



**NONRESIDENT
TRAINING
COURSE**



Information Systems Technician Training Series

Module 4—Communications Hardware

NAVEDTRA 14225A

PREFACE

About this course:

This is a self-study course. By studying this course, you can improve your professional/military knowledge, as well as prepare for the Navywide advancement-in-rate examination. It contains subject matter about day-to-day occupational knowledge and skill requirements and includes text, tables, and illustrations to help you understand the information. An additional important feature of this course is its references to useful information to be found in other publications. The well-prepared Sailor will take the time to look up the additional information.

Any errata for this course can be found at <https://www.advancement.cnet.navy.mil> under Products.

Training series information:

This is Module 4 of a series of 5. For a description of the entire series, see NAVEDTRA 12061, *Catalog of Nonresident Training Courses*, at <https://www.advancement.cnet.navy.mil>.

History of the course:

- *Sep 1997: Original edition (NAVEDTRA 14225) released.*
- *Apr 2003: Revised edition (NAVEDTRA 14225A) released.*

Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER
<https://www.cnet.navy.mil/netpdtc>

POINTS OF CONTACT	ADDRESS
<ul style="list-style-type: none">• E-mail: fleetservices@cnet.navy.mil• Phone: Toll free: (877) 264-8583 Comm: (850) 452-1511/1181/1859 DSN: 922-1511/1181/1859 FAX: (850) 452-1370	COMMANDING OFFICER NETPDTC N331 6490 SAUFLEY FIELD ROAD PENSACOLA FL 32559-5000

NAVSUP Logistics Tracking Number
0504-LP-102-0982

TABLE OF CONTENTS

CHAPTER	PAGE
1. Communications Hardware	1-1
2. Satellites and Antennas	2-1
APPENDIX	
I. Glossary	AI-1
II. Glossary of Acronyms and Abbreviations	AII-1
III. References Used to Develop this NRTC	AIII-1
INDEX	INDEX-1

Course assignments follow the index.

CHAPTER 1

COMMUNICATIONS HARDWARE

LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

- *Determine the equipment required for each communications system.*
- *Identify the hardware setup procedures for radio systems.*
- *Identify the use of COMMSPTS.*
- *Identify procedures and requirements for communications equipment as it pertains to OTAR/OTAT functions.*
- *Determine utilization, frequencies, and watches needed for distress communication equipment.*
- *Interpret how to monitor circuit quality equipment.*

The high-paced operations required of modern fleet units demand communication systems that are capable of providing high-speed, accurate, and secure transmission and reception of intelligence. To keep pace with the ever-increasing complexity of operations, today's communication systems are necessarily highly sophisticated and versatile. For our ships and submarines to operate effectively, whether independently or as part of a battle group, they must have communication systems and operators that are capable of meeting this challenge.

In this chapter, we will discuss various aspects of fleet communication systems. As an Information Systems Technician (IT), you will be responsible for knowing the different communication systems used by the Navy and what communication equipments make up a system.

COMMUNICATIONS SYSTEMS

Through equipment design and installation, many equipments are compatible with each other and can be used to accomplish various functions. Using this design concept, nearly all the communication needs of a ship can be met with fewer pieces of communications equipment than were previously required.

Communications can be maintained at the highest possible state of readiness when all levels of command understand the capabilities and limitations of the systems. Many communications failures are attributable to poor administration rather than to equipment failure or technical problems.

In this section, we will discuss predeployment readiness; low-, high-, very-high-, ultra-high-, and super-high-frequency communications systems; and equipment components that comprise these systems.

UNDERWAY PREPARATION

Ships deploying to overseas areas must be in a state of maximum operational and communications readiness. Type commanders determine the level of readiness of deploying ships and ensure they are adequately prepared.

A check-off list is an excellent method to ensure that step-by-step preparations are completed before a deployment. This list should cover all aspects of communications readiness and should begin well in advance of the underway period. Some of the points to be checked include scheduling of communications assistance team (CAT) visits, maintenance and operational checks of equipment and antennas, and consumable supply levels.

