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U.S. Space Systems: A Critical Strength And Vulnerability

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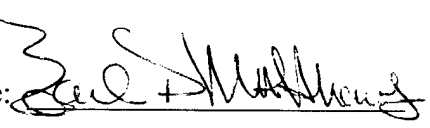
The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Air Force.

Signature: 

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15.Abstract: Desert Storm was the first war in which space systems were integrated into the operational and tactical order of battle on the ground and were largely responsible for the successful outcome. Since that time, the U.S. military has placed considerable emphasis on further integration of space into all operational areas. This growing commitment to space systems and the support they provide in the planning, preparation, and execution of major operations and campaigns could seriously threaten the effectiveness of the U.S. military if an adversary were to degrade or deny access to those systems. The increasing level of dependence on space systems creates both a critical strength and vulnerability. Space should not be viewed as the panacea of future wars because there are existing and emerging threats that could eliminate the support they provide. The United States was fortunate that conditions in the Persian Gulf were ideal for space systems and had the residual capability to optimally position it's assets. This paper will analyze the past, present, and future dependence on space systems and identify existing and future threats to space systems. The time is now for operational commanders to seriously look at what platforms (aerial and ground) are entirely dependent on space and what alternate systems are available. Of critical importance is the lack of a rapid space force reconstitution capability, the need for protection of critical space assets, and an offensive capability in space to neutralize enemy space systems.

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ABSTRACT of

U.S. SPACE SYSTEMS: A CRITICAL STRENGTH AND VULNERABILITY

Desert Storm was the first war in which space systems were integrated into the operational and tactical order of battle on the ground and were largely responsible for the successful outcome. Since that time, the U.S. military has placed considerable emphasis on further integration of space into all operational areas. This growing commitment to space systems and the support they provide in the planning, preparation, and execution of major operations and campaigns could seriously threaten the effectiveness of the U.S. military if an adversary were to degrade or deny access to those systems.

The increasing level of dependence on space systems creates both a critical strength and vulnerability. Space should not be viewed as the panacea of future wars because there are existing and emerging threats that could eliminate the support they provide. The United States was fortunate that conditions in the Persian Gulf were ideal for space systems and had the residual capability to optimally position its assets. The Defense Support Program, for example, also exposed a shortfall in space systems capability against the modern theater ballistic missile which exploits a short burn time. This paper will analyze the past, present, and future dependence on space systems and identify existing and future threats to space systems. It will also focus on space system support during recent operations and on plans for the acquisition of new space supported weaponry.

The time is now for operational commanders to seriously look at what platforms (aerial and ground) are entirely dependent on space and what alternative systems are available. Of critical importance is the lack of a rapid space force reconstitution capability, the need for protection of critical space assets, and an offensive capability in space to neutralize enemy space systems.

INTRODUCTION

The First Space War

Despite the fact that the United States has been active in space for well over three decades, it is only recently that space has matured into a warfighting medium. Desert Storm was the first war in which space systems were integrated into the mechanisms of battle on the ground and were largely responsible for the outcome.[1] Space systems support provided the operational commander with two crucial ingredients to success that his opponent simply did not have; information and control. The end result was the enlightenment of two groups. The U.S. military, namely the warfighter, saw the utility and realized the value of space support as a force enabler and its ability to provide a definitive advantage in the combat arena. Operational commanders embraced the newly employed capabilities and now want more. The other group was our potential enemies who also took notice of the great utility space systems provide. Almost every military in the world saw the value and contributions of space systems and are motivated to acquire their own capability or deny the United States the ability to exploit its capability.

The genesis of this paper is that space systems have become a critical strength to the operational commander because of the unprecedented levels of support they provide in the planning, preparation, and execution of major operations and campaigns. The United States has committed itself to improving the exploitation of space and will rely heavily on the capabilities it provides in the future. It is reasonably certain that in the next major conflict space systems, which represent one of the United States' critical vulnerabilities, will be the target of attack in an effort to gain access to and defeat its center of gravity. It is imperative that space systems, which have become of vital importance to the operational conduct of war, are protected. The preparation and execution of operational plans need to incorporate the contingency of the unavailability of space systems support.

