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INTEGRATION OF THE DEFENSE SATELLITE COMMUNICATION SYSTEM AND THE GROUND MOBILE FORCES SATELLITE COMMUNICATIONS SUPER HIGH FREQUENCY PROGRAM

by

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B.S., University of Missouri-Rolla, 1975

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Satellite communication can play a vital role in ongoing efforts to enhance communication systems available to the Ground Mobile Forces, i.e., the ground maneuvering units of the United States Army, Air Force, and Marine Corps. The interface of the Defense Satellite Communication System and the Ground Mobile Forces Satellite Communications Super High Frequency program is crucial to effective operational control of the limited space segment available. To facilitate an analytical examination of this crucial interface, a brief history of military communication satellites and the Ground Mobile Forces Satellite Communications program is included in the beginning of the thesis.

The management hierarchies of the Defense Communications Agency, the Ground Mobile Forces Satellite Communications Control System, and Tactical Communications Control Facilities and their interrelationships are examined in detail. Alternatives and recommendations for facilitating operational control of the limited space segment are presented.

This Thesis for the Master of Science Degree by

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of the limited space segment are presented.

This abstract is approved as to form and content.

Signed ____________________
Faculty member in charge of thesis

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Chapter 1

INTRODUCTION

The Department of Defense (DOD) is currently embarked on a course of action to provide "key force multipliers" through the use of advanced electronics technology.[1] Electronics is at the very "heart of whatever technological advantage we now maintain over the Soviet Union."[2] That advantage must be built on; exploiting it to the maximum. Serious thought must be given to the methods of managing advanced technology to "multiply the combat effectiveness of our forces."[3]

The above philosophy is the prime motivation for this thesis. How can communication satellite technology be managed to achieve a "key force multiplier" effect on the United States Ground Mobile Forces (GMF)? The GMF of the future will need increasingly capable Command, Control, and Communications (C^3) systems linking them to the National Command Authority (NCA) to maintain a high level of readiness in an increasingly complex international political arena characterized by rapidly changing spheres of influence and power.

Satellite communications can be a vigorous force in achieving "key force" enhancement of the GMF. One of the most important lessons learned from the evacuation of Vietnam and the "Mayaguez" rescue was the value of using satellite communications as a flexible, high-quality C^3 medium in crisis situations.[4]

In view of the potential of satellite communications for the GMF, the purpose of this thesis is to analyze the existing management systems for exercising operational control of the space segment used by the Ground Mobile Forces Satellite Communications (GMFSC) Super High Frequency (SHF) program. The existing system is a mixture of fixed and tactical communication typology and philosophy; predominately controlled by a fixed communications oriented agency, the Defense Communications Agency (DCA).

Examination of the critical interface points between the Defense Satellite Communication System (DSCS) of the Defense Communications System (DCS) and the GMFSC SHF program will be accomplished utilizing the conceptual framework discussed by Lawrence and Lorsch in their book, Developing Organizations: Diagnosis and Actions.[5] This framework is based upon the degree of integration and differentation needed for successful organizational interfaces. Differentation between the DSCS and the GMFSC SHF program can be attributed primarily to different interpretations of the same basic philosophical concepts of military communication system characteristics.

The GMFSC SHF program faces limitations in its use of the DSCS SHF space segment because it is considered as a special user network that must share available bandwidth and transponder power with other more classical DSCS user networks. Finite transponder power and beamwidth are available for satisfying SHF satellite communication user needs.

Close analysis of the need for efficient interface of the DSCS and the GMFSC SHF program provides a family of alternatives: maintenance of the status quo, circumvention of the essential problem, or attempting to affect smooth integrative interface of the two systems. The heart of this thesis is the evaluation of the above alternatives and the concluding recommendations.

In order to facilitate diagnosis of the system for operational control of the DSCS space segment available to the GMFSC SHF program, chapters two and three provide necessary background informa-.on needed to adequately scrutinize the system. Chapter two is a history of pertinent military communication satellite programs. Chapter three discusses the overall GMFSC program with emphasis on the SHF portion and equipment.

Chapter four analyzes the present and planned system of operational control of the space segment in terms of organizational interfaces, and discusses the impact of capacity limitations of the DSCS space segment. Chapter five provides alternatives for consideration in improving the interface of the DSCS and the GMFSC SHF program and coming to grips with the capacity imbalance. Chapter six is an executive summary of the preceeding four chapters and includes recommendations to be pursued by the military in managing the interface of the DSCS and the GMFSC SHF program in a manner that provides a "key force multiplier" effect.

To adequately cover the present philosophy of operational control or proportionment of the DSCS space segment to the GMF, it was necessary to sample a diverse selection of literature and documents. The range of material sampled included government documents, private enterprise sources, DOD contracted reports, books, articles, summaries of various briefings and conferences, and other unpublished sources dating from the 1960's to 1979.

A brief review of the more important reasons for enthusiasm by the telecommunications community with satellite communications since 1960 is needed before preceeding with a discussion of military communication satellites. Since 1960, communication satellites have been launched at an ever increasing rate for use by both government and private entities. The capability of satellite communications to satisfy both private and government telecommunication needs has long been recognized. The chief advantages from a commercial viewpoint are the relative insensitivity of satellite communications to distance versus cost factors, point-to-multipoint capability, and improved quality over long distances.[6]

The abo'.e capabilities and the additional capability to satisfy specific DOD needs for increased, jam resistance, mobility, reliability, and independence on propagation path (e.g., not having to propagate strictly through friendly territory) have all made satellite communications attractive for military use. Chapter two is an indication of how attractive.

FOOTNOTES

[1]Malcom R. Currie, "Electronics: Key Military Force Multiplier," Air Force Magazine, 59:7:39-45, July, 1976.

[2]Ibid.

[3]Ibid.

[4]Charles E. Williams, Jr., "Communications and Crisis Actions," Air University Review, 29:3:3-8, March-April, 1978.

[5]Paul R. Lawrence and Jay W. Lorsch, Developing Organizations: Diagnosis and Action, (Reading: Addison-Wesley Publishing Co., 1969), pp. 12-13.

[6]Howard Crispin, "Satellite Communications and the Growth of Earth Stations," Telecommunications, 13:4:25, April, 1979.

Chapter 2

MILITARY COMMUNICATION SATELLITES

Introduction

A selected historical review of military communication satellites will facilitate analysis of the GMFSC program. Included in this chapter is a brief discussion on the historical background of satellite communications, a review of important military satellites, and a discussion on planned military communication satellites.

Arthur C. Clarke, in a 1945 article in a British publication Wireless World entitled "Extraterrestrial Relays," published the first detailed forecast of communication satellites.[1] The article discussed synchronous orbits, earth coverage and spot beam antennas, multiple beam antennas, solar arrays for power sources, and optical and radio crosslinks between satellites.[2] Rough calculations for a voice link at a frequency of 4 GHz using 10 W of power were included in the article.[3] The next article on the subject was written in 1955 by John R. Pierce.[4]

The first space communication activity can be traced back to 1946 when the United States Army achieved radar contact with the moon. The Navy, in 1945, began communications experiments using the moon as a passive reflector. In 1959, the Navy established an operational communications link, available four to ten hours per day, between Hawaii and Washington, D.C. The link was terminated in 1963 due to progress in artificial, active satellites.[5]

The first man-made communications satellite, Project Score, was launched in 1958; followed by Courier in 1960. By 1960, several journals had printed numerous articles on satellite communications which discussed the merits of passive versus active satellites and nonsynchronous versus synchronous orbits.[6]

Military Satellites

Courier launched in October, 1960, was a relatively simple satellite designed for early experimental use. After Courier, no other military satellites were launched until June of 1966.[7] A program was started in April, 1960, Advent, to provide an operational military communication satellite. However, a number of problems developed with Advent. The difficulties were primarily a result of design requirements being way beyond available technology and as a direct consequence, the program was cancelled in May, 1962.[8] A similar problem developed with Fleet Satellite Communications (FLTSAT) discussed below.[9]

The discussion on specific military satellites is arranged categorically in order to facilitate grouping of satellite programs by specific categories of service: tactical (UHF) or strategic (SHF). For the most part, strategic satellites operate in the SHF band and normally provide long haul, wideband relatively permanent communication links. Strategic communication terminals include large fixed antennas, transportable ground stations, or large shipboard antennas. Tactical satellites operate in the UHF band providing quick reaction capability through the use of small land-mobile, airborne, or shipborne tactical terminals. Figure 2-1 below illustrates chronologically the development of tactical and strategic military communication satellites.

Type	Year (1900's)		
	66 67 68 69 70 71 72 73 74 75 76 77 78 79 80's		
Tactical	TACSAT&LES-6	GAPSAT(MARISAT)&FLTSAT LeaSat	
Strategic	IDCSP(DSCS-I)	DSCS-II	DSCS-III

Figure 2-1. Military Communication Satellites 1966-1980

Tactical Satellites

A new era in military tactical communications was ushered in with the launches of Lincoln Laboratory's Lincoln Experimental Satellite-Six (LES-6) and Hughes Tactical Satellite (TACSAT-1).[10] The LES-6 was used to investigate various aspects of tactical communications. TACSAT-1 was designed with UHF and X-band (8 GHz) capability and crossover modes (UHF receive and X-band

transmit or vice versa) allowing operation with a wide variety of terminals.[11]

Tactical Satellite Communications Interim Operational Capability (TACSATCOM IOC), as TACSAT-1 is commonly called, demonstrated the efficacy of Satellite Communications (SATCOM) by its employment for communications in Project Apollo, numerous military exercises and crisis, and Presidential communications support. The communications mission of TACSATCOM IOC ceased in 1972 due to an attitude control failure.[12]

Even though TACSAT-1 and LES-6 were experimental satellites, they stimulated the desire for additional TACSAT capability within the Department of Defense (DOD). As a result, the Navy began to plan for a Fleet Satellite (FLTSAT) Communication System to be launched in 1977. Because FLTSAT would not be launched until 1977, and TACSAT-1 had failed in 1972, the Navy contracted for a "gapfiller" capability, particularly during the years 1974 to 1977.

This interim satellite service is commonly called GapSat (or Gapfiller).[13] The GapSat channels are leased from the Maritime Satellite (MARISAT) System owned by the MARISAT Joint Venture[14] and managed by Communication Satellites (COMSAT) General Corporation.[15] The Navy utilizes one wideband and two narrow band UHF channels off each satellite in the MARISAT system. Remaining channels are used for commercial ship-to-shore service.

The Navy leases MARISAT service in the Pacific, Atlantic, and Indian Oceans.[16]

As discussed earlier, FLTSAT was to have been launched in 1977; however, due to management problems, the first satellite, FLTSATCOM-A (see Figure 2-2) was not launched until 1978. See Table 2-1 for FLSAT technical d tails.[17]

The FLSAT program was to have included a total of ten satellites but was scrubbed to five satellites by congress in 1979. These five satellites, along with Gapfiller, will satisify Navy needs until 1983. The Navy, as executive agent, was directed by congress to lease needed fleet satellite capacity after 1983. Hughes Corporation was awarded the contract for Leased Satellite (LeaSat) which will be UHF with one SHF channel for fleet broadcast.[18]

Air Force Satellite (AFSAT) Communications is in reality transponder capacity on FLTSAT and the planned LeaSat program. The primary mission of AFSAT is to provide rapid reliable, secure UHF communications for the command and control of United States Air Force strategic forces.[19]

Strategic Satellites

The launch of the Initial Defense Communications Satellite Program (IDCSP), later called Defense Satellite Communication System-One (DSCS-I), in 1966 ushered in an

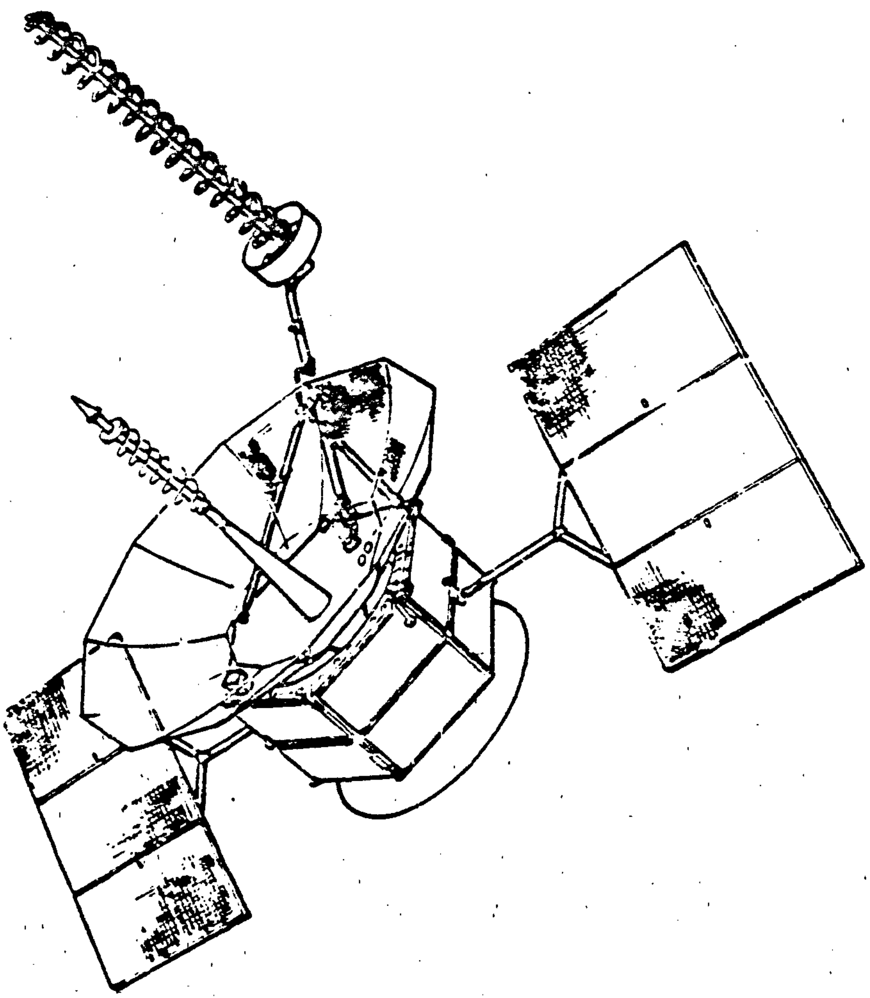

Figure 2-2. The FleetSatCom Satellite

TABLE 2-1

FLEETSATCOM TECHNICAL DETAILS

Configuration	1 X-band to UHF channel Nine 25-kHz channels (UHF) Twelve 5-kHz channels (UHF) One 500-kHz channel (UHF)
Transmitter	240-to 270-MHz band 12 transistor power amplifiers, each with some redundancy
Receiver	290 to 320 MHz, and ~8 GHz
Antennas	16-ft deployable UHF parabola, earth coverage, circularly polarized X-band horn, earth coverage, circularly polarized
Design Life	5 yr
Developed By	SAMSO TRW Systems Group

era of strategic satellite communications capability for DOD. DSCS-I provided more than 20 MHz of bandwidth and supported clear voice, secure voice, and imagery traffic for the Defense Communication System (DCS).[20]

Phase two (DSCS-II) and the planned phase three (DSCS-III) of the DSCS is discussed in greater detail because of their central role in the GMFSC SHF program. DSCS-II satellites (See Figure 2-3) launched in 1971 gave the DCS more capacity and a greater increase in connectivity between ground terminals than DSCS-I.

