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ABSTRACT

IS THE US PREPARED TO EXECUTE OPERATIONAL SPACE CONTROL?
by Major Tommy C. Brown, USAF, 50 pages

This study considers the argument for a more robust space control policy and force structure, to include the argument for an Anti-Satellite (ASAT) capability. This monograph addresses the validity of space control doctrine, as well as examining measures which ensure US access to space, and actions to deny that same use to an adversary.

Addressing the validity of space doctrine entails a brief synopsis of that doctrine, as well as detailing those trends in the world arena which warrant a review of space control policy. Key among these trends are the increasing reliance and requirement of US forces for space support, and the impact of information superiority in "3rd wave warfare." The proliferation of space-based surveillance, communications, and other technologies also affect what measures US forces require to protect access to superior space support.

While space control doctrine addresses the need to protect US access to space and space support, both the threat and operating environments have changed. A scrutiny of US space support assets and usage of those assets reveals some areas of potential vulnerability. Some of these areas remain vulnerable due to force structure, budgetary, or political constraints. Of particular interest in this regard are commercial satellite communications. In general, the vulnerability of space support and associated risk to operations must be clear to the supported theater commander. Armed with this information, as well as expertise from US Space Command, he can then take action to mitigate such risk.

Space denial operations also play a role in space control. While a lethal ASAT capability has obvious merit in this role, it does not address the full spectrum of the issue. Any targeting or negation strategy will have legal and political ramifications, requiring prior coordination at the national (and possibly coalition) level before execution. Countering an adversary's access to space support must contribute to exploitable information superiority, which may be local, temporal, or topical. ASAT employment is but one aspect of an integrated information denial campaign; one which requires integration with complementary measures to be operationally meaningful.

IS THE U.S. PREPARED TO EXECUTE OPERATIONAL SPACE CONTROL?

A Monograph
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INTRODUCTION

General Merrill "Tony" McPeak, US Air Force Chief of Staff during Operation Desert Shield/Desert Storm (Aug 90 to Apr 91) referred to that conflict as the first space war.[1] US and coalition forces relied upon space-based systems to an unprecedented degree for a wide spectrum of strategic and tactical support functions. Space systems provided commanders with intelligence, weather, navigation, and communications. Space support was thus key to establishing "information superiority" over the Iraqis. This reliance upon space support is striking, considering the inability of the US to assure its terrestrial forces access to this vital medium, or deny it to an adversary. The US won its first space war by default, with Iraq unable or unwilling to contest the issue. Such may not be the case in the future.

The downsizing of the US military has only served to increase its reliance upon space support at the same time the military is losing its superiority in space-based capabilities. Having witnessed the impact of losing the first space war, countries around the world have made acquiring space support a national priority. A number of nations have developed their own space-based capabilities, and are selling both satellites and data around the world, Commercial enterprises (including those in the US) are selling previously classified reconnaissance technologies to anyone who can pay for them.[2] Although US military strategy cannot identify its next adversary, that strategy must increasingly assume the US will contend with a space-faring opponent.

Although US military space doctrine addresses the need to prosecute space control measures, neither the political policy or force structure exists to fully execute this doctrine. Current US space control policy, as constrained by Congress, still reflects Cold War concerns over potential escalation, when interference with strategic satellites was a tacit declaration of war. The demise of the bipolar power structure underlying this policy removes the motive for restraint for all nations. Proliferation of advanced technologies and launch services provides a number of nations with the means for such interference. Thus an adversary could disrupt (or even destroy) a US military satellite with relative impunity, knowing the US response must be severely constrained. Otherwise, a US military retaliation would be escalatory, involving loss of life or violation of terrestrial sovereignty, and going beyond the pale of proportionality.

Complicating the situation is the potential emergence of "third party" space based surveillance. The French SPOT satellite provided Saddam Hussein with multi-spectral imagery used to plan his invasion of Kuwait. The same satellite also provided the same service to US forces.[3] Had France continued to provide Iraq with such imagery during Desert Storm, the US would have little recourse beyond vigorous diplomatic protests. Had a notional CNN-SAT broadcast live pictures of General Schwartzkopf's "Hail Mary" attack across the Iraqi desert, the US response could be equally feeble. However, even if the US possessed a lethal Anti-Satellite (ASAT) capability, as General Charles Horner, former USCINCSPACE, has recommended, the political cost and legal complications of destroying the offending platform would be prohibitive.

In, short the rules have changed for space. It is no longer the exclusive domain of superpowers, or even constrained to the strategic arena. Yet the US remains ill-prepared to carry out its space control doctrine, despite an ever-increasing need for the ability to do so.

This study will consider the argument for a more robust space control policy and force structure, to include the argument for an ASAT capability. This examination will address the validity of space control doctrine, as well as examining actions to ensure US access and use of space, and actions to deny an adversary's access and use of space.

Addressing the validity of space control doctrine entails a brief synopsis of that doctrine, as well as detailing those trends in the world arena which warrant a review of space control policy. Key among these trends are the increasing reliance and requirement of US forces for space support, and the impact of information superiority in "3rd wave warfare." The proliferation of space-based surveillance, communications, and other technologies will also affect what measures US forces require to protect access to space support.

While space control doctrine addresses the need to protect US access to space and space support, both the threat and operating environments are changing. An examination of US space support assets and usage of those assets may reveal areas of potential vulnerability. Some of these areas may remain vulnerable due to force structure, budgetary, or political constraints. If so, this decision should be the result of informed deliberations at the national level and made apparent to the supported commander. Other areas of vulnerability may be more amenable to changes in force structure, doctrine, or national policy.

The aspect of space control which garners greater public attention is the requirement to deny an enemy's access to space and space support. While General Horner's argument for an ASAT capability has obvious merit, it does not address the full spectrum of the issue. Countering an adversary's access to space support must contribute to exploitable information superiority, which may be local, temporal, or topical. ASAT employment must therefore be one aspect of an integrated information denial campaign. However, any targeting or negation strategy will have legal and political ramifications, requiring prior coordination at the national (and possibly coalition) level before execution.

SECTION I: VALIDATION

1-1: The Evolution of Space Control Doctrine

The concept of dominating space is not new, nor is the presence of contentious debate over the issue. The perceived need to deny an enemy the free use of space goes back to the early 1960's. The focus of efforts at that time employed a nuclear-tipped Thor rocket to defend the US against a Soviet Fractional or Multiple Orbit Bombardment System. The strategic nature of the concept and employment of space control measures thus evolved from the thermonuclear threat of the Cold War. Much of the focus upon space control continues in that same vein today.[4]

One response to this escalation of superpower power struggle into previously virgin territory was the sanctuary school of US space doctrine. This school of thought extends the deterrent nature of Mutually Assured Destruction into outer space. Space must remain a "war free zone" since national spacecraft are strategic stabilizing influences. They reduce uncertainty, and thus the likelihood of catastrophic miscalculation. Interference with such assets risks upsetting the delicate strategic balance and thus cannot be permitted.[5]

Other space control debates over ASAT development have seen a modified version of the sanctuary doctrine, questioning who would win a "space war." Following the dismantling of the US nuclear ASAT in 1975, this debate remained mostly academic for a decade, until the US began developing an air-launched ASAT weapon in 1984. The crux of this argument contended that the US and its allies possesses a much less robust space architecture than did its erstwhile opponent, the Soviet Union, but relied upon it much more. Since the Soviet Union already possessed an operational ASAT capability, developing an ASAT for the US could only lead to a series of escalatory engagements, with the US losing more in each exchange. The preferable alternative was to limit the potential for such a space war through arms limitations treaties. This rationale ultimately led to a Congressional moratorium on US ASAT testing, and the eventual cancellation of ongoing ASAT development.[6]

Within the US military establishment, however, a different doctrine developed, one still reflected in doctrinal publications. The focus of this doctrine was to avoid attritional warfare in space, acknowledging that US space forces would suffer disproportionately. The complementary tenets of space control doctrine required taking steps to deny an enemy the access and use of space while assuring and maintaining one's own. President Ronald Reagan's Strategic Defense Initiative (SDI) provided a significant boost to this school of thought, while reinforcing the strategic nature of its consequences. This school of thought maintained that in a future era of space-based strategic anti-ballistic missile (ABM) defenses, the nation able to successfully prosecute space control would "win" by default. Control of space would leave an opponent defenseless against the US nuclear arsenal, while maintaining SDI's ability to shield against the missiles of an enemy.[7] Thus this concept of space control parallels Alfred T. Mahan's "Command of the Sea" as being decisive and an end unto itself.

