Chapter 4
Renewed Interest in Space and The War in the Persian Gulf, 1985-1991

The Army Returns to Space

In the years after 1958, the Army's starring role in space was diminished until it became a mere glimmer. The service became a passive consumer, dependent upon others to decide its needs. This loss was described by an Army War College Strategic Studies Institute fellow in 1985: "Although the Army now heavily depends on space systems for communications, command and control, reconnaissance and weather information, its role has declined from being the lead service in space operations in the late 1950s to that of the customer of the services provided by space systems."[1] The spark that reignited Army interest in space came from President Reagan's Strategic Defense Initiative speech of March 1983. The basic antiballistic missile technology research that provided the SDI's underpinnings was done by the ABMA and by Nike-Zeus. Its successor organizations would start paying the Army dividends.

Work on SDI galvanized other parts of the Army. The chairman of the Army Space Council, the Vice Chief of Staff of the Army General Maxwell Thurman, started several initiatives. A formal space policy was drafted, the military personnel system identified officers who had space-related education, skills or background and a space activities skill code was created to keep track of them. At the same time, officers were sent to civilian university graduate schools in space-related disciplines to meet an anticipated demand for their services. While these initiatives were proceeding, the Army Space Council realized there was no clearly defined role for the Army in space. To remedy this oversight and develop an Army Space Master Plan, an Army Space Initiatives Study (ASIS) Group was established at Fort Leavenworth in 1985.[2]

The Army had numerous organizations with responsibilities involving space. The result was a hodge-podge grouping of offices and staff organizations competing with each other for resources and attention. An earlier report concluded

> Individuals and groups with interest in space can be found in the BMD Program Office, ODCSOPS (Office of the Deputy Chief of Staff for Operations and Plans), ODCSR-DA (Office of the Deputy Chief of Staff for Research, Development and Acquisition), OACSI (Office of the Assistant Chief of Staff for Intelligence), Long-Range Planning, the Army Space Program Office, and elsewhere. There appears to be little coordination of effort and a distinct need exists for better integration of the space program.[3]

The plethora of organizations led to competition for personnel and proponency and resulted in great confusion. The chaotic rush to participate in the "next new thing" led to creating new offices with space-related responsibilities that competed with already-established organizations. This absence of command unity led to anarchy. The many competing organizations resulted in too many diverse organizations being managed by too many high-ranking officers, all of whom declaring space as their "rice bowl." Unity of command required that the Army streamline its efforts and eliminate duplication and confusion.[4]

In the mid-1980s, two organizations rapidly developed and focused the Army's interest in space: the Army Space Institute at Fort Leavenworth, and the Army Space Agency (ASA) in Colorado Springs.[5] At this time, the ASI was the more dynamic organization of the two as it approached its mission, to show the Army how to use space, with a missionary zeal.

The Institute's focus was tactical and its mission was to make space products available to provide support to the Army at the small unit level. Before 1986, most military space systems supported the strategic missions of STRATCOM and NORAD. Now ASI wanted these systems to support tactical units as small as an infantry squad. The vehicle used to disseminate the wonders of space-based products to tactical units was the Army Space Demonstration Program. By June 1987, a series of space demonstration concepts had been created. They included experiments with LIGHTSATs, commercial weather receiver systems (WRAASE), Global Positioning System (GPS) receivers and satellite early warning systems. The initiatives were formally approved in August 1987. Over the next three years, ASI provided briefings about these systems to the Army's Major Commands and was working on demonstration projects.

By the time Iraq invaded Kuwait in 1990, Army units were aware of the various space-related products that were available and were demanding they be issued space-related devices like GPS receivers. The ASI was deactivated in 1990 and replaced by the TRADOC Program Integration Office for Space (TPIO-SPACE) as the Army demobilized after the Cold War. The Combined Arms Combat Development Agency and later Combined Arms Command-Combat Developments leadership did not believe there was enough support for space applications in the Army to warrant the Institute's relatively large investment in manpower and resources. As part of this reorganization, responsibility for the ASDP was given to ARSPACE and the ASDP was renamed the Army Space Exploitation Demonstration Program (ASEDP). Under its new name, ASEDP has continued to make inroads into getting space-based products into the hands of the people who need them, helping to operationalize and normalize the use of space by the warfighter. Its philosophy, goals and objectives remained unchanged.[6] The ASEDP stayed in ARSPACE until 1997, when a command reorganization placed it in the new SMDC Battle Lab.

The ASI's aggressive efforts to bring space products to the Army provided several lessons to the senior leadership. First, the use of space systems should not be confined to strategic-level missions because tactical units could also use the information they provide. The demonstration program showed these systems could provide commanders with better unit location information, weapon targeting data, communications, weather information and intelligence information. At the same time, ASI discovered that many space systems were unsuitable for tactical use. This led to their experiments in the LIGHTSAT program (to demonstrate and evaluate the operational capabilities of lightweight, relatively inexpensive, limited purpose satellites to provide space-based support to operational and tactical commanders for reconnaissance, intelligence collection, surveillance and target acquisition). The ASDP also convinced the Army of the utility of modifying off-the-shelf electronic products for its own use. By showing flexibility, ASI was able to use existing technology in the most effective manner. The ASDP also showed the Army's space community that it must be willing to train soldiers in their units on the space systems so they might better understand their capabilities. This willingness to train soldiers in the field if necessary stood the Army in great stead during the Gulf War.

U. S. Army Space Command Activated

Fig. 4-1. The unit insignia of the U.S. Army Space Command, authorized in December 1988, symbolizes the Army's responsibilities for missile defense and strategic defense planning and the significance of satellites in navigation, communications and surveillance.

As ASI was pursuing its vision, the Army activated an operational command to manage its space functions, U.S. Army Space Command (ARSPACE). The first Army space organization at Colorado Springs was an Army Staff Field Element, founded in 1984 as a liaison office to AFSPC. In 1985, it was renamed the Army Space Planning Group as a planning function was added to its liaison mission. In 1986, when USSPACECOM was created, the planning group was renamed the Army Space Agency and was designated as "the foundation of the Army's operational capability in space."[7] In 1988, ASA was reorganized and replaced by U.S. Army Space Command. The new command retained its predecessor's planning and coordination functions and received added responsibility for the Consolidated Space Operations Center Detachment, the U.S. Army NASA-Johnson Space Center Detachment and three Regional Space Support Centers. As ASI was deactivated, ARSPACE received responsibility for the space demonstration program, reassigning the Army Signal Command's Defense Satellite Communication System (DSCS) platform and payload control mission to its purview extended its operational role.[8]

The ARSPACE was the Army component command of USSPACECOM and was a Field Operating Agency of the ODCSOPS.[9] Directly tied to the Army Staff in the Pentagon, ARSPACE had five command roles. It would provide "USSPACECOM an Army perspective in planning for DoD space systems support to land forces and strategic defense operations" to ensure "integration of Army requirements." It would respond to "USCINICSPACE-directed taskings" and command "assigned forces" as well as plan "DoD space operations in support of Army strategic, operational and tactical missions."