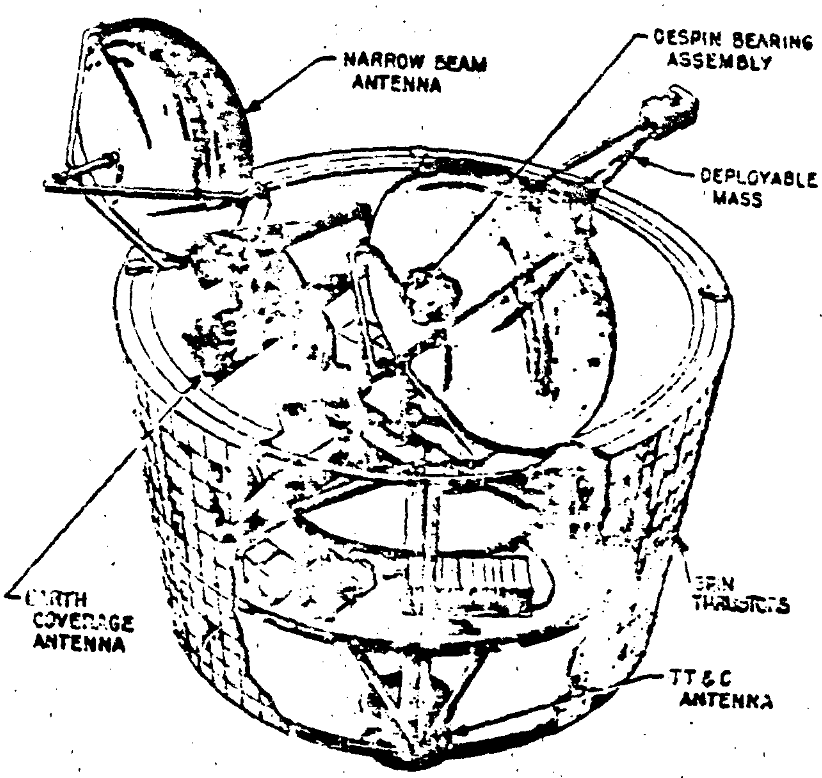

Figure 2-3. The DSCS-II Satellite

DSCS-II satellites have a command subsystem, multiple communication channels with multiple access capability, attitude control and stationkeeping capability, and some measure of hardening. The DSCS-I satellites had none of these features. DSCS-II satellites have four antennas: two horn antennas providing earth coverage (EC) and two parabolic reflectors providing narrow beamwidth (2.5^{o}) coverage (NC). Table 2-2 and Figure 2-4 give details of the DSCS-II satellite design.[21]

The communication subsystem of DSCS-II has four channels with the following characteristics:

Channel	*Bandwidth	Receive Antenna/ *Frequency	Transmit Antenna/ *Frequency
1	125	EC/7975-8100	EC/7250-7375
2	50	NC/8125-8175	EC/7400-7450
3	185	NC/8215-8400	NC/7490-7675.1
4	50	EC/7900-7950	NC/7700-7750

*Bandwidth and Frequencies All in MHz

This arrangement of channels allows flexibility to accomodate a wide variety of links and to interface with many different size terminals including fixed and small mobile terminals of the GMF.[22] Transponder power and channel assignments germane to CMFSC SHF terminals are discussed in Chapter 4.

The next generation DCS satellite system, DSCS-III, is scheduled for launch in July, 1979, the second, July, 1980. The DSCS-III program eventually expects to

TABLE 2-2

DSCS-II TECHNICAL DETAILS

Configuration	4 channels with 50- to 185-MHz-bandwidths, single conversion
Capacity	1300 two-way voice circuits or 100 Mbps digital data
Transmitter	7250 to 7375, 7400 to 7450, 7490 to 7675, 7700 to 7750 MHz 4 transmitter chains: 1 on, 1 standby for earth coverage, same for narrow-beam; each has driver and output TWTs 20-W output per transmitter ERP: 28 dBW (earth coverage) to any point on earth with an elevation angle $\geq 7.5^{\circ}$; 43 dBW (one narrowbeam antenna) or 40 dBW (two narrowbeam antennas) to any point within 1° of the beam axis
Receiver	7900 to 7950, 7975 to 8100, 8125 to 8175, 8215 to 8400 MHz Tunnel diode preamplifiers and limiter/amplifiers 7-dB noise figure
Antenna	2 earth coverage horns (1 transmit and 1 receive), 16.8-dB gain at edge of earth 2 narrowbeam parabolas, 44-in. diameter, 2.5° beamwidth, 36.5-dB gain on axis, steerable $\pm 10^{\circ}$ each axis All antennas mounted on a despun platform and circularly polarized
Design Life	5 yr
Developed By	SAMSO TRW

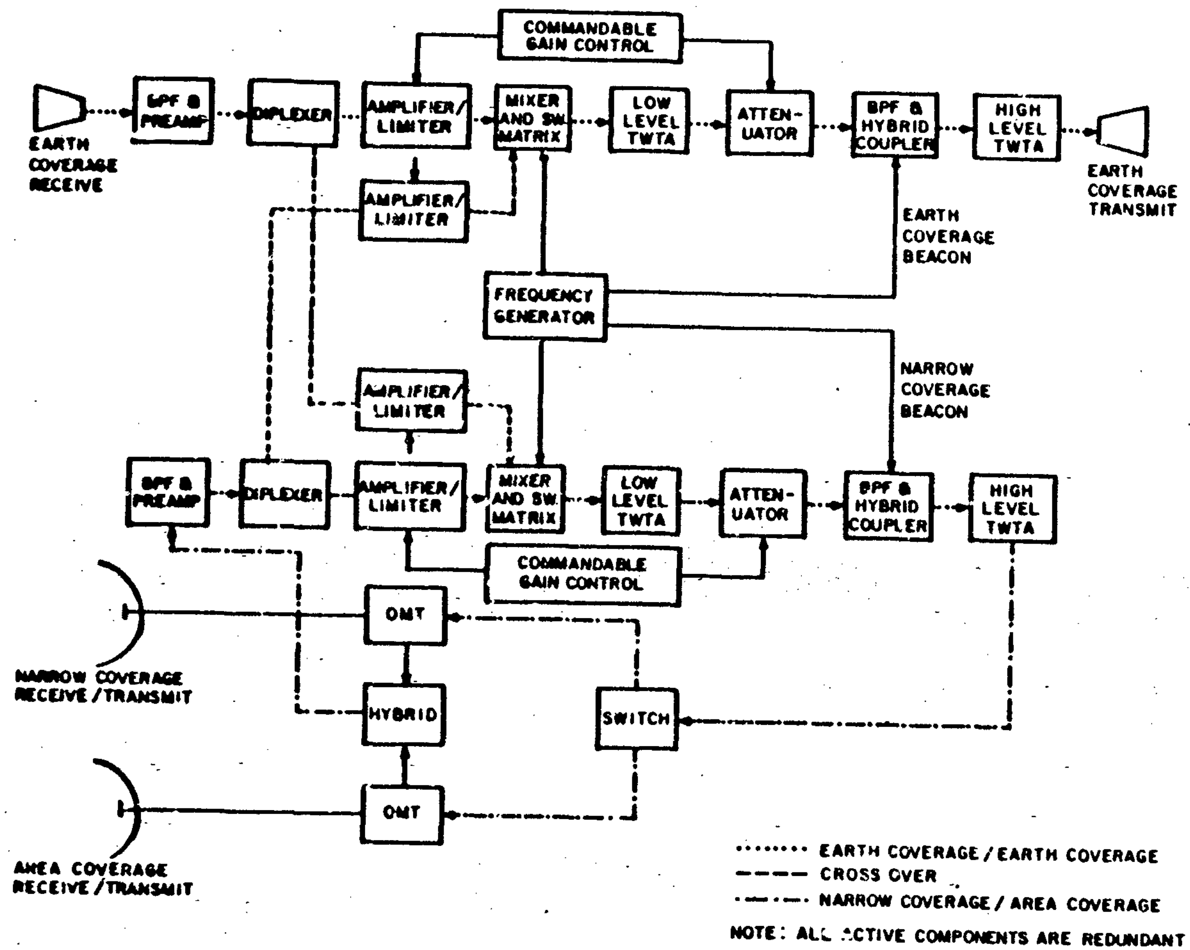

Figure 2-4. DSCS-II Block Diagram

produce about ten satellites in the early 1980's in addition to test models.[23] DSCS-III will have greater capabilities than DSCS-II satellites; however, the new satellites will be compatible with DSCS-II ground terminals.

The satellite design of DSCS-III (See Figure 2-5) will include six separate transponders in order to serve autonomous user communities, allowing each transponder gain and modulation and multiple access scheme to be optimized based on user needs. The use of multiple transponders also has the advantage of allowing transfer of users in the event of a transponder failure.[24]

An additional feature of the satellite is that it will be the first to have multiple beam antennas with a controllable beam size, in addition to earth coverage horns and a steerable parabolic dish. The uplink multibeam antenna will be able to form 61 beams, each one slightly greater than one degree. This is similar to the narrowbeam antennas on DSCS-II; however, DSCS-III multibeam antennas have the additional capability of forming any size or shape beam between their minimum limit and full earth coverage. The two downlink multibeam antennas will each be capable of forming nineteen beams. Thus, when mission operating areas change, antenna radiation patterns can be confined to specific areas, thereby maintaining high Effective Isotropic Radiated Power (EIRP) where needed while providing connectivity to dispersed users.[25]

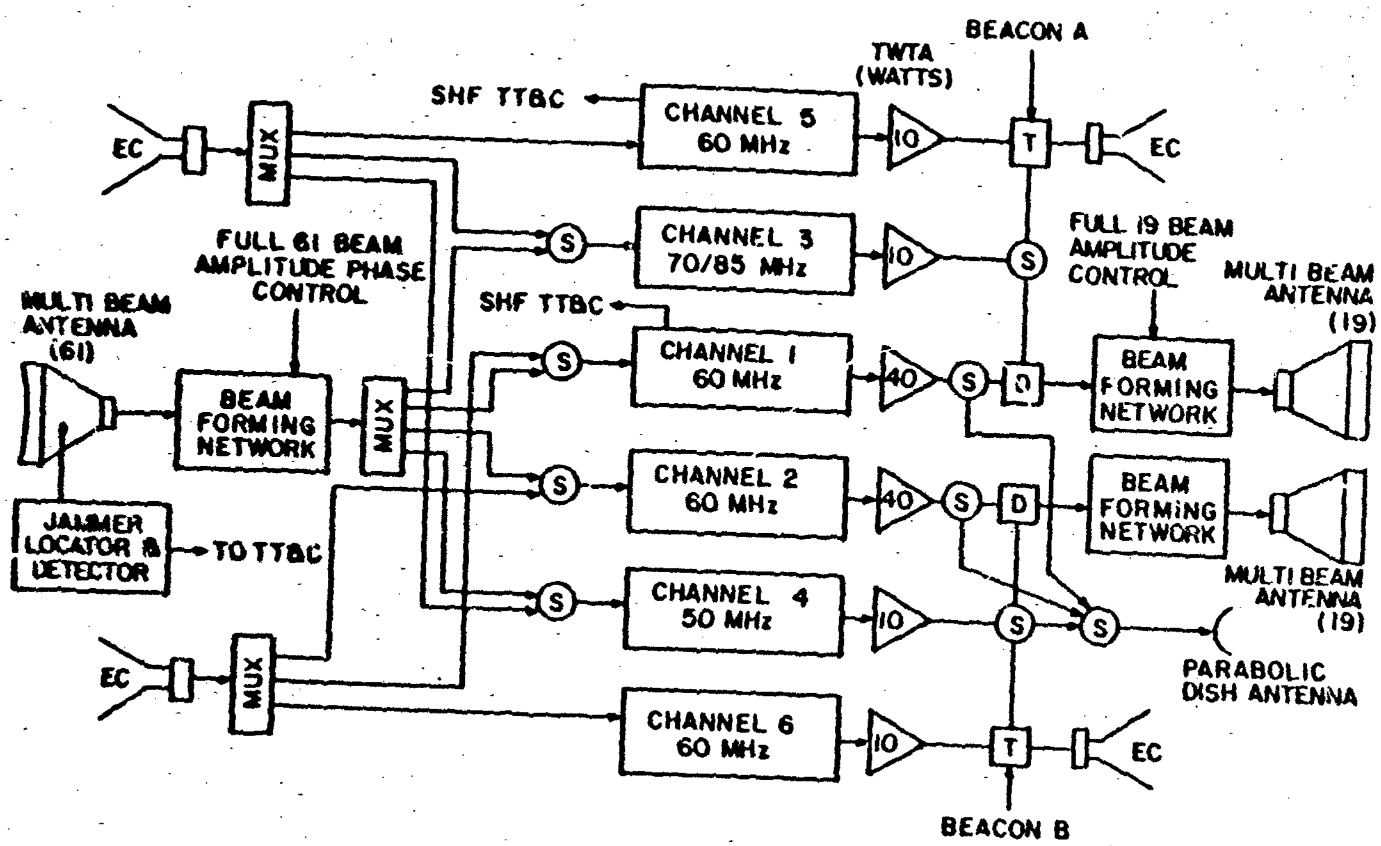

Figure 2-5. DSCS-III Block Diagram

FOOTNOTES

[1]United Nations Educational, Scientific and Cultural Organization, Communications in the Space Age, (Amsterdam: N. V. De Arbeiderspors, 1968), p. 11.

[2]D. H. Martin, Communication Satellites 1958 to 1980, (SAMSO Report, No. TR-77-76, 1977), p. 19.

[3]Ibid.

[4]George N. Krassner and Jackson V. Michales, Introduction to Space Communication Systems, (New York: McGraw-Hill, 1964), p. viii.

[5]Martin, op. cit., p. 19.

[6]Ibid.

[7]Ibid, p. 153.

[8]Ibid.

[9]Jon L. Boyes, "A Navy Satellite Communications System," Signal, 30:6:8, March, 1976.

[10]John M. Kuhn, "Operational Considerations for Tactical Satellite Communications Systems," Signal, 30:6:29, March, 1976.

[11]Martin, op. cit., p. 159.

[12]Kuhn, op. cit.

[13]Jon L. Boyes, "Navy's Fleet Satellite and Gap-filler Satellite Communications Programs," Signal, 28:7:3-7, March, 1974.

[14]The MARISAT Joint Venture has as partners COMSAT General Corporation (86.29%), RCA Global Communications (8.0%), Western Union International, Inc. (3.41%), and ITT World Communications, Inc. (2.3%).

[15]Edward R. Slack, "Financial Aspects of Lease Vs. Purchase for Satellites," Conference Record 1978 International Conference on Communications, IEEE, II (Oshawa, Canada: Alger Press Limited, 1978), 18.1.1-18.1.5.

[16]Ibid.

[17]National Aeronautics and Space Administration, NASA Reports, April, 1978, Vol. 9, No. 4 (Washington: Government Printing Office, 1978), p. 5.

[18]Statements by Lt. Col. Hoernig, USAF and Mr. Sherwin, MILSATCOM System Office, during telephone conversations February 21 and April 5, 1979.

[19]Lee M. Paschall, "The Air Force Satellite Communications System," Signal, 28:7:1, March, 1974.

[20]Fred M. Knipp and Joseph A. Buegler, "Military Satellite Communications Terminals," Signal, 30:6:16, March, 1976.

[21]Martin, op. cit., p. 171.

[22]W. J. Ciesluk et. al., "Review of Air Force Ground Mobile Forces (GMF) SHF Satellite Terminal Program," (MITRE Technical Report No. MTR-3457, July, 1977), p. 103.

[23]Martin, op. cit., p. 197.

[24]Ciesluk, op. cit.

[25]Ibid: Martin, op. cit.

Chapter 3

GROUND MOBILE FORCES SATELLITE COMMUNICATIONS (GMFSC) PROGRAM

This chapter discusses the need for the GMFSC program, a brief historical perspective of GMFSC, the components of the GMFSC program, and the GMFSC SHF program. Chapter one briefly covered the reasons for a proliferation of satellite communication since the early sixties, and the military advantages of satellite communications; however, to fully appreciate the GMFSC SHF program, knowledge of the specific needs of the GMF is essential.