The Basic Operational Communications Doctrine (U), NWP 4, provides suggested minimum check-off sheets, including a predeployment check-off sheet and a preunderway check-off sheet. The first sheet provides a timetable of required checks and objectives. The second sheet is tailored to individual ships and unique requirements.

LOW-FREQUENCY SYSTEMS

The low-frequency (LF) band (30-300 kHz) is used for long-range direction finding, medium- and long-range communications, aeronautical radio navigation, and submarine communications.

A low-frequency transmitter, such as the AN/FRT-72, is used to transmit a high-powered signal over long distances. Low-frequency transmitters are normally used only at shore stations or for special applications.

The low-frequency receive system is designed to receive low-frequency broadcast signals and to reproduce the transmitted intelligence.

HIGH-FREQUENCY SYSTEMS

The high-frequency (HF) band (3-30 MHz) is primarily used by mobile and maritime units. The military uses this band for long-range voice and teleprinter communications. This band is also used as a backup system for the satellite communications system. Figure 1-1 shows a common HF transmitter and figure 1-2 shows a common HF receiver.

VERY-HIGH-FREQUENCY SYSTEMS

The very-high-frequency (VHF) band (30-300 MHz) is used for aeronautical radio navigation and communications, radar, amateur radio, and mobile communications (such as for boat crews and landing parties).



Figure 1-1.—HF transmitter AN/URT-23-D.

ULTRA-HIGH-FREQUENCY SYSTEMS

The ultra-high-frequency (UHF) band (300-MHz to 3-GHz) is used for line-of-sight (short-range) communications. The term “line of sight,” as used in communications, means that both transmitting and receiving antennas must be within sight of each other and unaffected by the curvature of the Earth for proper communications operation.

The UHF band is also used for satellite communications. Although satellite communications are line of sight, the distance the signal travels is much greater than that of UHF surface communications, because the antennas remain in sight of each other.



Figure 1-2.—Receiver R-2368-URR HF.

As in the VHF section, the transmit and receive systems will be described separately.

SUPER-HIGH-FREQUENCY SYSTEMS

The super-high-frequency (SHF) band (3-30 GHz) is strictly for line-of-sight communications. It is configured much the same as the UHF system. SHF is mainly used for satellite communications. SHF satellite communications is a high-volume system that offers reliable tactical and strategic communications services to U.S. Navy elements ashore and afloat. The system is composed of the terminal segment, consisting of U.S. Navy-operated Earth terminals and mobile terminals. It also includes a portion of the Defense Satellite Communications System (DSCS) satellite segment. Navy Super-High Frequency Satellite Communications, NTP 2, Section 1 (C), provides comprehensive coverage of the Navy SHF satellite system.

EXTREMELY-HIGH-FREQUENCY SYSTEMS

The extremely-high-frequency (EHF) band (30-300 GHz) provides the services with interoperable and survivable SATCOM. In terms of capabilities, operations, and management, EHF SATCOM is considerably different from the UHF and SHF SATCOM systems. However, like other systems, the EHF satellite system consists of three segments: the space segment, control segment, and terminal segment. All segments have been designed to counter jamming, intercept, spoofing, and nuclear effects. The system uses a combination of directional antennas and advanced signal processing techniques to achieve significantly improved anti-jam (AJ) and low probability of intercept performance over existing UHF and SHF SATCOM systems.

PATCH PANELS

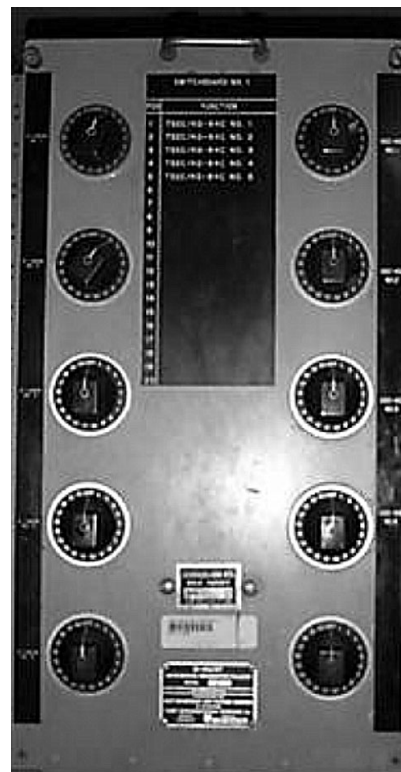
Patch panels are used for the interconnection and transfer of radio signals and equipment aboard ship.

