enormous shortcomings in the US's ability to understand, develop and exercise spacepower. The major problem with spacepower theory today is that it is based on a view that space systems provide information power and excludes directly coercive acts. While it is possible that information power can be coercive, spacepower as a subset of information power has proven not to be coercive. Continued emphasis on the information power of space systems will prevent spacepower from being decisive in the future. A holistic spacepower theory which embraces coercive action from space is needed to guide the development of future space systems.

An issue facing defense planners today is how to transform space forces and the incorporate spacepower into new operational concepts such as the Global Strike Task Force (GSTF). While this may seem to be a trivial task at first glance, it has actually proven to be fairly difficult. The difficulty arises from two areas. The first area is a certain amount of cultural inertia within the space community where many people view the medium to be a sanctuary and not a realm of warfare and conflict.[2] The second area, and the one discussed in this paper is that the space community has grown up as an information domain and is not intellectually prepared to embrace spacepower as a directly coercive force. This paper attempts to diagnose the current status of spacepower and to prescribe how space forces should be developed to maximize their usefulness as coercive instruments of national power.

A holistic spacepower theory is needed to tie space forces to an overarching operational concept and to understand their strategic and operational effects. Relying strictly on an information-based spacepower theory causes the development of space forces to be guided solely by budgetary pressures and the optimization of technical performance. A space force built around a holistic spacepower theory and doctrine should provide greater military effectiveness and posture the Air Force for future military space missions.

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[1]See article by Lt Gen Bruce Carlson, *Defending Space-Based Global Utilities* available on-line at: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj00/sum00/carlson.htm

[2] See discussion by Lt Col David E. Lupton in: *On Space Warfare, A Space Power Doctrine*, Lt Col Peter L. Hays in: *United States Military Space, Into the Twenty-First Century*, pp. 117-121 and Lt Col Larry J. Schaefer, *Sustained Space Superiority, A National Strategy for the United States*, pp. 5-9.

Spacepower as a Subset of Information Power

Space systems are used throughout the world every day to support a wide range of human activities. The United States (US) has established itself as the world leader in equipping its combatants with the latest in space technology and systems with dramatic improvements in war fighting effectiveness. The US has integrated space systems into theater operations with the various responsibilities mixed between combatant command staffs and warfighting component commanders such as the Joint Force Air and Space Component Commander (JFACC). To date, these various elements of spacepower have been information systems. The acceptance of spacepower as information power can be readily seen in doctrine, policy, spacepower theory and the current space force structure.

Spacepower in Doctrine

Doctrine is a good starting point to start a character profile of spacepower theory. Joint Publication (JP) 3-14, *Joint Doctrine for Space Operations*, defines spacepower as "the total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives."[1] This definition is very expansive, much like the definition of air power as conceived by Brigadier General Billy Mitchell where he defined air power as "the ability to do something in or through the air."[2] Both definitions are in the macro-context of understanding power to capture the composite influence of military, civil, and commercial enterprises. However, the definitions of power used by the military Services in their doctrine have generally emphasized the coercive effects of power. Table 4 provides the definitions of power in each medium today.

Medium	Power Definition
Air	USAF: Air and space power can control the depth, breadth, and height of the battlespace to allow joint forces to gain decisive advantage.[3]
Land	USA: Land operations seize the enemy's territory and resources, destroy his armed forces, and eliminate his means of controlling his population. Only land forces can exercise direct, continuing, discriminate, and comprehensive control over land, people, and resources.[4]
Sea	USN: Sea power in the broad sense . . . includes not only the military strength afloat that rules the sea or any part of it by force of arms, but also the peaceful commerce and shipping from which alone a military fleet naturally and healthfully springs, and on which it securely rests.[5]
Space	Joint: The total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives."[6] USAF: Space forces bring enhanced global presence, perspective, precision, and flexibility to the Air Force and military operations.[7]

Table 1. Definitions of Power

It is interesting to note that spacepower is defined in terms of capabilities that enhance the coerciveness of the other military forces. While the definition of spacepower may be satisfactory from an overarching sense, it is lacking in capturing what coercive military effects can be achieved by the exercise of spacepower. It is also interesting to note the JP 3-14 definition is centered on the concept of the nation-state as the central organizing feature of spacepower. That leaves one to question where purely commercial or non-national space activities contribute to spacepower as an influence on human activity. Thus the JP 3-14 definition must be seen as lacking in neither capturing the truly macroscopic influence of spacepower nor the unique coercive effects of military spacepower. Both the joint and Air Force definitions are consistent with the conceptualization of spacepower as information power rather than as a direct coercive force.

Spacepower in Policy

Policy is the second place to look for an understanding of spacepower. In the cover letter to Department of Defense Directive (DODD) 3100.10, *Department of Defense Space Policy*, the Secretary of Defense writes:

> "Strategic Enabler. Spacepower is as important to the nation as land, sea, and air power. It is a strategic enabler of the National Military Strategy and Joint Vision 2010. Space forces support the execution of strategy and the realization of doctrine by enabling information superiority through domination of the collection, generation, and dissemination of information."[8]

DODD 3100.10 clearly views spacepower as an element of informational power. Informational power is one of the four established dimensions of national power (i.e. DIME – diplomatic, informational, military, and economic). Aligning space under the informational element of national power is warranted since most space systems fielded to date are information systems. However, this definition is lacking in coming to terms with what spacepower can be as a coercive force versus what it has been. The United States is developing space-based missile defense capabilities which would be a military capability that is not captured by this definition. Also, this definition ignores the potential for space-to-earth weapons and the resulting diplomatic, military and economic effects.

The pervasive emphasis on space systems as information systems is an enormous barrier to the development of a spacepower theory. Virtually all space systems developed by DOD have been to collect or disseminate information. These include communications, weather observation, reconnaissance, navigation, intelligence and early warning. Under President Reagan, an attempt was made to develop space-based interceptors as part of a missile defense architecture. Development of these systems continues but there is no useful experience from which to develop space policy or doctrinal concepts. An area strikingly absent is the lack of space-based space control or force application systems. Many people think the US has the most to lose from militarizing space since it has the greatest number of space assets. This has proven to be a powerful argument in causing policy makers to proceed with extreme caution when considering space weapons. Space-based force application weapons have been discussed for years but none have been developed or fielded to date. With an almost exclusive information role, space forces have been deprived the operational experience needed to develop a holistic spacepower theory. Not surprisingly this has been codified into both policy and doctrine which as seen in DODD 3100.10 and JP 3-14 where no uniquely military coercive effects are attributed to space forces. Both documents cast space forces as simply an extension of terrestrial warfare in an information support role.

US Spacepower Theory

The third place to look for an understanding of spacepower would be spacepower theory. One quickly finds there is no comprehensive theory to prescribe why space systems matter or what effects they should be expected to exert on national or military objectives. General Howell Estes, the former Commander of United States Space Command (USSPACECOM), was so concerned about the lack of a spacepower theory that he chartered a study team to develop such a theory. The team met for almost two years and included over 130 participants who had in-depth experience with space systems. The collective resources of Air University, USSPACECOM, and Air Force Space Command were made available to support this undertaking. General Estes had the results of this study team captured in the book titled *Space Power Theory*. In the forward to the book, General Estes writes:

> "Even though the United States had been involved in space for 50 years, space theory and, therefore, policy and doctrine remain underdeveloped and somewhat disjointed. I believe the lack of theory and policy is having a negative effect on the maturing of

> spacepower and the perception of its importance by people in the world's spacefaring nations."[9]

Even with so much effort exerted to develop a spacepower theory, *Space Power Theory* does not propose a power theory. Gen Estes only claims that it "does a credible job of starting the debate about spacepower theory."[10]

The inability to cogently state a holistic spacepower is also recognized in more contemporary articles on the subject such as the article by Colin Gray and John Sheldon in the Fall of 1999.[11] This failure could be based on the conceptualization of spacepower around the idea that space forces are simply the information systems described in doctrine and policy.

Measuring the Coercive Power of Space Forces

There is a lot of writing on the subjects of Information Operations (IO), Information Warfare (IW) and Information in Warfare (IIW). Much of the theory and doctrine found in these sources apply to space forces. While IO appears to hold much promise as a coercive force, this paper only attempts to qualify the coercive nature of space forces as a subset of the overall IO construct. The conclusions drawn from this analysis will therefore tend to mitigate the effectiveness of IO since the preponderance of IO forces are not space-based. However, it should be a wake-up call to the space forces since it reveals they have to expand beyond this niche to increase their relevance to the warfighters.

