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THE LIMITS Of SPACEPOWER

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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 Navy.

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Abstract

THE LIMITS OF SPACEPOWER

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15.Abstract: The United States military has become highly dependent on space-based assets in the critical areas of communications, intelligence, surveillance and reconnaissance (ISR), and precision navigation. This dependence, coupled with the lack of redundant capabilities, leaves the U.S. particularly vulnerable in these areas, as we risk having this capability neutralized or destroyed. The CINC or JTF commander's staff must be knowledgeable of these vulnerabilities when planning a campaign or major operation, and should build alternatives, backup capabilities and redundancies into its plans and functions, in the event these critical assets are no longer available. One alternative to space-based communications and ISR capabilities is the use of unmanned aerial vehicles (UAVs). These platforms offer a variety of similar capabilities, including wide-band communications and a variety of intelligence-collecting sensors. Other technologies are in development to offer an alternative to the Global Positioning System (GPS). Space power, like air power before it, holds tremendous promise for conducting future military operations. We are still tapping its potential and exploring the unique ways it brings synergy to the battle. We must not be so enamored by its possibilities that we pass up sensible cost-efficient alternatives, thereby placing our warfighters at risk on the battlefields of the future.

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areas, as we risk having this capability neutralized or destroyed. The CINC or JTF commander's staff must be knowledgeable of these vulnerabilities when planning a campaign or major operation, and should build alternatives, backup capabilities and redundancies into its plans and functions, in the event these critical assets are no longer available.

One alternative to space-based communications and ISR capabilities is the use of unmanned aerial vehicles (UAVs). These platforms offer a variety of similar capabilities, including wide-band communications and a variety of intelligence-collecting sensors. UAVs have the advantage of being able to dwell over an area for considerable period of time, vice a low earth orbiting satellite, whose overflight times is measured in minutes. Other technologies are in development to offer an alternative to the Global Positioning System (GPS). The ease at which the signal can be jammed is a critical vulnerability which requires an alternative solution.

Space power, like air power before it, holds tremendous promise for conducting future military operations. We are still tapping its potential and exploring the unique ways it brings synergy to the battle. We must not be so captivated by its possibilities that we pass up or fail to develop sensible cost-efficient alternatives, thereby placing our warfighters at risk on the battlefields of the future.

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CINCs or JTF commanders are tremendously dependent on space power to conduct contingency operations in their area of responsibility. This dependence creates vulnerabilities that can be exploited by our adversaries. It is essential CINCs consider alternatives to space-based communications, intelligence, surveillance and reconnaissance (ISR), and incorporate them into their operations. This paper researches the vulnerabilities of space platforms, analyzes cost-effective solutions, and recommends alternatives and redundancies be built into CINCs plans and functions in the event space capabilities become unavailable for future operations.

Overview

The United States military is highly dependent on our space-based assets for a wide variety of critical capabilities at the operational level of warfare. The unique features of satellites allow for extensive broad-band communications, precise navigation, near real-time images of the battlespace, up to date intelligence on the enemy, current weather, and missile warning information. Satellites have become a dynamic force multiplier for the CINC or JTF commander and are essential for all future military operations. But migrating more and more missions to space and relying so heavily on space-based assets invokes a great deal of risk for the military of tomorrow. The lack of redundant capabilities coupled with our inability to control adversary actions or natural phenomena in the space environment leaves us acutely vulnerable in several key areas of military operations. There are only a small number of ground stations used to control satellites and they are easy targets to attack. The extended period of time and huge costs involved in launching and replenishing satellite systems caps a

problem of relying so heavily on space assets. A CINC or JTF commander's staff needs to plan for the contingency of our space-borne assets and the power derived from space being neutralized and our technological superiority eliminated. They should have alternative capabilities built into their plans, ready to implement in the event our space power has been neutralized.

