MEDIUM BRIGADE 2003: CAN SPACE-BASED COMMUNICATIONS ENSURE INFORMATION DOMINANCE?

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This thesis analyzes space-based communications support for medium brigade combat team forces over the next three years. The army?s reaction to changes in the national security environment and increased technology as outlined in Joint Vision 2010 has been to pursue digitization of the force and develop a new, ?Medium Weight? brigade-- rapidly deployable, reliant on high-capacity information architecture, and capable of early entry and stability and support operations. The study examined the role of satellite communications in the objective command and control system that considered the nature of the higher headquarters, adjacent units, and internal brigade requirements. Using the proposed Initial Brigade Combat Team concept, the study reviewed task organization, signal support structure, bandwidth requirements, and the operational employment of satellite communications assets during Operation Restore Hope, Somalia; Operation Uphold Democracy, Haiti; and Operation Joint Endeavor, Bosnia-Hercegovina. The study concluded that space-based communications will remain pivotal to successful command and control and projected signal organizations and equipment of the medium brigade can provide effective support. However, the army must address shortfalls in national satellite infrastructure, reconcile task organization difficulties, and integrate digitization efforts to effectively manage available communications capacities.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the United States Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

MEDIUM BRIGADE 2003: CAN SPACE-BASED COMMUNICATIONS ENSURE INFORMATION DOMINANCE? By MAJ Kenneth E. Viall, 116 pages.

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For Kimberly, Christopher, and Katherine, for your understanding,
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LIST OF ABBREVIATIONS

AAN	Army After Next
ABCS	Army Battle Command System
ACUS	Army Common User System
AECP	Army Experimental Campaign Plan
AFATDS	Advanced Field Artillery Tactical Data System
AOR	Area of Responsibility
ARFOR	Army Forces
ASAS	All-Source Analysis System
ASDC3I	Assistant Secretary of Defense for Command, Control and Communications
ATCCS	Army Tactical Command and Control System
AWE	Advanced Warfighting Experiment
BCTP	Battle Command Training Program
BOS	Battlefield Operating System
BSB	Brigade Support Battalion
BSC	Brigade Signal Company
C4ISR	Command, Control, Computers, Communications, Intelligence, Surveillance, and Reconnaissance
C2	Command and Control
CALL	Center for Army Lessons Learned
CCIR	Commander's Critical Information Requirements
COA	Course of Action
CONUS	Continental United States

CNR	Combat Net Radio
DAMA	Demand-Assigned Multiple Access
DBS	Direct Broadcast System
DOD	Department of Defense
DOIM	Directorate of Information Management
DISN	Defense Information Systems Network
DSCS	Defense Secure Communications System
DSN	Defense Switched Network
DSP	Digital Signal Processing
EHF	Extremely High Frequency
EM	Electromagnetic
EPLRS	Enhanced Position and Location Reporting System
EMP	Electromagnetic Pulse
EXFOR	Experimental Force
FBCB2	Force XXI Battle Command Brigade and Below
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FFIR	Friendly Forces Information Requirements
FLTSAT	Fleet Satellite
FM	Frequency Modulation
FY	Fiscal Year
GAO	General Accounting Office
GBS	Global Broadcast System

GCCS	Global Command and Control System
GHz	Gigahertz
GPS	Global Positioning Satellite
HF	High Frequency
Hz	Hertz
IPB	Intelligence Preparation of the Battlefield
IBCT	Initial (or Interim) Brigade Combat Team
ID	Information Dominance
INMARSAT	International Maritime Satellite
INTELSAT	International Telecommunications Satellite
IO	Information Operations
IP	Internet Protocol
IW	Information Warfare
JCS	Joint Chiefs of Staff
JCSE	Joint Communications Support Element
JDISS	Joint Deployable Intelligence Support System
JFACC	Joint Force Air Component Commander
JFC	Joint Force Command
JFLCC	Joint Force Land Component Commander
JTF	Joint Task Force
JTRS	Joint Tactical Radio System
JV2010	Joint Vision 2010
KHz	Kilohertz

LAN	Local Area Network
LDR	Low Data Rate
LF	Low Frequency
MCS	Maneuver Control System
MDMP	Military Decision-Making Process
MDR	Medium Data Rate
MEU	Marine Expeditionary Unit
MHz	Megahertz
MILSTAR	Military Strategic Tactical Relay
MSE	Mobile Subscriber Equipment
NCA	National Command Authorities
NTC	National Training Center
NTDR	Near Term Digital Radio
O&O	Organization and Operations
OODA	Observe, Orient, Decide, Act
OOTW	Operations Other Than War
OPFOR	Opposing Forces
OPORD	Operations Order
OPLAN	Operations Plan
PIR	Priority Intelligence Requirement
RSTA	Reconnaissance Surveillance Target Acquisition
SHF	Superhigh Frequency
SINCGARS	Single Channel Ground and Airborne Radio System

SMAR-T	Secure mobile Antijam Reliable Tactical Terminal
STAR-T	SHF Tri-Band Advanced Range Extension Terminal
STEP	Standardized Tactical Entry Point
TF AWE	Task Force Advanced Warfighting Experiment
TI	Tactical Internet
TIP	Theater Injection Point
TOC	Tactical Operations Center
TDMA	Time Division Multiple Access
TF XXI	Task Force XXI
TRAC	TRADOC Research and Analysis Center
TRADOC	Training and Doctrine Command
UAV	Unmanned Aerial Vehicle
UFO	UHF Follow-On Satellite
UHF	Ultrahigh Frequency
VHF	Very High Frequency
VTC	Video Teleconference
WIN	Warrior Information Network

CHAPTER 1

INTRODUCTION

Overview

To remain relevant on the modern battlefield, the Army must continually evaluate new technology and create new doctrinal concepts, organizations, and systems to fight and win our nation's wars. Changes in world political stability provide focus for offensive and defensive requirements and force composition. Weapons technology effects have caused direct and often rapid changes in doctrine and organizations throughout history. Increases in organizational size presented additional challenges to commanders as they sought to gain situational awareness and control their forces (Van Creveld 1985).

Command and control of forces above battalion level has relied increasingly on new technology. As early as the Civil War, the use of signal flags, balloons, and the telegraph by the newly created Army Signal Corps demonstrated the roots of technology's impact on command and control (Brown 1896). Spark-gap transmitters heralded the advent of wireless radio communications during World War I and allowed a wider span of control for operational commanders (Allard 1990). Frequency modulation radios and radio retransmission networks installed by numerous Signal Corps units increased the span of control during World War II (U.S. Army 1956).

Robust Signal Corps units demonstrated the unprecedented range and capacity of newly developed tactical satellite and tropo-spheric scatter radios during the Vietnam War (Ebener 1995). Each successive major development in technology from the Civil War to Vietnam resulted in corresponding changes in equipment and doctrinal organization of not only the operational Army as a whole, but also the supporting Signal Corps units who embodied the command and control system.

Currently, the Force XXI concept provides a conceptual framework for developing the future force (Training and Doctrine Command 1999). Within this framework, the Army's initial focus includes the concept of a medium brigade–rapidly deployable, reliant on high-capacity information architecture, and capable of early entry and stability and support operations. The medium brigade may provide an interim capability between existing light infantry and heavy mechanized forces and serve as a model for future combat forces.

Medium brigade concepts have evolved over the last few years from the conversion of an armored cavalry regiment with organic units into a new "strike force" unit to the limited activation of a strike force headquarters only without units in 2000. The strike force headquarters would participate in a series of experiments to validate the design by the year 2003. Recent developments in 1999 have changed the focus from the headquarters cadre unit without troops back to a complete structure with the subordinate units. Currently, the Army plans to convert two existing brigades at Fort Lewis to medium brigades within calendar year 2000 and develop the concept through experimentation through the year 2003. Key to the conversion will be the evaluation of new technology and systems into the organization as a proof of concept for applications throughout the Army.

Technology will not only provide increased capability to units but also present increased vulnerabilities for enemy exploitation. Information operations have become a new mission area where friendly forces seek to defeat enemy information capabilities while protecting and ensuring access to one's own. New capabilities for reconnaissance, surveillance, target acquisition, and command and control continue to be leveraged and fielded to units in limited experiments.

Modernization of legacy systems presents a greater challenge to organizations directly proportional to the density of fielded systems being replaced. Tactical satellite communications systems, including both space vehicles and ground terminals, are one example where long procurement times for expensive space vehicles requires a longer service life for tactical ground terminals. Ensuring the success of medium brigade operations in 2003 will require a review of satellite communications capabilities to ensure critical communications capabilities are available to ensure information dominance.

The Research Question

The primary research question is: Will projected space communications effectively support the medium brigade concept by the year 2003? To answer the primary research question, a number of secondary research questions were considered.

First, will satellite communications technology and equipment be available and sufficient to meet the requirements of future organizations? This question involves both military and commercial satellite coverage and capability and ground terminal equipment that must be sufficient and interoperable by 2003. Also, technical limitations might be imposed by frequency allocations, bandwidth, or physical infrastructure at military and commercial ground station locations.

Second, how will the organization of the medium brigade within a larger force contribute to increased information needs for command and control and information dominance? The command relationship between a medium brigade and higher headquarters and the information transfer linkages between echelons must be reviewed for their impact on satellite communications. This question also involved the ability of the Signal Corps and equivalent sister service units to organize communications teams to rapidly deploy and install critical communications links in support of their force components. The relationship between medium brigade signal support elements and existing joint and Army communications units including the Joint Communications Support Element (JCSE), the Power Projection for Army Command, Control, and Communications Company (Power PAC3), and other signal battalions at division and corps level could also reveal additional space-based communications requirements.

Finally, how will the expected mission and internal organization of the medium brigade, including the brigade signal company, contribute to increased requirements for space-based communications? This question involved the information transfer requirements of the medium brigade command nodes, battalions and subordinate units that would require satellite communications support based on operational concepts. Historical parallels of force deployments similar to the envisioned medium brigade which highlighted strengths and weaknesses in space-based communications support considered recent operations for factors not evident in other analysis.

Background

The Army relies on space-based communications to link national command authorities to deployed operational commanders. Space provides the ideal "high ground," accessible over vast distances, which enables critical communications to command and control deployed forces. Space-based communications have been vital to the execution of every operational deployment since Desert Storm. Demand for capability has exceeded supply in most cases.

Recently, additional military and civilian technologies have been tested during operational deployments for their applications for future forces. Existing satellite technologies are gradually being replaced or enhanced. Previously purchased systems like the Military Strategic Tactical Relay (MILSTAR) are reaching an initial operational capability. Innovative uses of direct broadcast satellites provide new possibilities for tactical applications.

The Army experimental campaign plan (AECP) provided a framework for validating new technologies and organizational designs through experimentation, resulting in a road map to the Army after next (AAN) (Caldera and Reimer 1999). Throughout early 1999, new organizational concepts for the military included the creation of a "Strike Force" headquarters by 2003, reliant upon high capacity communications capabilities, to be capable of integrating other subordinate units and rapidly deploying in support of a full range of military operations from war to humanitarian assistance. The strike force would be a medium-weight capability, filling a perceived void between the Army's digitized divisions and light forces.

The Army Vision published in October 1999, revealed Chief of Staff of the Army General Shinseki's vision for a different medium weight capability (Shinseki 1999). The "Strike Force" headquarters concept was tabled in favor of converting existing brigades at Fort Lewis using currently available technology to provide an earlier medium brigade capability equipped with survivable wheeled vehicles (Suro 1999). Given new technologies, new organizations, and uncertain missions, will the medium brigade in 2003 be able to coherently leverage space-based communications to support the fight as envisioned? This thesis will investigate space-based communications support for the Army's new organizational concept, from the perspective of the medium brigade headquarters communications planner.

Assumptions

Some initial assumptions were required to research this topic. The researcher assumed sufficient unclassified information was available to support a valid conclusion to the primary question. In addition, sufficient after-action review information would be available from the Center for Army Lessons Learned, interviews, or other accounts to confirm or deny meaningful parallels between communications support to previous deployments and the medium brigade concept. The researcher also assumed that the organizational concept for the medium brigade would be developed in enough detail to draw conclusions about the effectiveness of space-based communications based on unit functions, equipment, and assigned personnel.

Definitions

Communications Satellite: Military or civilian satellite providing one or more communications channels to link satellite terminal equipment within its area of earth coverage.

Defense Satellite Communication System (DSCS): Currently deployed constellation of communications satellites providing coverage of the West Pacific, East Pacific, East Atlantic, and Indian Ocean areas, primarily. Operates in the military (X-Band) frequency range.

Direct Broadcast Satellite (DBS): A method of transmitting high capacity, one-way digital satellite signals to small dishes. If required, return channel communications must be transmitted via a lower capacity link.

Global Broadcast System (GBS): A secure, military application of the DBS satellite system to provide a common operating picture to deployed headquarters.

Medium Brigade: For this thesis, the term medium brigade refers to the units being developed from the initial Strike Force concept. Also known as transformation brigades or Initial Brigade Combat Team (IBCT).

Military Strategic Tactical Relay (MILSTAR): An extremely high frequency, survivable, communications satellite characterized by inter-satellite communications links. MILSTAR terminals are not compatible with DSCS terminals.

MultiChannel SATCOM (M/C SATCOM): Generic term for higher capacity satellite systems, using the SHF or EHF frequency bands, that simultaneously provide multiple data connections for common-user voice, data, and messaging applications.

Satellite Communications Systems (SATCOM): Generic term for as single channel, multichannel, and data-based communications that rely on the use of a satellite as a relay or switching element. Composed of satellites in orbit providing various degrees of coverage of the earth, fixed control and gateway sites that control satellite operations and payloads and provide access to services, and deployable terminals which can move with warfighters to provide voice and data service.

Satellite Terminal Equipment: For purposes of this research, satellite terminal equipment is defined as the deployable system, including radio equipment, antenna, power generator, and software, which allows communications either by voice or data over a space-based communications satellite.

Single-Channel SATCOM (S/C SATCOM): Generic term for small satellite radios primarily used for voice and limited data applications that utilize the UHF and

EHF frequency bands. Typically operated in networks similar to FM radio employment.

Limitations

This thesis did not present detailed technical capabilities of space-based communications systems in general but did summarize pertinent aspects relevant to the discussion and directed the reader to other documents for more technical background information. The study also did not consider the effectiveness of other capabilities of space-based sensors to support the medium brigade except as they related to communications. Emerging organizational design for the medium brigade evolved over the research period of the thesis but the selection of 2003 as a baseline for analysis prevented conflicts of information between interested headquarters responsible for different dimensions of the medium brigade concept.

Lessons learned for previous deployments did not show enough resolution on the use of satellite communications to draw any empirical conclusions. Data gathered in conjunction with the medium brigade command post exercises and from other simulations was limited based on the model used within the simulation.

Delimitations

Review of satellite systems architecture was limited to the last six years due to rapidly changing technical programs. The search for parallels in deployments of augmented brigade task forces focused on the period beginning with Operation Restore Hope in 1993 to the present on operations more specifically representative of military operations other than war (MOOTW).

Because this thesis attempted to be predictive in some respects, projections of the state of future satellite launches, equipment modernization plans, and programs and budget approvals were extrapolated from current science and technology projections. Because this thesis is unclassified, specific intelligence and special satellite programs were not considered unless an unclassified, general conclusion could be drawn.

Significance of the Study

The results of this thesis may be relevant to the doctrinal organization of the medium brigade communications support element. The creation of the Initial Brigade Combat Teams by the summer of 2000 with satellite communications systems currently available parallels the Army's initial activation of the Power PAC3 Company long before advanced communications satellite capabilities became available. Little doctrinal basis existed for the employment and capabilities of the Power PAC3 Company outside of conceptual briefings (11th Signal Brigade 1994).

The medium brigade concept will continue to be developed using a series of exercises and experiments through the year 2003. This researcher hopes that this thesis may assist the medium-brigade communications planner to ensure realistic conditions and assumptions are in place for the experiment and to critically analyze the results. Thesis conclusions could also serve as a justification for additional resources or doctrinal changes to the signal support structure of the medium brigade.

CHAPTER 2

LITERATURE REVIEW

Overview

To determine if projected space communications will effectively support the medium brigade concept by the year 2003 (the primary research question), the subordinate elements of satellite communications, measures of effectiveness, and organizational design and requirements were used to deduce initial topics to evaluate. To conduct the initial literature review, the primary research question and first level subordinate questions as shown in the introduction focused the direction of the thesis and helped refine the secondary and develop the tertiary research questions. For each research area, the literature provided initial background information and an appreciation of the level of research conducted on subjects related to the thesis. Evaluation of extant secondary and primary research provided specific conclusions in some specific focused cases or leads to primary information sources in others. Literature of interest for this thesis divided naturally into a number of categories as outlined below.

Background

First, the nature of military organizations that fight and win conflict had to be reviewed to determine how a medium brigade might be employed. Much has been written about general command and control theory providing a framework with which to judge the effectiveness of communications to any headquarters, including the medium brigade. Recently, *Joint Vision 2010* provided the term command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) as a capstone concept for information superiority. Evaluating the organizations of headquarters and the information requirements of commanders and staffs provided insight into requirements and challenges for the new organizational concept. Specific lessons learned from the digitization efforts ongoing at Fort Hood and the results of previous advanced warfighting experiments (AWE) provided a more relevant snapshot of digital integration considerations.

Satellite Communications

A broad base of articles and doctrine addressed currently fielded satellite systems and terminals and how effectively current organizations employ these systems. System capabilities, limitations, frequency restrictions, physical infrastructure, and terminal availability provide general satellite planning considerations that remain relatively constant for medium brigade communications planning. For the future, near term satellite launches and terminal equipment fielding schedules lead to long-term conceptual requirements of systems yet to be designed or funded. Writers have recently begun to explore newer satellite communications technologies, information dominance, and *Joint Vision 2010.*

Signal Corps Organizations

The Signal Corps serves as the functional proponent for communications support to Army organizations and generally provides the organizations, both soldiers and equipment, to leverage satellite communications capabilities at all echelons. Understanding signal organizations becomes essential given the requirement for medium brigades to communicate with higher and adjacent units.

Medium Brigade Organization

When research for this thesis began, very little information had been published on the strike force or medium brigade, since they were new concepts for the Army.

Most valuable information available on the medium brigade could be found on the internet at the battle laboratories or through the CALL internet search engine. Additional detail became available as the results of medium brigade experiments were analyzed and published. Medium brigade information-transfer requirements between command nodes, higher headquarters, and subordinate units would require various degrees of satellite communications support. Medium brigade likely deployment areas and deployment timelines could have an effect on satellite communications availability.

Doctrinal Case Studies

Finally, some published accounts of similar deployments provided an initial base to begin the search for parallels. Lessons learned from the CALL database supported a more detailed analysis of particular operations. Of specific interest was Marine Expeditionary Unit (MEU) operations where satellite communications have been exercised since the medium brigade and the MEU seem to be the closest match in capabilities minus the extra digitization effect that the Army has envisioned. Primary and secondary source documents from previous operations specifically addressing satellite communications support to these contingencies were invaluable to highlight strengths and weaknesses in space-based communications support. Trends of interest included the increase in the use of tactical computers, complexity of command relationships, and the increasing role of information superiority and information dominance as new operational concepts.

Literature Review Results

Not surprisingly, current Army organizational doctrine, command and control theory, satellite communications capabilities, and older contingency operations in Somalia and Haiti have been well documented and generally researched along similar areas as this thesis. However, newer operations, technology, and organizational concepts like the First Digitized Corps/First Digitized Division and the Initial Brigade Combat Team have not been as widely addressed in available literature.

Command and Control Theory

In *Command and War*, Van Creveld offers an insightful look into the theory of command and control from the days of Napoleon until Vietnam. As the Vietnam conflict provided one of the first uses of space-based communications systems (Ebener 1995), it seems prescient that Van Creveld concludes that increased communications were actually detrimental to the prosecution of the war (Van Creveld 1985, 249).

Ken Allard highlights some of the interoperability challenges between services in a joint environment in his work, *Command and Control for the Common Defense.* Allard attributes some of the friction to service paradigms, and stresses caution when adapting new technology for use by the military services (Allard 1990). His book provides a benchmark for reviewing service organizations and programs without the prejudice of parochialism.

Satellite Communications

Satellite communications literature has been broadly grouped into three areas: doctrine, terminals, and infrastructure. Satellite doctrine concerns the vision, conceptual employment, and planning for use of satellite communications. Satellite terminals refer to tactical equipment employed and operated by primarily Signal Corps elements to provide access to satellite bandwidth. Satellite infrastructure includes both the military and commercial satellites themselves, as well as the strategic gateways offering access to national information infrastructure and the control and monitoring facilities that oversee satellite systems.

Satellite Doctrine

Field Manual (FM) 100-18, *Space Support to Army Operations*, describes general concepts for space support to the warfighter (U.S. Army 1995). Joint Publication 3-14 offers a more modern treatment of the subject with characteristics, capabilities, and limitations of the different satellite communications systems available (Joint Chiefs of Staff 1999a). Two of the communications questions posed in the planning section of the joint publication refer to the availability of satellite terminals to support the ground commander and the need for commercial satellite capabilities. These same questions must be answered in relation to the medium brigade.

