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SPACE CAPABILITIES AND LIMITATIONS

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SPACE CAPABILITIES AND LIMITATIONS

This article will complement your other readings as you examine space as it applies to "operational art." The national goals, strategy, policy and doctrine for space should help answer the fundamental question of "Why do we operate in space?" We will concentrate on some of the other (perhaps less esoteric) issues like What, Where, Who, How and maybe just a touch of When.

There is still no commonly accepted definition of "what" space is. Advancing technology in our air-breathing systems (aircraft) continues to blur the boundary between air and space. The U.S. Air Force coined the term aerospace a few years ago, which further muddled the situation. There is a continuing debate over whether space is a place or a mission. More on that later.

We need some working parameters, though. If we asked propulsion engineer, he would probably say around 28 miles above the earth is where space begins, since above that altitude an engine must be supplied with both fuel and an oxidizer. At 50 miles altitude or above, flight earns a crewmember the right to wear astronaut's wings. Another frame of reference is international law. The three treaties on space avoid an explicit altitude definition. However, in customary law the major space powers accept "the lowest perigee attained by orbiting space vehicles as the present lower boundary of outer space." For practical purposes, this is about 100 miles.

This minimum altitude of 100 miles can become important for some military applications. To understand why, we need at least some background in orbital mechanics and the physical laws that govern how bodies move in space.

There are essentially only two types of orbits of interest to the military--circular and ellipse. The key point about orbits is they are very stable and very predictable. Another important point is that there is a direct relationship between launch site and orbital plane. This is because the center of the earth must be a focus of the orbit and must lie in the orbital plane. This becomes important because a satellite's orbit will determine its ground track. (The path it follows over the surface of the earth).

The combination of type of orbit (circular or elliptical), ground track (based on orbit type and its relative motion to the rotating earth), and the altitude (eccentricity for the ellipse) will determine military utility.

Now that we have examined the types of orbits (without getting too deeply into apogee, perigee, eccentricity and nodal regression), we will look at some of the advantages various orbits offer for military applications.

Constant altitude (circular) orbits are generally used for satellites that perform their mission over the entire orbit. Varying altitude (elliptical) orbits are generally used for satellites that perform their mission at apogee or perigee. The inclination of an orbit (the angle between the equatorial plane and the orbital plane) determines the north and south latitude limits of the orbit. Thus for low earth global coverage (desirable for meteorological satellites, among others), we might use a 90° or polar orbit. A variation on that type orbit is used for satellites that have sensors in the visible light spectrum. For optimum utility, they should be in sunlit areas. To maximize this, these satellites are placed in "sun-synchronous" orbits, where their inclination is about 95-105 degrees (depending on altitude). At this inclination the spacecraft's ground track will appear to "regress" about 1 degree per day--just enough to compensate for the shift in sun angle caused by the earth rotating around the sun. The important thing to take away from this discussion is that many subtle characteristics of a satellite's orbit dramatically affect its utility for various military missions. Some orbit adjustments are possible (and in the case of very low-earth orbits, absolutely essential to counter atmospheric drag), but they are limited by on-board propellant storage capacity and are not likely to be very dramatic at all.

Another specific type orbit that is particularly useful from a military viewpoint is the geosynchronous orbit. This is a circular orbit at a particular altitude above the earth (about 22,300 miles) with a velocity (about 6,000 mi/hr) that matches the earth's rotational period. Geosynchronous and geostationary are <u>not</u> the same. Geosynchronous will match the earth's rotation, but may follow one of several types of figure 8 patterns, depending on inclination (up to 5°). Geostationary is a special kind of geosynchronous orbit with 0° inclination and satellite will appear to be "parked" above the equator. A common myth is that a satellite can be "parked" over <u>any</u> desired location on the globe to provide continuous coverage (e.g. Iraq) or they can be moved with relative ease. There are several physical laws associated with orbits that prohibit this. Two of the most important are: the plane of a satellite's orbit must describe a great circle where it intersects the earth's surface and the plane of a satellite's orbit <u>must</u> intersect the center of the earth. The combination of these two laws make equatorial orbit the <u>only</u> spot feasible for a "stationary" orbit.

The force of gravity very precisely determines which kinds of orbits can be achieved. Getting from one orbit to another by altering a satellite's speed and/or changing its direction can require tremendous expenditures of energy because of the high velocities and potential energies involved. Let's look at a somewhat simplified example (Fig. 1). If we had a satellite in a 170 nm circular equatorial orbit, its speed would be about

17,000 mph. If we desired to change this equatorial orbit to a polar orbit, it would require a 90° plane change (perhaps a radical example--but the math is easy!). The length of the two arrows, A1 and A2, represent the initial and final velocities respectively. The change in velocity to make this change in orbit is represented by the relative length of arrow C. Arrow C is about 1.4 times greater than either A1 or A2. In other words, it takes a 24,000 mph change in velocity to make a 90 degree plane change (without changing altitude). Fuel to accomplish this is a precious commodity in space. A good example is the space shuttle. It carries enough total fuel on board to change its orbital plane by less than 5 degrees.