The Case for Space

There are those who say space power will become as important as air power in the not too distant future. "The growth of space power closely resembles air power's evolution during the first half of this century."[1] Space power theorists advocate for more space capabilities and innovative concepts for warfighting from space, and outline how the nation will become as dependent on space as to rival its dependence on oil and electricity.[2] Both military and civil operations today depend critically on space capabilities.[3] This ever-increasing dependence has resulted in space becoming a vital national interest, and our space assets strategic centers of gravity. "Every time a new space mission is undertaken, it quickly becomes indispensable to... not only military, but political and civilian economic operations."[4] The NAVSTAR constellation of global positioning satellites has become indispensable for not only military navigation, but for anyone in the civil market that has a receiver. Space-borne communication has become a huge industry, with the demand for ever larger 'pipes' through which to transmit information growing at an exponential rate. Competition for these low-density/high-demand

[1] U.S. Space Command, Long Range Plan, Implementing USSPACECOM Vision for 2020, (Peterson AFB, CO, 1998), vii.

[2] Ibid.

[3] Ibid.

[4] Robert D. Newberry, Major, USAF, Space Doctrine for the Twenty-first Century, (Maxwell AFB, AL: Air University Press, 1998), 20.

assets is fierce and a growing concern for the future. Space forces not only support all manner of military operations 24 hours a day, 7 days a week in these areas, but also within the uniquely military areas of missile warning at both the strategic and theater levels, and intelligence, surveillance and reconnaissance collection. There seems to be no limit to the demand for on-orbit assets.

Space advocates cite several reasons why space will play an even more prominent role in the future. Space-borne assets provide continuous awareness of terrestrial events.[5] Satellites have the unique feature of being able to monitor events over a specific part of the earth continuously from geosynchronous orbit, or to provide periodic coverage of 100 percent of the globe from a polar orbit. Governments and businesses around the world are now heavily reliant on space-based capabilities, from the myriad of communications now possible (everything from instant messaging to broad-band communications to pagers) to instantaneous financial transactions and the trading of commodities, thus elevating the importance of space power. Space is seen as a panacea and the answer to all our future global access needs.

Commercial Space Industry

The commercial space sector has grown rapidly over the last decade, now surpassing the military in the number of space systems it operates. The commercial sector is a key factor in the space power equation. While the military continues to exert a significant influence over the nation's space policy, it will be the internationalized commercial sector who will now contribute the larger aspects of space power.[6] "Before 2020, the chances are high that the U.S.

[5] Ibid., 21.

[6] James E. Oberg, Space Power Theory, (U.S. Air Force Academy, CO: Government Printing Office, 1999), 125.

military will find itself conducting combat operations against an opponent with access to high-resolution imagery, GPS, and other space services..."[7] This will be a key planning consideration for a CINC or JTF commander in the future. Not only will the availability of commercial market satellites be an important consideration, but also the fact that our adversaries might have access to critical information (imagery, voice or data transmissions, etc). The commercial space sector, however, is only one area of concern when talking about the role space will play in future operations.

Space Power: Myth or Reality

While space capabilities have made quite a few advancements in the last forty years, space may not be the golden answer to future warfare, and relying so heavily on it could result in a failure to accomplish our assigned missions in the future. Space advocates cite the relatively short time "in which flying machines were developed, tested, and refined for increasingly sophisticated use" in military applications, and compare it with the rapid development of space-based capabilities.[8] However, "space power" is, and will remain for the foreseeable future, strictly a force enhancement - support role, supporting the forces fighting on the ground, in the air, and at sea. "Space power today is an immature form of military power...because it has yet to transition to anything approaching strategic force application in and of itself."[9] Furthermore, space power may not reach "a comparable stage by 2025 that air power achieved

[7] Barry Watts, "The Military Use of Space: A Diagnostic Assessment", Center for Strategic and Budgetary Assessments, Jan 2001, <http://www.csbaonline.org/4Publications/Archive/H.20/H.20010111.The_Military_Use_of_Space.html/> [20 April 2001], 3

[8] Oberg, 121.