Patch panels are red (fig. 1-3) or black (fig.1-4) to identify secure and nonsecure information. Red indicates that secure (classified) information is being passed through the panel. Black indicates that nonsecure (unclassified) information is being passed through the panel. Both panels are also labeled with signs. The red panel sign has 1-inch-high white block letters that read "RED PATCH PANEL." The black panel normally has two black signs containing



ITF01003

Figure 1-3.—Red patch panel (SA-2112).



ITF01004

Figure 1-4.—Black patch panel (SB-983).

1-inch-high white block letters. One sign reads "BLACK PATCH PANEL" and the other, "UNCLAS ONLY." In some instances, commonly used combinations of equipment are permanently wired together within the panel (called *normal-through*).

CRYPTOGRAPHIC EQUIPMENT

Some of the systems in the previous figures contained cryptographic equipment. Cryptographic equipment is only one of a number of the elements that make up a secure communications system. Though several different types of on-line crypto equipments are in use throughout the naval communications system, they are all designed to perform the same basic function: to encipher and decipher teleprinter or digital data signals.

Simply stated, the transmitter accepts a "plain text" teleprinter or data signal containing classified material from the classified patch panel (red). It then adds a "key," and relays the sum as "cipher text," or an enciphered signal. A key is a sequence of random binary bits used to initially set and periodically change permutations in crypto equipment for decrypting electronic signals.

Following this encryption, the signal is fed to the unclassified patch panel (black). Here, it is patched directly to the frequency-shift keyer (FSK) or the multiplex equipment of the transmitter and converted into an audio signal. The audio signal, now in a form suitable for transmission, is routed to the transmitter via the transmitter transfer switchboard.

On the receive side, the signal flow is quite similar to the send side in reverse order. The receiver accepts the enciphered signal from the black patch panel and generates a key to match the one generated by the transmitter. The receiver then subtracts the key from the cipher text input (which restores the plaintext teleprinter or data signal). Finally, it passes the signal on to the red patch panel for dissemination to the terminal equipment for printout.

For further information and operator instructions on a specific type of crypto equipment, refer to the applicable KAO publication.

SHIP-SHORE CIRCUITS

As we mentioned earlier, the fleet broadcast is the primary means for delivering messages to afloat commands. This section discusses a few of the other types of circuits by which a ship can transmit its message traffic ashore or to other ships for delivery or relay.

SHIP-SHORE CIRCUIT MODES OF OPERATION

The three methods of operating communications circuits are duplex, simplex, and semiduplex. The mode of operation at any given time depends upon equipment and frequency availability.

Duplex

Duplex describes a communications circuit designed to transmit and receive simultaneously. In such operations, each station transmits on a different frequency and both stations transmit concurrently. Both stations are required to keep transmitters on the air at all times and to send a phasing signal at the request of the distant end.

The two types of duplex operation are full duplex and half duplex. Full duplex (FDX) refers to a communications system or equipment capable of transmitting simultaneously in two directions. Half duplex (HDX) pertains to a transmission over a circuit capable of transmitting in either direction, but only one direction at a time.

Small ships traveling in company normally use duplex in a task group common net in which they terminate with a larger ship that is serving as net control. The net control ship provides the ship-shore relay services. Ships traveling independently can use this system for a non-call ship-shore termination to transmit their outgoing messages.

Simplex

Simplex is a method of operation that provides a single channel or frequency on which information can be exchanged. Simplex communications operation is normally reserved for UHF and those ships that do not have sufficient equipment for duplex operation. In some cases, a simplex circuit can be established when equipment casualties occur.