Since the US Congress has largely maintained a belief in the sanctuary school of thought, US military space control activities remained primarily defensive, enhancing the survivability of key elements to ensure US access to space.[8] Available options for space denial have been purely terrestrial, and thus virtually untenable. A US military reprisal for the loss of a satellite was limited to attacking enemy ground sites, with a resulting escalation into loss of life and violation of national sovereignty. Ironically, unilateral adherence to the sanctuary doctrine made strategic escalation a self-fulfilling prophesy. Recognizing the bankruptcy of space control doctrine without the means for space denial, every Commander in Chief (CINC) for US Space Command (USSPACECOM) since its inception in 1985 has called for the development of a US ASAT capability.[9]

The Executive Branch of the US government also seems to be at odds with Congress over the issue of space. The July 1994 National Security Strategy expressed the nation's objective of "Deterring threats to U.S interests in space and defeating aggression if deterrence fails." The current National Space Policy details the specific means by which to achieve this objective:

> The United States will conduct those activities in space that are necessary to national defense. Space activities will contribute to national security objectives by (1) deterring, or if necessary, defending against enemy attack; (2) assuring that forces of hostile nations cannot prevent our own use of space; (3) negating, if necessary, hostile space systems; and (4) enhance operations of United States and Allied forces.[10]

Furthermore, one of the measures the National Space Policy specifically directs is the development of an ASAT capability, "to achieve initial operational capability (IOC) at the earliest possible date."[11]

1-2: The Gulf War Legacy

In the aftermath of Desert Shield/Desert Storm General Colin Powell, Chairman, Joint Chiefs of Staff testified to Congress:

> "If there is one thing I've learned in the past two years, space is a new frontier of warfare. Land, sea, air, and space. We couldn't have done Desert Shield and Desert Storm unless we had total control of space--the ability to see from space, to talk through space, to monitor through space, to give warning through space--and we have to concentrate in the future on ensuring that we are never limited in our ability to operate in space."[12]

Because of the unraveling of the Soviet Union and its threat to US survival interests, national assets previously dedicated to the information needs of strategic users could be made available to theater and even tactical level military commanders. Each service had developed Tactical Exploitation of National Capabilities (TENCAP) programs to gain access to data previously too classified to be available. Equally significant was the enormous communications capability created in a theater otherwise lacking a supporting infrastructure. This capability relied heavily upon satellites to gather and distribute information among a wide variety of users. The unprecedented success of allied tactical exploitation of space assets provided coalition combat forces a uninterrupted flow of information regarding the status of enemy forces, friendly forces, and the battle itself.

At the same time, the coalition air forces were systematically dismantling Iraq's command and control infrastructure, denying the enemy the crucial ability to collect and disseminate information. The result was a net information differential heavily in the coalition forces' favor. Creating this differential set the conditions for the immensely successful air, sea, and ground operations to end the war.

In the aftermath of the Gulf War, this concept of an information differential has been the topic of any number of discussions and articles.[13] It has also been at the heart of an emerging joint doctrinal concept called Command and Control Warfare (C^2W). Published in the Chairman, Joint Chiefs of Staff Memorandum of Policy 30 (CJCS MOP 30), C^2W seeks to integrate a spectrum of lethal and other capabilities to create an exploitable information differential. Thus, C^2W notionally extends control of more conventional media (land, sea, air, space) to a dimension of "cyberspace," where information and its movement translate into combat power.[14]

Like other control doctrines, C^2W possesses no absolute metrics for success. Instead, the measure of success is relative, reflecting one's own command and control capabilities vs that of the enemy. Thus, introducing degradation, delay, and uncertainty into the enemy's command and control structure has little utility unless friendly C^2 structures remain viable. Conversely, a secure and viable friendly C^2 structure means one need not totally dismantle that of the enemy. Instead, success for the information campaign requires merely sufficiently degrading enemy C^2 to protract his reaction time.

Within the context of theater warfare and C^2W, space control becomes more analogous to Sir Julian Corbett's sea control, or Col John Warden's air superiority, rather than the Mahanian absolute envisioned under SDI. In short, space control can be relative, rather than absolute, its span limited in space and time. Within this framework, space control becomes but one means to an end, albeit a crucial one.[15]

Regardless of these factors, however, some space based capabilities constitute a Mahanian "fleet in being," in that their mere existence poses a potential threat to terrestrial forces. For instance, any foreign surveillance satellite possesses the potential to betray one's military preparations, even though it may be looking elsewhere for the moment. Similarly, communications satellites used for banking transactions or television broadcasts may also be used for military command and control, or intelligence dissemination. For example, the US military routinely uses leased commercial satellite communications channels (and did so throughout the Gulf War). Thus, many space-based capabilities may serve dual purposes, their functions being only as benign as their users at any given moment.[16]

General Horner has tied his requirement for an ASAT capability to protection of tactical ground forces, citing the potential danger of such dual-natured space based capabilities. Accordingly, the US military space community is turning to a more operationally oriented space control argument, one which also reflects the increasingly tactical use of previously strategic space based assets. The doctrinal concept of C^2 Warfare provides an overarching framework for the prosecution of space control operations, in support of both military and political objectives below the strategic level.

1-3: Trends in Space Support

1-3a: Increasing DoD Reliance on Space Support:

The renewed emphasis on protecting the US military's access to space arrives at a time when the demands placed upon space support are increasing for a number of reasons. Budgetary pressures are, and will continue to drive the force structure of the US military down. However, other pressures place a premium upon maximizing force capability. Superior information technology is the means by which the services hope to meet both sets of demands, creating a smaller, yet more capable force. The US Army's initiatives toward developing its Force XXI capability and digitized battlefield are illustrative of this trend. Enhancing combat effectiveness through superior information warfare may lead to modified (further reduced) force structure, in order to relieve some of the budget pressure on the services.[17]

These same budgetary pressures have reduced the forward presence of US forces, transforming the US military into a power projection force. The current National Security Strategy emphasizes the need to credibly deter and defeat aggression by projecting and sustaining US power in response to major regional contingencies.[18] This transformation places another premium upon information superiority, to enable decision makers and commanders to understand what events will precipitate a military response, and to determine the proper nature of that response. Force projection also means deploying forces into theaters devoid of supporting infrastructure, as was demonstrated in the Persian Gulf, Somalia, Rwanda, and Haiti. Strategic and tactical lift assets cannot support wholesale transportation of a deployable information support structure. Therefore, that structure must stem from space forces already deployed, and capable of global presence.

Another circumstance arising from the requirement for smaller, more deployable, yet capable force packages is the increased emphasis on split staff support. While deploying forces include supporting staffs, the Gulf War saw that staff relying quite heavily and routinely upon augmentation from CONUS supporting agencies. For example, General Horner's "Black Hole" air operations planning cell routinely turned to Col John Warden's "Checkmate" division and other agencies in the Pentagon for help.[19] Other services will increasingly rely upon split staff support as well. The US Army III Corps had begun tailoring its support staff for split based support in anticipation of forward deployment for crisis response. Its Deployable Joint Task Force Augmentation Cell (DJTFAC) provides rapid response for support to planning and execution of forward-deployed operations. However, its deployability means the

DJTFAC is too small to execute all the functions normally associated with a JTF or Corps staff, and thus relies upon communications with CONUS-based elements of the Corps staff for such support.[20]

Exacerbating this reliance upon "stay behind staffs" is the growing need of the US military to enhance its lethality through precision strike. Any such precision capability places a heavy burden upon intelligence preparation of the battlefield (IPB) for target identification, prosecution, and battle damage assessment (BDA). Theater planners require both a robust intelligence collection capability, and an extensive information dissemination network to deliver targeting-quality information to tasked units. These requirements can be antithetical to the need to rapidly deploy forces to undeveloped theaters.[21]

Smaller forces have also placed increased emphasis upon joint and combined force capabilities. Forces in theater must increasingly turn to other services (or even countries) to help overcome shortages or create efficiencies in combat capability. Integrating the activities of joint forces dispersed across a theater of operations requires the creation, communication, and maintenance of a common concept of the situation and the planned operation. This commonality also must extend to communications capabilities and procedures.[22]

Increased emphasis upon supporting theater and tactical operations with strategic space-based systems also creates new challenges. Information flow from strategic and space systems was not designed with tactical support in mind. Yet a tactical commander cannot afford the overhead cost required to sift through the vast number of raw data streams feeding strategic users and integrate disparate pieces into a product pertinent to his needs. These costs are prohibitive in terms of mobility (since large wideband satellite dishes are not very mobile), time (since most of the data received will be irrelevant to the immediate issue), and manpower (since manning reductions leave staffs ill prepared to take on additional functions). Thus the tactical commander requires a simple, rapid, integrated, tailored, yet adaptable product which supports his decision-making needs. Reconciling these requirements with existing architectures requires consideration of a number of tradeoffs.