[9] Watts, 4.

in 1945."[10] Unlike their air predecessors, there have been no space warriors fighting in space, no weapons fired from space to terrestrial targets, and no space-to-space engagements.[11] Space power theorists and the developers of space doctrine must be careful not to make the same mistake the air power zealots made in developing air doctrine in the 1930s by advocating a capability that did not exist and could not be proven until actual combat operations. This proved immensely costly to the B-17 bomber formations over Europe who were decimated by German fighter aircraft, tragically disproving the theory the 'bomber would always get through' with the lives of many brave airmen. Space power developers must "avoid overstatement and overconfidence" and understand the synergistic effects space can bring to the battlefield, and not feel compelled to advocate that space will be able to 'do it all' in the future, if only "properly understood."[12] A theory that "begins with erroneous premises will lead to faulty doctrine, which may result in the failure in the battlespace and on the battlefields of the future.[13] But if I am a CINC or JTF commander and read this, I might say "so what?" The answer to that question is critical to conducting future operations and contingencies if you are planning on using space-based capabilities. The CINC or JTF commander's staff can't take the space zealot's rhetoric at face value and assume space provides all the answers. They must be aware of the limits of space power as it exists today, and have redundant capabilities to fall back on in the event our space-borne capability is degraded or destroyed. Additionally, until operations advance to the point where weapon systems can be employed from space to directly

[10] Ibid.

[11] Oberg, 121.

[12] Ibid., 127.

[13] Ibid.

affect the outcome on the battlefield, true space power will remain a futuristic notion, hindered by the huge costs involved in satellite construction, launch operations and technological barriers. Until we can assure unfettered access to our space systems through positive space control operations, all systems will remain vulnerable.

It is important for warfighters to be educated in the unique contributions space can bring to the fight. It is also equally important for the warfighter to know what space can not do. I am reminded of the Army general who, during Desert Storm, wanted to park a low earth-orbit satellite right over Iraq to provide real-time imagery of the battle. In cases such as this, space may not be the answer. It is important the CINC's staff know what to do in situations such as: a particular overhead imagery satellite can only visit their AOR twice a day, the communication satellite they are using is completely saturated, or someone is jamming the GPS signal; i.e.: what are some alternatives? They can't go to the CINC and say, 'sorry, boss, no imagery today, the satellite didn't have the proper look angle...' They also need to understand the vulnerabilities involved in the satellite systems they are so heavily dependent on, and the fact that the assets might not be available to use when they need them the most.

Satellite Vulnerabilities

It is a well-known fact that satellites are vulnerable. The expense involved in satellite operations dictates that satellites be built with cost in mind (the heavier a satellite is, the more expensive it is to launch into orbit). Protective capabilities are not normally built into satellite systems, due to the cost involved. This lack of protective capability makes satellites vulnerable to a variety of threats, particularly jamming. Satellites in low earth orbit (LEO) can be easily

tracked, and being relatively close to the earth (120-300 miles), easily interfered with.[14] But, it is not just LEO assets that are threatened. The GPS signal at medium earth orbit (MEO – 12,000 miles) is particularly vulnerable to jamming or interference. Even communications satellites at geo-synchronous orbit (22,300 miles) can be interrupted. Electrical-optical sensors on imaging satellites are very sensitive to light—light a laser or directed energy weapon would transmit, for instance, essentially "blinding" the satellite's eyes. As the government's Defensive Technologies Study Team found in 1984: "survivability is...a serious problem for space-based components...the most likely threats are direct ascent anti-satellite weapons; ground or air-based lasers; orbital anti-satellites, both conventional and directed energy, or space mines."[15] Satellites are not only vulnerable from damage or destruction, but they also can be exploited and used against us. An adversary can take advantage of our satellites through other, more passive measures. Everyone can use the GPS signal, for instance. It is not encrypted, and there is nothing to prevent an adversary from equipping his weapons with GPS-guided devices to make them more accurate. Satellite imagery can be bought on the open market—imagery that could be vital to an adversary for detecting movement of our forces in an area of operations. Commercially available software to track satellites is readily available, leading an adversary to effectively cover and conceal his forces at the appropriate times, or to set up decoys for our satellites to observe.[16] Communications can be intercepted. We are not the only military with the capability of 'listening' to traffic on the airwaves. With the extensive

[14] U.S. Space Command, Long Range Plan, 4.