Initially the command was also given five missions. Aside from supporting USCINCSPACE as its Army component,[10] it would command the Defense Satellite Communication System Operation Centers (DSCSOCs) and manage joint tactical use,[11] plan for the possible fielding and operation of "Strategic Defense System (SDS) elements and anti-satellite (ASAT) weapons, should the United States choose to deploy them."[12] The command was also charged with assuring the Army's access and use of space-based capabilities to accomplish the goals of AirLand Battle Doctrine[13] and preparing for personnel and facility growth.[14]

The Future Security Environment Working Group Report and ARSPACE

The Report of the Future Security Environment Working Group validated the Army's new concentration on space-based assets and the creation of ARSPACE.[15] The working group concluded that the "rapid pace of technological innovation will probably continue over the next twenty years…. New technologies will revolutionize war in the same way that the Industrial Revolution changed warfare." These changes will lead to the "possible alteration of tactics, operational possibilities and possible strategic choices." The group also posited that only the superpowers would have the wherewithal to "sustain full spectrum change," although the possibilities remained open for niche changes dominated by regional powers. "We will see new areas of strategic concern and renewed possibilities for 'discarded options.'" The group's report explored emerging technologies and tried to ascertain "the implications of the new technologies for warfare."[16]

The working group identified nine types of emerging technologies that would influence warfare in the future. While not prescient, the technologies on the list were not generally known to the public or to the defense establishment at large. They included stealth technologies, unmanned vehicles, stand-off very high accuracy weapons and advanced strategic defense systems. The group also called for examining new cheaper space-based systems including newer GPS, anti-satellite weapons and satellite defenses, ballistic missile defense as well as advances in communications, reconnaissance, surveillance and weather technologies. The report then identified potential newcomers to space: India, China and Japan; space would no longer be the preserve of the Western powers and the Soviet Union. The group report then mentioned new sensors and processing technology, the ways greater use of computer-aided design (CAD) would ease and improve the "man-machine interface," and the importance of biotechnology weapons as well as directed energy and radio frequency weapons.[17]

The group members believed that these new technologies would change the face of warfare considerably, possibly ushering in a revolution in military affairs. Using weapons based on these technologies would "extend the battlefield to unprecedented depths" and at the same time, expose both sides to "increased infrastructure vulnerability." They believed future military operations would increase in speed and become more dependent upon information. This, in turn, would require "theater-wide integration of C^3I to support and a very rapid operational tempo (OPTEMPO)." Additionally, the weapons' increased destructiveness made the opening stages of a war more crucial than before. All this would lead to increased changes in military organization, doctrine and philosophy of command.[18]

The creators of AirLand Battle Doctrine anticipated many of these changes. They posited that future warfare would involve very mobile forces, linked by communications devices giving army and company commanders a common picture of the battlefield. Future armies would mount attacks throughout large theaters of operation, not along linear front. Battles would simultaneously expand in space and be shortened in time. Terms and concepts that first appeared in World War II, such as "deep attack," "flexible defense" and "follow-on forces attack," were refined using the new information technologies. This new approach may be observed in Army Field Manual (FM) *100-18 Space Capstone Doctrine*, which began circulating in draft in 1988. The draft noted that AirLand Battle doctrine "focused on a battlefield that was expanding in depth, duration and technology. Maturing technologies were found to be applicable to military missions."

When it spoke of future doctrine the manual emphasized the Army would capitalize on "emerging space capabilities," exploit those capabilities that "contribute to the successful execution of Army missions" and assure "access to space" in order to use space-based capabilities to accomplish "strategic, operational and tactical missions." These areas of responsibility included "ballistic missile defense, anti-satellite capabilities," the national test range, "national communications," the Military Man-in-Space Program and fulfilling "Army joint service taskings." The draft manual defined the operational and tactical missions as communications, reconnaissance and target acquisition, weather and environment monitoring, position location and navigation, fires support and support of the military man-in-space program.[19]

The Gulf War: The First Space War

Although not explicitly stated, the draft manual was explaining the role of space as a force enhancer. This was the focus that ASI and ARSPACE were publicizing and proselytizing. The demonstration of space-related technology as a force enhancer took place during the Gulf War. Following the Iraqi invasion of Kuwait in August 1990, the United States launched the largest military operation it had undertaken since the withdrawal of the last troops from Vietnam in 1973. More than 500,000 troops were sent to Saudi Arabia to protect the interests of the United States and its allies in the Persian Gulf region. As the United Nations imposed economic sanctions on Iraq and the U.N. Security Council condemned the invasion, the U.S., using bases in Saudi Arabia, began a logistics build-up, Operation Desert Shield, under the command of General H. Norman Schwarzkopf, commander-in-chief, Central Command. The efforts of the president and secretary of state resulted in

Fig. 4-2. ARSPACE personnel in Saudi Arabia during Operation Desert Shield/Desert Storm.

assembling a coalition of more than thirty nations to oppose the Iraqi dictator Saddam Hussein's invasion and pillage of Kuwait.[20] Operations Desert Shield and Desert Storm tested the Army's space-based technologies. Desert Storm has been called the "first space war" by some commentators because every aspect of military operations depended, to some extent, on support from space-based systems. The Army used these systems for position/navigation, weather, communications, imagery and tactical early missile attack warning. The assistance rendered was invaluable and the new technology, combined with AirLand Battle Doctrine, changed the way the Army fought. The conflict represented a watershed in the development of these systems.

Position/Navigation in the Desert

Navigation in the desert has always been problematic. Maps, if they exist, are not current and one area may be indistinguishable from another. Maps may also be next to useless because there are few terrain features on which to orient one's position. Navigation by the sun and stars may be hampered by clouds and sandstorms. While it is possible to navigate with map and compass, a better method of finding one's way was crucial to military success. Although other parts of space-based force enhancement can seem quite arcane, the value of one tool that emerged from the Gulf War was easily and quickly understood: the Global Positioning System.

Fig. 4-3. Global Positioning System satellite.