Where no HF simplex frequency is indicated or guarded, ships requiring a simplex ship-shore circuit must call on a duplex ship send frequency. The ship must state "SIMPLEX" in the call-up, indicating that the ship cannot transmit and receive simultaneously.

When a ship requests simplex operation on duplex circuits, the shore station may be required to shift transmitters before acknowledging call-up. If no reply

is received within 45 seconds, the ship should repeat the call-up procedures. If a third attempt is required, the ship should check equipment to ensure proper operation.

Semiduplex

Semiduplex communications circuits, used primarily on task force/task group/ORESTES, are a combination of the simplex and duplex modes. All stations except the net control station (NECOS) transmit and receive on the same frequency. The NECOS transmits and is received on a second frequency. The NECOS may transmit continuously, whereas all other stations must transmit in accordance with simplex procedures.

UHF/HF RELAY

The UHF/HF relay method permits long-range, uninterrupted communications during periods of hazardous electromagnetic radiation (HERO).

Modern radio and radar transmitting equipments produce high-intensity RF fields. It is possible for RF energy to enter an ordnance item through a hole or crack in its skin or to be conducted into it by firing leads, wires, and the like. Here is an example of HERO. An aircraft carrier is arming aircraft on board. During arming operations, all HF transmitters must be secured to prevent possible detonation of the ordnance. To maintain its ship-shore communications, the carrier transmits to a relay ship via a UHF circuit. The relaying ship then retransmits the signal on an HF circuit to a terminated NAVCOMTELSTA. On-line radio teleprinters can be relayed, as well as voice, using this circuit.

SECURE VOICE WORLDWIDE VOICE NETWORK

The secure voice network is designed to provide real-time voice communications between forces afloat and operational commanders ashore, using either HF or satellite connectivity. This system is commonly referred to as GPS Worldwide HICOMM.

System Control

This system consists of three separate networks. Each network has an area control station controlled by a FLTCINC; CINCLANTFLT, CINCPACFLT, or CINCUSNAVEUR. Each area has subarea control

stations determined by each FLTCINC to ensure worldwide coverage.

Satellite System Control

The secure voice system, using satellite transmissions, has limited shore access points at the four COMMAREA master stations. These sites serve as the interface channel to both the wideband and narrowband voice systems to extend calls to operational commanders ashore.

Net Membership

If a ship, aircraft, or shore station needs to enter the secure voice network, it must be prepared to do so with minimum time delay. Units desiring to enter the net on a temporary basis must specify the length of time and purpose for entering the net. They must also obtain permission from the appropriate control station. The area net control station (NECOS) is responsible for completing all calls originating from senior commands to all commands, ships, or aircraft within the specific FLTCINC's net. Certain rules must be observed when on the secure voice net, as follows:

- HF transmitter tuning is prohibited on secure voice. Transmitters must be calibrated and pretuned on a dummy load. Final tuning may be accomplished during live transmissions.
- All stations must maintain a continuous log-on secure voice. The actual time of significant transmissions must be entered into the log. When available, recording devices must be used in lieu of a paper log.
- The net operates as a free net unless otherwise directed by the area FLTCINC. NECOS retains the prerogative of exercising control over all transmissions to ensure proper circuit discipline.

FULL-PERIOD TERMINATIONS

Full-period terminations are dedicated circuits that provide communications between shore stations and afloat commands. These terminations require allocation of limited NCTAMS/NCTS assets. Therefore, the criteria for requesting, approving, and establishing such circuits is necessarily strict.

Termination Requests

Afloat commands and individual units can request full-period termination during special operations, deployments, intensive training periods, or exercises when primary ship-shore circuits will not suffice.

Commands should request full-period terminations only when traffic volume exceeds speed and capability of ship-shore circuits and when operational sensitivity requires circuit discreetness or effective command and control necessitates dedicated circuits.

The heavy demands placed upon NCTAMS/NCTSs for full-period terminations require maximum cooperation between shore stations and afloat commanders before and during an operation. Ships having a need for a full-period termination, either for training or operational requirements, must submit a termination request to the COMMAREA master station at least 48 hours before activation time.

