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THE NAVAL TELECOMMUNICATIONS SYSTEM:
A COMMAND AND STAFF
MANUAL

by

Robin M. Babb

March 1987

Thesis Advisor Carl R. Jones

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This thesis provides prospective Naval communications managers, senior officers, and supervisory command and control officers with a basic, non-technical description of the Naval Telecommunications System (NTS). It is suitable as a general primer for the communications manager, for new personnel indoctrination, for command briefings, and for general reference to the NTS. This thesis includes a description of the organic structure, administration, and operation of the NTS, its interaction with various major commands and agencies, the primary systems used within the NTS, and some plans for its future.

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The Naval Telecommunications System: A Command and Staff Manual

by

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Lieutenant Commander, United States Navy
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requirements for the degree of

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March 1987

ABSTRACT

This thesis provides prospective Naval communications managers, senior officers, and supervisory command and control officers with a basic, non-technical description of the Naval Telecommunications System (NTS). It is suitable as a general primer for the communications manager, for new personnel indoctrination, for command briefings, and for general reference to the NTS. This thesis includes a description of the organic structure, administration, and operation of the NTS, its interaction with various major commands and agencies, the primary systems used within the NTS, and some plans for its future.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to provide prospective Naval communications managers, senior officers, and supervisory command and control officers with a basic, non-technical description of the Naval Telecommunications System (NTS). This thesis includes a description of the organic structure, administration, and operation of the NTS, its interaction with various major commands and agencies, the primary systems used within the NTS, and some plans for its future.

B. SCOPE

This thesis is intended to be used as a tool in understanding the NTS and its role within the Naval command and control organization. It is suitable to be used as a general primer for the communications manager, for new personnel indoctrination, for command briefings, and for general reference to the NTS.

For more indepth information regarding the technical aspects of the NTS, this thesis must be supplemented with system and technical descriptions and field experience.

Even though this thesis has been written on an unclassified level, much of the information required to support an indepth understanding of the NTS is classified. The reader possessing the appropriate security clearance and need to know is encouraged to research the classified areas of the various systems and components of the NTS to gain a greater understanding of the NTS system dynamics and its relationship to battle management and responsiveness.

C. HOW TO READ THIS THESIS

Chapter Two is designed to give the reader an overall picture of the NTS: why it was created, what it encompasses, its mission, composition, and the purpose of the Naval Telecommunications Command. Chapter Three presents the reader with a detailed description of each component of the Naval Telecommunications Command and how each component functions in the chain of command which extends from the CNO down to the afloat unit. Chapter Four explains the support role major commands and agencies play to ensure the dynamics of the NTS. Chapter Five describes various systems used within the NTS, including the major satellite systems. Chapter Five also provides a description of communications media, such as the frequency spectrum, satellite communications, and fiber optics. Chapter Six discusses the overall effect on the NTS caused by a major system failure. Management tools used within the NTS to ensure overall effectiveness and readiness are also described in Chapter Six. Chapter Seven introduces the reader to systems being developed for the NTS and military communications in general.

II. THE NAVAL TELECOMMUNICATIONS SYSTEM: AN OVERVIEW

A. BACKGROUND

Communications provide the means of achieving command and control of the operating forces. "Naval telecommunications" is a comprehensive term that denotes the whole of the communications effort with the Department of the Navy. It refers to the concept of communicating, rather than to any formally established organization.

Since it is a vital key to command and control, Naval telecommunications must always be in a condition of readiness. A crisis or a war would not allow the Navy a grace period to procure new communications equipment and to train thousands of new personnel. In the event of hostilities, the operating forces must depend on existing communications facilities.

Historically, Navy command, control and communications (C3) systems and subsystems were developed independently to satisfy specific, sometimes urgent, operational requirements. Interfaces between systems and subsystems were often developed after the fact and interoperability problems were left to the Fleet Commanders to solve. The resulting systems and capabilities did not satisfy the information transfer requirements of modern Naval operations.

The Navy realized the inefficiencies and costs of independent system/subsystem development and sought the assistance of leaders in the telecommunications industry to study and analyze future Navy telecommunications policy and system needs. In 1972 this study group, the CNO Industry Advisory Committee for Telecommunications (CIAT), recommended the creation of the Naval Telecommunications System (NTS) based on a total system concept. This concept would address current system limitations, future objectives, and methods for evolutionary achievement of required telecommunications capabilities. [Ref. 1:p.1]

B. DEFINITION

The Naval Telecommunications System (NTS) is a complex of systems, subsystems, and equipments that provides telecommunications networks for the operation, administration, and command and control of Navy resources.

C. MISSION

The mission of the NTS is to provide and maintain reliable, secure, and rapid telecommunications based on war requirements to meet Naval command and control needs, ease Naval administration, and satisfy the Joint Chiefs of Staff approved requirements. [Ref. 2:p. 3-1]

D. COMPOSITION

The NTS is composed of portions of the Defense Communications System (DCS) and Naval telecommunications resources afloat and ashore established for fleet, air, surface, and subsurface support. The NTS encompasses the connectivity between forces afloat and ashore in the Navy Command and Control System (NCCS). Figure 2.1 depicts the interrelationships of the NTS and the DCS; their overall management authority and the complex of platforms, spectrum utilization, networks employed, and connectivities used to meet the requirements of the operating forces. [Ref. 3:p. II-5]

The following are not part of the NTS:

1. Postal and guard mail systems.
2. Special Intelligence (SPINTCOM) and Critical Communications (CRITICOM) terminals.
3. Passive communications intercept systems and associated terminals under the control of Commander, Naval Security Group (COMNVSECGRU).
4. Radio determination, radio astronomy, radiosonde and navigational stations or devices, except where specifically assigned.
5. Portable communications equipment (base and tactical).
6. Naval Air Traffic Control and Air Navigation Aids and Landing Systems (NAALS).
7. Marine Corps telecommunications systems operated and managed by the Commandant of the Marine Corps. These systems, however, are an operational extension of the NTS and, therefore, follow the operating procedures used within the NTS.
8. Instrumentation, measurement, and telemetry systems used to perform physical measurements (i.e., displacement, speed, acceleration, time, etc.) and provide the resulting data to a recording device or display station which do not involve other communications applications. [Ref. 3:p. I]

User end terminal devices are not NTS equipments per se except where these devices are part of the automated control of information flow through the network, e.g., Naval Communications Processing and Routing System (NAVCOMPARS), Local Digital Message Exchange (LDMX), Naval Modular Automated Communications System (NAVMACS), etc.

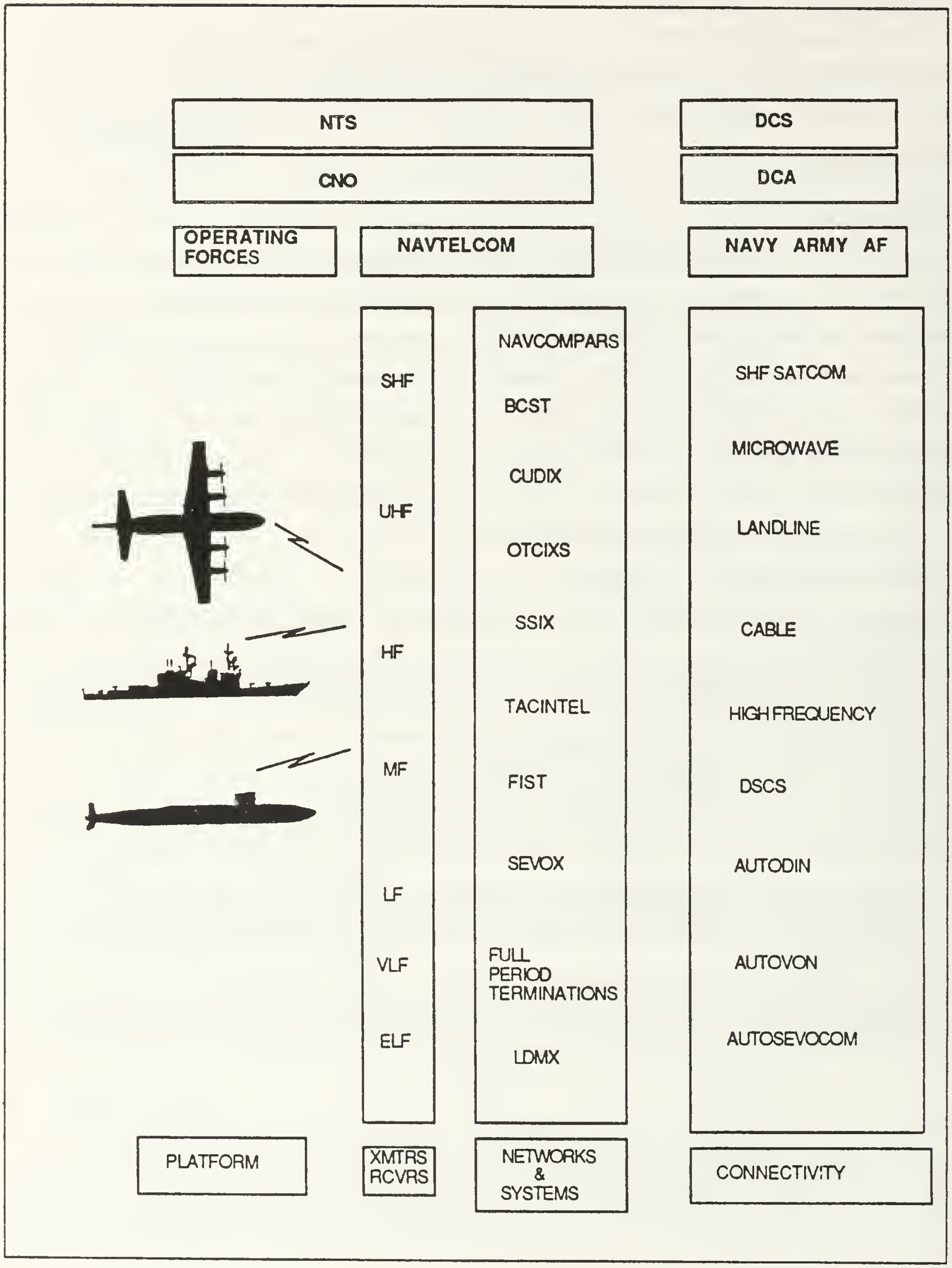

Figure 2.1 NTS Overview.

To meet Navy and Marine Corps operational requirements, the NTS may be expanded to incorporate or interface with communications systems of other services or countries.

E. ORGANIZATION

The Chief of Naval Operations (CNO) has overall management authority for the NTS. As an Echelon 2 commander reporting directly to the CNO, Commander Naval Telecommunications Command (COMNAVTELCOM) is the administrative manager of the NTS, commanding the shore elements of the Naval Telecommunications Command (NAVTELCOM). (See Figure 2.2)

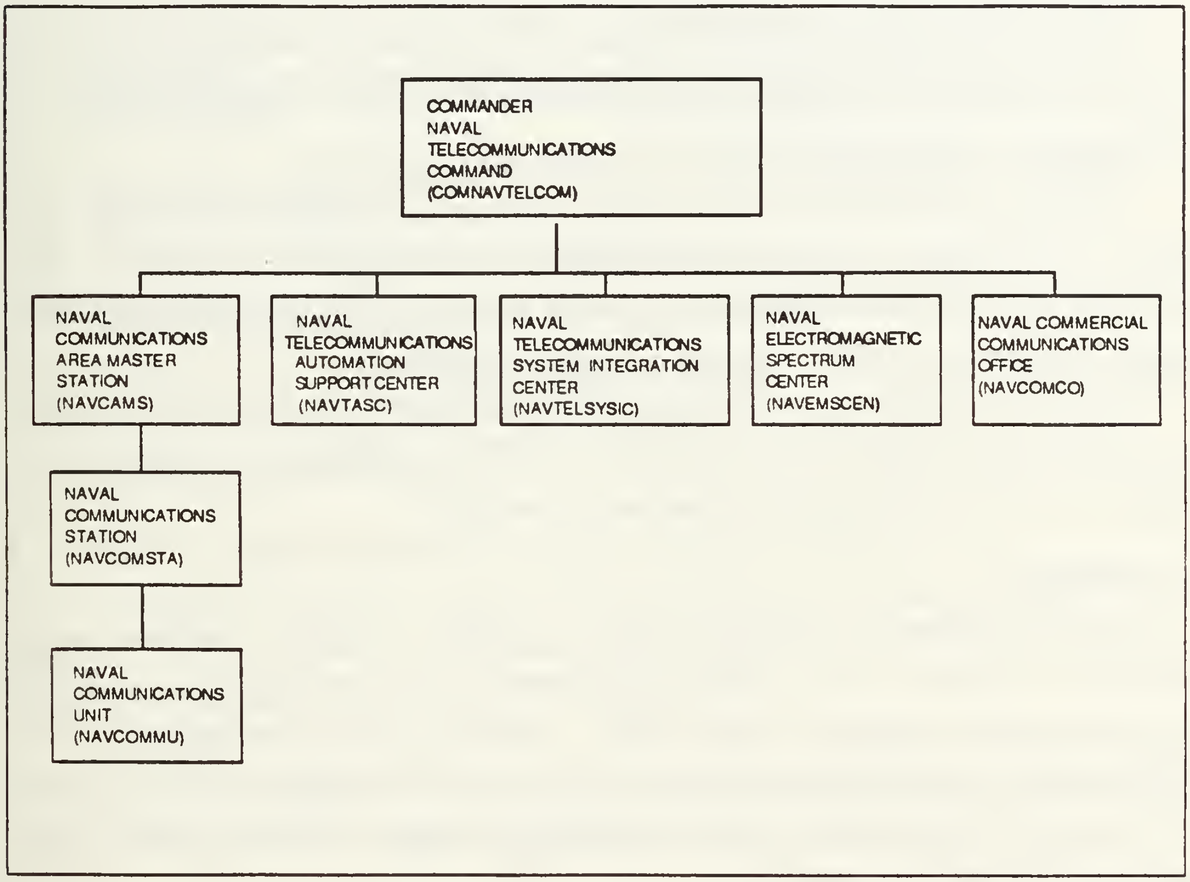

Figure 2.2 Naval Telecommunications Command Organization.

1. NAVTELCOM

The Naval Telecommunications Command consists of the following shore activities. Appendix A provides a complete listing of NAVTELCOM activities categorized by geographic area.

a. Four Naval Communications Area Master Stations (NAVCAMS)

b. Thirteen Naval Communications Stations (NAVCOMMSTAs)

c. Four Naval Communications Units (NAVCOMMUs)

d. Four Naval Communications Detachments (NAVCOMMDETs)

e. Forty-five Naval Telecommunications Centers (NTCCs), as assigned by CNO.

f. Ten ASW Support Communications Centers (ASCOMMs), as assigned by CNO

g. Seven Special Communications Sites (SPECOMMs)

h. Naval Telecommunications Automation Support Center (NAVTASC), Cheltenham, Maryland

i. Naval Telecommunications System Integration Center (NAVTELSYSIC), Cheltenham, Maryland

j. Naval Electromagnetic Spectrum Center (NAVEMSCEN), Washington, D.C.

k. Naval Commercial Communications Office (NAVCOMCO), Washington, D.C.

F. DEFENSE COMMUNICATIONS AGENCY (DCA) ASSETS

COMNAVTELCOM also serves as the operations and maintenance manager of elements of the Defense Communications System (DCS) assigned to the Navy. As such, COMNAVTELCOM ensures that the Navy elements of the DCS respond to the operational direction of the DCA and its subordinate elements.

The DCS is a complex of government-owned or leased point-to-point, long-haul circuits that exists to support the Army, Navy, Air Force, and other DOD activities. Chapter Four will provide a more detailed look at the DCS.

G. SYSTEMS

The NTS strives to maintain sufficient capability, reliability, flexibility, and redundancy to support CNO validated requirements for command and control of Naval forces and support of the DCS. Because of the vulnerabilities of communications systems, a mix of the entire radio frequency spectrum (ELF, VLF, LF, HF, VHF, UHF, SHF, AND EHF) is required to provide operating forces with effective communications capabilities.

Some of the systems used within the NTS that will be discussed in further detail in Chapter Five are: Satellite Systems, Naval Communications Processing and Routing System (NAVCOMPARS), Local Digital Message Exchange (LDMX), Primary Ship/Shore, Secure Voice, Fleet Broadcast, and Full Period Terminations.

III. NTS ORGANIC STRUCTURE

A. COMNAVTELCOM

Commander, Naval Telecommunications Command commands the major shore elements of the NTS; provides configuration control of the NTS; serves as the operations and maintenance manager of those assigned elements of the Defense Communications System (DCS); and performs other functions and tasks as determined by the Chief of Naval Operations (CNO) or other higher authority.

The major functions of COMNAVTELCOM are to:

1. Command, operate, and maintain the Naval Telecommunications Command.
2. Provide the management and configuration control of the NTS necessary to ease communications to, from and between the fleet and throughout the shore establishment.
3. Act as the Navy manager for assigned DOD common user switched and transmission systems.
4. Plan and coordinate system improvements.
5. Represent Navy policy in the technical execution of DCA, joint and allied telecommunications plans.
6. Coordinate the connectivity required to support the C3 and administrative requirements of the Department of the Navy.
7. Operate and manage individual specialized telecommunications systems, as assigned. [Ref. 4:pp. 2-4]

B. COMNAVTELCOM HEADQUARTERS ORGANIZATION

COMNAVTELCOM is responsible for carrying out missions and functions assigned by CNO. Figure 3.1 presents a structural chart of the COMNAVTELCOM Headquarters organization, located in Washington, D.C.

The Deputy Commander acts for and issues orders in the name of the Commander in all matters other than those of major policy nature or which involve censure, commendation, or major disagreement with other commands and agencies. In the absence of the Commander, the Deputy performs all the duties of the Commander, ensuring that any required action is taken within headquarters.

The Naval Telecommunications Command Operations Center (NTCOC) is the primary point of contact for overall operational direction of NAVTELCOM. Operating from COMNAVTELCOM Headquarters, the NTCOC reports the operational status of the NTS to COMNAVTELCOM, his Deputy, and Staff. The

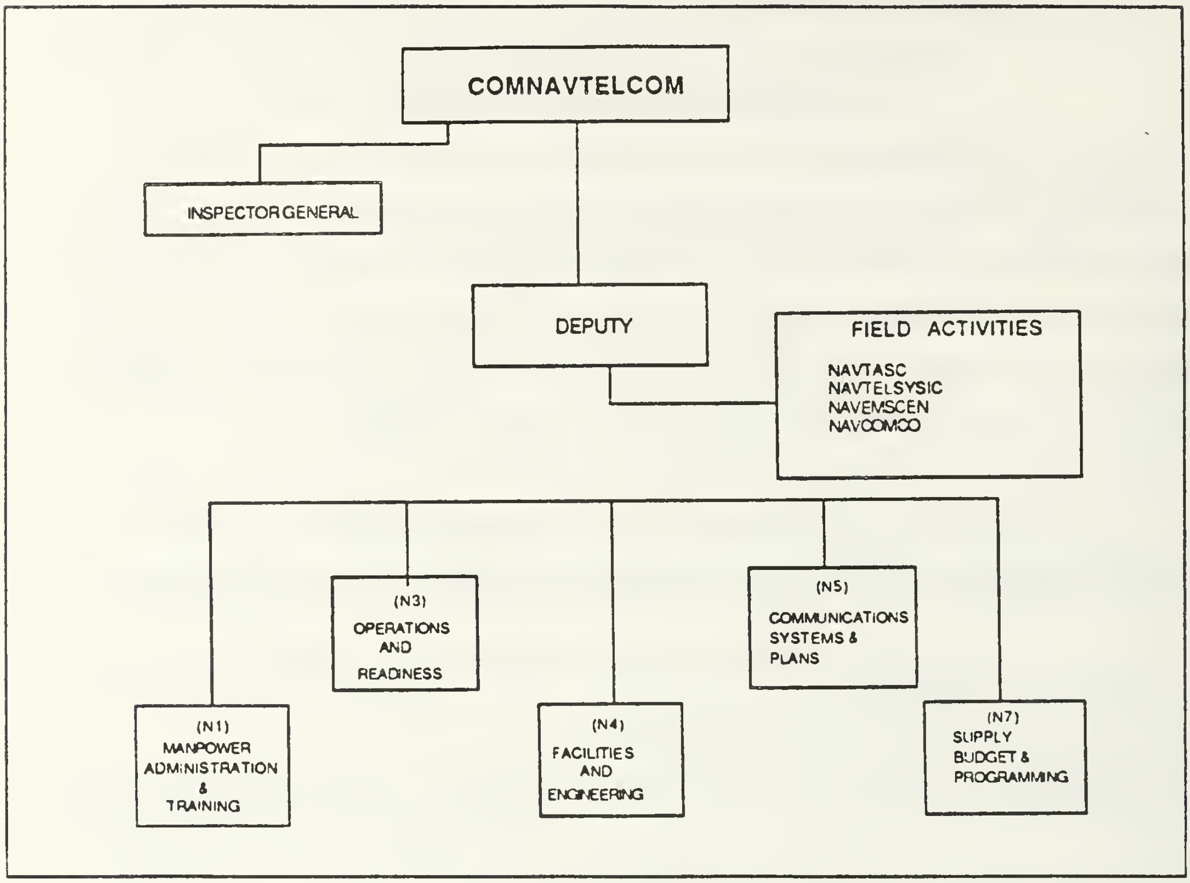

Figure 3.1 COMNAVTELCOM Headquarters Organization.

NTCOC receives real-time NTS status information via the Naval Telecommunications Operational Coordination Network (NTOCN). Each NTOCN station is equipped with at least one crypto covered teletype terminal. The stations are group by Naval Communications Area, with each station connected to a control center located at the NAVCAMS. Figure 3.2 represents the NTOCN's connectivity scheme. COMNAVTELCOM uses information reported on the NTOCN to provide CNO with daily status reports on the NTS, as well as information concerning major operations, exercises and contingencies that may impact on the NTS. [Ref. 3:p. VII-5]

The Inspector General is responsible for periodic inspections of COMNAVTELCOM's claimancy, i.e., the activies making up NAVTELCOM.

COMNAVTELCOM's Headquarters is divided into five major mission areas.

1. The Assistant Chief of Staff for Manpower, Administration and Training (N1) is responsible for the management of total force manpower resources, including the proper manning and training of resources required to satisfy mission objectives.

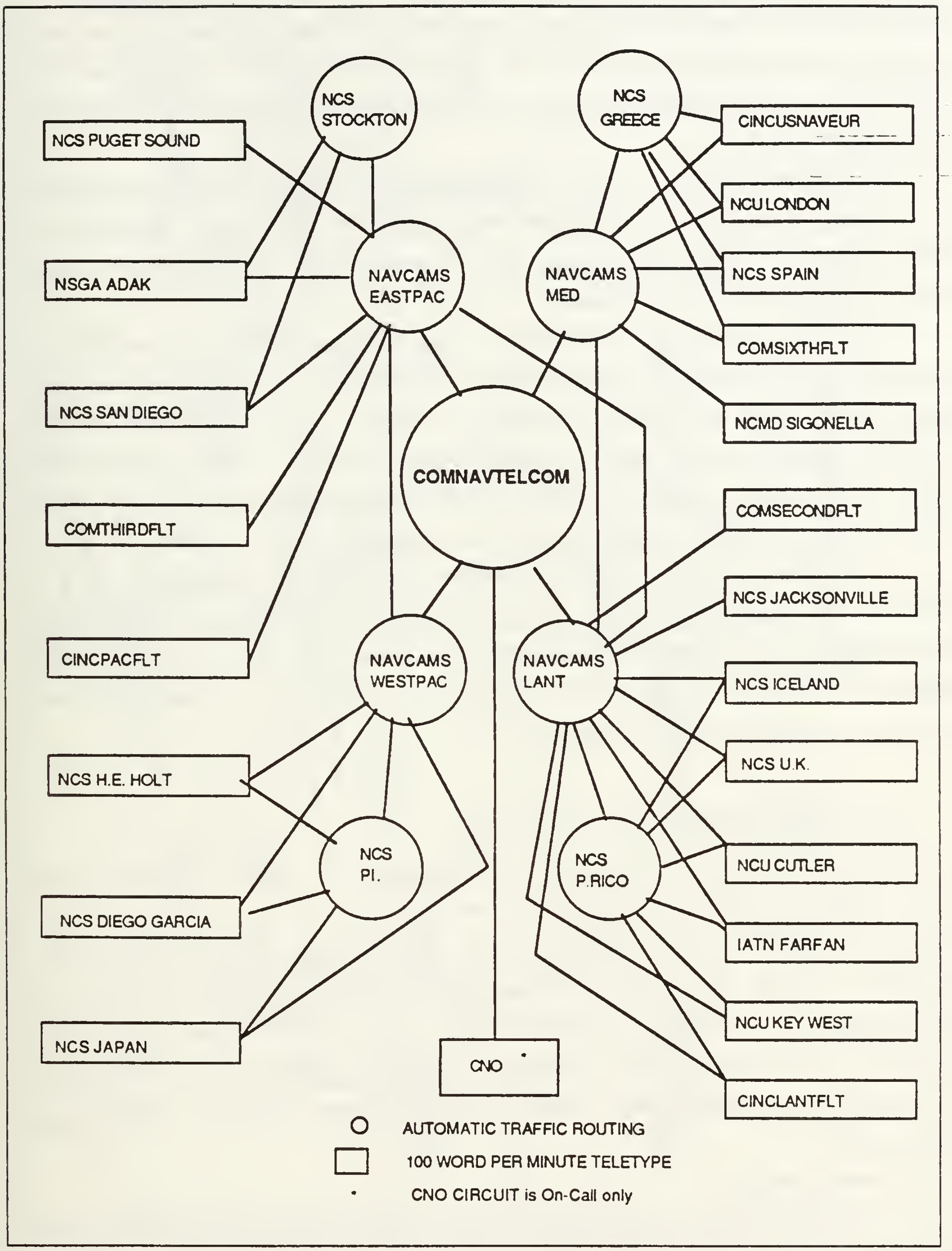

Figure 3.2 NTOCN Connectivity.

2. The Assistant Chief of Staff for Operations and Readiness (N3) is responsible for the operational communications plans, standards, protocols, readiness and analysis, publications and procedures for the NTS. N3 also operates special communications networks and conducts assistance visits to non-claimant telecommunications activities as manpower permits.

3. The Assistant Chief of Staff for Engineering and Facilities (N4) is responsible for the communications and facilities engineering of all assigned elements of NAVTELCOM, including planning for improvements, implementation and configuration control for the claimancy.

4. The Assistant Chief of Staff for Communications Systems Plans (N5) is responsible for the Navy-wide planning of the DCS and Navy common user switched systems, connectivity and communications automation. N5 is responsible for the Navy-wide communications plans and requirements of the various transmission systems which interrelate with the NTS and make it compatible with the DCS. N5 is also responsible for the Navy Commercial Communications leased activities.

5. The Assistant Chief of Staff for Supply, Budget and Programming (N7) is responsible for programming funds in the Planning, Programming, and Budgeting System (PPBS) cycle and the allocation and accountability of those funds upon budget execution. N7 is also the contractual management authority for the command and coordinates all supply matters. [Ref. 5:pp. 5-7]

C. AREA ORGANIZATION

The NAVTELCOM claimancy is organized into four Naval communications areas (NAVCOMMAREAs) worldwide, as shown in Figure 3.3
These areas correspond to the geographic areas of responsibility of the numbered fleet commanders. Figure 3.4 presents a breakdown by NAVCOMMAREA of Naval telecommunications activities and their associated Fleet Commanders-in-Chief (FLTCINC) and numbered fleet commanders. Mission requirements categorize the four basic types of stations listed: master, primary support, secondary support, and special support.