These trends alone hold significant challenges for the continuing adaptation of the US military to its new roles. However, this adaptation is not taking place in isolation. Other trends in the world and space communities will also impinge upon US space control policy and doctrine.

1-3b: Increasing Capabilities Outside DoD:

Perhaps one of the most significant changes in the nature of military space and its application toward terrestrial force capabilities is the rapidity with which the military has lost the technological edge in space. To a significant extent, this loss results from the same budgetary pressures which cause the military to be so dependent upon space-based capabilities. The US military can no longer afford to research, develop, and field DoD-unique space systems. Compounding this situation is the rapidity with which commercial space technology is evolving, outpacing the military acquisition cycle. Existing systems and those about to come on line are the result of Reagan-era budgets. The result is an extremely expensive, militarily unique space capability based upon 10 year old technology, which has been overtaken by faster-moving, more capable commercial development. Also feeding the pace of commercial development is the continuing declassification of military technologies. President Carter declassified technology associated with space based imagery capable of 10 meter resolution.[23] Landsat and SPOT satellites quickly followed, both of which have provided a great deal of militarily useful data, despite being commercial ventures. The US Central Intelligence Bureau is currently under direction to declassify technology capable of 1 meter resolution. Commercial ventures are already underway to exploit this trend.[24]

To some degree, the US military has also become victimized by its own success. One of the pressures feeding the trend to commercialized satellite imagery was the decisive impact of successfully integrating such capabilities into operational designs. The outcome of being on the wrong end of the information differential was sufficiently catastrophic to convince many governments and military establishments of the wisdom of investing in space support. Although relatively few nations have the infrastructure, technology base, or fiscal resources to become a space power, the availability of commercial licensing, data sales, and launch services make such support readily affordable to nearly any nation (as well as several non-national organizations). The potential threat of such availability becomes clearer when one considers the fact that Iraq was in the process of purchasing a Chinese-made surveillance satellite from Brazil when the Gulf War began.[25]

Thus, despite its origins in strategic defense, space control remains a viable, and even crucial doctrine, even after the passing of the Cold War power structure. Indeed, the changes in the world since the Gulf War only serve to reinforce and validate the need for a more operationally oriented space control policy, doctrine, and force structure. The dependence of the US military upon space support will only increase, given the nature of future operations and force structure. The next section will examine the characteristics of the existing military space support structure to identify potential areas to better assure access and vulnerabilities which could threaten that support.

SECTION II: ASSURED ACCESS TO SPACE SUPPORT

Providing terrestrial forces access to space support requires a tremendous architecture, the majority of which is invisible to the supported commander. This section examines key segments of this architecture, and assesses the vulnerability of each to interdiction through enemy action. These segments fall into three general categories; satellites, ground sites, and the communications links between them.

2-1: Satellite Vulnerability

The potential ability to physically destroy military satellites has held the attention of military planners for decades.[26] Despite the extreme difficulties in achieving the conditions to do so, destruction has a number of advantages over other potential means of space negation. In particular, satellites are high-payoff targets, in that they often comprise single points of failure in a space support architecture for a given theater. Although the enormous distances involved make satellites difficult to acquire and track, their movements are predictable once initially cataloged. Despite the hostile nature of the space environment, satellites themselves are quite fragile. A myriad of exploitable single points of failure exist in every design, despite system redundancies.

The character of the US military space infrastructure also adds to the attractiveness of targeting its satellites. Over time, the US had made the decision to base its space force structure on a small number of extremely capable, long-lived, and thus expensive satellite platforms. This reliance makes the potential loss of any one such platform a cause for national concern. The US military began acting upon this concern in the late 1980's by introducing a number of survivability initiatives for all segments of the US space infrastructure, to include satellites. However, only a few got underway before the end of the Cold War, and most were canceled in the budget reduction which followed.[27]

The trend toward tactical support from national space capabilities has exacerbated the demands placed upon these systems. Mr. Martin Faga, former head of the National Reconnaissance Office (NRO), admitted the inability of national space capabilities to meet this increased demand, which places an even greater value upon existing systems.[28] Thus the potential impact of losing even one such platform could have catastrophic consequences on intelligence flow into a theater conflict.[29]

The lack of a robust US launch infrastructure also compounds the attractiveness of satellites as high payoff targets for any potential enemy. If an enemy succeeds in destroying a satellite on orbit, a replacement may not be forthcoming for months. Any launch requires months of preparation, with facilities scheduled years in advance. As a result, military and some commercial users employ on-orbit spares, satellites which remain inactive until needed.

One such satellite was a second generation Defense Satellite Communications System (DSCS II) activated for the Gulf War.[30] However, this example also demonstrated the problems with exclusive reliance upon on orbit spares. This satellite had experienced some component failures during its inactivity, and required time for reconfiguring and testing before it could be operational. Space remains an extremely hostile environment, and spares degrade over time, reducing their useful lifetimes. Maintenance of on-orbit spares thus sacrifices some degree of cost efficiency for rapid reaction. As a result of continuing budget reductions, pressures are emerging which could drive the DoD to reduce its on-orbit spare posture.[31]

While negating space support through physical destruction of satellites presents obvious utility, the difficulties in doing so have thus far rendered it beyond the means of most nations. However, integration of readily available technologies would seem to provide any number of countries with a rudimentary ASAT capable of threatening low orbiting satellites. The ability to intersect an orbit at any given point in space has been considerably simplified by GPS availability, and the proliferation of ballistic missile technology. Information regarding the orbital parameters of US satellites is readily available in open source literature.[32]

The key difficulty in creating a viable ASAT weapon lies in resolving the endgame, actually getting the ASAT close enough to the target for its kill mechanism to be effective. Such maneuvering requires extremely detailed knowledge of the target position and motion, as well as that of the ASAT enroute. This requirement translates into the need for an extensive space surveillance capability. At present, only the US has this capacity. (Russia has some residual capacity, but lost much of it during the dissolution of the USSR.) The only alternative to such a network is an extremely sophisticated ASAT, with more complex detection/tracking sensors, requiring guidance control and fuel, in addition to some type of enhanced killing mechanism. This type of ASAT also requires considerable time to effect its intercept, as did the Soviet co-orbital ASAT. This time allows the target an opportunity to maneuver out of the ASAT path, albeit at a significant cost in fuel. The motivation to make the enormous investment in developing this capability (and potentially sell it to others) must depend upon the expected return.

Several factors affect this return, not the least of which is the nature of space as an operating medium. The use of a collision-based ASAT has a major drawback, when applied to a situation of less than strategic importance. Such a collision in space generates a large quantity of debris. Some of that debris will de-orbit fairly rapidly, and burn up harmlessly in the atmosphere. The remainder, however, will continue to orbit, gradually spreading to create a miniature "asteroid belt" through with other low earth orbiting satellites must fly. For any given orbit, the probability of collision between satellite and debris is quite small. Over time, however, this probability quickly increases to an unacceptable level.[33] The presence of flotsam from a myriad of previous space activities already poses risks to space platforms. USSPACECOM must track and catalog space debris to mitigate the threat to ongoing space activities, including those of the Space Shuttle.[34] Thus any space faring nation considering the employment of such an ASAT must weigh the tactical advantage conferred against the probability of debris-induced fratricide. The court of world opinion would also condemn the employment of such an ASAT because of the indiscriminate collision threat posed to all satellites in low earth orbit.

One ASAT technique which remains feasible is the first one employed decades ago; detonating a nuclear weapon in low earth orbit (LEO). This technique is really only viable for a non-space faring nation, or an international pariah (or non-national/terrorist entity). Even more than the debris hazard just mentioned, a nuclear ASAT presents a long term, inescapable, and wholly indiscriminate menace to LEO satellites. In addition to near-term effects (which are also indiscriminate), a LEO nuclear blast creates a miniature enhanced radiation belt which will greatly accelerate the degradation and ultimate failure of satellite components. No truly cost effective on-board defense is feasible in the face of such a threat.[35] The only viable defense to such action would appear to be a well thought out and clearly communicated strategic deterrent.

Direct engagement of a satellite by a space-borne ASAT platform is only one means of negating a satellite. Both the US and USSR have poured a great deal of money into research of directed energy weapons.[36] Such weapons can serve dual purposes of ASAT and ABM defense. These weapons fall into three general groups: particle beams, lasers, and high-power microwave (HPM) devices. Although SDI explored a number of proposals for placing such capabilities in space, the extreme technological risk and cost required to do so made each unacceptable. Pending a technological revolution, any future cost/benefit analysis stemming from tactical scenarios would arrive at the same conclusion.[37]

Terrestrial basing of such a system could provide a different calculus, however. The size and power constraints upon space platforms do not apply to ground stations. Indeed, the Soviet laser research (and nominal ASAT) facility at Dushanbe had the entire output of the Brezhnev hydroelectric dam at its disposal.[38] The ability to selectively disable or temporarily deny a space platform access to one's territory offers a powerful incentive for investing in such a weapon. However, the laws of physics place limitations upon the performance (and thus utility) of each class of energy weapons. Terrestrially based particle beam weapons, as currently envisioned, suffer prohibitive propagation losses.