Joint Vision 2010 defines a framework for future operational concepts based on information superiority (Shalikashvilli 1997, 19). Communications and enhanced command and control mechanisms will be the foundation. FM 100-6, *Information Operations*, defines information dominance and outlines the critical importance of signal support systems to provide an "end-to-end, protected, seamless, multi-gigabyte information transfer and processing capability for the warfighter" (U.S. Army 1996, 5-6). It stresses not only role of battle command in achieving information dominance but also the role of communications to facilitate better control of situations.

Prall wrote about space doctrine as it supported the emerging Airland Battle doctrine. While Airland Battle doctrine has been superseded by new concepts, his methods of study and background information provide useful information to construct a research methodology for the medium brigade (Prall 1991, 14).

Satellite Terminal Equipment

In his thesis, Hildebrand writes about the single channel satellite support to corps and division commanders. His discussion of communications while enroute to a deployment zone by using hatch-mounted satellite antennas in strategic aircraft through to the initial arrival to an operational area have parallels in the envisioned medium brigade headquarters (Hildebrand 1996, 18). Effective communications support to the medium brigade may include similar en-route mission planning capabilities using satellite systems.

In his master's thesis, Henry compares and contrasts the DSCS and MILSTAR satellite systems and their support to division and corps elements. He concludes that both systems provide a needed capability (Henry 1995). However, both types of terminals are not interoperable with each other potentially requiring dual employment at selected locations.

National Satellite Infrastructure

Recently, the first MILSTAR satellite launched failed to reach the required orbit; analysts now face the challenge of determining the best coverage with the remaining three satellites over the next three years. This situation highlights the fact that doctrinal satellite concepts, while sound, rely on extremely expensive programs subject to funding problems or delays. This factor must be considered in studying the medium brigade for 2003.

To bridge the gap between uncertain military capabilities, commercial satellite systems are also finding military applications. For example, the Teledesic system will provide a global data network similar to the voice network of Motorola's Iridium system (Ackerman 1998). Barrett describes the potential for the Spaceway System by Hughes Corporation to provide almost three thousand T1 equivalent circuits using relatively small satellite dishes (Barrett 1998).

Major Virginia Ashpole reviews all commercial satellite systems in her thesis with a particular focus on military applications to joint operations (Ashpole 1998). Major Birch describes an application of a direct broadcast satellite system to support a Marine Expeditionary Unit (1997). Satellite communications remains a growth industry. Both studies provide alternative solutions to mitigate the effects of shortfalls in military satellite communications capabilities. However, significant risk exists in competition for civilian satellite bandwidth, legal concerns related to employment during hostilities, and uncertain reliability or assurance of continued support. The investment in Motorola's Iridium system was lost, as the company's bankruptcy and lack of a buyer for the satellite constellation could result in the deorbit of the constellation over the next year.

Signal Support Organizations

The Army Signal Corps serves as the functional proponent for communications and computer equipment for the Army and designs the operational architectures for command and control systems. Generally, dedicated tactical signal units support divisions, corps, and theater armies; strategic signal units operate military communications infrastructure overseas and at critical gateways in the continental United States. Multichannel satellite teams are employed from division to echelons above corps levels (U.S. Army 1999). Single-channel satellite terminals are found from commander in chief (CINC) level down to individual tactical battalion (Hildebrand 1996).

Joint and Service Organizations

The Joint Communications Support Element (JCSE) provides the only dedicated unit trained to provide communications to two joint task force (JTF) and two joint special operations task force headquarters (JSOTF) simultaneously (JCSE 1998). JCSE has advantages in modern equipment, excellent training, and rapid deployment of tailored capabilities but limits deployment to forty-five days to maintain readiness for other contingencies. Prospective JTF commanders must request specific support through Joint Forces Command and specify their own inability to provide the required communications support and their plan to replace JCSE assets within the forty-five day period. Consequently, JTF commanders able to leverage their parent service communications organizations for equivalent support pay the deployment bill once without future disruption of support due to relief in place operations.

Echelons Above Corps (EAC)

Communications architecture at deployed theater level provides a basis for modification when constructing an ARFOR or JTF headquarters from an Army unit. EAC units provide critical connectivity using Tri-Service Tactical Communications Equipment (Figure 1) assets to adjacent units and the defense communications system, and accept connections from a higher headquarters (U.S. Army 1999).

Given the large geographic area characteristic of the theater area of operations, long range communications, such as satellite and tropo-scatter terminals, are prevalent. Shorter-range radio systems support connections to scattered subordinate headquarters where terrain allows unobstructed line-of-sight up to thirty kilometers. Satellite entry into the sustaining base provides "reachback" capabilities, allowing direct voice and data network connections to a strategic entry point responsive to Army priorities.

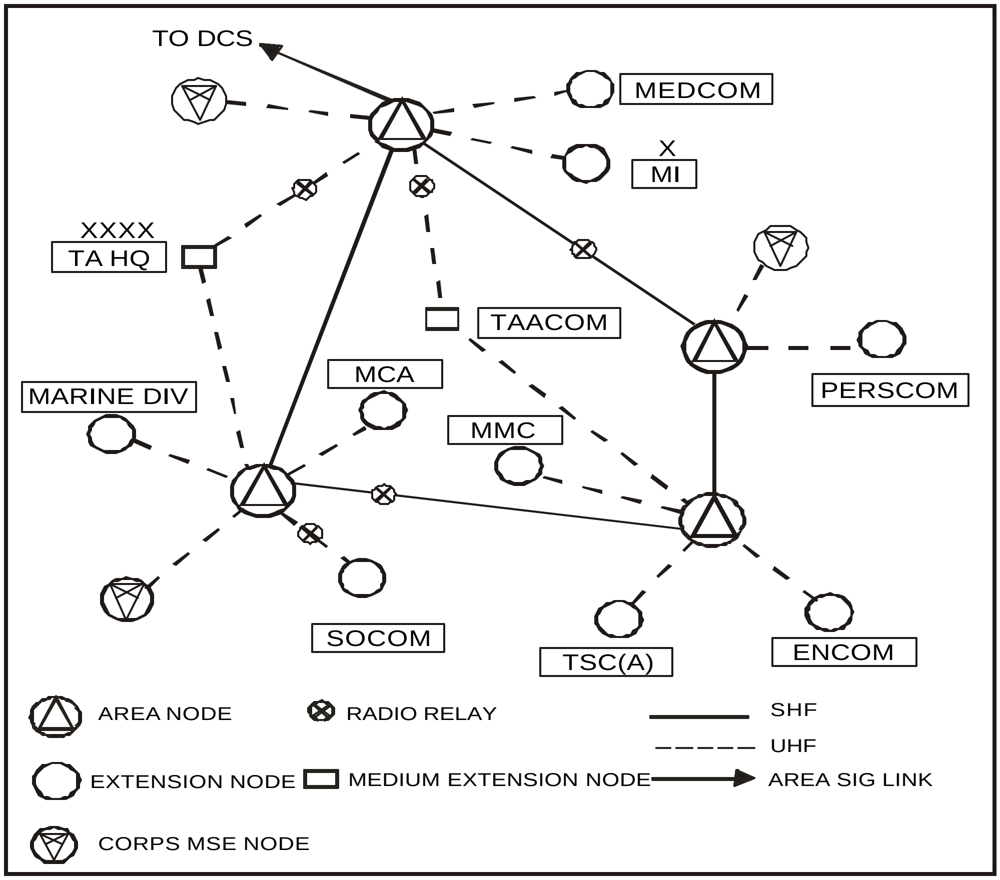

Figure 1. Echelons Above Corps Area Communications System (Source: FM 11-43, *Signal Leader's Guide*, 1999, 3-1)

Corps Signal Brigade

FM 11-55 outlines the role and doctrine of the corps signal brigade's employment of mobile subscriber equipment (MSE) to support a doctrinal Army corps as shown in figure 2 (U.S. Army 1998). The corps has a specific mission to employ tactical satellite in support of the corps and subordinate divisions. Satellite systems at this level are primarily used for range extension where existing MSE radio systems cannot be used due to distance or terrain masking constraints.

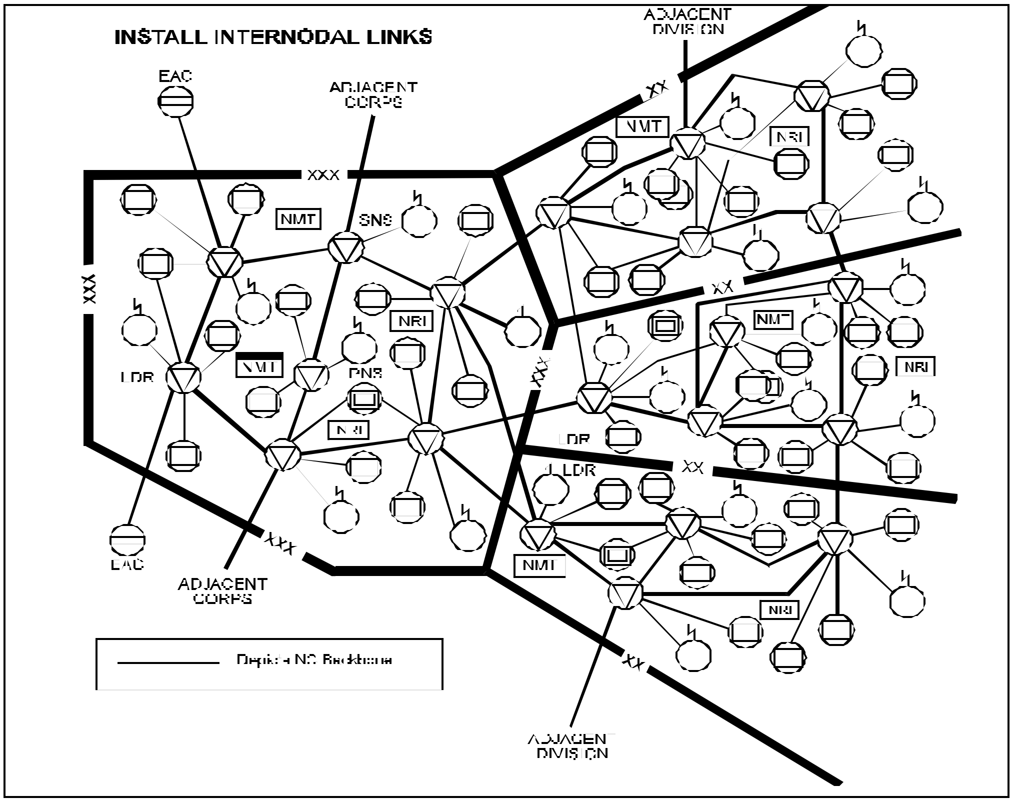

Figure 2. Doctrinal Communications for Fully Deployed Corps (Source: FM 11-55, *Mobile Subscriber Equipment Operations*, 1998, 2-2)

Division Signal Battalion

Division signal battalions are organized almost identically to corps area signal battalions but provide the most mobile area signal coverage to their divisions across a doctrinal eighty by fifty kilometer area as shown in figure 3 (U.S. Army 1998). Multichannel satellite systems are typically not available to exclusively support brigades or other subordinate units of the division. Single-channel voice over satellite comprises a warfighter net including the division command posts and all subordinate headquarters of the division.

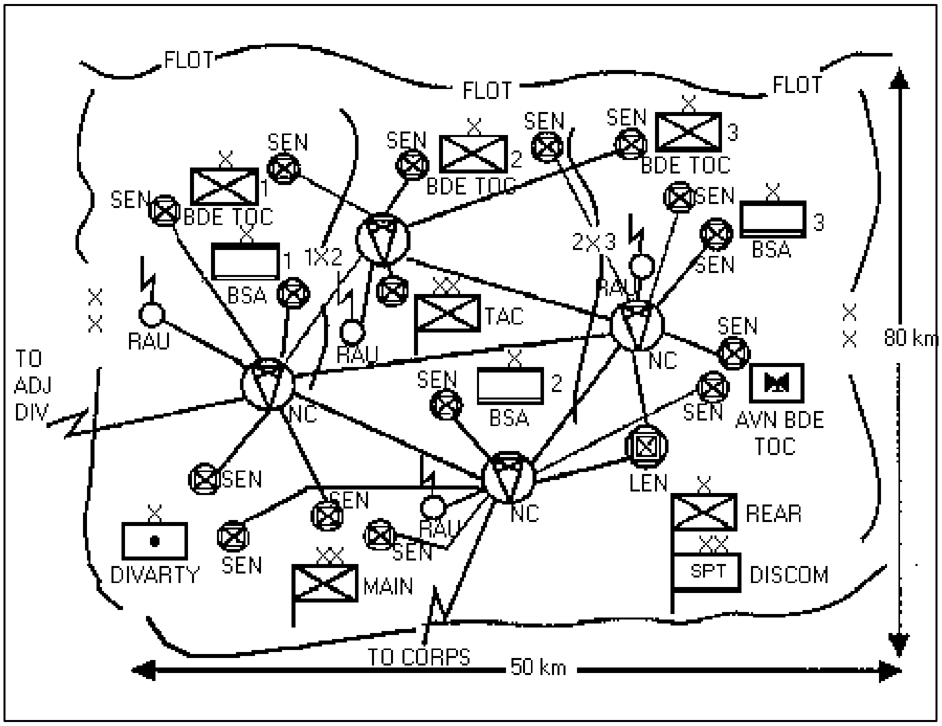

Figure 3 . Notional Divisional Communications (Source: FM 11-43, *Signal Leaders Guide*, 1999, 3-3)

Medium Brigade Organization

Breaking the Phalanx, by Douglas MacGregor, looks at radically different functionally organized units based on modern technology and communications (1997). The "Heavy Recon-Strike Group" has a close parallel with one possible employment of the medium brigade. Chapter 5, titled "Fighting with the Information Age Army in the Year 2003," provides an illustrative planning scenario based on many of the same assumptions that were made during the development of the medium brigade concept (MacGregor 1997, 77).

The *United States Army Posture Statement, Fiscal Year 2000*, states that digitizing the Army is one of the Army's goals in the modernization plan and that the strike force is an intermediate capability between the digitized division and a light force (Caldera and Reimer 1999). Most of the early information available on the strike force and medium brigade consisted of either newspaper articles containing general press information, or raw briefing materials containing outlined information. Information available initially did not include any discussion of the communications required except to state that a high capacity capability would be critical.

Initial models of satellite communications support to the medium brigade were based on notional information transfer requirements of current forces extrapolated forward in time (Hamilton 1999). Actual traffic analysis from early digitized division experiments and metrics taken from the Strike Force staff exercise provided a baseline for determining bandwidth requirements.

In his article in the *Army Times*, Seffers cautioned that the "Army After Next may rely too much on satellites," underscoring the need for a critical analysis of medium brigade communications (Seffers 1999). Lanaday quoted critics who believe the limited establishment of the strike force headquarters by 2003 without organic assigned combat units as a missed chance to experiment with new organizational concepts (Lanaday 1999).

The Operations and Organization (O&O) concept for the Initial Brigade Combat Team described the proposed mission, organization, and capabilities required for the unit (Combined Arms Center 1999c). Specifically, chapters addressed the organization of the Brigade Signal Company (BSC), a dedicated signal unit permanently assigned to the brigade. The C4ISR section presented basic information requirements for the unit but included planning assumptions of unlimited frequency access, unlimited satellite gateway access, and higher headquarters responsibilities, which were not restrained in developing this thesis.

Operational Parallels

In his monograph, Ebener discussed the difficulty of the 93rd Signal Brigade during Operation Desert Storm in integrating disparate communications capabilities inherent in an ad hoc organization (Ebener 1995, 20). He concluded that satellite communications to headquarters during Operation Desert Storm were critical, and demand exceeded the capacities of available military systems. Similarly, the 35th Signal Brigade (Corps) required additional satellite terminals from the 11th Signal Brigade (Theater) to provide adequate support to the JTF commander for Operation Uphold Democracy, Haiti. While not specifically focused on a medium brigade size element, his work demonstrates some of the challenges of applying ad hoc organizations to signal force structure.

Major Petit outlined some of the doctrinal challenges involved with equipping the 10th Signal Battalion in Somalia and Haiti to support the Army-level headquarters as part of the JTF (1997). Since the division only deployed one brigade to Operation Restore Hope, parallels may exist between previous task-organized deployments and expected medium brigade deployments in the future. Similar challenges faced by XVIII Airborne Corps, 10th Mountain Division, V Corps, and 1st Armored Division during operations after Desert Storm may confront future deploying forces. Increased technology could mitigate some challenges, yet could aggravate others or have other unforeseen effects.

Summary

This initial analysis of literature underscores the dearth of medium brigade research and communications support research in particular. The Army experimental campaign plan (AECP) prescribes a series of experiments to begin to refine the medium brigade concept. Significant amounts of information on medium brigade concepts will initially only be available as white papers, articles, or briefings due to the emerging nature of the doctrine. During the course of thesis research, more details of the Army tranformation strategy became available. Previous thesis and monograph work show a precedent for this type of study.

CHAPTER 3

RESEARCH DESIGN

Overview of Method

This master's thesis research sought to combine current technical capabilities, planned capabilities, and past and future organizational structures to determine if space-based communications would effectively support the medium brigade in 2003. The Army continued to experiment with medium brigade to determine the validity of the concept with modeling and simulation (TRADOC 1999). The research focus capitalized on ongoing efforts at Fort Leavenworth by the Training and Doctrine Command Research and Analysis Center (TRAC), the Signal Center at Fort Gordon, and the battle laboratories.

Selection of a Research Method

The research method consisted of a qualitative analysis following the model outlined in *Developing and Evaluating Educational Research*, by Gary Moore (Moore 1981). Historical research methods rely on primary and secondary sources to provide data to support conclusions. Moore outlines the application of a traditionally historical research model to educational research where quantitative studies focus too narrowly. The steps in the model are as follows:

1. Identification and Isolation of the Problem
2. Development of a Hypothesis
3. Collection and Classification of Materials
4. Organization of the Facts into Results
5. Formation of Conclusions

6. Synthesis and Presentation in an Organized Form.

Slightly different techniques of data gathering were required to answer the secondary research questions and ultimately to answer the primary question about the effectiveness of space communications support to medium brigade headquarters by 2003. In *Becoming Qualitative Researchers,* Corrine Glesne described three techniques to gather research data as participant observation, interviews, and document collection (Glesne 1992, 24). All three techniques had application throughout the research effort.

Participant Observation

Fort Leavenworth provided an ideal environment for gathering data as a participant given the Combined Arms Center role in developing first the strike force and their continued involvement with the medium brigade. The "Observer as Participant" role allows the researcher to interact with organizations involved with medium brigade development (Glesne 1992, 40). The Army Signal Center architecture branch also provided direct access to the development of the operational concepts of signal support organizations and the specific development of the medium brigade. Previous involvement of the researcher in Operation Desert Storm, Restore Hope, and Joint Endeavor provided a personal framework against which to examine detailed information relevant to the thesis.

Lessons learned reports collected by the Center for Army Lessons Learned (CALL) and other organizations leveraged direct experience of participants in ongoing operations. Although controversial topics appeared in sanitized form, enough concern for the issues presented existed to create the lessons learned report for the benefit of future planners.

Interviews

The ability to conduct interviews in person was limited by the regular college schedule. As other aspects of data collection uncovered gaps in information, selective contact with key personnel answered particular questions. If direct contact could not be made, oral history interviews of personnel involved in one of the case study operations, CALL lessons learned interviews, or unit lessons learned reports were reviewed to provide direct observations.

Document Collection

The combination of the Combined Arms Research Library and the internet provided an ideal resource for document collection. In particular, previous Master of Military Arts and Science thesis work and School of Advanced Military Studies monographs have covered various topics that support the answer to secondary research questions. In addition, ongoing work on the medium brigade activation has required substantial coordination between headquarters and source documents have become instantly available as they were written.

Applying the Research Method

Applying the general research method to this thesis, the following specific areas were addressed to guide the process. With each new review of information, the basic structure of the thesis evolved.

Identify and Isolate the Problem

This phase began with document collection at the start of the program and ended with the completion of an expanded question outline and hypothesis, forming the basis for chapter one of the thesis. Key definitions and background information were gathered related to previous space communications support for deployed elements.

Initial contacts with key personnel involved in developing, modeling, or fielding the medium brigade headquarters assisted in finding current information on the concept. These efforts resulted in an initial model of required communications for the brigade to assist in searching for operational parallels.

Develop a Hypothesis

This phase developed an initial categorization of factors related to effectiveness of communications support broadly grouped by requirements, environment, capabilities, and doctrine. These broad categories provided a baseline to support the historical review of similar deployments.

Collect and Classify Material

This phase focused initially on gathering the less volatile information supporting the questions of space capabilities projected through the year 2003. Existing fielding schedules of Army equipment and organizational changes were addressed independently of medium brigade organizational development. The Signal Center provided the latest information in these areas.

Information gathered was initially coded by supported area "to develop a more specific focus or more relevant questions" (Glesne 1992). Initial categorizations would be further refined during data analysis. Information discovered that provided a more detailed background in certain areas was added to the literature review chapter; information that provided initial answers to secondary questions was held for analysis in the chapters that follow.