[15] David W. Ziegler, Safe Heavens, Military Strategy and Space Sanctuary Thought, (Maxwell AFB, AL: Air University, 1998), 15.

[16] Ibid.

use of cell phones for modern communications, Operations Security becomes a particular weakness if we are not careful with what we say. USCINCSPACE has recently said "DOD space systems present our adversaries with lucrative targets...the national dependence on space-based systems equates to a vulnerability...and history shows that vulnerabilities are eventually exploited by adversaries, so the U.S. must be prepared to defend these systems."[17]

The nature of the threat to our satellites must be studied and analyzed. We know our assets are vulnerable. But if there is no threat to them, so what? Analysis indicates that there is a very real threat to our space-borne assets, as is even stated by our adversaries! China, in its efforts to exploit what it says is a revolution in military affairs, and to avoid what it perceives to be growing gap in its military capabilities compared to America, is looking at developing capabilities to conduct information operations...and "attacks on enemy satellites in space."[18] They are specifically looking at the feasibility of the use of anti-satellite weapons.[19] One line of strategic thought in China stresses a future conflict where they will have to attack their adversary's space satellite reconnaissance systems, and the need to have the capability to "strike first at enemy space capabilities..."[20] There is also the continuing threat Russia poses to our systems on orbit. Russia has a demonstrated anti-satellite capability, and while not actively continuing with research on it, the technology does exist and is available to export for profit to someone willing to acquire the capability. Additionally, our ground stations for commanding and controlling satellites are vulnerable to attack. An adversary would not have

[17] Warren Ferster, "U.S. Military Develops Plan to Protect Satellites", Space News, 17-23 February 1997, 26.

[18] Dr. Michael Pillsbury, China and the Revolution in Military Affairs, Prepared for The Office of Net Assessment, 8.

[19] Ibid., 6.

[20] Ibid., 15.

to come up with a capability to take on our satellite systems in space. Neutralizing the few critical ground nodes, space support facilities, or the data link segment of the system would be enough to disrupt space operations. By even partially impairing "the C3I "nerve network," US and allied troops, ships and aircraft could lose their ability to coordinate operations and strike targets in an accurate and responsive manner."[21] Given the scenario of an adversary that is causing such disruptions, and degrading or eliminating our access to the information provided by space-based platforms, there must be in-place alternatives to fall back on to continue the operation.

Alternative Considerations: Communications

First, we will look at alternatives to space-based communications systems. Even though communication capability has grown tremendously in the last 10 years, the requirement to transmit more and more information expanded as the capacity to carry it was created. CINC staffs have become dependent on huge files of imagery, video-teleconferencing, and e-mail traffic to conduct their operations. Military operations will be conducted in the future relying heavily on communication-intensive capabilities such as real-time video and sensor to shooter targeting. Warfighters have become accustomed to and dependent on this huge flow of data. But there is only so much capability available. Communications satellites are optimally used at geosynchronous orbit, where only so many parking spots for satellites are available. Experiments with a low-earth orbiting information system (Iridium) has proved to be a dismal failure. The extraordinary number of orbiting platforms needed (88) to make the system viable has proved not to be cost effective for the commercial sector. While the Department of

[21] Steve Lambakis, "Exploiting Space Control, It's Time to More Fully Integrate Space into Warfighting Operations", Armed Forces Journal, June 1997, 44.

Defense (DoD) has saved Iridium from its demise by paying for the costs to keep the system operating, and in return being able to use the system, the long-term costs associated with maintaining and replenishing the constellation will most likely be too costly for DoD. Both satellites and launch operations are extremely expensive and require long lead times. The typical price to launch a communications satellite is estimated to be around $200 million and requires a six month preparation time. Launching replacement satellites is simply not an option to a CINC whose operation could be over with in a matter of weeks or months.