MILITARY COMMITMENT TO SPACE

Growing Dependence On Space Support

Prior to the Persian Gulf War, space based systems primarily supported U.S. strategic interests. National satellite systems had been employed on an a limited basis in support of military operations in Libya in 1986 for Operation El Dorado Canyon; in the Persian Gulf in 1988 for Operation Earnest Will; and in Panama in 1989 for Operation Just Cause. When the Gulf crisis erupted in August of 1990, the potential contributions of the operational and tactical aspects of space warfare were not widely apparent throughout U.S. commands.[2]

As the United States began Operation Desert Shield, satellite systems were already in place providing important communications, navigation, surveillance, and weather information to national command authorities. In the weeks and months that followed, space systems played an important and ever expanding role in the planning and execution of the Coalition's efforts on the theater level. Two of the most visible systems were the Navstar Global Positioning System (GPS), which provided precise navigation data to forces, and the Defense Support Program (DSP), which detected the infrared signature of Iraqi SCUD missile launches. Space support was refined and improved throughout the conflict ultimately becoming an integral part of the intelligence, operations, and logistics aspects of combat. Perhaps no expeditionary force has ever had such detailed and current information about enemy dispositions. Certainly no commander since Napoleon had a clearer up-to-the-minute picture of the battlefield or of his own forces, or a better ability to communicate decisions and see how quickly they were carried out than General H. Norman Schwarzkopf. Directly attributable to space systems, the Coalition could not only posture effectively for defense, feint, and maneuver, but were also able to strike more accurately than ever because of detailed knowledge of target location, launcher location, and weather.[3] By the end of the war, space system support was widely recognized as a critical, valuable and necessary element of joint operations, largely responsible for the decisive victory.[4]

Despite the ultimate success of the war, some leaders were critical of the lack of pre-war plans to operationally integrate space support. General Charles A. Horner, the United States and Allied air component commander during Desert Storm who later became Commander in Chief, U.S. Space Command stated:

> We can do better than we did during Desert Storm. We have to make space efficient and responsive to wartime needs. We have to change our emphasis from strategic war to theater war. We have to get over the cold war and make sure we are equipping, training, and organizing to fight the kind of war that's probably going to be thrust upon us. All of us in the space community must concentrate our thinking on how we can directly support the warfighter.[5]

As a result, each of the services has already implemented vigorous programs to train and educates both the operational and tactical users of space products. Each of the component space commands has already established space support teams designed to go into the field and promote operational oriented understanding of space systems capabilities. In the future, this will provide force enhancement and ensure space systems are not viewed or treated as assets which are so unique as to be incompatible with operations planning or execution.[6]

Space Dependent Weapons

An indicator of exactly how acutely committed the U.S. military is to space exploitation can be seen in current acquisition programs for follow-on conventional ordnance. The Air Force and Navy are developing all weather precision guided munitions (PGM) which incorporate GPS navigation. The Joint Direct Attack Munitions (JDAM) and the Joint Standoff Weapon (JSOW) are conventional gravity bombs with large fins and a GPS guidance unit attached. A third program is the Triservice Standoff Attack Missile (TSSAM), which is a stealthy cruise missile with extraordinarily long range.[7] They are designed to replace the laser-guided bombs used with stunning accuracy against targets in Baghdad, which require clear weather and laser designation for delivery. Major General Larry L. Henry, Director of Operational Requirements in the Office of the Air Force deputy

chief of staff for Plans and Operations, exemplifies the current mentality toward exploiting space support:

> "...we want to be able to drop accurately through the weather and not need an illuminator to do it. The satellite based GPS guidance unit will make the dumb bomb smart and meet the need for an autonomously guided PGM. As we come down in force structure, the faster we put JDAM, JSOW, and TSSAM on our aircraft, the better. We have to give our aircraft maximum leverage."[8]

TENCAP (Tactical Exploitation of National Capabilities Program) is another effort to make national systems data available in a timely manner to enhance warfighting at the theater level. TENCAP includes numerous projects designed to utilize some of the capabilities of strategic satellites and provide support directly to combat forces. Two such projects are "Talon Sword" and "Talon Hook." Talon Sword successfully demonstrated sensor to shooter capability, when target data from an intelligence satellite was downlinked to the cockpits of an EA-6B and an F-16 carrying High Speed Anti-radiation Missiles (HARM's). The aircraft pursued a target from beyond visual range and fired over-the-horizon. With guidance fed to the missiles from the satellite information only, they scored perfect shots.[9] Talon Hook is a device that incorporates a tiny GPS receiver into emergency radios carried by aircrews. If an airman is shot down over enemy territory, he or she can transmit the exact location to rescuers via satellite. The electronic signal is so short it is nearly impossible to detect or trace.