Organize Facts into Results

Perhaps the most difficult aspect of constructing this thesis concerned the organization of the disparate factors related to the topic into analysis chapters that were readable, concise, and supportable. As the Army's direction changed from the strike force to the interim brigade combat team, information gathered months earlier had to be reviewed for continued applicability to the thesis. For example, the initial communications model for the strike force, coupled with analysis of network usage from the strike force staff exercise, generated an improved model to test in subsequent simulations (Hamilton 1999).

The network usage information could not be directly applied to medium brigade development expect for the generic lessons related to the use of digital systems command and control systems. Consequently, the underlying theme of the research topic shifted from deriving the best communications support structure for the strike force to reviewing the environmental and historical considerations that could define the success or failure of the medium brigade upon its anticipated mid-term operational capability.

A more detailed review of literature and lessons learned focused on finding specific parallels in brigade to division level task force deployments where space communications history was available. Dimensions of interest that matched the proposed medium brigade paradigm include communications requirements to a home station base of operations, an ad hoc arrangement of forces, or a rapid deployment of a brigade-sized task force. Continued refinement of the medium brigade communications model included a more detailed force structure analysis.

Formation of Conclusions

This phase initially focused on checking the latest doctrinal developments with the medium brigade concept. Despite the stated thesis delimitation that research would consider an earlier brigade model for the initial analysis, the framing of the conclusions might require an editorial comment if the basic medium brigade doctrine changed. In addition, reports on the outcomes of the medium brigade simulations were scheduled to be published at the completion of various experiments.

This area of research was considered the most volatile and could have had the most impact on the thesis if radical developments or changes in the structure, mission, or capabilities of the medium brigade were announced after the bulk of the primary research was completed. The primary focus of this phase was to complete the coding of data and develop a results matrix as described by Glesne and others and to summarize an initial conclusion (Glesne 1992, 137).

Synthesize Results

This final phase analyzed the results matrix for trends in satellite communications support. These trends would be critical to qualify the answer to the primary research question and to account for contradictory information to the thesis. Overall, comparative analysis of requirements, capabilities, and abilities would determine if communications would be effective. Leads for future research were presented.

Summary of Methodology

In summary, the research effort attempted to gather disparate information elements related to internal requirements, external environment, and organizational integration to determine the effectiveness of space communications support. Given medium brigade doctrine and requirements, would the satellite capability be available, the equipment available to use the satellites and the signal teams be able to employ the equipment at the right place and time to ensure the success of the medium brigade?

CHAPTER 4

SATELLITE COMMUNICATIONS

Overview

To determine whether projected space communications can effectively support the medium-brigade concept by the year 2003, one must first examine the nature of satellite communications systems themselves, and the means by which deployed forces use these systems. Current and future satellite programs support joint and service command and control, intelligence, and common user data networks. Joint and service communications organizations provide the equipment to leverage satellite communications systems. An Army medium brigade will be but one unit competing for these resources.

Satellite communications supporting deployed forces can be examined as three discrete elements. First, the space systems themselves and associated control systems are essentially constants based on expensive programs and launch schedules, and are relatively independent of Army organizational structures. Second, fixed ground stations provide gateway access to traditional communications services such as the Defense Switched Network (DSN) telephone system and while limited upgrades may be performed in response to a crisis, the gateway services may not vary significantly for an early deploying force. Finally, mobile terminal equipment allows deployed command posts and weapons platforms to communicate internally within a geographic region and externally with higher headquarters or sustaining base networks. The Army's ability to implement change to support new organizational concepts will be constrained by the existing satellite infrastructure and realistic estimates of a fair share of access in a competitive, prioritized environment.

Conceptual Framework

The simple model of satellite communications system shown in Figure 4 focuses the analysis from the least changing aspects to the most volatile. The center of the model consists of the military and commercial communications satellites available that can support military operations. The inner ring surrounding the satellites consist of the military and civilian organizations and equipment that use the satellite systems to provide communications services between nodes. The outer ring consists of units or other providers or consumers of information services that compete for limited satellite resources.

This analysis will consider the satellite systems and gateways, signal structure, and competing units and higher headquarters first to establish the operational context in which the medium brigade will operate. Medium brigade specific information requirements and internal signal structure will then provide a context to review previous operations for considerations related to the effectiveness of the communications support as a model for medium brigade operations in the future.

Satellite Communications Infrastructure

SATCOM systems vary in frequency band, type of orbit, and earth coverage achieved. Military and commercial systems have evolved and projections predict continued modernization of systems. The question of the availability of satellite communications technology and equipment for future force structures hinges in the near future on the existing national satellite infrastructure, continuing existing and currently funded modernization programs, leveraging commercial satellite systems to augment scarce military resources, and increasing the effectiveness of the support with gateway infrastructure improvements. This analysis provides a base understanding of what systems the medium brigade might be able to use.

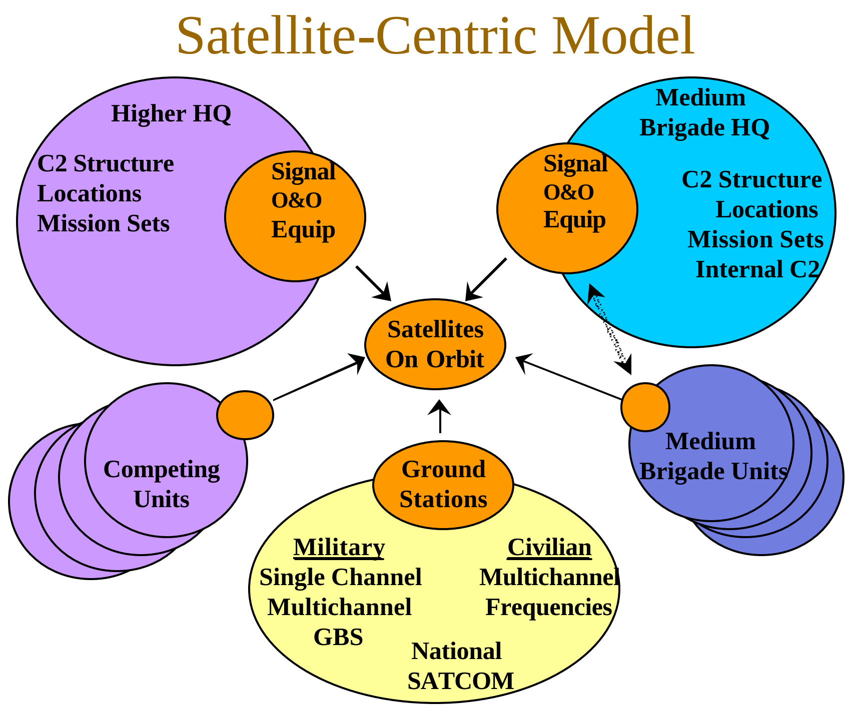

Figure 4. Basic Conceptual Model for Satellite Communications

The Training and Doctrine Commands System Manager for Tactical Satellite (TSM-SATCOM) at Fort Gordon constructs satellite architecture documents for the Army and serves as a linkage between doctrinal and material developers. TSM-SATCOM research provides a snapshot of satellite programs, including both spacecraft and user terminals (Figure 5), that guides the discussion to follow (2000).

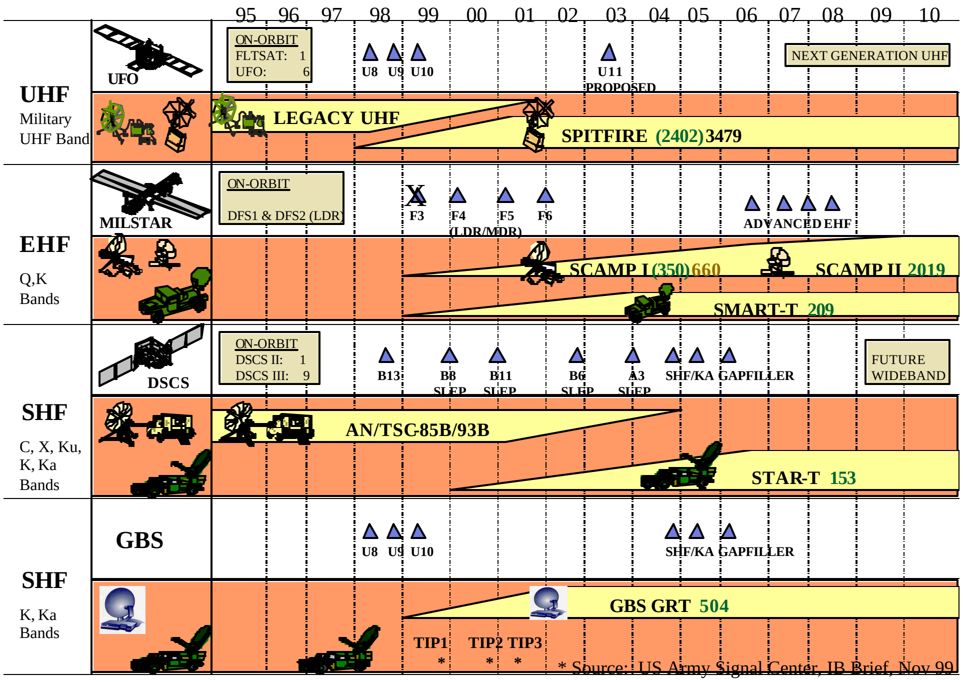

Figure 5. Army SATCOM Transition to Force XXI (Source: TSM-SATCOM, Signal Center, Fort Gordon, 2000)

Satellites

SATCOM systems can differ in purpose from single-channel voice networks similar to FM radio networks to multiplexed data groups allocated for different systems. In addition, communications paths can be designed as either single links (point-to-point) or as meshed networks (hub-spoke). Satellite-to-satellite cross communications can provide worldwide links without requiring multiple relays with ground stations.

UHF Follow-On and FLTSAT

Perhaps the simplest but most requested form of satellite communications is the UHF band voice or data network. The UHF Follow-On (UFO) and FLTSAT satellites offer wide-band and narrow-band channels that can be netted within the geographic "footprint" covered by the particular satellite (TSM-SATCOM 2000). The UHF band suffers most from crowded channels, susceptibility to jamming, and low data rates. However, the new availability of terminal equipment, techniques to increase throughput such as Demand Assigned Multiple Access (DAMA) scheduling protocols, and a mature constellation of second-generation satellites will ensure UHF TACSATs role for the next few years. For early deploying forces, UHF TACSAT offers enroute mission planning and communications and immediate voice recognition on a higher headquarters command network (JCSE 1998).

Defense Satellite Communications System (DSCS)

DSCS systems provide the current main access to higher data rate multiplexed circuits. Internal to a deployed theater, DSCS satellites can allow legacy Army terminals to extend voice and data networks between signal nodes of the theater network. External to the theater, the satellite can provide links to fixed ground stations offering access to the Defense Information Systems Network (DISN).

The first DSCS Service Life Extension Program (SLEP) satellites are scheduled for launch in calendar year 2000 to extend the utility of the DSCS satellites while the Army procures and fields the next generation, more capable system (TSM-SATCOM 2000). Increased user requirements related to the growth of information technology coupled with new terminal equipment sets capable of using the DSCS constellation

(Navy QuickSAT system on Command ships and Aircraft Carriers) will hasten the need for increased access at higher data rates (Department of Defense 1996).

Military Strategic Relay

Military Strategic Relay (MILSTAR) provides "worldwide, secure, survivable, anti-jam resistant comms for the warfighter" (TSM-SATCOM 2000, 6). The full system as designed would combine the single-channel feature of the UFO/FLTSAT constellation (MILSTAR Low Data Rate (LDR) Package) with the multichannel high data rate of the DSCS systems (MILSTAR Medium-Data Rate (MDR) Package) and the terminals would be proliferated at division level, providing unprecedented bandwidth over satellite and allowing a greater range extension capability than ever before. Two MILSTAR LDR satellites are currently on orbit providing single channel access.

However, a General Accounting Office report to Congress in November 1998 spoke of two problems with the MILSTAR program (Rodgriguez 1998). First, a critical component of tactical user support, the Advanced Communications Management System program, was behind schedule, causing delays in the acceptance testing of Army terminal equipment. Second, Congress reduced the original cold war purchase of MILSTAR satellites to only four, with a follow-on advanced capability unfunded for 2006.

In "Death of a Satellite: the Loss of Milstar 2," Debbie Linton portrays the failed launch of the first MILSTAR MDR satellite and some of the implications for the future.

> Increased communications capability using the MDR payload will be delayed at least one year. The Army multichannel satellite architectures . . . [are] aging and are expensive to operate and maintain. Further, they offer only limited low probability of intercept/low probability of detection and antijam protection. (Linton 1999, 4)

The remaining three MILSTAR MDR satellites in the program were scheduled for launch between 2001 and 2003. Given the failure of the first MDR satellite, without expensive (and unfunded) replacement, the three remaining programmed satellites will not be able to adequately cover the entire world as the DSCS or ideal MILSTAR system would. In addition, computer simulation predicted that by 2003, up to twelve percent of the channels might fail, with increasing channel degradation over time (Rodriguez 1998).

Global Broadcast Service (GBS)

The Global Broadcast System was designed to provide "a one-way, high speed flow of high volume information (data files, imagery, and voice) to joint forces that are garrisoned, deployed or on-the-move" (Kirzow 1999, 10). Using an initial package launched on the UFO 8, 9, and 10 satellites, the GBS phase II system will provide close to worldwide coverage and high data. The systems broad area coverage of 2,000 nautical miles and responsive coverage with a 500 nautical mile spot beam could be beneficial if a mission has a high enough priority. The value of the system comes from the content of the information that it disseminates.

Joint Forces Command has been designated the lead in constructing a theater information management implementation strategy to guide the operations of the permanent injection points and deployable theater injection points (McElwee 1999). The ability of the GBS system to support the medium brigade will depend on the coverage of the interim system fielded by 2003, the ability of the brigade to request information, and the quality of the information management plan of the higher headquarters (Department Of Defense 1996).

Commercial Satellite Systems

Commercial satellite systems support different requirements similar to military systems. Primarily telephone-based systems such as INMARSAT and Iridium provide individual voice, facsimile and low capacity data capability. Numerous systems such as those operated by the International Satellite Consortium (INTELSAT) provide high capacity multichannel data capabilities for a multitude of applications.

Recognizing the increasing importance of satellite communications and the strain on military satellite capabilities, the Commercial Satellite Communications Initiatives study reviewed military requirements and commercially available solutions and concluded:

> First, the satellite communications (SATCOM) capacity requirements of two major regional conflicts could be expected to surge more than twice the normal peacetime requirements. Second, significant cost efficiencies of satellite communications capacity are achievable through transponder leases. Third, an end-to-end integrated system is required to allow the JTF elements to "train as they fight." Finally, DISN itself must be fully integrated with end-to-end engineering, acquisition, and structured decision making across all services. (Department of Defense 1996, 3-16)

Advantages gained by using commercial systems include state-of-the art technology, limited investment in infrastructure, and almost immediate access to services. Although commercial satellite systems can provide immediate capabilities, there are a number of considerations for military usage.

> Leasing commercial SATCOM overseas can run many times what it costs to use COMSATCOM in the U.S. . . . there are distinct differences between military and commercial satellite systems. Military satellite communications (MILSATCOM) systems are designed to be used in war. But the reality of military communications is that many requirements do not need jamming protection and other security survivability measures built into military satellites. (Department of Defense 1996, 3-16)

In addition, there remain differences in the accessibility of terminal equipment required to properly use commercial satellites. Less expensive telephone sets can be procured to use the INMARSAT or Iridium systems. United States Atlantic Command lists two planning limitations of INMARSAT usage as the cost of the service and the ability of other nations to deny our use of the system in accordance with international agreements of the consortium (Department of Defense 1997). Units can also execute contracts to request a commercial company install their own terminal equipment and provide the finished service of data transmission.

Space Terminal Equipment

Given a limited number of types of communications satellites in orbit, numerous types of terminal equipment have been developed based on mobility, survivability, and data requirements. Satellite terminal sets, from small single-channel radios to large multi-channel vehicles, are modernized according to programs with long implementation times (TSM-SATCOM 2000). Although joint and service interoperability are required in these systems, modernization gaps between units may dictate the use of the lowest common denominator as a common standard for communication.

UHF TACSAT

Legacy terminals including the PSC-3 and MST-20 are being replaced by modernized PSC-5 SPITFIRE radios. These small radios enhance a unit’s ability to move and reestablish communications with no line-of-sight radio requirement. Hatch-mount antennas in a C-5 or C-141 aircraft coupled with a UHF TACSAT terminal provide strategic communications enroute to a mission area (JCSE 1998).

DSCS Systems

Legacy terminals in the Army system include the larger hub system, TSC-85B, and smaller spoke system, TSC-93B, operating in the X-band of the SHF frequency band (TSM-SATCOM 2000). These systems can mesh in various ways with a limit of one connection per spoke and four per hub. Standard eight-foot antennas provide the greatest mobility but least amount of power, with a substantial penalty in satellite power per channel, directly reducing data transmission bandwidth provided (JCSE 1998).

Shortages in available bandwidth available to the common user led the intelligence community to develop a specialized satellite terminal, the TROJAN Special Purpose Integrated Remote Intelligence Terminal (SPIRIT) II, AN/TSQ-190(V). This terminal provided a mobile, commercial solution using either the C-band or Ku-Band that required the lease of a commercial satellite channel to connect deployed locations back to the central switch at Fort Belvoir. The year 2002 marks the end of the ten year designed life cycle for the Trojan Spirit II (Long 1999). Modified Trojan SPIRIT II terminals will provide different services in support of Army units under the control of the Signal Corps.

The TSC-156 STAR-T terminal will be a tri-band satellite system capable of operating in the SHF range commercial C-band, Ku-Band, or military X-band. Fielding originally scheduled for fiscal year 2000 has slipped to fiscal year 2001 (TSM-SATCOM 2000). STAR-T terminals will provide corps and echelons above corps with the greatest data throughput. Delays in fielding by 2003 could mean a limited number of terminals could be supporting a higher headquarters to a medium brigade.

MILSTAR Systems

For single-channel use, the initial block I PSC-11 SCAMP system provides nuclear survivable voice and data over one of the orbiting low-data rate packages. The initial radio needs the substantial reduction in size and weight required in the next generation radio before it can be used for mobile operations. The follow-on echelon PSC-11 will not be fielded until 2006.

The multichannel TSC-154 SMAR-T terminals are available for fielding now and scheduled for delivery around the Army for the next several years. The loss of the first MDR payload satellite prevents effective training in the short term until the next MDR satellite is launched. Depending on the orbital position chosen for the second through fourth MDR satellite, various portions of the world will have no coverage or limited coverage, effecting training and actual deployment operations.

Space Considerations

Two final areas influence the effectiveness of satellite communications. First, the challenge of frequency allocations in an environment of increasing radios systems may degrade or preclude certain types of satellite communications. Second, physical limitations on the availability of critical service provided by satellite gateways may prevent effective support on reachback communications.

Frequency Conflicts

Competition between military and commercial satellite systems has evolved as more commercial systems are developed. The spectrum chart produced by TSM-SATCOM identified five bands between L-Band and EHF frequency that are “at risk” to commercial encroachment (TSM-SATCOM 2000). These issues transcend national boundaries and present additional challenges for operational employment of satellite systems. The *C4ISR Handbook for Integrated Planning (CHIP)* describes the problem as follows:

> Because national borders do not affect electromagnetic radiation, international agreements on the use of radio frequencies are important. Agreements on the international regulation of radio frequencies originate at World Administrative Radio Conferences, held under the auspices of the International Telecommunications Union (ITU). These radio regulations have the force of a treaty to which each signatory is bound under international law. (Department of Defense 1996, 2-19)

Additional concerns surround the use of commercial systems in a foreign country. International treaties regarding the use of "landing rights" may allow another nation the right to refuse our satellite terminals the right to receive and transmit information from their country.

Gateways

One of the major benefits provided by satellite communications is the access to information services of the Defense Information Services Network (DISN): Defense Switched Network telephones, Non-Classified IP-Router Network (NIPR-NET), Secret IP Router Network, Video Teleconferencing, and other services or circuits. This connection of services is usually performed at a strategic gateway, a combination of a large, fixed satellite terminal, and a robust technical control facility able to interconnect field users to garrison information services.   These gateway locations are tightly controlled and located around the world within the ground footprint of one or more DSCS satellites.

> Since the Gulf conflict, most of the requirements to extend DISN services to the deployed forces have necessitated the use of satellite connectivity. Many of the AORs in question have a very austere telecommunications infrastructure. With the continuing reliance on split based operations to support forward-deployed forces from CONUS, satellite requirements are increasing, which means that satellite communications have become the premier transmission medium for

> C4ISR systems, both intra- and inter-theater. (Department of Defense 1996, 5-10)

The Standardized Tactical Entry Point (STEP) is a program designed to ease the installation of a standard set of services. Most fixed DSCS stations will complete fielding of STEP packages by the year 2001. Future initiatives will provide the ability for commercial satellite systems to downlink into the site (renamed TELEPORT site) to access an identical menu of services. Additional satellite capability to receive military EHF signals and commercial C-Band and Ku-band signals will extend services to more tactical users.