GMF Needs for a SATCOM Program

The deficiencies of the present terrestrial communication systems, e.g., High Frequency/Single Side Band (HF/SSB), Cable, Line-of-Sight (LOS), and Tropospheric scatter (Tropo), available to the GMF generally fall under six categories: terrain or distance limitations, lengthy set-up and tear-down times, limited mobility, extensive logistical support requirements, requirements for physical security support, and limited reliability due to inherent propagation problems.[1]

Without the use of relays, LOS microwave systems are distance or terrain limited. Stringent sitting and path profiles are necessary, which impends on the rapid installation and reconfiguration of LOS microwave communication facilities. Physical security must be provided for antenna and any relay sites.[2]

Tropo systems have several disadvantages that limit their employment. Sitting and path profile restrictions are more critical than for LOS, requiring extensive preplanning and engineering, thereby limiting Tropo systems' usefulness in a rapidly changing tactical situation. Tropo employment is often restricted to rear areas or when a stable battlefield situation has been achieved.[3]

HF/SSB is also limited by a set of deficiencies; inherently low capacity, high power requirements with large, ungainly antenna arrays, overcrowded spectrum, and subject to degradation due to propagation anomalies.[4] Extensive use of cable can also have several disadvantages: weight and bulk of a large volume of cable reels, the requirement for terrain in which cable is laid to be friendly, and physical security required to maintain cable system integrity.

A GMFSC program offers several inherent communications system improvements to the GMF over the present terrestrial systems discussed above. Satellite systems are relatively free from sitting restrictions, are capable of extended range without terrestrial relays, and enjoy decreased set-up and tear-down times thereby increasing mobility.[5] Additionally, they are more flexible and interchangeable because all system nodes work off of one satellite transponder. If one node fails reroute, efforts are significantly easier than terrestrial systems. Satellite systems also require less logistic support due to their smaller size, operating without relays and flexibility. Because relays are not required, physical security requirements are also reduced.

A small word of caution is necessary at this point. The GMFSC program should not be viewed as the panacea for all crisis or battlefield communication problems. Satellite systems are vunerable to several existing and potential threats, e.g., jamming, and antisatellite interceptors (ASAT).[6] Additionally, management and availability of satellite transponder downlink power and bandwidth, as discussed more fully in chapters four and five, can have serious limiting effects on satellite systems capability.

Although satellite communications can serve as an initial link between an on-site commander and the NCA or a "backbone" system in a battlefield situation, the above limitations preclude a rational decision to exclusively develop satellite communication systems at the expense of terrestrial systems. The high degree of complexity required by the NCA to adequately control military forces to accomplish national political objectives requires a C^3 system with an uncomprimising degree of reliability, speed, and capacity. To accomplish this high degree of C^3 system performance, the communication system must possess adequate flexibility and backup. Thus, satellite and terrestrial systems, while each possessing unique capabilities and limitations, must be integrated in a manner that provides a synergistic C^3 system. Thus, for the above and other reasons beyond the scope of this thesis, the GMFSC program must be viewed as an essential part of a whole in the ongoing effort to improve crisis and battlefield management through updated C^3 systems that serve as "key force multipliers."

History of GMFSC Program

Synergistic philosophy was apparent in the request by the Deputy Secretary of Defense in 1965 for a tri-service effort to develop a joint program of land, sea, and airborne satellite terminals for operation in the UHF and SHF frequency bands. As a result, a joint Army, Navy, Marine Corps, and Air Force program directed by the Tactical Satellite Communications Executive Steering Group (TSEG) developed a family of UHF land, sea, and airborne terminals.[7] Later, the increasingly crowded conditions on the UHF band, and the need for multichannel and single-channel GMFSC identified by the Army's Integrated Tactical Communications System (INTACS) Study, led to the establishment of the GMFSC program.[8] The goal of the GMFSC program is the development of a family of satellite communication systems that will complement the existing and planned repertory of terrestrial GMF C^3 systems.

In January of 1978, the program was finally approved by the Army System Acquisition Review Council (ASARC). Specific responsibility for the GMFSC program implementation was officially assigned to the U.S. Army Satellite Communications Agency (SATCOMA), Fort Monmouth, N.J.[9] The GMFSC program includes both SHF and UHF terminal acquisitions which are discussed in greater depth below.

In December of 1972, RCA Corporation's Government Systems Division was awarded a contract for development of a new family of small tactical and strategic SHF satellite ground terminals by the SATCOMA project officer. After successful completion of the engineering development phase in 1976, RCA was given a contract for Low Rate Initial Production (LRIP).[10] A Full Production contract award will be made in 1979.[11] Sunk cost associated with the GMFSC program now totals approximately $91.0 million.[12]

Component Systems of the GMFSC Program

Complexities of operational control of the DSCS SHF space segment to be used by the GMFSC system are best appreciated if they can be related to the overall GMFSC program. Therefore, a capsule outline of the six component systems of the GMFSC program is provided to facilitate examination of the operational control of the SHF space segment. The intent of the GMFSC program is to procure six systems of ground terminals for operation with available and projected satellites. The six systems are: Multichannel SHF Initial System, Multichannel SHF Objective System, Single-channel UHF Manpack System, Single-channel UHF Nuclear Weapons Storage (NWS) System, Single-channel UHF Demand Assigned Multiple Access (DAMA) System, and the Single-channel SHF DAMA System.[13]

Multichannel SHF Initial System

The Multichannel SHF Initial System will ultimately include a total of 350 Army, Air Force, and Marine Corps terminals. The terminals are intended to replace selected terrestrial LOS and Tropo systems during the 1978 to 1984 time frame. The Multichannel SHF Initial System will utilize the DSCS II and III space systems.[14]

Multichannel SHF Objective System

The Multichannel SHF Objective System will have three to four times the capability of the above initial system by using DAMA techniques. Approximately 220 multichannel objective system terminals will be produced for the Army beginning in 1988. Air Force and Marine Corps requirements are not presently stated. The objective system will augment and replace selected parts of the initial system. It will utilize the same space segment as the initial system.[15]

Single-channel UHF NWS System

The Single-channel UHF NWS System will consist of approximately 220 terminals with delivery beginning in 1980. The system is designed to provide rapid and reliable communications for NWS sites. The space segment utilized will be the AFSATCOM, then LeaSat in 1985.[16]

Single-channel UHF Manpack System

The Single-channel UHF Manpack System will include 480 portable manpack terminals and net control stations to be developed during the 1980 to 1984 time frame. The Army's long-range patrols, forward operating units, and special forces intend to utilize the manpack terminals for a communications link between soldiers in battle. The terminals will also be employed by Marine Corps reconnaissance units and Air Force tactical operations units.[17] The GapSat, AFSATCOM, FLTSAT, and other future UHF satellites, e.g., LeaSat, will be used.[18]

Cincinnati-Electronics has an AN/PSC-1 "Manpack Transceiver" (see Figure 3-1 below) in the final stages of development and government operational testing by SATCOMA. Table 3-1 below includes technical specifications of the AN/PSC-1.[19]

Figure 3-1. AN/PSC-1 Manpack Transceiver

TABLE 3-1

AN/PSC-1 "MANPACK TRANSCEIVER" TECHNICAL SPECIFICATIONS

Antenna:	Collapsible helical and Whip for LOS
Power:	2-35 watts
Mode:	Voice or Digital Data LOS or Satellite Relay
Frequency Range:	225-400 MHz
Modulation:	BPSK/QPSK/CVSD

Single-channel UHF DAMA System

The Single-channel UHF DAMA program will comprise a total of 300 UHF DAMA terminals to be provided to the Army by 1981. The terminals will replace present low data rate radio teletype equipment and meet urgent requirements for command and control of nuclear fire units. The terminals will utilize the same space segment as the manpack terminals above.[20]

Single-channel SHF DAMA System

The Single-channel SHF DAMA System will be developed in the late 1980's to 1990's and will include 600 terminals supplied to the Army to replace critical circuits requiring high anti-jam capabilities. The space segment to be used is not stated at present.[21]

The above brief tabulation of the six systems of the GMFSC program serves to illustrate the complexities of providing adequate C^3 for tactical forces. As stated in chapter one, the purpose of this paper is to examine only one part of the GMFSC program, the SHF multichannel system. More specifically, only the operational control of the SHF multichannel space segment is explored in detail. Although there is, as discussed above, a single-channel SHF system, examination of that system is not included in the scope of this thesis. Therefore, the SHF multichannel system is referred to throughout this thesis as the GMFSC SHF system.

A more detailed listing and explanation of the ground terminals involved in the GMFSC SHF system, along with chapter two, is essential to a solid foundation for discussing the operational control of the DSCS SHF space segment.

GMFSC SHF System Ground Terminals

The distinction between the initial and objective SHF system ground terminals is not important to a survey of the mechanisms for interfacing the DSCS and the GMFSC SHF program. Nor does the fact that existing and planned SHF ground terminals have and will experience name, equipment, and capability changes impact significantly on the survey. Therefore, the following discussion on the present equipment provides a base point in the essential problem of providing integrated, responsive control of the SHF space segment.

The discussion on terminals is very brief and superficial by design (a complete discussion of each terminal would easily double the size of this thesis and provide little additional information germane to the hypothesis), however, the bibliography listings do contain detailed examinations of most of the SHF terminals existing or planned. And a review of these readings is essential to the serious student of the GMFSC SHF system.

Primarily, two designations of tactical (the classification of communication satellites as tactical or strategic is not to be confused with terminal classifications) satellite communication terminals are commonly found in the literature, large multipoint terminals (sometimes referred to as light transportable terminals), and medium multipoint terminals, also called small point-to-point terminals.[22] Additionally, the literature is replete with networking terminology or typology, e.g., nodal (multipoint), nonnodal (point-to-point), and internodal terminals, and hub-spoke and mesh networks.[23] Figure 3-2 below illustrates the concept of nodal and nonnodal terminals.

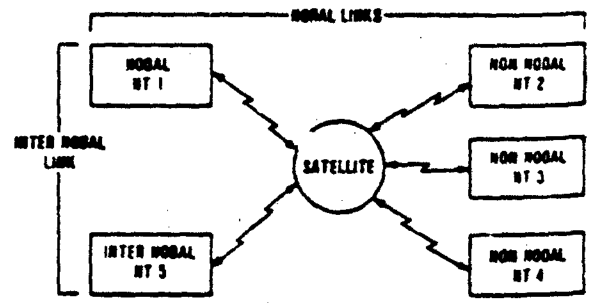

Figure 3-2. Multipoint Configuration
Nodal & Internodal

Nodal Terminal One (NT 1) is connected through the satellite to nonnodal terminals (NT 2, NT 3, NT 4) which are not connected to each other. NT 1 and NT 5 are connected through the satellite to each other. NT 5 is also connected through the satellite to another separate network, not illustrated on the figure, therefore, it is an internodal terminal. (Actually, NT 1 is also an internodal terminal and the link between NT 1 and NT 5 is an internodal link).[24]

A hub-spoke network would contain at least one nodal and two or more nonnodal terminals discussed above.

Figure 3-3 illustrates a hub-spoke network.[25] The hub or nodal terminal transmits a multiplexed signal (f_1) to all three spokes or nonnodal terminals. Each spoke terminal decombines f_1 selecting that portion destined for it. A separate signal (f_2, f_3, f_4) is transmitted by each spoke terminal to the hub terminal. The hub-spoke network is compatible with Army requirements for connectivity between higher and lower headquarters.

The Air Force requires more lateral connectivity using multipoint or nodal terminals as shown in Figure 3-4.[26] The mesh network offers increased flexibility and alternative routing. As indicated above, mesh and hub-spoke networks can be connected through an inter-nodal link. Because tactical systems are configured based on need using the concepts above, and much of the literature describes equipment capability in terms of network typology, a grasp of basic network terminology is essential to a complete understanding of GMFSC SHF terminals.

The brief description below of existing and planned terminals under the two general designations of SHF ground terminals and the special control terminal completes the compilation of background information necessary to conducting an audit of existing and contemplate space segment management systems.