Although these are examples of tactical acquisitions, they are indicative of a major movement within the U.S. military to maximize space capabilities at the operational level as well. With the requirement to perform missions with fewer forces, the commitment has been made to rely on space as the vital force multiplier required to maintain U.S. combat power. In the words of Togo D. West, Jr., Secretary of the Army; "...we are inextricably linked to space."

THE THREAT

Counterspace

There are a variety of hostile anti-satellite measures, some of which exist today and some which are known to be in development or technically feasible. These threats include: attacks against the ground-based telemetry, tracking, and command (TT&C) segments; Meaconing, Intrusion, Jamming and Interference (MIJI); Directed Energy Weapons (DEW); Particle Beam; High Energy Radio Frequency (RF) weapons; Space Mines; Electromagnetic Pulse (EMP); and Orbital interceptors.[10]

Attack of TT&C. Conventional attacks on ground installations controlling satellite constellations can render some systems inoperable or unusable. Navstar GPS has two ground link stations in the U.S. which maintain exact orbit parameters for the constellation. If both ground segments were eliminated, the system would be rendered useless. Given the ability of terrorists to bomb the World Trade Center and the Federal Building in Oklahoma City, the possibility of a successful attack against these satellite ground stations though remote, exists.

MIJI. Jamming of satellites or interfering with data links is possible. Communications satellites in the Ultra High Frequency band (UHF), like those used by tactical forces in theater, are very susceptible to MIJI. Super High Frequency (SHF) transmissions are also susceptible to MIJI but have a small footprint and are directional, making jamming difficult to accomplish.[11] There is a documented case of a U.S. communications satellite being interfered with for weeks, by a hostile state in the Middle East. When the U.S. satellite changed to a different frequency, the interference also changed channels, suggesting that the jamming was deliberate.[12] GPS satellites can also be spoofed (sent deceptive signals) which can induce accuracy errors. Spoofing has been demonstrated to be effective but it is isolated to a small area of coverage. In addition, photo reconnaissance satellites can be "dazzled" by electro-optical countermeasures temporarily "blinding" sensors.[13] Dazzling is technologically possible but there are no openly documented cases.

DEW. Directed Energy Weapons include lasers which from a ground-based site could damage solar cells, degrade electro-optics, vaporize control surfaces, and overheat electronic components of satellites in space. The former Soviet Union is known to have a high-energy laser research facility located at Sary Shagan. The United States has its own facility at White Sands missile range in New Mexico.[14] It is likely the Russians have some form of operational DEW capability.

Particle Beam. Powerful particle beam accelerators, similar to those now used in scientific research, might be focused in a tight beam that could be aimed from a ground or space based platform. The beam would be capable of damaging a satellite's electronic components. The Russians have explored its feasibility, however, and an operational unit will probably not exist until after the year 2000.[15]

RF Weapons. Also referred to as High Powered Microwaves (HPM), RF weapons could be employed against satellites out of geosynchronous orbits (19,600nm). These devices would produce damaging beams of electro-magnetic radiation that could burn out satellite electronics. Currently none of these weapons are known to exist.

Space Mines. A mine could be placed in orbit and, on command, maneuver next to a target satellite and stay within lethal range. A conventional or nuclear explosive device could then be used to destroy the target satellite on command, or if the mine is attacked or disturbed. Currently no country is known to employ space mines.[16]

EMP. Electromagnetic Pulse occurs as a result of nuclear warhead detonation. The electronics and communications subsystems of satellites in the line of sight of a nuclear burst could be seriously impaired or disrupted. Since space is a vacuum, radiation effects rather than the explosion can disable satellites over 1,000 kilometers away.[17] EMP is becoming a growing concern due to the feasibility, in the near term, of hostile Third World countries gaining access to a nuclear warhead and launching it into orbit on modified SCUD or No Dong type ballistic missiles. A single nuclear burst would have devastating and long lasting effects in space by damaging numerous satellites.