Satellite Summary

More military and commercial satellite systems involved in an operation imply more complexity. The various equipment fieldings and modernization programs by 2003 will provide not only increased capabilities but also the potential for incompatibility with other units and headquarters. The challenge to communications planners today remains to develop a minimum set of capabilities and leverage military and commercial satellite systems over the next decade to provide the best support to the tactical deployed units.

CHAPTER 5

ORGANIZATIONAL ANALYSIS

Introduction

Analysis so far has focused on factors relatively independent of particular Army organizational structures such as a medium brigade. Continuing with the conceptual model (Figure 4), consideration of higher headquarters and other adjacent units provides the organizational framework within which the medium brigade must operate. Organizational needs for command and control, intelligence, logistics, and operational information provide a communications support requirement that prescribes connectivity and limits available satellite communications available based on competing units.

Organizational Framework

Military organizations exist to fight and win our nation's wars. From timeless infantry soldiers to modern advanced weapons systems, the military evolves to incorporate new technologies and to prepare for specific threats. Headquarters design also evolves to capitalize on increased situational awareness provided by advanced technology. The span of control issue for elements larger than battalion influences command and control systems requirements.

To ensure information superiority, and perhaps information dominance, robust, secure, and high capacity communications systems must disseminate C2 messages, intelligence, logistics, and operational information across the battlefield. Flexible, adaptive signal units may have the responsibility to provide these communications links in support of organizations at all levels.

Headquarters Design

The organization of Army theater headquarters, corps, divisions, brigades and other subordinate units result from the integrated force development process which combines future operational capabilities and overarching and branch functional visions to develop future warfighting requirements. The force development process creates the tables of organization and equipment (TOE) that form the basis for all Army units. Through the Total Army Analysis (TAA) process, the Army then determines the numbers and types of units required to meet future national security needs and documents a total force of active, reserve, national guard, pre-positioned equipment sets, and unresourced units with Modified Tables of Organizations and Equipment (MTOE) against which personnel and equipment are authorized (Command and General Staff College 1999).

Key elements of the process are the rules that interrelate the basic building blocks of organizations by functions and missions. For example, the traditional staff sections in most headquarters provide specific functional assistance to modern commanders much as they did in the time of Napoleon (Van Creveld 1985). On another level, the relationship between units also stems from force development rules. For example, each Army division requires one division signal battalion to provide communications support. However, the division signal battalion itself relies on other units of the division for motor maintenance, medical, and transportation support.

Conversely, the division signal battalion provides Small Extension Node switches (SENS) that are attached to various headquarters in the division to provide voice and data communications to division headquarters, support command, artillery, maneuver brigade, and separate battalion command posts. These symbiotic relationships present in organizational design become important considerations when deploying tailored task-organized forces for specific missions.

Command and Control System

The art of "battle command" refers to the commander's ability leading and motivating soldiers in battle, and "visualizing the current and future state, then formulating concepts of operations to get from one to the other at least cost" (U.S Army 1993, 2-14). Successful battle command relies on information that is pertinent, correct, timely, in usable form, and even constrained to appropriate size to prevent overload (Sinclair 1996). Battle command decisions translate into action through some method of control of subordinate units.

Joint doctrine defines command and control (and parenthetically explain command and control systems) as follows:

> Command and control--The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission. (Joint Chiefs of Staff 1999b, 87)

The definition shows the distinction between elements of personnel, equipment, communications, facilities, and procedures and how these elements contribute to a C2 system. Satellite communications systems exist to provide a critical component of military command and control systems. The nature of the task organization of forces determines the communications connectivity required and "establishes the chain of command and the command and support relationships within the force" (United States Marine Corps 1995, 21).

Information Superiority

Recognizing the exponential advances in information technology and "the improved command, control, and intelligence which can be assured by information superiority," the Chairman of the Joint Chiefs of Staff established *Joint Vision 2010* (Shalikashvili 1997, 19). His intent was to provide an "operationally based template for the evolution of the Armed Forces for a challenging and uncertain future. It must become a benchmark for Service and Unified Command visions" (Shalikashvili 1997, 1). Recognizing the new security considerations of a post-cold war era, the vision predicts the relevance of technology beyond incremental improvements in current operational paradigms.

> Throughout history, gathering, exploiting, and protecting information have been critical in command, control, and intelligence. . . . what will differ [in 2010] is the increased access to information and improvements in the speed and accuracy of prioritizing and transferring data brought about by advances in technology. While the friction and the fog of war can never be eliminated, new technology promises to mitigate their impact. (Shalikashvili 1997, 15)

Information superiority must exist as a central requirement for transforming traditional warfighting capabilities to new operational concepts for the future. *Joint Vision 2010* defines information superiority as "the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same" (Shalikashvili 1997, 16). For friendly forces, information superiority superimposes on the command and control system with specific focus on the information required for successful battle command and decentralized control on a chaotic environment. Conversely, information operations targeting enemy information and information systems become more prominent factors in friendly operational art and critical in emerging concepts shown in figure 6.

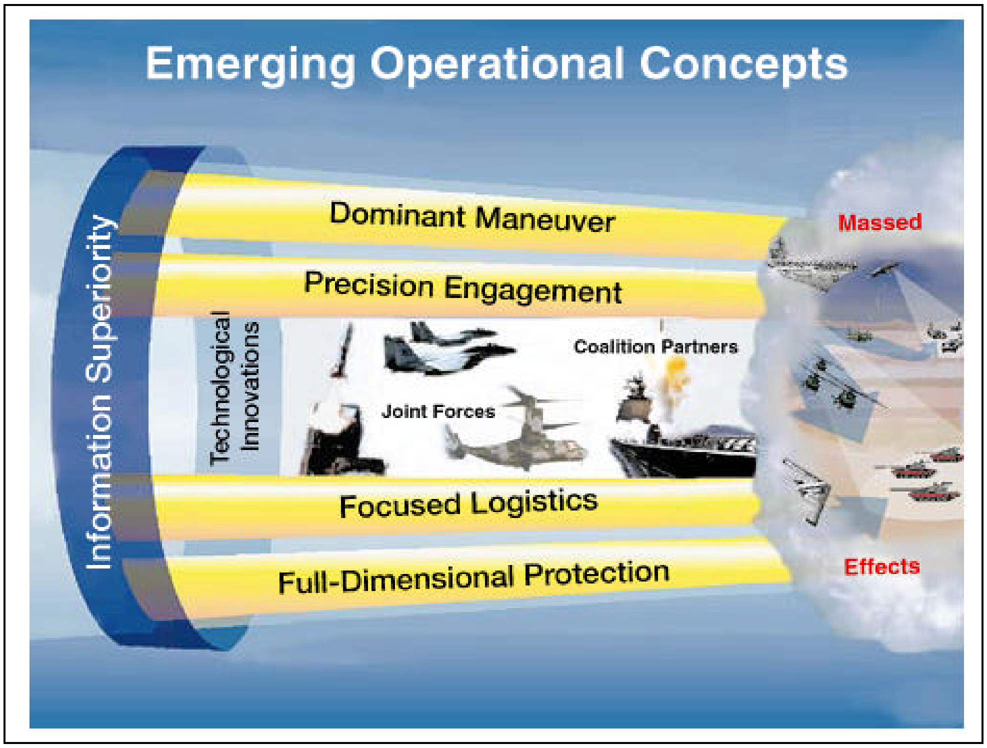

Figure 6. Emerging Operational Concepts of *Joint Vision 2010* (Source: *Joint Vision 2010*, Joint Chiefs of Staff, 1997, 19)

Based on information superiority and technological innovations, joint vision strives to mass effects of multiple systems versus simply to mass firepower at a decisive point. Successful implementation of these concepts will achieve full spectrum dominance; since:

> Enhanced command and control, and much improved intelligence, along with other applications of new technology will transform the traditional functions of maneuver, strike, protection, and logistics . . .[powerfully into] new operational concepts: dominant maneuver; precision engagement; full-dimensional protection; and focused logistics . . . taken together these four new concepts will enable us to dominate the full range of military operations from humanitarian

> assistance, through peace operations, up to and into the highest intensity conflict. (Shalikashvili 1997, 25)

Information superiority aims to "provide a commander with enhanced awareness of his area of responsibility, whether his objective is to close with and engage an adversary or render assistance in a humanitarian operation" (Shalikashvili 1997, 26). However, Major Sinclair's study of information technology in battle command reveals the paralysis of information at when tactical operations centers become "overwhelmed with information . . . and [they] failed to conduct an analysis of the information" (1996, 32). Without training and integration of systems, simply adding technology to existing organizations might not achieve information superiority.

> [Information] is not valuable for its own sake. Information is valuable only insofar as it contributes to knowledge or understanding. *The critical thing, then, is not the amount of information, but rather the key elements of information, available when needed and in useful form, which improve the commander's knowledge of the situation.* (United States Marine Corps 1995, 23)

In the article "Information Superiority and the Future of Mission Orders" from *Military Review,* Major Anthony Garrett examines the conflict caused by increased technology between "detailed orders/tactics approach (centralized control) and mission orders/tactics (decentralized control)" (1999, 1). Garrett describes the cultural desire to "establish and maintain order on the battlefield" and the "reluctance to learn mission orders doctrine" as primary impediments to effectively gaining the advantage of information superiority (Garrett 1999, 1).

Information Dominance

Army Vision 2010, the companion document to *Joint Vision 2010*, outlines the Army's strategic vision to meet the planning considerations outlined for the future. Applying *Joint Vision 2010* to land component operations, the Army grouped doctrinal activities common to all forces into six new "patterns of operations" that closely parallel conventional unit mission essential tasks: project the force, protect the force, shape the battlespace, decisive operations, sustain the force, and gain information dominance. Figure 7 shows the relationship between these patterns of operations and joint concepts and highlights the central role of information dominance (Reimer 1997). Army FM 100-6, *Information Operations,* defines information dominance as:

> The degree of information superiority that allows the possessor to use information systems and capabilities to achieve and operational advantage in conflict or to control the situation in operations short of war, while denying those capabilities to the adversary. (U.S. Army 1996, 1-9)

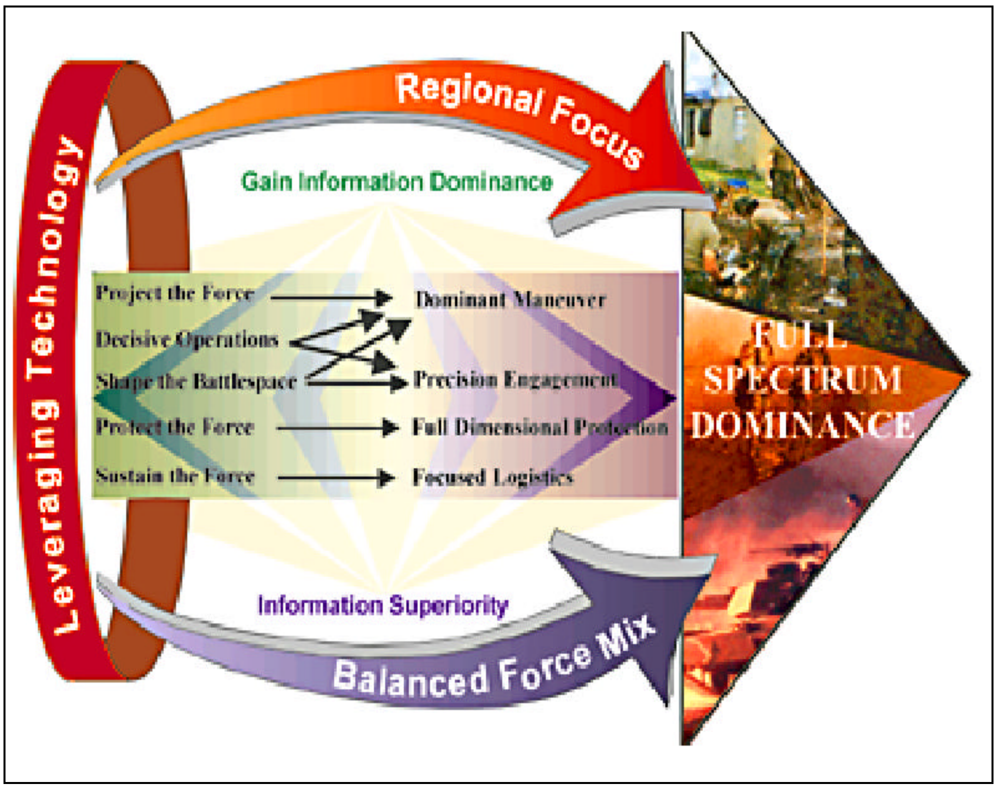

Figure 7. Information Dominance in Army Vision 2010 (Source: *Army Vision 2010*, Reimer, 1997, Department of the Army, 10)

In his thesis "Information Dominance and Military Decision Making," Major James Lee traces the impact of new technology, such as the Army Battle Command System (ABCS) computers, on digital brigade rotations at the National Training Center from 1997 to 1998. Citing the transitory nature of information dominance and the lack of empirical study on the impact of information dominance on operations, Lee emphasizes the importance of battle command and experience and the factors of intuition, inhibition, and expanded battlespace awareness (1999). Lee's findings envision increased demands for communications technology to support collaborative planning, video-teleconferencing, and automated command and control computers, separated by increased distances.

> Smaller more powerful forces will be able to appear dormant on the battlefield while they continue to plan and prepare for battle . . . when the time is right the small force will awaken and strike its enemy where it is least expected delivering a crippling blow at the decisive point. The asymmetric implications of this type of battle are enormous. . . . a sort of mid-to-high-intensity, guerrilla warfare tactic that advances, strikes, withdraws, and disappears based on the commander's intent. . . . a force that can deploy, strike and operate independently anywhere in the world while still maintaining communications with higher. (Lee 1999, 98)

The implications of this concept clearly require robust and secure satellite communications systems to handle increased bandwidth and increased unit dispersion across a non-linear battlefield.

Satellite Communications Impact

Ideally, the Army procures equipment for organizations based on requirements generated during the force development process in the form of generic mission needs statements (MNS) and more specific operational requirements documents (ORD) (CGSC 1999). However, information technology changes more rapidly than the acquisition cycle can react. Rapid acquisition of more powerful computers presents requirements for increased communications capacity faster than the Army modernization programs can compensate.

The issues of effective command and control, information superiority, or information dominance represent incrementally increasing demands on communications systems. The art and science of command and control theory grapples with the measures of effective use of information to succeed in battle. As this dynamic is the most difficult to quantify in terms of bandwidth requirements, brute force estimates of requirements based on different functional computer systems and connectivity drive the requirements for future communications systems hoping that future demand will be less than capacity. Alone, satellite communications cannot ensure information dominance, because of the complexity of the human dynamic of battle command and the use of information, yet battle command cannot achieve information dominance across the future battlespace without effective satellite communications.

Higher and Adjacent Units

In times of crisis, military forces deploy tailored units and capabilities, correctly sized for the strategic goal envisioned by the National Command Authorities (NCA). These forces can consist of a complete Combatant Command, such as United States Central Command under General Norman Schwarzkopf during Operation Desert Storm, with all subordinate services represented. More often, smaller JTFs are activated to participate in specific operations that do not require large amounts of military force. By definition, a JTF consists of more than one service component (Joint Chiefs of Staff 1999b). Implications for communications requirements to support command and control and information dominance are that similar systems and capability must be apportioned or potentially shared between the National Command Authorities, JTFs, and service or functional components. Joint and service communications support organizations subsequently may perform missions to support their own headquarters or common joint requirements.

Joint or Combined Task Force

Joint doctrine outlines the ability of joint force commanders (JFC) to activate JTFs "to accomplish the mission based on the JFCs' vision and concept of operations" (Joint Chiefs of Staff 1995, 2-11). JTF commanders must recognize that

> Unity of effort, centralized planning, and decentralized execution are key considerations. . . . Organization of joint forces also needs to take into account interoperability with multinational forces. Complex or unclear command relationships and organizations can be counterproductive to developing synergy among multinational forces. Simplicity and clarity of expression are critical. (Joint Chiefs of Staff 1995, 2-11)

Although the concept of information superiority had not evolved at the time, Joint Publication 3-0 recognized the importance of space as an operational environment akin to conventional battlespace areas, stating:

> Superiority battles are not limited to the air and maritime environments. JFCs seek to achieve superiority immediately in command, control, communications, computers, and intelligence (C4I)--space control is a necessary precursor to this superiority. (Joint Chiefs of Staff 1995, 4-5)

Space control and its relationship to communications becomes critical because "in the future the U.S. could find itself in a crisis situation, or war, with an adversary either operating their own space system, or relying on information from another nation's space system" (Lee 1993, 5).

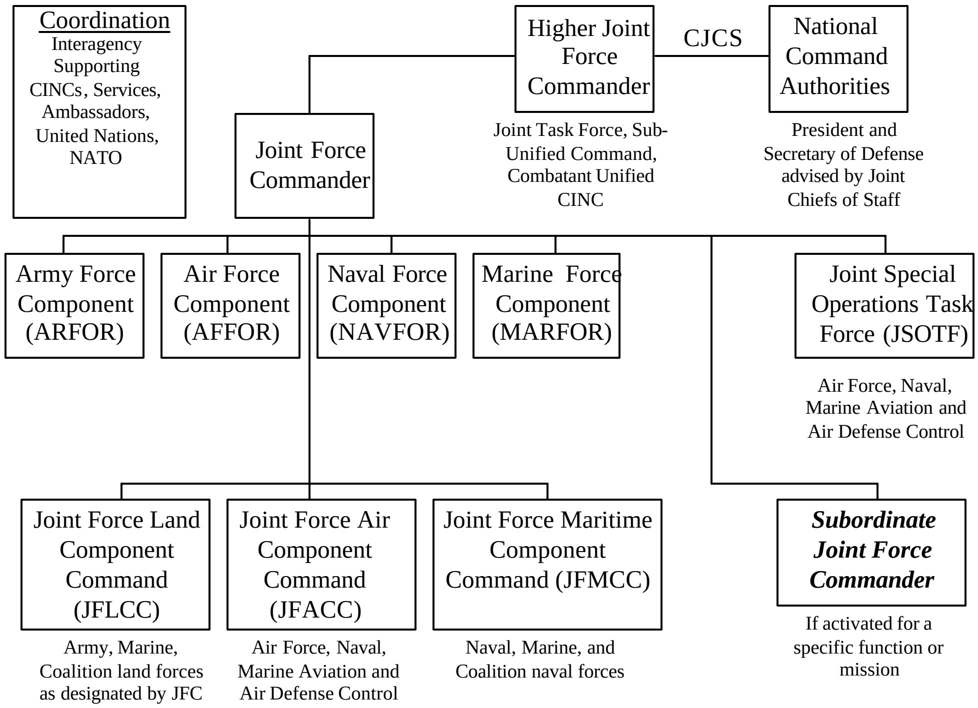

Figure 8. Generic Joint Task Force Structure

Given the potential complexity in the JTF structure shown in figure 8, the information connectivity and requirements of subordinate components provide the considerations for implementing the command and control system. Joint Publication 3-0 outlines the importance of communications connectivity but subordinates it to the role of the commander:

> Effective command at varying operational tempos requires reliable, secure, and interoperable communications. Communications planning increases options available to JFCs by providing the communications systems necessary to pass critical information at decisive times. These communication systems permit JFCs to exploit tactical success and facilitate future operations. Nonetheless, command style is dictated by the commander, not by the supporting communication system. (Joint Chiefs of Staff 1995, 2-17)

In her thesis, “The Command and Control of Communications in Joint and Combined Operations”, Major Jennifer Napper examines in detail the specific challenges associated with signal support organizations as they plan, implement, and manage complex communications networks in support of joint forces (Napper 1994). The thesis describes the conflict between joint doctrine and communications to service components and service doctrine and communications internal to services and the incompatibilities of equipment and investigates the command and control system supporting Operation Desert Storm as an illustrative case study. Specifically addressing satellite communications, Napper states:

> Desert Storm demonstrated the versatility of the satellite communications systems available. Not only were military systems used to maximum capacity, but numerous commercial leased systems were relied on heavily. Communications satellites carried the majority of the military trunk traffic in and out of theater. They extended the tactical links over the immense theater when the terrestrial systems proved inadequate…When traffic demands outpaced the satellite carrying capacity, the U.S. military reconfigured the space segment by repositioning satellites…when traffic demands exceeded even this capacity, the allies provided access through their systems. (Napper 1994, 60-61)

Intuitively, one can infer that the quest for information dominance today would result in the same exponential increase in demand for capacity during future operations.

JTF Components

Either service or functionally organized, or combinations of both, the JTF command and control organization can challenge the capacities of satellite systems and use all available terminal assets. Relationships between components can range from competition for limited satellite resources to mutual support for joint requirements.

Marine Forces

Marine Forces (MARFOR) provide internal communications support with a communications battalion doctrinally supporting each of three Marine Expeditionary

Forces when ashore. Due to their amphibious capability, MARFOR elements aboard Wasp class LHD ships can access high capacity satellite service via ship-mounted omni-directional antennas. Standard legacy satellite terminals (TSC-85 and TSC-93) provide satellite connectivity to ground headquarters (JCSE 1998). Early entry forces for the MARFOR consist of marine expeditionary units, revolving around a reinforced infantry regimental landing team (battalion size) with supporting aviation and logistics. Limited multi-channel satellite capacity would be available for early entry forces.