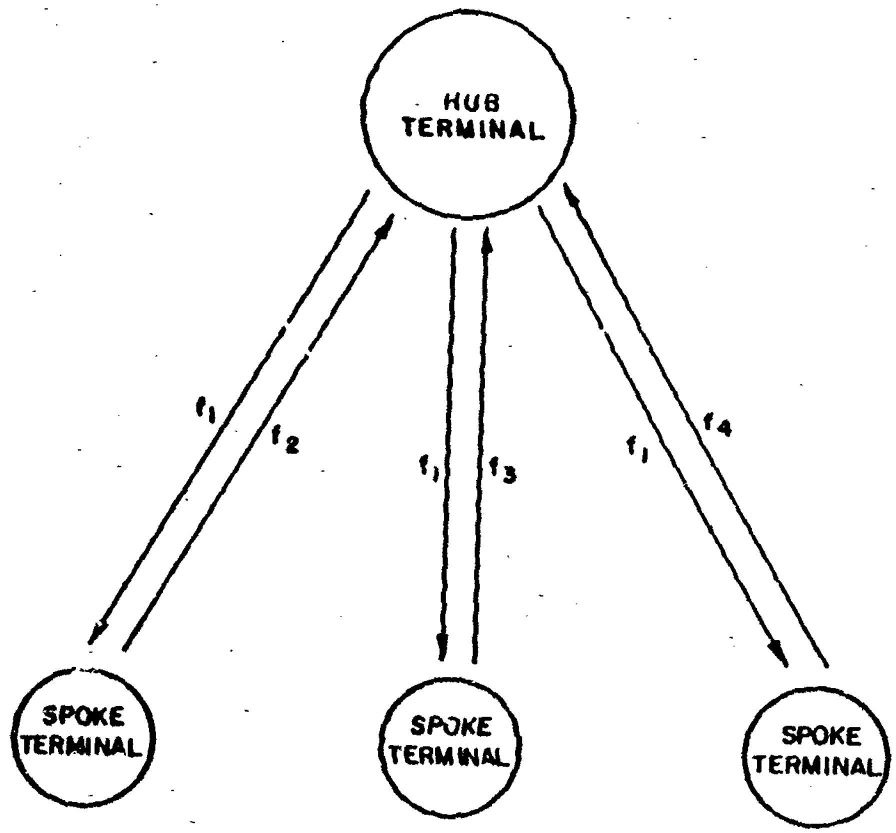

Figure 3-3. Hub-spoke Terminal Configuration

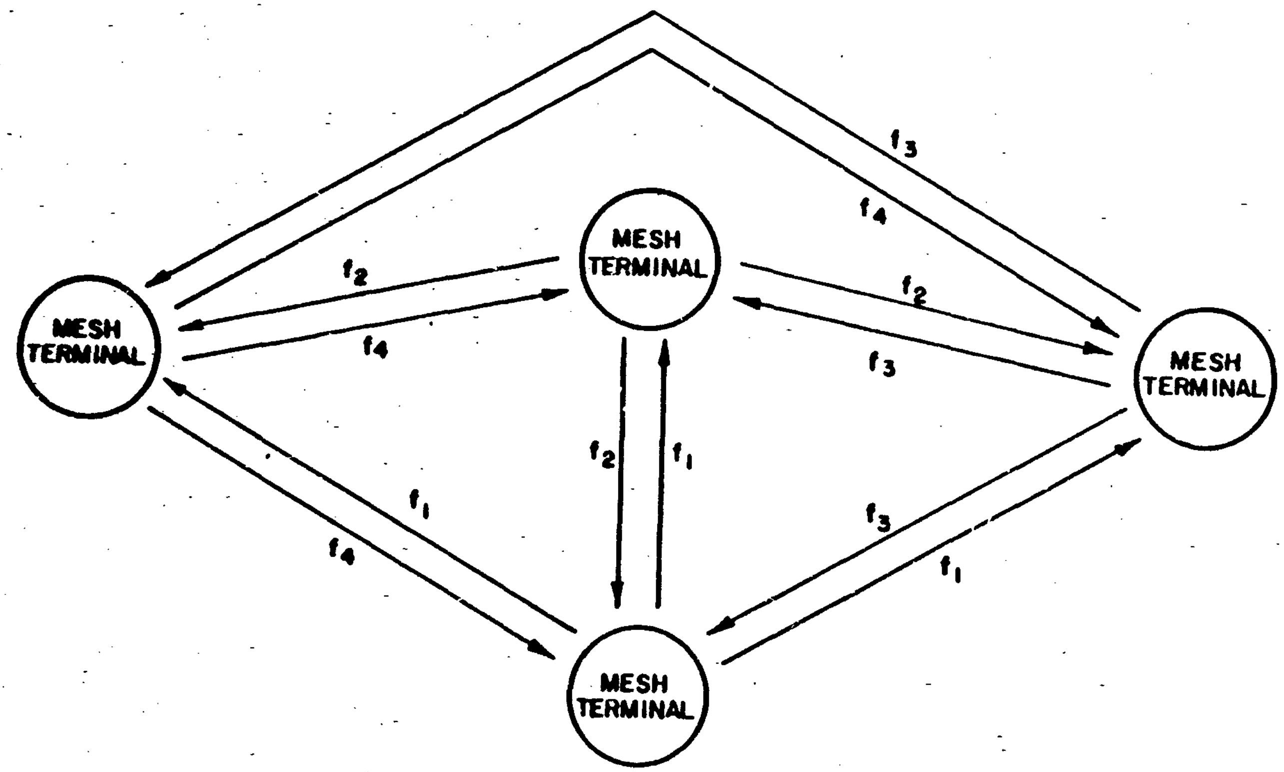

Figure 3-4. Mesh Terminal Configuration

Large Multipoint Terminal

The AN/TSC-86( ), "Light transportable terminal," is capable of single point-to-point operation using an 8-foot ground mounted antenna.[27] An alternate 20-foot high-gain antenna can be used for both transmit and receive of up to four independent carrier operations. It is intended for use as a tactical satellite communications terminal in satisfying contingency and quick-restoral requirements of strategic users in the DCS, diplomatic support missions, survivable network requirements, and special uses and intratheater trunking.[28] Figure 3-5 is a simplified AN/TSC-86 Radio Frequency (RF) section block diagram.[29]

Small GMF SHF Terminal Family

The family of small GMF SHF Terminals outwardly appear identical. The basic difference is attributable to the areas of subsystems redundancy, multipoint or nodal capability, and baseband multiplex equipment required, based on user applications of the separate military departments.[30] The three basic terminals are the AN/TSC-85(V)2, the only terminal capable of serving as the hub of a multipoint network, the AN/TSC-93 non-nodal terminal used by the Army, and the AN/TSC-94 configured for Air Force use. More varieties of terminals with at least some anti-jam capability are proposed.

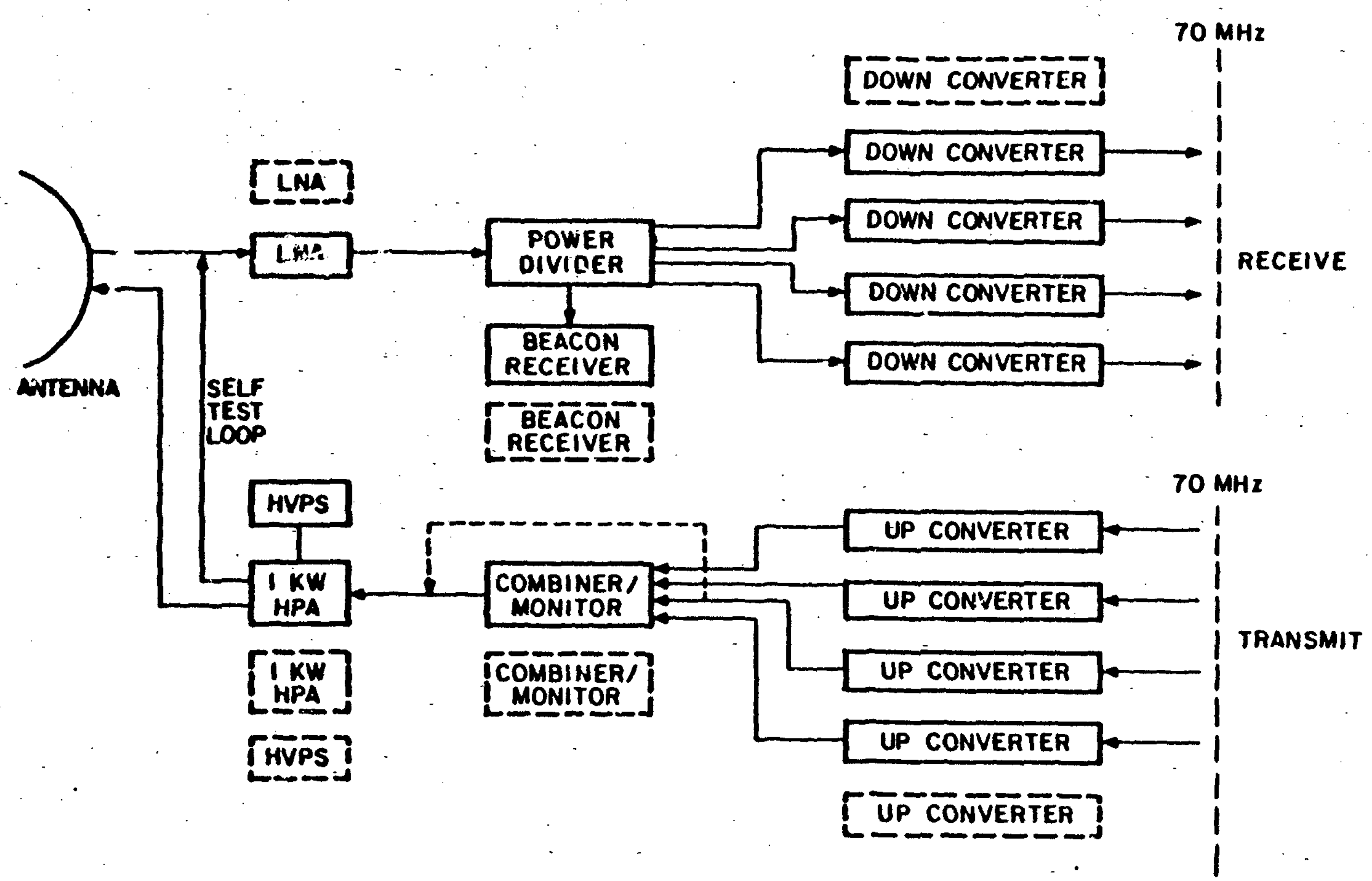

Figure 3-5. Simplified AN/TSC-86 RF Block Diagram

As mentioned earlier, the serious student should consult the Bibliography for more detailed information on the existing and planned terminals' technical characteristics and capabilities. Figure 3-6 and 3-7 are simplified block diagrams of the RF section of the AN/TSC-85 and AN/TSC-94.[31] The AN/TSC-93's RF section is similar to the AN/TSC-94 but with all of the equipment on line.

Satellite Communications Monitoring Center (SCMC)

The SCMC, nomenclatured the AN/TSQ-118,[32] serves as a centralized controller for the GMF SHF SATCOM system. The AN/TSQ-118 will include the following basic tools: automated spectrum analyzer, HP-2100 computer with peripherals, control orderwire system, and manual spectrum analyzer.[33] The AN/TSQ-118 plays a central role in the discussion of the DSCS and GMFSC SHF program interface discussed in chapter four.

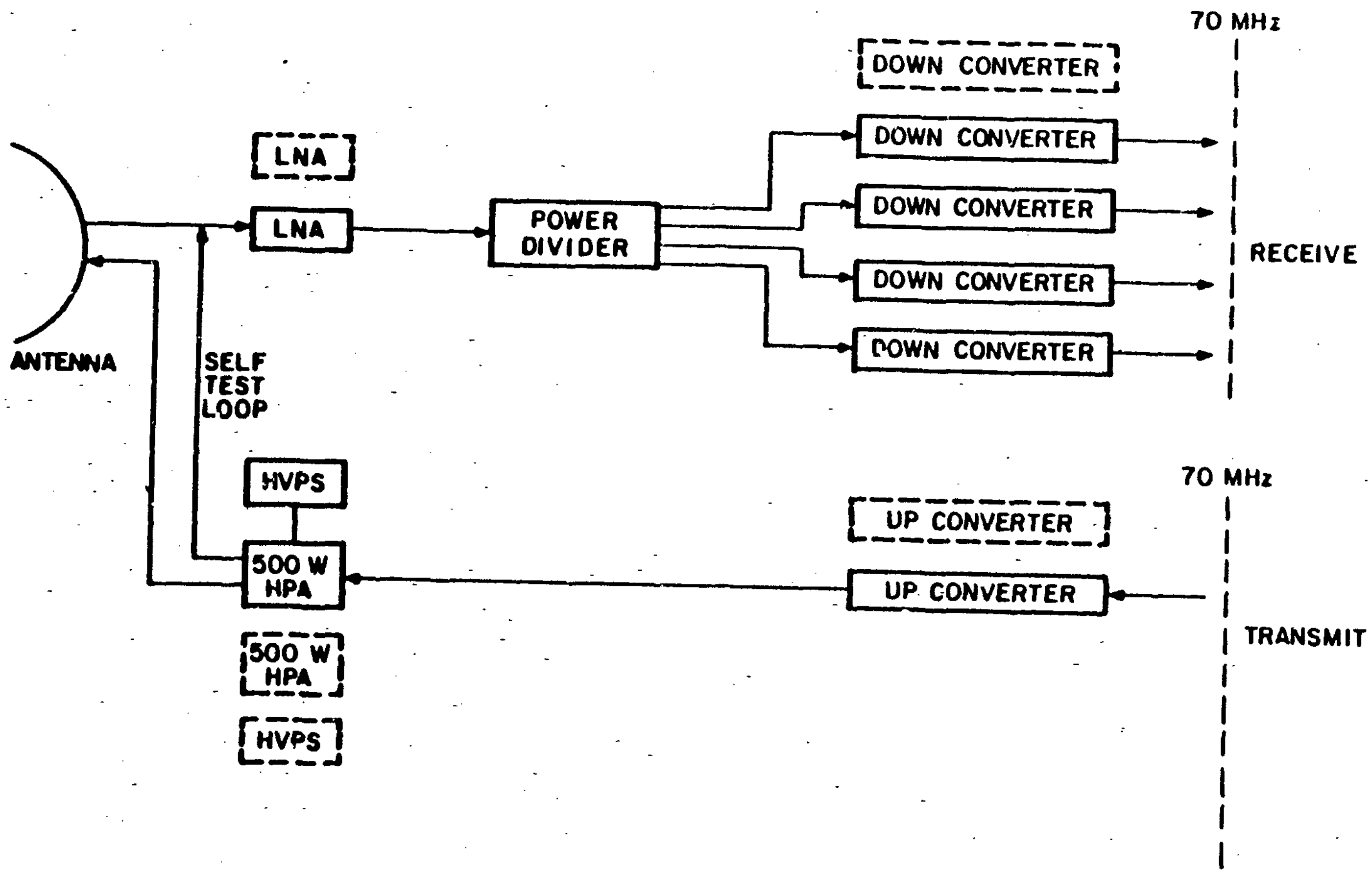

Figure 3-6. Simplified AN/TSC-85 RF Block Diagram

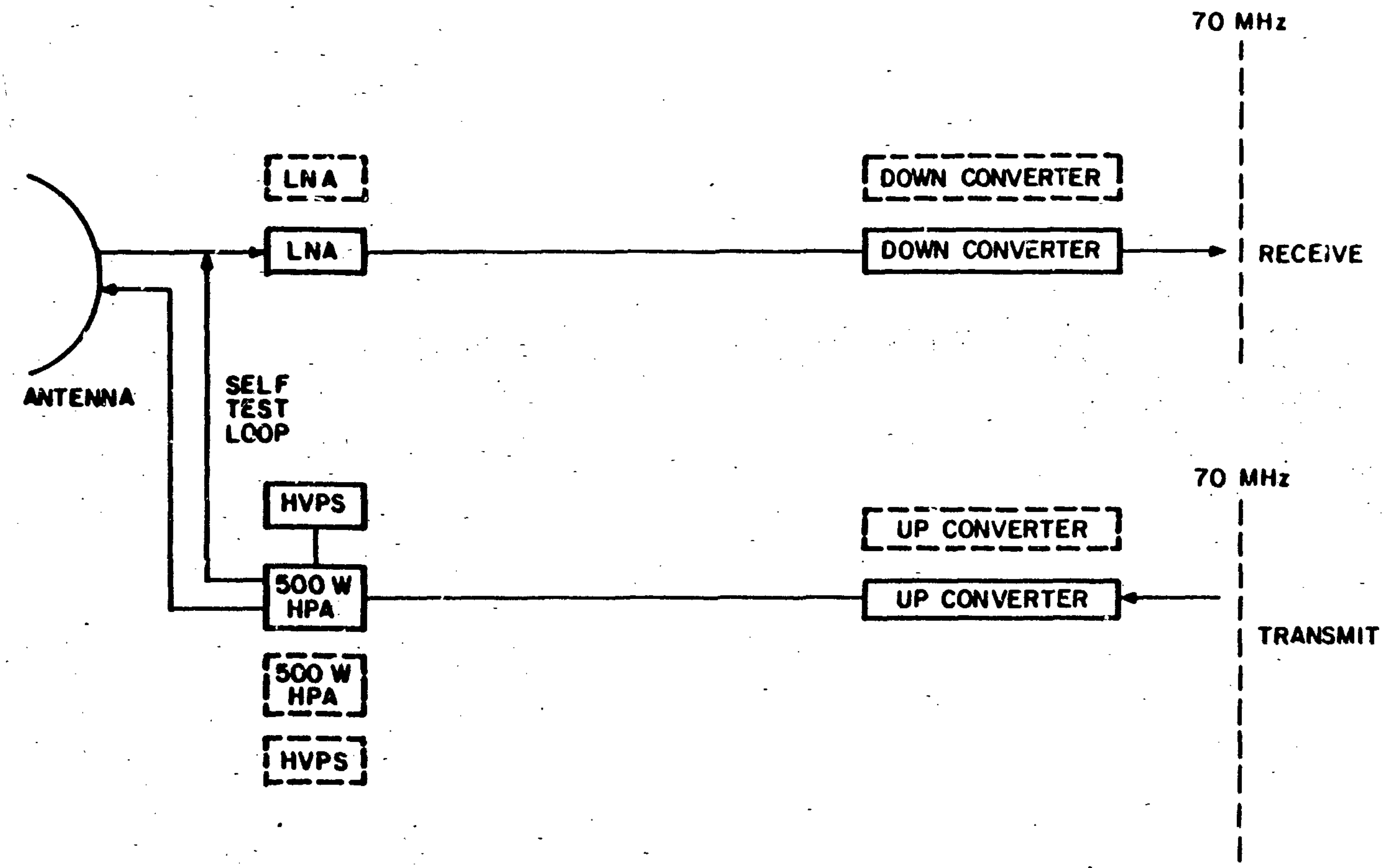

Figure 3-7. Simplified AN/TSC-94 RF Block Diagram

FOOTNOTES

[1] "Ground Mobile Forces Satellite Communications Program Memorandum," (Classified Confidential), U.S. Army Satellite Communications Agency, Fort Monmouth, New Jersey, January, 1978, p. I-3.