The Influence of Space on Human Activities

In the beginning of the space race, military projects competed with civil projects to see who would be the first into space. The Air Force was particularly aggressive in pursuing space forces with direct combat and combat support capabilities. This created an impression among the military leadership that space forces would become a new combatant arm and put the Air Force on a path to doctrinally consider space as an extension of air operations.[12]

As the space race matured, the Air Force planned to militarize space. Under the leadership of General Bernard Schriever, the Air Force started developing several combat-related space programs which were based on the same conceptual framework as airpower where space platforms were needed to carry payloads and dispense munitions. Unfortunately, most of these programs, such as the Dyna-soar hypersonic space vehicle and the military-man-in-space program were cancelled.[13] Other programs such as Intercontinental Ballistic Missiles (ICBM) were aligned as nuclear programs under Strategic Air Command (SAC) and not as elements of a space force. The space forces lost the platforms and payloads construct and started to view space forces as highly integrated systems built around the notion of a constellation. Also, space forces became increasingly vital for intelligence activities, indications and warning of attack and gradually became elements of arms control, transparency and other confidence building measures of the cold war. While there was still military rhetoric about space warfare capabilities, space systems were more closely aligned with peaceful activities and were viewed as information systems. This view became dominant and was enshrined in policy in part to enhance US treaty commitments for non-interference with National Technical Means (NTMs).

Since the Department of Defense (DOD) had originated many of the technologies needed to build space forces and space flight was extremely risky, it was only natural for DOD to develop its space forces as wholly-owned subsidiaries of its information architecture. Many of the space systems provided services which would normally be contracted from private industry but since the industries didn't originally exist, the DOD developed and operated them internally. As the space industrial base has matured, the DOD has been able to find contractual sources for space-based information services such as fixed communications, mobile communications and reconnaissance, which are comparable to their organic systems. There has also been a move within the US Government (USG) to move responsibility for some military space systems to other civil agencies such as the Department of Commerce becoming the lead agent for space-based weather systems and the Department of Transportation exerting more influence over space-based navigation services. Added to this, direct-to-home satellite television and radio emerged as a financially viable space-based services. Satellite operators were motivated to field systems which provided continuous and global services which reinforced the primacy of satellite constellations in force planning. They also reinforced the notion that space systems are simply information systems. Table 2 provides a snapshot of the influence of spacepower on human activities to date.

Space Service	Market Position	Effect
Fixed Communications	Established global utility, but fiber now dominant[14]	Global exchange of data and ideas
Mobile Communications	Competes with land cellular; Niche military capability; Becoming global utility	Global, real-time coordination
Direct-to-user Television and Radio	Competes with land cable; Becoming global utility	Regional exchange of ideas
Navigation and Timing	Established global utility; Still dominant	Global synchronization; Knowledge of location
Weather Sensing	Established global utility; Still dominant	Global transportation safety; Improved planning
Mapping and Reconnaissance	Competes with airborne recce; Becoming global utility	Global transparency
Early Warning	Niche military capability	Global transparency
Amateur Radio	Niche civil capability	Global exchange of ideas
Scientific Exploration	Niche civil capability	Scientific understanding

Table 2. Influence of Spacepower

This review reveals the tendency of spacepower to be viewed as information power which has been amplified by the development of space-based global utilities. These global utilities provide three major information effects:

- Global and regional exchange of ideas
- Global coordination and synchronization
- Global transparency

One way to further assess the influence of spacepower is to correlate the main areas of space influence with the four elements of national power. Any such analysis is subjective by nature and is probably best left as qualitative instead of quantitative.

Most diplomacy takes place through diplomatic channels with diplomats and embassies. Most of the important diplomatic information is exchanged directly between people since it is often best delivered in a nuanced manner. However, space systems have made "decisive" contributions to diplomacy by allowing transparency and support to arms control.

Within the information realm, it is more difficult to formulate an assessment. Since space is but one of many information sources, it has to be taken within a context of how much market share it represents or if it is a unique and "decisive" source of information. While space systems used to dominate the field of telecommunications, it is now only a few percent of overall telecommunications.[15] Space systems do seem to have found a lasting niche in global coordination with GPS, direct broadcast systems and support to mobile users. While space systems provide many unique transparency measures, they compete with many other information sources and do not provide the majority of the information content.

Military applications for space systems prominently feature global coordination for which space is a key enabler. The military also relies on space systems to gain much needed intelligence although airborne systems provide more situational awareness than do space systems. For the military, the exchange of ideas rates low since most military systems are isolated from outside users.

The economic assessment basically mirrors the assessment for informational power since the economic activity of space systems was included in that assessment. This analysis is shown in Figure 1.

Space Capability \ Instrument of Power	Diplomatic	Informational	Military	Economic
Exchange of Ideas	L	M	L	M
Global Coordination	L	H	H	H
Transparency	H	M	M	M

Legend:
Degree of Influence

H	High
M	Medium
L	Low

Figure 1. Space Influence on National Power

One can conclude from this comparison that the emphasis on space as an informational power in policy and doctrine is clearly justified – but this is just a self-fulfilling prophecy. The next question to ask is: What coercive power can be exerted from space's informational power?

Coercive Capabilities of Space-Based Information Systems

The analysis provided here qualitative. It is intended to capture the influence the US can have on other nations using space forces as information systems. These insights are intended to illustrate the weaknesses inherent in a space force that is limited to an information role.

Positive Acts

Positive acts seek to entice a country to cooperate with the United States based on what they will gain from the transaction. Space products and services are offered to friendly countries with reciprocal agreements to support US interests. Examples include:

- Support of international telecommunications accords such as the International Maritime Satellite (INMARSAT) system and the World Administrative Radio Conference (WARC) support both diplomatic and economic interests.
- US technical and diplomatic goals are often met by teaming with international partners for solar research, environmental monitoring and even the International Space Station (ISS).
- Worldwide sharing of space-derived weather data benefits American citizens wherever they are in the world by making air transportation safer.
- Economic activity is often regulated by the Department of Commerce in the granting of export licenses for space products and technologies in business deals that profit both sides.
- US satellite manufacturers are an important source of space-based telecommunications and imaging technology even for countries with robust indigenous satellite industries.
- Other economic measures include the purchase of "landing rights" to use satellite systems in a particular country.
- Militarily, the US has often shared sensitive space-derived intelligence products to members of alliances and coalitions to enhance the attainment of military objectives.
- Treaty verification by the use of space-based national technical means have supported US interests in international forums and a demonstrable sign of US support for allies.

The main supportive act the space forces can offer a potential ally is access to information. This could be an ability to "plug into" the global utilities for weather, timing, navigation, imagery, entertainment and educational services. It could also be an ability to gain access to limited information sources or value-added information products such as indications and warning of attack, assistance with disaster recovery, urban planning, agricultural planning, and exploiting natural resources. Gaining access to space services could be a big enough carrot to ensure potential allies join our team.

Negative Acts

Negative acts seek to deter or punish behaviors that undermine US national interests. Should the positive acts prove to be too weak, then one should consider what negative actions a space faring nation can exert. The most obvious one to consider is the imposition of embargoes on space-derived information which is really the denial of the supportive acts. Since so much information is either collected or transmitted through space, then a significant information deficit could be created by denying access to space-based global utilities. This could significantly degrade military or economic activities that rely on these information sources.

A second class of negative acts would be the dissemination of space-derived products in such a way as to counter a potential adversary's interests. This could be by sharing imagery with known enemies, countering propaganda by showing the facts on the ground, or leaking intelligence gained on adversary plans and operations. These actions currently would be considered information warfare more than space warfare since the means to implement them would not necessarily involve hostile action in space.

Is Spacepower Decisive?

The positive and negative information actions that spacepower provides seem to offer impressive measures for coercive acts such as Flexible Deterrent Options (FDO). In order to assess whether these can be decisive one needs to compare it to other forms of information power which are readily available. One quickly realizes that air, land, and sea forces provide many times the information value than space forces. Although space forces provide some vital and unique sources of information, they pale in comparison to terrestrial forces. Terrestrial forces provide a nearly comprehensive ability to gather information on adversary operations and to protect friendly use of information. Air surveillance radars are based on land, sea and air to provide a comprehensive air picture for the commander. Airborne sensors can detect and track ground objects and provide imagery. Electronic collectors provide vital sources of intelligence, indications and warning and geolocation of adversary forces. A recent trend is for terrestrial information systems to become weaponized as has been seen with the Predator Unmanned Aerial Vehicle (UAV)[16] and the Rivet Joint Signals Intelligence (SIGINT) platform.[17]

Spacepower as information power packs a much weaker punch when compared to other military air, land, and sea informational capabilities. One could argue the main decisiveness of space forces is the asymmetric vulnerability they offer an adversary if they were to be attacked. Yet, even this may not yield a decisive blow to US forces or cause them to lose on the battlefield.

Can Other Missions Make Spacepower Decisive?

Just because spacepower has been largely used as information power does not mean that is the only use for space systems. There are two potential developments which could cause spacepower to be decisive in the future. Looking to the other elements of national power, it appears there are opportunities for spacepower to be decisive for economic and military power.