Lasers also suffer from a number of propagation problems, to include simple cloud obscuration. High power microwave/radio frequency weapons can suffer from problems associated with atmospheric ionization.[39]

Regardless of terrestrial or space basing, each class of directed energy weapon requires extremely accurate pointing and tracking mechanisms to engage satellites in low earth orbit. Accurately slewing large aperture machinery quickly enough to cope with the high crossing rates associated with LEO satellites is not trivial. The introduction of GPS and ring laser gyroscope technology may mitigate this difficulty to some degree. However, the system must still be able to acquire and track the target so as to illuminate it with sufficient power for sufficient dwell time to generate the desired results. Targeting higher altitude satellites imposes far less stringent tracking requirements, but requires immensely greater power. In short, any terrestrially based ASAT still requires cueing and other support which again translates into the need for a significant space surveillance capability.

2-2: Ground Site Vulnerability

Although satellites make lucrative (if difficult) targets, each requires inputs from a controlling ground site to function. These ground sites not only uplink functional instructions, like where to image with what sensors, but also conduct on-orbit maintenance functions. For example, GPS satellites receive a daily clock update from the ground facility at Falcon AFB, CO. Without this update, the internal clock drift of each satellite could quickly render the entire constellation useless.[40] Other functions include hardware and software configuration changes, as well as anomaly resolution when a component malfunctions. Because of worldwide demand placed upon on-orbit systems, and line-of-sight requirements for satellite communications, the AF Satellite Control Network (AFSCN) is a distributed entity, with fixed sites around the world.

These AFSCN and other ground control sites also provide another group of potentially lucrative targets for negating a US space advantage. Similar sites also act as fusion centers and relays, capable of receiving multiple broadband satellite downlinks. These sites synthesize the data into usable information, and then disseminate the resulting product across tactical user networks. Figure 2-1 illustrates one such network. Disabling one or more AFSCN or ground processing sites could significantly reduce information throughput to the end users, or introduce enough delay to render the information far less useful. Such actions would not of themselves have catastrophic consequences, but the effects could be of long duration and affect a number of space systems.

Recognizing the potential impact of such losses, USSPACECOM has undertaken a number of steps to mitigate against such consequences. The creation of the Consolidated Space Operations Center (CSOC) at Falcon AFB, CO, replaced a far more vulnerable satellite control and test facility in California. Strategic systems like Military, Strategic, Tactical and Relay (MILSTAR) system and the Defense Support Program (DSP) have mobile satellite control facilities in case of emergency. Other system-specific control facilities, such as DSCS Operations Centers (DSCSOC) are dual-tasked to provide an internal backup capability in case a site drops off line. For example, Ft Dietrick, MD, serves as the primary DSCSOC for the Atlantic DSCS satellite, but also as the backup DSCSOC for the East Pacific DSCS satellite.[41]

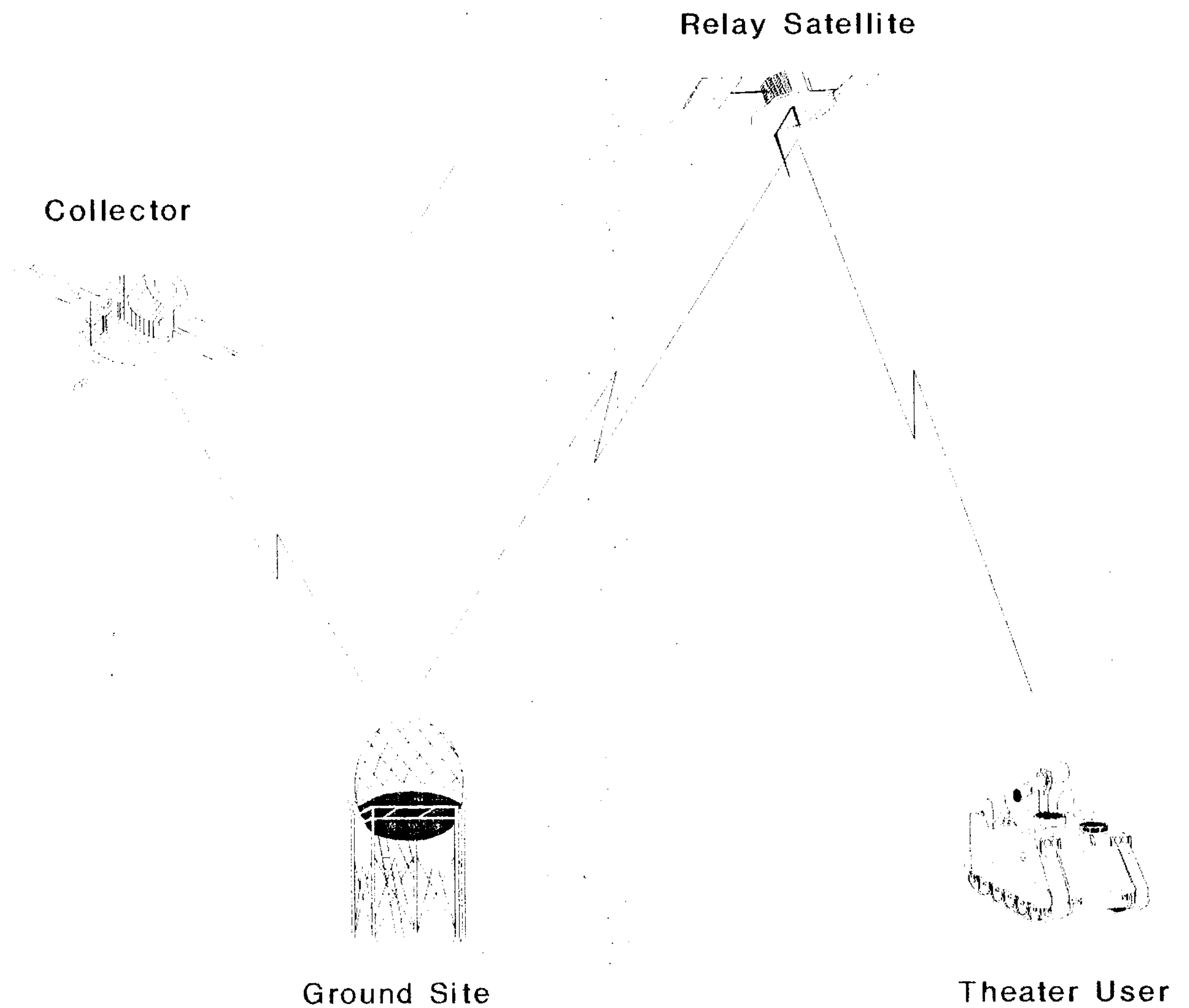


Figure 2-1: Notional Intelligence Data Flow

Another method used to enhance the survivability of satellite control is the use of on orbit relays. DoD uses channels on NASA's Tracking and Data Relay Satellite System (TDRSS) as well as the military Satellite Data System (SDS) to relay satellite commands, telemetry, and other data beyond line-of-sight to CONUS facilities, such as CSOC. MILSTAR will also possess a satellite-to-satellite relay capability. The ability to relay data in this fashion mitigates the potential impact of losing a few overseas control sites. The throughput of the system is limited, however, making the maintenance of a ground based AFSCN a continuing requirement.[42]