1. Master Station

The Naval Communications Area Master Station (NAVCAMS) is the major communications station in a NAVCOMMAREA. The NAVCAMS is responsible for

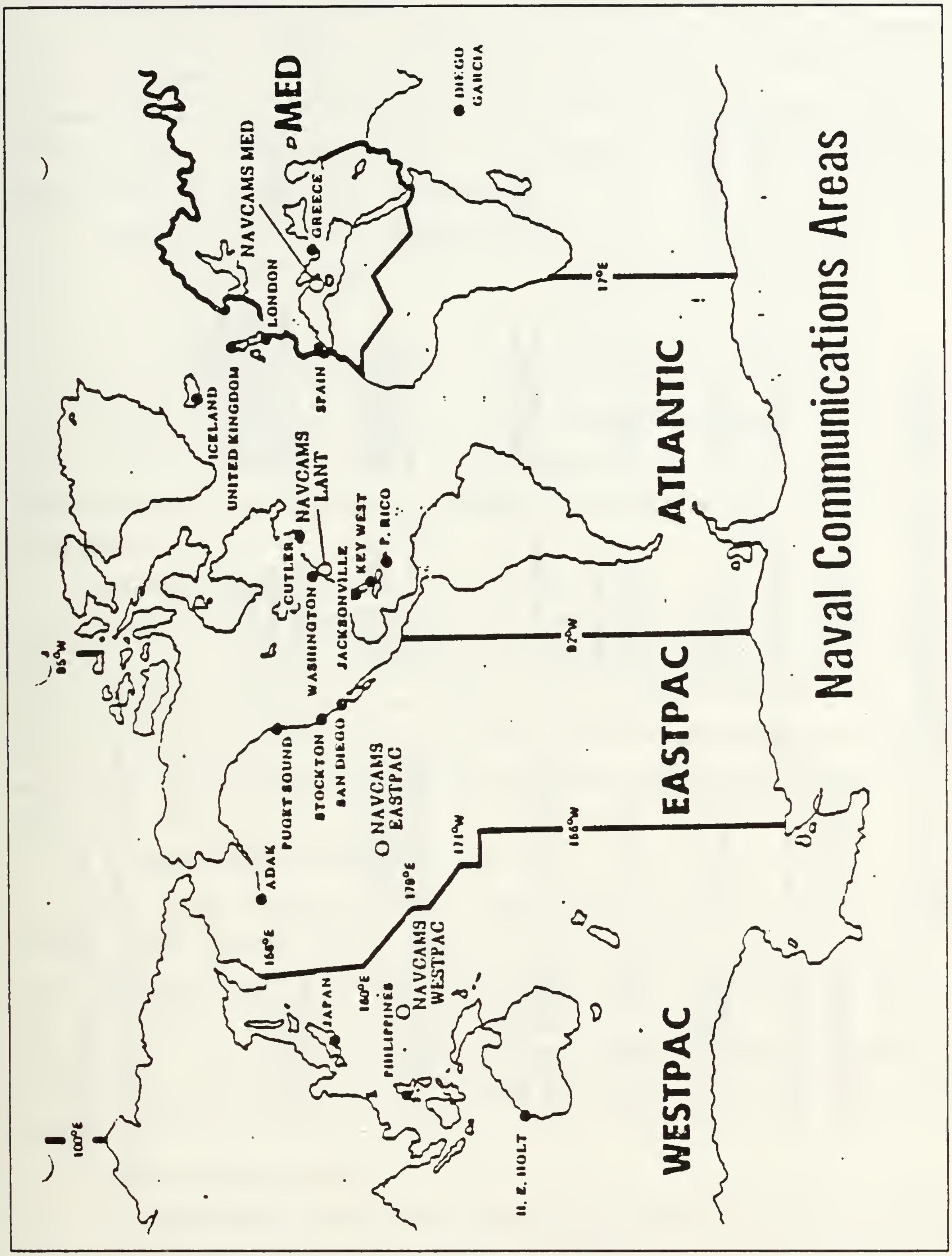

Figure 3.3 Naval Communications Areas (Pictorial).

NAVAL COMMUNICATION AREAS

NAVCOMAREA	EASTPAC	WESTPAC	LANT	MED
MASTER STATION	NAVCAMS EASTPAC	NAVCAMS WESTPAC	NAVCAMS LANT	NAVCAMS MED
FLEET COMMANDER in-CHIEF	CINCPACFLT	CINCPACFLT	CINCLANTFLT	CINCUSNAVEUR
OPERATING FORCES	THIRD FLEET	SEVENTH FLEET MIDEASTFOR	SECOND FLEET	SIXTH FLEET
PRIMARY SUPPORT STATION(s)	* NCS STOCKTON	NCS PHILIPPINES	NCS PUERTO RICO * NCS STOCKTON	NCS SPAIN
SECONDARY SUPPORT STATION(s)	NCS PUGET SOUND NCS SAN DIEGO NSGA ADAK (NAVTELCOMDEPT)	NCS DIEGO GARCIA NCS JAPAN NCS H.E. HOLT	NCU KEY WEST NCS U.K. NCS ICELAND	NCS GREECE
SPECIAL SUPPORT STATIONS		CFA CHINHAE CFA OKINAWA CFA SASEBO	NCS JACKSONVILLE NCU CUTLER ** NCU WASHINGTON ** NAVAUTODINSCEN Albany	NCU LONDON

* Swing CAMS (ALTCAMS For Both EASTPAC And LANT)

** Reports Directly to COMNAVTELCOM

Figure 3.4 Naval Communications Areas (listing).

overall communications in its assigned geographic region. It is also the primary fleet broadcast keying station (BKS) for the area, the entry point for Navy tactical satellite systems and primary operator and maintainer of at least one Defense Satellite Communications System (DSCS) terminal. The fleet broadcast is the primary means of delivering message traffic to ships at sea. The BKS is the activity responsible for placing message traffic directly into the broadcast.

The four NAVCAMS are located as follows:

NAVCAMS LANT	Norfolk, Virginia
NAVCAMS MED	Naples, Italy
NAVCAMS EASTPAC	Wahaiwa, Hawaii
NAVCAMS WESTPAC	Finegayan, Guam

NAVCOMMSTA Stockton is uniquely configured to operate as a "swing CAMS" for NAVCAMS LANT and NAVCAMS EASTPAC. As such, NAVCOMMSTA Stockton has the capability to perform most of the functions of a NAVCAMS.

2. Primary Support Station

Primary support stations are those designated communications stations that because of their size and equipment facilities are capable of carrying out the minimum essential functions required in the event of a NAVCAMS failure. They also supplement and extend those facilities of a NAVCAMS by providing tactical and DCS entry points during periods of extended fleet operations and contingencies. [REF. 3:p. IV-1]

3. Secondary Support Stations

Secondary support stations are activities which provide limited communications coverage within a specified NAVCOMMAREA. They provide limited HF or satellite coverage, including full period terminations, which may be remoted to the NAVCAMS or NAVCOMMSTA Stockton, depending on the station's configuration. A full period termination is a connection of circuits between two commands that is dedicated and keyed full time on designated frequencies. [REF. 3:p. IV-1]

4. Special Support Stations

Special support stations provide indirect fleet support and exist to enhance specific operational and management requirements ashore.

D. NAVCAMS

A Naval Communications Area Master Station (NAVCAMS) performs two major communications functions: (1) operational direction of communications resources within its assigned NAVCOMMAREA and (2) operation and maintenance of its own communications resources. These two functions are separate and are accomplished individually by the Area Operations Department and Communications Department, respectively. The Area Operations Department makes the NAVCAMS unique from a Naval Communications Station. [Ref. 3:p. IV-1]

1. Area Operations Department

The Area Operations Department is responsible for exercising operational direction of the Naval Telecommunications Command within the NAVCOMMAREA. Area Operations is also responsible for planning and allocating area communications operational requirements, coordination of the DCS related operational functions, real-time management of resources to correct unforeseen deficiencies or difficulties in satisfying requirements, and analyzing system performance to improve effectiveness and operating efficiency. A standard organizational chart for a NAVCAMS Area Operations Department is shown in Figure 3.5 There may be deviations from this organizational structure at the individual NAVCAMS, which must be approved by COMNAVTELCOM. [Ref. 6:p. 2-3]

a. Area Requirements Division

The Area Requirements Division is responsible to the Area Operations Officer for the operational configuration of communications equipment to satisfy requirements. Area Requirements is responsible for the following tasks:

a. Receive requests from system users for future service. Any correspondence or document which indicates a valid requirement for communications services is a request for service.

b. Prepare subsystem configurations using available resources to satisfy stated requirements. Configurations may specify equipment type, frequencies, and priority to support a specific circuit and its alternate routing.

c. Maintain status of available NAVCOMMAREA resources by station type, capability, availability, and current assignment.

d. Manage area telecommunications operating requirements (TELCORs) to include:

   (1) Area and station facilities report

   (2) Area and station summary TELCORs or Operations Requirements

   (3) DCS trunk and circuit data base

A TELCOR is a document unique to each telecommunications activity which specifies major communications equipment possessed by the command to meet mission-specified telecommunications requirements.

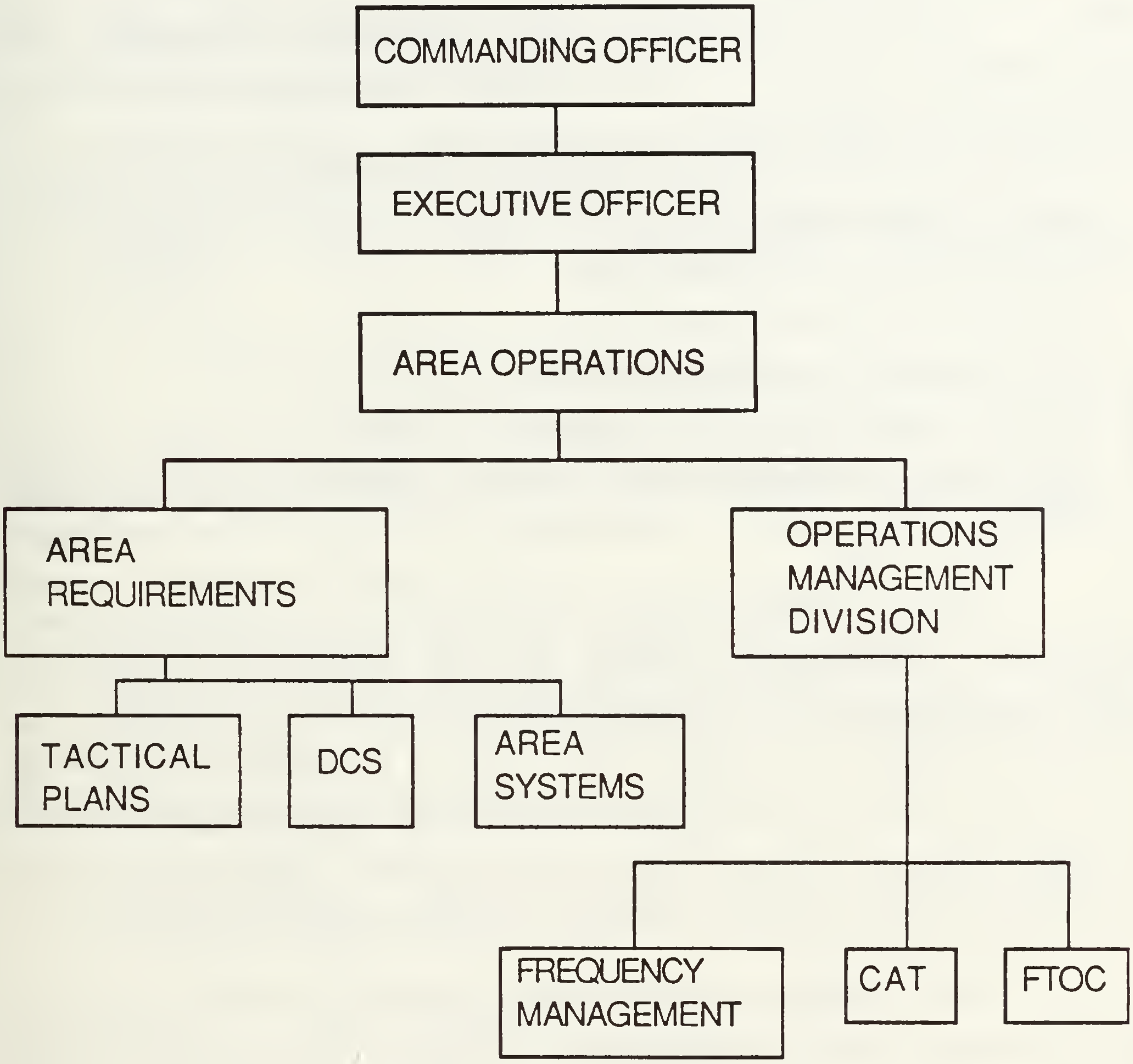

Figure 3.5 NAVCAMS Area Operations Department.

e. Develop and maintain area and inter-area tactical communications restoral plans.

f. Provide operational plans assistance when requested.

g. Develop and maintain contingency restoral plans for area trunks and circuits.

h. Coordinate all area operational communications planning with operational commanders and appropriate afloat units. [Ref. 6:pp. 34-36]

(1) *Tactical Plans.*

Each NAVCAMS has overall responsibility for operational and exercise planning within the NAVCOMMAREA. The Tactical Plans Officer is responsible for the following tasks:

a. Determination and assignment of the need for special communications support.

b. Satellite loading and scheduling.

c. Operational use of transmission paths.

d. Alternate circuit routing schemes.

e. Communications evaluation and analysis.

f. Special message routing, handling, and guard arrangements.

g. Scheduling and coordination of NTS/station outages with the FLTCINC, numbered fleet commanders, and other appropriate operational authorities. [Ref. 3:p. VI-2]

(2) *DCS Plans.*

The DCS Plans Division is responsible to the Area Requirements Officer for the documentation of tactical and DCS activation and deactivation, coordination and maintenance of the NAVCAMS OPNAV 2010-2 reports, and other clerical tasks as assigned. The OPNAV 2010-2 report is a classified document which provides the current status of a communications operating facility, including a listing of all communications circuits, landlines, voice switching facilities (AUTOVON, AUTOSEVOCOM), equipment, and authorized manpower assignments. [Ref. 6:p. 35]

(3) *Area Systems.*

The Area Systems Officer is responsible to the Area Requirements Officer for communications operational readiness planning. The Area Systems Officer reviews current requirements for DCA systems, determines future requirements for DCA systems and provides plans for their implementation.

b. Operations Management Division

This division in the Area Operations Department is responsible for the day-to-day operations and management of the NTS and DCS assets of the NAVCOMMAREA. Division personnel evaluate overall system performance in handling message traffic, direct changes in routing, and institute other traffic control measures. Specific responsibilities of the Operations Management Division include:

a. Operate a Fleet Telecommunications Operations Center (FTOC).

b. Provide for a Communications Assistance Team (CAT) for afloat and shore units.

c. Conduct analyses of area communications operations.

d. Assist fleet commanders with real-time operational and exercise communications planning.

e. Manage assigned frequency assets.

f. Coordinate with area communications stations and adjacent NAVCAMS for communications planning and contingency restoral.

g. Functions as Satellite Communications Area Control Activity to exercise operational direction of assigned satellite terminals within the area of responsibility, as designated by COMNAVTELCOM and the FLTCINC. [Ref. 3:p. VI-3]

(1) *Frequency Management Division.*

The Frequency Management Division is responsible for providing intra-area frequency management and interference protection support for the NTS within the NAVCOMMAREA to Navy and Marine Corps commands for tactical and assigned non-tactical operational communications. Specific responsibilities of the Frequency Management Division include:

- Manage radio frequency resources assigned to the NAVCOMMAREA. Plan, develop, and revise assignments of authorized frequencies and operating schedules to provide optimum operating assignments and interference protection to other NTS commands and activities for operational ship-to-shore, shore-to-ship, air-to-air, ground-to-air, and fleet and aeronautical broadcast communications.
- Formulate and provide frequency management direction and policy guidance to subordinate frequency coordinators.
- Be responsible for management and use of spectrum allocations within the NAVCOMMAREA. Formulate and develop frequency assignment plans for those portions of the spectrum allocated to support Navy and Marine Corps communications requirements.

The Joint Frequency Management Office, Atlantic (JFMO LANT) has been chartered by USCINCLANT to coordinate frequency assignments for USCINCLANT, CINCLANTFLT, and NAVCAMS LANT. This is an approved deviation from the standard organization. [Ref. 3:p. VI-3]

(2) *Communications Assistance Team (CAT).*

The CAT provides technical, operational, and administrative communications assistance and training to ships and shore units within the NAVCOMMAREA. Specifically, the CAT performs the following functions:

1) Conduct shipboard communications training and assistance visits for fleet and NATO units.

2) Present briefings on communications configurations and operations for fleet units and shore commands.

3) Coordinate with other NAVCAMS to ensure fleet units transiting to other NAVCOMMAREAs are provided with up-to-date communications information.

4) Coordinate with appropriate staffs and agencies to resolve shipboard technical problems identified during CAT visits.

5) Write and update Communications Information Bulletins (CIBs). A CIB is a document issuing procedures which are unique to a specific communications area. Each NAVCAMS publishes and maintains CIBs.

(3) *Fleet Telecommunications Operations Center (FTOC).*

Each NAVCAMS operates an FTOC which functions as the primary control point for the day-to-day utilization and operation of NTS assets within the NAVCOMMAREA. FTOCs inform COMNAVTELCOM and the FLTCINC on a near real-time basis of the operational status of their NAVCOMMAREAs, i.e., any situation which impairs, or may impair, the ability of any element of the NTS to support the fleet or National Command Authority (NCA). FTOCs operate control and coordination circuits with each station in their NAVCOMMAREA, as well as with the FLTCINC, the adjacent NAVCAMS, and COMNAVTELCOM's Naval Telecommunications Command Operations Center (NTCOC).

FTOC functions include the following:

1) Direct the NAVCOMMAREA communications activities to activate/deactivate or reroute circuits and allocate existing resources as required to provide reliable quality communications to forces afloat and to other assigned users of the NTS.

2) Receive near real-time reports from NAVCOMMAREA communications activities and operational forces on current status transmission systems and reconfigure portions of the system, when required, in accordance with standard alternate routing procedures and plans.

3) Receive reports from traffic handling facilities, such as message centers, NTCCs, and NAVCOMPARS/LDMX sites on traffic loading and backlogs. Receive reports on equipment problems which delay message or voice traffic relay or processing. Initiate corrective action as necessary to alleviate or correct problem areas.

4) Monitor and evaluate the operational impact of actual or potential disruptions or degradations to the NTS and assigned elements of the DCS. Provide timely reporting of such difficulties to the FLTCINC and COMNAVTELCOM. [Ref. 3:p. VI-4]

5) Manage the DCS elements within their assigned NAVCOMMAREA on a real-time basis. Details of this function will be included in Chapter Four.

2. **Communications Department**

The Communications Officer is responsible to the Commanding Officer for the management and operation of communications facilities, systems, and equipment. The Communications Department configuration of a NAVCAMS is similar to that of any NAVCOMMSTA. The Communications Department is divided into several major components: transmitter site, receiver site, communications center, and satellite earth terminal, when applicable.

The **receiver site** is equipped with the necessary facilities and equipment to receive radio frequency energy and convert it into usable signals. The basic functions include receiver tuning, DC/audio patch panel manipulation, quality monitoring of received signals, and antenna control.

The **transmitter site** is equipped with the necessary facilities and equipment to radiate radio frequency energy to distant stations. The basic functions include transmitter tuning, DC/audio patch panel manipulation, quality monitoring of transmitted signals, and antenna switching.

The **communications center** is subdivided into a message center, fleet center, and technical control. The **message center** prepares messages for transmission, receives and provides for the delivery of incoming messages, maintains required files of all traffic handled, and originates all service messages required for the proper and expeditious handling of all message traffic.

The **fleet center** is the division of the Communications Department that provides an interface between shore and afloat communications systems. Systems and circuits typically associated with fleet center operations include:

- NAVCOMPARS
- Fleet Broadcasts
- Full Period Terminations
- Primary Ship/Shore
- Other dedicated teletype circuits

The **technical control** division, commonly known as **tech control** is the focal point of the Communications Department. Tech control is the command's central monitoring point for all transmit and receive circuits. Specific functions of tech control include:

- Direct receiver and transmitter site operations to maintain reliable communication paths.
- Restore disrupted circuits via alternate paths.

- Replace failed equipment through patching facilties.
- Coordinate the use of shared frequencies.
- Coordinate and direct efficient communications with: tech control centers of connected NAVCOMMSTAs, AUTODIN Automatic Switching Centers, ships with full period terminations; the command's receiver site, transmitter site, message center, fleet center, computer center, and FTOC (for NAVCAMS only). [Ref. 6:pp. 12-30]

The **satellite earth terminal** is normally located in a remote area, separated from the Communications Station in order to minimize frequency interference. This terminal complex provides the transmission and receive capability between satellite users and satellite systems.

E. NAVCOMMSTA

A NAVCOMMSTA is a communications station with a primary responsibility for communications in a large, specific area. It includes all communications facilities and equipment required to provide essential fleet support and fixed communication services. Figure 3.6 presents a typical NAVCOMMSTA organizational chart. Only the largest stations or those receiving little or no support from host or nearby activities may require all of the departments shown. The Communications Department functions are identical to those already described for the NAVCAMS Communications Department. The Communications Officer is often also assigned the duties of Operations Officer.

F. NAVCOMMUS AND NAVCOMMDETS

NAVCOMMUs and NAVCOMMDETs are telecommunications facilities that are assigned limited or specialized missions. They are much smaller than NAVCOMMSTAs in terms of personnel and facilities.

G. NAVAL TELECOMMUNICATIONS CENTERS (NTCCS)

An NTCC is a shore telecommunications activity, normally serving more than one organization (both shore and afloat units). Each NTCC is responsible for the transmission, receipt, acceptance, processing, and distribution of incoming and outgoing messages.

NTCCs provide communications services to all approved DOD subscribers within their discrete geographical locations. For example, NTCC Little Creek serves all of the DOD commands located on or near Naval Amphibious Base Little Creek, Virginia. Service may also be provided to non-DOD government subscribers, if approved by CNO.

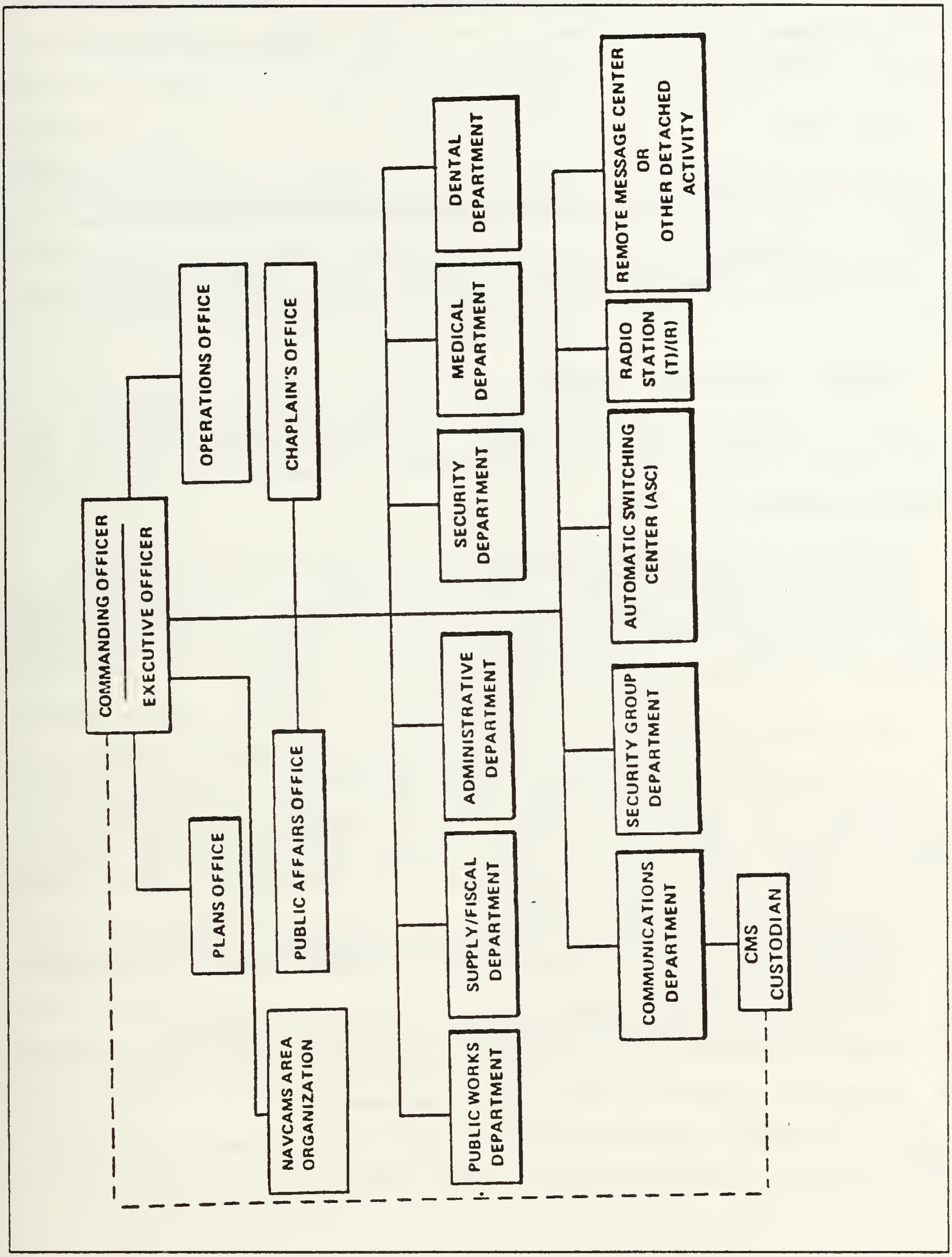

Figure 3.6 Typical NAVCOMMSTA Organization.

OPNAVINST 2300.42 promulgates the policy for the operation, consolidation, and maintenance of NTCCs. A listing of the forty-five NTCC assigned by CNO is provided in Appendix A.

H. ASCOMM

An Anti-Submarine Warfare Support Communications (ASCOMM) activity supports P-3 operational missions, providing data and voice links between the communications center and the aircraft. The ASCOMM is co-located with an Anti-Submarine Warfare Operational Center (ASWOC), acting as its communications center.

I. SPECIAL COMMUNICATIONS

Special Communications (SPECOMMs) handle general service messages that require special handling, as well as special intelligence (SI) messages that are governed by stringent controls.

J. NAVAL TELECOMMUNICATIONS AUTOMATION SUPPORT CENTER

NAVTASC provides, operates, and maintains a telecommunications automation support center where NTS software and firmware components are developed, maintained, and supported in compliance with established standards.

K. NAVAL TELECOMMUNICATIONS SYSTEMS INTEGRATION CENTER

NAVTELSYSIC was established on 15 September 1975 and is jointly manned by NAVTELCOM and SPAWAR systems command personnel. NAVTELSYSIC's functional mission areas include testing, software maintenance, and training. NAVTELSYSIC's specific functions include:

- Provide, operate and maintain a Naval telecommunications certification facility where all Naval automated systems ashore and afloat may be tested, integrated, operated and certified.
- Recommend and establish NTS standards for use afloat and ashore.
- Develop and implement network control and emergency software repair.
- Recommend approval of new automation equipment.

NAVTELSYSIC's current system test responsibilities include: NAVMACS, CUDIXS, LDMX, NAVCOMPARS, I-S/A AMPE, RIXT, and SSIXS. [Ref. 5:p. 18]

L. NAVAL ELECTROMAGNETIC SPECTRUM CENTER

NAVEMSCEN exercises the Department of the Navy management and assignment authority for national and international electromagnetic spectrum management matters. In support of this mission, NAVEMSCEN performs the following functions:

- Exercises centralized management and control over the acquisition, allocation, assignment, notification, and protection of DON spectrum resources.
- Participates in DON, DOD, allied, national, and international spectrum management policy, coordination, and guidance development conferences.
- Collaborates with appropriate offices of other government agencies to formulate spectrum management policies, standards, and procedures.
- Authorizes frequency assignment applications ensuring conformance, compliance, and compatibility with departmental, national, and international rules, regulations, and procedures.
- Develops technical standards, propagation analyses, and spectrum plans and projects.
- Provides guidance, training, and procedures for DON spectrum management.

NAVEMSCEN has access to a computer software to assist in day-to-day frequency allocation and assignment functions. The software includes automatic frequency assignment proposal analysis, generation of intermodulation-free frequency families, reduction and retrieval of usage information, and a number of propagation programs tailored to specific Naval requirements. [Ref. 5:p. 19]

M. NAVY COMMERCIAL COMMUNICATIONS OFFICE

NAVCOMCO manages Navy-leased dedicated and common user systems including AUTOVON, AUTODIN, AUTOSEVOCOM, Defense Switched Network (DSN), Defense Data Network (DDN), and Defense Commercial Telecommunications Network (DCTN). NAVCOMCO also developes policy and standards for base administrative telecommunications systems for ashore Navy and Marine Corps activities worldwide, provides overall support to major NAVTELCOM claimants for the lease, acquisitions and management of telecommunications equipment and service. [Ref. 5:p. 21]

IV. NTS INTERACTION WITH MAJOR COMMANDS AND AGENCIES

A. INTRODUCTION

The Naval Telecommunications System (NTS) denotes the whole communications effort within the Department of the Navy. This effort needs both guidance and support in order for it to fulfill its mission of providing reliable, secure, and rapid communications within the Navy. There are several commands and agencies that interact with NAVTELCOM in helping guide and support the NTS.

This Chapter describes the major commands and agencies that help make the NTS a dynamically functioning effort. The Offices of the Chief of Naval Operations (OPNAV) handle the overall planning, programming, and budgeting for the NTS. The Defense Communications Agency (DCA) manages the Defense Communications System (DCS), perhaps the largest complex of networks that interact with the NTS in providing point-to-point connectivity.

Space and Naval Warfare Systems Command is the primary technical authority for electronic systems and equipment used within the NTS. Naval Space Command manages the vital space communications resources of the NTS. The Frequency Managers (international, national, and military) manage the electromagnetic spectrum resources, ensuring that the subsystems of the NTS have the frequencies available over which vital communications links are established. The Fleet Commanders-in-Chief (FLTCINCs) are not only users of the NTS. They also exercise operational direction and control of the communications assets within their respective areas of responsibility.