Emergency commitments or a command directive may necessitate a lead time of less than 48 hours. Whenever possible, however, the 2-day limit must be honored to achieve maximum preparation and coordination. NTP 4 gives details of required information that must be included in a termination request message.

The COMMAREA master station will assign a shore station for a ship's termination circuit. Once the shore station has been assigned, both the ship and the station may begin coordination to identify specific equipment keylists and frequencies needed to effect termination. The shore station will also act as NECOS. Two hours before the scheduled termination, the shore station can coordinate with the ship by telephone, local circuitry, or by primary ship-shore.

When the ship shifts terminations, the securing of the current termination and the establishment of a new termination should coincide with a broadcast shift whenever possible. The ship must submit a COMMSHIFT message.

Termination Types

The six types of full-period terminations are as follows:

- Single-channel radio teleprinter using either radio path or landline transmission media;
- Single-channel low-data-rate satellite access using satellite transmission media;
- CUDIXS special satellite access for NAVMACS-equipped ships using satellite transmission media;
- Multichannel radio teleprinter using either radio path or landline transmission media;

- Multichannel radio teleprinter using SHF satellite transmission media; and
- Tactical intelligence (TACINTEL) access for TACINTEL-equipped ships using satellite transmission media.

Equipment Tests

To ensure that circuit equipment is in peak operational condition, complete system back-to-back off-the-air tests must be completed 24 hours before termination activations. Check crypto equipment back-to-back after daily crypto changes and before putting circuits into service.

An aggressive PMS and quality monitoring program is essential. When checking equipment, look for power levels, scorch or burn marks, proper operation of interlocks, and cleanliness. When cleaning and inspecting antennas, look for cracks, chips, or blistering of insulators. Also check for deterioration, loose connectors, and correct insulator resistance.

COMMSPOT Reports

COMMSPOT reports will be submitted by all ships, including nonterminated units, any time unusual communication difficulties are encountered. Ships will submit the COMMSPOT to the terminating communications station. Timely submission of COMMSPOT reports is necessary to minimize further deterioration of the situation.

Rules and general instructions for preparing JINTACCS formatted COMMSPOT reports are found in the Joint Reporting System (General-Purpose Reports), NWP 1-03, Supp-1 (formerly NWP 10-1-13).

PRIMARY SHIP-SHORE CIRCUITS

Primary ship-shore (PRI S/S) circuits are encrypted FSK/PSK teleprinter nets that permit ships to transmit messages for delivery ashore. This service is available to units that do not maintain a full-period ship-shore termination. Navy tactical UHF satellites or the HF/UHF spectrum may be used to conduct ship-shore circuit operations. Ships may use this circuit for coordinating and establishing a full-period termination with the shore station.

The frequencies for NCTAMS and NAVCOMTELSTAS that guard primary fleet

ship-shore circuits are listed in applicable CIBs distributed by the COMMAREA master stations. These frequencies are subject to change by the cognizant FLTCINC or by the NCTAMS.

OVER-THE-AIR TRANSFER (OTAT) AND OVER-THE-AIR REKEY (OTAR)

Significant vulnerabilities are associated with the handling of paper cryptographic material. Sound application of over-the-air transfer/rekey (OTAT/OTAR) procedures and techniques can reduce the amount of paper keying material required and reduce the potential for compromise. These procedures and techniques are contained in the NAG-16B Procedures Manual for Over-the-Air Transfer (OTAT) and Over-the-Air Rekey (OTAR).

OTAT/OTAR also makes the transfer of keying material more responsive to rapidly changing operational requirements. The use of NAG-16B was developed and verified by extensive use during operation Desert Shield/Storm. The specified procedures served as an effective vehicle for transferring keying to satisfy rapidly changing joint and Navy requirements. Expanded definitions, general procedures, and equipments are found in NAG-16B.

DISTRESS COMMUNICATIONS

Special methods of communication have been developed to use in times of distress and to promote safety at sea and in the air. Distress message traffic is best described as all communications relating to the immediate assistance required by a mobile station in distress. Distress traffic has priority over all other traffic. All U.S. Navy communicators must be familiar with distress signals to properly evaluate their meanings and to take appropriate action when necessary.