2-3: Communication Link Vulnerability

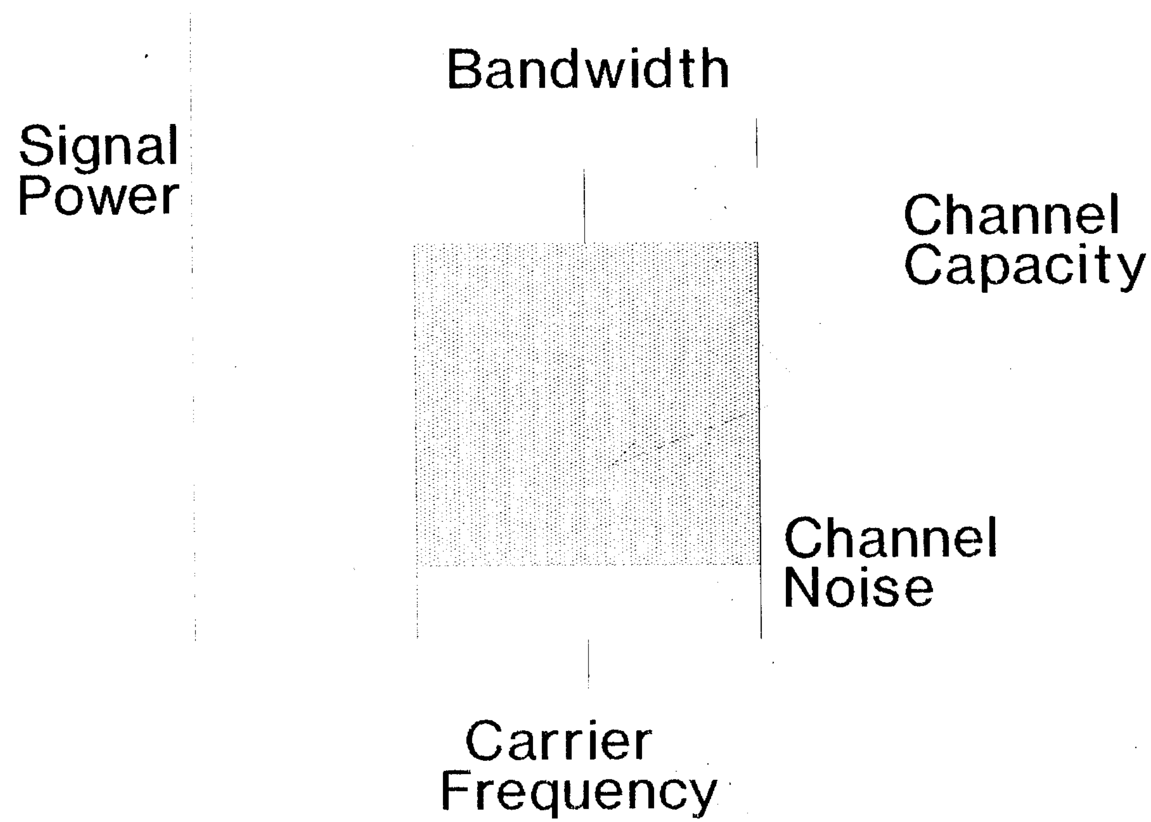
Discussions of potential vulnerabilities have thus far concentrated upon critical nodes in the space support architecture. Another area of concern lies with the linkages between these nodes. Without the communications links to connect them, the military space support capability dissolves into disparate and ultimately irrelevant individual pieces.

Providing long haul communications is the most prevalent space support service to theater and tactical forces. At any given time, 80% of US military communications relies directly upon satellites for connectivity.[43] Military satellite communications (MILSATCOM) provides the primary pipeline for strategic (and much tactical) intelligence flow into and throughout any given theater. While MILSATCOM provides an unprecedented mechanism for connectivity, it also may soon provide unprecedented challenges for distributing the increasing volume of data demanded by interconnected users.

As Figure 2-2 illustrates, three interrelated factors determine the information-carrying capacity of any communication channel. If one thinks of the channel as a cup filled with information,, channel bandwidth is the cup's width. The bandwidth available for any channel is about 10% of the signal frequency. Thus a signal of 3 gigahertz (3×10^9) frequency has about 300 megahertz (3×10^6) of bandwidth available. Thus higher frequencies are better for carrying capacity. Transmitter power is similar to the cup's height. However, the satellite itself imposes an upper limit upon transmitter power. If the signal power climbs above a certain point, the satellite amplifiers can "saturate," resulting in a signal too distorted to be useful. Noise in the channel determines where the cup's bottom lies. It is important to note that the relationship of power and noise actually determine the cup's depth. In general, signal power should exceed that of the noise in the channel by a factor of 10 or more. Failure to do so degrades or eliminates the ability of the receiver to extract the information contained in the signal broadcast. Transmitted signal losses and noise introduced enroute cause satellite communications to require far more bandwidth than other methods for a given message. For instance, transmitting an average television signal via satellite requires 36 megahertz (MHz) of channel bandwidth (which uses a 4 gigahertz (GHz) carrier frequency). By comparison, a local terrestrial television broadcast requires less than 10% of that figure. Hard-wired communications (e.g., cable) contains less noise, and thus require still less bandwidth.

The role of the satellite itself in such long-haul communications is quite simple. It merely receives the transmitted signal and re-broadcasts it (noise and all) back to the earth. Many satellites have steerable antennas to direct a fairly narrow spot-beam to specified locations. Most satellites also have additional earth coverage transmit and

Figure 2-2: Channel Capacity vs Bandwidth, Power



receive antennas, which extend selective coverage to most of the earth visible to the satellite. Although satellites themselves are complex machines, their functions are extremely basic. Almost all are simply repeater stations. The ground facilities mentioned previously perform antenna direction, power management, channel allocation, access, and all the other functions required to establish and maintain the communications links.

The tenuous nature of the satellite communication link, combined with the inability of the satellite to distinguish message from noise within the signal channel combine to make such links extremely vulnerable to hostile action. The reliance placed upon the availability of these channels by the US military provides more than ample motive for such action. Military sources acknowledge that, "Satellites were the single most important factor that enabled the US land-based forces to transition quickly and smoothly from almost nothing to an extensive tactical communications network in the area of operations."[44] The failure of Iraq to exploit that reliance in the Gulf War has perplexed many analysts. After the war, intelligence sources reported finding four Soviet-made ultra-high frequency (UHF) jammers of sufficient power to shut down at least 95% of the MILSATCOM links with the Navy.[45] In the end, one analysts' assessment was simple: "We got lucky this time." [46]

2-3a: UHF

The MILSATCOM systems which most concerns such analysts are those which use UHF for their operations. Such systems have a number of advantages which make them extremely useful for tactical operators. Perhaps the most important of these is availability. UHF networks have been in use for a long time, and have a number of satellites supporting them. AFSATCOM and FLTSATCOM originally carried Emergency Action Messages (EAM) to deployed forces at data rates as low as 75 bits per second. Since then, the Navy has augmented its FLTSATCOM constellation with a number of commercial UHF satellites (Gapfiller, LES-9, LeaSat, etc). Because of the nature of the EAM network, UHF equipment is in place and in daily use by US forces around the world. The US Navy, in particular, relies heavily upon UHF satellite communications because of the ability to use small antennas, coarse pointing accuracy, simple receivers, and modest amounts of power to convey and receive essential message and voice traffic.[47]

Unfortunately, these same characteristics make UHF communications the least survivable in a hostile communications environment. Because of its bandwidth limitations (5 - 25 KHz per channel), UHF is incapable of meeting the user demands for data dissemination. Operations in the Gulf War so saturated every UHF satellite in the region that rigorous channel management became necessary to minimize jamming by mutual interference from ground users.[48] For the same reason, UHF is incapable of incorporating any but the most rudimentary electronic counter-countermeasures (ECCM) for signal protection. Moreover, the low power and small antennas of tactical users make jamming satellite uplinks (and perhaps even downlinks) fairly simple.[49]

One unique and extremely expensive capability of selected AFSATCOM channels is that of regenerative communication. In a regenerative channel, the satellite segment of the communications link acts as more than an amplified echo. Within the satellite, processors demodulate the received signal to extract the original message, then perform error corrections, and remodulate the message onto a new signal for transmission to the receiver. The net effect of this procedure is to remove the vast majority of noise-induced errors in the signal, thereby greatly improving the chances the message will arrive intact at the receiver. Regenerative channels also complicate the problems of any would-be jammer.[50]

2-3b: DSCS

The primary MILSATCOM system which supports strategic inter- and intra- theater data flow is the Defense Satellite Communication System (DSCS). At present, and for the foreseeable future, DSCS will be the backbone of the Defense Communications System. It operates in the Super High Frequency (SHF) range, which provides ample bandwidth to support high data rate throughput lacking in UHF systems. As this discussion will explain, DSCS is the only MILSATCOM platform which does so.

DSCS operates at a nominal 7 GHz downlink (8 GHz uplink), which provides ample bandwidth for high data rate communications, such as imagery dissemination.[51] Unfortunately for the tactical user, high data rate communications (also called wideband communications) require very large antenna arrays. These large antennas (40 ft diameter) are necessary to generate and collect enough signal power for the receiver to extract the large amounts of data from the inevitable noise in the channel. Not only are such structures insufficiently mobile to support tactical operations, their signature (visible and electronic) would place them, and anyone nearby, at substantial risk by inviting an enemy attack. Accordingly, a few protected DSCS "gateway" stations receive most wideband communications, then relay data subsets to users via "hub and spoke" networks. Even relatively narrowband communications, such as voice and message channels via DSCS require large antennas. Ground

Mobile Force (GMF) networks also rely upon "hub and spoke" arrangements centered around 8 or 20 foot antenna dishes for intra-theater narrowband communications.[52]

Using DSCS channels for wideband communication leaves little bandwidth available for ECCM to protect this vital data stream. The third generation DSCS satellite (DSCS III) uses a unique combination of ground and satellite capabilities to protect the network from jamming. As mentioned previously in this section, the DSCS system has redundant ground control sites (DSCSOCs) around the world. Each monitors DSCS III satellites for signs of interference or jamming. If a DSCSOC detects a jammer, the DSCS III antenna can locate and isolate the jammer signal. The DSCSOC can then reconfigure the DSCS III satellite antenna to create a "null" (area of decreased antenna sensitivity) over the jamming site, thus preserving the data capacity of the channel.