There are many other commands and agencies that support the NTS effort whose descriptions are beyond the scope of this thesis.

B. OFFICES OF THE CHIEF OF NAVAL OPERATIONS (OPNAV)

The Chief of Naval Operations exercises overall authority throughout the Department of the Navy for communications (except over areas where the Commandant of the Marine Corps is responsible). This authority has been delegated to the Director, Space, Command and Control (OP-094).

1. Director, Space, Command and Control (OP-094)

The mission of OP-094 is to exercise centralized coordination over policy, planning, and integration of requirements for Navy command and control, including:

communications, space exploitation, space defense matters, reconnaissance, ocean surveillance (less SOSUS), and COMSEC. OP-094 is also responsible for determining the characteristics, development, appraisal, and coordination of program execution for C2 systems (including satellite communications, surveillance, navigation, and environmental sensing systems). OP-094 acts as principal advisor to the CNO on C2 matters; ensures optimum use of Navy information systems; and acts as the CNO's representative to other services and the government for matters involving COMSEC, communications, space matters, WWMCCS, information systems, and Navy Electromagnetic Impulse (EMI). [Ref. 7:pp. 3-5]

The OP-094 staff responsibilities are divided among five divisions. Figure 4.1 presents an organizational chart of OP-094.

a. Command and Control Planning and Programming Division (OP-940)

OP-940 is responsible for:

- Developing C2 plans and policies for the Navy and coordinating them with joint, allied, and national elements.
- Supervision and coordinating C2 planning, programming, and budgeting.
- Ensuring that requirements of the operational commander are incorporated in the planning and development of C2 communications systems.
- Acting as principal point of contact for Navy tactical C2 requirements. [Ref. 7:p. 940-1]

b. Naval Communications Division (OP-941)

Serving as principal staff advisor to the CNO on telecommunications matters, OP-941 exercises policy direction for the control, administration, and management of the NTS less space communications. OP-941 also assists OP-940 in developing overall planning, programming, and budgeting matters.

OP-941's functions include:

1. Coordinate telecommunications matters with appropriate Navy offices, other services and agencies, JCS, SECNAV, OSD, and allied Navies.
2. Coordinate with OP-940 in preparing telecommunications program support including: requirements definition, analysis and validation of cryptographic requirements, system concepts, planning, development, procurement and installation, and operations and maintenance support.
3. Determine priorities for communications programs and recommend priorities to OP-094 when necessary.
4. Act as the program sponsor for development, production and procurement of communications equipments and systems required by general purpose (less aircraft) and strategic forces.
5. Develop and recommend policy and direct the discharge of the Navy's responsibilities in matters relating to the DCS and the NCS.

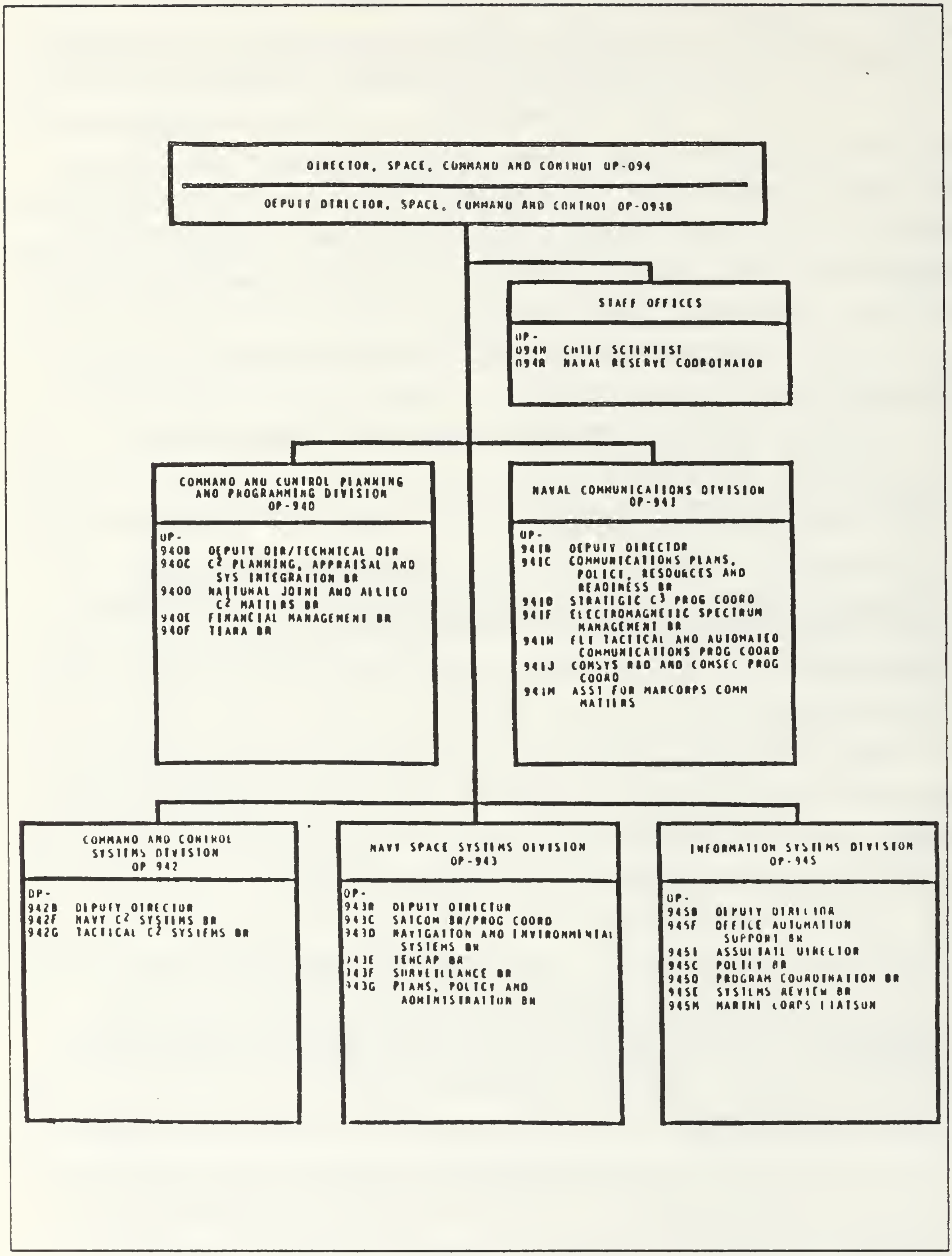

Figure 4.1 OPNAV-094 Organizational Structure.

6. Review Navy, joint and allied plans for communications implications; coordinate these with OP-940 to ensure that planning for communications systems meets C2 objectives and provides the interoperability and integration of Navy communications systems with joint, national, and allied systems.
7. Provide policy for the operation, maintenance, and management of the NTS.
8. Develop and recommend policy relating to employment of ~~strategic~~ communications assets.
9. Develop and recommend policy on matters pertaining to the use and management of the electromagnetic frequency spectrum within the Navy. Provide representation at joint, national, and international levels on such matters.
10. Coordinate Navy programs in support of requirements for automated communications systems afloat and ashore.
11. Validate cryptographic equipment requirements for ship, air, and shore systems.
12. Act as program sponsor and primary consultant for communications subspecialists, responsible for developing subspecialty requirements. Coordinate with subspecialty coordinators within OPNAV, CNET, and COMNAVMILPERSCOM to ensure that communications subspecialist needs are identified and met.
13. Act as program sponsor and coordinator for tactical communications acquisitions. Define requirements and manage development, procurement operation, and logistics support of tactical radio systems (less aircraft and satellite systems).
14. Coordinate assigned OP-094 Communications Navy Enlisted Classification (NEC)-related matters, including radioman (RM) "A" school.
15. Review concepts, methods, pocedures, and doctrine of the DON, joint, and allied communications.
16. Coordinate Electromagnetic Pulse (EMP) survivability efforts for Navy C2 programs. [Ref. 7:pp. 941-1 - 941-4]

c. Command and Control Systems Division (OP-942)

OP-942 acts as program sponsor, under OP-094, for assigned Navy C2 systems in compliance with approved plans and policies; assists in developing overall planning, programming, and budgeting matters required to execute assigned programs; ensures that developed subsystems are responsive to stated requirements and overall planning objectives; and acts as point of contact for participation in support of joint and allied matters that pertain to tactical data links and data link message standards.

OP-942's functions include:

- Recommend requirements and procedures for developing plans for use of Automated Data Processing (ADP) in the Navy C2 systems.
- Determine C2 training, foreign military, and Battle Group tactical training requirements for OP-942 programs.
- Act as the Navy C2 system ashore program sponsor and program coordinator for OP-941.
- Function as OP-094 for overseeing tactical development and concepts.

- Function as OP-094 coordinator for C2 systems postgraduate subspecialists. [Ref. 7:p. 942-1]

d. Navy Space Systems Division (OP-943)

OP-943's mission is to develop, under OP-094, a composite Navy space systems program for surveillance, communications, navigation, C2, environmental sensing, targeting, indications and warning; to act as the principal point of contact within the Navy for C2 space matters, including policy and planning for the exploitation and defense of space; to act as program sponsor for C2 space systems acquisitions; to ensure that Navy space systems are responsibe to the operational commanders; and to represent the DON in interdepartmental, DOD and national committees, boards, agencies, and studies related to space systems.

OP-943's functions include:

1. Assess future satellite and space concepts and applications as they relate to the Navy C2 plan.
2. Coordinate with OPNAV warfare and platform sponsors, the JCS, OSD, and other government agencies all non-programmatic space plans and policy issues.
3. Monitor all national space programs to determine Navy applicability, ensuring that those space systems developed consider support to Naval operations where feasible.
4. Act as OPNAV focal point for all radio navigation matters related to overall policy, performance standards and integration of ship, submarine and air requirements that can be satisfied by common systems. Recommend solutions in conjunction with radio navigation program coordinators for inclusion in the C2 plan.
5. Act as the resource sponsor for COMNAVSPACECOM.
6. Develop and recommend policy concerning Navy, national, and other space programs and Navy participation.
7. Act as central point of contact for all man-in-space issues, coordinating with NASA and other agencies on all Navy astronaut policies and issues.
8. Act as the space engineering and space operations curricula sponsor for the Naval Postgraduate School.
9. Determine space systems training resource requirements for programs supported by OP-943. Ensure resources are available to effectively implement and adequately support identified training needs. [Ref. 7:pp. 943-1 - 943-3]

e. Information Systems Division (OP-945)

OP-945's mission is to ensure optimum Navy information systems (ashore and afloat, combat and support) by providing policy, guidance, planning, standards, and assessment.

OP-945 serves as principal advisor to OP-094 on all matters pertaining to informations systems resources including: information resources management, information requirements, information and office systems, embedded computer resources, mission critical computers, data processing, records and forms management, postal affairs, and computer security. OP-945 also develops the top level information systems architecture for the Navy and strategic information systems plan in support of that architecture; assures maximum practicable standardization of information systems; designs and installs wide-area data networks serving Navy headquarters commands in the Washington, D.C. area; and provides a source of technical and management expertise in office automation and microcomputers for SECNAV and other Navy activities. [Ref. 7:p. 945-1]

C. DEFENSE COMMUNICATIONS AGENCY (DCA)

During World War II, the need for coordinated and standardized communications among the U.S. military services became apparent. Army and Navy facilities were sometimes duplicated in one geographic location, used different communications procedures and caused inefficient interservice communications. Since 1961, DOD has tried to standardize communications procedures throughout the services by the Defense Communications Agency (DCA).

The primary mission of the DCA is to perform system engineering for the Defense Communications System (DCS) and insure that the DCS is planned, improved, operated, maintained, and managed effectively, efficiently, and economically. DCA is also responsible for the following:

- Providing system engineering and technical support to the National Military Command System (NMCS) and the Worldwide Military Command and Control System (WWMCCS).
- Performing system architect functions for current and future Military Satellite Communications (MILSATCOM) systems.
- Procuring leased communications circuits, services, facilities, and equipment for the DOD. [Ref. 8:pp. 1-3]

1. Defense Communications System (DCS)

The DCS is a mixture of government-owned and leased telecommunications circuits, subsystems, and networks that provide the long-haul, point-to-point, and switched network telecommunications needed to satisfy the requiements of DOD and other government agencies.

As part of the overall National Communications System, the DCS comprises the major portions of the individual military branches' communications complexes and provides a single system that is responsive to DOD needs. Each military department maintains and operates its assigned portion of the DCS, but is responsive to the overall direction and supervision of the DCA.

The NTS and the DCS are two different communications systems that are constantly interfaced. A Naval message originated on board a ship and destined for a shore activity leaves the ship over the NTS, but final routing of often accomplished over the DCS circuits of the Navy. NAVCAMS, NAVCOMMSTAs, and NAVCOMMUs are the points where message traffic is transferred between NTS and DCS circuits. The DCS does not normally include land, ship, and airborne communications facilities of broadcast, ship-to-shore, shore-to-ship, and ground-to-air systems.

Operational control of the DCS is accomplished through a complex of communication control centers. Functions of these control centers include: tabulation, assembly, storage, and display of information on the current status of system components; allocation of circuits and channels to meet user requirements; and performance of continuous system analysis. The main objective of the communication control center is to assure optimal responsiveness of the DCS to the needs of its users. [Ref. 8:p. 1]

The focal point for all of these control centers is the DCA Operations Center (DCAOC), located in the Washington, D.C. area. The DCAOC maintains the status information on major trunking and vital circuits throughout the world. With this information the DCAOC coordinates restoral actions with DCA field elements.

Subordinate to the DCAOC are the four Area Communications Operations Centers (ACOCs), located in Hawaii, Germany, Alaska, and Colorado, that exercise operational control of DCS components in their geographical areas. Subordinate to the area centers are the Regional Communications Operations Centers (RCOCs), which take care of the DCS within their regions and ensure that the DCS is responsive to the changing needs of area commanders. [Ref. 8:pp. 2-5]

The following DCA systems commonly interface with the NTS.

a. AUTODIN

The Automatic Digital Network (AUTODIN) is a worldwide computerized, general purpose communications system that transmits both narrative and data traffic via secure means. The main objective of AUTODIN is to provide reliable, secure, and efficient communications, incorporating error detection and high speed transmission. AUTODIN consists of switching centers that are interconnected by trunk lines. Each AUTODIN Automatic Switching Center (ASC) has local lines that radiate from it to each subscriber terminal. There could be as many as 300 subscribers connected to one

ASC. The function of the ASC is to accept messages from its subscribers, determine their classification and precedence, and relay the correctly formatted messages to the addressed subscribers.

b. AUTOVON

The DCS Automatic Voice Network (AUTOVON) is a direct interconnected network between military and other government installations. It provides direct distance dialing service to support essential command and control, operations, intelligence, logistics, and administrative and diplomatic functions worldwide.

c. AUTOSEVOCOM

The Automatic Secure Voice Communications System (AUTOSEVOCOM) allows voice communications between commands in a secure mode. AUTOSEVOCOM is not available at all commands because of the special equipment and encryption devices required and the strict security measures that must be adhered to by all AUTOSEVOCOM network subscribers.

d. DSCS

The Defense Satellite Communications System (DSCS) is an integral part of the DCS, designed to provide vital communications to the U.S. and Allied forces throughout the world by means of SHF satellites. The DCA, under the guidance of the Secretary of Defense and the JCS, coordinates all phases of the space, terminal, and control segments of the DSCS.

2. Interaction with NAVCAMS

The NAVCAMS FTOC manages the DCS elements within its assigned NAVCOMMAREA on a real-time basis by:

- Assisting the DCA ACOC in restoral action within the NAVCOMMAREA.
- Assisting the DCA ACOC in the management of the AUTODIN system.
- Ensuring that all DCS reporting stations within the NAVCOMMAREA make the appropriate DCS reports to DCA ACOC on a real-time basis.
- Ensuring that NAVCAMS Tech Control keeps the DCA ACOC informed of AUTOVON or AUTOSEVOCOM problems as they occur. [Ref. 3:p. VI-4]

3. DCA Merger

At the time of this writing, DOD is planning the merger of the Joint Tactical Command, Control and Communications Agency (JTC3A) with the DCA. The merger is intended to reduce costs and simplify operations. JTC3A was formed to ensure the interoperability of tactical C3 systems for joint or combined operations. Although DCA primarily plans strategic C3 systems, the distinction between tactical and strategic communications has diminished. [Ref. 9:p. 6]

D. WORLDWIDE MILITARY COMMAND AND CONTROL SYSTEM (WWMCCS)

The WWMCCS provides the means for operational direction and technical administrtive support involved in the function of command and control of U.S. military forces [Ref. 10:p. 1]. The WWMCCS is a total system consisting of personnel, communications, equipment, facilities, and procedures required to plan, direct, and control the operational activities of the military. Communications allows the system to convey both routine and time critical information and to pass orders among components and facilities. The DCS provides the primary communications support to the WWMCCS through its world-wide long-haul communications resources.

The primary mission of the WWMCCS is to support the National Command Authority (NCA), which consists of the President and the Secretary of Defense or their duly deputized alternates or successors.

The Director, Command and Control (OP-094) is the designated OPNAV official responsible to the CNO for matters relating to the WWMCCS. The Director, DCA is responsible for managing the WWMCCS, which is composed of the following:

1. The National Military Communications System (NMCS). The NMCS is the priority component of the WWMCCS designed to support the NCA. It also supports the JCS in the exercise of their duties. The NMCS provides the means by which the NCA can: receive timely and accurate warning and intelligence reports; apply the resources of the military departments; assign military missions andprovide direction to the Unified and Specified Commands. The NMCS command structure includes the National Military Command Center (NMCC), the Alternate National Miitary Command Center (ANMCC), and the National Emergency Airborne Command Post (NEACP).
2. Command and control systems of the Unified and Specified commands.
3. WWMCCS-related management/information systems of the headquarters of the military departments.
4. Command and control systems of the headquarters of the service component commands.
5. Command and control support systems of DOD agencies.
6. Non-DOD systems, including systems that serve the White House Situation Room, the State Department Operations Center, the Central Intelligence Agency, U.S. Coast Guard Operations Center, and other agencies, activities, or centers that may be designated. [Ref. 11:pp. 1-6]

E. SPACE AND NAVAL WARFARE SYSTEMS COMMAND

Naval Electronics System Command (NAVELEX) was renamed in May 1985 as the Space and Naval Warfare Systems Command, commonly referred to as SPAWAR. The redesignation was an attempt to emphasize the Navy's need to integrate space technology into the warfare strategy. SPAWAR, an Echelon 2 Command reporting directly to the CNO, is the primary technical authority for electronics standards, standardization, compatibility, techniques, and procedures within the Department of the Navy.

The primary mission of SPAWAR is to provide the electronics systems needed to meet the command, control, communications and intelligence (C3I) requirements of the Navy and Marine Corps operating forces.

SPAWAR develops and manages the TEMPEST program for measurement and control of unintentional compromising electromagnetic emissions; provides system integration and coordination with respect to reconaissance, electronic warfare, special operations, and Naval intelligence systems; develops and manages a technical program to ensure the security and integrity of Navy ADP systems; develops C3I requirements and specifications for surface ship combat systems; and develops and provides life-cycle support of C3I software. [Ref. 12:pp. 1-5]

The SPAWAR organizational structure facilitates interface with and response to the needs of other Systems Commands and the resource and platform sponsors within the Office of the CNO. The SPAWAR structure is presented in Figure 4.2 The organization is divided into the following elements: Warfare Systems Architecture and Engineering, Space and Sensor Systems, Information Transfer Systems, Information Management Systems, and Weapons and Warfare Support Systems.

F. NAVAL SPACE COMMAND

The Naval Space Command located in Dahlgren, Virginia, was established on 1 October 1983. The CNO designated the Commander, Naval Space Command (COMNAVSPACECOM) as the Operational Manager for the FLTSATCOM and LEASAT satellite systems. (These systems will be discussed in Chapter 5.) As Operational Manager, COMNAVSPACECOM is responsible for effective operation and maintenance of assigned Navy resources to best satisfy DOD requirements. COMNAVSPACECOM's major responsibilities include:

1. Communicate directly with Air Force and Army Satellite Communications Operational Managers to coordinate satellite access support actions.

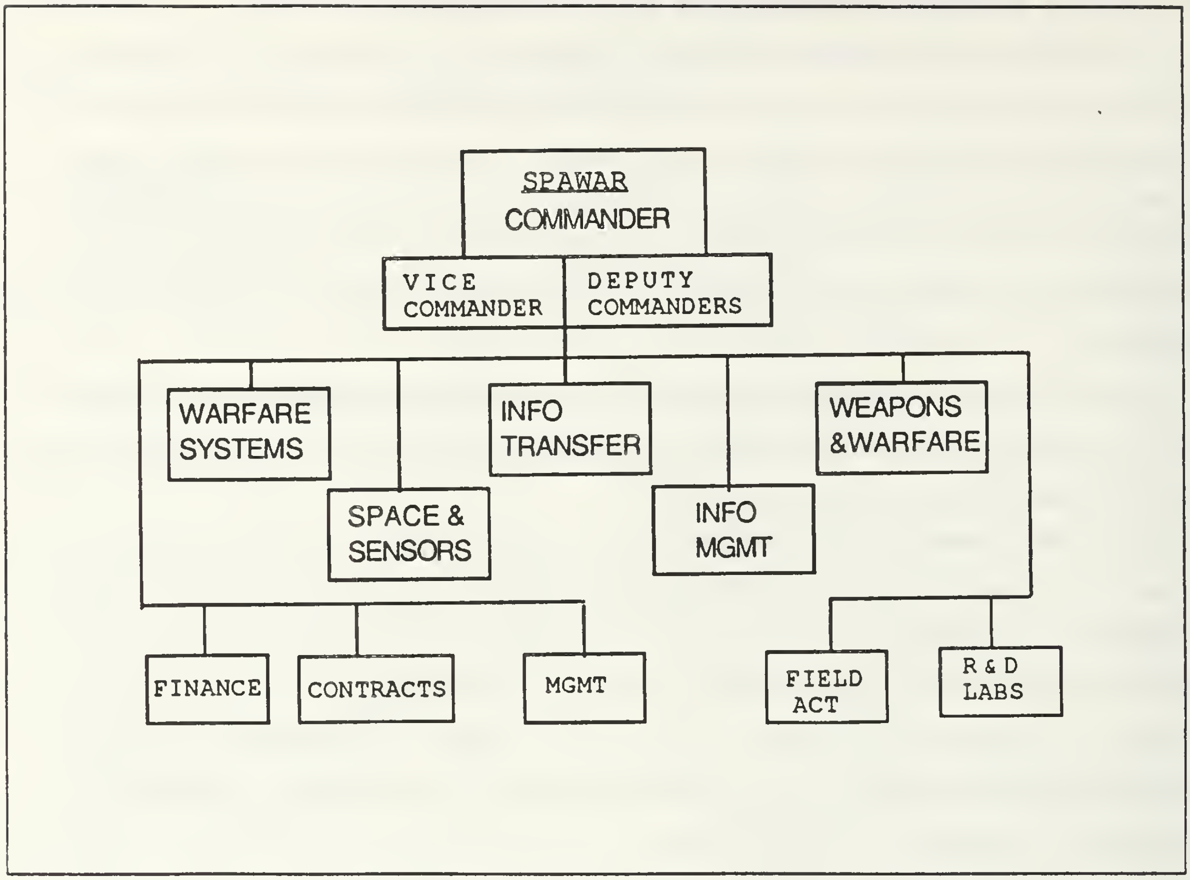

Figure 4.2 SPAWAR Structure.

2. Prepare, update and forward FLTSATCOM and LEASAT systems operation and control concepts to the CNO, the Navy's UHF SATCOM Executive Agent, for approval.

3. Provide recommendations to the CNO concerning systems utilization and development of follow-on systems and plans for contingency use of FLTSATCOM and LEASAT systems.

4. Implement system changes directed by the CNO.

5. Provide guidance on system operations and procedures to system users.

6. With COMNAVTELCOM, determine technical requirements for compatibility, interoperability, interface, and interconnection with other communications systems.

7. Provide an impact assessment on existing SATCOM users, the NTS and/or DCS.

8. Plan guidance for space segments required to support future communications capabilities and design engineering efforts. [Ref. 13: p. 2-6]

The Air Force Space Command was established in September 1982 to consolidate Air Force space activities. It also organizes, trains, equips, and administers forces in support of North American Aerospace Defense Command. The U.S. Army Space Agency was established in August 1986 to plan Army participation and operate space support for Army strategic operational, and tactical operations. [Ref. 14:pp. 3-5]

The U.S. Space Command was activated on September 23, 1985 to consolidate assets affecting U.S. activities in space. USSPACECOM is manned by representatives from the Navy Space Command, Air Force Space Command, and Army Space Agency. USSPACECOM has responsibilities in both the space operations and aerospace defense areas. In the space operations area it is responsible for space control and space support. To insure space control, USSPACECOM must assure access to space for our forces and be capable of denying space access to potential adversaries when and if required. Space support means operating satellites in support of other unified and specified commands and national agencies. In the aerospace defense area, USSPACECOM is responsible for integrated warning of aerospace attack and planning and requirements development for Ballistic Missile Defense. USSPACECOM is also tasked with providing integrated warning and assessment of attacks on the continental U.S. mounted by ballistic missiles, bombers, cruise missiles, and space related threats. [Ref. 14:pp. 1-2]

G. FREQUENCY MANAGERS

The electromagnetic frequency spectrum is managed by a hierarchy of international, national, and military organizations.

1. International

The International Telecommunications Union (ITU) was created in 1865 to regulate the use of the electromagnetic spectrum and to create conditions where interference-free operations can occur. The ITU established international cooperation to ensure improvement and rational use of all telecommunications; promotes the development of telecommunications support facilities and their operation; and coordinates the actions of all nations in providing adequate services to meet all requirements.

The ITU, which consists of 134 member countries, is made up of six structural entities:

a. Plenipotentiary Conference. This Conference, which meets every five years, determines the general policies for the ITU's effective functioning.

b. Administrative Conferences. These Conferences, called World Administrative Radio Conferences (WARCs), meet every 10 to 20 years, and are responsible for reviewing and updating radio frequencies.

c. Administrative Council. This Council meets annually in Geneva, Switzerland to decide on the procedures for implementing ITU regulations. This Council also assists new and developing countries in the area of telecommunications.

d. General Secretariat. The Secretariat provides the administration of the union by scheduling meetings, providing all secretarial work, maintaining records, and publishing reports.

e. International Frequency Registration Board (IFRB). The IFRB is made up of five independent members of the ITU who were elected by the Plenipotentiary Conference. This board makes the official records of the date, purpose, and the technical characteristics of frequency assignments made by the member countries. The IFRB also advises the union on the maximum number of channels in each spectrum segment.

f. International Radio, and Telegraph and Telephone Consultative Committees. These Committees provide recommendations for resolving any technical issues referred to them by the Conferences. [Ref. 15:pp. II-1 - II-3]

2. National

Under the Communications Act of 1934, the framework for national regulation of the use of the frequency spectrum was established with the Federal Communications Commission (FCC) regulating non-government use of the spectrum. The FCC assigns space in the spectrum to private users, such as radio and TV stations; regulates the use of spaces assigned to private users; coordinates with the government on non-government use in shared spectrum bands and in other bands that might have an impact on government operations.

Government use of the spectrum is carried out by the National Telecommunications and Information Administration (NTIA) which is directed by the Assistant Secretary of Commerce for Communications and Information. The FCC and the NTIA work together to ensure the regulation process makes effective use of the spectrum in the achievement of national goals.

The Interdepartment Radio Advisory Committee (IRAC) is subordinate to the NTIA and is made up of members from various government agencies, including the three military departments. Each government agency conducts technical studies to determine its specific spectrum usage requirements and coordinates them with the other agencies. These requirements are then presented to IRAC for approval. The IRAC responsibilities include:

a. Assure compliance with regulations of each frequency application.

b. Assign frequencies to U.S. government radio stations.

c. Develop and execute policies, programs, and procedures.

d. Print and distribute an updated list of frequency assignments to government radio stations.

e. Resolve national policy, planning, allocation, assignment, and notification issues.

f. Maintain permanent subcommittees on technical issues, systems review, frequency assignment, and international notification. [Ref. 15: pp. II-3 - II-5]

3. Military

The Joint Chiefs of Staff establishes policy and provides guidance on joint and interservice frequency engineering and management issues. This JCS guidance is based on the concept of the sharing of frequency resources between government, non-government, and international requirements.