Economic Applications

One potential development is for space systems to provide a significant portion of future energy supplies. It is possible to field large solar farms in space as an alternative to fossil fuels or nuclear energy. Although space lacks any natural resource, it has rich "deposits" of solar energy. There are credible proposals to harvest sun light from space and beam it down to earth as an energy source.[18] Should this occur on a wide enough scale, then spacepower could become more important since it would be needed to assure access to energy. Since the development of a space-based energy source would have to be undertaken by a space-faring nation and many alternative energy sources would continue to exist, it is unlikely for this development to make spacepower decisive for a very long time.

Military Applications

Military applications are an area where spacepower could become a decisive force. Although spacepower has been focused on developing information power since the cancellation of the dyna-soar and manned orbiting laboratory, this may not continue to be the case in the future. The development of military spaceplanes and kinetic weapons operating in and through space is both feasible and affordable by the US.[19] Space-to-earth impacting munitions could readily and easily destroy key infrastructure in adversary countries and make it nearly impossible to conduct normal operations. These weapons would also enjoy a lack of effective countermeasures for many years, if ever. Additionally, space-based kinetic weapons could hold the most feared adversary capabilities at risk such a hard and deeply buried targets associated with weapons of mass destruction. Just the demonstration of such weapons could be decisive in compelling an adversary to comply with US demands.

The continued development and fielding of space-based missile defenses are also non-information-based uses of spacepower which could yield decisive results by making it increasingly difficult for an adversary to strike the US homeland through space.

Developing a Holistic Spacepower Theory

The development of new military capabilities in space should cause one to reconsider the conceptual framework underpinning space operations today. The practice of fielding space forces with narrowly focused information capabilities will need to yield to a more versatile and general-purpose space force based on a platforms-and-payloads construct. This will not be easy since the transition would challenge currently accepted norms in the space forces. For example, consider how a space information system is conceived and fielded today. The first step is to develop a signal or payload which meets an information need. Next, different constellation alternatives are considered for how to provide the information in a continuous or highly repetitive manner. Often trade-offs are made between fielding fewer high altitude systems or more low altitude systems. A system constellation is then selected based on the merits of the "business case" of how to most efficiently obtain or distribute the information. Finally, a spacecraft "bus" is designed to carry and care for the payload. Generally, no single platform meets the requirements and one is forced to maintain the constellation, which makes the exercise of spacepower an expensive maintenance activity.

This type of constellation-based space forces also inhibits the development of spaceflight skills. While one would intuitively assume there is an operational art to spaceflight, constellation maintenance keeps the operators yoked to a static flight regime for which conformance dominates over critical thinking. The individual spacecraft are much too precious to allow a Second Lieutenant to "fly" them and there would be no point in letting the junior officers fly the satellites since the daily mission orders only calls for the maintenance of "wings level" flight. This is a contributing factor to the Space Commission's finding that "mastering near-earth space operations is still in its early stages"[20]

Therefore it would appear that more reform is needed for space forces than just giving them new missions. New operational approaches and mindsets are needed for them to effectively perform non-information missions. An appropriate space forces CONOP would be to consider each spacecraft as a "tail number" which is "flown" by its crew. Developing a competency in the art of space flight ought to be the mantra of the space force. Depending on the mission requirements, several platforms may need to work as a composite team to accomplish the mission and may have to include non-space assets. Satellite flying skills would be needed to achieve precise time-over-targets in coordinated "attacks" as well as proficiency for spacecraft crews to fly "solo" missions as required. Crew stations would need to be standardized and their roles better codified. New methods will be needed to measure crew proficiency rather than the current standard of "doing your time" by measuring tour lengths. Training programs would have to become more robust by deploying systems in space for training and maintaining crew proficiency as is done for traditional weapon systems. One must be prepared to put Lieutenants and NCOs at the controls, rather than just monitoring the telemetry stream. One must also be prepared to accept mishaps and losses as the space corps becomes proficient in the art of spaceflight.

The space order of battle should fluctuate based on mission demands. Maintaining a fix force level regardless of peace or war is difficult to justify for anything but global utilities. In this regard, operational spacecraft need to be considered as ruggedized military gear instead of fragile scientific instruments. Interoperability across platforms and with launch systems would be paramount for this type of force. Finally, the space operators view of their area of operations needs to changed to a space-centric view rather than the current terrestrial view with mercatur earth maps and 3-D earth simulations. Reviewing the early development of airpower theory and air forces may provide an adequate roadmap for the space forces to find solutions to these issues.

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[1] Joint Publication 3-14, *Joint Doctrine for Space Operations*, 9 Aug 2002, p. GL-6. Available on-line at: www.dtic.mil/doctrine/jpreferencepubs.htm.

[2] Mitchell, William, *Winged Defense*, Dover Publications Inc., New York, Reprinted 1988, p.3.

[3] Air Force Doctrine Document 1, Air Force Basic Doctrine, September 1997, p. 37. Available on the internet at: www.doctrine.af.mil.

[4] Field Manual 3-0, Operations, Headquarters Department of the Army, Washington DC, 14 June 2001, para 1-17. Available on the internet at: www.adtdl.army.mil/cgi-bin/atdl.dll/fm/3-0/toc.htm.

[5] Naval Doctrine Publication 1, *Naval Warfare*, date. Definition is a quote from Alfred Thayer Mahan. Available on-line at: www.nwdc.navy.mil/Library/Documents/ NDPs/NDP1

[6] JP 3-14, p. GL-6.

[7] Air Force Doctrine Document 2-2, *Space Operations*, 27 Nov 2001, p. vii.

[8] Cohen, William, OSD Memo: *Department of Defense Space Policy*, 9 July 1999. Available on the internet at: www.dtic.mil/whs/directives/.

[9] Oberg, James E., *Spacepower Theory*, Government Publishing Office, March 1999, p.ix.

[10] Oberg, p.xi

[11] Gray, Colin S. and Sheldon, John B., *Space Power and the Revolution in Military Affairs*, Airpower Journal, Fall 1999, p. 30.

[12] Spires, David N., *Beyond Horizons*, Air University Press, 1998, p.73 and p.96.

[13] Spires, p.132-133.

[14] Mandell, Mel, *120,000 Leagues Under the Sea*, IEEE Spectrum, April 2000, pp. 50-54.

[15] Mandell, Mel, *120,000 Leagues Under the Sea*, IEEE Spectrum, April 2000, pp. 50-54.

[16] See article on Predator Hellfire testing. Available at www.afmc-mil.wpafb.af.mil/HQ-AFMC/PA/news/archive/2001/feb/predator_hellfire_test.htm

[17] See 4 Nov, 2002 Aviation Week article on Rivet Joint being used for information warfare. Available at: www.aviationnow.com/content/publication/awst/20021104/avi_news.htm

[18] There have been several studies on the feasibility of space-based solar power stations. A useful reference on this topic is available at: www.spaceref.com/directory/future_technology/solar_power_satellites/

[19] For a discussion of space weaponization, refer to Lt Col Thomas D. Bell's Jan 1999 article titled "Weaponization of Space: Understanding Strategic and Technological Inevitabilities." Occasional Paper No. 6, Center for Strategy and Technology, Air War College.

[20] Space Commission Report, p. 17.

Airpower as a Model for Spacepower

In considering ways to develop a theoretical- and doctrinally-based force structure, one should consider the logic process used in the development of airpower. This is best described by Brigadier General William "Billy" Mitchell in his book *Winged Defense.* Billy Mitchell was able to articulate the linkage between air power theory, air doctrine, and air forces. His seminal work in *Winged Defense* provides an excellent template from which to model a logic process useful for space forces.

The greatest challenge when writing on a new and complex topic is to organize one's thoughts in a way to facilitate understanding. Establishing a hierarchy of ideas and showing the logical relationships between concepts helps the author to express their ideas effectively to the reader. Readers can easily miss the meaning of an argument by positing it in a vague or obscure way, or by presenting the information out of a logical context. *Winged Defense* provides many key precepts of air power in such a way to make them understandable to the average person living in 1926. The train of thought between Billy Mitchell's experience in World War I and immediately after, his understanding of the air environment, his theory of air power, his proposed air doctrine, and finally the force structure he proposed, formed a power vision. The most compelling aspect of his work was that a majority of these concepts were later proven correct in World War II and up to the present day.

Hierarchy of Air Concepts and Relationships

Early air power advocates such as Gulio Douhet, Sir Hugh Trenchard and Brigadier General William "Billy" Mitchell foresaw the use of air forces as instruments of national power.

While each of them, and many others, wrote extensively on their views of air power theory, Billy Mitchell stands out as one who developed his ideas into a strategy to organize, train, and equip air forces. His book, *Winged Defense*, provides tremendous insight into the usefulness of a power theory to guide force development. Establishing such an understanding for space operations should provide a useful context for the development of a spacepower theory.

Billy Mitchell foresaw applications of air power across a wide range of missions. The subtitle for *Winged Defense* is "The Development and Possibilities of Modern Air Power – Economic and Military." Billy Mitchell approached air power from a macroscopic view by considering the influence of air power upon mankind as a whole and upon warfare as a specific activity. This is reflected in his definition of air power as "the ability to do something in or through the air."[1] Based on his understanding of probable military air missions, he recommended the development of a general-purpose air force. This objective air force was thought to provide the necessary platform mix and flexibility to accomplish anticipated air missions.