2-3c: MILSTAR

The latest generation of military-unique MILSATCOM platforms is the Military, Strategic, Tactical, and Relay (MILSTAR) system. MILSTAR is a remnant of the Reagan-era space control doctrine. This system, as originally designed, would provide unprecedented, uninterruptable communications capability (to include continuous nuclear command and control) throughout a protracted strategic nuclear exchange. Its survivability features are numerous. The system design included satellite crosslinks, regenerative channel processing, mobile ground control elements, semi-autonomous satellite operation, antenna nulling, and extremely high frequency (EHF) operation. Using 20 GHz downlinks (44 GHz uplinks), MILSTAR will have unprecedented signal bandwidth, when it becomes operational.

This bandwidth will not translate into wideband communications capability, however. MILSTAR was designed for nuclear users requiring small physical and electronic signatures as well as extremely robust communications links. MILSTAR terminals have very small antennas, but compensate by using enormous bandwidth to create low probability of detection/interception (LPD/LPI) communications signals with unprecedented ECCM protection. Signal bandwidth used for such protection is unavailable to carry data. The entire MILSTAR architecture was designed to execute only one, narrowly-defined function. It was to ensure the same narrowband Emergency Action Message got through to all required users, regardless of any and all foreseeable circumstances. As a result of this design, MILSTAR is presently incapable of supporting wideband communications.[53]

The next generation MILSTAR satellite (Block II) will be capable of supporting medium data rates (up to 1.5 million bps) but is already inadequate to keep up with the rapidly increasing demand of tactical and theater users.[54] Estimates by the General Accounting Office and DoD place SATCOM throughput requirements to support the current pace of military operations at 1 billion bits per second. By 1997, the DoD expects that figure to rise by another 50% to 1.5 billion bps.[55] Even this growth figure may be conservative, in light of the increasing emphasis on military "information operations." By way of comparison, a single DSCS II satellite can relay only 410 million BPS, (within its field of view) with no ECCM protection. DSCS III offers some protection, but only 375 million bps.[56] In short, military-specific communications satellites are inadequate to meet current requirements, much less those in the near future. Meeting the information requirements of the Gulf War required more SATCOM capability than was available. After saturating FLTSATCOM, Gapfiller, LES-9, and LeaSat, Defense Information Systems Agency (DISA) mobilized 2 DSCS II satellites, 1 DSCS III, the British SkyNet, 2 INTELSATs, and INMARSAT.[57]

2-3d: COMMERCIAL

One singular feature stands out regarding the SATCOM support pressed into service to support the Gulf War: As with the National Reserve on land and the Civil Reserve Air Fleet (CRAF) in the air, the US military required augmentation in space from commercial SATCOM. This trend will continue in the future, and appears to be the only means of supporting the DoD's growing requirements. Budgetary pressures, prolonged acquisition cycles, and the rate of technology growth has placed the commercial sector in charge of the future of MILSATCOM, as well as other elements of DoD space activities.[58] While acknowledging that dedicated satellite systems will still be needed for some defense-unique services, DoD acquisition officials have indicated that the future direction of MILSATCOM must lie with less survivable commercial systems.[59]

Given the growing DoD reliance upon satellite communications and the potential impact of its loss upon military command and control, the issue of commercial SATCOM survivability warrants further scrutiny. In general terms, making SATCOM survivable does not make efficient use of resources, as MILSTAR's design has already demonstrated. Survivability is thus diametrically opposed to profitability in commercial enterprise. Unless the US military can underwrite those inefficiencies which contribute to survivable commercial support, no incentive exists for the industry to provide any on its own.

The potential threat to commercial SATCOM is no less than any posed to military SATCOM. Indeed, signal piracy of commercial SATCOM has already been demonstrated. Without the addition of significant amounts of on-board processing, a satellite will treat the strongest received signal as legitimate, treating anything else as noise. In 1986, an individual calling himself "Captain Midnight" overpowered the legitimate uplink to a Hughes Galaxy satellite. As a result, Home Box Office viewers across America received a new satellite downlink containing Captain Midnight's protest at HBO scrambling its signal. Although he used commercial equipment, a simple 10 foot parabolic antenna with a modest (250 watt) transmitter would have the same effect.[60] If such an effort were combined with the ability to mimic a military encryption code, the result could be a command and control catastrophe.

2-4: Assuring Access

At present, theater communications links would appear to provide an enemy with a high payoff target set for only a modest investment. Indeed, General Horner himself admits, "The way we gather and disseminate data...is our vulnerability. The enemy will seek out our key nodes, just like we sought out Saddam Hussein's."[61] At the same time US forces require increased and reliable space based communication support, the nation has been forced to accept increasing risk in the reliability of that support in order to keep abreast of demand.

Accordingly, the key lesson for a theater commander in this examination of vulnerabilities versus viable threats is that his assured access to space support is not assured without active measures on his part. To understand the threat, he must first understand his degree of reliance upon a space architecture and its vulnerabilities. Space lines of communication are just as vital as any other form, and warrant equal attention. The commander's intelligence preparation of the battlefield (IPB) must therefore include an analysis of enemy threats to US forces' assured access to space support.

Fortunately, the commander has access to considerable assistance in this regard. USSPACECOM and its service components can provide Space Support Teams (SST) to augment CINC planning and execution staffs.[62] Similar teams can help in the CINC's deliberate and crisis planning processes by assisting his staff prepare the Space Operations Annex (Annex N) to an Operations Plan (OPLAN).[63] The importance of incorporating these teams early in the planning process and throughout execution cannot be overstated. By virtue of his reliance upon space support, the terrestrial commander has become an integral part of the space control effort. As the reliance of US forces upon space support increases, so will the significance of orchestrating all applicable assets to protect access to that support.

The execution of space control doctrine must thus include terrestrial forces, including those of the theater commander.[64] Assuring access to space requires that the theater campaign plan include specific measures to negate the enemy's ability to interfere with that access. Failure to give adequate priority or resources to this requirement will assure increased difficulty (and casualties) in the endeavors to follow. Just as air superiority is the Air Force's first priority in a theater of operations, establishing information superiority must be a priority in order to set the initial conditions for success in other media.[65] Although this section focused upon building one aspect of this information superiority, the next will address negating that of the enemy.

SECTION III: SPACE DENIAL OPERATIONS

Any potential enemy's space support architecture will contain the same segments (and vulnerabilities) as that supporting US forces. While US space force structure enjoys some unique capabilities, it remains extremely limited in terms of exploiting these vulnerabilities. In general, existing US space negation capabilities are limited to operations against an enemy's ground sites. This section examines the potential to develop both lethal and non-lethal negation capabilities directed against the other segments, as well as some of the issues associated with each.

The previous section outlined the difficulties facing an enemy seeking to negate the space segment of the US space support architecture. The same difficulties exist for potential US space denial operations, with one exception. The US maintains the Space Surveillance Network (SSN), a far-flung net of outposts which serve to survey, track, and catalog every object in space larger than a softball.[66] Like so many other strategic assets, this network's original focus was those objects launched from the Soviet Union. But once in orbit, the space vehicles (and debris) of all nations may be tracked with comparable facility over time. The potential contribution of this capability to space denial operations is invaluable.

Although the space surveillance network can catalog and even identify many space objects by function, a significant limitation lies in its inability to determine the intent of that function. For instance, the Space Defense Operations Center (SPADOC) at Colorado Springs may know that a given object is a Russian high resolution photo-intelligence satellite, but cannot know who or what the satellite is imaging (unless satellite maneuvers betray its intentions). SPOT uses an internal array of mirrors to afford it a wide area access without maneuvering, although it can only image a small segment at a time.[67] SPADOC provides commanders with satellite transit (SATRANS) warnings of reconnaissance-capable satellite overflight. For the majority of sensors, however, a theater commander cannot know when his operation is the target of satellite collection efforts.