JCS has developed the following specific guidance to Unified and Specified Commands governing the use of the frequency spectrum.

a. Planning for use of the spectrum must be done early to allow time for coordination and processing the requirement before its intended use.

b. DOD components are encouraged to use the frequency engineering and analysis capabilities of the Electromagnetic Compatibility Analysis Center (ECAC). ECAC is a JCS/DOD-directed organization which maintains a comprehensive electromagnetic data base and appropriate mathematical models to study and analyze electromagnetic compatibility problems submitted to it by the military and other DOD agencies.

c. DOD components shall participate in the Frequency Resource Record System (FRRS).

d. Components must advise the assigning authority when the frequency assignment is no longer needed.

e. Commanders will forward requirements to the Military Communications Electronics Board (MCEB) for intercommand requirements, intra-command frequencies where interference to U.S. national or registered international assignments may occur, and space frequencies.

f. Commanders will assign frequencies for their own intra-command use as long as national or international protection is not required, NTIA and FCC installations are not involved, and the host government agrees. [Ref. 15:p. II-5]

a. Department of the Navy (DON)

There are five categories of organizations involved in spectrum management within the DON: sponsors, managers, developers, users, and coordinators.

Sponsors are organizations that establish policy, provide funding, and give overall direction to ensure the spectrum management program effectiveness. Managers lead, direct, and control to ensure effective, efficient, and coordinated use of the spectrum. Developers provide the required communications electronics tasks used to accomplish the Navy's mission, which include basic research, advanced and engineering development, production and procurement. Users install and operate the systems in the accomplishment of their individual missions. Coordinators resolve frequency management and coordination issues within their respective geographic regions. Table 1 lists the organizations that fit into these five categories. [Ref. 15:pp. III-1 - III-8]

TABLE 1

ORGANIZATIONS IN SPECTRUM MANAGEMENT

SPONSORS	DEVELOPERS	USERS	COORDINATORS
Command and Control (OP-094)	Naval Air Development Center	CINCLANTFLT	CINCLANTFLT
Naval Telecommunications Command (NAVTELCOM)	Naval Ocean Systems Center	CINCPACFLT	CINCPACFLT
Depty Chief of Naval Operations (Submarine Warelare) (OP-02)	Naval Personnel R&D Center	CINCUSNAVEUR	CINCUSNAVEUR
Depty Chief of Naval Operations (Surface Warfare) (OP-03)	Naval Weapons Center	CNET	NAVCAMSLANT
Depty Chief of Naval Operations (Air Warfare) (OP-05)	Naval Coastal Systems Center	CNAVRES	NAVCAMSEASTPAC
Depty Chief of Naval Operations (Plans, Policy and Operations) (OP-06)	Naval Surface Weapons Center	CNAVPERS	NTCC Bangor
Office of Naval Warfare (OP-095)	David W. Taylor Naval Ship R&D Center	BUMEDS	AFC Western US
Commandant of U.S. Marine Corps	Naval Underwater Systems Center	NAVSECGRU	
	Navy Maintenance Support Office	NAVTELCOM	
	Navy Maintenance and Supply System Office	NAVOCEANCOM	
	ASW Systems Project Office	NAVINTCOM	
	Navy Astronautics Group	NAVLEGSERCOM	
	Naval Ordnance Test Unit	NAVCIVPERSCOM	
	Polaris Missile Facility	NAVDATACOM	
	Naval Plant Representative Office	NAVDISTWASH	
	Strategic Weapons Facility	CNO Shore Activities	
	Naval Submarine Support Base	USMC Shore Activities	
	Naval Supply Systems Command	CNR Shore Activities	
	Naval Air Systems Command	CI Shore Activities	
	Naval Sea Systems Command		
	Office of Naval Research		
	Space and Naval Warfare Systems Command		

Authority for the use of radio frequencies by Navy and Marine Corps activities within the United States and Possessions (US&P) is obtained fromthe NTIA through the IRAC. US&P is defined as the 50 States and District of Columbia, Commonwealth of Puerto Rico, and the following territories and possessions: Navassa Island, Culebra, Mona, Vieques, Quita Sueno Bank, Roncador Bank, Serrana Bank, Serranilla Bank, Virgin Islands, Baker Island, Guam, Howland Island, Jarvis Island, Johnston Island, Kingman Reef, Midway, Mariana Islands, Pamyra Island, American Samoa, and Wake Island. [Ref. 15:p. III-5]

Authority to use a radio frequency within the US&P by Navy and Marine Corps forces or activities is through a specific assignment normally made by NAVEMSCEN.

b. Military Communications Electronics Board (MCEB)

The MCEB provides a forum on military communications electronics matters for the DOD and government agencies, such as the U.S. Coast Guard and the National Security Agency. The MCEB is composed of senior communications officers of the Army, Navy, Air Force, Marine Corps, JCS and DCA staffs, and a National Security Agency representative.

The primary objective of the MCEB is to achieve interoperability and standardization in the various functional areas of military communications electronics for which the board is assigned responsibility by the Secretary of Defense or the JCS. The MCEB provides military radio frequency engineering and management policy within DOD; governs use of the spectrum within DOD; conducts a formal 5-year review of all US&P frequency assignments; develops common procedures for interservice coordination and allocation of frequencies; and prepares and issues Joint Army, Navy, and Air Force Publications (JANAPs) and Allied Communications Publications (ACPs). [Ref. 16:pp. 1-4]

H. FLEET COMMANDERS-IN-CHIEF (FLTCINCS)

FLTCINCs maintain authoritative direction and control of Naval broadcasts, ship-to-shore, air-to-ground, and other direct fleet support telecommunications functions performed by activities of the Naval Telecommunications Command within their geographic areas of responsibility. According to NWP-4, this authoritative direction and control involves the adequacy of the telecommunications arrangements, the effectiveness of the services rendered, and the responsiveness in satisfying the operating requirements of the operating forces in the areas of command of the respective FLTCINCs. Direct coordination and liaison between COMNAVTELCOM and the FLTCINCs is authorized. Since COMNAVTELCOM has delegated full authority to the commanding officer of each NAVCAMS to direct the operations of NAVTELCOM activities within the NAVCOMMAREA, the NAVCAMS is normally the primary point of contact through which the FLTCINC exercises direction and control of communications assets. [Ref. 2:p. 1-5]

Frequency assignments for Naval use are made through the Unified Commander to the FLTCINC for scheduling to meet overall operational requirements. The FLTCINC acts as the clearing house for all requirements in that area of responsibility and for all subassignments of frequencies assigned to the FLTCINC for meeting these operational requirements.

FLTCINCs may, in a major emergency, assume temporary operational control of any NAVTELCOM resource within their area of responsibility. FLTCINCs may not, however, interfere with any NAVTELCOM assets that are already scheduled for, or engaged in mission support for other FLTCINCs or higher authority. The FLTCINC will immediately advise the CNO, COMNAVTELCOM, and the affected NAVCAMS of the emergency and its estimated duration. Figure 4.3 shows the chain of command between FLTCINCs, DCA, and NAVTELCOM. [Ref. 3:p. V-1]

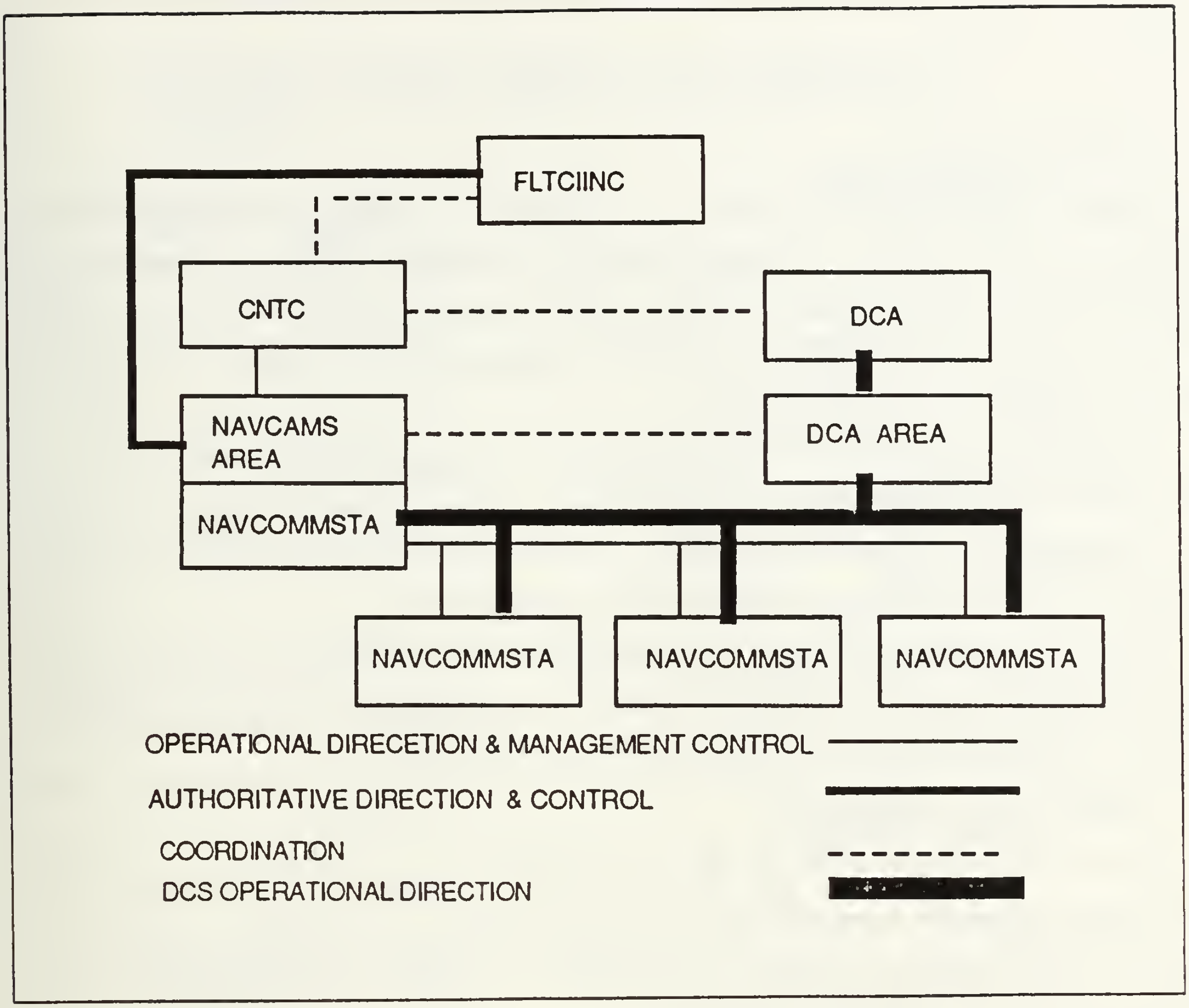

Figure 4.3 Chain of Command Within A NAVCOMMAREA.

V. SYSTEMS USED WITHIN THE NTS

A. INTRODUCTION

The NTS was defined earlier as a complex of systems, subsystems, and equipments that provides telecommunications networks for the operation, administration, command and control of Navy resources. These systems and subsystems were each designed for specific purposes, yet the common underlying purpose for each is service to the fleet.

A specific system may have various methods of transmission available, such as landline, HF, UHF Line of Sight, or satellite paths. These transmission media should not be confused with the individual systems. They are not part of the system; they are the means over which the systems information is transferred.

Chapter Five first presents a brief description of the transmission media most commonly used within the NTS. The reader is then provided with non-technical descriptions of the major systems and subsystems of the NTS.

B. FREQUENCY SPECTRUM

Basic to the discussion of the NTS is an appreciation for the size and nature of the frequency spectrum, a natural resource that is limited and controlled. Figure 5.1 shows the electromagnetic spectrum and provides an enlarged view of that portion representing the radio frequency spectrum.

Radio waves of different frequencies differ in their properties. Table 2 lists the different radio frequency bands used by the DOD. Additionally, Appendix B provides the reader with an overview of the theory and use of radio wave propagation. A discussion of the characteristics of each band and their uses follows.

ELF (Extremely Low Frequency) (0-3 KHz)

This frequency band possesses the characteristic of seawater penetration which makes it suitable for providing long range underwater communications to our submarine forces. The need for a long antenna (several miles long) and the very slow data (a few characters per minute) required by this frequency band, make it impractical for other uses. Another disadvantage is the requirement for an extremely high power source.

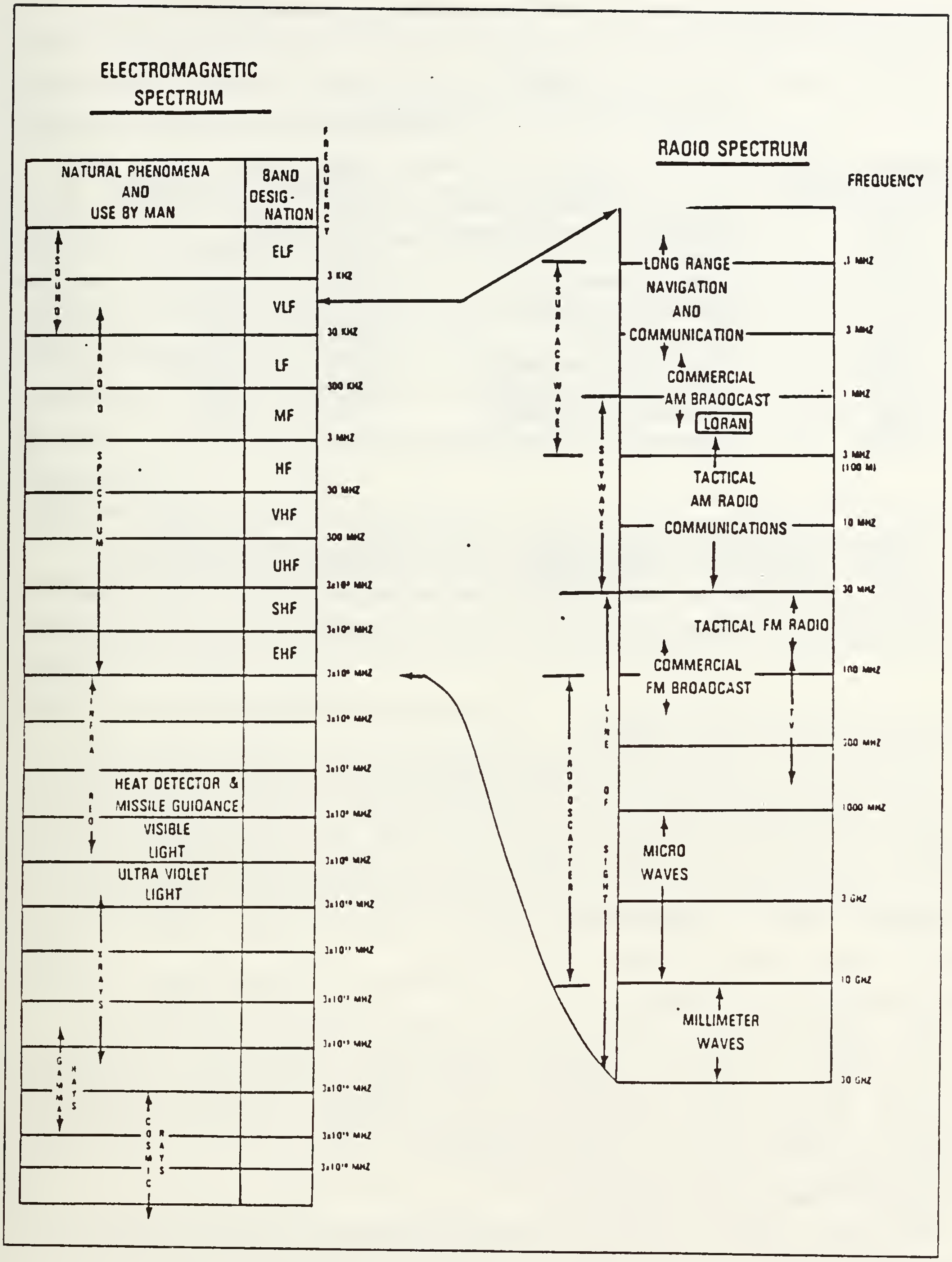

Figure 5.1 Frequency Spectrum.

TABLE 2

RADIO FREQUENCY SPECTRUM

ABBREVIATION	BAND	FREQUENCY RANGE
ELF	Extremely Low Frequency	Below 3 KHZ
VLF	Very Low Frequency	3 KHZ - 30 KHZ
LF	Low Frequency	30 KHZ - 300 KHZ
MF	Medium Frequency	300 KHZ - 3 MHZ
HF	High Frequency	3 MHZ - 30 MHZ
VHF	Very High Frequency	30 MHZ - 300 MHZ
UHF	Ultra High Frequency	300 MHZ-3 GHZ
SHF	Super High Frequency	3 GHZ - 30 GHZ
EHF	Extremely High Frequency	Above 30 GHZ

KHZ.......Kilohertz (one thousand cycles per second--1,000 cps)
MHZ.......Megahertz (one million cycles per second--1,000,000 cps)
GHZ.......Gigahertz (one billion cycles per second--1,000,000,000 cps)

VLF (Very Low Frequency) (3-30 KHz)

A low data rate and very long antenna requirement also restrict the use of the VLF band as a normal practical means of communications. However, it has a limited application for long range communications between elements of the World Wide Airborne Command Post system and for near surface communications to elements of our submarine forces. In addition to its use for nuclear survivability restoral, it is occasionally used for radio navigation transmissions.

LF (Low Frequency) (30-300 KHz)

The comments for the VLF band also apply to the LF band. Additionally, the LF band is used to support aeronautical radio navigational systems. This band contains the original radio telegraph frequencies used extensively for transoceanic systems before the development of underwater cable.

MF (Medium Frequency) (300-3000 KHz)

This band is primarily used for commercial amplitude modulated (AM) radio broadcasting frequencies. In the military it is used for navigational systems support and for aircraft and maritime communications. The upper end of the band is used for mobile land transmitters and for amateur use. The MF band provides highly reliable medium range communications and has significant unrealized potential for emergency communications due to the large number of transmitters available across the country.

HF (High Frequency) (3000-30000 KHz)

The HF band is used commercially for shortwave radio broadcasting, international ship-to-shore radio telephone, and amateur radio communications. The military has used the band extensively for long distance communications requirements and for tactical or mobile communications. Although military uses of HF have diminished in recent years with the development of satellite communications, the HF band continues to serve a vital role in long-haul communications. The combination of a manageable antenna size and the long-haul characteristics of the HF signal makes the HF frequency band practical for use by the military and diplomatic communications of all nations.

VHF (Very High Frequency) (30-300 MHz)

A large portion of this band is used to support commercial frequency modulated (FM) radio communications, as well as line of sight (LOS) transmissions and military multichannel troposcatter communications. This frequency band is also capable of supporting TV broadcasting.

UHF (Ultra High Frequency) (300-3000 MHz)

Part of this band has been allocated for TV broadcasting. It is also used extensively to support troposcatter multichannel, LOS multichannel, and single channel satellite communications. The UHF band is used to support early warning radar, navigational devices, aviation communications, and satellite communications. Much of the military LOS, air-to-air, and air-to-ground communications rely on this frequency band.

SHF (Super High Frequency) (3-30 GHz)

Utilization of this frequency band is mostly restricted to point-to-point or LOS communication transmissions. Frequencies in excess of one GHz are referred to as microwaves and provide the primary means of transmitting commercial long distance telephone calls. The wider bandwidth available at these frequencies makes it possible to transmit numerous telephone calls, TV programs, or high speed data transmissions simultaneously. Besides being used extensively for ground LOS systems which require a relay tower approximately every 30 miles, the band also supports large numbers of commercial and military multichannel satellites, and various types of radar systems.

EHF (Extremely High Frequency) (30-300 GHz)

New communications technology has been directed at the use of this vast frequency band. In the millimeter wave the transmitted signals suffer severe attenuations in rain or snow. This band will be used primarily for short range wide bandwidth systems, possibly inter-city communications. The EHF band will also support various radar and satellite sytems. [Ref. 17:pp. 36-40]

C. OTHER TRANSMISSION MEDIA

In addition to use of the frequency spectrum, there are other media used by the military for transferring information. These media include leased or government owned landlines, which can be categorized as open wires, paired cables, coaxial cables, and fiber optic wave guides.

Wire and cable is a very dependable means of communications which can interconnect closely located activities and can be integrated with radio systems. It is more secure than radio and significantly reduces the problem of interception. Unfortunately, wire and cable are subject to damage, wire taps, loss of signal strength over distances, and are difficult to maintain in a mobile environment.

The introduction of fiber optic cable has provided significant improvements in noise supression, capacity, bulk and weight, and overall resistance to Electromagnetic Pulse (EMP). Fiber optic communications is information transfer by means of photons (light) rather than electrons as in conductive metallic cable systems. The photons are directed from the source through a glass fiber, or optical waveguide, which is a fine strand of very pure glass, weighing on the order of only one ounce per kilometer and being no wider than a human hair, approximately 5 to 100 micrometers in diameter. At the end of the optical waveguide is an interface to the electrical domain: a source or optical coder at the transmitting end and a detector or optical decoder at the receiving end. The electrical signal to be transmitted is converted at the source into a light signal, which is then transmitted through the fiber. At the receiving end, the detector converts the light signal back to its electrical equivalent. [Ref. 18:p. 1]

D. SATELLITE COMMUNICATIONS SYSTEMS

1. General

For purposes of this discussion, a satellite is defined as a man-made vehicle that is in a particular orbit relative to the earth. A satellite communications system uses these orbiting vehicles to relay radio transmissions between earth terminals or other satellite vehicles. A typical satellite system includes the following segments.

Space Segment:

One or several spacecraft, usually with in-orbit spare capability. The spare capability could be extra transponders on the same spacecraft or it could be an entire spare spacecraft. A transponder is a receiver transmitter combination which receives a signal on the uplink frequency and transmits the same signal on the downlink frequency.

Earth Terminal Segment:

A system may include a great variety of earth stations. These stations may vary in size of dish, transmitting power, receiving sensitivity, capacity, etc. Usually a certain number of these stations may constitute a subnetwork dedicated to a specific service. The earth stations of a subnetwork are usually similar and all operate in the same access mode.

Control Segment:

These telemetry, tracking, and Command (TTC) stations track the position of the satellite, send commands for station keeping and attitude control, and receive telemetry indicating the status of the spacecraft. [Ref. 19:p. 15]

There are two types of communications satellites: active and passive. A passive satellite simply reflects radio signals back to earth. An active satellite acts as a repeater, amplifying those signals received and retransmitting them back to earth. An active satellite provides a much stronger signal to the receiving terminal than that provided by a passive satellite.

A typical operational link involves an active satellite and two earth terminals. One station transmits to the satellite on a frequency called the uplink frequency. The satellite amplifies the signal, translates it to a frequency called the downlink frequency and then transfers it back to earth where the signal is picked up by the receiving terminal. The basic concept of a satellite communications system is illustrated in Figure 5.2

The Navy's current satellite assets include the UHF SATCOM systems of GAPFILLER, FLTSATCOM, and LEASAT; the SHF SATCOM system of DSCS; and others. The system architecture for the UHF Follow-on system and the UHF/SHF/EHF system of MILSTAR are presently being designed and developed.

2. Gapfiller

In 1976 three Maritime Satellite (MARISAT) satellites were launched and placed in near-equatorial geostationary orbits over the Atlantic, Pacific, and Indian

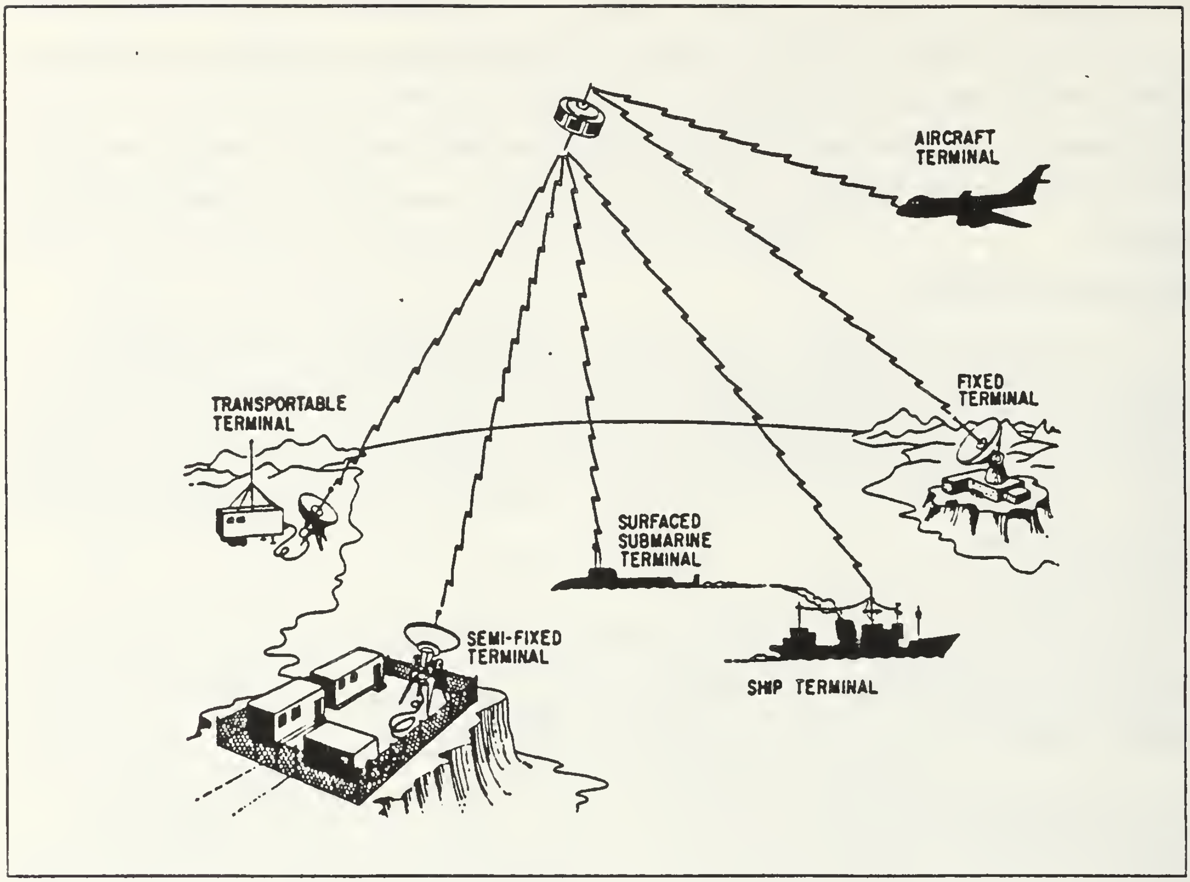

Figure 5.2 Basis Satellite Communications Operations.

Oceans. These MARISAT satellites were procured and managed by the Commercial Satellite (COMSAT) General corporation. The Navy leased the UHF transponder on each of these satellites for communications. In order to distinguish between MARISAT management and control and Navy control functions, the Navy's leased portions of MARISAT were given the adopted name of GAPFILLER. The name was chosen to signify "filling the gap" between the first generation satellite system and the follow-on Fleet Satellite Communications (FLTSATCOM) system. The Navy employs the GAPFILLER constellation with limited applications. All three satellites are physically and electrically identical, each providing one 500 KHz wideband and two 25 KHz narrowband channels. The frequency plan for all GAPFILLER satellites is identical. The LEASAT constellation of satellites, first launched in February 1984, are the GAPFILLER replacements. Table 3 depicts the GAPFILLER launch and service history. [Ref. 20:p. 67]

TABLE 3
GAPFILLER'S LAUNCH AND SERVICE HISTORY

SATELLITE NAME/LOCATION	LAUNCH DATES (M/D/Y)	SERVICE DATES (M/D/Y)	EARTH LONGITUDE (EQUATOR)
GAPFILLER (F1) ATLANTIC OCEAN AREA	2/19/76	4/5/76	15W
GAPFILLER (F2) INDIAN OCEAN AREA	10/14/76	1/12/77	73E
GAPFILLER (F3) PACIFIC OCEAN AREA	6/9/76	7/17/76	176.5E

3. Fleet Satellite Communications System (FLTSATCOM)

The first satellite of the FLTSATCOM constellation was launched in 1978. These satellites are, by design, considerably larger and heavier than the GAPFILLER satellites and are the spaceborne portion of a worldwide Navy, Air Force, and DOD communications system that enables communications between Naval aircraft, ships, submarines, ground stations, Strategic Air Command, and the Presidential Command Networks of the National Military Command System (NMCS). Other users employ this satellite system on a scheduled, not-to-interfere basis. Each of the FLTSATCOM satellites is deployed in a near-equatorial geostationary orbit and provides near-worldwide single/dual earth coverage on a 24 hour per day basis. As a rule, the FLTSATCOM launch and ascent operations begin 30 days prior to launch and continue through liftoff of the Atlas Centaur booster until placement of the satellite into orbit. These launch and injection activities occur at Cape Canaveral, Florida and the Satellite Test Center at Sunnyvale, California, and are supported by a network of worldwide tracking stations.