[2] Ibid.

[3] W. J. Ciesluk et. al., "Review of Air Force Ground Mobile Forces (GMF) SHF Satellite Terminal Program," (MITRE Technical Report No. MTR-3457, July, 1977), p. 2.

[4] Ibid.

[5] "Ground Mobile Forces Satellite Communications Program Memorandum," op. cit.

[6] "Our Satellites--How Vulnerable?," Air Force Magazine, 60:7:72, July, 1977.

[7] "Ground Mobile Forces Satellite Communications Program Memorandum," op. cit.

[8] Army Research, Development, and Acquisition Agency, Army Research, Development and Acquisition Magazine, July-August, 1978, Vol. 19, No. 4 (Washington: Government Printing Office, 1978), p. 18.

[9] Ibid.

[10] B. E. Tyree, J. Bailey, and V. Chewey, "Ground Mobile Forces Tactical Satellite SHF Ground Terminals," Conference Record of 1978 International Conference on Communications, IEEE, III (Oshawa, Canada: Alger Press Limited, 1978), 40.5.1.

[11] "Ground Mobile Forces Satellite Communications Program Memorandum," op. cit.

[12] Ibid.

[13] Ibid., pp. I-7-I-9.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18]Army Research, Development, and Acquisition Agency, *op. cit.*, p. 19.

[19]*Ibid.*

[20]"Ground Mobile Forces Satellite Communications Program Memorandum," *op. cit.*

[21]*Ibid.*

[22]Ciesluk, *op. cit.*, p. 6.

[23]*Ibid.*: Army Research, Development, and Acquisition Agency, *op. cit.* 18: Tyree, *op. cit.*

[24]Tyree, *op. cit.*

[25]Ciesluk, *op. cit.*, p. 8.

[26]*Ibid.*, p. 9.

[27]Statements by Captain Fred Thourot, U.S.A.F., Air Force Communication Service (AFCS) Headquarters/XPQS Office, during telephone conversation March 19, 1979, indicates that the AN/TSQ-86B will be renomenclatured the AN/TSC-100.

[28]Army Research, Development, and Acquisition Agency, *op. cit.*, p. 19.

[29]Ciesluk, *op. cit.*, p. 25.

[30]Army Research, Development, and Acquisition Agency, *op. cit.*, p. 18.

[31]Ciesluk, *op. cit.*, pp. 26-27.

[32]Same telephone conversation with Captain Thourot, the AN/TSQ-118 will be renomenclatured the AN/MSQ-114.

[33]"SHF Ground Mobile Forces Satellite Communications--Operating and Control Procedures, Book A: Control by a TSQ-118 (Unstressed Environment)," (Ford Aerospace and Communications Corporation, Procurement Division, Code W61-DEX, Contract Report DAEA 18-69-A-0038, Change 5, January, 1979), p. A3-1.

Chapter 4

INTEGRATION OF THE DSCS AND GMF COMMUNITY

Communication satellite technology has the potential to multiply the effectiveness of the GMF by providing improved C^3 capability. However, available technology must be managed in the most efficient manner. Thus, the purpose of this thesis is to examine the present system for exercising operational control of the DSCS space segment.

The management system examined is the system presently planned to be used in the post 1982 time frame. The basic issue is the interface of the DSCS and the GMF Community. Examination of this interface leads to the development of alternative actions, with varying potential for improving the operational control of the DSCS space segment assests available to the GMF.

To accomplish an audit of the interface between the DSCS and the GMF Community, the Military Satellite Communication (MILSATCOM) system control related to the GMFSC SHF program will be examined. The interface prior to 1982 is not expected to be elaborate due to limited GMFSC SHF terminal employment. Therefore, only that period after 1982 is examined in detail. The capacity issue must alsc be examined and recommendations for dealing with this limitation integrated into any action undertaken to improve the management of communication satellite technology available to the GMF.

MILSATCOM System Control

Exactly what is MILSATCOM system control? MILSATCOM system control, as defined by the MILSATCOM Systems Office in DOD Directive 5105.44,[1] embodies the concept of different control functions being accomplished by different levels of command. Control functions include:

1. Operational Control: Control exercised to determine the location of satellites and earth terminals, and parameters of earth station operations, e.g., allocation of satellite power, bandwidth, access time, and operating frequencies.

2. Satellite Communications Control: Control exercised to ensure that earth stations operate within assigned parameters and procedures.

3. Satellite Control: The control of satellite components or subsystems, including orbital control and switching of subsystems or components.[2]

MILSATCOM system control can also be defined in terms of the mission it supports. "The use of the word 'mission' rather than 'capability' or 'functions' is intentional."[3] "Mission" stresses the military nature of MILSATCOM system control. The following set of missions is used by Ronald P. Sherwin in "Management and Control of Military Satellite Communications Systems," which appeared in volume two of the Conference Record: 1978 International Conference on Communications:

Mission 1: Management Control. The means for providing long-term system management and planning by a cognizant executive agent.

Mission 2: Communication Control. The means for maximizing the communications capability (capacity) available to the individual user and user networks.

Mission 3: Operational Control. The means for allocating operational assets, e.g., satellites, and earth terminals, to meet user requirements, including day-by-day resource apportionment and user discipline and conflict resolution.[4]

For the purpose of this thesis, Mr. Sherwin's Mission two should have added to it the concept of controlling user capacity request based on scenario dictates. The control of request for capacity necessarily rests with the user. The need for capability to exercise control over capacity request and its resulting impact on the effective management of communication satellite technology is discussed in greater detail below.

Control function definition one, and missions two and three are the essential embodiment of "operational control of the DSCS space segment" as used throughout this thesis. With the above as a guide, it is now possible to investigate the architecture for exercising operational control of the DSCS space segment in the post 1982 time frame. In order to adequately discuss MILSATCOM related to the GMFSC SHF program, it is necessary to divide the examination into two parts: DSCS SHF SATCOM Control and GMFSC SHF Operational Control.[5]

DSCS SHF SATCOM Control

This section addresses the relationship of the DSCS to the DCS, and the inter-relationship of the DSCS to users and Special Users subnets, e.g., North Atlantic Treaty Organization (NATO), GMF, the United Kingdom (UK), and Diplomatic Telecommunications Service (DTS); see Figure 4-1.

Satellite communication networks normally provide transmission media for interswitched or point-to-point, user networks. Therefore, the control system for a single user network must be closely integrated into the control structure for the overall SATCOM network. Thus, the relationship between the DSCS, the DCS, and Special Users networks must be integrated to provide the best overall C^3 system and subsystem available to each user.

Operational control of the DSCS is accomplished through the Defense Communications System Operations Control Complex (DOCC). DOCC is the mechanism through which operational control of the total DCS network is accomplished. DSCS control is segmented into: DCS

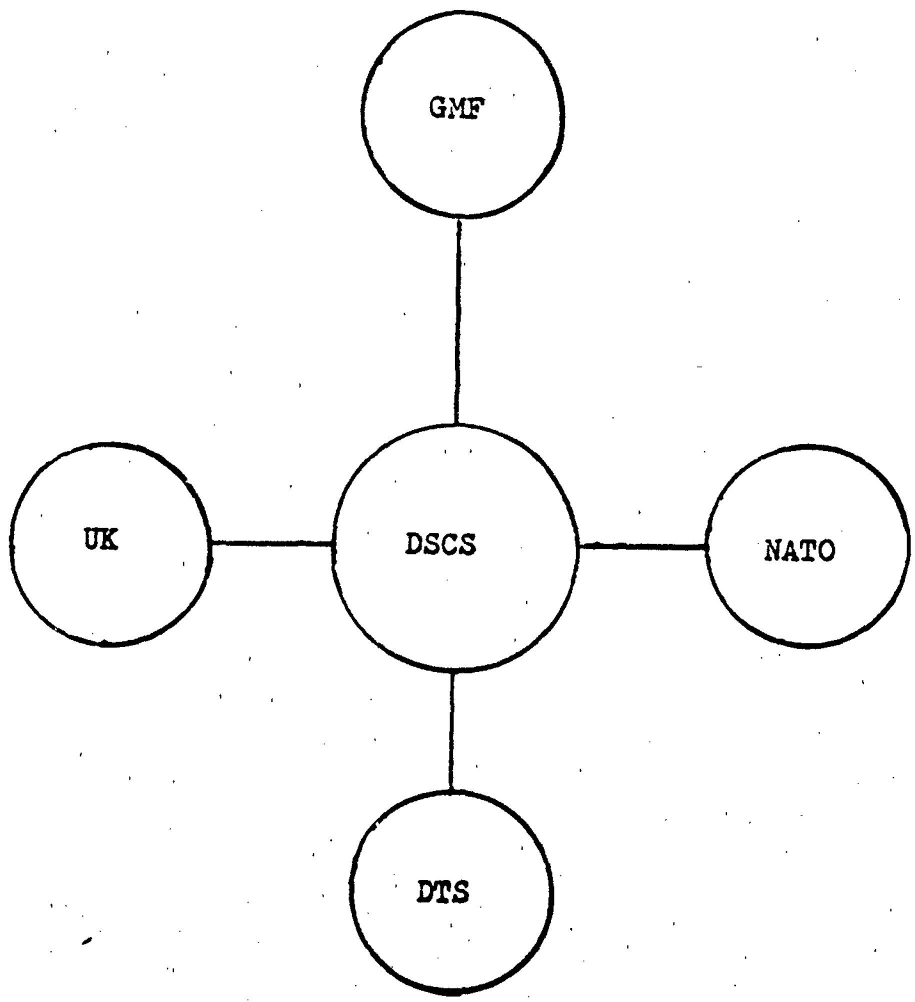

Figure 4-1. DSCS Special Users

technical control, satellite control, and SATCOM network control. DCS technical control is presently performed by DSCS related technical control facilities (TCF). The primary function of these TCF is the interface of DSCS users and the remainder of the DCS. Present plans are to include these TCF as part of the upgrade of DCS System Control (SYCON) using Automated Technical Control (ATEC) equipment which began LRIP in 1978.[6]

Satellite control functions are presently performed by the Air Force Satellite Control Facility (AFSCF) under the direction of the Defense Communication Agency (DCA). This largely manual system will be replaced by an automatic system which is part of the planned upgrade of the DSCS; the Real-Time Adaptive Control (RTAC) program. The RTAC program will transfer direct control of satellite telemetry and command support functions to the DCA. SATCOM network control activities will also become more fully automated under the RTAC program.[7]

Through elements of the DOCC, DCA exercises SATCOM network control over power and frequency usage of DSCS space segment assets. DCA authorizes, monitors, and coordinates access for all users of DSCS, including Special User subnets. Figure 4-2 illustrates the relationships within the DOCC germane to DSCS space segment allocation.

The DCS operates as directed by the Joint Chief of Staffs (JCS) in carrying out military missions and

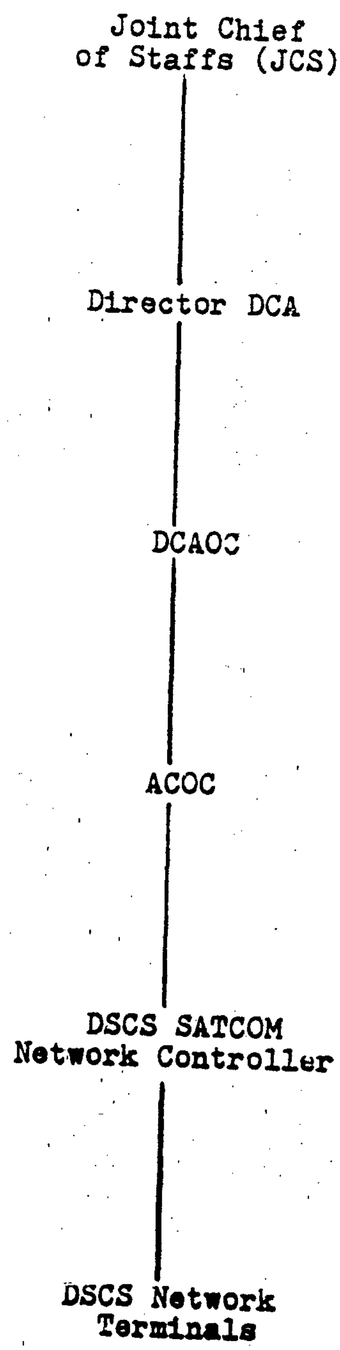

Figure 4-2. DOCC Relationships

operations. The highest level of satellite communications management in the DOCC is the DCA Operations Center (DCAOC) located at DCA Headquarters. The DCAOC is the sole interface with the AFSCF concerning satellite control functions. RTAC will eliminate AFSCF involvement in DSCS.

The DCAOC has direct communications with the National Military Command Center, the AFSCF, and DCA Area Communications Operations Centers (ACOC).

The DCAOC responsibilities with regard to the DSCS include: overall executive level management of the space subsystem; focal point for all matters related to earth subsystem milestones, link requirements, and initial link establishment parameters; and managerial control over the DSCS control subsystem. Specific functions in relation to the GMF consist of monitoring, evaluating, and coordinating of DSCS Special User requirements and control subsystem procedures.

The ACOC is the next lower level of operational control within the DOCC, and serves as the focal point for SATCOM Network Control. The ACOC is responsible for control and management of all earth terminal accesses to a DSCS satellite. This responsibility is shouldered by the SATCOM Network Controller.

The SATCOM Network Controller is collocated with other DCS Network Controllers at each ACOC in order to ensure "orderly integration"[8] of the DSCS into the DCS.

The SATCOM Network Controller responds to all DCAOC directions related to the DSCS network and controls network operations on a near real-time basis. The DCAOC, in turn, serves as the interface between the SATCOM Network Controller and the AFSCF for maintaining satellite status. Each area SATCOM Network Controller is responsible for operational direction of earth terminals, including Special Users, operating through the satellite in his area.

At the fourth level of control, reporting directly to SATCOM Network Controller, are individual DSCS earth terminals and Special User Network Control Terminals (NCT). NCT maintain control over their network ensuring all terminals within their subgroup operate within established power and frequency allocations.

It is this connection between the SATCOM Network Controller and NCT where the majority of DSCS and GMFSC SHF program interface takes place. To fully examine this and other important interfaces between the DSCS and GMFSC SHF program, the GMF Satellite Communications Control System (GMF-SCCS) must be explored.

GMFSC SHF Operational Control

The planned GMF-SCCS is, in itself, an integration of GMFSC and Joint Tactical Communications (TRI-TAC) Program control hierarchy. The TRI-TAC Program is a jointly staffed DOD organization which was established in 1971 by the Deputy Secretary of Defense as a result of the Blue Ribbon Defense Panel Report published in July, 1970. Under the concept of management recommended by the Panel, TRI-TAC is concerned with four areas: interoperability, communications commonality, centralized management of telecommunications, and cost.[9] TRI-TAC has designed a control equipment architecture known as Tactical Communications Control Facilities (TCCF) for joint tactical communications in the post 1982 period. The TCCF functions as an automated information management and control system for the Joint Task Force (JTF) Commander-in-Chief/Commander (CINC/CDR) in joint military operations. The hierarchical levels of management and control have specific functions, responsibilities, and authorities. Component systems, e.g., individual systems of the Air Force, Army, or Marine, and joint systems, i.e., systems composed of individual component subsystems designed to fulfill JTF needs, are subdivided, for span of control purposes, with each subdivision managed by a specified level of TCCF. The levels of TCCF are as follows: Communication System Planning Element (CSPE), Communication System Control Element (CSCE), Communications Nodal Control Element (CNCE), and Communications Equipment Support Element (CESE).