Orbital Interceptors. Orbital interceptors are more commonly known as ASATs (anti-satellite). The Russians currently have an operational ASAT capable of destroying U.S. satellites in low-earth orbit up to 2,000 kilometers. The co-orbital interceptor launches into an orbit similar to the target and uses a conventional warhead to destroy it. It is possible that the interceptor could be modified to employ a larger booster which could extend its range to geosynchronous orbit. In addition, the Russians have an inherent direct-ascent ASAT capability to attack low altitude satellites with a conventional or nuclear warhead.[18] The type of satellites most vulnerable to ASATs are the low earth orbiting reconnaissance observation satellites. While ASATs require some highly sophisticated technology, the deployment of a rudimentary ASAT capability by a country such as China, Israel, or India before the year 2000 is not out of the realm of possibilities. The Brazilian space launch vehicle (SLV), any of the Indian SLVs, the Israeli Jericho II or Shavit, the Iraqi Al-Abid, and even the Saudi DF-3 boosters have thrust available to reach low-earth orbit if they are employed in a direct-ascent mode. These platforms could be used to scatter small objects, such as nails or ball bearings, in front of a target satellite and affect a covert kill of the satellite.[19]

The ASAT has been the most controversial of all space programs. The United States had been developing an ASAT program until the late 1980s when Congress ended the funding. The main argument among critics, other than financial considerations and the potential for increased space debris, is that the employment of an ASAT capability would "militarize" space--the same argument that led to the demise of the Strategic Defense Initiative. However, many space activists argue that when countries started to use national space capabilities to support military operations, space was forever militarized. The bottom line is that wars at the end of this century, and into the next, will hinge upon an ability to deny hostile adversaries lethality-enhancing use of space. Thus, the United States needs to develop a capability to protect its own space assets and have the ability to deny or neutralize enemy space systems. The issue of space control will be hotly debated as more countries develop the capability to degrade U.S. access to satellites.

Many of the counterspace capabilities mentioned pose potential threats in time of war, but will not be operational for 10 to 20 years and beyond. However, space threats do warrant careful consideration by the operational commander and his staff while planning how "space control" will be established and maintained in the future.

Foreign Technology Proliferation

Perhaps the most imminent threat to U.S. national security and its position as a world leader in space is the proliferation of technology and emerging commercial space systems. Desert Storm made it quite clear that access to space is fundamental to modern war fighting and national security. Many Third World countries are pursuing a piece of the space frontier to strengthen their political position in the world. Ulterior motives exist, however, due to the fact that many of the emerging commercial technologies have military capabilities and applications. The most vivid example of this is in the current proliferation of commercial space-based observation platforms.

Except for the United States, the former Soviet Union, and China, remote sensing satellites have operated for commercial or scientific uses, and have had very limited military purposes. Depending on the type, satellites have provided high quality photographic, multispectral, and radar imagery. For military purposes, 2-meter resolution imagery is optimum and allows general identification of troop units, while 30-meter resolution allows for detection of airfields, ports, and harbors. The first U.S. civil space-based earth imaging system called Landsat (land satellite) provides 30-meter resolution and is directly downlinked to ground stations in a number of foreign countries where data is processed and distributed locally. The French satellite SPOT system offers 10-meter resolution to anyone on the open market and Russia is now selling (from its archives) 2-meter resolution imagery of almost any area in the world. Between 1995 and 2000, Brazil, Canada, China, France, India, Japan, and Russia will all field new systems with 5 - 10 meter resolution. Additionally, South

Korea, Israel, Pakistan, South Africa, Taiwan, Argentina, and the United Arab Emirates have expressed interest in operating their own independent systems.[20]

In the near future, access to outstanding resolution imagery will be widespread and uncontrolled. This has serious military implications considering that 30-meter Landsat imagery was used by U.S. forces during Desert Storm. From a military standpoint, even 30-meter resolution imagery allows forces to understand terrain and the position of permanent facilities, enabling easy interpretation of this data into battle plans before a conflict. The new systems to be fielded and the potential force enhancement they provide may be available to the next Saddam Hussein and will have a definite impact on the operational commander.

IMPACT ON THE OPERATIONAL COMMANDER

Future wars will be fought by men and women relying heavily on capabilities derived from space systems. The United States may be pitted against adversaries who also have military space assets, challenging U.S. space systems during military operations. Exploitation of these systems will be the distinguishing factor of the next century's warfare. Firmly embedded in space operations are distinctive advantages afforded operational commanders in planning and conducting all operations. The operational commander must understand what systems, intelligence, communications, weather, or weapons, are dependent on space. A theater commander must know when an adversary's space system threatens his operations and be able to choose an appropriate response. The current U.S. warning network uses ground-based sensors deployed throughout the world. In the future, the United States will need to field less vulnerable space-based systems to reduce the possibility of foreign interference.