Each FLTSATCOM satellite provides twenty-three communications channels in the UHF frequency range. These are shared by the Navy, Air Force, DOD, Presidential communications system, and other users as validated and approved by the JCS. The Air Force portion of each FLTSATCOM satellite is part of the USAF

Satellite Communications System referred to as AFSATCOM, and is defined as the 5 KHz transponders making up the Air Force communications payload on each FLTSATCOM. Of the 23 communications transponders on each of the FLTSATCOM satellites, one 500 KHz wideband and twelve 5 KHz narrowband channels have been assigned to the Air Force. The Navy is assigned ten 25 KHz transponders per satellite, and use one dedicated 500 KHz transponder on the Indian Ocean satelite. The Navy's channel one (Fleet Satellite Broadcast) configuration of each FLTSATCOM satellite is an SHF injected uplink and UHF downlink. All other channels are UHF uplink and downlink. The Navy is assigned as Executive Agent of the FLTSATCOM constellation by JCS. [Ref. 20:p. 69]

Operational concepts, capabilities, and procedures for FLTSATCOM are defined in NTP-2 and in the CIBs promulgated by the NAVCAMS. Table 4 reflects the launch and service history of FLTSATCOM.

TABLE 4

FLTSATCOM LAUNCH AND SERVICE HISTORY

SATELLITE NAME/LOCATION	LAUNCH DATES (M/D/Y)	SERVICE DATES (M/D/Y)	EARTH LONGITUDE (EQUATOR)
FLTSAT (F1) CONUS AREA	2/9/78	4/4/78	100W
FLTSAT (F2) INDIAN OCEAN	5/4/79	6/15/79	72E
FLTSAT (F3) ATLANTIC OCEAN	1/17/80	2/15/80	23W
FLTSAT (F4) PACIFIC OCEAN	10/30/80	1/12/81	172E
FLTSAT (F5)	8/6/81	NOT IN SERVICE	----
FLTSAT (F6)	1/86 (TBR)	TBD	TBD
FLTSAT (F7)	12/86 (TBR)	TBD	TBD
FLTSAT (F8)	7/87 (TBR)	TBD	TBD

4. LEASAT

The first generation Naval space communications started with the launch of the GAPFILLER satellite system in 1976. Two years later the FLTSATCOM system was launched and put into service. For close to a decade these two systems have provided stable and efficient communications links in support of national and military mission requirements in the UHF spectrum of satellite communications. In August 1984, the third generation satellite system was launched. Unlike FLTSATCOM, this system was made available on a leased basis. Hence, the program adopted the name LEASAT, signifying LEAsed SATellite. LEASAT's are the replenishment satellites for GAPFILLER.

There is some commonality in design features between LEASAT and GAPFILLER. Like GAPFILLER, LEASATs are spin-stabilized and have a despun earth-oriented antenna farm; the difference being that LEASAT has a nominal 30 rpm rotation rate vice the 100 rpm of a GAPFILLER satellite. The solar arrays of LEASAT are essentially the same as those of GAPFILLER, although considerably larger. Batteries are included in the spacecraft for the purpose of providing electrical power during the vernal and autumnal equinoxes. LEASAT has a three-battery system, and permits full load power even with the loss of one of the three batteries. Due to size and weight requirements, LEASAT satellites are uniquely designed for launch from the Space Shuttle. This type of launch maneuver places the satellites in a circular parking orbit for later insertion into final orbit over the equator with a 3 degree inclination. [Ref. 20:p. 72]

LEASATs have a reduced complement of communications payload transponders (13 versus 23) as compared to GAPFILLER and FLTSATCOM, yet they will serve expanding Navy SATCOM mission requirements by employing a Demand Assigned Multiple Access (DAMA) technique. Each LEASAT has a communications payload consisting of one fleet broadcast SHF uplink/UHF downlink channel, one 500 KHz wideband transponder which employs frequency division multiplexing for twenty-one 25 KHz channel accesses, six 25 KHz relay transponders, and five 5 KHz narrowband channels used by the Air Force. Each of the LEASAT satellites are equipped with four frequency plans: whiskey, xray, yankee, and zulu. The primary purpose of these frequency plans is to preclude interference at points in which earth satellite coverage overlaps the coverage of an adjacent satellite. Each of the four frequency plans are divided into a series of uplink and downlink frequencies which correspond to a channel assignment within the groups of eight 25 KHz channels and five 5 KHz channels. The xray, yankee, and zulu plans are identical to those of the FLTSATCOM frequency plans alpha, bravo, and charlie, respectively. The whiskey frequency plan has no counterpart on FLTSATCOM. Table 5 depicts the LEASAT launch and service history. [Ref. 20:p. 72]

TABLE 5
LEASAT LAUNCH AND SERVICE HISTORY

SATELLITE NAME/LOCATION	LAUNCH DATES (M/D/Y)	SERVICE DATES (M/D/Y)	EARTH LONGITUDE (EQUATOR)
LEASAT (F1) CONUS	8/84	1/85	105W
LEASAT (F2) ATLANTIC OCEAN	11/84	2/85	15W
LEASAT (F3) PACIFIC OCEAN	4/85	6/85	178E
LEASAT (F4) INDIAN OCEAN	8/85	11/85	77E

5. **Defense Satellite Communcations System (DSCS)**

DSCS is a high-capacity SHF satellite system that provides worldwide communications for command and control, crises management, and intelligence data transfer. The overall DSCS program management is the responsibility of the Director, Defense Communications Agency (DCA), who coordinates all phases of the ground, sea, airborne, and space segments. The DSCS includes the satellites as well as all terminal equipment beyond the user interface to the earth terminal complex. The DSCS satisfies many diverse requirements that necessitate non-interfering, simultaneous operation of ever-changing combinations of terminals that are large, medium, or small; fixed, transportable, or mobile; air, land, or sea terminals; and either strategic or tactical. Among the many communications requirements supported by the DSCS are the following: Wideband data, Navy ship/shore, Diplomatic Telecommunications Service, Airborne Command Post, Ground Mobile Forces, Presidential missions, contingency extension of the DCS, AUTOVON and AUTODIN trunking, AUTOSEVOCOM, NATO, and Secure conferencing. [Ref. 21:pp. 1-6]

The system is being implemented in phases. Phase I provided limited operational capability from 1967 to early 1975. The Phase I space subsystem at maximum capability consisted of 26 low-power satellites drifting slowly in near-synchronous, near-equatorial orbits, each satellite supporting only one duplex communications link connecting two earth terminals. The Phase I satellites are no longer operational.

The DSCS Phase II satellites provide the DSCS operational space segment as of the beginning of 1983. They are much larger than the Phase I spacecraft and have greatly increased communications capability. They are launched in pairs utilizing a Tital 3C launch vehicle whose Transtage carries the satellites into a geostationary equatorial orbit and dispenses them with the correct velocity and spacing. The first two DSCS Phase II spacecraft were launched in November 1971. As of September 1982, fourteen Phase II satellites have been launched, four were not placed in orbit due to launch vehicle failures, and six are currently operational with varying degrees of availability. [Ref. 22: pp.1-1 - 3-3]

The DSCS Phase III spacecraft are of greater complexity and capability than the Phase II. They will eventually be placed in the same orbital positions and utilize the same frequency bands as the Phase II spacecraft but will not be interchangeable with them due to different channelization. The DSCS III satellite is launched by either a Tital 3C or by the Space Shuttle. The DSCS III satellite is designed to have a continuous operating on-orbit mission life of ten years with the ability to maintain longitude and latitude within 0.1 degree throughout the designed mission life. [Ref. 22:pp. 3-1 - 4-4]

6. MILSTAR

The MILSTAR program will provide a new generation EHF/SHF/UHF satellite system for meeting projected requirements for essential wartime communications. The MILSTAR program will develop a survivable terminal and satellite system that is jam resistant, has a low probability of communications interception and exploitation. and provides relay features for satisfying strategic and tactical communications needs.

MILSTAR, as envisioned, will comprise several satellites in its constellation. some of which will be in geosynchronous orbit over the equator and others will be in highly elliptical polar orbits. MILSTAR satellites will be switching centers in space, controlling access to the system and routing messages to end users. They will automatically search for potential users, scanning the earth with narrow antenna beams. They will be the first satellites that can function autonomously; if the terrestrial control centers are destroyed, MILSTAR satellites could maintain their positions and function for months. [Ref. 23:p. 1]

MILSTAR will create crosslinks among its constellation satellites, thus enabling messages to be relayed aound the world above the atmosphere without reliance on intermediate downlinks to ground stations. MILSTAR satellites and terminals will form the most complex communications system ever developed.

7. FLTSATCOM EHF Packages (FEPs)

Two FLTSAT EHF Packages (FEPs) have been built for flight on FLTSAT 6 and 7 satellites. The FEPs incorporate spread-spectrum and on-board signal processing techniques to provide robust communications at extremely high frequencies (EHF). An FEP is fully MILSTAR compatible, though less capable than a full MILSTAR satellite payload. The FEPs will provide early operational test and evaluation of MILSTAR terminals. [Ref. 24:p. 1]

8. UHF Follow-on

The following discussion is a synopsis of a memorandum for the Commander, Space and Naval Warfare Systems Command from the Office of the Chief of Naval Operations (OP-943C) dated 3 March 1986.

UHF satellite communications is unique to those highly mobile. tactical operations that it currently supports and will continue to support in the future. Some of the UHF Follow-on requirements are outlined below:

- The spacecraft will be designed for dual-launch by the Space Shuttle and an Expendable Launch Vehicle (ELV). The FLTSATCOM and LEASAT programs have experienced launch vehicle failures and with the uncertainty of the Space Shuttle's schedule, there is a new requirement for launch by an ELV.
- The UHF Follow-on system will provide two satellites per footprint coverage area.
- There will be no crosslinking between satellites.
- The satellites should be able to survive up to one month of autonomous operation with a 90% reliability of reacquisition by ground control stations.

E. LDMX

The Local Digital Message Exchange (LDMX) is a computerized communications system which automates the message processing functions of a communications facility to provide reliable, accurate communications and data exchange at high speed. The LDMX simultaneously transmits and receives messages over AUTODIN and other remote terminal circuits to provide high speed processing, system reliability, secure communications, cost savings, and flexibility. The LDMX system has been installed at the NTCCs serving major commands.

The LDMX system automatically receives, identifies, and files traffic for processing and future reference. Incoming messages are automatically arranged by precedence, processed, edited, and printed on reproducible mats for delivery. Outgoing traffic is entered via an optical character reader (OCR) or via magnetic tape, paper tape, or card reader. The system formats the outgoing message; creates a header; validates the message identifiers, precedence, and classification; searches system files to assign correct routing indicators; and arranges the message by precedence for automatic transmission. The LDMX system automatically logs, inventories, controls, and acknowledges receipt of all incoming and outgoing messages. [Ref. 25:p. 8-2-1]

A significant feature of the LDMX system is the natural accumulation of statistical information and accounting data which provides accurate verification of the reliability and performance of the system. Message processing data is provided in a series of statistical analysis of summaries that includes:

- A bar chart providing an hourly volume of incoming or outgoing traffic.
- A summary report showing the number and average length of incoming or outgoing messages, the number of messages delivered to a remote printer, and the number of various classifications and precedences.
- A listing with information concerning duplicated, misrouted, and missent messages.
- A speed of service report giving maximum, average, and minimum processing times by precedence, classification, or selected originator.
- A listing of service messages sent and received.

F. NAVCOMPARS

Naval Communications Processing and Routing System (NAVCOMPARS) is a single, integrated, automated system with the capability to provide a communications interface between the fleet, selected shore commands, and DCA networks. NAVCOMPARS performs the following functions:

- Provides on-line communications with AUTODIN switching centers.
- Provides on-line communications interface with afloat and shore subscribers.
- Provides off-line communications interface (torn tape) with afloat and shore subscribers. Off-line communications interface is generally used when the media is not of landline quality.
- Processes messages that are formatted in AUTODIN compatible format (JANAP 128).

- Converts DD-173 (Optical Character Recognition) forms into JANAP 128 message format.
- Provides filing, retrieving, and accountability of messages.
- Provides local delivery analysis.
- Provides distribution assignment. NAVCOMPARS analyzes the message beginning with the classification line and the first four lines of text, excluding references, to determine internal distribution based on flagword assignment for selected commands.
- Provides over-the-couunter and electronic courier circuit (ECC) delivery.
- Provides message storage and delivery to fleet units. Messages are queued in NAVCOMPARS in "first in first out" by precedence order for fleet subscribers.
- Provides broadcast delivery analysis. Headings of messages destined for delivery via the Fleet Broadcasts are analyzed and transmitted over the appropriate channel of the multichannel and single channel broadcasts.
- Provides broadcast keying. NAVCOMPARS segregates broadcast messages by delivery analysis and provides queuing to provide the composition of multichannel and single channel broadcasts.
- Provides broadcast screens. NAVCOMPARS service center processes broadcast screen requests from ships for rebroadcast of messages missed.
- Provides semi-automatic readdressal service.
- Provides on-line bookkeeping, analysis, and automatic recall services for the Common User Digital Information Exchange Subsystem (CUDIXS). [Ref 26:p. 2-1 - 2-6]

G. RIXT

The Remote Information Exchange Terminal (RIXT) is a multimedia remote input/output terminal linked to either a NAVCOMPARS or LDMX system. The terminals are modular in design so they can be expanded to meet the growing needs of the users. The RIXT depends on the NAVCOMPARS or the LDMX for the majority of its message processing functions. Messages may be entered into a RIXT from an OCR, paper tape, magnetic tape, card reader, or a video display terminal (VDT).

H. FLEET SATELLITE BROADCAST (FSB)

The Fleet Satellite Broadcast (FSB) is the primary means of providing the fleet with record traffic and information in a high-level jamming environment. The FSB is a one-way, send only, simplex communication channel from shore to ship. The FSB is a result of the evolution of the single channel CW broadcast of the 1940s transmitted simultaneously on VLF, LF, and HF to the multichannel TTY broadcasts of the 1960s transmitted on LF and HF.

The FSB serves all Navy surface units, designated Coast Guard ships, and USMC radio communications shelters, as required during joint operations. The individual channels of the FSB which a ship "copies" is dependent upon the ship type, the ship mission/task assignment, and the force commander or special units embarked on that ship. The FSB is divided into NAVCOMMAREAs and the fleet user copies the broadcast for the area in which it is located.

The FSB is structured for eleven 75 bits per second (bps) TTY channels for general service record message traffic, two 75 bps TTY channels for special intelligence message traffic, and two 75 bps channels for fleet weather data. One channel in the FSB transmission provides frame synchronization. The general service message traffic is received for the broadcast from the NAVCOMPARS at the NAVCAMS/NAVCOMMSTA, queued according to precedence, and channeled automatically into one or more of the eleven 75 bps channels. The special intelligence message traffic is received from the shore STREAMLINER system, queued according to precedence, and channeled automatically into one of the two 75 bps intelligence channels.

Each of the FSB fifteen TTY channels is encrypted individually by appropriate cryptographic equipment. At the NAVCAMS/NAVCOMMSTA, the fifteen individual encrypted 75 bps channels and the sixteenth frame synchronizing channel are multiplexed into a 1200 bps serial data stream. This data stream is transmitted by SHF uplink to the appropriate FLTSATCOM/LEASAT spacecraft. The SHF uplink is primarily a spread spectrum transmission providing an anti-jam capability. The FLTSATCOM/LEASAT spacecraft receives the SHF FSB signals, processes the signals, and retransmits them by UHF. The ship receives the UHF signal stream, demultiplexes the stream into the fifteen individual FSB channels and, depending upon the particular ship configuration, the appropriate individual FSB 75 bps channels are decrypted and then patched to the individual subscriber terminals onboard the ship.[Ref. 20:p. 19]

I. CUDIXS/NAVMACS

The Common User Digital Information Exchange System (CUDIXS)/Navy Modular Automated Communications Subsystem (NAVMACS) is a shore-based and shipboard configuration to exchange data traffic between a shore station and fleet unit via the UHF satellites. The shore-based CUDIXS element is a receiving point for ship-to-shore message traffic from a maximum of sixty surface ships in the network. Ten of these sixty surface ships are designated "Special Subscribers" which can also receive (shore-to-ship) high volumes of message traffic. Without CUDIXS/NAVMACS this shore-to-ship traffic would be transmitted on the Fleet Broadcast or via a designated full period termination. (Refer to Section Q for a description of a full period termination.) The remaining fifty surface ships in this network are designated "Primary Subscribers", who have a one-way message traffic flow (ship-to-shore) and receive their message traffic normally via the FSB. The NAVMACS element has similar equiment to CUDIXS; it follows the CUDIXS link control protocol and processes message traffic onboard the ship.

The primary collection point for message traffic to be transmitted or received on the CUDIXS/NAVMACS link is the NAVCOMPARS. Message traffic for transmission on the CUDIXS link for the Special Subscribers can be input to NAVCOMPARS by over-the-counter facilities at the NAVCAMS/NAVCOMMSTA. Message traffic originating at other locations is passed directly to the NAVCOMPARS processor via AUTODIN Automatic Switching Centers.

Incoming message traffic originating at both the Primary and Special Subscribers is passed from the CUDIXS processor to NAVCOMPARS. Depending upon message routing, the traffic may be distributed by NAVCOMPARS, passed to the AUTODIN Automatic Switching Center, or both.

CUDIXS/NAVMACS provides improved operational communications including increased message traffic throughput rates, increased traffic volume, and improved link reliability. [Ref. 20:p. 23]

J. SSIXS

The Submarine Satellite Information Exchange Subsystem (SSIXS) was designed to complement existing VLF and MF/HF communication links between shore-based submarine Broadcast Control Authorities (BCA) and submarines via the UHF satellites. SSIXS provides the submarine commander with the capability of receiving messages transmitted via the satellite at scheduled intervals. Between broadcasts the submarines may transmit messages to the BCS, including a request for any messages held in queue. The shore terminal responds and transmits all messages held for the querying submarine. A single SSIXS network may have up to 120 submarine subscribers. [Ref. 20:p. 27]

K. OTCIXS

The Officer in Tactical Command Information Exchange Subsystem (OTCIXS) is designed to provide a two-way UHF satellite link to support Battle Group over-the-horizon (OTH) command and control and tactical targeting communications requirements. OTCIXS is capable of handling both TTY message traffic and tactical data processor (TDP) formatted data on an automatically controlled time-shared basis over the same OTCIXS satellite channel. The TTY will be used to pass tactical command and control information and the TDP capability will be used to exchange surveillance and targeting information among surface ships and submarines within a Battle Group.[Ref. 20:p. 31]

L. TACINTEL

The Tactical Intelligence Subsystem (TACINTEL) is used for transmission of special intelligence communications. TACINTEL is essentially a computerized message processing installation that makes it possible to transmit and receive message traffic via a satellite in a controlled environment. A polling scheme is used that can support a net membership of 23 subscribers within a satellite footprint. [Ref. 20:p. 43]

M. TELETYPEWRITER (TTY) SUBSYSTEM

The Teletypewriter (TTY) Subsystem is an expansion of existing teletypewriter communication networks, but uses satellites as relay stations. There are numerous applications in the Navy for the 75 bps TTY including full period terminations, backup circuits for CUDIXS/NAVMACS and TACINTEL, and contingency circuits during crisis situations. [Ref. 20:p. 43]

N. DAMA

The UHF Demand Assigned Multiple Access (DAMA) subsystem was developed to multiplex several baseband subsystems, or users, on one 25 KHz satellite channel. DAMA has created the effect of adding more satellite circuits per channel to UHF satellites. Without DAMA, each satellite communications subsystem requires a separate satellite channel. Transmission congestion is relieved by allowing many different transmissions to take place on the same channel through time sharing. To the individual user subsystem, it appears that the subsystem has exclusive use of a single satellite channel. [Ref. 20:p. 45]

O. FLEET IMAGERY SUPPORT TERMINAL (FIST)

FIST is a compact, simple to operate and maintain, suite of computer equipment which is linked to other FIST users on a time sharing basis via standard Navy secure communications equipments and channels (landlines and/or satellites). FIST provides rapid, secure, and reliable near-original quality imagery to operational commanders. Its primary mission is to disseminate high resolution imagery to tactical users. Its secondary missions include the transmission of imagery obtained by tactical units to component and/or upper echelon Navy and national organizations, and the exchange of textual and graphic intelligence products. FIST users can transmit and receive imagery, text, and graphics, as well as enhance, annotate, manipulate, reproduce, and display them in CRT, paper, transparency, or photograph form.

P. PRIMARY SHIP/SHORE

Primary Ship/Shore permits random, secure, and unscheduled access to shore communications facilities by fleet units which do not normally maintain a dedicated termination for message transmission. Ship/Shore circuits are established by designated NAVCAMS/NAVCOMMSTAs who accept and relay messages from fleet units. Primary Ship/Shore is normally operated in the full duplex mode, with separate send and receive frequencies that are promulgated by the area NAVCAMS in the Communications Information Bulletins (CIBs).

Message traffic from submarines, by virtue of its need for quick transmission, has a higher priority over that of surface units, except for surface ships with FLASH or IMMEDIATE traffic to send. When both submarines and surface units have FLASH or IMMEDIATE traffic, the submarine has precedence.

The respective NAVCAMS/NAVCOMMSTA is the Net Control Station (NECOS) for its ship/shore circuits. It is asked with ensuring proper circuit discipline and expediting the flow of traffic. Primary Ship/Shore is available to the fleet via HF, UHF, and designated channels of the FLTSATCOM and LEASAT satellites. [Ref. 25:p. III-2-1]

Q. FULL PERIOD TERMINATIONS

A termination in the communications community is generally defined as a full time, dedicated circuit between a unit at sea or on land and a major shore relay node such as a NAVCAMS or NAVCOMMSTA. As a rule, full period terminations do not use Primary Ship/Shore for message transmission. Primary Ship/Shore may be used for coordination of the termination establishment. Full period terminations are routinely assigned an unique area routing indicator for the station they are terminated with. This ensures the proper and timely routing of message traffic to and from the terminated unit. Senior operational commanders normally require full period terminations for command and control support. Criteria for requesting a full period termination usually include the following:

- Traffic volume exceeds primary ship/shore capability.
- Operational activities require circuit discreteness.
- Effective command and control necessitates dedicated circuits.
- Training purposes.

There are basically two types of termination. One is the single channel radioteletype termination. The other is the multichannel radioteletype termination which is capable of handling up to 16 channels using a frequency division multiple access (FDMA) scheme. The medium used for full period terminations is either HF, UHF LOS, or satellite. [Ref. 25:p. III-4-1]

R. NAVY HIGH COMMAND WORLDWIDE VOICE NETWORK (HICOM)

HICOM is an HF, single sideband network consisting of three separate voice nets on an area basis for worldwide coverage. CINCPACFLT, CINCLANTFLT, and CINCUSNAVEUR maintain positive control over these nets. Numbered fleet commanders, designated subordinate commanders, aircraft carriers, cruisers, and command ships, as well as any other command designated by the CNO or FLTCINC, are required to maintain a continuous guard on HICOM.

HICOM's intended use is to relay unclassified, operational information. Due to the unsecure nature of the HICOM network, the frequencies used are general knowledge to foreign intelligence. Maximum use of available secure voice circuits instead of HICOM is suggested. [Ref. 25:p. V-3-3]

S. FLEET HIGH COMMAND SECURE VOICE NETWORK (HICOMSEVONET)

HICOMSEVONET is an HF, narrow band secure voice network between shore terminals and afloat units designed to interface with AUTOSEVOCOM. HICOMSEVONET consists of HF secure voice terminals located at selected NAVCAMS/NAVCOMMSTAs/NAVCOMMUs and afloat units. The shore commands with AUTOSEVOCOM interface capability continuously guard selected frequencies for itinerant and full period secure voice communications as directed by the FLTCINC. [Ref. 25:p. V-3-10]

T. SATELLITE SECURE VOICE

The Satellite Secure Voice system provides an interface between the AUTOSEVOCOM and SATCOM secure voice equipped ships via GAPFILLER, FLTSATCOM, and LEASAT. Fleet satellite voice communications depends on all units listening for a clear channel before transmitting. If the net is a directed net, permission must be obtained from the net control station before transmitting to a station other than net control. If the net is a free net, any station may use the net when clear.

Satellite Secure Voice transmits and/or receives secure voice communications via a half-duplex, push-to-talk satellite link. Control of the voice channel is maintained by the Secure Voice controller at the respective NAVCAMS/NAVCOMMSTA within the satellite footprint. [Ref. 20:p. 37]

VI. NTS CONTINGENCY OPERATIONS

A. INTRODUCTION

In order to insure the reliability and continuity of communications within the Naval Telecommunications System (NTS), contingency backups or similar systems which provide like functions are available for nearly every major system. This Chapter presents some possible backup processes that occur when a major system fails or is "down". In reality there are varying degrees of failure within a system and numerous restoral scenarios, depending on the severity of the failure. The failure cause could range from a blown fuse that could be replaced within seconds to complete destruction caused by sabotage, war, or an act of God. This Chapter does not attempt to define or differentiate the myriad of specific restoral actions which could be implemented to correct a partial system failure. Rather it concentrates on general restoral processes in the case of a complete system failure. The reader is referred to a NAVCAMS Catastrophe Communications Plan for specific, predictable restoral situations.

Table 6 provides a summary of the major systems discussed in Chapter Five including the system's purpose, its users, the medium(s) employed, the existing backup or alternate system(s), and additional systems that could fail because of their dependence on the major system.

B. SATELLITE CONTINGENCY PLANS

1. FLTSATCOM

In the event of a failure of one of the FLTSATCOM spacecraft, contingency repositioning plans have been developed to facilitate orderly transition from a four to a three satellite constellation. The repositioning plan would be invoked by JCS on the advice of the CNO and Chief of Staff of the Air Force. During repositioning, any disrupted users would be restored in accordance with assigned access priority and as earth coverage and channel capacity permit. Satellite users have been trained to immediately shift to the HF multichannel or single channel broadcast in their areas for further instructions in the case of satellite signal failure. [Ref. 3:p. IX-2]

2. LEASAT

The LEASAT constellation consists of three spacecraft and does not, in itself, provide strategic connectivity. In the event of a LEASAT spacecraft failure,

TABLE 6

CONTINGENCY OPERATIONS WITHIN THE NTS

SYSTEM	PURPOSE	USERS SUPPORTED	MEDIUM EMPLOYED	BACKUP SYSTEM(S)	OTHER SYSTEMS AFFECTED BY FAILURE
NAVCOMPARS	1	ALL NAVY UNITS	LANDLINE	ALT ROUTING, HAND SEGREGATION	CUDIXS/FSB/F P TERMS/RIXT
LDMX	1	NAVY SHORE COMMANDS	LANDLINE	ALT ROUTING	RIXT LINKS
RIXT	1	NAVY SHORE COMMANDS	LANDLINE	ECC or OTC	
BROADCAST:					
FSB	3	FLEET UNITS	SHF & UHF SATCOM	HF BCST	
MULCAST (HF)	3	FLEET UNITS	HF	SINGLE CHANNEL HF & FSB	
SINGLE CHANNEL (HF)	3	FLEET UNITS	HF	MULCAST or FSB	
CUDIXS/NAVMACS	2	NAVMACS EQUIPPED UNITS	UHF SATCOM	F P TERM, PRI S/S & FSB	
SSIXS	2	SUBMARINES	UHF SATCOM	LF, VLF BCST, PRI S/S	
OTCIXS	7	FLEET UNITS W/I BATTLE GROUP	UHF SATCOM	TTY SATCOM	
TACINTEL	6	TACINTEL EQUIPED UNITS	UHF SATCOM	TTY SATCOM	
FULL PERIOD TERM	2	FLEET UNITS	UHF SATCOM	HF F P TERM, PRI S/S	
FULL PERIOD TERM	2	FLEET UNITS	HF	PRIMARY S/S	
PRIMARY SHIP/SHORE	4	FLEET UNITS	HF or UHF SATCOM	UHF or HF PRI S/S	
HICOM	5	FLEET & SHORE UNITS	HF or UHF SATCOM	NBSV or PRI S/S	
NBSV	5	FLEET & SHORE UNITS	UHF SATCOM	HICOM	

PURPOSE LEGEND:

1. Provide communications interface between fleet, shore commands and DCA networks.
2. Exchange message traffic between fleet units and shore commands
3. Broadcast messages to the fleet.
4. Transmit messages from a fleet unit.
5. Provide voice communications for shore and afloat commands.
6. Transmission of SI communications.
7. Support Battle Group OTH command and control.

repositioning of the remaining two satellites would be dependent on the world's tactical situation at that time and in accordance with non-interfering frequency plans to preclude adjacent satellite interference. [Ref. 3:p. IX-3]

C. MAJOR SYSTEMS CONTINGENCY OPERATIONS

The area FLTCINC has the authority to direct any operational adjustment or temporary network changes required to support contingencies or emergency situations. Satellite users, in particular, are subject to pre-emption from their assigned accesses by authority of the FLTCINC in the event of higher priority requirements.

1. NAVCOMPARS

A NAVCOMPARS is installed at each NAVCAMS and at NAVCOMMSTA Stockton. Figure 6.1 depicts the NAVCOMPARS interface between land and satellite systems. At each site the entire system consists of two identical NAVCOMPARS: one is used for processing and the other is a standby, performing administrative functions. In case one NAVCOMPARS fails, the standby system can be put on-line within minutes. In the event of a complete NAVCOMPARS failure where both systems fail, there is no way to segregate message traffic to get it to the proper points of transmission (i.e., CUDIXS, Fleet Broadcast, Full Period Terminations, etc.). The message traffic must be alternately routed through AUTODIN to the primary restoral station, normally the adjacent NAVCAMS. Table 7 presents the restoral plan for a NAVCOMPARS failure.