If a ship becomes involved in a distress situation, communications personnel should send distress messages on normal operating encrypted circuits. If the need for assistance outweighs security considerations, the ship's commanding officer may authorize the transmission of an unclassified distress message on one of the national or international distress frequencies.

When a ship in distress is traveling in company with other ships, the ship in distress will transmit the distress message to the officer in tactical command (OTC), who will take appropriate action.

DISTRESS FREQUENCIES

Several frequencies in different bands are designated for the transmission of distress, urgency, safety, or search and rescue (SAR) messages. The following frequencies have been designated for use during a distress or emergency situation:

- **500 kHz**—International CW/MCW distress and calling;
- **2182 kHz**—International voice distress, safety, and calling;
- **8364 kHz**—International CW/MCW lifeboat, life raft, and survival craft;
- **121.5 MHz**—International voice aeronautical emergency;
- **156.8 MHz**—FM United States voice distress and international voice safety and calling; and
- **243.0 MHz**—Joint/combined military voice aeronautical emergency and international survival craft.

During SAR missions, the following frequencies are authorized for use:

- **3023.5 and 5680 kHz**—International SAR frequencies for the use of all mobile units at the scene of a search. Also for use of shore stations communicating with aircraft proceeding to or from the scene of the search. CW and voice are authorized.
- **123.1 MHz**—International worldwide voice SAR use.
- **138.78 MHz**—U.S. military voice SAR on-the-scene use. This frequency is also used for direction finding (DF).
- **172.5 MHz**—U.S. Navy emergency sonobouy communications and homing use. This frequency is monitored by all U.S. Navy ASW aircraft assigned to a SAR mission.
- **282.8 MHz**—Joint/combined on-the-scene voice and DF frequency used throughout NATO.

The control of distress message traffic on any designated frequency is the responsibility of the station in distress. However, this station may delegate its responsibility to another station on the frequency.

Distress Watches

Navy units at sea have always maintained listening watches on distress frequencies. Communication watch requirements vary according to the operational

mission of the ship and available equipment assets. Ships in company normally divide distress watch requirements among the group.

STATUS BOARD

The technical control of the shore station that is NECOS for fill-period terminations and PRI S/S circuits must maintain a status board. The status board should indicate, as a minimum, all systems/circuits that are active, tuned in, or in a standby status. It should also indicate all inoperative equipment. The watch supervisors must verify the accuracy of the information contained on the status board at watch turnover and update while on watch. The status board must show the following minimum information for active and standby circuits:

- Functional title of circuit,
- Frequency(ies), both send/receive, if fill-duplex operation is used,
- Circuit designator, from communication plan,
- Transmitter and receiver designations,
- For shore stations, keying line designations,
- Terminal equipment designation (for example, R-2368/URR #1),
- Crypto equipment, keying material, and restart time,
- Operating position or remote control unit designation; and
- Remarks, as appropriate.

QUALITY MONITORING

In recent years, the volume of communications has increased dramatically. This rapid expansion has led to the installation of increasingly sophisticated equipment. Such factors as frequency accuracy, dc distortion, inter-modulation distortion (IMD), and distribution levels are critical to the operation of communications systems.

Satisfactory operation of these systems demands precise initial line-up and subsequent monitoring. System degradation is often caused by many small contributing factors that, when combined, render the system unusable. Simply looking at the page printer or listening to the signal is inadequate.

Simply stated, quality monitoring is the performance of scheduled, logical checks that will

ensure continuous, optimum performance and, in many cases, prevent outages before they occur. Some communications personnel quite often fail to realize the benefits of quality monitoring. An attitude develops that questions the need for quality monitoring. The result of this incorrect attitude is that circuits are either UP or DOWN. Personnel with this attitude perform no quality monitoring when the circuits are UP and are, therefore, forced to treat each outage as if it were a unique occurrence.

With no precise information concerning the trend of the system's performance, personnel must jump from one assumed probable cause to another assumed probable cause, while valuable circuit time is lost. A ship with an aggressive quality monitoring program usually has personnel who are thoroughly familiar with all installed communications systems.