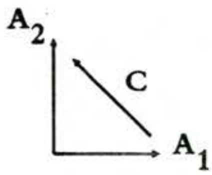

Figure 1

MILITARY SPACE SYSTEMS

Historically, military operations have evolved successively through the areas of land, sea surface, underwater, air, and space. Each new area of operation has been important to total military capability, and the optimum military posture requires proper cross support and cooperation. As technologies advance, the emphasis on the various regimes and the nature of their interlocking varies, but no new operational medium has, in itself, provided a panacea for solving all military problems. The Department of Defense (DOD) has been analyzing constantly the military contributions that they can obtain from space operations. The DOD is trying to strike a proper balance between developments in the newly-opened regime of space and military efforts in the older regimes of land, sea, and air.

There is a limitation on the DOD in developing space systems that could threaten the security of other nations. Under the terms of the outer space treaty, which went into force on 10 October 1967, the United States agreed not to place weapons of mass destruction in outer space or in orbit around the earth. The treaty bans military maneuvers on celestial bodies. As a result, the DOD is using the medium of space for warning, surveillance, communication, navigation, and weather systems to assist in maintaining an effective deterrent posture.

SYSTEMS AND PROGRAMS

In this section we will describe some of the space programs undertaken with the active participation by the DOD.

MILITARY SPACE COMMUNICATIONS SYSTEMS. Space communications systems can augment ground-based command and control systems. Basically, a command and control system is a composite of equipment, skills, and techniques capable of performing the clearly-defined function of enabling a commander to exercise continuous control of the forces and weapons in all situations. It provides the commander with the information needed to make operational decisions and with a means for disseminating those decisions.

As advancements are made in technology, the military is using this technology to develop communications satellite systems that are more jam resistant, provide two-way communications among mobile units, ships, tactical aircraft, the national command authorities, and the strategic forces. The complexity, range, and speed of military systems continue to increase. As the need for positive communications becomes critical, space-based systems will provide an ever increasing amount of communications.

There are five active military space communication programs. These include the Defense Satellite Communications Systems (DSCS), the Fleet Satellite Communications System (FLTSATCOM), the Air Force Satellite Communications System (AFSATCOM), the Satellite Data System (SDS), and Milstar.

Defense Satellite Communications Systems. Phase II of the DSCS is a second generation program that has replaced the successful initial DSCS. The space portion of DSCS II consists of spin-stabilized advanced communications satellites in synchronous orbit around the earth. Being significantly more powerful than the previous satellites, the Phase II spacecraft provide high capacity, super high-frequency (SHF) secure voice and data links for the Worldwide Military Command and Control System (WWMCCS). They support terminal deployments for contingencies; restoration of disrupted service overseas; presidential travel; global connectivity for the Diplomatic Telecommunications Service; and transmission to the continental United States of some surveillance, intelligence, and early warning data.

The DSCS II operational system consists of four active satellites and two spares orbiting the earth. Each satellite contains propulsion systems for orbit reposition to support contingency operations.

In DSCS III, the antenna design allows the user to switch between fixed earth-coverage antennas and multiple beam antennas. The latter will provide an earth-coverage beam as well as electrical steerable area and narrow-coverage beams. The first Phase

III satellite was launched in October 1982, but the complete Phase III system is still being developed.

Presently, the Satellite Control Facility (SCF) at Sunnyvale, California, handles the communication capabilities and positioning of DSCS II through a worldwide network of SCF stations. The planners and designers of the DSCS III system will design it so that selected Defense Information Systems Agency (DISA) managed satellite configuration control elements (SCCE) will have the ability to control both the satellite's communication capabilities and its position as well. The current operation plan for DSCS III requires that the SCCE assume the primary role in controlling the satellite communications systems with the AFSCF continuing to perform the functions of controlling the other satellite systems and maintaining the proper satellite orbit as in DSCS II. This will increase the flexibility of DSCS by providing a more direct response to communications systems user requirements and by providing DSCS III with backup capability for the SCF, should it ever be needed.

Air Force Space Command manages the design, development, production, and launch of the DSCS spacecraft. The DSCS II spacecraft are 9 feet in diameter, 13 feet tall, and weigh 1,200 pounds. The DSCS III spacecraft are approximately 9 feet in diameter, 7 feet tall, and weigh 1,900 pounds. They are three-axis stabilized. As well as being electromagnetic pulse (EMP) "hardened," they have sensors on board that report jamming attempts to the ground station, where directions can be returned to the steerable antennas on the spacecraft allowing it to "null" the jammer. A complete DSCS III ground terminal will fit aboard a C-5 aircraft and is readily transportable to support forces as required.