The origins of the GPS may be traced to the 1960s and is part of the larger human quest to locate itself in featureless terrain. Predictably, the first customer for this system was the Navy. Using maritime chronometers, sextants and tables to determine local noon and one's position at sea or in featureless terrain on land depends upon clear weather. A space position/navigation system that would work in all kinds of weather was on many wish lists. Work began in earnest in the mid-1970s, but the first satellites were not launched until the late 1980s. At the time of the Gulf War, only a partial system was in place.

The GPS is a position/navigation tool that uses a network of satellites that function as spaceborne beacons continuously transmitting a signal that can be used by a receiver to determine the operator's location. It is used for military, commercial, scientific and recreational purposes today, from mapping to surveying to air traffic control to search and rescue operations. The system itself has three segments, space, user equipment and control. The first segment, space, consists of a constellation of satellites placed in orbit allowing a receiver to pick up signals from several of them-one can determine one's location in two dimensions if the receiver picks up signals from three satellites; three dimension location information may be obtained if the receiver gets signals from four satellites. There were "16 usable (experimental and operational) satellites" in service at the time of Desert Storm "providing approximately 24 hours of two-dimensional coverage and 19 hours of three-dimensional coverage."[21]

The user segment consists of different types of receivers as well as test equipment, antennae and software. The two types of receivers used during the Gulf War were the "manpack/vehicular (M/V) models" and the commercial small, lightweight, GPS receivers (SLGRs). The M/V models weighed between 10 and 20 pounds and could "receive the precision-coded signals" resulting "in close to 10-meter positioning accuracy." The SLGRs were hand held and could receive signals with "15- to 30-meter accuracy."[22] The SLGR "fits in the side pocket of BDU trousers, weighs a little over four pounds and operates on two lithium batteries."[23] The control segment consisted of several tracking stations in Hawaii, Diego Garcia, Ascension Island, the Marshall Islands and Colorado Springs. The stations track each satellite, compute orbital and clock corrections, and transmit that information to the Master Control Facility, which sends the corrections back to the satellites.

Fig. 4-4. Soldier using a Small Lightweight Global Positioning System Receiver in Operation Desert Shield/Desert Storm.

The GPS may be the ideal system for the soldier. It continuously provides accurate position and velocity data from any location in the world while weather and other environmental conditions have no effect on its performance. It fits the 1986 CACDA definition of a perfect position/navigation system. This definition demands that such a system must provide coverage throughout the world, the user can be passive, an adversary can be locked out of the system, it must be capable of handling a large number of users without becoming saturated, and it must be able to resist electronic interference measures employed by a foe. It also must be unaffected by natural disturbances, provide real-time responses to its users, and be available for combined operations. There must be no difficulty allotting frequencies and it must provide a common grid reference for all users. The data it provides cannot be changed by differences in altitude (for land and air forces) nor by changes in time of day or year. It must provide accurate data to a moving vehicle and be portable enough to mount on a vehicle. Finally, the equipment must be relatively simple to maintain by the unit's soldiers.[24]

The Army began GPS field demonstrations in 1989. Many of the units deployed during Desert Storm the following year clamored for the equipment. The ASI and ARSPACE organized "train-the-trainer" programs at Fort Bragg, Fort Stewart and Fort Campbell as the SLGR receivers were distributed. However, "as more units deployed to the Gulf, this train-the-trainer effort could not be sustained." A training support package was prepared and delivered to units receiving the SLGRs, but distributing the packages was "limited by competing demands for other critical supplies, reducing their effectiveness as a training tool."[25]

The GPS was a success in Desert Shield and Desert Storm; most users were pleased with the system and the Center for Army Lessons Learned (CALL) reported that "comments…did not generally relate to system problems but to the fact that there were not enough receivers to go to all of the users who wanted them."[26] Lack of training led to troops' misunderstanding the system's capabilities and limitations. For example, some users thought they were more accurate than they really were and others believed GPS only worked in specific parts of the world. Nevertheless, the system was a great success. In a letter to the ARSPACE commander, Major General J. H. Binford Peay, III, commander of the 101st Airborne Division (Air Assault), touted its wonders.

> The SLGR is working wonders and is the most popular piece of equipment in the desert. We use it for everything and it is used by everybody…cooks, log resupply, navigation by aviation, fire support officers and commanders. Navigation is the singularly most difficult thing in the desert. Maps are inaccurate and the terrain features do not facilitate orientation. The entire area operations is one big enemy avenue of approach and without the SLGR, firepower would be hampered and under-utilized.[27]

The system allowed combat units to navigate quickly to their objectives, helped guide convoy movements and supported resupply operations. Iraqi minefields were discovered and marked using GPS data. Forward artillery observers employed GPS when using artillery or close air support, and batteries exploited the system to conduct field artillery surveys on the fly. Signal units used GPS to help position communications units. The SLGRs and the M/V units were used in a variety of combat roles in the desert. However, the rush to deploy units resulted in a series of problems. Most of them had their roots in the lack of formal training on the system. The CALL reported, "There were not enough GPS receivers available to cover all the applications for which they could have been used….The only receivers available to some infantry brigades were with Air Force or fire support elements." Sometimes these elements accompanied reconnaissance sorties solely "to provide GPS support." With only one receiver allotted to each field artillery battery, the commander had to decide whether to use GPS as either a navigation tool or a survey control tool.[28]

The problems enumerated were symptomatic of a more general difficulty that was only partly attributable to the lack of training. There was a fundamental lack of familiarity with the way GPS functioned and its designed function. This was due in part to soldiers' general ignorance of the ways in which space-based products could aid them to carry out their missions. Because they had never been exposed to it, they had not developed the intuitive sense of its strengths and limitations that come from using it regularly and considering it a normal part of their equipment.[29]

Weather Forecasting and Space-Based Systems

Unlike their general lack of knowledge about GPS, senior commanders understood they needed responsive weather reporting and forecasting before Desert Shield started. Earlier in 1990, TRADOC presented a concept for a Division Standardized Command Post. The new concept would allow the division staff to shed excess vehicles and equipment, making it easier to maneuver and deploy. Instead of an Air Force weather team attached to division headquarters, along with their communications and weather equipment, the new division weather team would be sharply reduced in size and would only disseminate weather information, not produce it. Several divisions and the Intelligence School relayed caustic remarks back to TRADOC about their new concept.[30] The objections illustrated that senior commanders understood the role weather plays in operations, the value they placed on having weather reports and forecasts tailored to their individual needs, and the importance they placed on being able to collect and disseminate weather information to their subordinate units themselves.