Naval Forces

Naval Forces (NAVFOR) rely heavily on single-channel FLTSAT (UHF) satellite communications for over the horizon message dissemination between the sustaining base and the myriad of ships. Command ships, aircraft carriers, and helicopter carriers have been retrofitted with multi-channel SHF satellite communications to support modern data rates and systems including secure local area networks and video teleconferencing (JCSE 1998). Due to power considerations based on omni-directional antennas on ships, fewer ground-based terminals may be able to use the same satellite transponders and data rates may be significantly reduced.

Air Forces or Joint Force Air Component Command

Air Forces (AFFOR) center operations understandably around air bases and their communications squadrons also employ legacy satellite terminals (TSC-100 and TSC-94) while modernizing to a commercial concept called Theater Deployable Communications (JCSE 1998). Given the strategic reach or air power, satellite communications becomes critical to linking in theater operational headquarters and air bases with strategic supporting bases and headquarters outside of the theater area of operations.

Special Operations Forces

Unique special operations missions and requirements coupled with separate program and funding authority allow the special operations community to procure limited numbers of specialized advanced satellite communications terminals. Support ranges from smaller operating bases communications (112 Signal Battalion) to full joint special operations task force communications as shown integrated with notional task force communications in figure 9.

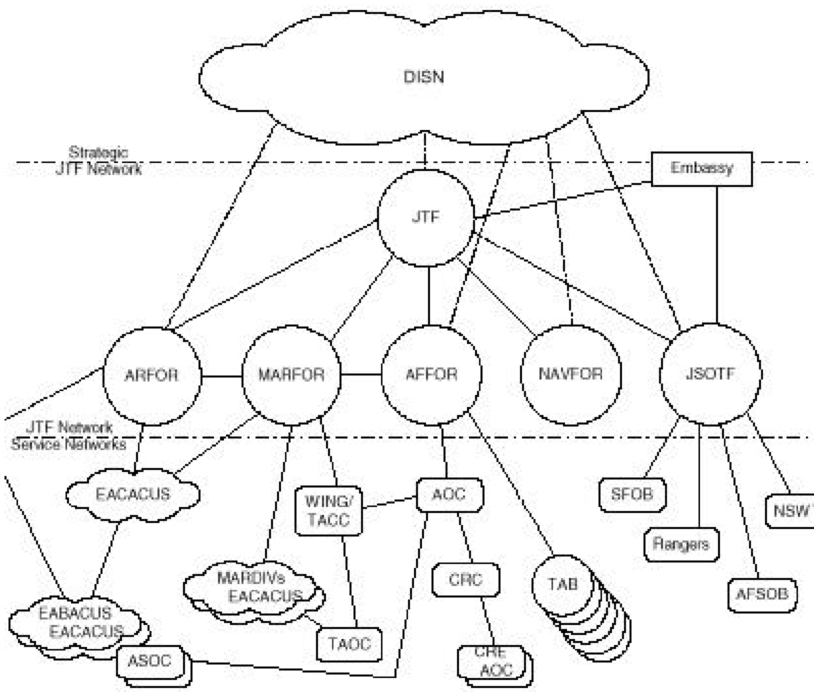

Figure 9. Notional Joint Task Force Connectivity (Source: GTE Reference Guide for Network and Nodal Managers, 1998, 6)

Combined Forces

Operations within a combined alliance present conflicts of competition, interoperability, and liaison. Most other nations lack the military specific satellite communications systems that United States military services depend on. Recognizing this issue, joint doctrine warns:

> JFCs should anticipate that some forces from alliance or coalition member nations will have direct and near immediate communications capability from the operational area to their respective national political leadership. This communications capability can facilitate coordination of issues, but it can also be a source of frustration as leaderships external to the operational area may be issuing guidance directly to their deployed national forces. (Joint Chiefs of Staff 1995, 6-5)

Potential conflicts for commercial bandwidth also reveal the challenge of finding interoperable communications systems to link allied forces with United States forces. Often, exchange of liaison teams coupled with organic national communications means can circumvent security and language considerations and greatly enhance command and control. Establishment of effective liaison teams becomes "critical to developing and maintaining unity of effort in coalition operations" (Joint Chiefs of Staff 1995, 6-8).

Interagency

Interactions with other governmental and nongovernmental agencies may be required during sensitive operations, such as MOOTW. Connectivity between the deployed JFC and the NCA provides for direct contact when required.

> JFCs should have a responsive and reliable link to appropriate US agencies and political leadership. Where senior JFCs are in the chain of command between the deployed JFC and the NCA, provisions should be made for bypassing intermediate points in the chain of command for exceptional and emergency situations. The conditions and supporting communications systems for such bypassing should be established by the appropriate military and political leadership early. (Joint Chiefs of Staff 1995, 6-5)

Such connectivity can usually only be achieved with satellite communications systems.

Another dynamic of interagency operations presents additional competitions for limited satellite bandwidth. For example, the Defense Intelligence Agency has a Tri-band Satellite JWICS Flyaway package that can provide data rates up to T1 (1.544 Mps) (Department of Defense 1996). Army Material Command, Pacific Command, and other agencies can acquire and use satellite terminals that compete within a JTF environment.

Army Forces Headquarters

According to the medium brigade O&O concept, the medium brigade will rely on an Army forces headquarters (ARFOR) as its most likely higher echelon. ARFOR organization for MOOTW falls far short of a full theater Army structure due to constraints in force composition and strength. Significant task organization will be required to convert an existing nucleus of an division or corps to perform the doctrinal missions of the ARFOR.

ARFOR Organization

The Combined Arms Center, Fort Leavenworth, organized and designated Task Force Training, Leader Development, and Soldier Support as the lead agency for the Strike Force organizational development (1999a). Significant effort revolved around conducting simulations and command post exercises to determine the feasibility of the Strike Force organization. With the shift from a Strike Force to medium brigades at Fort Lewis, the Combined Arms Center established Task Force ARFOR to continue to evaluate the changes necessary for corps and division organizational structure for these echelons to function as an ARFOR, potentially including the execution of Title 10 tasks, operational planning, and tactical employment of Army units in theater.

Doctrinal Army organizations such as divisions and corps can provide the balance of Army forces to an operation and assume the role of the ARFOR headquarters. The headquarters organizations expand rapidly to perform functions doctrinally assigned to higher echelons during larger operations. For example, a division as an ARFOR assumes a much greater role in logistics support to Army forces without the buffer organizations between it and the JTF.

ARFOR Command and Control

Despite the stated role of the ARFOR in supporting the medium brigade deployment, the speed of medium brigade arrival might preclude effective support if the ARFOR is itself expanding its organization to meet new mission requirements and deploying to an operational area. Recognizing this dilemma, the Combined Arms Center had developed the concept of an "Early Entry Command Post (EECP)" of the ARFOR to be deployable to theater within the same ninety-six hour time frame as the medium brigade (Combined Arms Center 2000b).

Significant augmentation of command and control systems would be required to account for increased span of control, liaison requirements, and interface with a JTF. Analysis at Fort Leavenworth estimated an increase of 136 personnel per corps and 170 personnel per Force XXI Division to convert existing table of organization and equipment units to ARFOR headquarters. The majority of the increase supported the command and control battlefield operating system as direct communications support cells for main and rear command posts, liaison teams, or public affairs and legal support (Combined Arms Center 2000b).

ARFOR Signal Support

Petit's study of operational communications support concluded that the divisional signal battalion would require substantial augmentation to support the division in the role of an ARFOR headquarters (1997). Factors of communications planning expertise in joint task force communications and the shortage of satellite and high capacity telephone switching must be quickly resolved. Recognizing the value of satellite communications to a deployed force, joint doctrine states:

> Use strategic and tactical satellite communications only when terrestrial systems cannot meet user requirements. Operate satellite systems as a last resort. This limited resource should be employed in those critical situations where no other means can fulfill the requirement. (Joint Chiefs of Staff 1996, 2-8)

The ARFOR headquarters could be geographically separated beyond line-of-sight range of the medium brigade precluding the use of terrestrial systems for interconnectivity. Access to strategic information systems under the "split-based" concept presents a challenge between elements of the JTF and internal to the ARFOR organizations. The Combined Arms Center organization and operational concept for the ARFOR describes the importance of "reach-back" communications as follows:

> The ARFOR will optimize reach-back up to theater of origin or less to minimize staff and units within the AO. "Reach-back" is an electronic tether and enables the ARFOR to leverage organic and non-organic resources from outside the AO. Reach-back reduces the ARFOR footprint in the AO without compromising its ability to accomplish it assigned missions . . . [and] enhances operational agility and further reduces force protection requirements. The ARFOR will execute reach-back on a routine, deliberate basis as a combat power and sustainment multiplier in five primary areas: fires/effects, intelligence and information, planning and analysis, force protection, and sustainment. (Combined Arms Center 2000a, 4)

Implications for the medium brigade signal support include competition with its higher headquarters (ARFOR) for the same limited "reach-back" capabilities or reliance on the ARFOR to provide the same capabilities, transferring the communications burden onto theater systems.

Medium Brigade

The development effort for the medium brigade concept is part of a larger Army transformation effort to design the force structure for the Army of 2010 and beyond. *Joint Vision 2010* describes the future operational environment and the challenges services with the requirement that "all organizations must become more responsive to contingencies, with less 'startup' time between deployment and employment" (Shalikashvili 1997, 31). The initial analysis and focus on brigade operations will support a "key initial step for the fundamental transformation of our operational force" (Combined Arms Center 1999c, 2).

Transformation will occur in three phases: near-term, from fiscal year 2000 to 2003; midterm, from fiscal year 2003 to 2010; and far-term (objective force), fiscal year 2010 and beyond. The near-term effort will use state-of-the-art available equipment to allow two brigades at Fort Lewis to establish initial and interim brigade combat teams to evaluate the O&O concept and provide a model for science and technology agencies to design next generation equipment prototypes. Midterm efforts build on a revised organizational and operational concept and "focus on the leap-ahead capabilities required for the future combat system . . . supporting decisions in the FY03-05 that lead to systems prototyping in the FY08-10 time frame" (Combined Arms Center 1999c, 7). Ultimately the objective will be to create

> A strategically responsive force that is dominant across the full range of military operations and in all environments. . . . a force decisive against both asymmetric and "traditional" opponents; dominant in open, close, and complex operational environments. It will have a core capability for the MTW fight, yet be versatile for the rapid response, mission tailoring, and complexity required of

> offensive, defensive, stability and support operations. (Combined Arms Center 1999c, 2)

The choice of the mid-term to scope this thesis coincides with the period of greatest risk--if science and technology, acquisition processes, and organizational design fail to converge toward objective forces, the Army considers the fiscal year 2003 period to be the critical decision point for the future of the transformation efforts.

Organizational Analysis Summary

From the art of battle command to the science of designing command and control systems to achieve information dominance, the Army continues to experiment with new organizational design to meet the tenets of *Joint Vision 2010.* Within a complex context of shifting task organization and competing requirements, early deploying medium forces will confront issues of command and control and information superiority to achieve the required overmatch of capabilities to support successful operations.

CHAPTER 6

OPERATIONAL ANALYSIS

Introduction

Satellite communications and organizational analysis has focused primarily on the theoretical considerations based on projected capabilities and the environment for medium brigade operations. Significant analytical effort throughout the combat development community in the Army has leveraged most applicable modeling and simulation mechanisms to support the development of the medium brigade O&O concept. Although each component provides valuable input to the process, qualitative factors of command and control and information superiority prove difficult to model with fidelity.

The Vector-In-Commander model provides the TRADOC Research and Analysis Center a tool to model and evaluate advanced technological concepts and equipment supporting future force development. A robust communications model can represent "high and low resolution . . . information flow between various echelons," and TRAC developed the model considering that "the communications system is the nucleus of command and control" (TRAC 1999, 2). Perhaps recognizing additional need for qualitative input, medium brigade analysis included "combat modeling using the Computer Assisted Map Exercise (man-in the loop variant of the Vector-in-Commander model)" (Combined Arms Center 1999c, A-2).

Although it may seem intuitive that real world missions may ultimately reveal the previous limitations of the modeling and simulation systems, the paradox remains that the force organization must evolve based on analysis derived from the models. The challenge becomes synthesis of real world operational factors into the models or consideration of these factors qualitatively coupled with supporting model results. With the increased involvement of United States forces in operations after the end of the cold war, the services expend significant effort capturing lessons learned and documenting operational employment of forces to adjust training, doctrine, and equipment requirements for future operations. For example, the Joint Universal Lessons Learned System allowed Allard to study the operational context of Operation Restore Hope for his book *Operation Restore Hope: Lessons Learned* (1996). Review of the brigade mission and capabilities provides a lens through which previous operations can provide insights that modeling and simulations cannot.

Brigade Mission and Capabilities

Since brigade design will naturally evolve due to analysis and technological advancement, this thesis places more emphasis on exploring the required capabilities of the units and missions it might be expected to accomplish than on the details of current initial force design. The O&O concept further recognizes that "the uncertainties of the future environment will preclude design of mission-specific units; our forces must be mission capable across the full spectrum of operations" (Combined Arms Center 1999c, 2). Analysis must include factors reviewed previously related to mission, organization, command and control, information superiority, and signal support structures considered across the likely operational environment within the expected deployment parameters of the unit.

Brigade Employment

As a premier force for small scale contingency operations, the brigade could be deployed worldwide and expect to encounter complex and urban terrain and a variety of weather conditions. The brigade will not conduct forced entry operations itself, but will require a semipermissive entry via a C-130 capable airfield or follow a forced-entry unit after airfield seizure. As an early entry force, the brigade will deploy the basic brigade structure within ninety-six hours of deployment with combat forces able to "not only arrive in an area of operations in time to be strategically decisive, but also overwhelmingly dominate the situation from the first moments of our arrival" (Combined Arms Center 1999c, 5). Given this environment coupled with the reliance on an ARFOR headquarters for command and control, early contention for airlift with forced entry force sustainment packages, ARFOR Early Entry Command Post, and air force ground support units may require strict and realistic control of force flow into the area to meet deployment standards. Upon arrival, the brigade must conduct and sustain operations for 180 days without relief.

Brigade Organization

The expected brigade organizational structure modifies existing brigade concepts by varying degrees based on an analysis of supporting unit capabilities usually task organized to traditional brigades to create brigade combat teams. Some typical supporting elements (signal, engineer, and logistics functions) will be slightly modified but permanently assigned; other elements may be provided as mission requires but must be able to rapidly integrate their functions in support of brigade operations.

The O&O concept describes the organization as shown in Figure 10. and presents the detailed analysis for each subordinate unit of current doctrinal construction and likely objective architecture. Overall, the brigade will be a

> Mounted, infantry-heavy organization . . . with three mounted, infantry battalions, each composed of three combined arms rifle company teams . . . the Reconnaissance, Surveillance and Target Acquisition (RSTA) squadron; an anti-

tank company; an artillery organization of either cannon or rockets (analysis dependent); an engineer company; a signal company; a military intelligence company; a forward [brigade] support battalion; and a Brigade headquarters and headquarters company. (Combined Arms Center 1999c, 6)

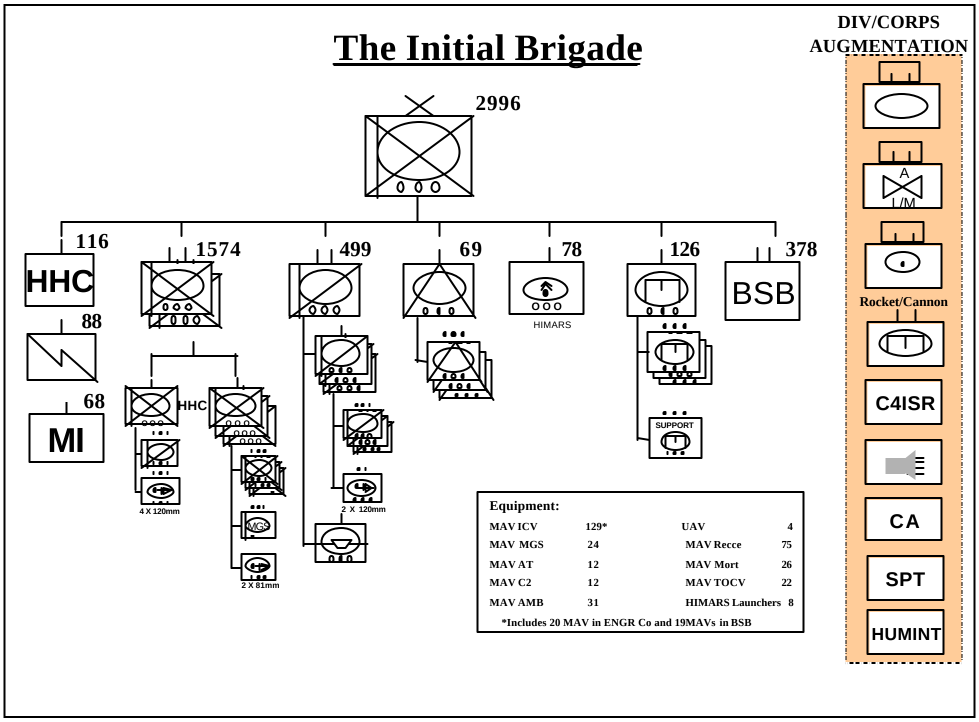

Figure 10. Initial Brigade Organization (Source: US Army Signal Center, Initial Brigade Brief, 1999)

. Medium brigade command nodes dispersed in an area of operations may require satellite communications support to meet the brigade internal information transfer requirements supporting command and control or information superiority.

Infantry Battalion

Infantry battalions doctrinally rely on tactical radio and in the future short range tactical internet for command and control and situational awareness. Infantry Center analysis initially recognized few shortfalls at the battalion level for communications although integration of digital capabilities on platforms will be essential (Combined Arms Center 1999c). Operational employment may require dispersion over complex terrain where single channel tactical satellite and direct broadcast satellite downlinks supplement local tactical internet.

RSTA Squadron

The RSTA Squadron will combine multiple capabilities and technologies under one commander, capable of "leveraging information technology and air/ground scout capabilities in complex and urban terrain . . . [and developing] the situation by focusing early on designated areas of operation and multi-dimensional and asymmetrical threats" (Combined Arms Center 1999c, 7-6). Combined Arms Center analysis of the dispersion of RSTA Squadron units within the area of operations and information transfer requirements revealed that the "RSTA squadron must integrate state of the art voice, digital, and video communications system to provide critical and timely information to the brigade commander" (1999c, A-13).

Fires and Effects

Without a currently fielded field artillery system that meets the deployment requirements of the medium brigade, science and technology efforts must develop one that also capitalizes on information superiority to mass artillery and other effects in support of brigade operations. Sensor-to-shooter linkages over extended terrain could easily require satellite communications to ensure timely information flow.

Brigade Support Battalion

The brigade support battalion will provide logistical support within constraints to meet the thirty-day self sustainment goal for the brigade overall. The battalion concept envisions supply-point distribution (subordinate units come to logistics support area for supplies) operating over the fifty-by-fifty kilometer expected battlespace for brigade operations. The battalion structure allows for only limited communications system repair, requiring low density, critical system to maintain a "War Reserve Spares Kit (WRSK)" of replacement components to meet operational readiness requirements (Combined Arms Center 1999c).

Military Intelligence Company

The intelligence architecture, besides general command and control, easily requires the most robust communications due to the different sensors, classifications, and types of information gathered to support analysis. The Trojan Spirit satellite terminal, which the intelligence community developed to provide strategic and intelligence only dedicated reach-back via commercial satellite systems, had already approached the end of its projected life cycle and the fundamental requirements it serviced were being included in the Army Signal Corps Warrior Information Network satellite architectures (Long 1999). Intelligence Center analysis of the medium brigade concept revealed:

> Reliable communications (both internal to the brigade and external to higher headquarters and theater/joint/national organizations/agencies) is absolutely essential to successful analytical support from the MI company . . . ability to collect, process, analyze and disseminate combat information and intelligence. Mitigation of this risk is achieved through th euse of redundant, non-terrestrial communications platforms (Trojan Spirit). (Combined Arms Center 1999c, F-16)

Brigade Command and Control

Specifically for small scale contingencies, joint doctrine described command and control factors and warns that:

> Each operation other than war can be unique. There is no single C2 option that works best for all such operations. JFCs and their subordinates should be flexible in modifying standard arrangements to meet the specific requirements of each situation and promote unity of effort. (Joint Chiefs of Staff 1995, 5-4)

In addition to the challenges of organizing command and control relationships, fundamental questions of battle command and the role of information dominance can also vary between operations. According the *Joint Vision 2010*, the key to success for adapting organizations based on technological and operational developments is to

> carefully examine the traditional criteria governing span of control and organizational layers. . . . We will need organizations and processes that are agile enough to exploit emerging technologies and respond to diverse threats and enemy capabilities. As we move forward, we may require further reductions in supervision and centralized direction. (Shalikashvili 1997, 31)

Little empirical data exists that provides precise bandwidth requirements for medium brigade operations. The closest parallel exists in the digital equipped brigade of the first digitized division, whose requirements have been studied in more detail and actual usage data collected (figure 11). However, while the analysis shows interesting trends in traffic usage related to particular phases of the operation, the impact of information superiority and battle command remain unmeasurable.