Fleet Satellite Communications Systems. The Fleet Satellite Communications System (FLTSATCOM) was a major and essential step in modernizing Navy communications. It helped relieve the Navy of its dependence on high-frequency transmission for beyond-the-horizon communication and adds needed capabilities not possible at high frequency, such as antijam fleet broadcast. Operating at ultrahigh frequency, FLTSATCOM allows relatively low-cost terminals with simple antennas for use on highly mobile platforms. Unlike the DSCS, FLTSATCOM has a relatively small capacity because of its much lower operating frequency. The FLTSATCOM system provides a satellite communication system for high-priority communication requirements of the Navy and Air Force that encompasses almost the entire world. This system supports other DOD needs as well.

The space segment consists of four satellites in geosynchronous equatorial orbit. Each satellite has 23 communication channels in the ultrahigh and superhigh frequency bands. The Navy has exclusive use of 10 channels for communication among its land, sea, and air forces worldwide. The Air Force uses 12 others as part of its (AFSATCOM) system for command and control of nuclear capable forces. The satellite system has one 500 kilohertz channel allotted to the national command authority.

The ground segment of the FLTSATCOM system consists of communications links among designated and mobile users, including most U.S. Navy ships and selected Air Force and Navy aircraft, as well as global ground stations.

Air Force Satellite Communications System. A general war-survivable satellite communications system for command, control, and communications (C^3) of our nuclear capable forces must withstand massive physical and jamming attacks in the execution of its mission. This is the goal of the AFSATCOM program. The AFSATCOM-1, which has a modest antijam capability, consists of Air Force transponders installed on host satellites. AFSATCOM transponders on the Satellite Data System (SDS) are providing north polar coverage. Transponders on the FLTSATCOM satellites will provide equatorial coverage. Transponders installed on additional satellites in the SDS and FLTSATCOM provide proliferation of coverage to increase survivability. The Air Force is planning for AFSATCOM II, which will emphasize a major upgrade in antijam capability and improvement in satellite physical survivability.

AFSATCOM will employ short, low-speed messages for force execution, force report back, and force redirection. The use of such teletype messages coupled with suitable antijam techniques will permit relatively simple ultrahigh frequency low-power terminals aboard our operational vehicles to reliably and securely communicate by satellites that large land-based jammers stress.

Satellite Data System. The SDS Program is a multipurpose communications satellite program that provides polar coverage for command and control of the strategic forces. Satellite Data System satellites are placed in highly elliptical orbits similar to those of the Soviet Molynias. They provide communication's links with nuclear and other forces in the polar regions uncovered by geostationary satellites. Additionally, it provides a high-data base communications link between the remote tracking station of Thule, Greenland, and the Satellite Control Facility at Sunnyvale, California.

MILSTAR

Of all the strategic C^3I systems now being developed, the Milstar satellite communications systems is probably the most controversial. Milstar stands for military strategic tactical and relay, meaning that the system will be used to control both strategic and tactical forces and to relay intelligence information from spy satellites and other sources. And unlike its predecessor DSCS, Milstar is being designed from the beginning to carry out its functions during all-out war, with the attendant electronic countermeasures and attacks by antisatellite weapons.

Milstar is also the most expensive satellite communications program ever conceived. The initial development contracts alone are worth more than $2 billion if all options are exercised, with Lockheed receiving $1.05 billion for development of the spacecraft and TRW another $1 billion for the communications payload.

EXPLOITING EHF

If the technological promise of Milstar is achieved, the DOD will be getting a very capable system for its money. The primary communications payload will operate in the EHF range, with probable uplink and downlink frequencies around 44 GHz and 20 GHz, respectively. It will also retain UHF capability to avoid obsoleting some $2 billion worth of UHF terminals now in service.

The EHF range has the advantage of higher data rates and allowing highly directional transmissions with relatively small antenna arrays, making interception difficult. The 44-GHz uplink antenna, for example, could be as small as one meter in diameter. In addition to being highly directional, an EHF signal can be spread over a one-GHz bandwidth, which is too great to permit effective broadband jamming. Fast frequency-hopping will further enhance Milstar's security and anti-jam characteristics.

In addition to the intrinsic advantages of EHF, the Milstar communications payload will have much more extensive on-board signal processing capability than previous systems, thus reducing the necessity for complex ground terminals. The spacecraft itself will also be designed to be less dependent on ground functions. In fact, the Air Force is said to be striving for an unprecedented degree of autonomy in the Milstar constellation--possibly as long as six months of operations without ground support. Both the spacecraft and communications equipment will, of course, be hardened to the maximum possible degree against electromagnetic pulse and other nuclear effects.