The CSPE is primarily responsible for achieving optimum allocation of communication resources in meeting tactical communication requirements. It is that level within any hierarchical structure of management and control that accomplishes broad systems planning, engineering, and overall systems management. It serves as the focal point for all coordination effort between JTF components and outside agencies while maintaining continuity between communications support capabilities and operational requirements. The CSPE, because it is the highest level of management and control, designates areas of responsibility, and extent of control.

The CSCE is responsible for dynamic control of large subdivisions of the total communication system. It is subordinate to the CSPE. With the assistance of automation, the CSCE provides real or near real-time management to maintain optimum system effectiveness. The CSCE, at the direction of the CSPE, carries out the day-to-day planning, engineering, and control functions of the communications system. It is to the CSCE that most user requirements in both a static and changing tactical environment are addressed. The CSCE provides the necessary coordination and direction to meet user requirements in a timely manner through its information input and output links with its designated CSPE, other CSCE's, and subordinate CNCE's and CESE's.

It is important to note that it is at this level, the theater CSCE, that the GMF-SCCS manager functions. The GMF-SCCS and its integration into the TCCF is described in greater detail below.

CNCE's are subordinate to their designated CSCE. CNCE's function as nodal managers, and are the interface point between the transmission and switching subsystems. Each CNCE exercises management and technical control over its associated subordinate activities; coordinating with other CNCE's.

Each CESE is responsible only for that equipment and circuitry peculiar to itself. The CESE responds to all management and control functions initiated by the CNCE that pertain to transmission subsystems. The CESE has self-test and remote sensor equipment, and is primarily maintenance oriented.

The integration of the GMF-SCCS and TCCF can best be visualized with the aid of Figure 4-3.[10] The DCA ACOC relationship to the TCCF and GMF-SCCS is depicted for continuity and is discussed in the next section.

The GMF-SCCS, under the direction of the TCCF, controls the GMFSC. The GMF-SCCS is composed of: a management level containing a GMF-SCCS manager, a Control Facility level, and a Network Terminal (NT) level. The GMF-SCCS provides technical management and control of allocated bandwidth and power in support of the Theater JTF CINC/CDR.

The GMF-SCCS manager is an integral part of the Theater CSCE staff and assists the Theater CSCE in

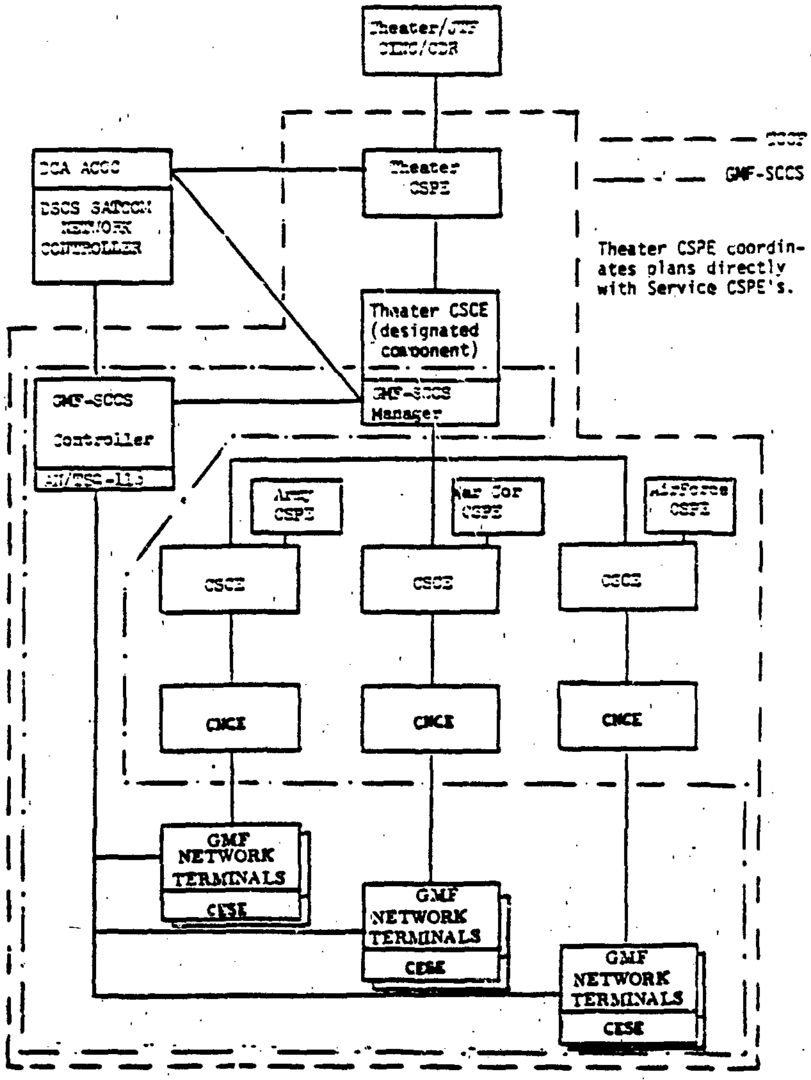

Figure 4-3. JTF TCCF And GMF-SCCS

managing satellite communications. The GMF-SCCS manager is the essential interface in the information input and output link between the Theater JTF CINC/CDR and the GMFSC system in supporting user communication requirements with satellite communications.

At the heart of the GMF-SCCS is the GMF Control Facility which contains a GMF-SCCS controller and a Satellite Communications Monitoring Center (SCMC), AN/TSQ-118. The SCMC allows near real-time control of GMF NT's. The GMF-SCCS controller operates the GMF Control Facility.

GMF NT's are the actual satellite terminals as discussed in chapter three. They are under the operational control of the GMF-SCCS controller in all matters related to allocated bandwidth and power, or space segment access.

Interface of the DSCS and GMFSC

The GMF, as depicted in Figure 4-1, is a Special User of the DSCS Network. Therefore, the GMF-SCCS controller has a real-time direction and coordination interface with the DSCS SATCOM Network Controller (Figures 4-2 and 4-3). The DSCS SATCOM Network Controller, as part of the ACOC, has DCA area authority for the DSCS.

Problems, e.g., the need to increase GMFSC authorized satellite power or bandwidth, which cannot be resolved at the lowest Theater JTF and DCS interface, i.e., the GMF-SCCS controller and DSCS SATCOM Network Controller, is referred up the hierarchical level (see Figure 4-4). If the problem cannot be resolved at the ACOC and Theater CSPE level, the CSPE refers the problem through the CINC/CDR to the JCS for resolution.

Evaluation of the DSCS and GMFSC Interface

The preceeding discussion is sufficient to begin an analysis of the presently planned system for integrating the DSCS and GMF Community after 1982. All of the available literature and documents from which the above examination of the planned system was based, amply describe the interface of the two systems in terms of "mechanistic" organizational chain of command or authority relationships. The Ford Aerospace and Communications Corporation's volumes on operating and control procedure provide a complete documentation flow for accomplishing allocation of space segment resources from the DSCS down to the GMF NT's.

Excellent work has been done by many different individuals and agencies within the DOD and contractors. However, the evidence suggests that the present system designers overlooked the "humanistic" element involved in any organizational interface.

Organization and Management theory provides insight into the humanistic element and its role in organizational

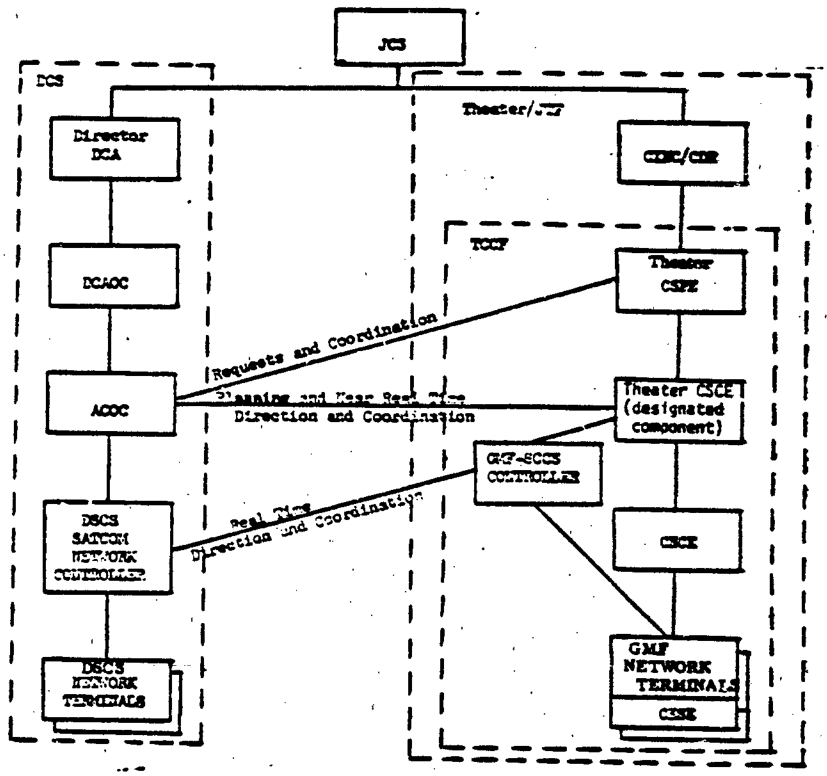

Figure 4-4. GMF/DCS Functional Interfaces

interfaces. The model developed by Lawrence and Lorsch in their book, Developing Organizations: Diagnosis and Action, examines organizations at three levels of interface: organization-environment interface, the group-to-group interface, and the individual and organizational interface. The model suggests organizations should be designed with differentiation and integration in balance to meet the needs for coordination and interaction involved in efforts to accomplish task or goals.

The prime interface of interest in the GMFSC and DSCS relationship is the group-to-group interface. If both the GMFSC SHF program and the DSCS are viewed as part of a much larger system providing C^3 to the NCA, this relationship becomes more apparent. The humanistic element is still a very valid concern at the group-to-group interface as expressed by most organizational and management theory.

The key ingredients in most definitions of organizations are individuals and their interactions which are shaped by structure and individual and joint goals.[11] Generally, all organizational and management theory from the Traditional, e.g., Taylor's Scientific Management, Max Weber's Bureaucratic model, and Henry Fayol's Administrative management theory, to General Systems theory attribute some value to the human element. Admittedly, the Traditional school held a rather pessimistic view of man, and the General Systems theory is not as "humanistic" as the Behavioral theories. However, General Systems theory's definition of open systems, as being composed of components or subsystems operating within boundaries which delineates them from some broader suprasystem, has at its core, understanding of human envolvement in organizational interfaces. The smallest subsystem is two individuals interacting for goal or task accomplishment.[12]

It, then, is not unreasonable to analyze the interface between the GMFSC SHF program and the DSCS as individuals interacting with perceptions shaped by different mechanistic organizational structures and tasks or missions. Attempting to understand the critical interface points in this manner provides valuable insight into the need for possible alternatives which can help improve operational control of the limited DSCS space segment available for use by the GMF.

Differentiation, as defined by Lawrence and Lorsch, between groups results from the "internal characteristics each group must develop to carry out planned transactions with its assigned part of the environment."[13] Differentiation based upon desired goals and the need for interaction with the outside environment at times is not just minor variations in outlook, but can involve "fundamental ways of thinking and behaving."[14]

Evidence indicates that there is significant differentiation between the DSCS and the GMFSC SHF program. DSCS is a subsystem within a larger suprasystem, DCS, with a primary mission of managing the JCS's predominately fixed world-wide communications network. DSCS, therefore, has the orientation of a "fixed" communication system manager. Classical definitions of military communications requirements for speed, reliability, and capacity are important parameters of performance accepted by the "fixed" communications community. The "tactical" communication system manager, however, must also be highly concerned with requirements for mobility, economy of resources, and flexibility in meeting changing battlefield dictates.[15]

Differentiation is also apparent from the definition of the GMFSC as a Special User of the DSCS. Each Special User has unique satellite communications needs. The GMF's unique need is for satellite communications in support of a Theater JTF in a tactical situation. Thus, the GMFSC manager's task is to provide "tactical" communications for the CINC/CDR.

Differentiation is further evidenced by the distinction as either DCS quality or Tactical quality of communications.[16] This distinction in communication quality reflects the different interpretation and weighting of the same basic philosophical concepts or parameters, e.g., speed, reliability, capacity, mobility, economy of resources, and flexibility, of military communication systems by "fixed" and "tactical" system managers. Thus, differentiation between the GMFSC community and the DSCS can be attributed to different perceptions and task or missions resulting from either a "fixed" or "tactical" communication system orientation.

The result of this differentiation between the GMFSC community and the DSCS is a polarization of individual attitudes and expectations within each group. The stress of operating in a crisis or contingency environment coupled with the real possibility of interface points being physically several thousand miles apart can accent this polarization leading to a breakdown in crucial information flow at critical interface points. Therefore, a means of facilitating integration by minimizing the effects of differentiation on individuals involved at critical interface points between the GMF-SCCS and the DSCS can help improve operational control of DSCS assets available for use by the GMFSC SHF program.

Concern must be directed to two aspects of the integration issue: which units or subgroups are required to work together and how much interdependence is required. In the operational integration of the DSCS and GMFSC SHF program, the main interface is between the GMF-SCCS and the ACOC with the key individuals being the DSCS SATCOM Network Controller and the GMF-SCCS Controller. There is a need for strong interdependence between the two groups. Both must work closely together because of shared interest in maintaining control over the DSCS space segment allocations available to the GMF. However, motivations are different. The DSCS SATCOM Network Controller is concerned with maintaining total DSCS integrity in his area, while the GMF-SCCS is interested in maintaining control of only the GMFSC SHF program in order to ensure the best possible C^3 system for the JTF CINC/CDR.[17]

In such situations "it is often necessary for organizations to develop more complicated integrating mechanisms."[18] The basic mechanism for interfacing is the mechanistic or organizational management hierarchy. In this instance, there is a need for development and testing of a "supplemental" integrating device or an individual coordinator whose basic function would be facilitating integration between the DSCS and GMF.[19]

Before proceeding with the discussion of alternatives and recommendations for improving the operational control of the DSCS space segment, it will be fruitful to first discuss the essential factor necessitating any MILSATCOM control system for the SHF space segment. Capacity, or more specifically limited capacity, is the single most critical factor in providing SHF satellite communications to the GMF.

Capacity Limitations

The examination of capacity limitations is important from two standpoints. First, appreciation of the factors causing capacity limitations and the effect of capacity limitations on the GMF deepens understanding of the need for a MILSATCOM control system. Also, capacity limitation issues are an essential part of alternatives discussed in chapter five.

The factors contributing to capacity limitations of unguided (radio) electromagnetic wave transmission systems are familiar to most telecommunication managers or system engineers, and therefore, are only briefly recountered here. Most factors can be considered to be under one of four general categories: Economical, Technological, Spectrum, or Political.[20]

Economic factors would include the cost of obtaining more capacity, or improving the existing management structure to provide a better distribution of capacity. Technological limitations are often equipment design, propagation characteristics, and information capacity of various spectrum bands. The radio frequency spectrum is itself a limited resource and must be utilized and shared by all spectrum users, both national and international. Because the radio frequency spectrum does not respect man-made political boundaries, both national and international cooperation is necessary to prevent chaos.

A complete discussion covering the effect of each of the above factors on the capacity, now or planned to be available to DSCS users, is beyond the scope of this thesis. The bibliography does, however, contain many interesting readings treating the above and their effects on MILSATCOM.[20] Suffice to state that due to the aggregate of economic, technical, spectrum, and political factors, the capacity of the DSCS space segment is limited.