During the Gulf War, the primary weather imagery receiver the Army used was the WRAASE commercial weather receiver.[31] It was selected because it could get information directly from civilian weather satellites as they flew over the Middle East, including imagery, television and infrared observations.[32] The military system, the Defense Meteorological Satellite Program (DMSP), comprised polar-orbiting satellites that provided indirect support to Army at echelons below corps and direct support to the Army Service Component Command of Central Command.

The only differences between these satellite types were the spatial resolution of the imagery and the amount of time between consecutive imagery. Geostationary imagery resolution was on the order of 10 kilometers, providing very large-scale views of the weather and taking a new picture of the same portion of the earth every half hour. Polar-orbiting satellite imagery resolution was on the order of 2-4 kilometers, providing a smaller scale look at the weather. The DMSP imagery had a resolution on the order of 0.4 kilometers, allowing meteorologists to identify smaller scale weather phenomena. Polar-orbiting satellites pass over every part of the earth about once every twelve hours.[33]

The units deployed with the WRAASE receivers. As Desert Shield began, the intelligence section of the XVIII Airborne Corps and the 30th Engineer Battalion (Topographic) requested ASI provide them with additional weather support. ASI responded by integrating weather imagery and terrain analysis systems. Two FORSCOM Automated Intelligence Support System computers were outfitted with the Weathertrac commercial software package and networked with the WRAASE receivers. The ASI noted, "this combination allowed the staff weather officer to enhance the visible and infrared imagery available from the weather satellites as they pass over Saudi Arabia 8-10 times a day. With the limited knowledge of Saudi weather…this satellite weather information provides the one means of seeing the battlefield." The relationship between satellite weather and satellite terrain imagery data was formalized when the 30th Engineer Battalion established a Topographic Technology Exploitation Cell (TTEC) to analyze satellite imagery, combining weather and terrain data and producing updated maps.[34]

Weather satellites and the data they delivered were used in novel and unexpected ways in Desert Storm. When combined with multi-spectral imaging, the data aided in target planning, as well as planning, executing and redirecting ground movement. Despite its recognized utility, tactical units did not have access to all the available weather information.

After the war, CALL identified three trends in satellite weather support, including integrating weather and terrain analysis through the TTEC and distributing weather support receivers throughout the operational theater. The CALL reported, "U.S. Central Command took steps to procure more receiver terminals to enable the use of weather data at all levels of command. New, lightweight prototype desktop receivers were distributed to ensure the Army had access to real-time weather data from a variety of weather satellites." The third trend was the demand for raw weather data by analysts outside the staff weather office. The Center recommended this demand be satisfied by collocating satellite weather receivers with unit intelligence and terrain analysis staffs.[35]

Multispectral Satellite Imagery

The Army also used multispectral satellite imagery to update its maps of Saudi Arabia, Kuwait and Iraq. The Defense and Army mapping communities gave the forces on the ground up-to-date maps. These maps relied on information obtained from two types of satellites and two types of ground systems.

The satellites were LANDSAT and SPOT. LANDSAT is a U.S. Department of Commerce earth resources satellite system that provides coverage of the entire earth every 16 days and takes multispectral pictures at 30-meter spatial resolution. The width of one pass is 185 km. Imagery can be used to create maps to about 1:80,000 scale. Imagery must be purchased and cannot be shared indiscriminately because of copyright restrictions. When the Gulf War took place, two LANDSAT satellites were operating. SPOT is a French satellite that performs the same functions as LANDSAT and can view every part of the earth every 26 days. It has three different bands at 10- and 20-meter resolution. Imagery can be used to produce maps to a scale of approximately 1:25,000. The width of one pass is approximately 60 km. Images are available commercially and cannot be shared.[36]

Ground systems consisted of Multispectral Imagery (MSI) Workstations and FORSCOM Automated Intelligence Support System (FAISS). The MSI workstations were part of the ASDP to show potential users "the value of multispectral imagery for producing image maps, conducting image analysis and providing up-to-date broad area views of the battlefield. The workstations consisted of high-speed desktop computers" running a commercial program, Earth

Resources Data Analysis System, that performed a wide variety of tasks relating to "image analysis, image enhancement, data merging and terrain visualization." The FAISS was used as an "intelligence analysis workstation." Division terrain analysis teams could use the system to automate terrain analysis.[37]

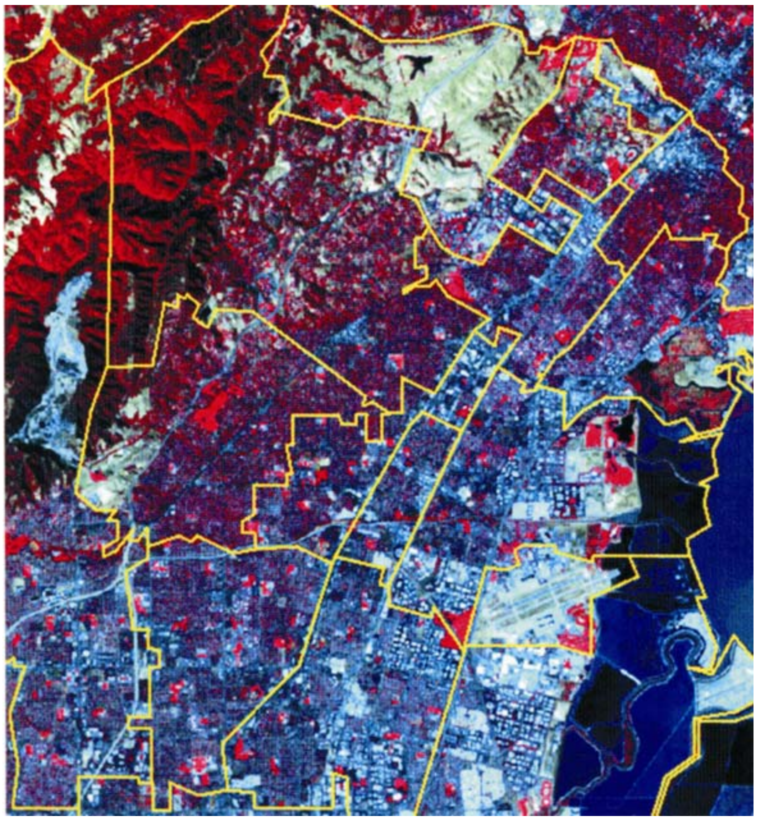

Fig. 4-5. An example of a multispectral satellite image.