The planned configuration of the Milstar space segment is six geosynchronous satellites, including one orbital spare. Four of these will be in equatorial positions, with two more at higher and lower latitudes for polar coverage. The spacecraft will be connected by 60-GHz crosslinks to avoid relay through ground stations. The geosynchronous altitude would make it difficult for antisatellite weapons to attack the Milstar constellation; nonetheless, the spacecraft will include self-protection capabilities.

EARLY WARNING

The Defense Support Program is a key element of U.S. strategic surveillance, designed to provide the earliest possible detection of a ballistic missile launch. An outgrowth of the Midas program, DSP began development in 1966 and was declared operational in 1973.

The DSP system normally consists of three satellites in geosynchronous orbits over South America, the central Pacific and the Indian Ocean. The DOD regards this configuration as the minimum necessary to detect SLBM launches from the Atlantic or Pacific, or ICBM launches from the Soviet Union. Built by TRW, each spacecraft is about 10 feet long and 9 feet in diameter and weighs approximately 2,600 pounds; it can be launched either by the space shuttle orbiter or a Titan 34D expendable booster.

The system's primary sensor is a 12-foot telescope. Infrared energy is gathered by a Schmidt-type optical system and focused on an array of 2,000 detectors, each of which "sees" a terrestrial area less than two miles square; this allows both detection of a missile's heat plume and determination of its launch site. Data from the DSP satellites is relayed through the Defense Satellite Communications System to ground stations at Buckley Field, CO and Alice Springs, Australia.

EVOLUTIONARY UPGRADES

The DSP satellites are gradually being upgraded to increase their detection capabilities and to reduce their vulnerability. Through a development program being conducted under contract with Aerojet Electrosystems, recent satellites have an increased number of detection cells in the focal plane, as well as a second-color focal plane for enhanced detection capabilities in other parts of the spectrum.

The DSP satellites' 22,300-mile orbital altitude keeps them relatively safe from anti-satellite weapons, but they can be threatened by ground-based lasers, and are dependent on vulnerable ground communications lines and on overseas facilities, such as the one in Australia. Details of the steps being taken to correct these shortcomings are classified, but most experts believe that they include laser sensors and shields; higher-powered transmitters to allow operation with smaller, mobile ground terminals; and nuclear radiation hardening. Late-generation satellites may also be equipped with laser communications crosslinks to allow direct relay from the Indian Ocean satellite to the processing station at Buckley Field.

NAVIGATION SYSTEMS

Navigation is essential to military commands for precise delivery of weapons on designated targets, deployment of troops, and scheduled rendezvous of units at designated objectives. Increases in the military's mobility and in the sophistication and accuracy of their weapons have created the requirement to improve position-fixing and navigation capabilities. This and the worldwide distribution of military operations requires a navigation system with all-weather global coverage. At present, there are many navigation aids of various types that provide position-fixing capabilities over great sections of the earth for a large number of users.

Doppler Shift Influence. A major breakthrough in navigation procedures came with the first Soviet Sputnik in 1957 when scientists noted that a graphical frequency plot of the "beeps" received from the satellite formed a characteristic curve of Doppler shift. This concept was the basis for the Navy's Transit system and the follow-on Navy Navigation Satellite system, an all-weather navigation system that has been in use since 1964. It has enabled naval fleet units equipped to use the system to accurately establish their positions anywhere on the seas. There are several pairs of Transit satellites in "storage" orbits with 1000 year orbit life.

NAVSTAR Global Positioning System. The NAVSTAR Global Positioning System (GPS), known as NAVSTAR, is a space-based radio navigation network that will satisfy the precise positioning and navigation needs of all the military services. In the fully operational system, satellites circling the globe every 12 hours will beam continuous navigation signals to earth. With proper equipment, a user can process the signals and determine position within tens of feet, velocity within a fraction of a mile per hour, and time within a millionth of a second. The fact that the satellite employs an atomic spaceborne clock with an approximate drift rate of 10^{-3} seconds is a unique feature of the system. If a user has a clock that is in synchronization with the satellite clocks, the user can measure the time difference between transmission and reception.

To receive this information a NAVSTAR user only needs to push a few buttons. A user's set will select automatically the four most favorably located satellites, lock onto their navigation signals, and compute the user's position, velocity, and time. Engineers are developing receiving sets for integration with aircraft, land vehicles, and ships. Special lightweight ground receivers or SLGR's were used extensively by ground troops in Desert Storm. Possible applications of NAVSTAR include precision all-weather weapon delivery; enroute navigation for space, air, land, and sea; aircraft runway approach; photomapping; and range instrumentation and safety operations.