The secondary restoral station is used in case of a concurrent outage at both the station and its primary restoral station. According to Fleet Operations Telecommunications Procedures (FOTP), the alternate station should be processing failed station traffic within one hour of the initial outage. The FTOC at each of the involved NAVCAMS/NAVCOMMSTA are the key coordinators of the broadcast shifting, keeping the respective FLTCINC, numbered fleet commander, and COMNAVTELCOM advised of the situation.

Once the broadcast has been shifted to the alternate station, in order to reduce confusion and possible errors at the AUTODIN Automatic Switching Center(ASC), the broadcast remains at the alternate station for at least eight hours. At the time of system failure, any messages with IMMEDIATE or above precedence must be manually removed from the system and transmitted to the afloat unit via torn tape through the Fleet Center.

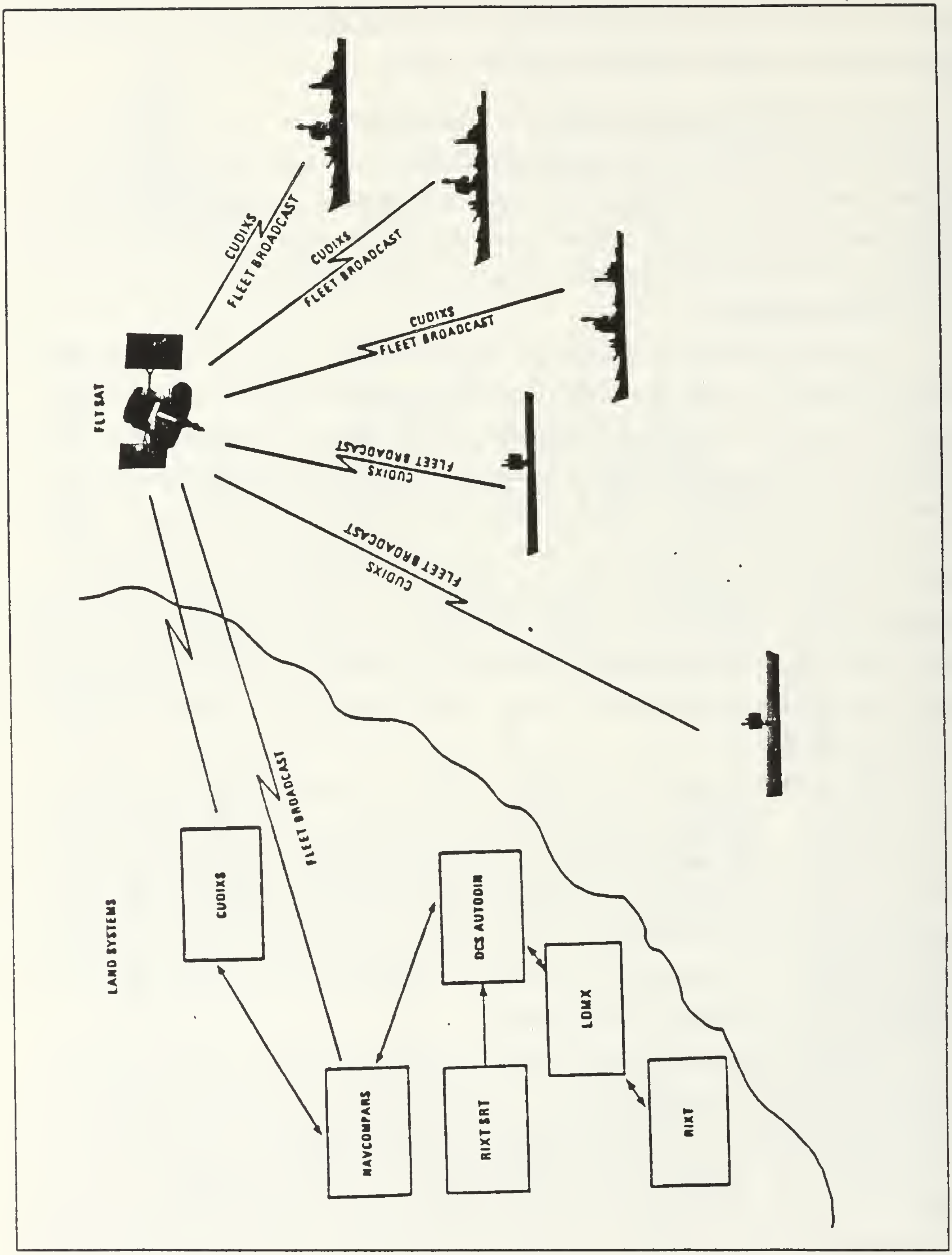

Figure 6.1 NAVCOMPARS Connectivity.

TABLE 7

RESTORAL PLAN FOR NAVCOMPARS FAILURE

STATION	PRI RESTORAL	SEC RESTORAL
NAVCAMS EASTPAC	NCS STOCKTON	NAVCAMS WESTPAC
NAVCAMS LANT	NAVCAMS MED	NCS STOCKTON
NAVCAMS MED	NAVCAMS LANT	NAVCAMS WESTPAC
NAVCAMS WESTPAC	NAVCAMS EASTPA(	NCS STOCKTON
	* NAVCAMS MED	* NAVCAMS MED

*NAVCAMS MED assumes IO FSB uplink via IO Gateway only whe NAVCAMS WESTPAC experiences loss of uplink capacity.

At least monthly each NAVCAMS shifts its NAVCOMPARS, Broadcast, and frequency management functions for a 48 hour period to its adjacent NAVCAMS and primary support station for training purposes.

2. LDMX

In the event of a total LDMX failure, the message traffic would be sent out via alternate routing to an AUTODIN ASC in accordance with the station's contingency restoral plan. Since the subscriber terminals message traffic would not be accepted by the failed LDMX system, the subscribers messages would either follow their individual contingency plans or hand carry their messages to the LDMX site for alternate routing and delivery.

3. RIXT

If a RIXT system fails there is normally no automated system backup unless there is an electronic courier circuit (ECC) linking the RIXT station with the LDMX or NAVCOMPARS host computer. Usually, the backup in case of a RIXT failure is for the RIXT system personnel to hand carry all messages to and from the host computer site.

4. **Fleet Broadcasts**

FLTSATCOM satellites have two channels allocated for the Fleet Satellite Broadcast (FSB). The first channel, which is used as the primary mode for FSB transmission, is configured for an SHF uplink and UHF downlink. The second FSB channel is designed for backup use only and is configured for a UHF uplink and downlink. Normally, this secondary channel is used for Satellite Secure Voice and is preempted for FSB transmission when required. [Ref. 3:p. VII-9]

Major combatant fleet units have the capability of receiving the Fleet Satellite Broadcast and retransmitting it within their area. The following areas have NAVCOMMSTAs/NAVCOMMUs with the capability of receiving the Fleet Satellite Broadcast by satellite, HF, microwave, or landline and retransmitting or rekeying it on HF links.

Greece	Australia
Spain	Japan
United Kingdom	Phillippines
Puerto Rico	Adak
San Diego	Iceland

5. **CUDIXS**

A total CUDIXS failure at a NAVCAMS could be handled in the same manner as a NAVCOMPARS failure, with alternate routing to the adjacent NAVCAMS. Backup or alternate systems to CUDIXS are satellite or HF full period terminations or a combination of the Fleet Broadcast and Primary Ship/Shore.

6. **SSIXS**

All SSN submarines are being equipped with dual SSIXS installations to provide for redundancy. In the event that both systems fail, the submarine could copy the LF, HF, or satellite broadcast and use Primary Ship/Shore.

7. **OTCIXS**

OTCIXS provides for two-way satellite support for Battle Group over-the-horizon command and control and tactical targeting communications requirements. Without OTCIXS the Battle Group would be assigned a satellite channel as a relay for teletypewriter communications.

8. **TACINTEL**

TACINTEL is used for transmission of special intelligence (SI) communications. In the event of a total TACINTEL failure, a channel of the satellite would be assigned, if available, to relay teletypewriter message traffic.

9. Full Period Terminations

An afloat unit requiring a full period termination for operational vice training purposes normally will have a message volume too large for the Fleet Broadcast and Primary Ship/Shore to efficiently handle for an extended time period. For a NAVMACS-equipped unit, an assignment as a special subscriber on CUDIXS/NAVMACS is construed as a full period termination. If the termination is via HF, a satellite termination would be an alternate, and vice versa.

10. Primary Ship/Shore

An alternate for HF Primary Ship/Shore is satellite Primary Ship/Shore, and vice versa. Another alternate is a primary subscriber assignment on CUDIXS/NAVMACS for NAVMACS equipped ships, or a temporary multichannel or single channel full period termination. A ship within a Battle Group could also receive and transmit messages through a designated control ship with an established termination, capable of relaying the message traffic via HF, UHF Line of Sight, or VHF circuits.

11. HICOM and SATCOM Secure Voice

HF HICOM and SATCOM Secure Voice are alternate systems for each other. The most common problem with SATCOM Secure Voice is an inadvertent steady key on the satellite channel, causing interference. The steady key occurs when the system operator fails to unkey the equipment when the transmission is completed. After the steady key and interference continue for 15 minutes, the area NAVCAMS sends out a fleet advisory informing the fleet of the interference, including the satellite, channel, circuit usage, date and time the interference began, and the type of interference. If the interference continues for an hour, the circuit is normally restored via an alternate satellite channel, if available. [Ref. 3:p. IX-5]

12. DCA Systems

Message traffic entering an LDMX or NAVCOMPARS often is relayed via an AUTODIN ASC. Each LDMX and NAVCOMPARS site is dual-homed to the AUTODIN system, i.e., it is linked with two separate independent ASCs. Loss of one ASC would not catastrophically affect the operation of the LDMX or NAVCOMPARS.

The same is true of the AUTOSEVOCOM and AUTOVON systems. In order to reach its final destination a voice phone patch could be detoured around any failed AUTOSEVOCOM or AUTOVON switch.

D. MANAGEMENT TOOLS

The NTS has several management and operational tools available to ensure its optimum efficiency and readiness. A description of some of these tools follows.

1. Publications

a. Naval Telecommunications Procedures (NTP)

NTPs are comprehensive procedural publications containing information that is standardized throughout the NTS. NTPs provide a basic framework for communications operation and management covering topics ranging from radiotelephone operations to satellite operations.

b. Fleet Telecommunications Procedures (FTP)

FTPs contain general communications information and procedures which are standardized throughout an ocean area but not worldwide. FTPs are issued and reviewed jointly by the two NAVCAMS with adjacent/overlapping ocean areas (e.g., EASTPAC and WESTPAC, LANT and MED). NAVCAMS LANT has primary cognizance over the LANT/MED FTP and NAVCAMS EASTPAC over the EASTPAC/WESTPAC FTP.

Urgent changes to FTPs are normally issued by the NAVCAMS through CIBs. As general communications procedures are standardized worldwide, they are removed from the FTPs and included in the appropriate NTP.

c. Communications Information Bulletin (CIB)

CIBs are promulgated by each NAVCAMS and issue procedures unique to the specific NAVCOMMAREA. CIB topics include frequency plans, procedures for entering the NAVCOMMAREA (in-chopping), common equipment and system problems and solutions. Joint CIBs are used as interim guidance until they are formally included into the FTP.

2. CHIRPSOUNDER

The AN/TRQ-35(V) CHIRPSOUNDER or "Tactical Frequency Management System" is composed of a transmitter located ashore, and a receiver and spectrum monitor on designated afloat units. It provides a display of frequencies that are propagating, the signal strength, and the path of reception. The receiver also shows multi-path areas to be avoided for data or multichannel operations. CHIRPSOUNDER is most valuable for maintaining HF full period terminations. [Ref. 25:p. X-6]

3. COMMSPOT

A special Communications Report (COMMSPOT) is submitted to the area NAVCAMS by any fleet unit encountering significant communications difficulties. The NAVCAMS takes aggressive action in resolving any problem reported by a COMMSPOT.

4. Monthly System Performance Reports

Submission of monthly system performance reports to COMNAVTELCOM are required from all automated sites to measure failure rates and to identify problem areas. The report statistics are also used to compute system availability and reliability for systems, such as NAVCOMPARS, LDMX, RIXT, CUDIXS, and SSIXS. Availability thresholds are a key factor in designing and procuring new systems for the NTS. [Ref. 3:p. X-13]

5. Operational Exercises

Frequent operational tests and exercises are performed to measure the readiness of a NAVCOMMAREA to support communications requirements under various conditions. SMALLPIPE is a series of contingency exercises that simulates the loss of the satellite. SMALLPIPE tests the fleet and shore ability to shift from a satellite to an HF communications environment.

The following requirements also exist within each NAVCOMMAREA to ensure station and operator proficiency in an HF environment.

- Each NAVCOMMSTA will be assigned monthly at least two full period HF terminations lasting at least 72 hours.
- Each afloat unit that is capable of a single channel or a multichannel termination will maintain a quarterly HF training termination for at least 72 hours. [Ref. 3:p. IX-3]

6. Operational Inspection (OI)

Operational Inspections are methods of evaluating the readiness of communications activities. The objectives of an OI are to:

- Evaluate the operational readiness and effectiveness of the communications station in the performance of its assigned operational mission.
- Determine if the station is meeting its Telecommunications Operating Requirements (TELCOR), and ensure that the TELCOR requirements are current and valid.
- Ensure communications systems at the station are operating at peak efficiency.
- Identify deficiencies in operations and provide assistance in correcting the deficiencies when required. [Ref. 27:pp. 1-5]

VII. THE FUTURE NTS

A. INTRODUCTION

The NTS of the future must provide the communications to support Navy command and control functions worldwide. It must be robust enough to perform effectively during peacetime, crises, and a nuclear or protracted war. This capability can be achieved if the following attributes are carefully considered and the proper tradeoffs made during the planning and design of new systems.

Survivability

Ability to continue to function in an orderly manner after nuclear or conventional attack or other intentional damage has been incurred.

Flexibility

Ability to provide a range of services in varying conditions; ability to reconfigure and/or provide alternate routing for required services.

Invulnerability

System's protection against jamming, intrusion, and electronic countermeasures.

Endurability

Ability to function after an initial incident or hostile action

Interoperability

Ability to access and operate with non-NTS systems and networks.

Quality

Fidelity of the service product.

Availability

Ability of the system to perform its designated functions at any given time for the duration of the mission.

Responsiveness

Amount of time required for the system to respond to stimuli, such as requests for service, despite increased load levels on the system.

Connectivity

Actual or potential links that provide communication paths between users.

Usability

Ease with which a user can utilize the system for a specific purpose.

Capacity

Amount of information that may be passed per unit of time.

Compatibility

Ability to operate in an environment with other systems without mutual interference.[Ref. 27:pp. 1-14]

B. FUTURE CHALLENGES

The requirements of military communications systems are unique because of the need for survivability, resistance to electronic warfare and countermeasures, and interconnection of various types of platforms (i.e., air, surface, subsurface, mobile, and fixed).

The Navy is now facing a crucial period of planning to both support the Maritime Strategy and the theory of deterrence and to endure in the case of a nuclear war. Some of the systems the military is considering are now addressed.

1. ISDN

The Integrated Services Digital Network (ISDN) is an end-to-end digital network providing simultaneous customer services from central offices across integrated subscriber loops. ISDN will integrate traditional and yet to be determined telecommunicatioins services on one network. The initial standards defining the ISDN were approved in 1984 by the Consultative Committee on International Telephone and Telegraph (CCITT). If properly planned, DOD's implementation of ISDN technology can be extremely cost effective while increasing mission capability.

ISDN technology will be implemented in phases. The first phase includes increasing digital network capability through the use of digital transmission equipment, digital end user devices, and increased use of common channel signaling to improve control functions. The second phase will include standardization of equipment and the simultaneous transmission of voice and data will become more common. In the last phase, expected to begin after 1990, video, high speed data, and other services will be provided over ISDN. [Ref. 28:pp. 43-47]

One of the challenges the NTS and DCS will face in the future is the managing of the complex transition from old networks, like AUTODIN and AUTOVON, into the more capabile ISDN. The NTS must interactively merge both new requirements and new capabilities with the users as new services and features are made available by new technology.

2. Satellite Systems

Rapid advances in electronics and networking theory along with the lower costs of space and terrestrial hardware are supporting more capable satellite communications systems. More intelligent satellite-based controllers, highly proliferated satellite constellations for enhanced physical survivability, and extensive interoperability among most systems are characteristics of future satellite communications systems.

As space hardware becomes less expensive, the number of spacecraft per constellation will grow or "proliferate". Proliferated systems are inherently robust against conventional physical attacks and jamming. An enemy must effectively jam or destroy all satellites in view of a particular user in order to deny communications to that user. This becomes increasingly more difficult as the number of satellites increases or anti-jamming satellite techniques improve. The concept of proliferated systems is known as "cloudstat" because of the large number of "cloud" of spacecraft. interconnected with crosslink capabilities that provide added support and worldwide connectivity. This trend is apparent in such systems as MILSTAR. [Ref. 27:pp. 146-148]

C. SUMMARY

The introduction of small, low-cost, reliable, solid state electronic devices has brought a new era to both military and commercial communications. The exploitation of this advanced technology will help maintain and enhance the "force multiplier" concept necessary to achieve a more effective C3 system for the military. Included in these new technologies are fiber optics, lasers, packet switching, spread spectrum. millimeter waves, local area networks (LANs), wideband HF, and meteor burst communications. The key to providing effective communications systems is to embed these technologies in new developments and to field them quickly. An appropriate system "architecture" must also be established and a strong system engineering/analysis effort conducted in order for new technology advances and equipment acquisitions to be employed in the most cost effective manner. [Ref. 28:pp. 194-217]

APPENDIX A

THE FOLLOWING NAVTELCOM ACTIVITIES REPORT DIRECTLY TO COMNAVTELCOM for administrative and operational control:

NAVEMSCEN WASHINGTON DC
NAVTASC CHELTENHAM MD
NAVTELSYSIC CHELTENHAM MD
NAVAUTODINSCEN ALBANY GA
NAVCOMCO WASHINGTON DC
HQ NAVMARCORMARSTA CHELTENHAM MD

NAVCOMMU WASHINGTON DC
- NTCC CRYSTAL PLAZA
- OPNAV TCC
- NTCC WARD CIRCLE
- NTCC GREAT LAKES
- NTCC NEWPORT
- NAVTELCOM OPS CENTER

The following activities, organized by NAVCOMMAREA report to COMNAVTELCOM for administrative control and to the area NAVCAMS for operational control. Internal components of an activity, such as NTCCs, ASCOMMs, NAVRADSTAs, etc. are listed under the parent command.

1. LANT NAVCOMMAREA

NAVCAMS LANT NORFOLK VA
- NAVCAMS LANT DET IANTN FARAN PM
- NAVRADSTA R SUGAR GROVE WV
- NAVRADTRANSFAC ANNAPOLIS MD
- NAVSATCOMMFAC NORTHWEST VA
- NAVSATCOMMDET GUANTANAMO BAY
- NTCC BREEZY PT
- NTCC CHARLESTON
- NTCC HAMPTON ROADS
- NTCC LITTLE CREEK
- NTCC NAVEASTOCEANCEN NORFOLK
- NTCC NSC NORFOLK
- NTCC NSC DET CHARLESTON
- NTCC PORTSMOUTH
- SPECOMMDIV NORTHWEST

NAVCOMMSTA JACKSONVILLE FL
- NTCC CECIL FIELD
- NTCC MAYPORT
- ASCOMM JACKSONVILLE

NAVCOMMSTA KEFLAVIK IC
- ASCOMM KEFLAVIK
- SPECOMMDIV ICELAND

NAVCOMMSTA ROOSEVELT ROADS RQ
- NAVRADRECFAC SABANA SECA RQ
- NAVRADTRANSFAC ISABELA RQ

NAVCOMMSTA THURSO UK
- SPECOMMDIV EDZELL
- NAVCOMMDET EDZELL

NAVCOMMU KEY WEST FL

NAVCOMMU CUTLER ME

2. MED NAVCOMMAREA

NAVCAMS MED NAPLES IT
- NTCC AGNANO
- NTCC CAPODICHINO
- NAVCAMS MED DET SIGONELLA
- ASCOMM SIGONELLA

NAVCOMMU LONDON UK
- NTCC MACHRIHANISH
- NTCC ST MAWGAN

NAVCOMMSTA ROTA SP
- NAVRADTRANSFAC MORON AB
- ASCOMM ROTA
- SPECOMMDIV ROTA

NAVCOMMSTA NEA MAKRI GR
- NAVCOMMDET SOUDA BAY

3. EASTPAC NAVCOMMAREA

NAVCAMS EASTPAC HONOLULU HI
- NTCC BARBERS PT
- NTCC CAMP H M SMITH
- NTCC FORD ISLAND
- NTCC PEARL HARBOR
- ASCOMM BARBERS PT
- SPECOMMDIV HONOLULU
- NAVRADTRANSFAC LUALUALEI

NAVCOMMSTA PUGET SOUND WA
- NAVCOMMDET WHIDBEY ISLAND
- NAVRADSTA T JIM CREEK OSO WA
- NTCC BREMERTON
- NTCC SEATTLE

NAVCOMMSTA STOCKTON CA
- NTCC ALAMEDA
- NTCC CONCORD
- NTCC MARE ISLAND
- NTCC MOFFETT FIELD

NAVCOMMSTA SAN DIEGO CA
- NTCC LONG BEACH
- NTCC LONG BEACH ANNEX
  - NAVWEPSTA SEAL BEACH
- NTCC LONG BEACH ANNEX FL
  - ANAL CEN CORONA
- NTCC MIRAMAR
- NTCC NORTH ISLAND
- NTCC PT MUGU
- NTCC SAN DIEGO
- NTCC SILVER STRAND
- NTCC THIRTY SECOND STREE
- NAVRADTRANSFAC CHOLLAS H
- NAVRADRECFAC IMPERIAL BE

NAVSECGRUACT ADAK AK
- NTCC SWEEPERS COVE
- ASCOMM ADAK
- SPECOMMDIV ADAK

NTCC MONTEREY
NTCC OAKLAND
NTCC TREASURE ISLAND
ASCOMM MOFFETT FIELD
NAVRADTRANSFAC DIXON
NAVRADRECFAC SKAGGS ISLAND

4. WESTPAC NAVCOMMAREA

NAVCAMS WESTPAC GUAM GQ
- NTCC AGANA
- NTCC NIMITZ HILL
- ASCOMM AGANA
- SPECOMMDIV GUAM
- NAVRADTRANSFAC BARRIGADA

NAVCOMMSTA DIEGO GARCIA
- ASCOMM DIEGO GARCIA

NAVCOMMSTA HAROLD E HOLT EXMOUTH AS

NAVCOMMSTA PHILLIPPINES SAN MIGUEL
- NTCC CUBI PT
- NTCC SUBIC BAY
- NAVLINKSTA MT SANTA RITA
- NAVRADTRANSFAC CAPAS
- ASCOMM CUBI PT

NAVCOMMSTA YOKOSUKA JA
- NAVRADRECFAC KAMI SEYA JA
- NAVRADTRANSFAC TOTSUKA JA
- NAVRADTRANSFAC YOSAMI JA
- NTCC YOKOSUKA JA

APPENDIX B
RADIO WAVE PROPAGATION

The information in this appendix was extracted from Navy Education & Training Course #10228-6, Radioman 3 & 2.

The transmission of radio waves through space is known as WAVE PROPAGATION. An electromagnetic wave must be propagated through space to a receiving antenna to establish a communications system. In any radio communications system, energy in the form of electromagnetic waves is generated by the transmitter and fed to an antenna by means of a transmission line. The antenna radiates this energy out into space at the speed of light. Receiving antennas, placed in the path of the traveling radio wave, absorb part of the radiated energy and send it through a transmission line to a receiver.

Successful communication by means of radio waves depends on the power of the transmitter, the frequency used, the distance between the transmitter and receiver, and the sensitivity of the receiver. The ability of the earth's atmosphere to conduct energy to its destination, together with the nature of the terrain between the sending and receiving points, may be responsible for the frequency used to transmit the radio signal. Interferring signals can make reception impossible at a desired time. Also, the amount of noise present at the signal frequency and transmission line losses may combine to make unintelligible an otherwise good signal.

Depending upon the frequency used, the primary medium for transmission may be the surface of the earth or the free space surrounding the earth, (normally both). By far the more complex of these two mediums is free space. Therefore, it is necessary that the nature of free space be known so that its effects on the quality of transmission may be predicted. Weather conditions, changes in the level of radiation from the sun, and physical obstructions on the earth's surface all affect the quality and reliability of transmission. Because we cannot control the phenomena existing in the propagating mediums, our knowledge of them is of primary importance to achieve successful communications.

1. TERMS AND DEFINITIONS

In our discussion of radio wave propagation, a number of terms are used that could tend to confuse you, if the terms are not understood. Therefore, the following list of defined terms is provided for your reference.

ATMOSPHERE - The mass of space surrounding the earth, including the troposphere, stratosphere, and ionosphere. Also called "free space".

ATTENUATION - The decrease in signal strength of a radio wave.

CONDUCTIVITY - A measure of the ability of a material to act as a path for electron flow. (Measured in mhos per meter).

CRITICAL FREQUENCY - That frequency below which an electromagnetic wave is bent back to earth by a layer in the ionosphere.

DIFFRACTION - The bending of an electromagnetic wave around the edge(s) of a solid object.

DIRECT WAVE - A radio wave that is propagated in a straight line through space from the transmitting to the receiving antennas.

DISTORTION - An undesired change in an electromagnetic waveform.

FADING - The variation of radio signal strength, usually gradual, during the time of reception.

GIGAHERTZ (GHz) - An expression denoting 1000 MHz.

GROUND WAVE - A radio wave that travels (propagates) close to the earth's surface and reaches the receiving antenna without being influenced by the ionosphere. The ground wave includes all components of a radio wave traveling over the earth except the sky (ionospheric) wave.

HERTZ (Hz) - Cycles per second.

INCIDENT WAVES - A term denoting that portion of a radio wave passing from one medium into another which will result in that wave being reflected, refracted, diffracted, or scattered.

IONOSPHERE - That part of the earth's outer atmosphere where ionization is present in sufficient quantity to affect the propagation of radio waves. Also known as that portion of the atmosphere above the stratosphere.

MAXIMUM USABLE FREQUENCY (MUF) - The highest frequency or frequencies that may be used at a specified the time of day for radio communications between two points.

NOISE - Any extraneous electrical disturbance tending to interfere with the normal reception of a transmitted signal.

FREQUENCY OF OPTIMUM TRANSMISSION (FOT) - The most reliable frequency for propagation at a specific time.

LOWEST USABLE FREQUENCY (LUF) - The lowest frequency that may be used during a specific time, depending upon power and bandwidth requirements.

PROPAGATION - The transmission of electromagnetic (radio) waves from one point to another.

REFLECTION - The phenomenon occurring when a radio wave strikes the surface of the earth at some distance from the antenna and is returned upward toward the ionized layer of air.

REFRACTION - The phenomenon occurring when a radio wave obliquely passes from one medium to another of different density, causing the wave to change direction.

SPACE WAVE - Sometimes called the tropospheric wave. A radio wave that travels entirely through the earth's troposphere.

SKY WAVE - A radio wave that is propagated or acted upon by the ionosphere.

SUNSPOT NUMBERS - The number of dark, irregularly shaped areas on the surface of the sun caused by violent solar eruptions. Counted and averaged over a period of time, they are used to predict the average sunspot activity. The average of these numbers is called "smooth sunspot numbers".

SURFACE WAVE - That part of the ground wave that is affected chiefly by the conductivity of the earth.

STRATOSPHERE - That part of the earth's atmosphere lying between the troposphere and the ionosphere.

TROPOSPHERE - The lower part of the earth's atmosphere, lying between the surface of the earth and the stratosphere.

2. DIFFRACTION, REFLECTION, AND REFRACTION

One of the many problems encountered in the propagation of radio waves is the changeable conditions of the transmission path through the various mediums. As a radio wave is traveling through space, it can be affected adversely or in such a manner as to enhance communications. It may change direction, velocity, or be completely absorbed within the propagating medium.

The atmosphere of the earth is the common medium for propagation and a study of radio propagation is concerned chiefly with properties and effects of this medium. Radio waves travel in two ways from a transmitter to a receiver: by means of GROUND WAVES, which travel close to the surface of the earth or by SKY WAVES, which travel up to electrically conducting regions of the earth's atmosphere and are returned to earth, (see Figure B.1). Some forms of transmission are combinations of both ground waves and sky waves.