Intelligence is essential to success in any military operation. It is imperative that commanders know enemy force disposition, strength, and the environment where the combat will take place. Today theater commanders enjoy real-time situational awareness in otherwise denied areas. Recognizing the need to provide this wealth of information to the operators when they need it, satellites are becoming the norm of operations rather than the exception. For example, U.S. operations in Desert Storm and Just Cause implicitly assumed that surprise was achievable because observation by the enemy was impossible beyond their front lines. Such an assumption could prove dangerously misplaced in future wars. The operational commander must be aware of the limitations of specific satellites (his own and the enemy's) and be prepared for their degradation in battle. Deception will become a critical component in defeating the enemy's sensors. Camouflage, smoke, and decoys are just as useful against space platforms as they are against aerial reconnaissance. Development of expertise regarding the adversary's space systems is needed to ensure that commanders know

exactly when foreign remote sensors will be in range to image them, what those sensors are capable of seeing, and how to defeat them.

Space warning assets provide a much larger warning and intercept envelope than ground-based radar, enabling the theater commander to take effective action. The United States was fortunate that conditions in the Persian Gulf were ideal for DSP, and had the residual capability to optimally position its assets. DSP also exposed a shortfall in its capability against the modern theater ballistic missile which exploits a short burn time. The theater commander must understand that the DSP system may not be as robust next time. This will be true especially if other demands are being made from multiple theaters. Also, DSP cannot provide quality warning in every theater, and it cannot give a launcher location accurate enough to target. If the operational commander can rapidly engage the enemy's weapons while they are still over the enemy's territory it will significantly impact the adversary's decision to use such weapons.

Commanders cannot relay battle plans to deployed forces without established assured communications. In the Persian Gulf, over 90% of U.S. communications requirements into, out of, and within the theater were supported by military and commercial communications satellites. While these links were not targeted by enemy jamming, this may not be the case in the future. For maximum benefit to the theater commander, small tactical terminals need to be deployed to link individual units with overhead networks. In an immature theater, without spaceborne communications, the rapid transfer of battlefield information from tactical to operational commanders and strategic-level decision makers would not be possible. By using capabilities of both military and commercial satellite communications systems, the chances of U.S. forces being isolated will be diminished.

Without a doubt, a significant advantage in war is delivering weapons on target. The lack of GPS in Desert Storm would have degraded the timing and tempo of the air and ground campaigns, and diminished the accuracy of weapons, resulting in more civilian casualties and more friendly fire incidents.[21] GPS enables U.S. forces to maneuver using all-

weather, day-night accurate positioning, navigation, timing and velocity data. For example, Iraqi forces in the Gulf War were limited to known roads in their own country, while coalition forces freely roamed the desert like native nomads. Precise navigation supports other critical uses as well: minefield clearance, artillery fire support, precision guided munitions employment, and covert missions. A theater commander needs to deny this capability to his adversaries in future conflicts while maintaining the utility for himself, or he may find a crucial element of his forces rendered ineffective. For example, in the future GPS will provide enemy cruise missiles with enough accuracy to successfully attack ports or airfields well behind the line of battle. Military planners will need to pay particular attention to these vulnerabilities.

Rendering hostile space systems ineffective ensures greater freedom of action for our terrestrial and space forces. Space control consists of operations designed for protection of our space systems, negation of enemy space systems (including terrestrial elements), and the necessary supporting surveillance. Space control includes a broad spectrum of measures including diplomatic efforts, downlink or ground station denial, or destruction of enemy space systems. Today the United States does not have destruction capability against satellite or anti-satellite systems, limiting counterspace operations to attacks against the terrestrial infrastructure. During the Gulf War, the U.S. destruction of Iraqi satellite ground communications stations on the first night of Desert Storm was a perfect example of space control. In the future, operational commanders will need to place greater emphasis on the enemies autonomous mobile units. Unanticipated system failures and multiple area coverage requirements may require the immediate placement of tactical satellites into orbit. To meet these challenges, a rapid space force reconstitution capability is essential to space operations to provide space support assets necessary to meet joint requirements in future combat environments.

CONCLUSION

It is likely that whoever controls the vastness of space at the beginning of any future war will be the victor at its end. Just as seapower and airpower were the champion force in the 19th and 20th centuries, space power will be the champion force in the future. The United States military is currently placing significant emphasis on using space in future wars. Troops are being educated and encouraged to use space. Access is being made more readily available and the leadership is pursuing it at full speed. The military services are procuring space supported weapons systems like 74,000 JDAM kits, 22,000 JSOWs, 550 TSSAMs, and GPS in every Air Force aircraft by the year 2000.[22] In the future, the theater commander executing the war will expect GPS satellite support to be there. If for some reason it's not available, there is a high probability that weapons will miss their targets, or that platforms (aerial or ground) will not be positioned properly.