The NAVSTAR satellites are in a 10,900 nautical mile (20,178 kilometer) circular orbit with an orbit period of 12 hours. A fully operational system will position at least 21 operational satellites equally spaced in six orbital planes to provide global coverage. This "linked" system provides a nuclear blast action capability. The satellites are EMP "hardened."

A master control station communicates with the satellites through three ground antennas. Through these links, the control station updates the satellites with information so users receive optimum navigation data. Air Force Space Command acts as executive agent for the Department of Defense in managing the NAVSTAR GPS program.

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

Timely knowledge of weather conditions is of extreme importance in the planning and execution of military field operations. Real-time night and day observations of current weather conditions provide the field commander with greater flexibility in the use of resources for imminent or ongoing military operations. The military has established firmly the importance of meteorological data from satellites in the effective and efficient conduct of military operations, and new applications continue to appear as the scope and quality of meteorological satellite data improve.

Although there are other meteorological satellites in use by the civilian community, the Defense Meteorological Satellite Program (DMSP) satellites are designed to meet unique military requirements for weather information. During the Vietnam era, commanders used DMSP data gathered over Southeast Asia to plan daily air, sea, and ground operations.

Through the DMSP satellites, military weather forecasters detect and observe developing cloud patterns and follow existing weather systems. The data help identify severe weather such as thunderstorms, hurricanes, and typhoons. Visible and infrared imagery are used to form three-dimensional cloud-plural analyses of various weather conditions. An important feature of this imagery is its near constant resolution across the 1,600 nautical mile wide data swath. Although the primary mission of DMSP satellites is gathering weather data for military uses, its information is actually a national resource. Data gathered by the satellites are made available to the civilian community through the Commerce Department's National Oceanic and Atmospheric Administration (NOAA).

The sensor payload performs many missions for the DMSP system. The Operational Linescan System (OLS) is the primary sensor on board the spacecraft providing visual and infrared imagery.

The newer DMSP satellites contain an additional imaging system known as the mission sensor system, microwave imager (MSS/MI). The sensor is a passive microwave radiometer that detects and images microwave energy that the atmosphere and surface of the earth emit. These measurements will provide military meteorologists information about ocean surface wind speed, age and coverage of ice, areas and intensity of precipitation, amount of water and clouds, and moisture of soil.

DMSP satellites carry sensors that make temperature and moisture measurements. The infrared temperature/moisture sounder measures infrared radiation emitted from different heights within the atmosphere, allowing forecasters to plot curves of temperature and water vapor versus altitude, important for planning and employing laser and infrared sensors and illuminators for precision guided munitions. The satellite uses a microwave temperature sounder to measure microwave radiation emitted from different heights within the atmosphere. This instrument allows forecasters to plot curves of temperature versus altitude even over cloudy regions of the globe.

Two of these DMSP satellites are generally on orbit at any one time. They orbit at an approximate altitude of 450 nautical miles in near-polar, sun-synchronous orbits. Each scans a 1,600 mile wide area and can image the entire earth every 12 hours.

DMSP satellites record data throughout their orbits on tape recorders and play the data back to ground stations. The satellites are also capable of providing weather data on real-time basis to the Air Weather Service and Navy terminals, which provide military commanders in the field with photographic-quality prints of cloud cover four times a day.

OPERATIONAL UTILITY OF SPACE SYSTEMS

The capabilities provided by space assets have become increasingly important in augmenting and complementing other land, sea and air systems used in the decision-making process. For example, space based sensors provide reconnaissance and surveillance necessary for early warning, not just of ballistic missile attack on the United States, but of any hostile intent toward U.S. forces/allies in other theaters. Space also provides secure voice and high rate data communications essential to support national command authority (NCA) decision-making, mobilization, and to ensure unity of effort among the services and their subordinate echelons. In a mature theater the impact of these systems is significant due to the existence of the appropriate "downlinks", already in place, where data and information can be received, processed and transmitted in near-real-time.

Today, the majority of space systems are strategically oriented and are an essential element in the ability to deter aggression. They are used to monitor the action of nations hostile to U.S. interests, provide warning, and reduce the element of surprise. Space systems can help to detect violations of international agreements. They can also provide warning and information on actions that may indicate an intent to initiate hostilities. This can provide the advance warning and verification needed for U.S. forces to react decisively which may avert further escalation of a crisis. Since space systems can threaten fulfillment of an adversary's objectives and presents him with a dilemma. That is, any attempt to attack or degrade U.S. space systems/capabilities signals intent to do something inimical to our interests. Conversely, an attack after the initiation of hostilities will have allowed us to observe the enemy's preparations for war and provides time to respond. During the transition to war, surveillance and the near-real-time dissemination of intelligence information is critical, since this is the key for taking the initiative at all levels of war. Space capabilities also enhance our ability to mobilize and deploy by providing long-haul, non-line of sight communications and information via remote sensing capabilities. The use of many of these same space systems is planned and programmed to augment the theater command, control, communications, intelligence and target acquisition infrastructures and systems found in a mature theater as they relate to the execution of the theater campaign plan.