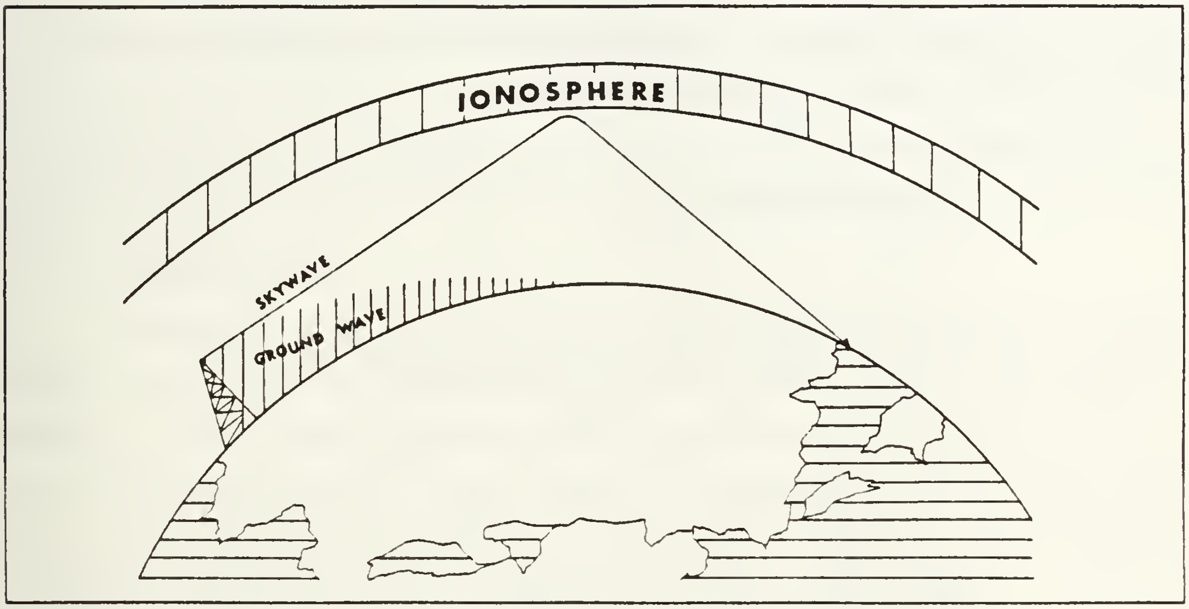

Figure B.1 Ground Waves and Sky Waves.

Like other forms of electromagnetic radiation, radio waves can be diffracted, reflected, and refracted. Ground waves are affected partially by the curvature and electrical characteristics of the earth. Sky waves are affected in varying degrees by the constant changes taking place in the upper atmosphere.

a. DIFFRACTION

A radio wave is bent when it passes the edge of an object. If a beam of light shines on the edge of an opaque screen in a room, it can be observed that the screen does not cast a perfectly outlined shadow. The edges of the shadow are not outlined sharply because the light rays are bent around the edge of the screen which decreases the area of total shadow. The bending, called DIFFRACTION, results in a change of direction of part of the energy from the line-of-sight path.

Figure B.2 shows the diffraction of waves around a solid object. The lower the frequency of the wave, or the longer the wavelength, the greater the bending of the wave. Thus, sound waves are diffracted more than radio waves. Diffraction aids in explaining why radio waves of proper frequency can be received on the far side of a mountain or down in a valley and why sound waves can readily be heard around the corner of a building. In the propagation of radio waves at a distance, diffraction is a significant consideration because the largest object to be contended with is the bulge of the earth itself, which prevents a direct passage of the wave from the transmitter to the receiver. By using high power and very low frequencies, the waves of a transmitted signal can be made to encircle the earth by diffraction.

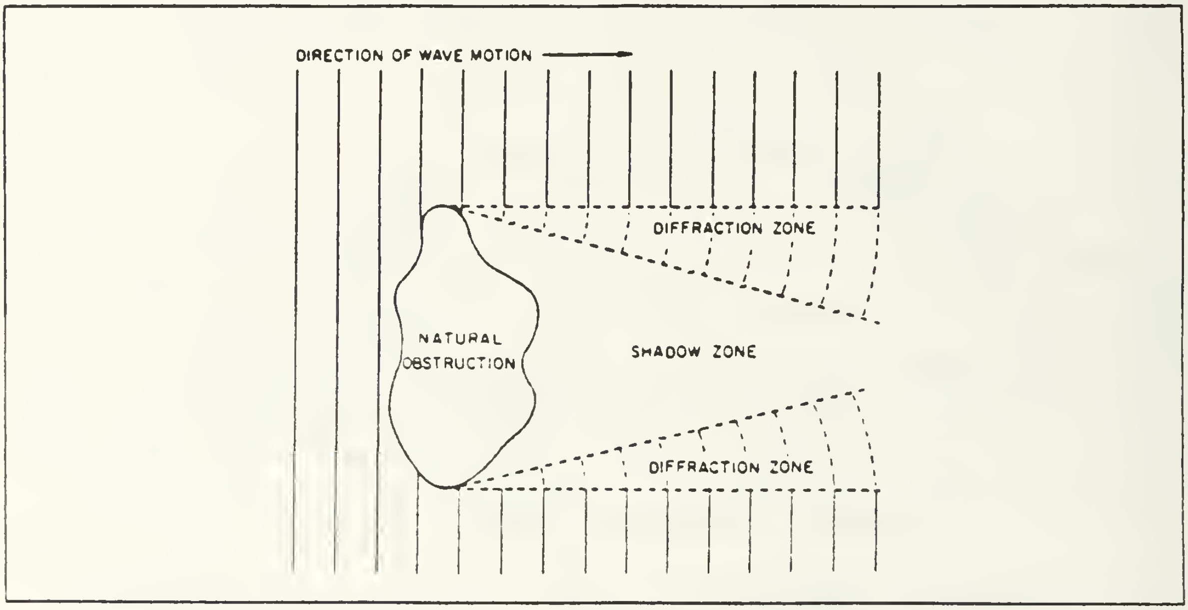

Figure B.2 Diffraction of Waves.

b. REFLECTION

Radio waves may be reflected from any sharply defined substances or objects of suitable characteristics and dimensions which are encountered in the medium of travel. For reflection to occur, the object, or material doing the reflecting, must have the right type of surface, and it must be larger than the wavelength of the incident wave. Figure B.3 shows an incident radio wave striking water. Water is a good conductor and reflector of radio waves. Large, smooth metal surfaces of good electrical conductivity (such as copper) are efficient reflectors.

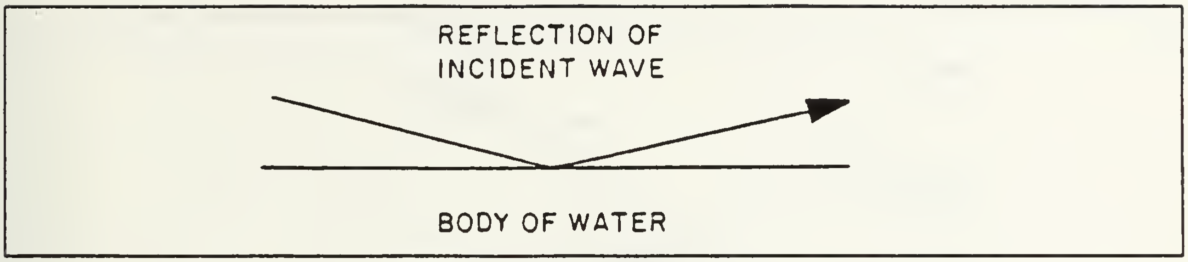

Figure B.3 Reflection of an Incident Wave from a body of water.

As previously mentioned, reflection takes place only when the reflecting surface is large compared to the wavelength of the incident wave and smooth for an appreciable portion of a wavelength. When these conditions are not met, scattering occurs. Scattering is undesirable for certain types of communications, but it is utilized to a great extent in others.

c. **REFRACTION**

Whenever a radio wave passes from one medium into another of different density, it will be bent to some degree. Figure B.4 shows a radio wave striking the surface of a body of water. The water, being more dense than air, tends to bend the radio wave back toward the "normal". The denser medium tends to slow and bend the radio wave. The amount of bending that takes place is referred to as the "Index of Refraction". The higher the index of refraction, the greater the bending.

Whenever a radio wave passes from a dense to a less-dense medium, it bends away from the normal. Figure B.5 illustrates this principle. The "more dense" mediums and the "less dense" ones are normally layers that exist in the atmosphere. It must be remembered that whenever a radio wave is propagated, it is constantly being diffracted, reflected, and refracted, simultaneously.

A common error is the assumption that reflection and refraction are very similar because they return radio waves back to earth for reception. However, as shown in Figure B.6 the refracted wave is "bent" back to earth. As radio waves are propagated, some of them make large angles with respect to the horizontal along the earth. These waves are refracted a small amount and pass on through the various layers of the atmosphere and into outer space. Still other waves of the same radio signal make small angles, thereby travelling a greater distance in the layered medium and may be bent back towards earth gradually. The net result is as though the wave had been reflected back to earth.

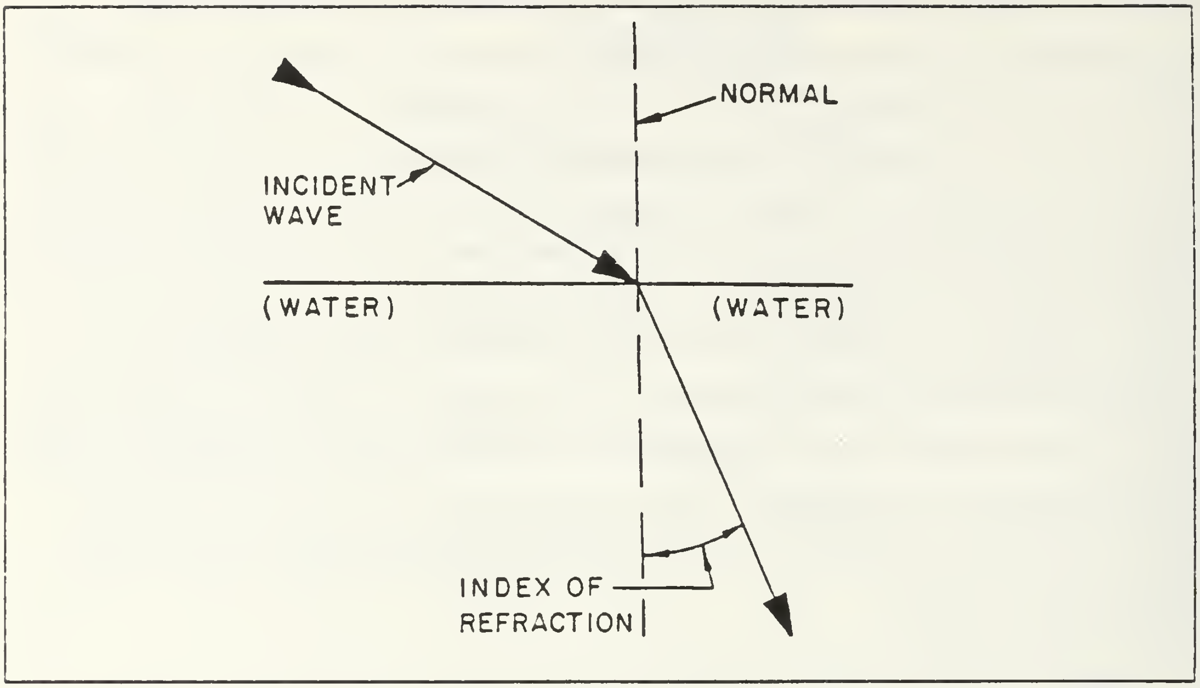

Figure B.4 Refraction.

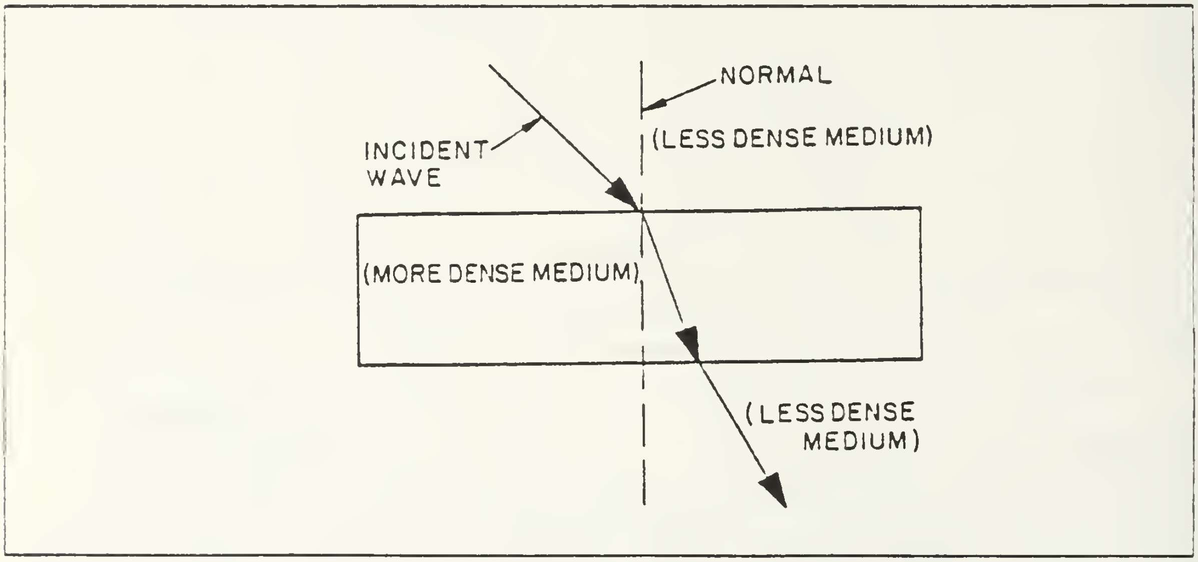

Figure B.5 Radio Wave passing from a more dense medium.

3. COMPOSITION OF THE EARTH'S ATMOSPHERE

The atmosphere about the earth is not uniform. Changes in moisture content, temperature, and density occur at different heights and geographical locations or even

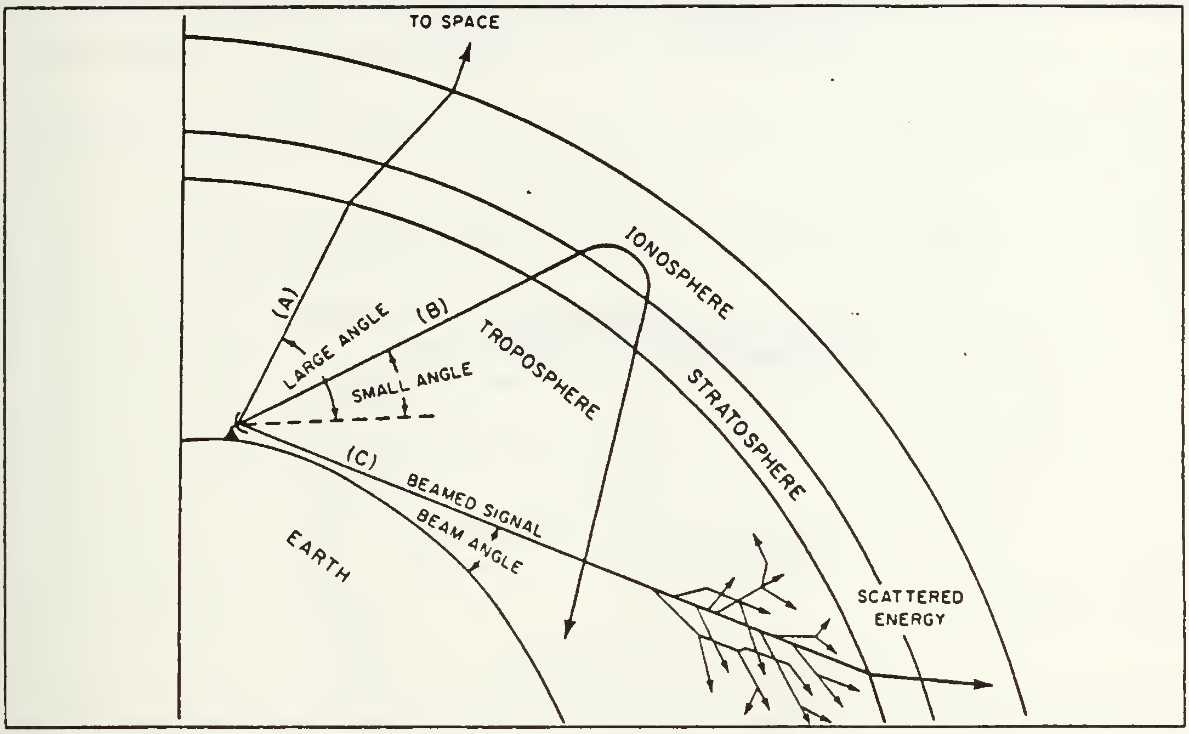

Figure B.6 Refraction of Radio Waves in the Atmosphere.

with changes in time of day, night, season, or year. To assist in understanding the effects of these changes on radio waves, three regions have been identified in the atmosphere. These three regions are the troposphere, stratosphere, and ionosphere. Their positions with relation to each other are shown in Figure B.7 The troposphere extends from the earth's surface to heights of about 6 to 60 miles. The stratosphere, lying between the troposphere and ionosphere, extends from approximately 10 to 50 miles above the earth's surface. The ionosphere extends from approximately 50 miles to 250 miles above the earth's surface.

4. TYPES OF RADIO WAVE PROPAGATION

The radio wave that is transmitted from an antenna has two major components: the ground wave and the sky wave. The ground wave component of the transmitted radio wave consists of two parts. One part travels along the ground and follows the curvature of the earth and is called the surface wave. The second part is the space wave, which undergoes refraction, reflection, or scattering in the troposphere. The sky wave, is radiated in an upward direction and may be returned to earth at some distant location due to refraction or scattering from the ionosphere. The amount of bending

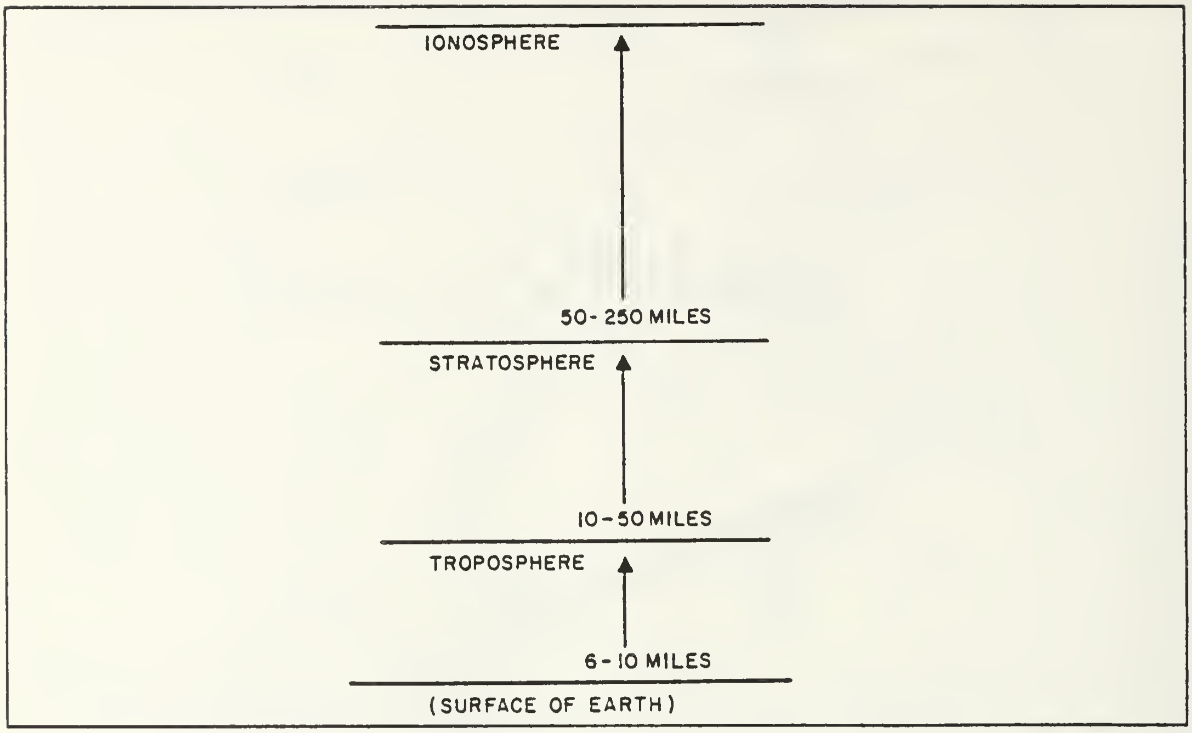

Figure B.7 Atmospheric Mediums.

of the sky wave by the ionosphere depends upon the frequency of the wave and the density of the layers in the ionosphere. The higher the frequency of the radio wave, the farther it penetrates the ionosphere, and the less it tends to be bent back toward earth.

a. SURFACE WAVE

A surface wave is that part of the ground wave that is affected chiefly by the conductivity of the earth and is able to follow the curvature of the earth's surface. The surface wave is not confined to the earth's surface. Parts of it extend upward to considerable heights in the troposphere, diminishing in strength as it increases height.

The earth itself is a partial conductor and, upon contact with its surface, some of the energy of the surface wave is absorbed and rapidly wasted in the form of heat. Losses suffered by surface waves are sometimes extensive, resulting in a badly attenuated (weakened) communications signal. The amount of attenuation depends on the relative conductivity of the earth's surface, which may vary according to terrain. Table 8 gives the relative conductivity for various types of surface. As can be seen, sea water is the best type of surface for surface wave transmission. Sea water makes possible the long-distance coverage attainable by fleet broadcasts that use surface wave transmissions of very low frequencies.

TABLE 8

RELATIVE CONDUCTIVITY OF SURFACE TYPES

Type of surface	Relative conductivity
Sea Water	Good
Large bodies of fresh water	Fair
Wet soil	Fair
Flat, loamy soil	Fair
Dry, rocky terrain	Poor
Desert	Poor
Jungle	Unusable

In general, the surface wave is transmitted as a vertically polarized wave and remains vertically polarized at appreciable distances from the antenna. Vertical polarization is used because the earth has a short-circuiting effect on a horizontally polarized wave. Overall, vertical polarization is superior to horizontal polarization except in heavily wooded or jungle areas. The reason is that most foliage grows vertically and absorbs vertically polarized energy.

b. SPACE WAVE

While the characteristics of the surface wave serve to explain long-range propagation of very low frequencies using high power, they do not seem to apply to reception of higher frequencies within and slightly beyond the radio horizon. Such signals are considered to be propagated via the space wave.

Space waves are composed of two components: DIRECT WAVES and GROUND-REFLECTED WAVES. The direct waves travel in a direct line-of-sight path from a transmitting antenna to a receiving antenna. This component is limited only by the distance to the horizon (or line of sight) from the transmitter plus the small distance added by the atmospheric diffraction of the wave around the curvature of the earth. This distance can be extended by increasing the height of either the transmitting or receiving antenna, effectively extending the radio horizon. Figure B.8 shows the possible routes that a ground wave might take.

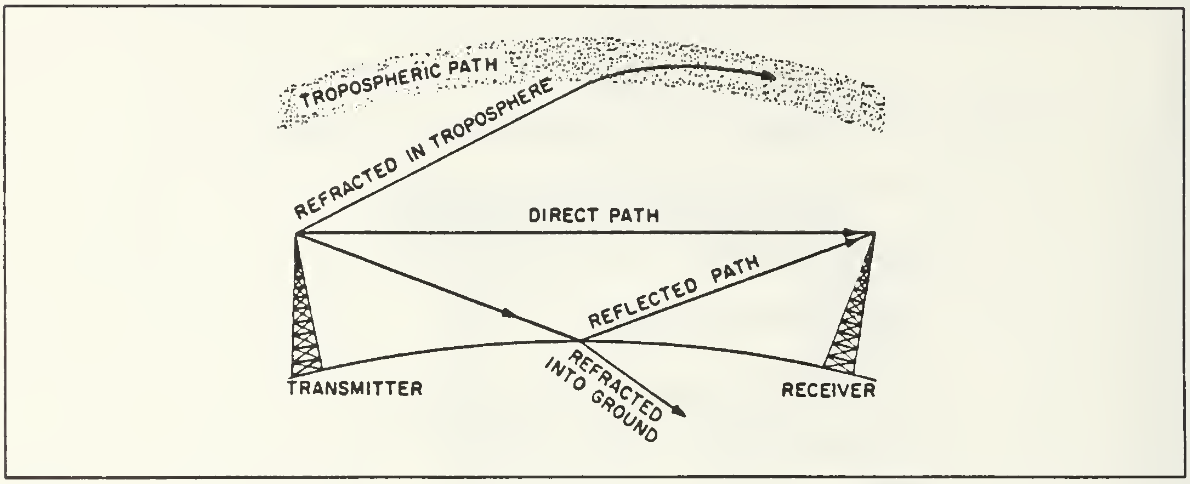

Figure B.8 Possible routes for ground waves.

A ground-reflected wave, as its name indicates, reaches the receiving antenna after it is reflected from the ground or sea. In Figure B.9 it may be seen that the waves start out with fronts of equal phase, continuing in phase up to the point of reflection of the ground component. Beyond this point, corresponding waves are 180-degrees out of phase. This phase reversal is important in determining the effect of the combining of the reflected wave with the direct wave upon arrival at the point of reception. Because the reflected wave travels a longer time in reaching its destination, a phase displacement (over and above the 180-degree shift caused by reflection) results. Thus, the reflected wave arrives at the receiving antenna, nearly 180-degrees out of phase with the direct wave. An undesirable cancellation of signal energy results.

c. SKY WAVE

That portion of the radio wave which moves upward and outward and is not in contact with the earth is called the sky wave. It behaves similarly to the ground wave in that some of the energy is refracted, reflected, and scattered, and some of the energy is lost in dissipation within the atmospheric layers. A receiver located in the vicinity of the returning sky wave will receive strong signals even though the receiver is several hundred miles beyond the range of the ground wave.

Ionospheric refracted sky waves are generally the only usable waves for long range communications. Figure B.10 illustrates some of the many possible paths that

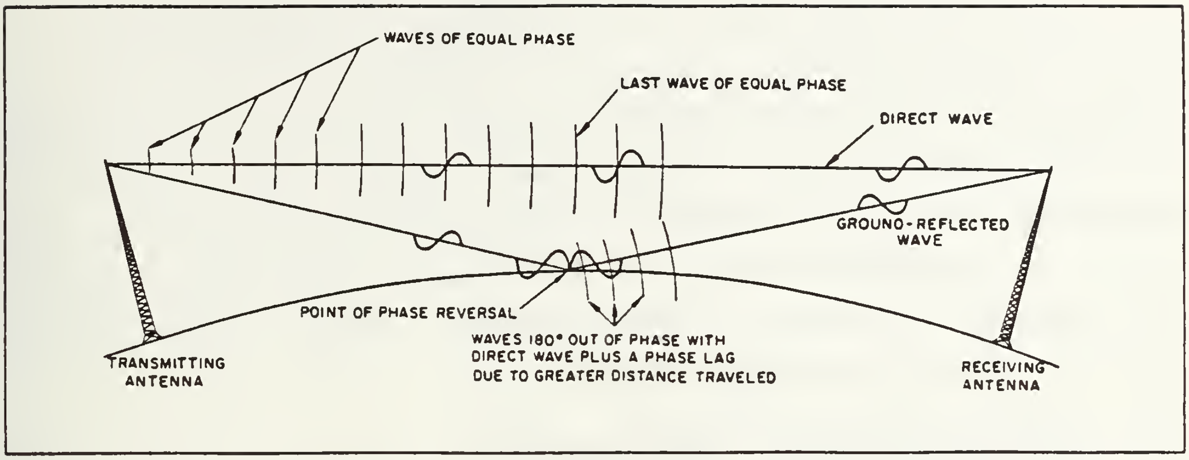

Figure B.9 Direct and ground reflected waves.

radio waves of various frequencies may take between a transmitter and a receiving station by refraction in the ionosphere. Notice that some of the waves, which are assumed to be of too high a frequency for refraction in the ionosphere, pass on through and are lost into space. Other radio waves, which are assumed to be of the correct frequency for refraction from the ionosphere, are returned to earth and provide communications.