The impact of multispectral imaging technology through the TTEC was felt on corps-level operations. According to an ASI report,

> Two thirds of the intelligence preparation of the battlefield [IPB] can now be combined using as current information as the last satellite pass allows. One month old LANDSAT imagery combined with weather satellite passes is providing a quantum leap in the ability of the commander to see his battlefield. IPB can be accomplished on the fly and not remain a pre-deployment or pre-exercise pursuit.[38]

The slow procurement process for LANDSAT imagery left the "topographic units without up-to-date imagery until November." The Army was also unable to get the money to pay the royalty rights for the large amount of SPOT images already in the possession of the Air Force. These delays hindered the topographic analysts' work and left Divisions with very little time to exploit available capabilities.[39] Nevertheless, "MSI was excellent for tactical planning. It provided accurate, updated maps, broader coverage and allowed planners the best available product before deployment to Saudi Arabia. The MSI terrain analysis supported the development of obstacle updates, proper routes, water locations, soil type, trafficability, etc."[40]

Space-based Communications Systems

The Army has been interested in using space-based systems for communications purposes since the first satellite systems were placed in orbit. Civilian and military satellite communications systems were of paramount importance to the command and control network the Army built during Operations Desert Shield and Desert Storm. An extensive voice and data communications network was needed to support the units in Saudi Arabia.[41]

The network used during the Gulf War consisted of military and civilian satellite communications systems. The Military Satellite Communications (MILSATCOM) system had three parts, (1) the Defense Satellite Communications System (DSCS), (2) the Fleet Satellite Communications (FLTSAT) System and (3) the Air Force Satellite Communications (AFSAT) System. The DSCS provided the greatest anti-jam transmission capacity while the other two had smaller transmission capacities, with no anti-jam capabilities.[42]

The Army had approximately 200 DSCS ground mobile force terminals that were normally placed in corps, division and echelons above corps headquarters. The FLTSAT and AFSATCOM systems had portable terminals and were used by command networks. All three systems were shared by government users. However, before the Gulf War, tactical units had made minimal use of these systems in exercises or contingency operations. In Desert Storm, the tactical users had priority and MILSATCOM services were provided from all resources. The Army deployed more than 1,500 terminals to Saudi Arabia (more than 75 percent were single channel portable military and commercial sets). The satellite networks were used for inter- and intra-theater communications, the latter was especially important given the lack of a communications infrastructure in the theater of operations. Approximately 50 percent of the communications traffic was carried by the DSCS terminals; the commercial INTELSAT system carried another 25 percent, while the remaining quarter was carried by FLTSAT, AFSATCOM and commercial terminals.

Operations Desert Shield and Desert Storm used much of the existing capacity of military and commercial communications satellite systems. Satellites were moved to better serve the operation and experimental satellites were used because of the high demand. The rapid movement and dispersion of units on the battlefield meant that maneuver units at levels below those usually issued with satellite communications receivers required them. MILSATCOM was used through the division level, but the rapid movement of the units meant that units frequently moved beyond line of sight and FM transmission and relays could not be established.

During the Gulf War, satellite communications was the backbone of long haul and intra-theater connectivity. The operations in the Persian Gulf War saw the beginning of three trends in the Army's use of satellite communications. Once satellite communications systems were the purview of higher headquarters. Since 1991, however, tactical units have made greater use of satellite communications systems, especially when deployed to places with rudimentary or nonexistent communications infrastructure. In the Gulf War, the DSCS was used by brigade-sized units. Second, the Army used commercial satellite systems to supplement its own communications network. Finally, the demand for communications support outstripped the capabilities of the available military systems. Part of the problem in the Gulf War stemmed from user inexperience that resulted in poor site selection, self jamming, and inadequate frequency planning that overloaded the satellite systems. The Army used this resource inefficiently because it had a limited amount of equipment, minimal control over satellites and complicated coordination procedures.

Theater Missile Defense

Space-based systems also played an important part in tactical early missile attack warning by supplying critical information on missile launches.[43] The early warning system was based on the Defense Support Program (DSP) satellite system developed in the 1970s. This system used a constellation of satellites equipped with infrared sensors to detect missile launches and determine trajectories and impact areas. During the Gulf War, after Patriot Air Defense units deployed to Saudi Arabia, USSPACECOM developed the Tactical Event Reporting System (TERS). The TERS modified a strategic system for tactical use and was designed to make tactical missile warning data available to the tactical commander in near real-time.

Fig. 4-6. Photo of a Scud fragment.

Fig. 4-7. Photo of damage caused by a Scud strike.

Operating the TERS was fraught with problems. Soldiers were not trained to use the equipment but, in retrospect, this proved to be a minor problem because the system itself "left much to be desired."[44] The original DSP system was designed to track Soviet strategic missiles that flew longer, further and had brighter infrared signatures than tactical Scud rockets. Therefore, TERS could not predict specific impact areas nor could it provide vectoring data to Patriot air defense batteries. The system was used to warn allied forces of impending missile impact.[45] However, the warnings were not timely because it generally took about two minutes to transmit them, leaving very little response time.[46] Finally, "Brigades operating away from the corps air defense artillery umbrella experienced difficulty receiving missile warning alerts."[47] Despite these shortcomings, TERS represented a breakthrough in early missile warning systems, a breakthrough that was exploited after the war.

Lessons Learned from the Gulf War

In this brief period the Army began to explore the possibilities inherent in using space-based systems. The activities of the ASI and ARSPACE brought these systems down to the tactical level. However, institutionalizing these changes has proven difficult because of institutional inertia and the short life of combat lessons learned.

The Gulf War demonstrated that space-related systems and products can successfully support the Army's operations. Units used GPS to navigate, control convoys and resupply operations, mark and breach minefields and for artillery surveying and fire direction. Tactical units can use weather receivers to obtain crucial weather information quickly. When weather information was combined with multispectral satellite imagery, maps using the latest intelligence can be created and distributed in a timely manner. Tactical missile detection has used space-based systems to warn units of incoming rocket attacks. As will be related, each of these capabilities has been improved since the end of the Gulf War.

It was also obvious that few commanders fully grasped the potential of the space-based systems to which they had access. Few understood how military space-related systems and their products can help them improve their tactical practices and their grasp of the operational art. This is a failure of imagination that can be remedied by fully integrating the uses of space into the Army educational system's curricula. As related above, both ASI and ARSPACE exposed tactical units to space-related systems and products. However, before the Gulf War, most units had not become acquainted with them. When the deployment began, both the Army Space Command and the Army Space Institute organized ad hoc training on the GPS and WRAASE weather receiving systems, allowing large numbers of soldiers to become acquainted with, use, and understand the idea of space support in position/navigation and weather intelligence. If schooling includes lessons on the use and deployment of space assets, then unit exercises will also use them.