At the operational level of war the focus is on planning and conducting operations, as part of the campaign plan, designed to defeat the enemy force using simultaneous and sequential operations. To accomplish this, headquarters need to see the battlefield in sufficient depth to discover the enemy's intent and to evaluate the effectiveness of friendly combat operations. Surveillance satellites enable commanders to see deep and to locate and identify enemy strategic and operational assets necessary for planning operations to disrupt the enemy's operational tempo. It is the responsibility of the theater or task force commander to develop requirements for space capabilities, ensuring they are integrated with conventional systems, and requested of the appropriate agency for action. For example, space based reconnaissance and surveillance systems can gather data on areas, denied to other systems, that enables commanders at this level to see their entire area of interest and identify enemy resources. Access to data from space systems facilitates the attainment of agility by providing a better understanding of the battlefield and disposition of enemy forces. Additionally, space based communications assets provide the connectivity required for command and control of forces over extended distances, enabling commanders to synchronize operations and ensure concentration of combat power at the right place and time. Further, these assets provide the means for timely orientation of reconnaissance against time sensitive targets. Not only does space based reconnaissance help identify targets, but part of the space communications network transmits the targeting data to strike elements, facilitating the execution of deep operations and destruction of the enemy throughout the battlefield.

Space supports tactical units by facilitating command and control by providing early warning, intelligence information, weather and environmental monitoring, mapping and position location. Specifically, the constellation of global positioning system satellites provides location and navigation support to tactical forces as well as enhancing synchronization on the battlefield by identifying unit locations, boundaries and coordination points. Weather imagery and data from satellites is critical in determining the effects of weather on operations, equipment and personnel, both friendly and enemy. This information is also essential to planning and scheduling operations where weather related delays are possible.

As conflicts intensify, the communications links may be degraded while the requirements for voice and data communications increase.

Some of the unique capabilities of satellite communications systems are:

- Not limited to line-of-sight between ground terminals.
- No requirement for ground relay stations.
- No requirement to position terminals on high ground.
- Setup time for mobile terminals is fast, often within 30 minutes.

Satellite communications systems are a crucial part of the overall military communications system. They have been in use by U.S. forces since the mid-1960's. Communications satellites provide a significant part of strategic and long-haul administrative traffic. The military uses these systems to provide communications at the national, unified, theater and NATO level. Fixed stations with large antennas are currently in use in many locations. They provide high volume communications over long distances. They are, however, easily identified sites and are not considered survivable in a high-intensity conflict. There are a significant number of portable systems in U.S. operational and tactical units that can transmit and receive over satellite links. There are, however, only a limited number of channels available on current communications satellites and the priority of users restricts access at tactical level. The chart on page 14 describes some space communication capabilities.

SPACE BASED COMMUNICATIONS ASSETS

SATELLITE	MILITARY /NATIONAL /GOV CIVIL /COMMERCIAL	DOWNLINK	USING ORGANIZATION & INTERFACE	MILITARY APPLICATION	REMARKS/REALITY
DSCS	Military	Worldwide Mil Inst Comm Center TSC 85/93 Corps/Div/Sep Bde	NCA, JCS, CINCS Corps, Div via telephone	C3 Readiness Reporting Admin/Log Reporting Database Update Mission Updates Movement Coord	High capacity, super high frequency, worldwide secure voice, high data rate communications AUTOVON, AUTODIN, AUTOSEVECOM Access based on national priorities
FLTSAT/ AFSATCOM	Military	Worldwide UHF Manpack Airborne, Shipborne terminals	NCA, JCS, CINCs	C3 Readiness Reporting Admin/Log Reporting Database Updates Mission Updates Movement Coord Electronic Messages EAM Nuclear Release	FLTSAT and AFSAT channels are dominated by higher priority users (NCA, JCS, etc.) AFSATCOM designed for EAM, SAC C2 and JCS/CINC inter-netting
LEASAT	Commercial	Worldwide Airborne, Shipborne, shore terminals	USN Ships, Aircraft, and shore stations	C3 Ship-to-ship Ship-to-shore Shore-to-aircraft/ship Readiness Reporting Admin/Log Reporting Mission Updates	Leased by USN as adjunct to FLTSAT. Carries AFSATCOM transponder. No antijam or nuclear hardening.
INTELSAT	Commercial	Worldwide	Army units via commercial telephone	C3 Readiness Reporting Admin/Log Reporting Database Updates Mission Updates Movement Coord	Commercial telephone lines required.
NATO III	Military	Comm Ctr	NATO units Theater/Corps Div telephone	Theater comm C3 Admin/Log Reporting Mission Updates Movement Coord	NATO secure SHF interoperable with DSCS equipment

RECONNAISSANCE, SURVEILLANCE AND TARGET ACQUISITION

Reconnaissance satellites provide one of the most effective deterrents because of their ability to monitor arms limitation agreements, force deployments and other indicators that would provide early warning of an intent to initiate military action.