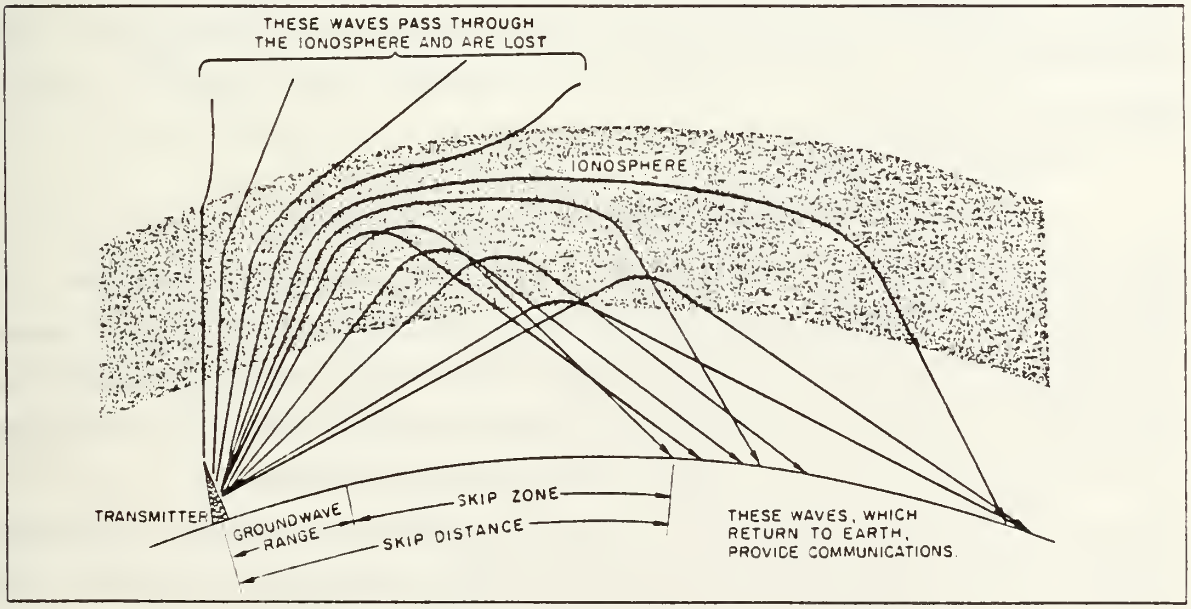

Figure B.10 Possible paths for radio waves.

In Figure B.10, notice that the term SKIP DISTANCE is the distance from the transmitting antenna to the nearest point at which the refracted waves return to earth. Also notice the difference between the skip distance and the SKIP ZONE. The skip zone is the zone between the end of the ground wave and the point where the sky wave first returns to earth. The skip distance depends upon the density of the ionosphere. The skip zone depends upon propagation characteristics of the ground wave in relation to the sky wave. The zone itself may vary from minute to minute for the same signal as propagation conditions change. Generally, however, the zone is relatively stable and remains approximately the same.

5. BASIC TROPOSPHERIC PROPAGATION

Tropospheric radio wave propagation depends on weather conditions. Weather conditions in the troposphere vary from minute to minute, making it the least predictable layer of the atmospheric medium. The troposphere is the lowest region of the atmosphere, extending from the earth's surface to a height of from 6 to 10 miles above the surface. Virtually all weather phenomena occur in this region of the atmosphere.

Refraction of radio waves in the troposphere is a function of various meteorological variables. Because of the uneven heating of the earth's surface, the air in the troposphere is in constant motion. This motion causes small turbulences, or eddies, to be formed. These turbulences are quite similar to whirlpools of water. The turbulence is at its greatest intensity near the surface of the earth and gradually diminishes with altitude.

a. Tropospheric Wave

A tropospheric wave is that component of the ground wave that is refracted in the lower atmosphere by rapid changes in humidity, atmospheric pressure, and temperature. At heights of a few thousand feet to approximately 1 mile, huge masses of warm and cold air exist near to each other, causing rapid changes in temperature and pressure. The resulting refraction and reflection make it possible to communicate over greater distances than that possible using the ground wave alone.

Temperature inversion is a common cause of tropospheric refraction, especially when warm layers of air are located above cooler layers. This may result from the rapid cooling of the earth's surface after sunset or the heating of air above a cloud layer by reflection of sunlight from the upper surface of clouds.

b. Forward Propagation Tropospheric Scatter Communications

The troposphere is used for many types of communications, such as radiotelephone, radioteletype, and data transmission. Much of this is made possible through a system known as forward propagation tropospheric scatter (FPTS), also known as tropo-scatter. Basically, troposcatter utilizes the reflective and refractive properties within the troposphere. When a radio signal is beamed to an area in the troposphere, part of it goes through a complex series of partial reflection and refraction, causing energy to be scattered and to become partly diffused. This "beaming" is done via parabolic antennas. These antennas are very directional, hence lending themselves well to this type of communications. Figure B.11 illustrates the way that these parabolics are used for tropo-scatter.

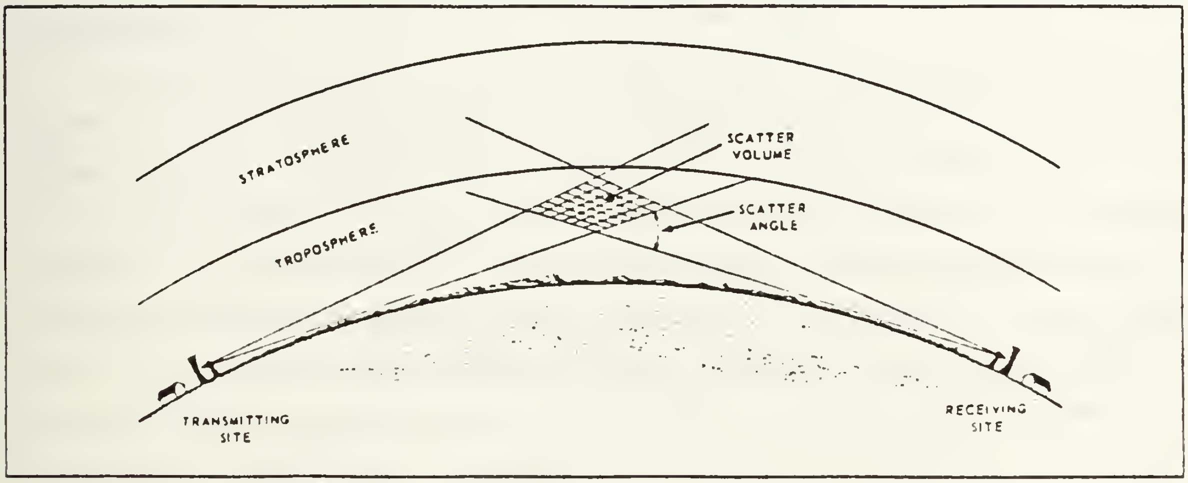

Figure B.11 Tropo-scatter propagation.

The scattering phenomenon in the troposphere is based on the theory that turbulences prevailing in the troposphere cause scattering of the signal beyond the horizon. The term "scattering" tends to imply that the signal is spread in all directions. However, this is not the case. A characteristic of tropo-scatter is that the energy in the main beam is scattered in a forward direction, hence the use of the term "forward-propagated". The lower the angle of the beam with respect to the horizon, the better the forward-propagation characteristics of the signal. A receiving parabolic, beamed at the same area in the troposphere as the transmitting antenna, will pick up the transmitted energy for further processing.

The amount of received energy decreases as the height of the scatter is increased. There are two reasons for this: (1) the scatter angle increases as the height is increased, thus decreasing the forward propagation characteristics, and (2) the amount of turbulence decreases with the height in the troposphere, thus reducing the amount of reflection and refraction taking place at any one time in the beamed signal. It should be noted that as greater distance is attempted with FPTS, the received signal level decreases. This is because the angle must be increased to achieve greater height, thus decreasing the receive potential. The beam take-off angle of transmitting and receiving antennas for FPTS is always kept as low as possible, depending upon local terrain and general geographical location.

Since tropospheric scatter depends on turbulences in the atmosphere, changes in atmospheric conditions will affect the received signal level. Both daily and seasonal variations are noted. These changes are associated with a term known as "long-range fading" characteristics. There is also a term known as "rapid-fading", which is associated with multi-path transmissions or multi-path propagation. The signals received at any one time are the sum of all the signals received from each of the turbulences in the main beam. Since turbulent conditions are constantly changing, the transmission paths and individual signal levels are also changing, resulting in a rapidly changing signal. Although the signal level is constantly changing, the average signal level is relatively consistent. Therefore, no complete signal fade-out occurs.

Another characteristic of a tropospheric scatter signal is that most of the transmitted beam is not picked up by the receiving antenna, the efficiency is very low, and the signal level at the receiving station is very low. To compensate for this low efficiency in the scatter, the incident power must be high. Thus, high-power transmitters and high-gain antennas are used to concentrate the transmitted power into the beam, thus increasing the intensity of energy radiated. The receiving antennas are also very sensitive, thus enabling them to detect low level signals for further processing. Since troposcatter is considered to relatively short-range, a series of relay stations with built-in signal amplifiers are used to achieve long-range transmission.

6. BASIC IONOSPHERIC PROPAGATION

The ionosphere is found in the rarefied atmosphere, beginning at approximately 40 to 50 miles above the earth. It differs from other atmospheric layers in that it contains a much higher number of positive and negative ions. It is known that the atmosphere is under constant bombardment by radiation and particle showers from the sun as well as by cosmic rays. Radiation from the sun includes not only light rays that can be seen, but also the entire spectrum, ranging from infrared rays to ultraviolet rays. Radiation from the sun is capable of dislodging some loosely bound electrons from gas atoms that make up the dense gases in the upper atmosphere. Therefore, the ionosphere has a large number of ionized gas atoms as well as free electrons unassociated with any atom.

At altitudes above 350 miles, the particles of air are far too sparse to permit large-scale energy transfer. Ultraviolet radiations from the sun are absorbed in passage through the upper layers of the ionosphere so that below an elevation of 40 miles, very few ions exist that would affect sky wave communications. Therefore, sky wave communications depends primarily upon the ionospheric conditions existing at the time of transmission.

Densities of ionization at different heights make the ionosphere appear to have layers. Actually, there is thought to be no sharp dividing line between the various layers, but they do exist and will be separated here for explanation and clarity.

Figure B.12 shows the various layers associated with the ionosphere at night and during the day. The ionized atmosphere at an altitude of between 40 and 50 miles is called the "D" layer. Its ionization is low and has little effect on the propagation of radio waves except for the absorption of energy from the waves as they pass through it. The D layer is present only during the day. Its presence reduces the field intensity of radio wave transmissions during the day.

The "E" layer exists at altitudes between 50 and 90 miles. It is a well defined layer with greatest density at an altitude of about 70 miles. This layer is strongest during daylight hours and is also present, but much weaker, at night. The maximum density of the E layer appears at about mid-day. During this part of the day, the ionization of the E layer is sometimes sufficient to refract frequencies in the upper HF band back to earth. This action is of great importance to daylight transmissions for distances up to 1,500 miles.

The "F" layer extends approximately from the 90 mile level to the upper limits of the ionosphere. During daylight hours the F layer is divided into two sections: the F1 and the F2 layers. Shortly after sunset, the F1 and the F2 layers combine into the single F layer.

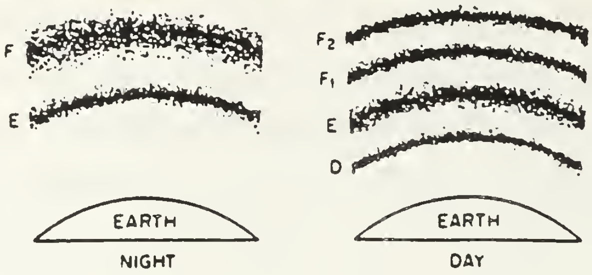

Figure B.12 Ionospheric layers at night and day.

In addition to the layers of ionized atmosphere that appear regularly, erratic patches of ionized atmosphere occur at E layer heights in the manner that clouds appear in the sky. These patches are referred to as "Sporadic E" ionizations. These sporadic ionizations may appear in considerable strength and prove quite harmful to electronic transmissions.

7. EFFECT OF IONOSPHERE ON THE SKY WAVE

The ionosphere has many characteristics. Some waves penetrate and pass entirely through it into space, never to return. Other waves penetrate but bend. Generally, the ionosphere acts as a conductor and absorbs energy in varying amounts from the radio wave. The ionosphere also bends (refracts) the sky wave back to the earth, as shown in Figure B.13

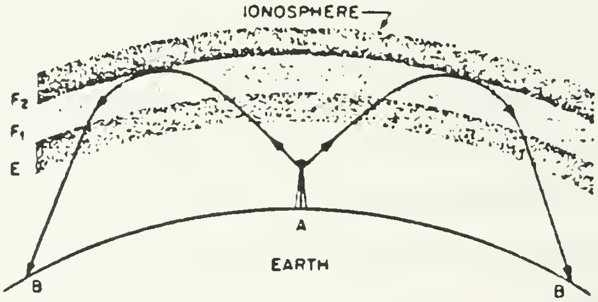

Figure B.13 Ionosphere bends waves back to earth.

The ability of the ionosphere to return a radio wave to the earth depends upon the angle at which the sky wave strikes the ionosphere, the frequency of the radio wave, and the ion density. When the wave from an antenna strikes the ionosphere at an angle, the wave begins to bend. If the frequency and angle are correct and the ionosphere is sufficiently dense, the wave will eventually emerge from the ionosphere and return to earth. The sky wave in Figure B.14 is assumed to be composed of rays that emanate from the antenna in three distinct groups that are identified according to the angle of elevation. The angle at which the group 1 rays strike the ionosphere is nearly vertical and will not be returned to earth. The radio wave strikes the ionosphere, is bent out of line slightly, but passes completely through the ionosphere and is lost.

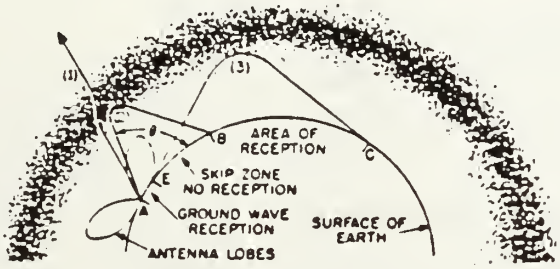

Figure B.14 Three groups of radio waves.

The angle made by the group 2 waves is called the CRITICAL ANGLE for that frequency. Any wave that leaves the antenna at an angle greater than this angle will penetrate the ionosphere.

Group 3 waves strike the ionosphere at the smallest angle that will be refracted and still be returned to earth. At any smaller angle, the waves will be refracted but will not return to earth.

As the frequency increases, the initial angle decreases. Low frequencies can be projected straight upward and will be returned to the earth. The highest frequency that can be sent directly upward and still be refracted back to the earth is called the CRITICAL FREQUENCY. At sufficiently high frequencies, regardless of the angle at which the rays strike the ionosphere, the wave will not be returned to earth. The critical frequency is not constant but varies from one locality to another, with the time of day, with the season of the year, and with the sunspot cycle.

Because of this variation in the critical frequency, frequency tables are issued that predict the maximum usable frequency (MUF) for every hour of the day for every locality in which transmissions are made. These frequency tables are prepared from data obtained experimentally from stations scattered all over the world. All of this information is pooled and the results are tabulated in the form of long range predictions that remove some of the guesswork from transmissions.

a. **Absorption in the Ionosphere**

As a radio wave passes into the ionosphere, it loses some of its energy to the free electrons and ions contained in this part of the atmosphere. Since absorption of energy is dependent upon collision of particles, the greater the density of the ionized layer, the greater the probability of collision, and therefore, the greater the absorption. The highly dense D and E layers provide the greatest absorption for the ionospheric wave.

b. **Variations in the Ionosphere**

Sky wave intensity varies from minute to minute, month to month, and year to year because of variations in the ionosphere. Since the ionosphere exists primarily because of the radiation of the sun, any variation in the strength of this radiation will cause a corresponding change in the ion density of the upper atmosphere. Some of the variations in the ionosphere are periodic and their effects on radio frequencies can be anticipated. Others are unpredictable, and while their effects are pronounced, there is little that can be done but to realize that they may occur. Periodic variations can be divided into daily, seasonal, and sunspot cycle variations. Unpredictable variations are usually the result of the sporadic E layer and Short Wave Fadeouts (caused by sudden solar flare-ups).

c. **Periodic Variations**

Daily variations are caused by the 24-hour rotation of the earth about its axis. In the daytime, the ionosphere consists of the four ionized layers previously mentioned. At night in the F region, only the F2 layer exists insofar as regular HF propagation is concerned. The nighttime F2 layer is formed by a combination of the daytime F1 and F2 layers that merge during evening hours.

Seasonal variations occur as the intensity of the ultra-violet light which reaches any given spot in the earth's atmosphere varies with the position of the earth in its orbit around the sun.

Sunspot activity varies in conformance to an 11-year cycle. Sunspots are proportional to approximate solar radiation and to the total ionization of the atmosphere. During periods of high sunspot activity, ionization of various layers is greater than usual, resulting in higher critical frequencies for the E, F1, and F2 layers, and higher absorption in the D layer. Consequently, higher freqnencies can be used for communication over long distances at times of greatest sunspot activity. Increased absorption in the D layer, which has the greatest effect on the lower frequencies, requires higher frequencies. The overall effect is a general improvement in propagation conditions during years of maximum sunspot activity.

8. FADING

Fading is the variation of radio signal strength at the receiving end of a transmission. Signals received over an ionospheric path may vary in intensity over short periods of time. There are three major reasons for fading. When the radio wave is refracted in the ionosphere or reflected from the earth's surface, random variations in polarization of the wave may occur, causing changes in the received signal level because of the inability of the antenna to receive polarization changes. Fading may also occur if the operating frequency selected is too close to the MUF (Maximun Usable Frequency). If this is the case, any slight change in the ionosphere might cause a change in signal strength. Fading also results from absorption of the signal energy in the ionosphere. Absorption fading occurs for a longer period of time than other types of fading because of the length of time required for an ionized layer to change in ionization potential. However, the major cause of fading on ionospheric circuits is caused by multipath propagation.

a. Multipath Fading

"Multipath" is the term used to describe the types of propagation that undergo changes enroute to the receiving site, causing them to arrive in a time frame that is later than the signal reflected from the ionosphere.

Figure B.15 shows the various paths a signal can travel between two sites. One signal, the ground wave, may follow the path XYZ. Another signal, refractd from the E layer (XEA), is received at A, but not at Z. Still another path (XFZFA), results from a greater angle of incidence and two refractions from the F layer. At point Z, the received signal is a combination of the ground wave and the sky wave. If these two waves are received out of phase, they will produce a weak or fading signal. If they are received in phase, the waves will produce a stronger signal. Small alterations in the transmission path may change the phase relationship of the two signals, causing periodic fading. This same addition of signal components occurs at point A. At this point, the double-hop signal from the F layer may be in or out of phase with the signal arriving from the E layer.

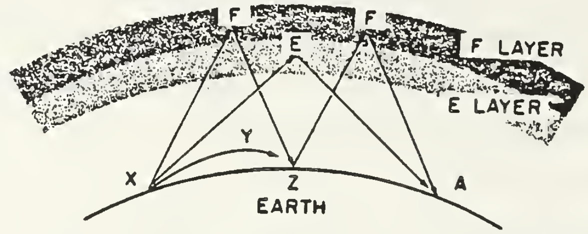

Figure B.15 Various paths of signal travel.

b. **Selective Fading**

Fading resulting from multipath propagation is variable with frequency since each frequency arrives at the receiving site via a different path. When a wide band of frequencies, such as multichannel single sideband, is transmitted, the frequencies in the sideband will vary in the amount of fading. This variation is called selective fading. Whenever selective fading occurs, all frequencies within the envelope of the transmitted signal may not retain their original phase relationship and relative amplitudes. This fading may cause severe distortion of the signal and limit the total bandwidth which can be transmitted.

APPENDIX C
USEFUL ACRONYMS AND ABBREVIATIONS

ABKS	Alternate Broadcast Keying Station
ACOC	Area Communications Operations Center
AFSATCOM	Air Force Satellite Communications
A/J	Anti-Jam
ALCEP	AUTOSEVOCOM Life Cycle Extension Program
AM	Amplitude Modulation
AMCC	Ashore Mobile Contingency Communications
ANMCC	Alternate National Military Command Center
ASC	Automatic Switching Center
ASCOMM	Anti-Submarine Warfare Support Communications
ASU	Approval for Service Use
ASWCCCS	Anti-Submarine Warfare Command Control Communications Subsystems
ASWIXS	Anti-Submarine Warfare Information Exchange Subsystem
ASWOC	Anti-Submarine Warfare Operations Center
AUTODIN	Automatic Digital Network
AUTOSEVOCOM	Automatic Secure Voice Network
AUTOVON	Automatic Voice Network
BCA	Broadcast Control Authority
BCST	Broadcast
BKS	Broadcast Keying Station
BPS	Bits Per Second
CARP	Contingency Alternate Routing Program
CAT	Communications Assistance Team
C3	Command, Control, and Communications
CHNL	Channel
CIB	Communications Information Bulletin
CINCUSNAVEUR	Commander-in-Chief, U.S. Naval Forces Europe
CIU	Control Interface Unit
CLF	CINCLANTFLT
CMCS	Communications Monitoring and Control System

CMIO	COMSEC Material Issuing Office
CNE	CINCUSNAVEUR
CNTC	COMNAVTELCOM
COMNAVSECGRU	Commander, Naval Security Group
COMNAVTELCOM	Commander, Naval Telecommunications
COMOPS	Communications Operating Performance Summary
COMSAT	Commercial Satellite
COMSEC	Communications Security
CP	Card Punch
CPF	CINCPACFLT
CPU	Central Processing Unit (Computer)
CSS	Command Switch System
CUDIXS	Common User Digital Information Exchange Subsystem
CW	Continuous Wave
DAMA	Demand Assigned Multiple Access
DCA	Defense Communications Agency
DCMS	Director COMSEC Material System
DCS	Defense Communications System
DDN	Defense Data Network
DOD	Department of Defense
DOS	Disk Operating System
DPSK	Differential Phase-Shift Keying
DRAMA	Digital Radio and Multiplex Acquisitions
DSCS	Defense Satellite Communications System
DSR	Data Speed Reader
EAM	Emergency Action Message
ECC	Electronic Courier Circuit
ECM	Electronic Counter Measures
ECS	Executive Control Subsystem
EDAC	Error Detection and Correction
EHF	Extremely High Frequency
EIRP	Effective Isotropic Radiated Power
ELF	Extremely Low Frequency
ELINT	Electronic Intelligence
EMCON	Emission Control

ESM	Electronic Warfare Support Measures
EW	Electronic Warfare
FBM	Fleet Ballistic Missile Submarine
FCD	File Control Block
FDUX	Full-Duplex
FEC	Forward Error Correction
FIFO	First-In First-Out
FIST	Fleet Imagery Support Terminal
FLTCINC	Fleet Commander-in-Chief
FLTBCST	Fleet Broadcast
FLTSATCOM	Fleet Satellite Communications
FLTSEVOX	Fleet Secure Voice
FM	Frequency Modulation
FMPE	Fast Memory Parity Error
FOC	Full Operational Capabilities
FOTACS	Fleet Operational TELECOMM Automated Control System
FOTP	Fleet Operational Telecommunications Program
FPP	Flagword Peripheral Processor
FSB	Fleet Satellite Broadcast
FSC	Fleet Satellite Communications
FSK	Frequency Shift Keying
FSM	Frequency Spectrum Monitor
FTOC	Fleet Telecommunications Operations Center
FTP	Fleet Telecommunications Procedures
FY	Fiscal Year
GAPSAT	Gapfiller Satellite
GENSER	General Service
GHZ	Gigahertz
HAZCON	Hazardous Condition
HDR	High Data Rate
HDUX	Half-Duplex
HF	High Frequency
HFDF	High Frequency Direction Finding
HICOM	High Command Voice Network
HSLP	High Speed Line Printer

Hz	Hertz
IEMATS	Improved Emergency Message Automated Transmission System
IFF	Identification, Friend or Foe
IOC	Initial Operational Capabilities
ISABPS	Integrated Submarine Automated Broadcast Processing System
JCS	Joint Chiefs of Staff
JRLEXT	Journal Extract Tape
JTIDS	Joint Tactical Information Distribution System
Kbps	Thousand bits per second
KHZ	Kilohertz
LDMX	Local Digital Message Exchange
LDR	Low Data Rate
LEASAT	Leased Satellite
LF	Low Frequency
LOS	Line of Sight
LPI	Low Probability of Intercept
LRI	Limited Range Intercept
MARISAT	Maritime Satellite
MEECN	Minimum Essential Emergency Communications Network
MF	Medium Frequency
MHz	Megahertz
MILSATCOM	Military Satellite Communications
MMPE	Main Memory Parity Error
MOU	Memorandum of Understanding
MPPE	Memory Protect Parity Error
MPS	Message Processing Subsystem
MTU	Magnetic Tape Unit
M1/M2	RIXT Printers
NARDAC	Navy Regional Data Automation Center
NAVCAMS	Naval Communications Area Master Station
NAVCOMCO	Naval Commercial Communications Office
NAVCOMMAREA	Naval Communications Area
NAVCOMMDET	Naval Communications Detachment

NAVCOMMSTA	Naval Communications Station
NAVCOMMU	Naval Communications Unit
NAVCOMPARS	Naval Communications Processing and Routing System
NAVMACS	Naval Modular Automated Communications Subsystem
NAVSECGRUACT	Naval Security Group Activity
NAVTELCOM	Naval Telecommunications Command
NAVTASC	Naval Telecommunications Automation Support Center
NAVTELSYSIC	Naval Telecommunications Systems Integration Center
NBSV	Narrow Band Secure Voice
NCA	National Command Authority
NCCS	Navy Command and Control System
NEACP	National Emergency Airborne Command Post
NECOS	Net Control Station
NMCC	National Military Command Center
NRRF	Navy Radio Receiver Facility
NRTF	Navy Radio Transmitter Facility
NSA	National Security Agency
NTCC	Naval Telecommunications Center
NTCOC	NAVTELCOM Operations Center
NTOCN	Naval Telecommunications Operational Coordination Net
NTP	Naval Telecommunications Procedures
NTS	Naval Telecommunications System
OCR	Optical Character Reader
OI	Operational Inspection
O&M	Operations and Maintenance
OPNAV	Office of the Chief of Naval Operations
OSU	Optical Scan Unit
OTAM	Off-The-Air Monitoring
OTC	Officer-in-Tactical Command
	Over the Counter
OTCIXS	Officer-in-Tactical Command Information Exchange System
OTH	Over the Horizon
PABX	Private Automatic Branch Exchange
PAGERRS	Paging Errors
PARKHILL	HF Wideband Tactical Secure Voice System

PESFIL	Performance Evaluation System File
POA&M	Plan of Action and Milestones
P/P	Point to Point
PSK	Phase Shift Keying
PTR/PTP	Paper Tape Reader/Paper Tape Punch
RADAY	Radio Day
RADSTA	Radio Station
RATT	Radio Teletype
RCS	Receive Control Subsystem
RDT&E	Research, Development, Test and Evaluation
RFCS	Radio Frequency Carrier Shift
RFO	Reason for Outage
	Radio Frequency Outage
RIXT	Remote Information Exchange Terminal
ROME	Read Only Memory Error
SAFM	Special Advisor for Frequency Matters
SATCOM	Satellite Communications
SBMSS	Shore Based Message Service System
SCI	Sensitive Compartmented Information
SCP	Software Change Proposal
SHF	Super High Frequency
SI	Special Intelligence
SIGINT	Signals Intelligence
SITREP	Situation Report
SMDD	Storage Module Disk
SOP	Standard Operating Procedures
SPECOMM	Special Communications
SPINTCOM	Special Intelligence Communications
S/R	Send/Receive
SRPA	Statistical Report for Performance Analysis
SRPAFL	SRPA Magnetic Tape
SRT	Standard Remote Terminal
SRTMA	Statistical Report for Traffic Management Analysis
SRVC	Router Assist Report
S/S	Ship-Shore

SSIXS	Submarine Satellite Information Exchange Subsystem
SSMA	Spread Spectrum Multiple Access
SSME	Spread Spectrum Multiple Equipment
SSMPS	Shore Station Message Processing Set
STREAMLINER	Special Intelligence message traffic
STROFAC	Stabilized Routing for Afloat Commands
SURTASS	Surveillance Towed Array Sensor System
TACAMO	Navy Airborne VLF Relay
	Take Charge and Move Out
TACINTEL	Tactical Intelligence
TACSAT	Tactical Satellite
TADIXS	Tactical Data Information Exchange Subsystem
TCO	Telecommunications Certification Office
TCS	Transmit Control Subsystem
TDMA	Time Division Multiple Access
TELCOR	Telecommunications Operating Requirement
TEMPEST	Investigation, studies, or prevention of compromising emanations
TPS	Transmit Processing Subsystem
TRI/TAC	U.S. Joint Tactical Communications Program
TSR	Telecommunications Service Request
TT&C	Tracking, Telemetry and Control
TTY	Teletype
UCP	Unified Command Plan
UHF	Ultra High Frequency
UNITREP	Unit Status and Identity Report
VDT/CRT	Video Data Terminal/Cathode Ray Tube
VERDIN	LF/VLF communications
VFCT	Voice Frequency Carrier Telegraphy
VHF	Very High Frequency
VINSON	VHF/UHF wideband tactical secure voice system
VIP 1710	UNIVAC Verifier, Interpreter, and Punch (Keypunch)
VLF	Very Low Frequency
VP	Patrol Aircraft
VQ	Reconnaissance Aircraft

WARP	Worldwide AUTODIN Restoral Plan
WHCA	White House Communications Agency
WWMCCS	World Wide Military Command and Control System

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