Sinclair's conclusion after reviewing early digital rotations at the National Training Center (Desert Hammer VI) revealed that despite potential information superiority, "digitally enhanced brigade did not perform significantly better than a non-digitized brigade . . . systems were not fully integrated . . . [and] battle command was not enhanced" (Sinclair 1996, 30). Despite the challenges to date in achieving the kind of information superiority through digitization that the Army envisions, the investment for the future force must continue, since the far term objective requires "maximization of C4ISR and logistic reach-back capabilities, split-based operations, and aggressive application of technological innovations and information technology" (Combined Arms Center 1999c, 1-10)

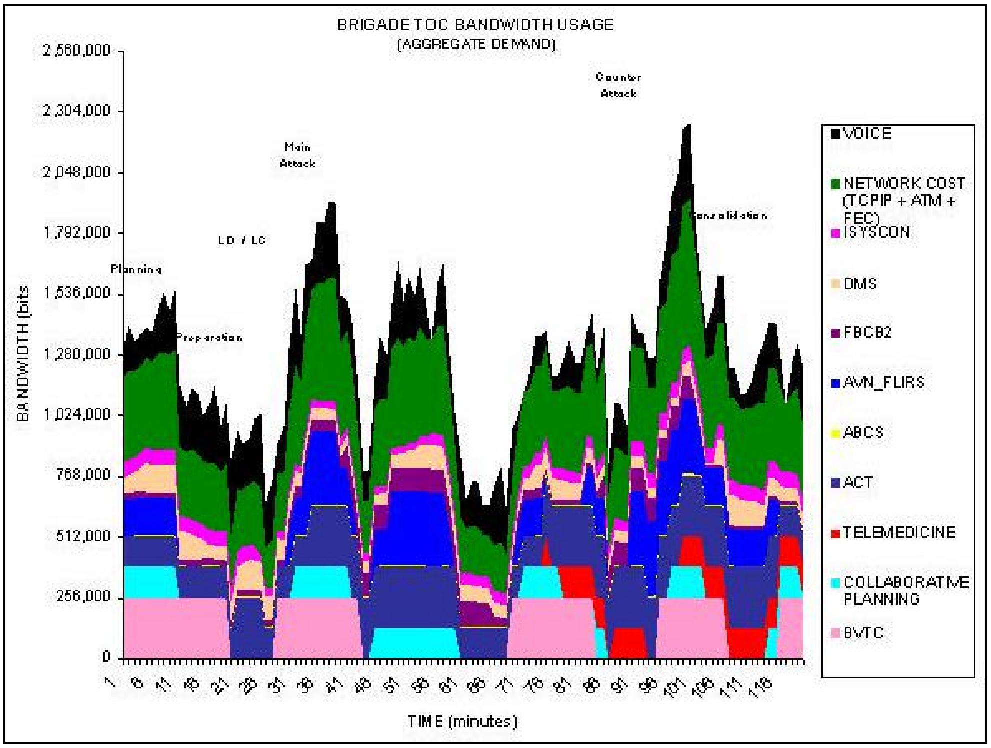

Figure 11: Digital Brigade Bandwidth Usage (Source: United States Army Signal Center, Fort Gordon, Georgia)

The TRADOC Research and Analysis Center has led the analytical efforts of the branch and proponent schools and internally conducted modeling and simulation of medium brigade operations to assist in the revision of the O&O concept. One of the key results of the analysis is that "situational understanding is the fundamental force enabler across all brigade battlefield operating systems and the foundation for risk mitigation with respect to Brigade vulnerabilities" (Combined Arms Center 1999c, B-5). The analysis also concludes that:

> The brigade must have the capability to achieve information dominance and deny the enemy the capability to achieve surprise or to template the force and engage it with heavy fires. . . . the Brigade must be equipped with Army Battle Command System (ABCS) family of systems in order to carry out effective information management and achieve the quality of information sharing necessary for multi-echelon collaborative planning within the execution focused command and control environment of the Brigade. (Combined Arms Center 1999c, B-5)

Brigade Signal Support

Potentially, medium brigade signal support elements might provide immediate capabilities that do not exist readily in other areas of the ARFOR. Pressure to employ these assets in liaison, headquarters support, or ARFOR specific roles may detract from medium brigade operations. The medium brigade signal support elements will also interface with existing joint and Army communications units including the Joint Communications Support Element (JCSE), the Power Projection for Army Command, Control, and Communications Company (Power PAC3), and other signal battalions at division and corps level. Rapid advances in technology must preserve interoperability to ensure lateral and vertical communications can be implemented.

The question of required capabilities for medium brigade units relates to the organization and interrelationship between command nodes, higher headquarters, and subordinate units. At the Strike Force exercise in September, 1999, TRAC captured "information about the volume of message traffic between Army Battle Command System (ABCS) boxes [computers]as well as network bandwidth usage" (Combined Arms Center 1999b, 14). Despite the traffic analysis, the use of collaborative planning tools and difficulties in relating information transfer to organizational effectiveness limit the usefulness of the data collection. The C4ISR and brigade signal company chapters in the Initial Brigade O&O concept describe the results of TRADOC analysis in this area.

> The Army's organizational and mental agility must be supported by an equally agile C4ISR capability. The force will not be reliant on line-of-sight communications and the commander must be able to access his C4ISR products wherever he is in the area of operations. The command post will be where he is not where the staff is. (Combined Arms Center 1999c, F-12)

Achieving this stated objective regarding line-of-sight communications equates to either satellite or aerial retransmission capabilities (manned or unmanned aerial vehicle). Robust satellite connectivity, airborne command nodes, and terrestrial data capability (figure 12) are all outlined as key elements to overcome the challenges inherent in the expanded battle space envisioned for the brigade. With the proliferation of digital ABCS computers throughout the medium brigade, terrestrial data capability helps manage the risk that satellite or UAV non-availability may degrade information flow.

In addition to challenges of competition from adjacent, higher, and subordinate elements for communications resources, adversary nation capabilities must also be considered.

> The relative advantage the U.S. now enjoys with regard to satellite reconnaissance, communications, and navigation will erode as countries capable of using space-based programs for military purposes increase and commercialization of space makes these capabilities available to all. Apart from the loss of our asymmetrical advantage in this area, access to commercial systems will allow even low-tech forces to enter the world of information age capabilities. (Combined Arms Center 1999c, 2-4)

Signal team ability to integrate the new capabilities may influence the effectiveness of the communications support provided as new technology becomes available.

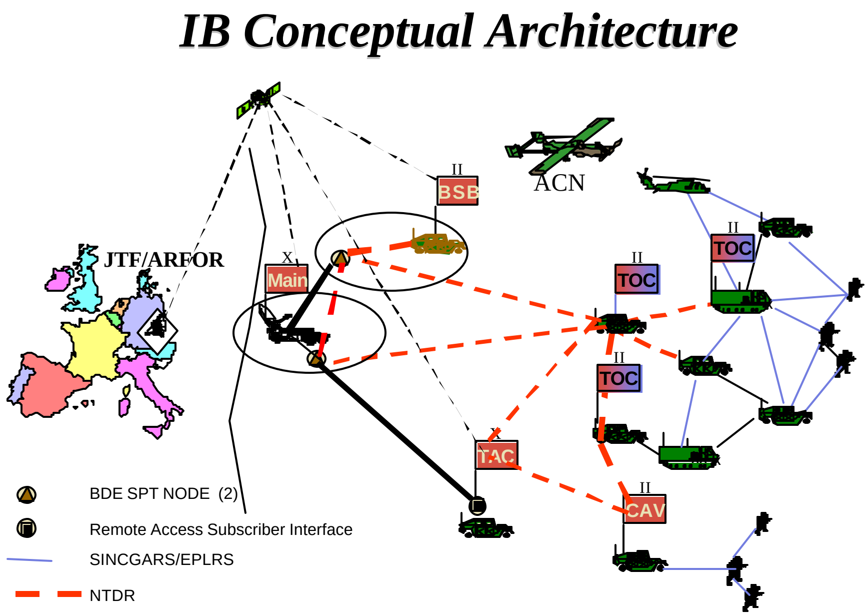

Figure 12. Initial Brigade Conceptual Architecture (Source: U.S. Army Signal Center Initial Brigade Brief, January 2000)

Operational Case Studies

The Army in the development of the brigade organization has considered many historical parallels of force deployments similar to the envisioned medium brigade. Small scale contingency operations provide the framework upon which future capabilities are built. The complexity of this environment presents numerous challenges to brigade operations, since:

> Historically, small scale contingencies, (Panama, Haiti, and Kosovo) have occurred in regions of weak infrastructure (especially roads, rail, bridges), complex terrain with large urban areas and diverse weather patterns. Humanitarian issues, such as overpopulation, resource shortages, natural disasters, and inadequate local, regional, and global response capabilities complicate operations in these areas. (Combined Arms Center 1999c, 2-8)

The relationship of the unit organizations internally and externally translate into the command and control C2 systems composition of personnel, equipment, facilities, communications, and procedures. Operations over time have increasingly challenged the capacity of space-based communications support to meet the requirements of command and control and information superiority. Civilian news agencies, nongovernmental organizations, and threat forces also must be considered as competitors for frequency spectrum and non-military controlled communications resources. As the size of the deployed force decreases and reliance on satellite communications increases threats of asymmetric attack on critical systems could come from the "pervasive presence of guerrilla, terrorist, paramilitary, special police and militia organizations . . . [who] can be expected however to have robust communications utilizing convential military devices augmented by commercial equipment such as cell phones" (Combined Arms Center 1999c, 2-9).

Operation Restore Hope

Operation Restore Hope provides an example where the 10th Mountain Division deployed as an ARFOR headquarters under the 1st Marine Expeditionary Force as a Joint Task force to Somalia from late 1992 to 1993. Though the information technology requirements were smaller by today's standards, doctrinal considerations of operations in areas of extreme heat, little infrastructure, and complex multinational task organizations provide some insight.

Not long after deployment, the Marine-based JTF was "[challenged] to head a multinational coalition of 20 countries . . . [and] align these operations with as many as 49 different U.N. and humanitarian relief agencies--none of which was obligated to follow military directives" (Allard 1996, 29). Coupled with poor infrastructure and roads, deployment of forces was limited by a semi-permissive airstrip and a port capable of handling one ship at a time for sealift offloading (Allard 1996). Consequently, the long shipment time conflicted with requirements to install communications systems. Citing the force flow turbulence, Allard recommended that future forces “organize JTF Headquarters in modules, each with its associated logistics and communications, and to deploy them in successive stages as capabilities are added to the force” (Allard 1996, 42).

Within the first few weeks of deployment, tactical satellite systems became the critical long-range communications mechanism between extremely dispersed operational areas (figure 13).

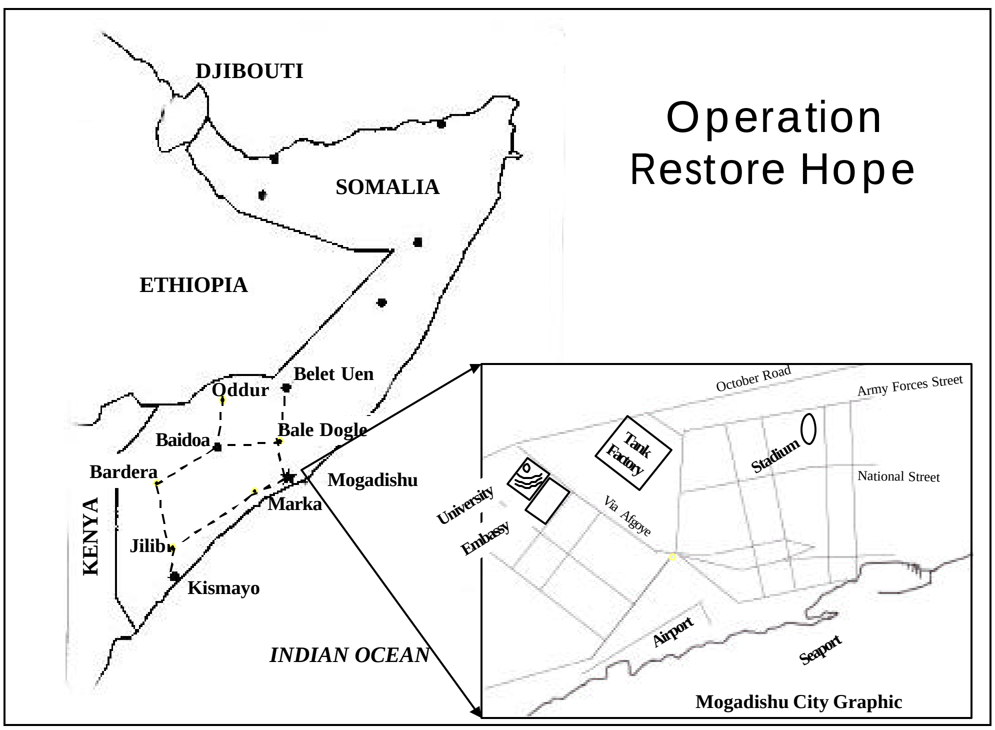

Figure 13. Operation Restore Hope Operational Area with Mogadishu City Graphic

Command and control lessons considered the impacts of nations from platoon to brigade, national sensitivity, new organizations, such as the civil-military operations center, and the creation of humanitarian relief sectors as a C2 measure, concluding that "inherent difficulties with command and control demand effective communications among strategic, operational, and tactical levels" (Allard 1996, 75).

The city of Mogadishu hosted many of the JTF headquarters and units because of the airport, seaport, and limited fixed facilities (figure 14). Communications requirements soon confronted nondoctrinal situations including the operations of infantry units "more than 50 miles from their headquarters," requiring satellite communications (Allard 1996, 78).

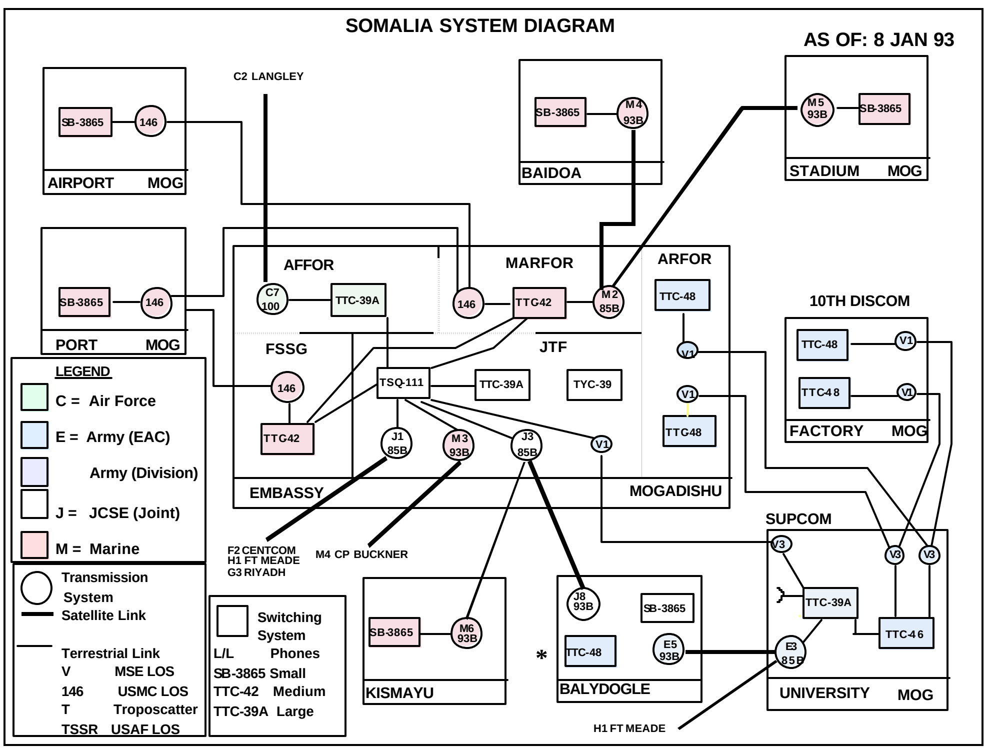

Figure 14. Somalia Network During Early Operations, January 1993 (Source: 11th Signal Brigade, Network Engineering Diagrams, 1993)

Multichannel satellite terminals using the DSCS system provided external communications for voice and data circuits to strategic gateways at Fort Meade and Camp Buckner, as well as service component “reachbacks” (USAF to Langley) and a CINCCENT command and control link to headquarters at Macdill Air Force Base, Florida. Internally, DSCS terminals provided the range necessary to connect remote sites and in one case, connected the stadium complex within the city of Mogadishu when terrestrial communications were not yet available. Arriving terrestrial systems replaced satellite terminals, especially the TRC-170(V)2 tropospheric scatter radio system, since the systems’s 150-mile planning range proved sufficient to interconnect most of the remote locations from the central hub of Mogadishu.

Satellite capacity was also constrained by competition with other operations in Saudi Arabia, which fenced much of the available bandwidth from the primary DSCS satellite over the Indian Ocean. To meet communications requirements, the JTF used the DSCS IO-reserve satellite, whose decreased state of health presented challenges since the satellite had such perturbations in its orbit that tactical satellite antennas struggled to track the satellites location at the extreme edges of its position (Department of Defense 1996). For increased communications capabilities, the JTF and ARFOR both contracted separately for commercial satellite terminals, over which numerous voice trunks and specific data circuits could be installed. Commercial high capacity satellite bandwidth was quickly leased by news and other organizations, requiring the United States forces to lease two T1 circuits over Russian satellites to augment JTF data requirements (Department of Defense 1996). Other commercial systems such as the INMARSAT, though high cost and eventually redundant to military systems, provided initial communications to dedicated operational users, primarily telephone service with limited facsimile and electronic file transfer (Department of Defense 1996).

Simultaneously, ongoing operational missions coupled with the requirement to replace JCSE communications assets kept most satellite communications systems in theater operational in system supporting the communications network by February, 1993 (Figure 15).

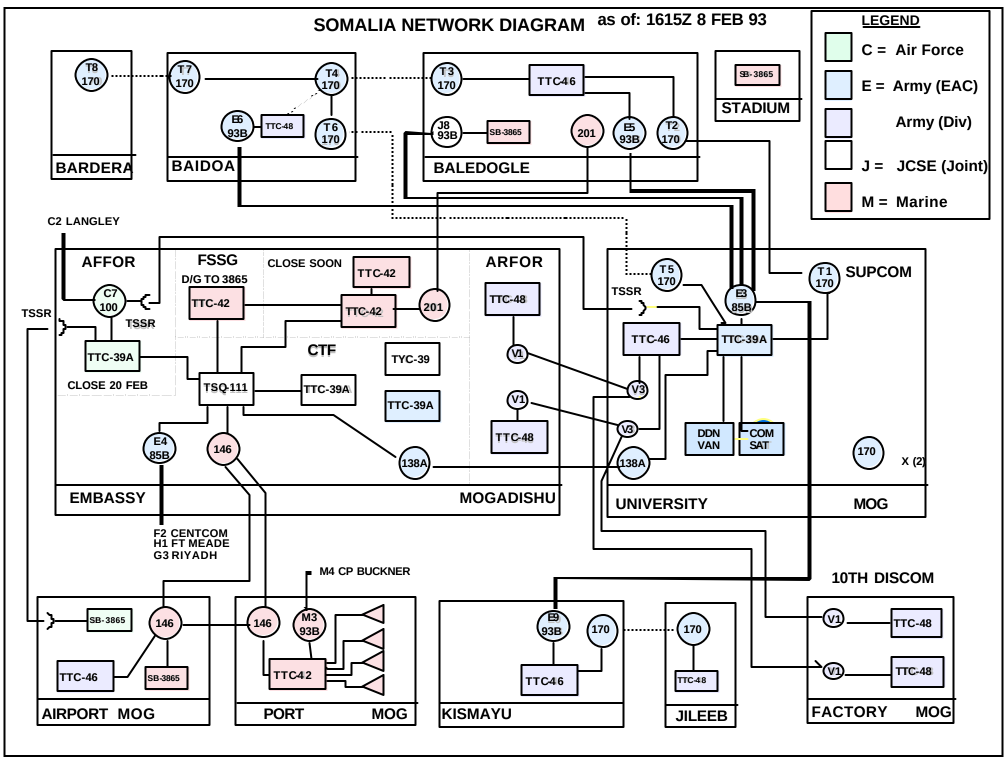

Figure 15. Somalia Network During Transition February 1993 (Source: 11th Signal Brigade, Network Engineering Diagrams, 1993)

Transition plans for the communications network required the deployment of additional satellite and telephone switching systems by the ARFOR to relieve the JCSE provided systems. After completion of the transition, and with the relief offered by commercial satellite systems, tactical satellite systems became useful for support of engineering efforts and other operational missions and the communications network stabilized for the duration of the JTF deployment until transition would once again occur to the United Nations organization (Figure 16).