A very capable answer to this problem is unmanned aerial vehicles (UAVs). UAVs incorporate cutting-edge technologies, can carry a wide variety of payloads, are relatively small and therefore stealthy, and can dwell over an area for long periods of time.[22] You could deploy a system of UAVs, for example, as communications platforms. Global Hawk UAVs have the capability to provide line of sight data link communications, can be launched from ranges up to 3,500 miles, and loiter over an area for over 40 hours at an altitude of 65,000 feet.[23] Global Hawk's capacity is essentially the same as a Defense Satellite Communications System (DSCS) satellite, and costs $10 million; compared to a $140 million DSCS satellite and its $85 million Atlas booster![24] The U.S. Army has seen the requirement to look for additional capability. "Our tactical communication satellite systems are very congested" cited

[22] Steve Kosiak and Elizabeth Heeter, "Unmanned Aerial Vehicles – Current Plans and Prospects for the Future", Center for Strategic and Budgetary Assessment, July 1997, <http://www.csbaonline.org/4Publications/Archive/B.1...B.19970711.Unmanned_Aerial_Ve.html/> [20 April 2001]

[23] Ziegler, 29.

[24] Ibid.

Maj Gen Steven Boutelle, Army Program Executive Officer for Command, Control and Communications Systems.[25] "There needs to be a mix of platforms, we can't just rely on satellites for our future communications needs," he added, stating they were hard at work on the Army's Tactical Unmanned Aerial Vehicle (TUAV) concept of operations.[26] This UAV will be outfitted with a communications and data relay payload. They have also sponsored a series of flight tests using the larger communication relay payload onboard a Hunter UAV. The Army will require even more systems to keep their units and vehicles connected, as the Army's Future Combat System (FCS), a distributed network of ground platforms, is fielded.[27]

Another area where communications can be enhanced is through the use of fiber optics. The robust fiber optics capability that exists between major operations centers needs to be optimized and expanded. This will provide for secure, large volume transmissions of large data files, freeing up bandwidth for use by the warfighter in the fight. Fiber optics provides many advantages, offers a redundant capability, and is more difficult to disrupt. These are just a few of the cost effective alternatives to relying on satellites for communications.

Alternative Considerations: ISR

Our low earth orbiting ISR satellites are strategic assets providing global coverage. They were primarily designed for use during the Cold War to provide intelligence on the Soviet Union. Like other orbital systems, they have now been asked to perform missions that task the limits of their capability. Due to the limitations of low earth orbit orbital mechanics, large numbers of satellites are required to provide continuous coverage (refer to the Iridium

[25] Marc Strass, "Army Seeks to Supplement Military Communications Satellites", Defense Daily, 4 April 2001, 2.

[26] Ibid.

[27] Ibid.

comment). They are of limited usefulness to a theater commander. Some are only able to pass over an AOR two times a day, and if weather obscures the area of interest, that overflight is useless for some assets. UAVs are the answer here as well. There are UAVS out there that provide "state-of-the-art intelligence collecting technologies, including TV cameras, electro-optical (EO) and infrared (IR) sensors, synthetic aperture radar (SAR)/moving target indicators, electronic signals intelligence equipment, lasers, even sensors to detect chemical agents and radioactivity.[28] These capabilities are at least equal to if not better than their orbiting counterparts. They range from smaller, remotely controlled drones to glider-size craft that can fly independently for hundreds of miles on pre-programmed missions."[29] UAVs became an essential part of Desert Storm, when UAVs "filled in the gaps in the intelligence coverage provided by satellites and manned reconnaissance aircraft...locating and reporting on Iraqi ground units...providing an immediately responsive intelligence collection capability.[30] UAVs were also used for reconnaissance missions in Somalia, Haiti and Bosnia. Advancements in UAV technology will continue to grow, especially in the areas of miniaturization of electronics, stealth and the ability to carry munitions.[31] UAVs were used extensively in the recent conflict in Kosovo, where they performed a significant portion of the reconnaissance and surveillance mission. New technologies for locating extremely hard-to-find targets—using UAVs, are currently under development. Using radar in multiple bands (fused radar using multi-spectral bands), coupled with extensive computing power and innovative algorithms for

[28] Kosiak and Heeter, 2.