Chapter four of the MITRE Corporation report "Review of Air Force Ground Mobile Forces (GMF) SHF Satellite Terminal Program," contains an excellent example of the effect of DSCS space segment limitations on the GMFSC SHF program. The illustration indicates that in one instance, the DSCS Indian Ocean Satellite, the tentative allocation of DSCS II transponder power for the GMF falls approximately one third short of the Air Force's austere channel requirements for a representative Air Force Forces deployment.[22] It must be emphasized that the total tentative allocation is one third short of austere Air Force requirements, other component requirements in a joint operation would also have to be addressed. The MITRE report also indicates that DSCS III will do little to improve the capacity available to the GMF.[23] Thus, it can be seen that the capacity issue is a driving force behind any effort to improve the interface between the DSCS and the GMFSC SHF program.

Therefore, the alternatives considered in the next chapter address the capacity and interface issue.

FOOTNOTES

[1]"Department of Defense Directive 5105.44," Military Saltellite Communications Systems Office, October, 1973.

[2]Ronald P. Sherwin, "Management and Control of Military Satellite Communications Systems," Conference Record of 1978 International Conference on Communications, IEEE, II (Oshawa, Canada: Alger Press Limited, 1978), 31.3.1.

[3]Ibid.

[4]Ibid.

[5]The discussion on DSCS SHF MILSATCOM Control, and GMF-SCCS is heavily drawn from two major sources: Sherwin, op. cit., pp. 31.3.1-31.3.5: "Ground Mobile Forces Satellite Communications (GMFSC) Operational and Control Concepts: Volume II, Control Concepts," (Classified Confidential), U.S. Army Satellite Communications Agency, Fort Monmouth, New Jersey, November, 1977, pp. 2-1--2-46. Hereafter cited as GMFSC Control Concepts.

[6]Roy D. Rosner, "Communications System Control for the Defense Communications System," Conference Record of 1978 International Conference on Communications, IEEE, II (Oshawa, Canada: Alger Press Limited, 1978), 31.1.1.

[7]Robert L. Drummond, "Network Control and Coordination with the U.S. Defense Satellite Communications System (DSCS)" (AIAA paper No. 74-477 presented at the Fifth Communications Satellite Systems Conference, Los Angeles, California, April, 1974), pp. 1-4: R. P. Sherwin and J. T. Witherspoon, "Real Time Adaptive Control (RTAC) for the Defense Satellite Communications System" (AIAA paper No. 76-272 presented at the Sixth Communications Satellite Systems Conference, Montreal, Canada, April, 1976), pp. 1-3.

[8]GMFSC Control Concepts, op. cit., p. 2-13.

[9]"TRI-TAC," Joint Tactical Communications Office Pamphlet, July, 1976, p. 2-3.

[10]GMFSC Control Concepts, op. cit., p. 2-2b.

[11]Herbert G. Hicks, The Management of Organizations, (New York: McGraw Hill, 1967), pp. 3-70.

[12]Fremont E. Kast and James E. Rosenzweig, Contingency Views of Organization and Management, (Chicago: Science Research Associates, Inc., 1973), pp. 1-19.

[13]Paul R. Lawrence and Jay W. Lorsch, Developing Organizations: Diagnosis and Action, (Reading: Addison-Wesley Publishing Co., 1969), pp. 12-13.

[14]Ibid.

[15]"Corps Signal Communications," U.S., Department of the Army Field Manual No. 11-92, 1971, p. 2-1: "Doctrine," U.S., Department of the Army Field Manual No. 24-1, pp. 24-27.

[16]GMFSC Control Concepts, op. cit., p. 2-14.

[17]The masculine gender, e.g., he, him, his, etc., is used throughout the discussions related to management in chapters four, five, and six for grammar, syntax, and simplicity's sake. Hopefully, such usage will not be misconstrued as a sexual bias.

[18]Lawrence, op. cit.

[19]Ibid.

[20]Office of Telecommunications Policy, The Radio Frequency Spectrum United States Use and Management, (Washington: Executive Office of the President, 1975), p. B-2.

[21]Articles in the bibliography by the following authors should contribute to an appreciation of the essential factors behind limited capacity of MILSATCOM: William J. Cook, Richard G. Gould and John E. Miller, E. R. Jacobs, and Edward R. Slack.

[22]W. J. Ciesluk, et. al., "Review of Air Force Ground Mobile Forces (GMF) SHF Satellite Terminal Program," (MITRE Technical Report No. MTR-3457, July, 1977), pp. 95-103.

[23]Ibid., p. 107.

Chapter 5

ALTERNATIVES

Limited capacity is the prime factor necessitating effective operational control of the DSCS space segment assets. The preceeding analysis of the planned system of interfacing the DSCS and the GMFSC SHF program in the post 1982 time frame provides a framework of three alternatives which may be pursued. The first alternative is to do nothing to improve the interface, or more succintly, to maintain the status quo. The second alternative is to avoid the problem of improving the interface by greatly increasing the capacity of the space segment. This is essentially an attempt to circumvent the interface problem. The final alternative is an integrative approach that attempts to affect smooth interface of the two systems by creating a "supplemental" integrating device, and deals with capacity limitations.

Therefore, to enhance the ability of communications satellite technology to provide a "key force multiplier" effect on the GMF, chapter five includes an examination of each of the above alternatives. Criteria for evaluating each alternative includes: feasibility, potential costs, and potential benefits. Feasibility is the probability of carrying out an alternative in the near or far term. Potential costs are only examined in a qualatative context. The most important potential benefits are ones that improve the C^3 system available to the GMF, thereby enhancing the combat effectiveness of the GMF.

Maintenance of the Status Quo

This alternative completely disregards the analysis performed in chapter four. Included in this alternative are the following actions: accept the analysis as valid, but not particularly pertinent, accept the present mechanistic interface, and test the existing system in JCS directed exercises. Perhaps the single most important virtue of this alternative is testing the existing system for interfacing the DSCS and GMF after 1982. Admittedly, only a limited number of terminals will be available to accomplish testing prior to 1982, however, this should not unduely restrict testing. The planned system can be tested during JCS directed exercises by simulation of that part of the system that is missing or not required due to actual deployed equipment strength.

Actual testing may establish the need for a reevaluation of the present largely mechanistic system. Reevaluation may point to the need for the humanistic element in organizational interfaces. This potential benefit, the ease of accomplishment, and the obvious low cost, in terms of immediate expenditures, are the positive values of adopting this course of action.

The possibility of being caught with the flag at half-mast is the major negative value. An actual contingency is the wrong time to discover that the present system is inadequate.

The above action also completely neglects the capacity limitation issue. Efforts to deal with capacity limitations can take at least two directions: seeking technological alleviation, or attempting to manage available capacity in the best possible manner. The possibility of technical assistance increasing space segment capacity, thereby decreasing the need for effective integration of the DSCS and GMF is at the heart of the second alternative.

Circumvention of the Interface Issue

The means by which technology can be employed to decrease the capacity limitation of the space segment are numerous, however, only three are addressed: component system enhancement, bandwidth expansion, and quantitative increases.[1] These three should not be considered as the only means available to the GMF community. Rather, they are presented as examples of the many technical avenues open to enhance the GMF C^3 system.

Component system enhancement incorporates such technological changes as better antenna subsystems, accessing schemes, and coding systems. Antenna subsystem improvements include multiple beam antennas as planned for DSCS III.[2] The intent of most antenna subsystem improvements is to improve antenna gain, thereby improving signal-to-noise performance allowing capacity increase through bandwidth versus signal-to-noise trade offs.

Accessing schemes, e.g., Demand-Assigned Multiple Access (DAMA), such as that planned for use by the Single-channel UHF and SHF GMF systems, by using Frequency-Division Multiple Access (FDMA) or Time-Division Multiple Access (TDMA) techniques improve system utilization. FDMA makes available a pool of frequencies, assigning them on demand to users. TDMA makes available a stream of time slots, assigning them on demand to users.[3] For spectrum reasons, TDMA-DAMA is the most probable system of the future.

The ½ convolutional encoder and Viterbi decoder planned for use in the GMFSC SHF terminals can, by providing sufficiently powerful error detection capability, lower required energy per bit to noise ratio, henco received signal to noise ratio.[4] The effect of such a technique is to provide for a power versus bandwidth trade which can increase usable capacity of a system.

Bandwidth expansion is somewhat analogous to increasing the diameter of a water pipe to increase the volume of flow. However, while increasing the diameter of a pipe may have little or no effect on other water systems, increasing the bandwidth of a radio system might have disastrous effects on other radio systems. Increasing the actual bandwidth of a system involves careful planning.

Perhaps the best avenue open to the GMF for increasing satellite communications capacity is to move tactical or mobile UHF systems to SHF and to move strategic or high data and high capacity SHF system to the Extremely High Frequency (EHF) band.[5,6] The EHF band includes those frequencies in the 30 to 300 gigahertz range.[7] In 1977, there were eight satellite systems in operational or proposal stages in the 18-40 GHz range, and it was predicted that by 1990, the 20 to 30 GHz band would become the new super-highway for heavy route traffic.[8]

Operating in the higher EHF band has many advantages as a result of larger available bandwidth, e.g., increased capacity, and TDMA-DAMA bandwidth room, however, the one major limiting factor at these bands is the reduction in link availability due to rain attenuation. Recent literature indicates that progress is being made in studying and analyzing rain phenomenon and its effects on satellite communications. As a result of this ongoing effort, availability enhancement techniques are being postulated and tested, e.g., multiple local sites, angle diversity, and utilizing two or more separate paths.[9]

Thus, the use of the EHF band can provide benefits to the GMF C^3 system of the future. The primary benefit will be in terms of increased capacity. The effects of rain attenuation and possible enhancement techniques will have to be compared with the value of such needed capacity gains.

The third possible avenue open to the GMF in efforts to increase communication satellite capacity is technically the simplest to understand; make quantitative increases in the number of communication satellites in orbit. This would result in the additional benefit of decreasing the ASAT vulnerability of the GMFSC program by providing for a proliferated crosslinked network if used in conjunction with the DSCS space system.[10] However, such an option is obviously extremely expensive, and in terms of continuing Congressional interest in military satellite communications, as evidenced by LeaSat discussed in chapter two, highly unlikely.

The monetary aspect of technological means of increasing satellite capacity is perhaps the largest stumbling block to pining total hope on technology. It can be deduced intuitively that at least the semblance of a rough corollary exist between the significance of a capacity increase and the more advanced the technology required. Usually, it is the case that the more futuristic the technology is over present off-the-shelf components and systems, the higher the costs.

The above is not to say that the DOD should completely abandon research efforts. The third alternative below includes a philosophy for improving the C^3 system available to the GMF which acknowledges the continuing need for research and development. The main fault of adopting alternative two is in relying solely on technology to diminish the need for improving allocation of available resources. It is unlikely that significant increases in capacity will be made available to the GMFSC SHF program before the 1990-2000 time frame.

The costs of futuristic technology can be high if the DOD is the sole end user. However, as recent literature indicates, many commercial telecommunications users such as national and international financial institutions are becoming increasingly interested in improvements in satellite capacity and security. It has been estimated that the daily transfer of funds over telecommunications networks is a mind-staggering $302 billion. In the United States alone, monetary related telecommunications is growing at a rate of 20%.[11] It is almost certain that the money behind this growing need cannot fail to stimulate telecommunications companies to increase their efforts to provide technological improvements in at least some areas of interest to the DOD. Hopefully, the GMF will be able to capitalize on any technological improvements that can benefit the GMFSC SHF program.

The potential benefits of technological methods to increase capacity are quite high, if they mature in a timely manner. If a technological breakthrough provides a ten fold increase in satellite communications capacity to the GMF after the war was lost for lack of capacity, it is of little benefit or consolation. Something must be done now.

Integrative Alternative

Providing an improved interface between the DSCS and GMF involves four different, but highly related actions: a "supplemental" integrating device, user capacity control and education, technology, and testing.

"Supplemental" Integrating Device

The analysis in chapter four of the planned system for integrating the DSCS and GMF in the post 1982 time frame pointed out the need for a "supplemental" integrating device or an individual whose basic function would be facilitating integration between the DSCS and GMF. Figure 5-1 below will assist in understanding the functional relationships of this individual, the GMFSC Liaison Officer (GMFSC-LO).[12]

Figure 5-1 indicates that the provision of a "supplemental" integrating device can be accomplished by locating a GMFSC-LO with the DSCS SATCOM Network Controller. This is the preferred method. The JTF

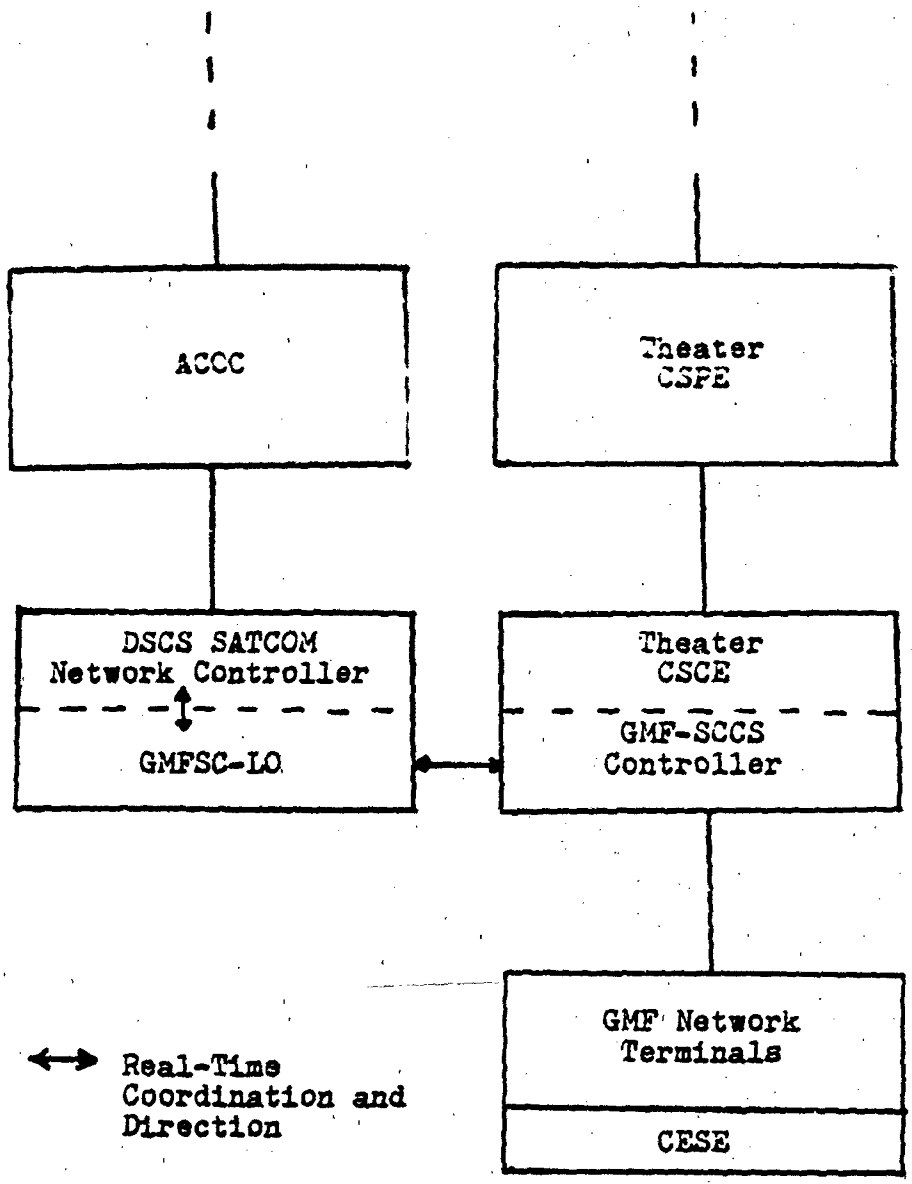

Figure 5-1. Functional Relationships of the GMFSC-LO and the DSCS and GMF-SCCS

CINC/CDR is able to maintain greater integrity of his C^3 system if the GMF-SCCS Controller remains a colocated part of his theater CSCE staff.