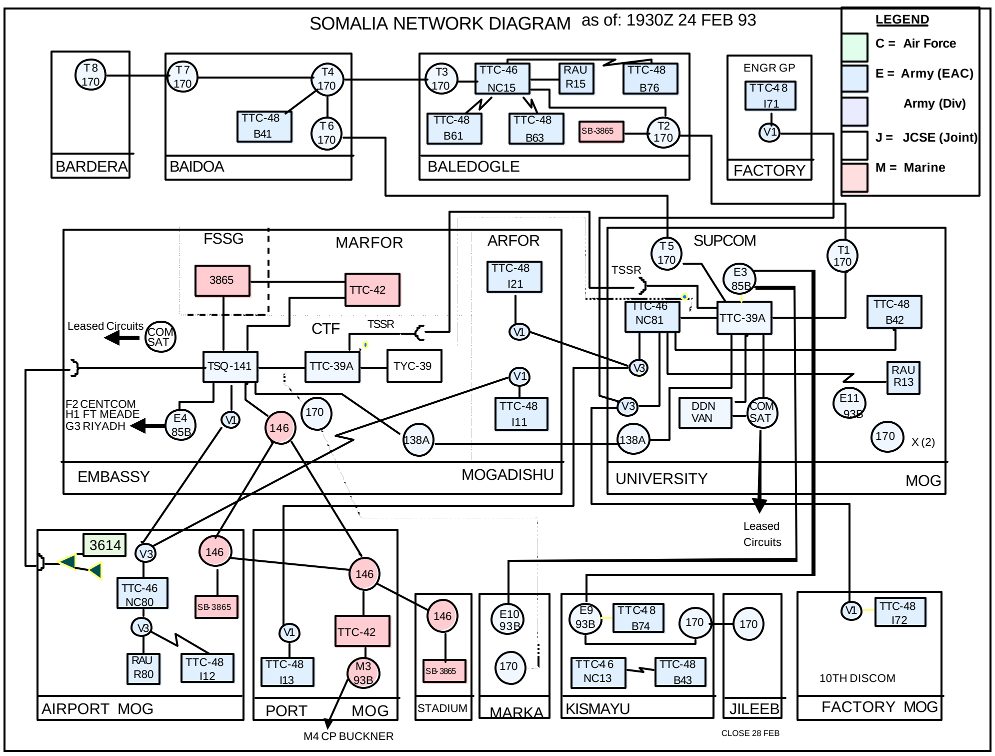

Figure 16. Somalia Network After Transition February 1993 (Source: 11th Signal Brigade, Network Engineering Diagrams, 1993)

Given this complex environment and shifting requirements, Allard stresses the importance of adaptive leaders to solve problems through innovative solutions, ensuring that "communications support provided to U.S. forces was generally superb, with connectivity helping to overcome some of the inherent difficulties of ensuring that unity of effort, if not command, was being exercised" (Allard 1996, 77). Transition to United Nations control caused the consolidation and replacement of most Air Force, Marine, and JCSE owned communications systems with Army systems. Within Army force design, 10th Mountain Division and XVIII Airborne Corps communications systems returned to home station, ensuring their availability to support another deployment, while theater signal assets from the 11th Signal Brigade and 67th Signal Battalion provided support to joint, multinational, and Army forces remaining in Somalia (Figure 17).

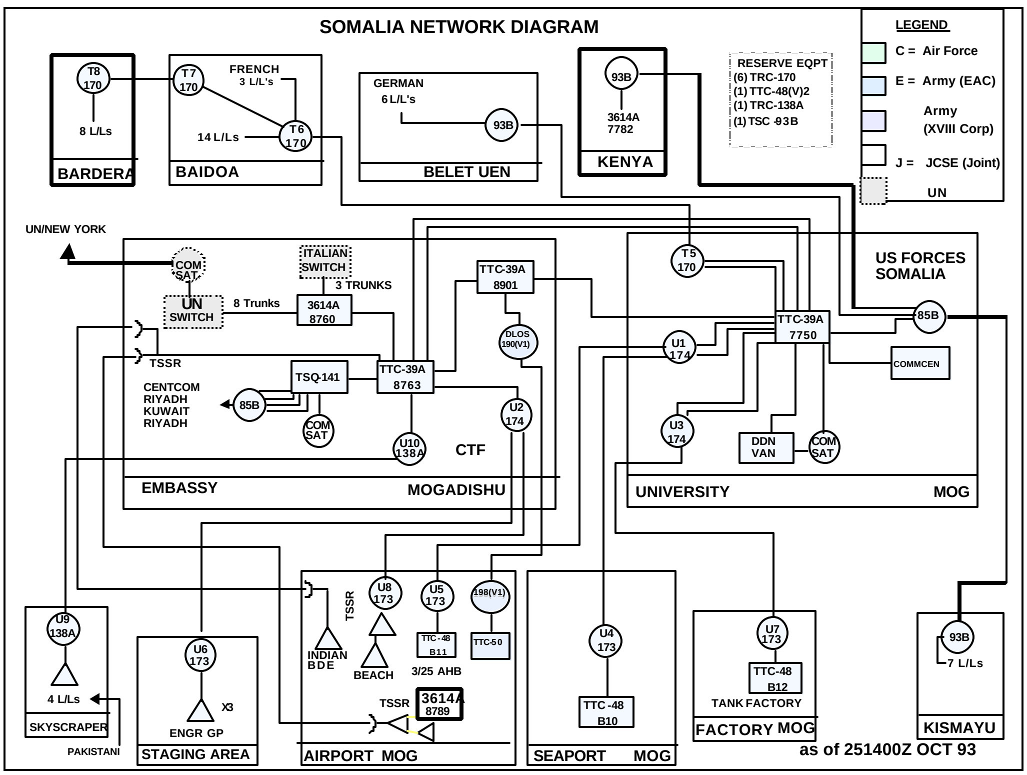

Figure 17. Somalia Communications Network in October 1993 (Source: 11th Signal Brigade, Network Engineering Diagrams, 1993)

Operation Uphold Democracy

Operation Uphold Democracy provides an example where the 10th Mountain Division deployed as an ARFOR headquarters and subordinate JTF-190 command under the XVIII Airborne Corps as the JTF-180 command to Haiti from late 1994 to 1995. A more recent operation, its characteristics include operations with naval forces, island geography and tropical climate, and competition with other ongoing operations for resources. Planners recognized the utility of tactical satellite communications and the challenges of constructing a command and control system for ARFOR and JTF requirements (figure 18).

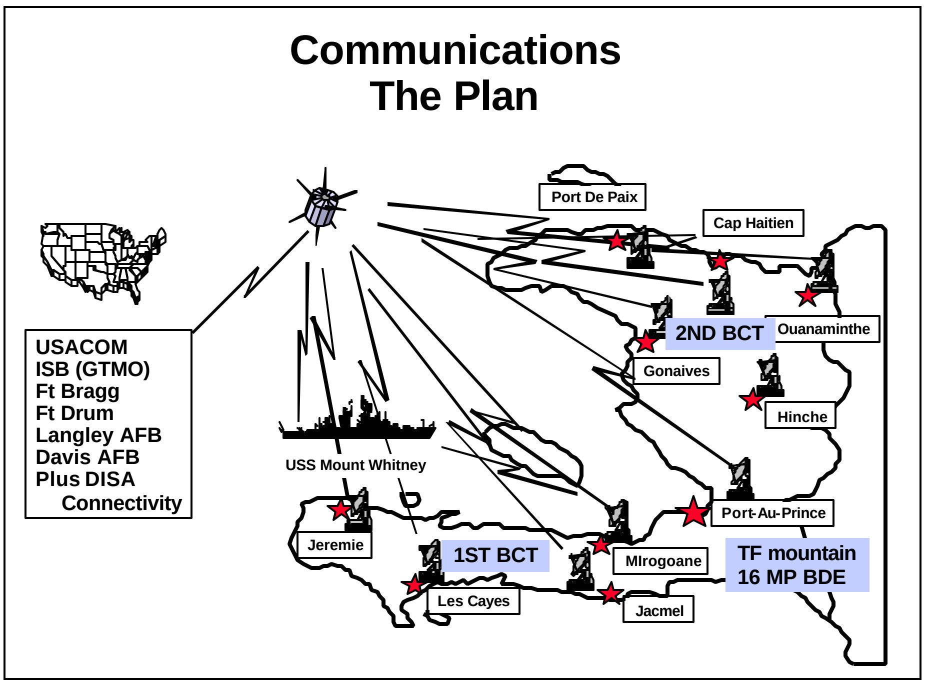

Figure 18. Haiti Communications Plan (Source: 10th Mountain Division, Operation Uphold Democracy, CD-ROM, 1995, Chapter 17)

Similar to Operation Restore Hope, 10th Signal Battalion formed the nucleus for the signal support task force and integrated elements from 35th Signal Brigade (XVIII Airborne Corps) and 11th Signal Brigade (theater strategic signal) (10th Mountain Division 1995). Initially, the 10th Mountain Division would use

> . . . organic division communications systems for the joint headquarters and its elements (intra-theater) and EAC communications systems for the joint headquarters and above (inter-theater). The architecture was an MSE . . . single channel TACSAT, and SINCGARS [radio] network at the JTF HQs and below and TRITAC, single channel TACSAT, and special circuits at the JTF HQs and out. MSE telephone switches and mobile telephones were committed to infantry battalion level (non-doctrine). Haiti's mountains and the distance between areas required the use of SATCOM (PAP to Cap Haitien was more than 80 air miles). The total plan required a large committment of satellite resources for both internal and external use. (10th Mountain Division 1995, 17-8)

This virtual compression of the communications network eliminated separate echelons of division, corps, theater, and JTF, making the best use of doctrinal signal support structures. Planners allocated some Army equipment for support of ARFOR specific requirements, and filled JTF requirements with combinations of Army equipment and expected JCSE support. When the operational plan shifted from the sequential forced-entry and transition to stabilization force to the hybrid deployment of both JTF headquarters near simultaneously when the forced-entry option was aborted, communications requirements rapidly exceeded capabilities for early arriving forces.

> Execution of the communication plan was complicated during deployment with the concurrent operation of two JTFs and the dynamics of the operation as it unfolded. The plan had the initial JTF HQs C2 system to be either those in place (non-permissive forced entry) or called in from JCSE, if necessary (permissive). The actual execution resulted in the only systems initially on the ground being a fragile single channel TACSAT capability. The assault CP (JTF 190) arrived late on 19 September and by early morning 20 September MSE connectivity was established to JTF 180, USACOM and the rear. The expansion of forces did not occur as planned. The communications network grew to be a massive structure around PAP with connection to Gonaives and Cap Haitien. (10th Mountain Division 1995, 17-10)

Requirements for tactical satellite again drove the employment of multiple terminals supporting JTF requirements for links back to the United States and internal links to remote bases of operations in theater (figure 19). Single channel satellite including one of the first operational uses of EHF provided limited but critical command and control communications while the majority of forces deployed into the area (10th Mountain Division 1995).

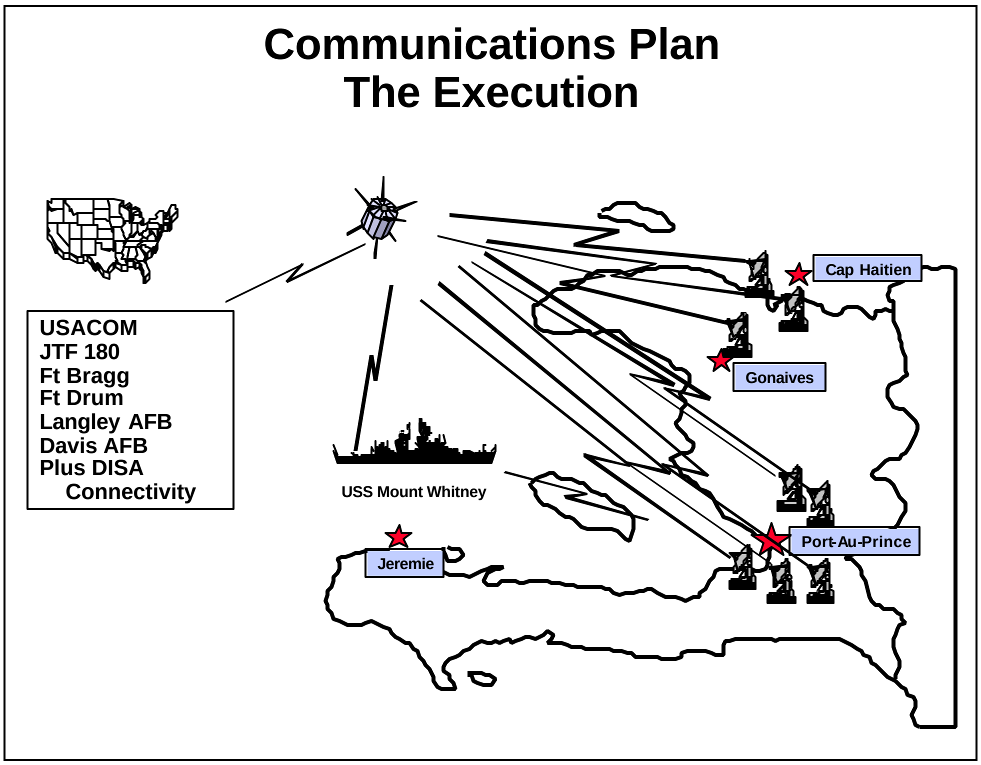

Figure 19. Haiti Communications Execution (Source: 10th Mountain Division, Operation Uphold Democracy, CD-ROM, 1995, Chapter 17)

Operation Joint Endeavor

Operation Joint Endeavor provides an example where the 1st Armored Division deployed as an Multinational Division (North) headquarters under a North Atlantic Treaty Organization led headquarters to Bosnia-Hercegovina from late 1995 to 1996. The longest operation undertaken by one organization during the period studied for this thesis, it provides examples of multi-national integration, mountainous geography and cold climates, and extensive satellite communications reliance.

The early air deployment of the Task Force Eagle assault command post to Tuzla base required immediate tactical satellite connectivity (figure 20).

Figure 20. Task Force Eagle Early Entry Communications (Source: 22nd Signal Brigade, 27th Regimental Signal Symposium, Fort Gordon, GA, 1996)

Tactical satellite systems deployed into Croatia during the Sava river bridge crossing supported command and control and preparation for the movement of 1st BCT into Bosnia. Due to force protection prohibitions on initial occupation of remote sites before mine clearing, satellite communications terminals provided the linkages between subordinate brigade combat teams, the Task Force Eagle command posts, and the higher headquarters Allied Rapid Reaction Corps (Premo 1996). The satellite communications architecture required to support the deployment of Task Force Eagle grew in complexity with competing requirements for interconnections between deployed forces, national support elements providing logistics support, command headquarters, and strategic gateways (figure 21).

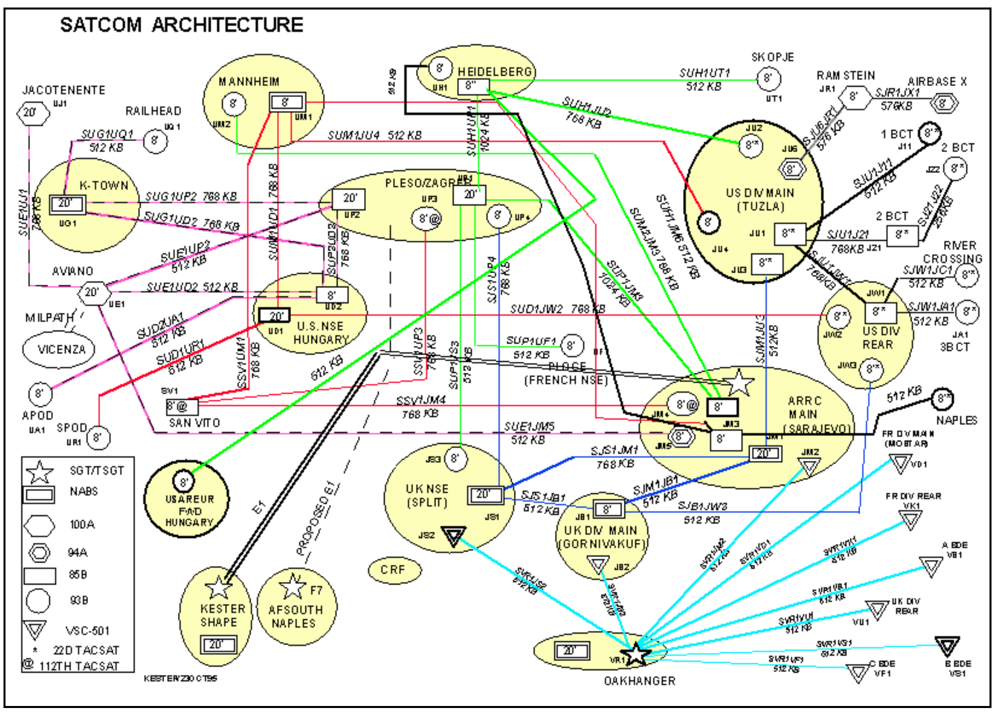

Figure 21. European Theater Satellite Architecture During Operation Joint Endeavor (Source: 5th Signal Command, Operation Joint Endeavor Lessons Learned, 1996)

Satellite teams were also instrumental in linking Task Force Eagle liaison teams at the Nordic-Pole, Russian, and Turkish Brigade to the Task Force Eagle headquarters and provided voice, data, and messaging service (figure 22). These satellite teams are not doctrinally designed or resourced for this purpose requiring creative training and presenting problems in systems engineering of equipment for each mission.

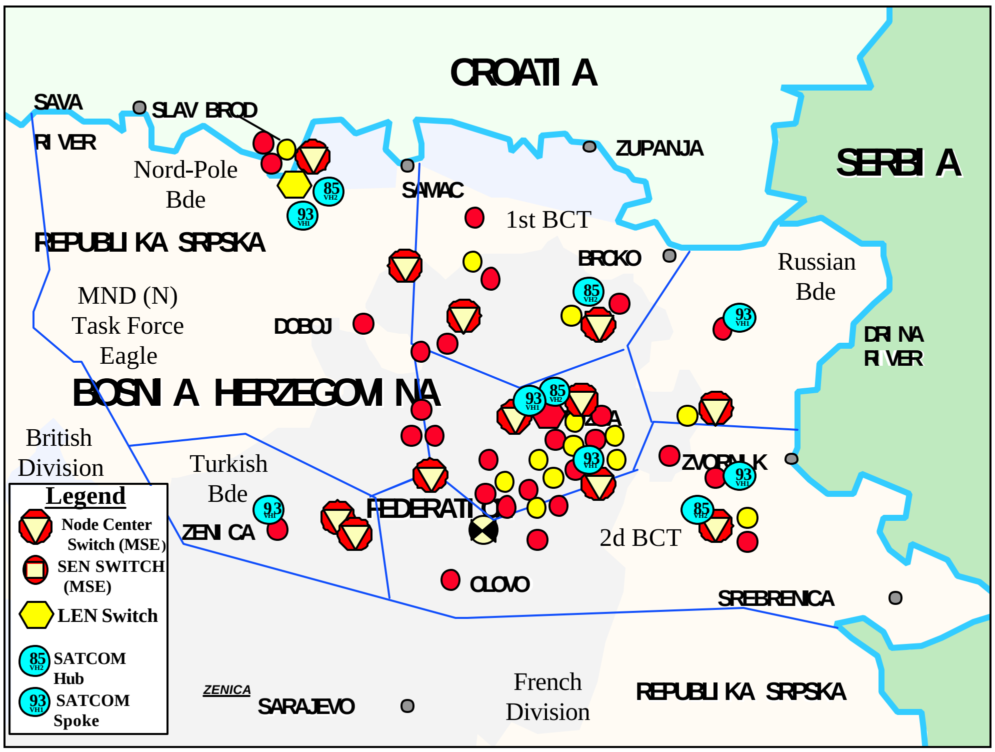

Figure 22. Task Force Eagle Network End State (Source: 22nd Signal Brigade, 27th Regimental Signal Symposium, Fort Gordon, GA, 1996)

Envisioned ARFOR Early Entry Command Post structure can find a close parallel in the Assault Command Post lessons learned. Advanced extensions of satellite services during Joint Endeavor included the provisioning of video teleconferencing directly to the subordinate brigades. Exploratory work experimented with the Joint Broadcast System to provide high-capacity information. Tactical satellite systems moving with brigade combat teams provided dedicated, high-capacity communications. Despite the success of satellite system employment during the operation, more capacity could have enhanced operations since "nothing happens without satellites . . . there are not enough single and multichannel systems to meet requirements" (Premo 1996).

Operation Allied Force

Task Force Hawk consisted of elements of V (US) Corps deployed to Tirane, Albania in early 1999 in support of NATO military operations centered on Kosovo. TF Falcon consisted of 1st Infantry Division deployed into Kosovo to establish the Kosovo Force (KFOR) to enforce peace in the region. Initial impressions of the efficacy of satellite communications must consider the fact that operations in Bosnia and in other operational areas continued to place high demands on military and commercial satellite communications architectures (Fletcher 1999).

Conducting split based operations required satellite communications that found constraints in limited lift assets, satellite availability, competition with deploying air force and other JTF elements, and the lack of sufficient STEP gateway capacity to provide initial strategic communications services. Early deploying elements of Task Force Hawk leveraged the robust strategic communications architecture that had evolved in Europe supporting ongoing operations in Bosnia by connecting early-deploying MSE switching equipment via tactical satellite to STEP gateways (figure 23).