[29] Ibid., 1.

[30] Ibid., 3.

[31] Ibid.

sorting through huge amounts of data, will allow US forces to locate the stealthiest of threats (aircraft, cruise or ballistic missiles), and to find well-hidden targets on the ground.[32] Long endurance UAVs such as Predator and Global Hawk will be the platform of choice, because of their ability to "stare" at objects on the ground for many hours, unlike satellites, whose overflight times are measured in minutes.[33] Predator UAVs carry EO/IR/SAR sensors, have a range of 500 miles, can fly to an altitude of 25,000 ft., and dwell for 20 hours, while the previously mentioned Global Hawk carries an EO/IR/SAR payload.[34] These assets can also be fitted with meteorological packages to provide weather data in the event of a loss of a weather satellite.

UAVs are also much less costly than their air-breathing or orbiting counterparts. Over the last two decades, the entire amount DOD has spent on UAV development has been $2 billion.[35] During the period FY 1998-2003, the government plans to spend a total of $1.8 billion to acquire additional UAVs, about the same amount it costs to launch and place in orbit one MILSTAR satellite![36] UAVs have an unlimited capacity to accept missions due to their inherent flexibility, and can now be equipped with precision munitions, and will likely be used for long-range strikes, close air support and assisting the warfighter in urban operations. They are also being considered for an Information Operations role, because they are relatively inexpensive and survivable.[37] UAVs have been considered to "replace manned aircraft,

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[32] David A. Fulghum, "New Radars Peel Veil from Hidden Targets", Aviation Week and Space Technology, January 18, 1999, 58.

[33] Ibid., 59.

[34] Kosiak and Heeter, 11.

[35] Ibid., 1.

[36] Ibid.

[37] Ibid., 4.

satellites, and other systems in certain roles.[38] To take advantage of the tremendous potential UAVs have to offer the warfighter, CINC staffs must support the development and acquisition of these systems to give them a much more robust capability to fight the next conflict. For the price of one satellite, you could have a round the clock, responsive, networked, replenishable capability, providing real-time situational awareness of the battlespace—a capability you would never get from a satellite.

Alternative Considerations: Navigation

The Global Positioning System constellation of NAVSTAR satellites has revolutionized precision navigation in almost every facet of military operations.[39] The U.S. Air Force and Navy each expect to have about 7,000 GPS-equipped platforms, the U.S. Army around 30,000, with all services in possession of over 500,000 weapons using some form of GPS guidance by 2006.[40] This growing dependence on the GPS system has "raised worries that critical military capabilities are hanging on a single constellation of satellites."[41] The problem with this dependency is that the GPS signal can be easily jammed, thereby defeating the capability. A jammer the size of a hockey puck costing only $500 can radiate 1W of power, making it effective up to a range of 70km.[42] Russia has for sale a 4W jammer on the market and claims it is effective to 150-200km, and is commercially available to anyone that has the $4,000 to pay for it.[43] The result of this has been a tremendous emphasis and huge sum of money spent on

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[38] Ibid., 13.

[39] David Foxwell and Mark Hewish, "GPS: is it lulling the military into a false sense of security?", Janes International Defense Review, Vol. 31, September 1998, 33.

[40] Ibid.

[41] Sandra Erwin, Threat to Satellite Signals Fuels Demand for Anti-jam Products, National Defense, June 2000, 23.

[42] Foxwell and Hewish, 33.

[43] Erwin, 25.

developing an anti-jam or jam-proof capability into our receivers and weapons in order to counter the effects of an adversary's ability to degrade GPS. A U.S. Defense Science Board study concluded recently that the three main GPS priorities for DoD should be "anti-jam, anti-jam, anti-jam."[44] Intentionally degrading the signal is not the answer, as many areas of the civilian sector are now as heavily dependent on GPS as the military. GPS has become a part of everyday civilian life, in everything from commercial aviation to renting a car, and has lost a significant degree of its military utility. An alternative to GPS navigation is required to maintain the technological edge of precision navigation and munitions delivery.