Commercial space systems played a large role in the Gulf War and had a large impact on the military. Although the military DSCS carried about half of the communications traffic in the war, the INTELSAT system carried another quarter-the commercial system supplemented the military system. The WRAASE weather receiver was a commercial product and the topographical units' services expanded because of the commercial equipment and software bought during the war. Even the much heralded GPS could not be distributed to the majority of units until the Army bought and sent commercial receivers to the Persian Gulf.[48] Using commercial systems presented unique situations for the wartime commander. For example, although the Iraqis continued to receive weather forecasting information from three National Oceanic and Atmospheric Administration satellites and while the U. S. government feared this information could be used to launch Scud attacks, the satellites remained in service because they also supplied weather forecasting data to American allies in the region.[49] In a second instance, the Air Force could not share SPOT imagery with the Army because the latter could not pay the image royalties to the SPOT Corporation.[50]

A final enduring lesson from the Gulf War is the relatively short shelf life of combat experience. If the Army is to retain its interest in space and space-based systems and products, the Army's space community must make a greater effort to capture and disseminate the lessons it learns from observation and historical study of training, exercises and combat operations.

The Post-Gulf War Operation in Somalia

As the armistice took hold along the Iraq border, the United States found itself involved in Somalia. Beset by a lingering civil war that had destroyed all central authority, Somalia suffered from starving refugees, factional fighting and the proliferation of weapons. All of these troubles produced an anarchic situation. The problems of Somalia led the U.N. to commit peacekeeping forces to the area. In 1992-3, the United States mounted Operations Restore Hope and Continue Hope. The collapse of all central authority in Somalia, the inability to distinguish friend from foe, and the extremes of the Somali climate, presented new and unfamiliar challenges to the United Nations whose previous experience had been limited to peacekeeping operations in states that had not yet descended into chaos.[51] American troops committed to Somalia faced many of the same physical conditions they had faced in the Saudi Arabian desert.[52] Years of civil war had left very little in terms of dependable infrastructure. In these conditions space-based systems provided direct support to the deployed soldiers.

Standard map coverage for the region was either unreliable or nonexistent. At the beginning of the deployment, the division's standard was based on an old Russian map series. The TENCAP systems were used to produce the initial maps for the 10th Mountain Division's deployment. In fact, this imagery provided the commanders with their first reconnaissance of the area and was the initial source for terrain mapping. LANDSAT imagery was eventually purchased[53] to make maps of the uncharted areas of the Somalia-Ethiopia border. A problem highlighted in the after action report and lessons learned process was integrating signals intelligence into tactical planning and rapidly producing tactical maps to support ground operations.

Communications was a problem as the division acting as the Army forces command used INMARSAT as its primary communications medium in the initial phases of deployment. Single-channel tactical satellite radios were the primary vehicle for communicating over long distances until a long-haul communications system could be installed. The ARSPACE supported the division's deployment with SLGRs, multispectral imagery processing equipment and INMARSAT terminals. Initially, the 10th Mountain Division did not have any SLGR sets, INMARSAT terminals, trained WRAASE operators or any good maps. Within thirty-six hours of its alert by FORSCOM, ARSPACE sent equipment and trainers to the division's home station at Fort Drum. Using assets at Fort Drum, Fort Bragg and in Somalia, the division was able to provide for its communications and imagery needs. In addition, the division used SPOT imagery to update its maps and GPS to provide the troops with accurate position and navigation data.[54] The Seascape weather satellite receiver supported the Joint Task Force headquarters in Somalia with timely Defense Meteorological Satellite Program weather forecasts.[55]

In the late 1980s and early 1990s, as a result of the Strategic Defense Initiative and Operation Desert Storm, the armed forces became increasingly dependent upon space to wage war successfully. Space resources played a critical part in intelligence, communications, mapping, missile warnings, navigation, targeting and weather reporting and forecasting. At the same time, these assets were vulnerable to attack from potential adversaries. A determined enemy might easily destroy or nullify reconnaissance, communications and navigation satellites, paralyzing American forces.

The Army found itself increasingly dependent upon space to conduct its operations. The typical soldier relied on space-based systems to determine his position, locate the enemy, communicate with friendly forces, and fire "smart weapons." For the Army, space was becoming the new "high ground," an important part of firepower and information dominance on the battlefield of the future. It became crucial for the Army and the other armed services to take steps to improve their space technology and astronaut programs.[56]