3-1: Lethal Anti-Satellite Considerations

Negation of space based collection must then be based upon a potential, rather than demonstrated, threat, if such negation is to have operational utility. Imposing such a criterion greatly complicates the legitimacy of lethal space denial means, such as the conventional ASAT weapons seen to date. International conventions further add to this dilemma, with national sovereignty residing with each satellite. US space policy has clearly enunciated this convention by asserting the status of satellites as national property, with rights of peaceful passage through and operation in space without interference.[68] According to this convention, lethal negation should only be legitimately considered after demonstrably hostile behavior (thereby exercising the right of self defense). Such an employment scheme would relegate lethal ASAT means to "revenge-only" weapons, offering little protection or support to terrestrial operations. Providing proof of hostile collection activity could also compromise US capabilities and sources best left undisclosed.

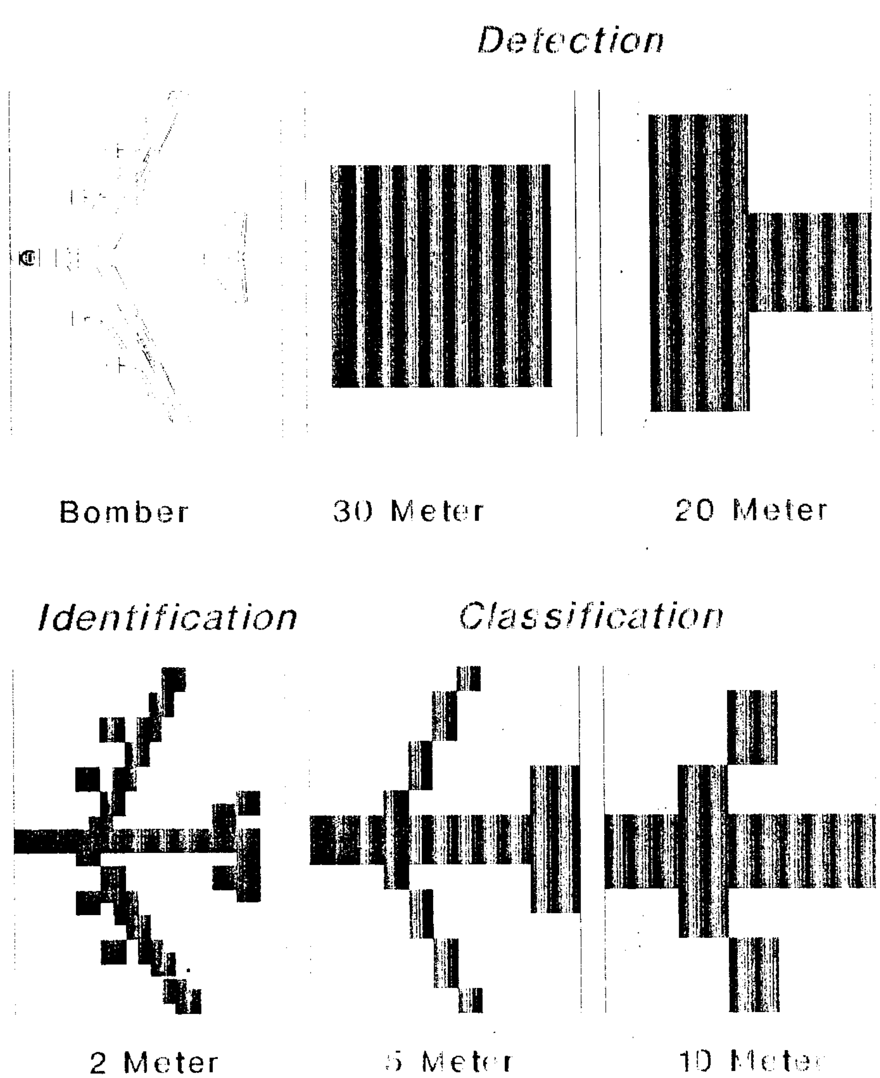
Based upon ASAT developments to date, the priority concern for space denial seems to be limited to low earth orbiting imaging satellites. Both the canceled F-15-based Miniature Homing Vehicle and contemporary

Army ASAT program have been direct ascent vehicles to engage satellites below 2000 km altitude.[69] Public statements by DoD leaders reinforce the impression of high-resolution imaging satellites as primary threats.[70] One could thus conclude that image resolution above that altitude is not sufficiently threatening to warrant negation. However, required resolution must be linked to the military function being performed. As Figure 3-1 illustrates, SPOT, specifically considered a threat, is capable of only 10 meter resolution. Yet this resolution is militarily useful for purposes of target detection and classification. Already in development are a number of imaging systems like the Murakaba, capable of 0.8 meter resolution from 1800 km altitude.[71]. The ability of current ASAT concepts to negate such platforms is uncertain at best, despite the great military utility of such a satellite.

Adding yet another dimension to this politico-military labyrinth is the potential for uncontrolled distribution of data from these third party satellites to provide military information to an enemy. Military and other analysts have made much over the notional impact of a third party satellite inadvertently (or otherwise) negating the coalition deception plan in the Gulf War. The Russians, for example, were certainly aware of General Schwartzkopf's left hook into the Iraqi flank, and had considerable interest in the outcome of events in the area. Had they used this knowledge to attempt to influence that outcome, the US would probably have demurred at employing a lethal ASAT as means for negation or retribution. (Not the least of NCA considerations would be the ongoing coalition use of data from these same Soviet sources.)[72]

The same is true of a notional mediasat covering future military operations. The relationship between governments, military, and the

Figure 3-1: Image Resolution vs Function



media is generally cool at best. The introduction of a mediasat capable of 1 meter imagery with no means for distribution control presents a nightmare scenario for many within the DoD. Yet, the US Commerce Department has already received permit applications for just such a platform. The Secretary for Space Commerce expects private satellites to be on orbit as early as 2000.[73] General Horner would be inclined to destroy such a satellite, lest it threaten military operational security. The subtleties of implementing such a strategy within the context of international law and domestic policy become almost unfathomable to the military theater commander simply trying to win a war.[74]

Such political concerns will thus keep operational control of lethal ASAT means with the National Command Authorities (NCA). Ongoing ASAT concept studies reflect this requirement for strategic command and control.[75] However, as the US Navy is particularly aware, such a strategic focus can obviate the operational contribution space denial might otherwise confer. For example, the politically-driven ASAT targeting strategy of the 1980's ignored Navy needs to negate the suite of Soviet ocean reconnaissance satellites which would otherwise target Navy ships. In general, it would therefore appear that lethal means for space denial will not be available for theater level space control or C^2W operations.

3-2: Non-Lethal Anti-Satellite Considerations

While the majority of attention has focused upon lethal ASAT technology for the past 30 years, nonlethal means for negation also exist. One of the simplest of these is a result of the SATRANS message; concealing or camouflaging those assets of interest to the enemy until danger of detection is past. However, the proliferation of imaging technology and potential third party data sharing present a protracted danger which would be difficult to hide from without undue interference with operations. Such terrestrial countermeasures can still play an important role in conjunction with other space denial and C^2W operations.

3-2a: Economic Negation

The US employed another nonlethal space denial technique in the Gulf War which has great potential in the future. France's SPOT multispectral imagery was (and remains) a commercial commodity, available to anyone for a price (including both the US and Iraq). Although Iraq bought SPOT imagery to plan its Kuwaiti invasion, US diplomatic and economic pressures were able to cut off this flow of space-based imagery thereafter.[76] In the future, economic incentives, combined with a lethal ASAT alternative, could influence the flow of data to a potential enemy, or slow its distribution. As commercial enterprises expand into intelligence-capable systems, their profit motive and competition could create opportunities for economic pressures and incentives as another means of negating an adversary's access to space support. US possession of a lethal ASAT would present corporations with a straightforward choice between profit and loss. Such a "carrot and stick" approach to space denial could also keep the US out of a" bidding war" with an opponent, vying for access to commercial space support. General Horner was more explicit, seeking the ability to tell a commercial vendor, "You either quit selling the enemy pictures or we can fix it so you can't sell him the pictures."[77]

3-2b: Blinding

A less subtle, yet still nonlethal means of negating a potential enemy's space-based collection efforts is by using some means to blind the sensor. Clouds provide a naturally occurring example of blinding a sensor via obscuration. Specular solar reflection off a smooth ocean can also temporarily blind certain types of satellite sensors. These two examples suggest alternative means of negating imaging sensors.