Satellite early warning systems can provide the first indications of a ballistic missile attack. This acts as an effective deterrent to the escalation of the level of conflict that might involve an attempt to negate U.S. strategic strike forces. Capabilities are, however, limited when the range of the missile is short due to the characteristics of the sensor or the ability to provide timely warning to units within the theater.

Intelligence preparation is a crucial process employed by commanders at all echelons prior to and during combat operations. Space systems can provide critical information on conditions and activities throughout the depth of the theater. Space systems can help link collection, processing and dissemination resources so that intelligence information is shared rapidly. The Tactical Exploitation of National Capabilities (TENCAP) program has been successful in providing greater access to national systems at operational and tactical levels. Classification levels of sources and products may hinder the timeliness of intelligence provided to allied commands. The Joint Tactical Exploitation of National Systems manual contains the procedures for commands to obtain TENCAP support.

Space systems are already capable of detecting and quantifying nuclear explosions. Each Global Positioning System satellite carries a nuclear detection (NUDET) sensor. A ground terminal to receive and process the data will be in the theater, NUDET sensors can be used to detect the detonation of enemy nuclear weapons and can be used for post strike analysis and damage assessments of NATO. The information provided by space systems will help to verify other reports and eliminate doubts and confusion.

ENVIRONMENTAL MONITORING

At the operational level, information on the weather is focused on general trends, climatology, seasonal changes and weather patterns which can effect large scale operations. Specific weather information is usually only needed for planning the use of special weapons.

At the tactical level, weather effects mobility, trafficability and visibility. Although it is not possible to control

SPACE BASED ENVIRONMENTAL MONITORING ASSETS

SATELLITE	MILITARY /NATIONAL /GOV CIVIL /COMMERCIAL	PROCESSING	MILITARY APPLICATION	REMARKS/REALITY
DMSP (weather)	Military	USAF in MARK IV Van or at AFGWC	Worldwide Local and battle area weather. 3-4 passes/day	DMSP available by FAX or direct downlink.
GOES-East (weather)	US Government (NOAA)	USAF, NOAA every 30 minutes picutres retrans as WEFAX	General weather of Atlantic Ocean Eastern CONUS Central America South America Worldwide WEFAX	WEFAX is processed imagery retransmitted via GOES satellites and includes composites from METEOSAT, GMS and TIROS satellites
METEOSAT (weather)	European	Every 30 minutes pictures retrans as WEFAX. Repeats every 3 hours	General weather of Europe Mediterranean Southwest Asia Africa	WEFAX is processed imagery retransmitted via METEOSAT satellites and includes composites from GOES, GMS and TIROS satellites
METEOR (weather)	USSR	Multiple satellites Picture received direct as satellite passes overhead	Local and battle area weather. 4-6 passes per day	May be encrypted in crisis
TIROS (weather)	US Government (NOAA)	Multiple satellites Picture received direct as satellite passes overhead	Local and battle area weather. 3-4 passes per day.	Low altitude visual and IR pictures.
LANDSAT (MSI)	US Government (operated by EOSAT Corp)	Worldwide Two satellites Data mailed to user in tape, casette, optical disk or floppy disk	Multispectral images can be used for terrain identification to include: - vegetation - soil boundaries - land cover - snow/ice cover - geological data - healthy vs stressed vegetation - trafficability analysis - perspective views - Bathymetric maps - Mapping	Military services may procure LANDSAT MSI data from DMA Military MSI manipulation and analysis considered R&D Requires account with DMA, SPOT, MOS-1
SPOT 1	French Government	Worldwide Data mailed to user in digital format Data stored at EROS Data Center		
MOS-1	Japanese Government	Worldwide Data mailed to user Data stored at EROS Data Center		

the weather, specific knowledge of the weather in the area of operation can be used to increase the combat effectiveness of forces. The fielding of large numbers of lasers, night vision devices and other sophisticated optical devices has made the requirement for precise weather data and forecasts even more critical than in the past. The chart on page 16 gives a presentation of meteorological space systems.

Although space systems today are not capable of detecting the type and extent of coverage of chemical weapons it is a capability that may be developed in the future. Obviously, the ability to detect and report the use of such weapons from space would be preferred to relying on manned reconnaissance in order to report the location of contaminated areas.