Winged Defense provided an amazingly prescient view of air power for its day. Table 3 provides selected excerpts to convey the essence of Billy Mitchell's ideas. These ideas are grouped into logical headings which were not a part of the original text. However, these logical groupings are useful gain clarity in the hierarchy of air concepts and relationships between them.

Air Powe Theory	p.4, "…air covers the whole world, aircraft are able to go anywhere on the planet." p.4, "…one place is just as exposed to (air) attack as another place." p.16, "As air power can hit at a distance, after it controls the air and vanquishes the opposing air power, it will be able to fly anywhere over the hostile country." p.34, "The theory is to show that aeronautics can establish airways anywhere in the world and be able to operate from them; that wherever air power can operate, it can dominate sea areas against navies, and land areas against armies..." p.214, "The influence of air power on the ability of one nation to impress its will on another in an armed contest will be decisive."
Air Forces	p.113, "As important as anything else is the placing of one man in charge of aviation who can be held directly responsible for the aeronautical development of the whole country…" p.163, "There are three great branches of an air force." (i.e. pursuit, bombardment and attack) p.197, "Of course to make for efficiency it is necessary to have just as few types of airplanes as possible." p.198, "Constant development and experimentation must go on to keep up with the nations most rapidly gaining in the art and science of flying."
Air Doctrine	p.140, "…if you did not have sufficient control of the air to be able to operate, your ground force could not carry on against the enemy who had supremacy of the air." p.199, "It was proved in the European war that the only effective defense against aerial attack is to whip the enemy's air forces in air battles." p.217, "The system of command of military air power should consist in having the greatest centralization practicable." p.221, "Unity of command is essential to air forces."
Air Employment	p.6, "The airmen fly over the country in all directions constantly, winter and summer they go, as well as by night and by day." p.24, "…the American aviation at the battle of Chateau-Thierry, with seventy-five per cent of its strength killed, wounded, and missing in little over two weeks, kept right on fighting with as great morale as if these losses had not occurred." p.29, "…in the midst of the Chateau-Thierry struggle, with the Allies shot out of the air, we had to evolve our own system and salvation as best we could."

Table 3. Summary of Concepts in *Winged Defense*[2]

Air Force Structure as an Extension of Airpower Theory

One area where Billy Mitchell's conceptualization of air power was particularly prescient was his argument for what types and quantities of aircraft would be needed for an air force. Within the discussion of the composition of air forces, Billy Mitchell had a well-conceived operational concept of differentiating between aircraft platforms and their payloads. This platforms-and-payloads construct was the basis for his understanding of different air missions and aircraft operational performance. The building block approach, centered on the aircraft as the conceptual element, greatly facilitated the theoretical construction of an air force. Table 4 captures Billy Mitchell's ideas for an objective air force, force structure.

Platform Type	Attributes					Missions
	Payload	Range	Speed	Ceiling	Other Capabilities	
Pursuit - Defense - Offense - High Altitude	 50 cal machine gun 50 cal machine gun 50 cal machine gun	 n/a 800 mi 800 mi	 150 mph 200 mph 200 mph	 25,000 ft 25,000 ft 40,000 ft	 maneuverable diving climbing	 Bomber and Attack Escort Offensive Counter-Air Defensive Counter-Air
Bombardment	4,000 lbs of bombs	800 mi	135 mph	35,000 ft	n/a	Naval force interdiction Strategic Attack
Attack	6 machine guns	800 mi	n/a	300 ft	n/a	Close Air Support Air Interdiction

Table 4. Air Power Architecture in *Winged Defense*[3]

The maturity in Billy Mitchell's conceptualization of air forces stands in contrast to other air theorists of his day. There was a countervailing tendency to view air power as a constellation of capability which was the composite capability of all aircraft. Using the constellation conceptualization, the individual aircraft didn't really matter and less thought was given to describe their operational requirements and capabilities. Gulio Douhet's book, *Command of the Air*, demonstrates this point where he saw air forces as an essentially monolithic bomber force where quantity was the major measure of merit for a strategic bombing force. His major conclusions are shown in Table 5.

Air Forces	p.21, "This gives us the concept of the basic unit of power needed for effective bombing operations; namely, *the unit of bombardment must have the potentiality to destroy any target on a given surface*. In my opinion, the extent of this surface should be exactly the area of a circle 500 meters in diameter. Then if the above assumptions are correct, this unit should be 10 planes…" (italics in original) p.44, "War today is fought by masses of men and machines." p.45, "From this conclusion may be drawn that there should on the whole, be very little difference between one type of plane and the others..." p.45, "The organization of a combat unit must be such as to include a number of planes which can fight in formation..." p.49, "An Independent Air Force should always operate in mass." p.118, "Therefore from all points of view, it is best that the bulk of an Independent Air Force be made up entirely of battleplanes designed for aerial combat and for bombing offensives against the surface."

Table 5. Summary of Concepts in *Command of the Air*[4]

Over time, Billy Mitchell's conceptualization of air power around the platforms-and-payloads construct prevailed. It was later expanded upon by Major Alexander DeSeversky 16 years later in the book *Victory through Air Power*. Major DeSeversky stated that "aircraft types must be specialized to fit not only the general strategy but the tactical problems of a specific campaign."[5] He discussed the need for a minimum number of aircraft types but foresaw the need for extremely specialized aircraft for high-priority missions. The continual adaptation and refinement of Billy Mitchell's ideas provided the level of granularity needed to develop doctrine and pursue the operational art of airpower.

Spacepower thought has not emerged with a clear conceptual underpinning like Billy Mitchell had for airpower. Spacepower has taken a path more akin to Douhet's thinking where individual spacecraft are of little consequence. What matters in space operations is the "constellation" which more closely resembles Douhet's air fleets than Mitchell's platform-centric view. Spacecraft constellations are the basic building block of space thought which has caused spacepower to take a different approach to in the development of forces and gaining proficiency in the operational art of space flight.

Template for Developing Forces Based on Warfighting Competencies

Billy Mitchell's highly detailed template for an air force came at a time when much of the technology was still in its infancy. However, for the Army Air Corps, it was a breakthrough for the development of airpower. It set into motion a commonality of thought in airmen to allow them to advocate from a common perspective for how resources should be prioritized. Achieving a common perspective on air doctrine, determining what platform types were needed, the general approach to air operations, and the major operational attributes needed for aircraft. This commonality of thought allowed the early airmen to use their limited resources to advance aerospace technology down a path of maximizing the military utility in an effort to prove the veracity of airpower theory. It also laid a solid foundation for the separatist movement to create and independent Air Force by codifying the belief in independent air action for decisive/strategic effects and the logic of air superiority whereby the adversary air forces must first be defeated. This was key to building a potent air force as a separate military branch rather than keeping air power subservient to land forces commanders. This thought process is shown below in Figure 2.

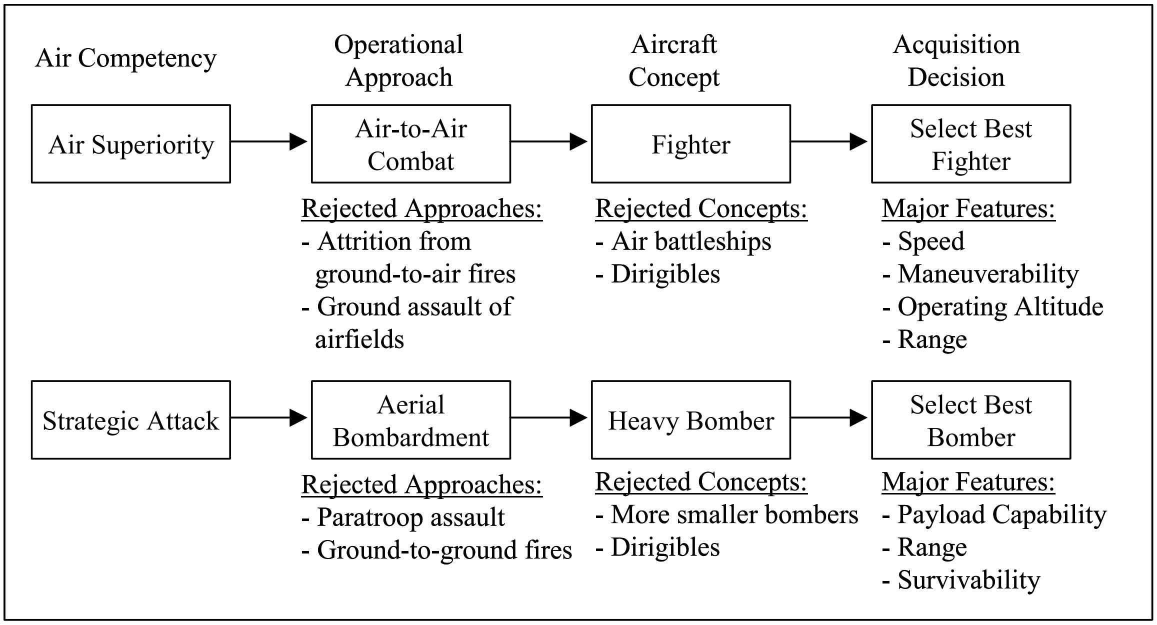

Figure 2. Template for Developing Air Forces

Billy Mitchell's clarity of thought for how to develop an air force continues to influence the United States Air Force today as can be seen with the Global Strike Task Force and the other Task Forces spearheaded by the Air Staff. Codifying key air concepts such as air superiority and strategic attack as core competencies provided the Army Air Corps with a needed focus and helps to Air Force better organize, train and equip the forces that will be needed in the future. These core competencies and doctrinal corollaries identify how to best prosecute a war and which behaviors and skills will be rewarded by the organization.