A nonlethal ASAT system, using GPS and SSN data (and large amounts of fuel) for positioning could release a gaseous or aerosol cloud to temporarily obscure large areas of the earth from a satellite's optical and infrared sensors. Over time, the cloud would disperse, with the satellite none the worse for being thus negated. Less subtle, but more effective, would be the application of some substance directly to the targeted satellite's optics. By using a slowly sublimating compound, the engagement would leave no permanent damage to the target, yet effectively negate its ability to compromise military operations. A less elegant man-made cloud could entail the positioning and deployment of a lightweight "window shade" between the imaging satellite and target area. Given the development of large aperture sensors and mylar solar sails, such a concept is not as farfetched as it might sound. Although the cost effectiveness remains uncertain, a number of agencies are currently examining similar nonlethal negation mechanisms.[78]

A more direct means of negating an optical or infrared sensor would involve using laser energy to dazzle or blind it. One interesting advantage of such a means of negation is that it works only on satellites looking at the target area. Unfortunately, this also means the laser must be in the vicinity of the protected area. As explained previously, atmospheric properties can also adversely affect laser performance. The principal advantage of this type of negation (vs lethal laser engagement) lies in the reduced power requirements for the laser. The technology exists to dynamically compensate for atmospheric effects at modest power levels, as demonstrated at the USAF AMOS/MOTIF facility in Maui, Hawaii. The laser frequency must also lie within the bandwidth of the target sensor, since such blinding relies upon the concentrated intensity of the laser to saturate the sensors and light amplifiers within the satellite. Thus an optical sensor requires an optical laser frequency, vs infrared, or some other part of the spectrum. By targeting the sensor, such a scheme uses the focusing effect by the satellite optics to concentrate the laser energy upon the most sensitive (and vulnerable) satellite components. Slight increases in laser power could result in sensor damage, unless the satellite incorporates some type of shutter protection. However, this protection scheme also negates the sensor, thus achieving the same end.

3-2c: Jamming

As is the case with the US military space architecture, communications links abroad provide potential targets for space denial operations. Unlike the US, other nations have not invested heavily in ECM resistant SATCOM capability, and rely upon relatively vulnerable commercial SATCOM channels. Although simple jamming is possible, (within a number of constraints), Captain Midnight offers another potentially more viable strategy.

Jamming a signal is effective only so long as the jamming occurs. C^2W can be more effective over time by reducing or eliminating an enemy's confidence in his C^2 network. By combining the ability to steal satellite channels with the potential ability to break into an enemy's encryption scheme, a theater commander can plant false information into the enemy C^2 network. Even if the such deception efforts are not successful in themselves, they reduce the enemy's perception of reliability in his C^2 mechanism. Since speed and reliability of information flow are the key measures of merit in any such C^2 mechanism, the enemy decision process must slow down, or accept the risk associated with increased uncertainty. A few such instances of false data planted in the C^2 system could completely negate the enemy's access to space support, by eradicating his confidence in the validity of such support.

Two trends are already underway, however, which may make such C^2W far more difficult in the future. Commercially available encryption capabilities may soon outstrip any government's ability or resources to "break" them. Recently, the National Security Agency (NSA) and the Clinton Administration proposed the inclusion of a "clicker chip" in US telecommunication devices to allow a "backdoor" access to encrypted information.[79] Such efforts are indicative of the formidable capabilities of commercially available encryption means,

The other potential trend the US must contend with is a move toward distributed SATCOM networks. A number of initiatives are underway to reduce SATCOM reliance upon large fixed antennas and geostationary satellites. Such networks will instead use a large number of low earth orbiting satellites, capable of supporting cellular communication. Motorola, for example, is developing the Iridium system, which will use a constellation of 66 crosslinked LEO satellites. The system is designed to support any type of telephone transmission (to include fax and other data) between any two points on the earth at any time. Although only capable of supporting low data rate transmission (2400 baud) the network uses an automated switching/routing to ensure connectivity.[80] Such data rates may be adequate to support future enemies who will probably not share the extreme throughput requirements of US forces. At present, no lethal or nonlethal concepts appear adequate to interdict the communication flow of such a system.

3-3: Restoring Space Denial Feasibility

Executing space control in its classic sense may rapidly become to difficult to be cost effective. The ready availability of militarily useful imaging technology, contract launch service, third party technical (and other) support, and extremely robust SATCOM networks present a capability which may exceed the modest negation means available to the US military.

Applying the doctrine of space control (and space negation in particular) in an operational context thus requires some modification in practice. The US may be unable to totally "deny and enemy's use of space," but may be able to sever selected links to space support, and degrade others. The theater commander must be able to integrate this capability into his operational plan. By integrating a deployed Space Support Team into his staff, his intelligence preparation of the battlefield (IPB) can identify beforehand what access to space support the enemy possesses, and equally important, <u>how the enemy will use that access.</u> Understanding the relationship between enemy capabilities and enemy intent can identify key decisive points for applying the means for negation. The commander can then integrate these decisive points into his overall plan, so as to achieve space and informational superiority at a time and place of decisive advantage.

SECTION IV: CONCLUSIONS

Despite the best intentions of the adherents of the sanctuary school of space, such an outlook defies reality. Space has become a warfighting medium, one in which the US enjoys a decided (but perhaps temporary) advantage. According to Gen McPeak, if the US is to maintain that advantage, it must be prepared to abandon Cold War ideas about "militarizing" space.[81] As the US demonstrated in Desert Storm, the "militarization" of space has already occurred.

The pace of that militarization is increasing. As the US military continues to draw down, it must increasingly turn to support from space systems to maintain its operational capability. The same budgetary pressures which are driving the drawdown are also pressing military forces to increasingly employ commercial capabilities for space support. Theater commanders must understand and accept the increased risk to link survivability inherent in this reliance upon commercial support.

The space support which afforded the US its margin of victory in the Gulf War will be even more crucial in the next conflict. Yet the proliferation of satellite technology means that margin is rapidly diminishing. A number of nations have developed their own high resolution imaging satellites, with more on the way. For nations unable to create their own space support systems, both the means and incentive exist to buy such support on the open market. Ostensibly, space control will therefore be essential as a means to re-establish a degree of asymmetry, and help restore the margin of victory. By denying an enemy access to space support while preserving that of US forces, a theater commander may yet succeed in creating an exploitable information differential. However, space control doctrine still seems to reflect the strategic flavor of the Cold War, The result is a mismatch of ends and means, as evidenced by the pursuit of a strategically unacceptable solution for an operational/tactical problem. General Horner's proposal to use lethal ASAT negation of SPOT provides an illustrative example of this mismatch. As a consequence, Congress continues its reluctance to field a tactical weapon with such enormous strategic ramifications.[82]

Further complicating this policy question is the operational return gained from using such politically costly means. Space control doctrine and policy are currently unlimited. The demands of current space denial concepts are unconstrained, and are thus impossible. The destruction of every satellite and ground station owned by an enemy country would not utterly sever its access to space support. The commercial availability of surveillance data and robust communications networks such as Iridium will ultimately prove too costly to destroy, even if the national will to do so were present. The Mahanian concept of space control is thus both unacceptable and infeasible.

In light of this growing difficulty of denying an enemy's access to space or space-based support, it is time to look again at C^2W and control of other media. Air superiority and sea control are limited concepts. They are limited in scope, location, and time, as required to support a larger end. Control of space must fit into similar constraints. As the US moves further away from the Cold War, the potential for space control to become strategically decisive decreases. The transformation of space as the battleground for national survival to a combat support function for theater "vital" interests must be accompanied by a transition in space control doctrine. Space control, once envisioned as Mahanian, an absolute and decisive end, is now only a means, one which must fit into the ends dictated by theater objective, and those of the supporting C^2W campaign.

Space control operations should be oriented toward contributing to the information differential which the theater commander can exploit to his advantage. Accordingly, space negation efforts, as a subset of C^2W require focus and integration with other information negation activities, all contributing to the same desired endstate. Consequently, the Space Support Team must become an integral part of the theater planning and execution staff. Annex N of the CINC's OPLAN provides a rudimentary framework for this integration. However, space control under the aegis of C^2W creates additional dimensions to the construct of battlespace. This construct overlays unfamiliar temporal and topical contexts upon the traditional dimensions of height, width, and depth of the battlefield. This added layer of complexity also creates additional requirements to compete for already scarce resources. Within this vision of C^2W and space control, terrestrial assets may thus be inadequate to support the needs of even a limited space control campaign. Given the political nature of lethal ASAT employment, the US military needs to explore nonlethal methods of satellite negation, such as blinding, jamming, and other means.

In summary, space support has made a necessary transition from the strategic to the operational and tactical realms of the battlefield. Space control, as a military doctrine seems to be lagging behind, not yet in consonance with the needs of the US military faced with a "new world order." The pursuit of a lethal ASAT capability reflects the needs of strategic policy, but remains operationally irrelevant. Thus, even after space control doctrine makes the transition to emphasize operational support, the US military will lack a suitable force structure to implement it. However, the genesis of the USSPACECOM's space support teams has created the mechanism to execute operational space control when the doctrine and forces become available to do so.

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(11) National Space Policy, p 10.

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