The U.S. Navy has been working some alternatives to satellite-derived navigation. "There is too much emphasis on building protection into GPS satellites and receivers and not enough attention devoted to developing other technologies for precise navigation" said Mr. Dave Uhler, the Navy's deputy assistant secretary for C4I, electronic warfare and space systems.[45] As a result, the Navy has been looking at alternatives to GPS navigation for its cruise missiles. A technology based on terrain-mapping radar called precision terrain-aided navigation (PTAN) provides an "autonomous, GPS independent precision navigation" capability.[46] The advancements made in computer data processing and storage, as well as the extensive mapping of the world that has taken place since the 1980s, allows for "significant improvements" in terrain contour matching capability, and at a cost that is affordable.[47] As technological improvements and breakthroughs are made, we must take advantage of the new capabilities

[44] Foxwell and Hewish, 34.

[45] Erwin, 25.

[46] Ibid., 27.

[47] Ibid.

and stay one step ahead of our adversaries. Unfortunately, we allowed the military advantage of GPS to escape to the point where our adversaries can not only deny it to us, but use it against us as well. The CINC or JTF commanders staff must be aware of the capabilities and vulnerabilities of the GPS system, and be able to plan for alternatives in the event the much vaunted GPS signal becomes useless.

Space as the Alternative?

Much of this paper has examined the limits of our space capabilities and looked to ground or air-breathing alternatives in the event these capabilities were denied us. But, could the answer lie in space after all? It would if we could develop and deploy decentralized and diversified satellite constellations in a cost-effective manner. Instead of having few, very highly valued assets, we could create constellations of smaller, cheaper, reliable satellites performing the communications, ISR and navigation missions. As one space expert prescribed: "a space architecture with smaller distributed satellites...more directly responds to the needs of today's primary users and can adapt more readily to the changes in both requirements or technical opportunity."[48] If the size and weight of satellites could be reduced, it would be cheaper to place more of them on orbit, and would "foster survivability by eliminating single point failures in mission capability."[49] It would complicate your adversary's attack plan by giving him more targets to shoot at. But before you shoot, you must first locate. Considerably smaller satellites would be extremely difficult to identify and track, and thus defeat. Miniaturizing technology is well on its way to becoming economically feasible. The

[48] Christian C. Daehnick, Blueprints for the Future: Comparing National Security Space Architectures, Masters Thesis, School of Advanced Airpower Studies, June 1995, 3.

[49] Ziegler, 30.

Phillips Laboratory, for instance, has developed and will begin space-based testing of miniaturized components that could lead to grapefruit-sized smart satellites within a decade.[50] In order to take advantage of the unique capabilities space-based platforms brings to the fight, we MUST reduce launch costs and develop a cheap, reliable space vehicle. If we don't, space will remain too expensive and too inaccessible to adequately support operations on the ground. But if I am on the CINC or JTF commanders staff, how does that help me now? By knowing the capabilities and limitations of our space assets, the staff will be able to plan for and conduct operations using the most effective system to accomplish the mission. Since CINC staffs also prepare to fight the war of the future, they must be aware of future capabilities, whether it is on the ground, in the air, or in space, and advocate for the capability that is going to most assist them in winning the next war.

Conclusion

The tremendous role we have given our satellites to play in future military operations leaves us vulnerable in several key areas of operations. Space power advocates have convinced many that space holds the answers to the majority of our communications, intelligence collection and navigation requirements. We now assume satellite communications will always be available and with even more capacity in the future. We are heavily dependent on space-based imagery and other technologies for planning and conducting military operations. We have become dependent on GPS for navigation and weapons delivery precision. We have put virtually all of our eggs in the space basket, potentially setting

[50] Anne Eisle, "Lower Costs Drive Development in Europe, Japan, and the United States", Space News, 17-23 February 1997, 8.

ourselves up for catastrophic failure in the next conflict, should our adversaries neutralize our space assets, denying us the capabilities we depend on to win the war.