Billy Mitchell for Space

For the development of space forces, one should question what an equivalent Billy Mitchell figure would say about spacepower. Using the Mitchell methodology in Table 3, it is possible to adapt Billy Mitchell's theories on airpower directly to spacepower by substituting the word "space" for "air." In making this conversion from air to space, one needs to consider if the fields of aeronautics and astronautics are compatible at a strategic level. Certainly at a tactical level, the two fields are fairly dissimilar. Aeronautics relies on the mass flow properties of air over a surface to provide lift and drag for an aircraft. In contrast, astronautics describes how spacecraft motion is controlled by the mass of celestial objects, spacecraft speed and the distance from celestial objects. Another tactical contrast is seen in the differences in propulsion systems between air-breathing engines and rocket motors. However, at a strategic level of conceptual thought, air and space operations have many similarities which should lend some credibility to using a Mitchell methodology for space. Space forces can operate anywhere over the surface of the earth although the dwell time may be short. The time of arrival to any point of the earth can be pre-selected and the spacecraft can achieve a desired time-over-target. Spacecraft can conform to a platforms-and-payloads construct and be designed to carry ordinance which can impact the earth or information systems to observe the earth. Adapting Billy Mitchell's three types of aircraft into equivalent spacecraft requires some adaptation of similar space terms. First, the pursuit aircraft would need to be considered as a platform that can match the energy state of its target in a way as to be able to rendezvous with it. This leads to an equivalent spacecraft type of a rendezvous system where it can become co-orbital with a space "target" to either engage, inspect or dock with it. Second, the bombardment aircraft would need to be considered as a platform that can attack terrestrial targets. This leads to an equivalent spacecraft type of a re-entry system where deposit energy or projectiles from space to earth. Third, the attack aircraft would need to be considered as a platform that can hit other targets for impact effects. This leads to an equivalent spacecraft type of a conjunctive system where it can cross orbital paths with a space "target" to either engage or inspect it. These results are shown in Table 6.

Space Power Theory	- Space engulfs the whole world, spacecraft can observe or attack anywhere on the planet. - Spacepower can establish access to anywhere in the world; wherever spacepower can operate, it can dominate sea areas against navies, land areas against armies, and airspace against air forces. - Spacepower will be decisive on the ability of one nation to impress its will on another.
Space Forces	- As important as anything else is the placing of one person in charge of space forces who can be held directly responsible for their development. - There are three main types of space forces. (i.e. rendezvous, re-entry and conjunctive) - It is necessary to have just as few types of spacecraft as possible.
Space Doctrine	- If you do have sufficient control of space, your terrestrial force cannot carry on against the enemy who had supremacy of space. - The only effective defense against space attack is to whip the enemy's space forces. - Unity of command is essential to space forces.
Space Employment	- The spacemen fly over the globe in all directions constantly, winter and summer they go, as well as by night and by day.

Table 6. Billy Mitchell for Space

The resulting spacepower theory seems to account for the current information-based force structure of space but also promotes the holistic view of space desired in this paper. It also requires a more refined discussion on how to adapt the platforms-and-payloads construct to space forces.

A Platforms-and-Payloads Space Force Structure

Continuing to model the discussion on Billy Mitchell's work, it is possible to prescribe a space force structure based on the platforms-and-payloads construct. The three substitutions for aircraft types described above will need some further refinement and definition. Considering the pursuit aircraft again, one quickly realizes the intent is to be able to rendezvous with other aircraft for the purpose of shooting them down. A similar capability is needed for rendezvous spacecraft but there will be two obvious classes of these spacecraft based on the altitude regime of the target spacecraft. There should be, in theory, rendezvous spacecraft specialized for low-earth and deep space operations. Rendezvous operations would be needed to inspect resident space objects for verification, intelligence and negation purposes. When considering the information missions performed by spacecraft today, many of these missions would be performed using rendezvous-type spacecraft in the future.

The bombardment aircraft were needed for strategic attack against adversary centers of gravity. A similar capability would be needed for the "re-entry" spacecraft systems. These systems could deposit either kinetic or directed energy on the earth to attack targets. Re-entry systems could either fly sub-orbitally through space, stage in space for short periods of time, or remain in space as a forward-based deterrent. They could also orbit the moon as an intermediate staging base.

The attack aircraft were needed for tactical attack and interdiction and were well-suited for straffing ground targets. A similar capability would be needed for "conjunctive" spacecraft. They would need to be able to intercept "targets" in space by flying across their orbital path. Conjunctive systems would not rendezvous with their targets in a co-orbital manner but would rather fly-by at high rates of speed. During these intercept operations, one could still interrogate or negate targeted objects. One advantage of this type of spacecraft is the ability to quickly maneuver to conjunct with the intended target whereas a rendezvous spacecraft may take many days or months to become co-orbital with it. Conjunctive-type spacecraft could perform many existing information missions but with a novel operational approach. They could fly in highly elliptical orbits and provide continuous coverage of various earth regions by fielding two or three spacecraft spaced 120° apart.

To describe the operational characteristics of these spacecraft, some space terms will have to be used which may not be widely understood by airmen. The term "range" will still describe the operational capability of the spacecraft's fuel load although it will not describe the distance flown by the spacecraft. Spacecraft use fuel to change its energy state in two ways.

First, it can accelerate or decelerate to change its height above the earth which is measured as the radius of its orbit (r). Changes in radius are annotated using the abbreviation Δr. Second, it can change the inclination of its orbital plane (i) relative to the earth. Changes in inclination are annotated using the abbreviation Δi. The amount of fuel it takes to accomplish these maneuvers can be measured in absolute terms using pounds or kilograms of propellant. However, the rocket equation one uses to calculate fuel consumption, relies more on the percentage of spacecraft weight taken up with fuel rather than the absolute weight of the fuel and spacecraft. Therefore fuel loads could be described using mass fractions which is abbreviated as m*. Upon closer examination, even the mass fraction reduces to the effect of fuel use on the velocity of the spacecraft. The change in velocity is called delta velocity and is abbreviated as delta-v or Δv. Ultimately, the term Δv is the most useful in describing the operational characteristics of a spacecraft. Each of these three types of spacecraft are described in Table 7 using these terms.

Platform Type	Attributes				Missions
	Payload	Range	Delta Velocity	Other Capabilities	
Rendezvous - Deep Space - Near Earth	Both: - Information system - Negation	Both: $\Delta i = 5°$ $\Delta r = 100$Km $\Delta r = 4{,}000$Km	 500 m/sec 1,000 m/sec	Autonomous Operations	Force Enhancement Offensive Counter-Space Defensive Counter-Space
Re-entry	- Kinetic munition - Directed Energy	Δi = n/a $\Delta r = 100$Km	1,500 m/sec	Fail Safe C2	Naval force interdiction Strategic Attack
Conjunctive	- Information system - Negation	$\Delta i = 20°$ $\Delta r = 5{,}000$Km	1,500 m/sec	Radiation hard (Van Allens)	Force Enhancement Offensive Counter-Space

Table 7. Space Power Architecture

The performance of each of these spacecraft can be plotted on a common scale as shown in the Figure 3 below.