POSITION AND NAVIGATION

Successful operational execution is dependent, in part, on the ability to position forces and weapons accurately and to navigate quickly. The Department of Defense is deploying Global Positioning System (GPS) satellites. The constellation is expected to be completed by 1993. Each service is acquiring GPS receivers ranging from lightweight, hand-held types to those mounted in vehicles, aircraft, ships and selected precision weapons systems. The accuracy of the position, elevation, velocity, direction of movement and timing information provided to the user is determined by the type set used. The GPS receivers also provide the common grid reference for the Enhanced Position Reporting Locating System (EPLRS). The timing signal available from GPS satellites can be used to synchronize electronic warfare and other systems. All NATO nations are acquiring GPS receivers for their military forces. At 10,900 miles altitude the 24 satellites in the GPS constellation cannot be not easily negated.

VULNERABILITIES

It is evident from the previous paragraphs that the U.S. military already depends heavily on space systems to provide significant strategic, operational and tactical capabilities. This trend continues to expand as more space systems with enhanced capabilities are developed. It is therefore, essential that the United States have the ability to assure its continued access to space, defend its space assets, monitor all space systems in orbit, and to deny an adversary unrestricted use of space when it's against national interests.

The former Soviet Union was the only nation that had an operational anti-satellite (ASAT) system. If in their national interest, it could be used to negate certain key U.S. space systems. Generally, low earth orbit satellites are the most vulnerable. The number of ASAT systems and their capabilities are not sufficient to negate all U.S. space systems but could have significant impact against certain critical systems. At present the United States does not have the means to negate or destroy enemy satellites, although some research is being conducted.

In high-intensity conflict we can anticipate that some of our space systems, like anything else on the battlefield, will be disrupted, degraded or destroyed. At present, the United States has an extremely limited capability to reconstitute, augment or replace satellites on short notice. Not only did the Soviets have more satellites in orbit than the United States but more than 80% of all satellites had a military mission. They provided much the same capability that the United States has. The Soviets repeatedly showed they had a significant surge capability to replace inoperative systems or to add to their capabilities to meet specific needs. The U.S. does not!

The United States has a satellite tracking system that currently monitors and catalogs about 7,000 objects in space. This system can also provide advance warning to military units when an adversary's satellite will be passing overhead.

DEPENDABILITY OF SPACE SYSTEMS

The dependability of space systems to support military operations is contingent on the reliability of the space system, accessibility by users and the threat to degradation or destruction by an adversary.

The reliability of space systems is very high once the system is launched and the satellite is placed in position and activated. The majority of failures that do occur happen during launch or initial deployment of the satellite. The operating systems on the satellites are, as a minimum, designed to function over long periods in the natural space environment. Without the shielding effects of the earth's atmosphere the environment in space is hostile. Satellites are constantly bombarded by micrometeorites and high levels of natural radiation from the sun and outerspace. Satellites are designed to operate in this harsh environment, often for many years, therefore, even civilian satellites must have some hardening against electromagnetic interference. Military satellites are hardened against even higher levels to counteract deliberate attempts to disrupt or negate their capabilities.

In spite of the numerous satellites that are currently operating, the demand for space systems exceeds their capabilities. Some systems, such as the Global Positioning System and weather satellites, transmit their data over wide areas to any user capable of receiving and processing the signals. These systems do not receive any signals from the users, therefore they cannot be overloaded. Systems which receive signals from terrestrial users or do not cover large areas require control of user access so that the service is provided to users in order of priority. Within DoD, space systems are considered joint assets and priority of need and access is determined by the Joint Chiefs of Staff.

Space systems, like all other systems on the battlefield, can be subjected to a variety of hostile measures in an attempt to limit their effectiveness. These threats include electronic warfare, satellite interceptors, directed energy weapons and nuclear weapons. Currently, potential adversaries, other than the former Soviet Union, do not have the ability to attack satellites. In any conflict, an attack of our satellites would be a strategic act that may signal an escalation of the level of conflict. Even if attacked, a satellite's vulnerability is dependent on the type of satellite, its orbit (inclination, altitude and relative velocity), its size, construction, maneuverability, autonomy and many other factors. Satellites are very difficult to negate. The ground control stations and electronic transmissions to and from the satellites are much more likely targets.

SUMMARY

The command, control, communications, intelligence and support requirements, together with the potential of harsh environments, lack of host nation or established in-theater U.S. military communications infrastructure and problems inherent with the deployment of U.S. forces over long distances, make contingency operations one of the most difficult environments in which U.S. forces could be committed. Space assets can help!

The use of space systems increases the U.S.'s ability to detect war preparations and deter aggression. Today our shrinking global presence and reductions in forward deployed units have resulted in more reliance on remote sensing and long haul communications to monitor world events and to implement our national security policies. The use of space systems can provide early indications of the intent of potential aggressor nations. This information may allow the United States to quickly initiate political actions or deploy U.S. military forces to deter aggression. If war should start, space systems can provide invaluable, enhanced capabilities to our forces.