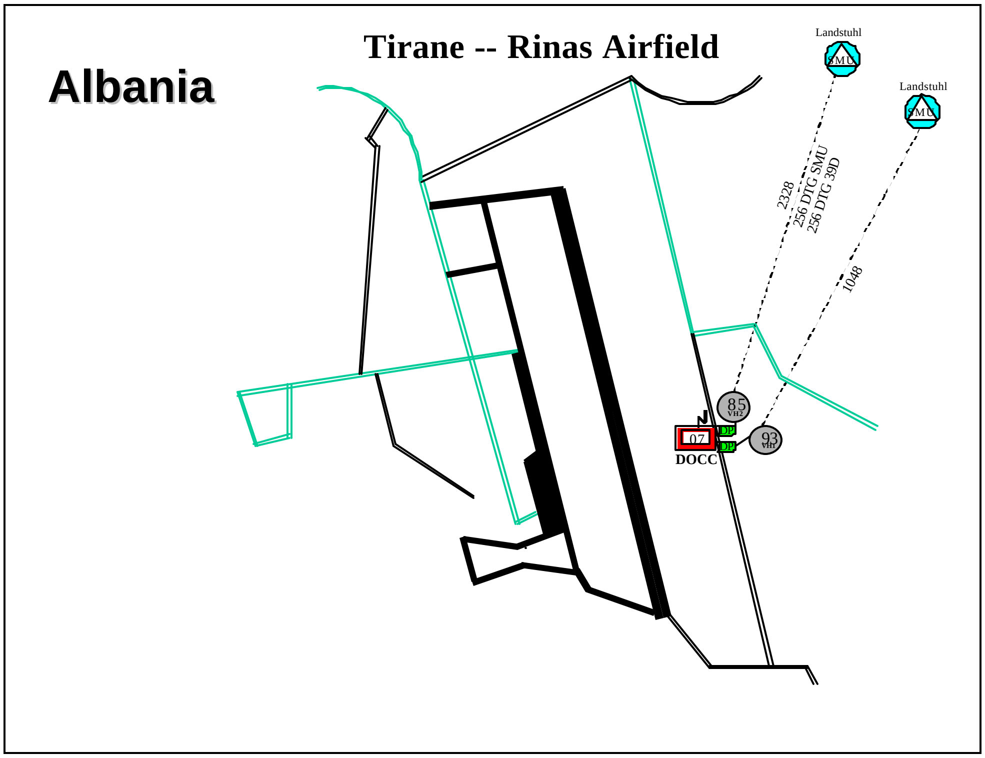

Figure 23. Task Force Hawk Initial Entry (Source: 22nd Signal Brigade, Brief to 27th Signal Regimental Symposium, Fort Gordon, GA, 1999)

The presence of switch-multiplexer units (SMU) at the STEP sites facilitated rapid interconnection of telephone switching systems. Additional communications systems deployed with subsequent force packages and met requirements as they evolved around the airfield at Tirane, Albania (figure 24). Terrestrial MSE line-of-sight radios extended a small MSE communication network around the confined operational area and also linked into Air Force provided satellite and switching systems on Tirane airfield in support of JTF Shining Presence, the refugee and humanitarian relief mission (Lasher 1999).

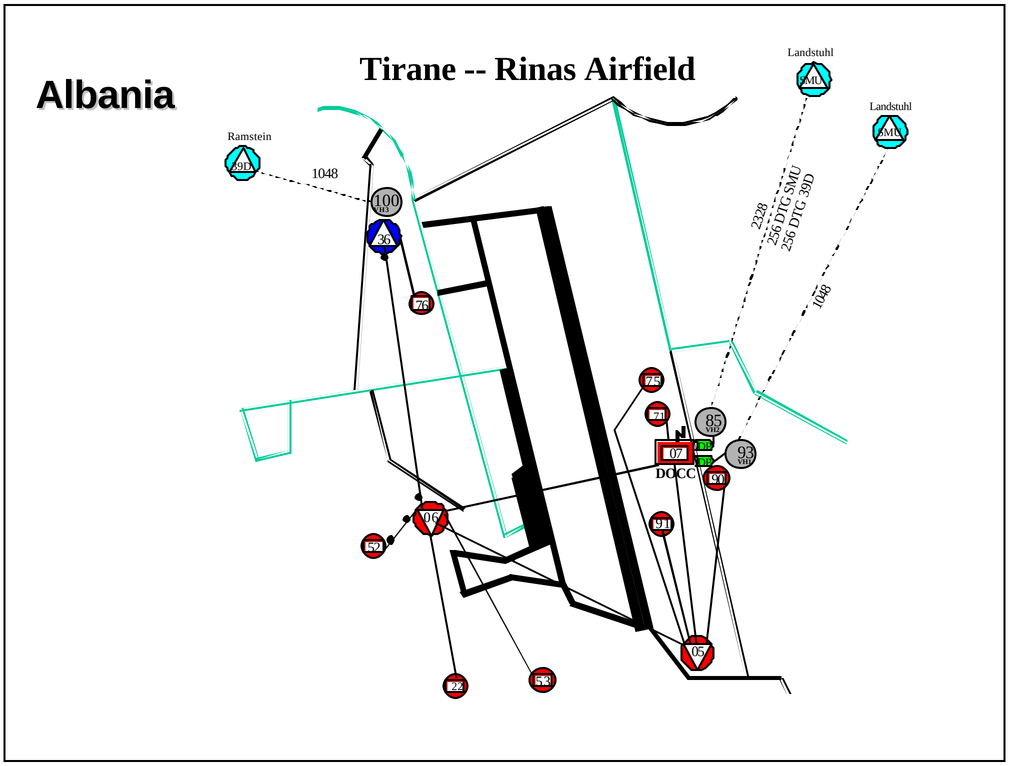

Figure 24. Task Force Hawk Internal Expansion (Source: 22nd Signal Brigade, Brief to 27th Signal Regimental Symposium, Fort Gordon, GA, 1999)

Coupled with expanding requirements in the operational area as more force package units arrived, the need for increased bandwidth could not be completely satisfied by available military satellite systems.

> Satellite resources day to day is a scare commodity for SHF & UHF . . . no one else would have been serviced without taking someone off. . . . EUCOM [was] apportioned 60 channels Feb 99; increased to 77 in May 99 [with] 17 extra channels reallocated from ACOM, CENTCOM, PACOM. . . . [the] loss of channels hindered numerous missions to include special ops, humanitarian ops, training, and testing. (Lasher 1999, 16)

Commercial satellite transponders leased by the Department of Defense provided immediate bandwidth but required terminal equipment to take advantage of the capability. Two Trojan Spirit terminals provided traditional support for high-speed data communications. An Army Material Command satellite “Fly-away Package” (FAP), was deployed to provide additional capacity in Tirane (Figure 25).

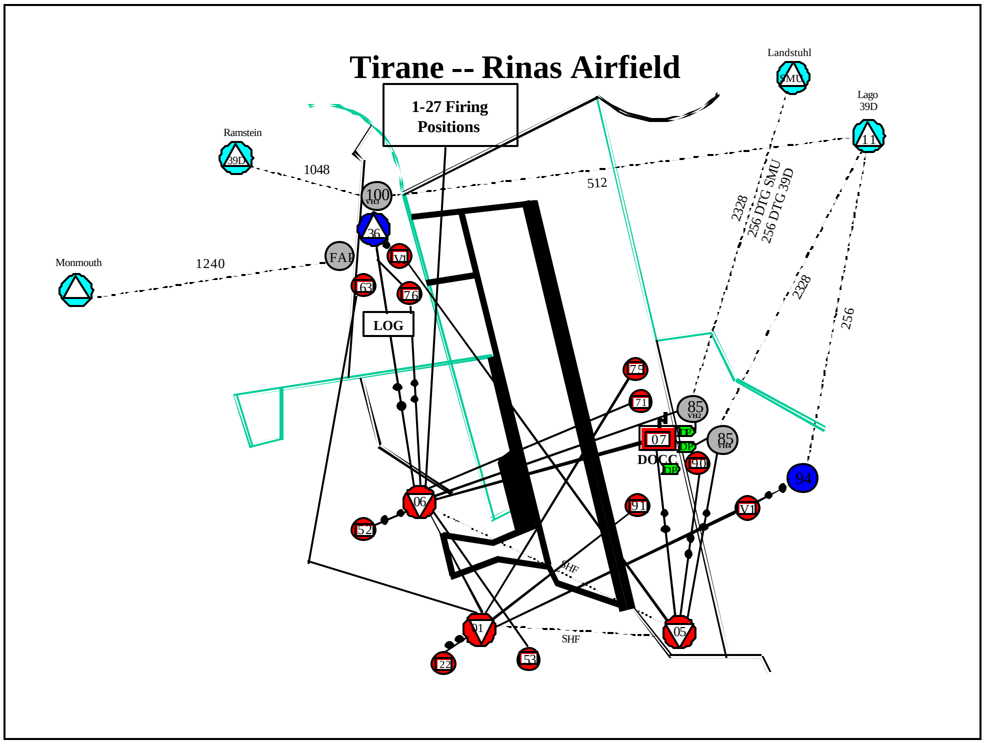

Figure 25. Task Force Hawk Reachback (Source: 22nd Signal Brigade, Brief to 27th Signal Regimental Symposium, Fort Gordon, GA, 1999)

At end state, the tactical communications network would include a composite mix of Army and Air Force tactical and commercial satellite terminals with a total bandwidth utilization close to eight megabits (figure 26). This total split into components as roughly twelve percent for dedicated DSN lines, fifty-six percent data and special circuits, and thirty-two percent common use tactical telephone lines (Fletcher 1999).

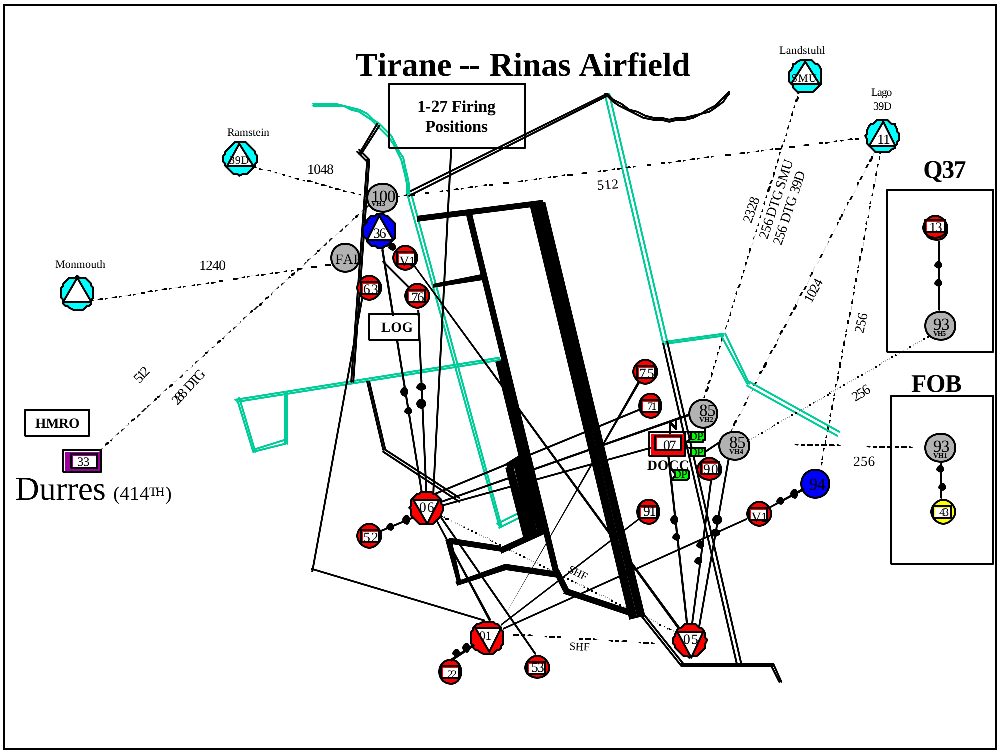

Figure 26. Task Force Hawk End State (Source: 22nd Signal Brigade, Brief to 27th Signal Regimental Symposium, Fort Gordon, GA, 1999)

Within the operational area, tactical satellite systems were required to overcome severe terrain considerations for the emplacement of field artillery radar sites and forward operating bases closer to the Kosovo border. The number of tactical satellite terminals employed for Task Force Hawk equaled the doctrinal allocation for an entire Army division (Fletcher 1999). The dual constraints of satellite capacity and satellite terminal availability were amplified by competition from existing theater missions in Bosnia and the Former Yugoslavic Republic of Macedonia, and new Kosovo related missions including JTF Noble Anvil, JTF Shining Hope, Task Force Hawk, and Task Force Falcon (figure 27).

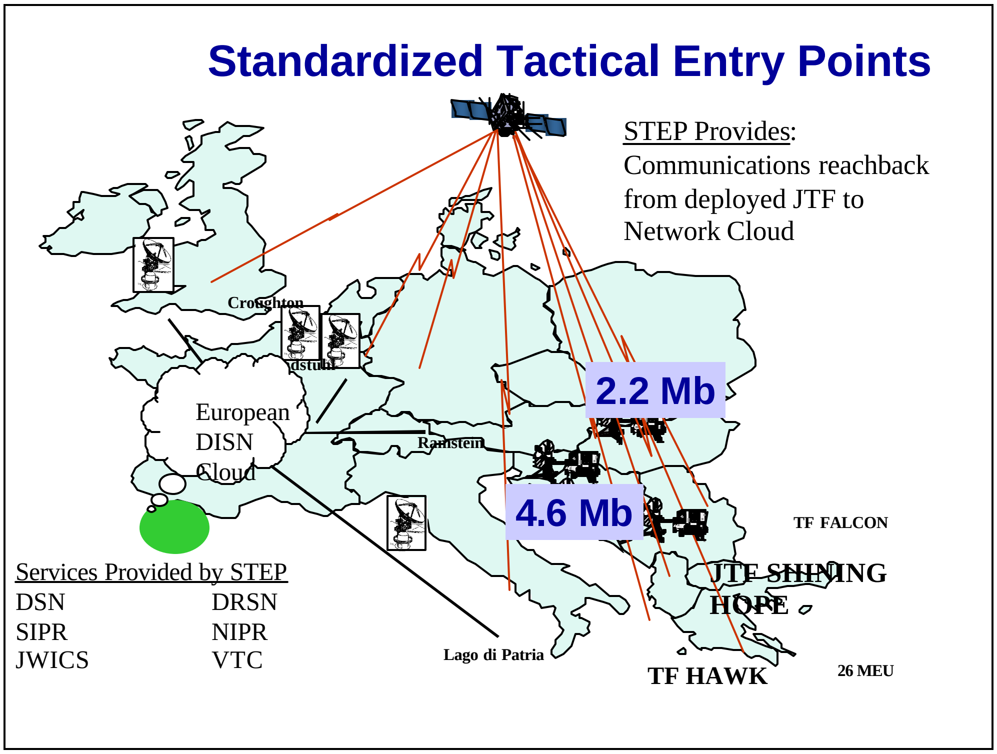

Figure 27. Kosovo Related Operations (Source Lasher, HQ EUCOM: A Look Ahead. Briefing, 27th Signal Regimental Symposium, Fort Gordon, GA, November 1999)

Operational Summary

Summarizing these considerations across a range of operations including Operation Restore Hope, Operation Uphold Democracy, Operation Joint Endeavor, and Operation Allied Force, table 1 shows key elements potentially of interest to medium brigade design. The narrow consideration of ARFOR and brigade operations, organization, command and control, and information requirements with respect to space-based communications precluded the same depth of review that the Combined Arms Center conducted to initially generate the brigade combat team O&O concept. Rather, a complementary focus on space-based communications provides results of direct applicability to the organization of the brigade signal company.

Table 1. Operational Analysis Summary

Area **Dimension**	**Restore Hope (Somalia)**	**Uphold Democracy (Haiti)**	**Joint Endeavor (Bosnia)**	**Allied Force (Kosovo)**
MIL Satellite Availability	DSCS (-) , UFO	DSCS	DSCS(-), NATO Skynet	DSCS(-), NATO Skynet, UFO
Commercial Satellite	Limited, Contracted	Contracted	Available, Contracted and Organic	Available
Gateways	Pre-STEP, Complex	Pre-STEP, Complex	STEP, Germany, Robust	STEP, Limited
Higher HQ	BCT, 10th Mtn	BCT, 10th Mtn	2 BCT, 1 AD, ARRC	V Corps DOCC, BCT, 1 ID
Signal Support	Ad hoc, division to JCSE	Ad hoc, division, Corps, EAC	Task Organized, Division to EAC	EAC, Corps, Division
Environment	Desert, Urban, dispersed	Island, Urban, Rugged, dispersed	Urban, Rugged, Limited Sites	Urban, Rugged
Legitimacy	UN,Multinational	UN	UN, NATO,	NATO

Medium brigade forces will operate on complex terrain and uncertain conditions and given their early deployment requirements, will encounter all the growing pains that operational missions endure, as plans become reality and unexpected circumstances or conditions evolve. Allard's warning that "the basic doctrinal principles that govern U.S. command relationships are appropriate for peace operations - and should have been applied in Somalia" implies that despite our best science and technology, organizational design, and doctrinal development, intangibles such as leader development, political environments, and operational complexity can induce friction in otherwise simplistic operations (Allard 1996, 55). Establishment of modular, interoperable organizations with organic equipment, coupled with mental agility and flexibility in employment, should prepare future forces to meet any challenge.

CHAPTER 7

CONCLUSION

Introduction

This thesis analyzed space-based communications support for medium brigade combat team forces over the next three years. The Army's reaction to changes in the national security environment and increased technology as outlined in *Joint Vision 2010* has been to pursue digitization of the force and develop a new, "medium weight" brigade--rapidly deployable, reliant on high-capacity information architecture, and capable of early entry and stability and support operations. Satellite communications will play a pivotal role in any communications architecture designed to support brigade operations. Assessing the effectiveness of the satellite communications architecture now can provide insights that may help guide materiel and doctrine development to achieve the desired objective force.

Research Methodology

The research effort attempted to gather disparate information elements related to internal requirements, external environment, and organizational integration to determine the effectiveness of space communications support. Given medium brigade doctrine and requirements, would the satellite capability be available, the equipment available to use the satellites and the signal teams be able to employ the equipment at the right place and time to ensure the success of the medium brigade? The qualitative analysis developed a conceptual model for satellite communications that considered the broad areas of satellite architecture, organizational design, and operational employment.

Conclusions

Space-based communications will remain pivotal to successful command and control and the establishment of information dominance. However, the presence and capability of the space-based communications systems by themselves can not ensure information dominance, due to factors of organizational employment and intangibles of battle command. Conversely, information dominance cannot be achieved without reliance on robust space-based communications as a prerequisite.

Projected signal organizations and equipment of the medium brigade can provide effective support to command and control and limited support to ensuring information superiority. Expected reliance on MILSTAR satellite constellation presumes future fixes for the less than ideal MILSTAR coverage caused by the loss of one of the MDR satellites. STAR-T terminals that leverage MILSTAR capabilities have also been delayed and are not certain of widespread Army fielding at the mid-term period of the medium brigade. Improvements to strategic gateways and Direct Broadcast System fielding offer great capabilities but must be doctrinally integrated into operations before their true impact can be assessed.

Organizational influences of ARFOR of JTF requirements will require task organization changes that impact on satellite requirements. Existing communications databases that capture all doctrinal requirements quickly encounter the reality of ad hoc organizational deployments requiring in theater reallocation and prioritization. Modernization gaps between units and generations of systems could present interoperability challenges. Loss of focus and commitment to the transformation process could mean that the Army might not finish fielding one system before another program diverts resources.

Operationally sizing bandwidth requirements for deploying forces becomes an inexact science due to an increased lack of digital discipline by information consumers. Previous management of data systems by circuit, while inefficient from an overall systems perspective, limited the impact of one system on the operation of another. Common user data networks, such as the tactical internet, must address prioritization and methods of restriction to ensure systems can operate. Communications management will ideally become simplified with the integration of modular capabilities within weapons platforms, command posts, and sensors, supported by realistic traffic analysis and threat vulnerability assessments.

Recommendations for Further Study

One area of research for future study entails an investigation of the relationship between information transfer requirements and successful operations, including the new paradigms of digitized forces and networks. Lee's thesis "Information Dominance and Military Decision Making" coupled with this thesis's focus on medium brigade operations could provide an initial start point (1999). In addition, detailed technical studies of the requirements and employment of MILSTAR EHF communications would be extremely beneficial as the military struggles with strategy to overcome the loss of one of the four medium-data rate satellites.

Summary

The study examined the role of satellite communications in the objective command and control system that considered the nature of the higher headquarters, adjacent units, and internal brigade requirements. Using the proposed Initial Brigade Combat Team concept, the study reviewed task organization, signal support structure, bandwidth requirements, and the operational employment of satellite communications assets during Operation Restore Hope, Somalia; Operation Uphold Democracy, Haiti; and Operation Joint Endeavor, Bosnia-Hercegovina.

The study concluded that space-based communications will remain pivotal to successful command and control and projected signal organizations and equipment of the medium brigade can provide effective support. However, the Army must address shortfalls in national satellite infrastructure, reconcile task organization difficulties, and integrate digitization efforts to effectively manage available communications capacities.

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