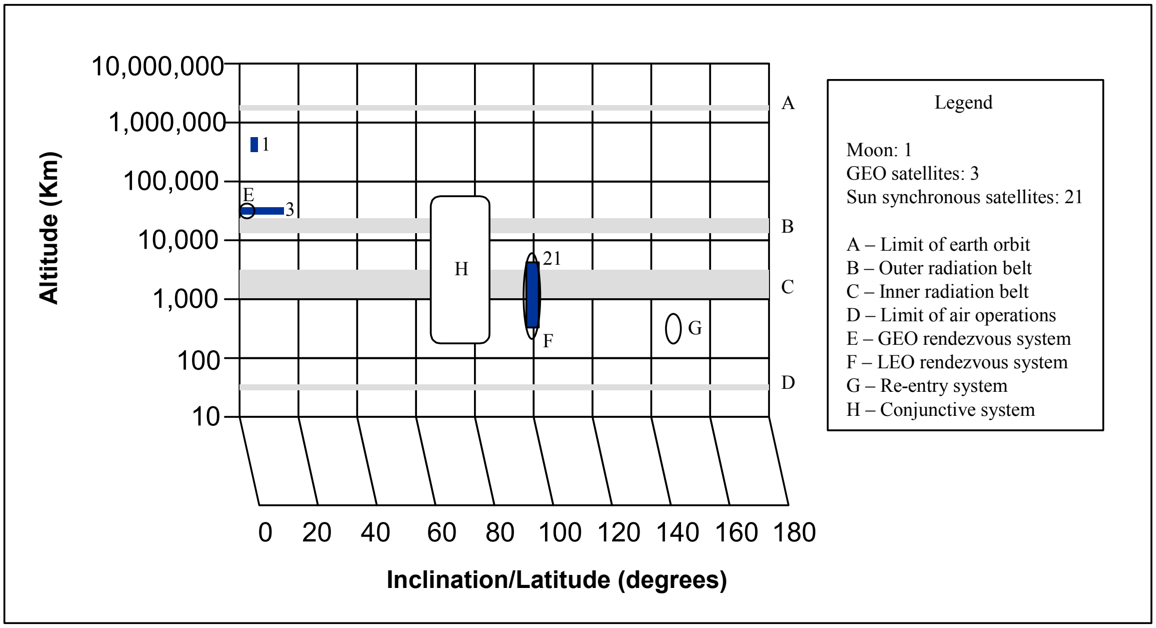

Figure 3. Spacecraft Performance Ranges

Codifying individual types of spacecraft could offer the space community the same benefits it gave the early airmen. As performance parameters become widely understood and accepted, the space community could speak with one voice for what forces they need rather than leaving it the various assigned missions to define an ad hoc and non-interoperable force structure. These types of systems can unify space thought about core competencies and their tie to the space force structure. An example of such an argument is provided in Figure 4.

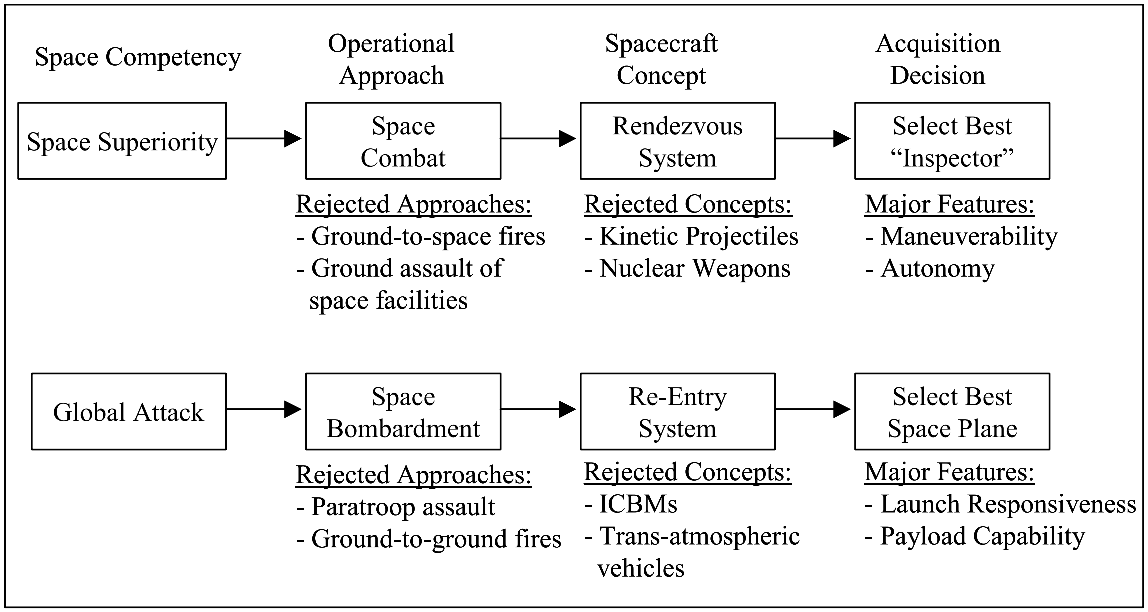

Figure 4. Template for Developing Space Forces

Space Common Operational Perspective

Such an independent view of space operations highlights the need for a new Common Operational Perspective (COP) for space. The informational nature of space operations to date have placed a premium on communicating with terrestrial forces using their perspective. As space becomes viewed as a separate operating medium, a space-unique view will be required.

The development of airpower provides a useful framework from which to develop to a space COP. Take for instance the flight envelope shown in Figure 5. One can gain an understanding of aircraft performance from studying performance diagrams such as this. It also allows one to directly compare different aircraft performance. It is important to note that both the x- and y- axes translate to the energy state of the aircraft. Altitude can be converted into Potential Energy (PE) using the equation:

$$PE = gh$$

Mach number can be converted into Kinetic Energy (KE) using the equation:

$$KE = \frac{1}{2}mv^2$$

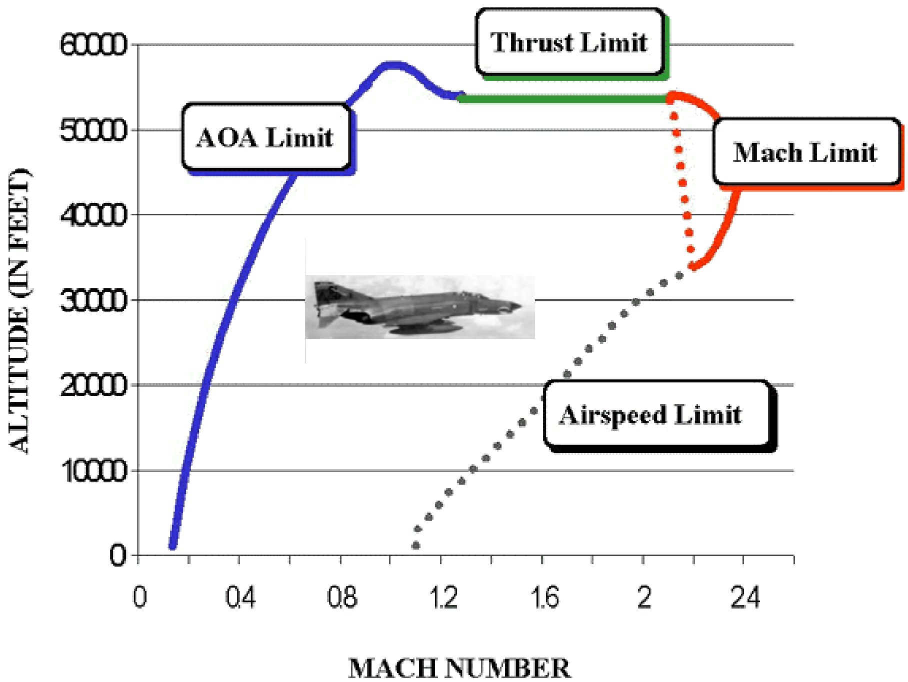

Figure 5. F-4 Flight Envelope

As mentioned previously, there are two major maneuvers spacecraft can make that require it to expend energy. The first is to change altitude and the second is to change inclination. One can use this perspective to plot "where" everything is in space. This is shown in Figure 6.

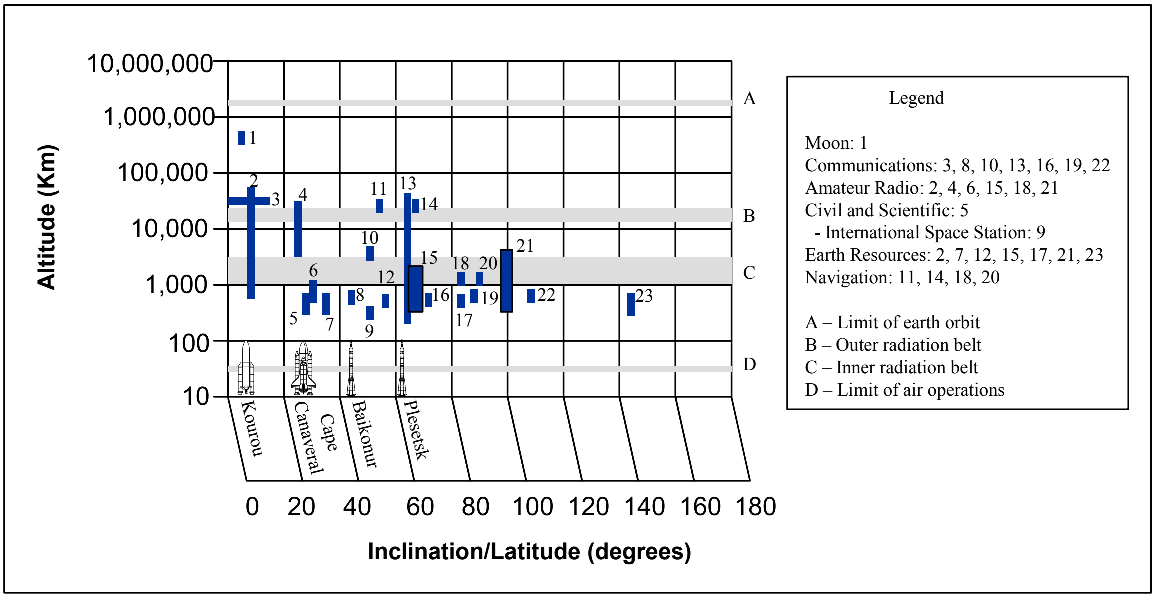

Figure 6. A Space Common Operational Perspective (COP)