However, as outlined in the Ford Aerospace and Communications Corporation "Book M: Management Methods and Techniques," it is possible that under certain scenarios locating the GMF-SCCS controller and an AN/TSQ-118 with the DSCS, SATCOM Network Controller could be required. When this is done, the problem of providing an effective interface between the DSCS and GMF would be greatly simplified. It can reasonably be assumed that the two controllers would be in close enough physical proximity to accomplish face-to-face communications, as required.[13] However, in the more probable course of events, the GMF-SCCS Controller would be located within the deployed theater. Therefore, more must be said about the GMFSC-LO position and functional relationships with the DSCS and GMF-SCCS.

The GMFSC-LO would be directly responsive to the GMF-SCCS Controller. His function would be to represent the GMF position to the DSCS. The GMFSC-LO, by virtue of being colocated within the DSCS, should also be able to more effectively relate the DSCS position to the GMF. The credibility of the GMFSC-LO representing the DSCS position to the GMF will be higher than that of the DSCS SATCOM Network Controller. After all, the GMFSC-LO will be from the GMF camp.

A highly qualified GMFSC-LO and the added bonus of being in face-to-face communication with the DSCS SATCOM Network Controller should combine to provide the GMF higher credibility with the DSCS. The qualifications of a GMFSC-LO are thus a matter of importance.

The GMFSC-LO should be an Officer or Senior Noncommissioned Officer well versed in managing tactical communications. The GMFSC-LO should also be experienced in the GMFSC SHF program and equipment, the GMF-SCCS, and TRI-TAC TCCF equipment and architecture. The above qualifications are baseline requirements. It would be extremely beneficial if the GMFSC-LO also possessed the following qualifications: comprehensive knowledge of JTF and component communications systems, both satellite and terrestrial (for alternate routing and backup capability), familiarity with the DCA's DOCC, and the mechanistic organizational procedures for interfacing the DSCS and the GMF.

The GMFSC-LO must have adequate communications, both voice and data, with the GMF-SCCS. It is possible that the GMFSC-LO and DSCS SATCOM Network Controller could share common communication links with the GMF-SCCS. The GMFSC-LO, however, must be totally familiar with all primary, secondary, and even tertiary methods of maintaining communications with the deployed GMF-SCCS.

It might be considered difficult to find an individual with all of the above mandatory and beneficial qualifications. However, the best pool of talent would probably lie within the telecommunications planning staffs for JCS exercises and contingencies at the JTF and component level.

Doubt might still exist as to the need for a "supplemental" integrating device to facilitate the interface of the DSCS and GMF. To clear up such doubt, the example of JCS directed exercise Solid Shield 76 (SS-76) in the Southeastern United States will provide the final argument. SS-76 was in serious jeopardy when the Federal Aviation Administration (FAA) warned the military that unless critical telecommunications links between the FAA and Military Air Traffic Controllers could be activated and proven reliable, the FAA would not turn exercise needed Air Space over to military control.

There was a multitude of management problems, e.g., authority versus responsibility imbalances, and problem identification procedures, involved in the failure to activate tactical telecommunications in a timely manner. Prominent to the overall problem was the lack of an effective interface between two elements of the Air Force Forces telecommunications management hierarchy. This near disaster in SS-76 resulted in the rewrite and successful testing from 1976 to 1978 of a Tactical Air Command regulation; that, in addition to correcting other management deficiencies, provides for a "supplemental" integrating device. This is accomplished by providing an individual well versed in the particulars of one element's telecommunications system being placed on the staff of the other unit, higher in the management hierarchy.[14]

Capacity Control and Education

The above action to provide a more effective interface should be complemented by efforts by GMF commanders to emphasize the effect of limited space segment capacity on the GMF C^3 system. GMF communicators should assist commanders by taking the initiative. GMF commanders should be provided with realistic GMFSC SHF space segment capabilities in the near and far term. GMF communicators should also heavily involve Operations personnel in the development of telecommunications annexes for possible exercise and contingency scenarios.

The old axiom that "communications is a service and that communicators provide" should not be viewed as prohibiting military telecommunications managers from emphasizing the real limitations of existing and planned system. The cost, in terms of money, material, and personnel, of providing services must also be discussed. Creative means of providing communications, based on a thorough understanding by the communication manager of user mission and needs, can help trim overstated needs.

Additionally, GMF telecommunications managers must push for greater Electronic Warfare and Austere Communications play in JCS directed exercises. Future Battle Staff Managers need this enhanced training to provide a realistic background for managing future crisis or contingency situations.

Technology

The third part of this alternative is to continue efforts to improve communication satellite technology that can help satisfy military telecommunication needs. However, technology should not be pursued for the sole purpose of alleviating poor management. Rather, management should be perfected to best utilize available technology, providing a "key force multiplier" effect.

The important operative idea is that technology can improve the system's capability while management can improve its utility. Thus, the prime goal of GMF telecommunication managers and planners should be to provide the best integration of the DSCS and GMF which, in turn, improves operational control of limited space segment capacity while remaining cognizant of the possibilities of technology to improve the GMFSC program.

Testing

Any good plan should be tested. The best way to test the above alternative is to do so during JCS directed joint exercises. Such testing can provide ample opportunity for improving the operational control of the DSCS space segment; hofefully, before an actual crisis or contingency.

With careful planning, JCS exercises can also serve as an excellent vehicle for testing new technology for wider application. A key concept that GMF telecommunications managers must remember is that testing of new technology must not be allowed to interfere with exercise objectives.

Evaluation

Establishment of a program that includes the above actions would not be overly difficult. The major factor involved is the manpower to shape the above concept into a workable, detailed plan. The above alternative would not be costly. The only major overhead cost would be that associated with preparation of a management concept similar to Ford Aerospace and Communications Corporation's that included the GMFSC-LO position and function.

Potential benefits are high. The vehicle of testing the GMFSC-LO and capacity actions afforded by JCS exercises could be invaluable in proving the system and training personnel before an actual crisis or contingency develops. The option to improve system performance as technology matures also adds to the attractiveness of this option. Thus, the GMF can have the best C^3 system at their disposal when the need arises.

In view of the discussion of the above three alternatives, what should be done? Chapter six, in addition to reviewing the preceding five chapters, provides the answer.

FOOTNOTES

[1]A complete technical discussion of each of the possibilities, while interesting, is well beyond the scope of this paper. However, the bibliography contains numerous references with excellent discussions on each topic.

[2]R. B. Dybal's paper "Multiple Beam Communications Satellite Antenna Systems," presented at the Institute of Electrical and Electronics Engineering, Inc., 1974, International Conference on Communications, June 17-19, 1974, is an excellent discussion on the basics of multiple beam antenna technology.

[3]James Martin, Telecommunications and the Computer, (Englewood Cliffs: Prentice-Hall, Inc., 1976), pp. 496-503.

[4]J. A. Heller's paper "Performance and Implementation of the Viterbi Decoding Algorithm for Satellite and Space Communication," presented at the above IEEE Conference Report is a good discussion on Viterbi decoding algorithm.

[5]Robert L. Drummond, "Future Trends in MILSATCOM Systems," Conference Record of 1977 International Conference on Communications, IEEE, II (Chicago: Design Business Forms, Inc., 1977), 31.3-287.

[6]The volume of literature on EHF, Millimeter wave (MMW), or K Band technology is large and continues to grow each year. The bibliography contains numerous articles on this subject and should prove interesting reading to the serious student of the GMFSC program.

[7]"Frequency Management and Electromagnetic Compatibility," U.S., Department of the Air Force, Air Force Manual 100-31, October, 1974, p. 1-2.

[8]Louis Cuccia, Carl Hellman, and Wasson Quan, "Above 10 GHz SATCOM Bands Spur New Earth Terminal Development," Microwave System News, March, 1977, pp. 37-46.

[9]P. E. Brandinger, "20-30 GHz Communication Satellite Systems Design," Conference Record on 1978 International Conference on Communications, IEEE, I (Oshawa, Canada: Alger Press Limited, 1978), 10.4.1-10.4.3.

[10] S. Nichols et. al., "Alternative Communication-Satellite Configurations: Volume 1. System Concepts and Evaluation," Naval Research Lab, Washington, D.C., Report No. NRL-8134 (Distribution limited to U.S. Government Agencies only), September, 1977, p. xiii.

[11] C. E. White, "Electronic Banking - A Mixed Blessing," Telecommunications, 13:4:65, February, 1979.

[12] For simplicity and ease of understanding, Figure 5-1 does not include all hierarchical relationships as indicated in chapter four, Figures 4-3 and 4-4. The impact of neglecting these relationships is nil because they remain the same regardless of whether or not this alternative is undertaken.

[13] It is understood that the DSCS and GMF would be interfacing under a tactical 24 hour a day environment and that more than one Controller would be involved in each system. However, this distinction is not important to the discussion. In military telecommunication operations, sufficient overlap is normally provided to ensure continuity of operations.

[14] "Management and Status Reporting for Tactical Communications-Electronics Systems," U.S. Air Force, Tactical Air Command, Tactical Air Command Regulation 100-5, August, 1978, p. 4.

Chapter 6

RECOMMENDATIONS

Chapter one stated that the purpose of this thesis was to analyze the interface of the DSCS and GMF utilizing the conceptual framework developed by Lawrence and Lorsch. The objective for accomplishing the analysis was to seek a method for improving the planned system of exercising operational control of the space segment used by the GMFSC SHF program after 1982. Improvements in the management of communication satellite technology can be an important factor in achieving "key force" enhancement of the GMF.

Chapters two and three provided the historical background on military communication satellites, and the GMFSC program necessary for a complete understanding of the GMFSC SHF program. Chapter two traced the beginning of military space communication activity to 1946 when the United States Army achieved radar contact with the moon. This history of tactical and strategic communications satellites from 1966 to 1980 was reviewed. DSCS II and III were examined in greater detail because of their significance as the GMFSC space segment.

The need due to deficiencies in present tactical terrestrial communication systems, e.g., HF/SSB, Cable, LOS, and Tropo for a GMFSC program was outlined in chapter three. However, it was pointed out that the GMFSC program should not be considered as the panacea for all GMF communication needs. Because of satellite system vulnerabilities, e.g., jamming, and ASAT, the GMFSC program should be viewed as an essential part of a whole, which includes terrestrial systems, in the ongoing effort to improve GMF communications. The history of the GMFSC program and the different component systems of the program were surveyed. The AN/TSC-86, 85, 93, and 94 ground terminals of the GMFSC program were briefly explored to provide continuity.

Chapter four's detailed analysis of the planned interface of the GMF and the DSCS in the post 1982 time frame included an examination of the management structure of the DCA, TRI-TAC, and the GMF-SCCS. The conclusion of the analysis was that operational control of the space segment is necessary due to real capacity limitations and can be improved by providing a "supplemental" integrating device as described by Lawrence and Lorsch in their book, Developing Organizations: Diagnosis and Actions.[1] The "supplemental" integrating device or individual is most needed at the DSCS SATCOM Network to GMF-SCCS Controller interface.

Chapter five takes the position that essentially three alternatives can now be pursued by GMF military telecommunication planners and managers. They can choose to disregard completely the analysis of chapter four, thereby maintaining the status quo. They can attempt to eliminate the essential need, that of limited capacity, for better integration of the DSCS and GMFSC through technology. Or GMF telecommunications planners and managers can accept, as valid, the need for a "supplemental" integrating device or GMFSC-LO and adopt a synergistic course of action designed to address this need and the capacity issue through education and technology.

The recommended course of action is that GMF telecommunications planners and managers adopt option three essentially as outlined in chapter five. The alternative needs to be fleshed out in detail and tested thoroughly. However, the provision of a GMFSC-LO position colocated with the DSCS SATCOM Network Controller, actions to deal with present capacity limitations through education and training, maintaining a vital interest in future technology with the capability to increase system capacity, and a thorough ongoing evaluation effort during JCS directed exercises will all combine to provide a "key force multiplier" effect for the GMF.

FOOTNOTES

[1]Paul R. Lawrence and Jay W. Lorsch, *Developing Organizations: Diagnosis and Action*, (Reading: Addison-Wesley Publishing Co., 1969), pp. 12-13.

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APPENDIX

GLOSSARY OF ABBREVIATIONS

ACOC	Defense Communications Agency Area Communications Operations Center(s)
AFSAT	Air Force Satellite
AFSATCOM	Air Force Satellite Communications
AFSCF	Air Force Satellite Control Facility
ASARC	Army System Acquisition Review Council
ASAT	Antisatellite
ATEC	Automated Technical Control
BPF	Band Pass Filter
BPSK	Binary Phase Shift Keying
C^3	Command, Control, and Communications
CESE	Communications Equipment Support Element
CINC/CDR	Commander-in-Chief/Commander
CNCE	Communications Nodal Control Element
COMSAT	Communication Satellite(s)
CSCE	Communication System Control Element
CSPE	Communication System Planning Element
CVSD	Continously Variable Slope Delta
DAMA	Demand Assigned Multiple Access
dB	Decible
dBW	Decible (referenced to one watt)
DCA	Defense Communications Agency
DCACC	Defense Communications Agency Operations Center

DCS	Defense Communications System
DOCC	Defense Communications System Operations Control Complex
DOD	Department of Defense
DSCS	Defense Satellite Communication System
DTS	Diplomatic Telecommunications Service
EC	Earth Coverage
EHF	Extremely High Frequency
ERP	Effective Radiated Power
FAA	Federal Aviation Administration
FDMA	Frequency-Division Multiple Access
FLSAT	Fleet Satellite
GapSat	Gapfiller Satellite
GHz	Gigahertz
GMF	Ground Mobile Forces (ground maneuvering units of the Army, Air Force, and Marine Corps)
GMFSC	Ground Mobile Forces Satellite Communications
GMF-SCCS	Ground Mobile Forces Satellite Communications Control System
GMFSC-LO	Ground Mobile Forces Satellite Communications Liaison Officer
HF/SSB	High Frequency/Single Side Band
HPA	High Power Amplifier
HVPS	High Voltage Power Supply

IDCSP	Initial Defense Communications Satellite Program
INTACS	Integrated Tactical Communications System Study
JCS	Joint Chief of Staffs
JTF	Joint Task Force
kHz	Kilohertz
LeaSat	Leased Satellite
LES	Lincoln Experimental Satellite
LNA	Low Noise Amplifier
LOS	Line-of-Sight
LRIP	Low Rate Initial Production
MARISAT	Maritime Satellite
Mbps	Megabits per second
MHz	Megahertz
MILSATCOM	Military Satellite Communications
MUX	Mutiplexer
NATO	North Atlantic Treaty Organization
NC	Narrow Coverage
NCA	National Command Authority
NCT	Network Control Terminals
NT	Network Terminal
NWS	Nuclear Weapons Storage
QPSK	Quadriphase Phase Shift Keying
RF	Radio Frequency
RTAC	Real-Time Adaptive Control

SATCOM	Satellite Communications
SATCOMA	Satellite Communications Agency
SCMC	Satellite Communications Monitoring Center
SHF	Super High Frequency
SS	Solid Shield
SYCON	System Control
TACSAT	Tactical Satellite
TACSATCOM IOC	Tactical Satellite Communications Interim Operation Capability
TCCF	Tactical Communications Control Facilitie(s)
TCF	Technical Control Facilitie(s)
TDMA	Time-Division Multiple Access
TRI-TAC	Joint Tactical Communications Office (Program)
Tropo	Tropospheric Scatter
TT&C	Telemetry, Tracking, and Command
TWT	Travelling Wave Tube
TWTA	Travelling Wave Tube Amplifier
UHF	Ultra High Frequency
UK	United Kingdom
W	Watt