The real threat to satellites in a future war is hard to determine. In the short term, other than MIJI and ground attacks on control segments, or a nuclear burst by a militant group, the Russian ASAT is the only major threat today that could inflict crippling damage on U.S. satellite systems. Given the current state of affairs in Russia, the health of their ASAT program is suspect. However, advanced lasers and particle beam weapons will be of real concern in the future.

Space systems and the support they provide significantly leverage the tools in the operational commander's tool kit. Information and control are two key ingredients necessary to effectively conduct a war. Space systems provide timely and accurate information about the enemy and the environment. They allow the operational commander to apply the principles of war with more certainty and confidence as he formulates the operational design of a campaign. Space systems allow the operational commander to control the theater by providing instant and assured communications with his forces. Considering the exchange of

information, the speed and clarity with which decisions will be made will facilitate understanding, smooth timing, and maintain the tempo of operations.

The United States needs the capabilities space systems provide. The operational commander needs space control and space systems to be the force multiplier that will help retain his combat power in war and peace. During the Desert Storm "left hook," it was the assistance of GPS that gave new meaning to the principles of maneuver and surprise. DSP facilitated unity of effort among the Coalition partners and increased security for Israel by providing initial warning of SCUD launches.

Threats do currently exist that could reduce, disrupt, or destroy the capabilities of U.S. space systems. If an adversary chose to target a specific capability such as communications, they could employ multiple methods like direct attack on a ground site, together with a concentrated jamming effort. The operational commander and forces in theater could be seriously affected.

Given the increased reliance on military space systems, the United States should regard spacelift as strategic lift, raising it to the same level of importance as airlift and sealift. The operational commander should have the decision authority and capability to reliably and responsively launch space assets and other high-priority space systems. Finally, and most importantly for the United States, while the information provided by space systems may improve the capabilities of Third World forces, such information is no substitute for training, experience, good morale, and high-quality equipment.

RECOMMENDATIONS

The United States needs a full-featured set of systems able to neutralize enemy space capabilities while protecting its own. These features include soft kills such as jamming, deception, and interference, and hard kills that disable or destroy space systems. To maintain the U.S. technological edge, and be assured of uninterrupted space support in the future, steps must be taken to control and protect space capabilities. The first step toward better control would be to organize Department of Defense (DOD) and national space assets under the direction of one body. Military space initiatives must be closely coupled to civil and commercial efforts to ensure all receive the benefits of advanced technology investments while increasing U.S. national competitiveness in the world market. Only with a focused, integrated approach to space will the United States be able to operate superior space forces.

A space control strategy must also be established. During the Gulf War, U.S. space forces were virtually unopposed, a condition that may never exist again. The operational commander must know what space can do and how to exploit it while preparing the battlespace and controlling the conflict. Critical enemy space-related nodes will need to be interrupted or destroyed in future conflicts, whether on the ground or in orbit. The United States should strongly consider either resurrecting the ASAT program or develop some other means for negating enemy use of space assets to provide a reliable deterrent capability for the future.

During Desert Storm, DSP provided the initial SCUD alert, GPS provided navigation to all types of weapon systems, and communications satellites provided nearly 90% of all Coalition communication links. Backup systems (unmanned aerial vehicles, tactical satellites, and fiber optics), should be investigated and training conducted for alternate or communications-out contingencies. An operational commander should be cognizant that GPS may also be used by an adversary and should plan his actions accordingly. Theater commanders must ensure the security of ground segments by increasing fortifications (barbed

wire, concrete barriers or troops); conducting deception and covert exercises against enemy sensing platforms; encouraging redundancy in new weapons systems; and conducting theater emission control exercises with planned autonomous operations of forces. In the future, the trend for Satcom will be to use commercial satellites, thereby reducing satellite development and operation expense to DOD, and limiting the number of military space launches. Thus, the operational commander must ensure that the capability exists to encrypt information on demand and that sufficient bandwidth is available to handle surge requirements. Finally, operational commanders must find ways to make enemy imaging of friendly forces work in their favor through increased emphasis on operational and strategic deception. Though not specifically aimed at space-based sensors, the threatened amphibious landing in Desert Storm is an outstanding example of an operational feint that could be used to deceive such observations.

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