End Notes

[1]Colonel Jan V. Harvey and Colonel (ret) Alwyn H. King, "Space: The Army's New High Ground," *Military Review* 65.7 (July 1985):38-51. The quote appears on p. 39; Colonel Harvey was the SSI fellow.
[2]Major Linas A. Roe and Major Douglas H. Wise, "Space Power is Land Power: The Army's Role in Space," *Military Review* 66.1 (January 1986):16.
[3]Cited by Harvey and King, 47.
[4]For a sketch, see Lieutenant Colonel Patrick Gagan, "The Army Space Command," *Military Review* 58.3 (March 1988):44-51, especially 47-49. He includes a chart ("Selected Army Organizations with Space Responsibilities: Offices (commands, agencies, activities, centers, directorates, elements, councils and groups) and their Senior Officers") on p. 47 that lists 23 Army organizations with an interest in space in 1985.
[5]The ARSPACE traces its roots to the Army Staff Field Element established to act as liaison to the U.S. Air Force Space Command (AFSPC) and initiate planning for Army participation in the unified U.S. Space Command (USSPACECOM) in 1984. In 1985, this staff field element became the Army Space Planning Group, the Army component of USSPACECOM. In 1986, the planning group was designated the Army Space Agency, a Field Operating Agency of the DCSOPS. In 1988, the ASA became ARSPACE and in August 1992, ARSPACE became a subordinate command of the U.S. Army Space and Strategic Defense Command, a predecessor of the U.S. Army Space and Missile Defense Command.
[6]The program's goal was to demonstrate to field commanders the latest relevant space technology from the academic, commercial and government research and development communities. Its governing philosophy maintained that (1) products from space-based systems are critical to rapid force projection operations, (2) using space-based products allows the force to dominate the contemporary battlefield and (3) space-based capabilities significantly enhance combat effectiveness. It maintained its three-fold set of objectives, to (1) educate tactical commanders on ways to use space-based assets, (2) assist in defining requirements for Army development, and (3) demonstrate new technology for possible development by the Army. A partial list of its post-Gulf War successes includes Satellite Multispectral Imagery Mapping, GPS Tracking, Command, Control and Communications ($TRAC^3$), the Mission Planning and Rehearsal System (MPRS), Space Enhanced Command and Control, the Joint Tactical Ground Station (JTAGS), the Gun Laying and Positioning System, Advanced Communications Satellite Technology (ACTS), the Digital Reconnaissance Tool, Commercial Space Package, the Army Space Support Team, the Army Theater Missile Defense Element (ATMDE), the Laser Boresight and the Global Broadcast Joint In-Theater Injection Terminal.
[7]U.S. Army Space and Missile Defense Command Historical Office and Science Applications International Corporation, Space Warriors: The Army Space Support Team (unpublished ms held at USASMDC Historical Office), 1-5.
[8]Space Warriors, 1-5. In 1990 ARSPACE received the mission to command the DSCS Operations Centers (DSCSOCs).
[9]Unless otherwise noted the next two paragraphs concerning command missions and roles are based on "31 July Information Paper."
[10]There were three facets to the first mission. The ARSPACE would run the Consolidated Space Operations Center (CSOC) Detachment and would perform duties in the GPS Mission Control Complex and the GPS Master Control Station. U.S. Army Kwajalein Atoll Complex contributed sensor information for the ARSPACE's Space Surveillance Network and supported USCINCSPACE's space control mission. It controlled the Army Astronaut Detachment at the Johnson Space Center. The detachment's purpose was to enhance the Army's ability to execute AirLand Battle Doctrine using manned space capabilities.
[11]The Defense Satellite Communications System was a super high frequency satellite subsystem of the Defense Communications System designed to provide secure voice and high data rate communications worldwide. ARSPACE was responsible for operations and maintenance of all the DSCSOCs.
[12]The ARSPACE was responsible for ground-based SDS elements (radars, surveillance tracking systems and interceptors). It would be the focal point for their combat and materiel developments weapons and be responsible for developing a concept of operations and force structure for their use as the Army was given the lead to develop system architecture for ASAT weapons.

[13]In terms of supporting AirLand Battle, ARSPACE would work with Corps and Division Tactical Operations Centers to support planning and training and contingency mission execution using the full spectrum of space support, position and navigation, communications, reconnaissance, weather and terrain sensing satellites. In terms of Theater Missile Defense, it would demonstrate the ability to provide theater warning.

[14]Growth in personnel strength reflected its increased responsibilities and facility growth was based on the idea of building a 50,000 square foot building to accommodate the command.

[15]Report of the Future Security Environment Working Group, October 1988.

[16]Report of the Future Security Environment Working Group, October 1988, pp. 26-27.

[17]Report of the Future Security Environment Working Group, October 1988, pp. 27-34.

[18]Report of the Future Security Environment Working Group, October 1988, pp. 33-34. The working group concentrated on the Soviet Union as the great potential enemy and believed future warfare would be a fight between peer enemies. The end of the Cold War saw the involvement of the United States Army in many smaller operations against forces that were not its peers in equipment or space-based assets. The most recent example was Operation Anaconda executed against al-Qaida holdouts in the Shah-i-Kot valley of Afghanistan. Even though American forces had unrestricted access to space-based intelligence systems as well as spy planes and unmanned aircraft, all these measure failed to discover that there were no civilians in the valley nor were they able to portray accurately the enemy's size, location, principal weapons and course of action. The enemy found simple low-tech ways to hide from the overhead systems (in caves, in rock crevasses, under trees or by pulling earth colored blankets over themselves). The lessons to be learned are that a technologically backward enemy can still surprise his high tech foe and that, while useful, technological superiority is not a panacea and ought not to be viewed in that way. See Sean Naylor, "The Lessons of Anaconda," *New York Times on the Web*, 2 March 2003, http://www.nytimes.com/2003/03/02/opinion/02NAYL.html?pagewanted=all&position=top, accessed on 2 March 2003.

[19]Space Capstone Doctrine [Draft] (FM 100-18) FY 88, pp. 1-2, 2-4, 4-2.

[20]See Joseph P. Engelhardt, comp., *Desert Shield and Desert Storm: A Chronology and Troop List for the 1990-1991 Persian Gulf Crisis* (Carlisle Barracks: Strategic Studies Institute, U.S. Army War College, 25 March 1991) for a list of the nations that made up the coalition and a list of forces and/or equipment each contributed to the effort.

[21]Center for Army Lessons Learned (CALL) Newsletter No. 91-3, *The Ultimate High Ground!: Space Support to the Army; Lessons from Operations DESERT SHIELD and DESERT STORM*, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003.

[22]CALL Newsletter No. 91-3, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003.

[23]U.S. Army Space and Missile Defense Command Archives, Army Space Command Box 4, *STAR*NET ARSPACE Newsletter*, 1.1 (15 February 1991).

[24]*The Army Position and Navigation Master Plan* (May 1986), p. II-1.

[25]CALL Newsletter No. 91-3, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003.

[26] CALL Newsletter No. 91-3, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003

[27] "Letter from Major General J.H. Binford Peay III to Colonel Ronan Ellis, Commander, ARSPACE, 16 October 1990." The SLGR continued to work wonders and after the war, the ARSPACE commander noted, "The SLGR was our greatest success in terms of volume and probably our single most significant contribution to Desert Storm. See "Memorandum from Colonel Michael Keaveney on Assuming Command, 1 April 1991."

[28]CALL Newsletter No. 91-3, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003.

[29]In 1991, the new ARSPACE Commander wrote, "The SLGR was our greatest success in terms of volume and probably our single most significant contribution to Desert Storm." "Memorandum from Colonel Michael Kearney to ARSPACE, Subject: Assuming Command, 1 April 1991."

[30]See Space Warriors, p. 1-17 reports that one of the less temperate replies was, "stupid, absolutely absurd!"

[31]The information in the following paragraphs, unless otherwise noted is from CALL Newsletter No. 91-3, Chapter 2, "The Battlefield Environment, Section A - Weather," http://call.army.mil/products/newsltrs/91-3/chap2.htm accessed on 10 January 2003 and "Briefing, WRAASE."

[32]The Army received its weather information from Geostationary and Polar weather satellites. Geostationary satellites placed over the United States (GOES), and Europe (METEOSTAT) provided weather imagery for the Gulf War. Satellites in polar orbit from the United States (TIROS) and the U.S.S.R. (Meteor) provided real-time television and infrared imagery as they passed over the Persian Gulf area.