Space Concept of Operations

The AF space CONOP today is based on the 1960s ICBM program. The initial CONOP for space forces was developed as a platforms-and-payload approach roughly like the early air paradigm. In this case, the missile was the platform and the spacecraft was the payload. However, once the spacecraft was placed on orbit, its operations remained static based on constellation maintenance. This approach served the Air Force well for ICBMs and for space as information systems but has been found lacking for developing more robust space forces. Adapting space forces to a truer form of the platform-and-payloads construct requires a thought process more akin to naval air operations on an aircraft carrier. The missile is like the aircraft carrier which carries one to the operational area. It then deploys spacecraft which are analogous to the carrier's flying units. The spacecraft themselves have to be operated and can carry a wide variety of payloads. Therefore, the adaptation of the platform-and-payload construct to space requires three categories of space equipment. These are boosters, spacecraft, and payloads.

The second space CONOP change is to develop standard crew positions with credible operator skills. Spacecraft should be purchased as separate configuration items from the payloads they carry. Crews need to be qualified for space flight based on their ability to control the spacecraft and cause it to attain mission performance parameters. Space ratings should identify how competent an operator is in mastering space flight or their crew position. This alternative approach challenges today's approach where space operators have duties more consistent with command post officers, maintenance officers or contract monitors.

Space operators should have more theater deployable modules from which to conduct space flight operations. Their modules should deploy to theater analogous to Global Hawk and Predator operations rather than remaining in garrison at Schriever AFB.

Such a new approach to space operations will have significant impacts on the role on the space acquisition centers. System Program Offices (SPOs) will need to be organized to purchase space hardware as individual items rather than monolithic "systems-of-systems." Future SPOs will need to be organized into three major departments for boosters, spacecraft and payloads. Fortunately the booster element is already organized this way so the major change will be with the existing spacecraft SPOs. Treating the mating of payloads to spacecraft as a launch base activity, such as loading munitions on airplanes, should give the space operators greater control over the space forces and increase its responsiveness. The laboratories and Federally Funded Research and Development Centers (FFRDCs) would now be able to participate in a more meaningful way in the development of space forces. They would be able to develop and test modifications to space hardware without having a monolithic SPO to shut them out of the process. They could experiment with new technologies and gain easier access to space by negotiating their own way onto spacecraft with fewer people to say "no." This should institutionalize a structure whereby spiral development can work more effectively than it does today.

Crew Stations

There are several functions which should be common across all three spacecraft types. These functions should be codified into standard crew stations and managed as distinct career fields and space ratings.

Spacecraft Commander. This person would need to be an officer and act as a combined pilot and navigator. This person would need to maintain overall situational awareness of the space environment and the spacecraft in particular (e.g. where the vehicle is over the earth, relationship to sun and earth pointing, etc.). They would need to track where vehicle is as compared to its intended location as "fragged" in the Space Tasking Order (STO). They would maintain platform orientation to enable operations of the mission controller and payload operators. This person would control all spacecraft maneuvers and be responsible for safety of flight. This position would require a space rating.

Mission Controller. This person would manages the contact between the spacecraft (both platform and payload(s)), relays, and ground sites and would act as the communications officer. They would monitor antenna angles and fields of view to receive sites, monitor transmission quality (bit error rate, etc), plan for communications outages and hand-overs to alternate sites. This position would require a space rating.

Payload Operator(s). This position could be either an officer and enlisted member as required by supported community. Standard specialties would include weapons system officer, intelligence officers and NCOs and communications officers and NCOs on most missions. The intelligence and communications career fields would need to have exchange programs with the space forces to have them operate the payloads carried by spacecraft on information missions. These people would carry ratings in their field of specialization. Only the weapons system officer requires space rating and would have to be an officer.

Surveillance NCO. This person would manage the space surveillance sensor. Every spacecraft should carry self-awareness sensors to detect attacks and space surveillance sensors to detect other objects in space. They would maintain situational awareness of conjunctions with other space objects which will occur ahead and behind track of the spacecraft and recommend possible maneuvers to the pilot to conjunct with high-value targets. They alert the spacecraft commander to safety of flight risks and conjunction opportunities to interrogate other spacecraft. This persons maintains contact with the space situational awareness center, operates space surveillance sensor based on their priorities and forwards space track data and imagery products to the space catalogue.

Maintenance NCO(s). These people would monitor the health and status of key sub-systems and identifies potential problems. They would work with technical support and contractors to assist with anomaly resolution. These positions would not require space ratings.

Spacecraft Maneuvers

One topic of discussion which should give space advocates hope for the future is future spacecraft maneuvers. One may question whether space operations should merit such a new approach if the day-to-day operations are simply going to degenerate into the predictable routine like those today. The US has been remarkably complacent with the orbital regimes that are used today. Most people are familiar with geosynchronous (GEO), semi-synchronous, sun-synchronous and geosynchronous transfer orbits (GTO). The Soviets developed the molniya orbit as a way of using a highly elliptical orbits to provide polar communications in the absence of coverage by geosynchronous spacecraft. Each of these orbits are now well understood and no new orbits have been added to the lexicon in the past couple of decades. Future space operations will require the codification of new orbit types to facilitate understanding and discussion. Most of these orbits will describe the relative motion of one spacecraft to another rather than the motion around the earth. The following orbits and maneuvers are offered for consideration.

Rondure. Rondure is defined as "something circular or gracefully rounded."[6] The rondure is as much a maneuver and as a distinct type of orbit. It is an orbit that is slightly more elliptical than the "target" satellite one is inspecting. A special case of the rondure would be at geosynchronous altitudes where you would us a slightly elliptical orbit with a 24-hour period. This causes the spacecraft to drop below and rise above the geosynchronous belt. In doing so, it will speed up and slow down relative to the other geosynchronous spacecraft. One can therefore circle around another satellite to inspect it from ahead, behind, above and below once every 24-hours. Such an orbit could be used to verify the status of friendly or hostile spacecraft and provide some amount of protection and attack warning to friendly satellites. A variation of rondure would be an inclined rondure to gain off-axis access to another spacecraft.

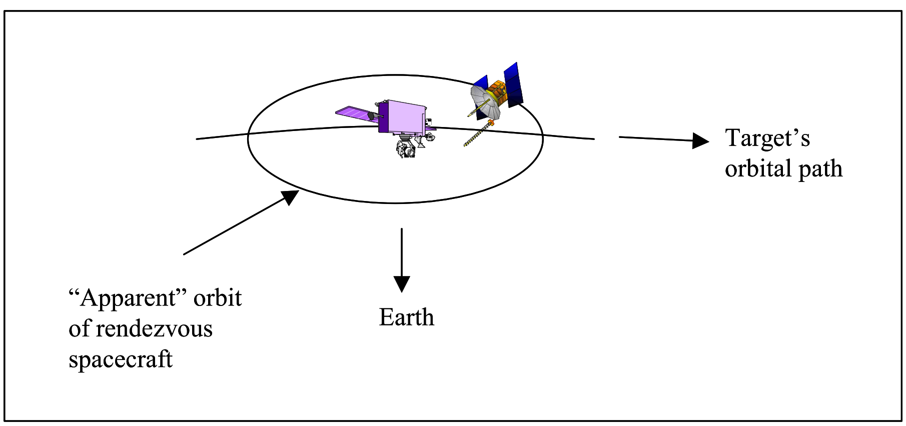

Figure 7. The Rondure

Osculatory Orbit. To osculate means to kiss.[7] This orbit is a highly elliptical orbit whose apogee is at geosynchronous altitude so that it "kisses" the GEO belt. This orbit allows one to quickly conjunct with almost any object in space and would be a preferred orbit for conjunctive type spacecraft. The two major variations of this orbit are the semi-synchronous 12-hr osculatory orbit and the non-synchronous osculatory orbit. The repeating orbit allows one to place a GEO spacecraft under twice-a-day observation which also enable twice-a-day observation of a region of the earth. Two ocsulatory spacecraft in 12-hour orbits can be placed 120° apart to provide near-continuous coverage of a region on the earth. Three or more such spacecraft can provide continuous coverage. The non-repreating osculatory orbit is particularly useful for mapping and surveillance of space by offering many conjunction opportunities at high and low altitudes.