Recommendations

When planning to conduct a campaign or major operation, CINC or JTF staffs must utilize the full range of capabilities available to them. They do not want to be so heavily dependent on space-based systems that their operations are jeopardized. They must build alternative, backup and redundant capabilities into their plans and functions in the event space platforms are neutralized or destroyed. There are other systems they could use to provide the required capability. UAVs have outstanding potential, and could provide a seamless, networked, real-time picture of the battlespace, while also providing tremendous communication bandwidth to meet virtually all theater requirements. CINCs must acquire and incorporate a networked system of UAVs into their operations as alternatives for communications and ISR. CINCs must support the continued development of an alternative navigation capability like PTAN, and incorporate its use into their operations. The GPS jamming problem could soon become so significant that the system becomes totally ineffective. CINCs should also support the development and fielding of miniaturized constellations of satellites, when that capability becomes affordable. CINCs must also ensure the defense of downlink stations in their AOR is a high priority, to ensure the security of these single-point-failure nodes from attack.

Space power, like air power before it, holds tremendous promise for conducting future military operations. We are still tapping its potential and exploring the unique ways it brings synergy to the battle. We must not be so enamored with its possibilities that we pass up or fail to develop sensible cost-efficient alternatives, thereby placing our warfighters at risk on the battlefields of the future.

BIBLIOGRAPHY

Daehnick, Christian C. Blueprints for the Future: Comparing National Security Space Architectures. Masters Thesis, School of Advanced Airpower Studies, (June 1995): 3.

Eisle, Anne. "Lower Costs Drive Development in Europe, Japan, and the United States." Space News, (February 1997): 8.

Erwin, Sandra. "Threat to Satellite Signals Fuels Demand for Anti-jam Products." National Defense, (June 2000): 23-25.

Ferster, Warren. "U.S. Military Develops Plan to Protect Satellites." Space News, (February 1997): 26.

Foxwell, David and Hewish, Mark. "GPS: is it lulling the military into a false sense of security?" Janes International Defense Review, (September 1998): 33-34.

Fulghum, David A. "New Radars Peel Veil from Hidden Targets." Aviation Week and Space Technology, 18 (January 1999): 58.

Kosiak, Steve and Heeter, Elizabeth. "Unmanned Aerial Vehicles – Current Plans and Prospects for the Future." Center for Strategic and Budgetary Assessment. July 1997. <http://www.csbaonline.org/4Publications/Archive/B.1...B.19970711. Unmanned_Aerial_Ve.html/> [20 April 2001].

Lambakis, Steven. "Exploiting Space Control, It's Time to More Fully Integrate Space into Warfighting Operations." Armed Forces Journal, (June 1997): 44.

Newberry, Robert D. Space Doctrine for the Twenty-first Century. Maxwell AFB, AL: Air University Press, 1998.

Oberg, James E. Space Power Theory. United States Air Force Academy, CO: Government Printing Office, 1999.

Pillsbury, Michael Dr. China and the Revolution in Military Affairs. Prepared for The Office of Net Assessment. Washington, DC: 1995.

Strass, Marc. "Army Seeks to Supplement Military Communications Satellites." Defense Daily, 4 (April 2001): 2.

United States Space Command. Long Range Plan, Implementing USSPACECOM Vision for 2020. Peterson AFB, CO, 1998.

Watts, Barry. "The Military Use of Space: A Diagnostic Assessment." Center for Strategic and Budgetary Assessment. Jan 2001. <http://www.csbaonline.org/4Publications/Archive/H.20/H.20010111.The_Military_Use_of_Space.html/> [20 April 2001].

Ziegler, David W. Safe Heavens. Military Strategy and Space Sanctuary Thought. Maxwell AFB, AL: Air University Press, 1998.

BIBLIOGRAPHY

Doe, John B. *Conceptual Planning: A Guide to a Better Planet*, 3d ed. Reading, MA: SmithJones, 1996.

Smith, Chris. *Theory and the Art of Communications Design.* State of the University Press, 1997