[33]Ten-kilometer resolution resembles the views seen on TV weather forecasts while 0.6-kilometer resolution allows one to identify phenomena like fog and sandstorms.

[34] Space Warriors, p. 1-18.

[35]CALL Newsletter No. 91-3, Chapter 2, "The Battlefield Environment, Section A--Weather" http://call.army.mil/products/newsltrs/91-3/chap2.htm accessed on 10 January 2003.

[36]CALL Newsletter No. 91-3, Chapter 2, "The Battlefield Environment, Section B-Terrain" http://call.army.mil/products/newsltrs/91-3/chap2.htm accessed on 10 January 2003. During Desert Shield and Desert Storm Iraq did not purchase images.

[37]CALL Newsletter No. 91-3, Chapter 2, "The Battlefield Environment, Section B-Terrain" http://call.army.mil/products/newsltrs/91-3/chap2.htm accessed on 10 January 2003.

[38] Major Korpsel and Mr. Freeman, Input to LAMP: Space Support for Desert Shield (Fort Leavenworth: Army Space Institute, September 1992).

[39]Space Warriors, 1-19.

[40]"Memorandum from Colonel Michael Keaveney on Assuming Command, 1 April 1991." He went on to state, "We trained TOPO unit personnel and acquired proper equipment for them; provided upgrades into Saudi Arabia; and initiated and completed a very significant MSI intel or IMINT project, merging classified imagery and unclassified LANDSAT and SPOT imagery."

[41]Voice communications were needed for command and control purposes on all different levels. Data circuits were used to transmit logistics information, imagery and other messages. The units in the field also had to communicate with other theaters and bases in the continental United States that were supporting them. The military communications satellite systems were supplemented by INMARSAT (international maritime satellite system) and INTELSAT (international telecommunications satellite system) satellites.

[42]Unless otherwise cited, the material about communications is based on CALL Newsletter No. 91-3, Chapter 4, "Communications" http://call.army.mil/products/newsltrs/91-3/chap4.htm accessed on 10 January 2003.

[43]Material about tactical missile warning systems is based on CALL Newsletter No. 91-3, Chapter 3, "Tactical Early Missile Warning" http://call.army.mil/products/newsltrs/91-3/chap3.htm accessed on 10 January 2003 and Space Warriors, 1-19-20.

[44]Space Warriors, 1-20.

[45]Craig Covault, "USAF Missile Warning Satellites Providing 90 Sec. Scud Attack Alert," *Aviation Week and Space Technology* 134.3 January 21, 1991: 60.

[46]"Spacecraft Played A Vital Role in Gulf War Victory," *Aviation Week and Space Technology* 134.16 April 22, 1991: 91.

[47]CALL Newsletter No. 91-3, Chapter 3, "Tactical Early Missile Warning" http://call.army.mil/products/newsltrs/91-3/chap3.htm accessed on 10 January 2003.

[48]CALL Newsletter No. 91-3, "Chapter 1, Position/Navigation (POS/NAV)," http://call.army.mil/products/newsltrs/91-3/chap1.htm accessed on 10 January 2003 and Ricky B. Kelly, Centralized Control of Space: The Use of Space Forces by a Joint Force Commander (Masters Thesis, School of Advanced Airpower Studies, Air University, Maxwell Air Force Base, Alabama, September 22, 1994), pp. 24-25.

[49]"Iraqis Still Receive Weather Data from U.S. Satellites," *Aviation Week and Space Technology* 134.4 (January 21, 1991):26.

[50]See CALL Newsletter No. 91-3, Chapter 2, "The Battlefield Environment, Section B-Terrain" http://call.army.mil/products/newsltrs/91-3/chap2.htm accessed on 10 January 2003.

[51]The establishment of a coalition force representing 28 nations, highlighted deficiencies in U.N. procedures and structures developed over nearly forty years of operations. The U.N. civilian operation was never fully staffed and could not provide effective humanitarian, political, and security leadership needed for the peace enforcement operations to succeed. The elaborate administrative procedures developed over forty years to support peacekeeping operations were unsuitable for the fast-moving political, economic, humanitarian and military operations in this frequently hostile environment.

[52]The following section on Somalia is based on summaries from the following sources unless otherwise specified: Army Space Reference Text, 2-21 Operation Restore Hope and 10th Mountain Division (LI), "Somalia After Action Report for the Secretary of Defense, Complete Lessons Learned;" 10th Mountain Division (LI), "After Action Report: Executive Summary." The latter two documents are available at the CALL Restricted Database, Central Command, Somalia, Operation Restore Hope (1992), Operation Continue Hope (1993). Also, see Daniel G. Dupont, "Army Space Command Sent to Train Ft. Drum Soldiers: Somalia Operation May Be Army's Largest Use of Space Technology to Date," *Inside the Army* 14 December 1992:3.
[53]The funds for purchasing LANDSAT imagery were not immediately available.
[54]Also see, Space Warriors, 1-14, 1-15. The Army also used space-based systems in Bosnia during Operation Restore Promise. See "Army Space Command Provides Mission Rehearsal System for Use in Bosnia," *Inside the Army* 15 March 1993; Genevieve Anton, "Troops Trained to Use Space-Age Tools," *Colorado Springs Gazette-Telegraph* 21 May 1993:B-2 and Sue McMillis, "Army Space Command Helps Plan for Possible Pilot Rescues in Bosnia," *Colorado Springs Gazette-Telegraph* 3 March 1993.
[55]The DMSP consists of sun-synchronous, polar orbiting, low earth orbiting satellites that provide daily world wide coverage with higher resolution images than those available from geosynchronous satellites. The Joint Task Force Headquarters received its DMSP from its supporting Staff Weather Officers.
[56]See Colonel Jan V. Harvey and Colonel (ret) Alwyn H. King, "Space: The Army's New High Ground," *Military Review* 65.7 (July 1985):38-51; Major Linas A. Roe and Major Douglas H. Wise, "Space Power is Land Power: The Army's Role in Space," *Military Review* 66.1 (January 1986):4-17; Lieutenant Colonel Clayton R. Newell, "The Army and Space," *Army* 37.9 (September 1987):59-61; Paul A. Robblee, Jr., "The Army's Stake in Emerging Space Technologies," *Parameters* 18.4 (December 1988):113-119; and Igor D. Gerhardt, "Space the Air Land Battle, *Army* 40.6 (June 1990):43-47.