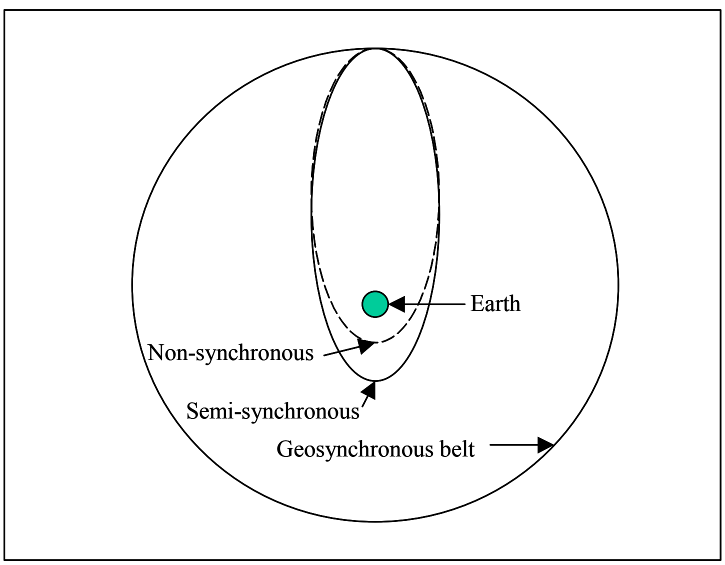

Figure 8. Osculatory Orbits

Non-Keplarian Orbits. Space operators today are content to operate their spacecraft relying on traditional orbital mechanics described by Johannes Keppler. Keplarian orbits refers to orbits for which the energy of the spacecraft is fixed and therefore the craft completes predictable circles or ellipses around the earth. A non-Keplarian orbit would be one where the operator continuously expends energy to change the energy state of the spacecraft. There are two types of non-Keplarian orbits one should expect to use in the future. The first would be a hover maneuver to maintain a fixed geometry between a rendezvous spacecraft and its “target.” A hover maneuver implies there is a critical viewing angles that needs to be maintained which cannot be attained through co-orbital operations since matching orbits requires the rendezvous system to be either in-track with the target either in front or behind it. A second non-Keplarian orbit would be a continuous thrust to change altitude using a low thrust propulsion system.

Lunar Orbits. The 1998 recovery of HGS-1 by Hughes Global Services Inc. should have alerted people to the potential utility of lunar orbits.[8] In many cases, lunar orbits can provide more fuel efficient orbit changes than using traditional maneuvers. The moon also offers a potentially attractive intermediate staging base by storing spacecraft in orbit and allowing for their return to earth with relatively little warning or risk of failure.

Retrograde Orbits. A final class of orbits to consider are those in which the spacecraft flies against the earth’s rotation. These are called retrograde orbits and have an inclination of greater than 90º. A brief review of figure 5 reveals that very few spacecraft operate in retrograde orbits. The notable one in figure 5 is Israel’s Offeq satellite which is indicated as number 23. Offeq only operates in this orbit due to the available launch geometry Israel has over the Mediterranean. Retrograde orbits are not suited for information missions but they present interesting opportunities for conjunctive and re-entry type systems performing Space Control and Force Application missions. A retrograde geosynchronous orbit may be particularly useful for future Space Control operations.

The descriptions of these "new" orbits is neither complete nor adequate. However, they serve to illustrate the point that space flight is still in its infancy for humankind. Hopefully a more mature view of space operations and the adoption of a new space CONOP will cause the US space forces to explore the realm of the possible in orbit around our own planet. There is no reason to stagnate around the currently populated orbits and the military space program ought to be leading the development of new spacecraft types and exploring orbital regimes.

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[1] Mitchell, William, *Winged Defense*, Dover Publications Inc., New York, Reprinted 1988, p.3.

[2] Mitchell, pages as cited in table.

[3] Mitchell, pp.163-189.

[4] Douhet, Giulio, Command of the Air, 1942, translated by Dino Ferrari, Office of Air Force History, Washington DC, 1983, pages as cited in table.

[5] DeSeversky, Alexander P., Vistory Through Air Power, Simon and Schuster, New York, 1942, p.143.

[6] Webster's II New Riverside University Dictionary, The Riverside Publishing Company, USA, 1984.

[7] Webster's Dictionary.

[8] See Hughes Global Services Inc. Press Release dated 17 June 1998. Available on-line at: www.hughesglobal.com/pressreleases/98_06_17_hgs1ready.html

Conclusion

Spacepower has been slow to develop as a coercive force on human activities. Space systems have been vital to establishing several global information utilities and exert a significant influence as an instrument of national informational power. However, for the foreseeable future, spacepower is not expected to exert a decisive influence as a war fighting instrument. The main concern with space in warfare is the efficient use of space resources and not necessarily their effective use since they exert very little coercive force. The current command and control (C2) approach of splitting responsibilities for space between combatant command staffs and the JFACC should work sufficiently for information superiority and constellation maintenance.

The one development which could most readily transform space forces into an effective warfighting force would be the development of space kinetic weapons. If such weapons were to be developed, the whole concept of space forces as constellations, spacepower theory and space doctrine would have to be revised and follow a new development path along the lines Billy Mitchell prescribed for airpower. Hopefully this paper has described the initial vector one would need to take to transform spacepower from information power to a coercive force. The spacepower theory, force structure, common operational perspective, and CONOP described provide continuity with the legacy of Air Force leadership in space while posturing the space forces to undertake new and more challenging roles as an instrument of national security.

Bibliography

Air Force Doctrine Document 1, *Air Force Basic Doctrine*, September 1997. Available on the internet at: www.doctrine.af.mil.

Air Force Doctrine Document 2-2, *Space Operations*, 27 Nov 2001. Available on the internet at: www.doctrine.af.mil.

Air Force Materiel Command Public Affairs Release, *Predator Hellfire Missile tests "totally successful,"* Feb 2001. Available on-line at: www.afmc-mil.wpafb.af.mil/HQ-AFMC/PA/news/archive/2001/feb/predator_hellfire_test.htm

Aviation Week and Space Technology, *Infowar To Invade Air Defense Networks*, 4 Nov 2002. Available at: www.aviationnow.com/content/publication/awst/20021104/avi_news.htm

Bell, Lt Col Thomas D., *Weaponization of Space: Understanding Strategic and Technological Inevitabilities*, Occasional Paper No. 6, Center for Strategy and Technology, Air War College.

Carlson, Lt Gen Bruce E., *Defending Space-Based Global Utilities* available on-line at: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj00/sum00/carlson.htm

Cohen, William, OSD Memo: *Department of Defense Space Policy*, 9 July 1999. Available on the internet at: www.dtic.mil/whs/directives/.

Commission to Assess National Security Space Management and Organization, *Report of the Commission to Assess National Security Space Management and Organization*, Washington D.C., 11 January 2001.

DeSeversky, Alexander P., Vistory Through Air Power, Simon and Schuster, New York, 1942.

Douhet, Giulio, Command of the Air, 1942, translated by Dino Ferrari, Office of Air Force History, Washington DC, 1983.

Field Manual 3-0, Operations, Headquarters Department of the Army, Washington DC, 14 June 2001. Available on the internet at: www.adtdl.army.mil/cgi-bin/atdl.dll/fm/3-0/toc.htm.

Gray, Colin S. and Sheldon, John B., *Space Power and the Revolution in Military Affairs*, Airpower Journal, Fall 1999.

Hays, Peter L., *United States Military Space, Into the Twenty-First Century*, Air University Press, Maxwell AFB, AL, September 2002.

Hughes Global Services Inc. Press Release, *HGS-1 Arrives in Earth Orbit, Ready for Customers*, 17 June 1998. Available on-line at: www.hughesglobal.com/pressreleases/98_06_17_hgs1ready.html

Joint Publication 3-14, *Joint Doctrine for Space Operations*, 9 Aug 2002. Available on-line at: www.dtic.mil/doctrine/jpreferencepubs.htm

Lupton, David E., *On Space Warfare, A Space Power Doctrine*, Air University Press, Maxwell AFB, AL, June 1988.

Mandell, Mel, *120,000 Leagues Under the Sea*, IEEE Spectrum, April 2000.

Mitchell, William, *Winged Defense*, Dover Publications Inc., New York, Reprinted 1988, p.3.

Naval Doctrine Publication 1, *Naval Warfare*. Available on-line at: www.nwdc.navy.mil/Library/Documents/ NDPs/NDP1.

Oberg, James E., *Spacepower Theory*, Government Publishing Office, March 1999.

Schaefer, Larry J., *Sustained Space Superiority, A National Strategy for the United States*, Air University, Maxwell AFB, AL, August 2002.

Spaceref.com. Available on-line at: www.spaceref.com

Spires, David N., *Beyond Horizons*, Air University Press, 1998.

Webster's II New Riverside University Dictionary, The Riverside Publishing Company, USA, 1984.