QUALITY MONITORING PROGRAM

The primary function of the quality monitoring program is the direct measurement of signal quality characteristics, including:

- Dc distortion,
- Audio distribution level,
- Frequency accuracy of RF signals,
- Spectrum analysis, and
- Loop current.

These measurements are broad categories and can be broken down to specific tests for specific systems.

Quality Monitoring System

Figure 1-5 is a diagram of a quality monitoring system and RCS interface. The system was designed to provide a means of monitoring and evaluating performance of any communications system used by forces afloat.

The monitoring system is a grouping of specific test equipments into a console designated as the AN/SSQ-88 Quality Monitoring Set (fig. 1-6). The set contains equipment for measuring and analyzing signals sampled by sensors installed in each communications circuit interface. The system should be operated only by personnel with sufficient knowledge to analyze the signals being transmitted and received via the ship's circuits, including individual channels of the multichannel circuits.

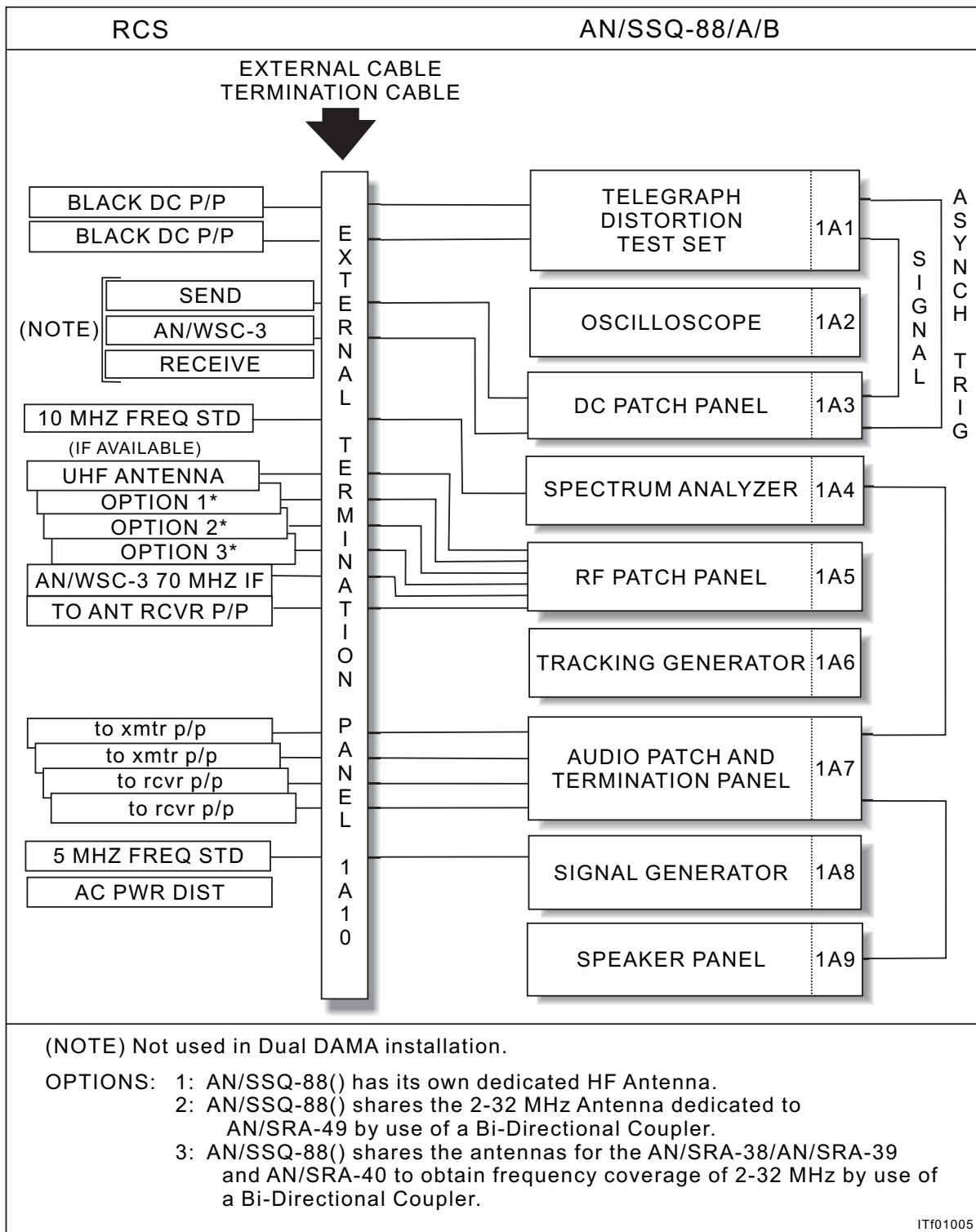


Figure 1-5.—AN/SSQ-88 Quality Monitoring Set and RCS interface.

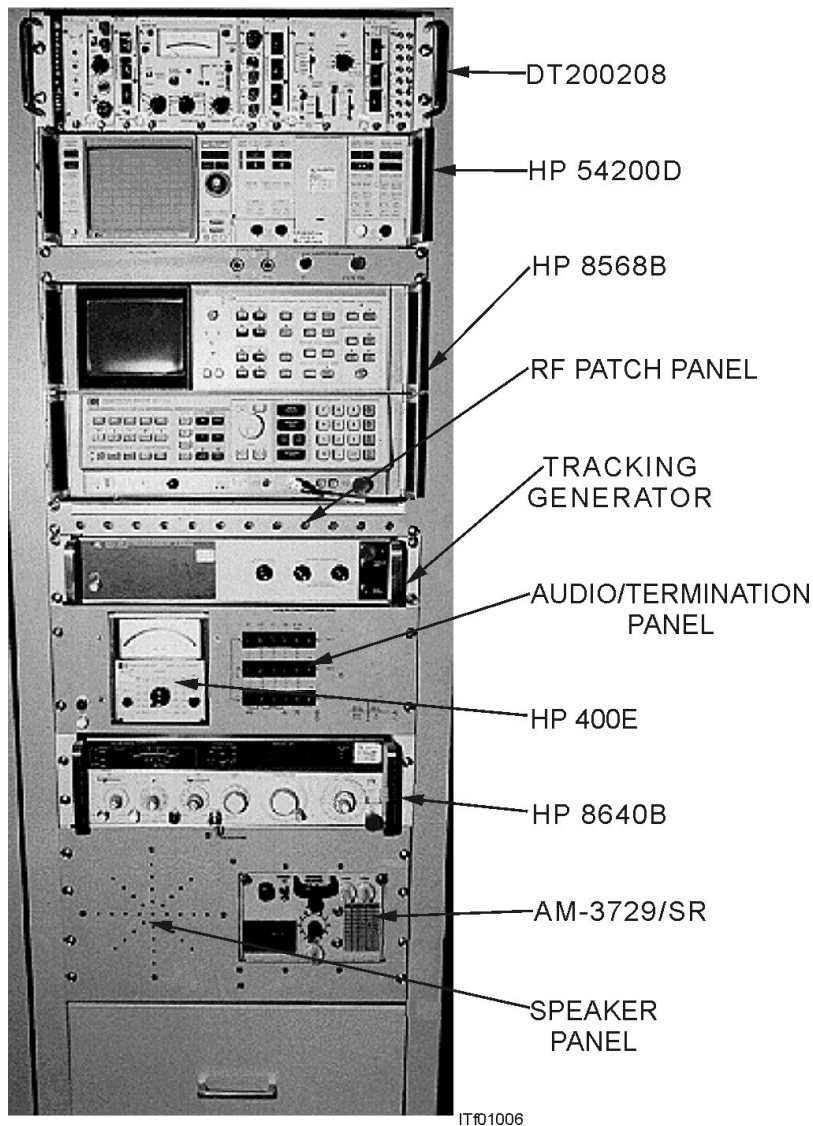


Figure 1-6.—AN/SSQ-88 equipment configuration.

The console configuration shown in figure 1-6 may not be compatible with all ships; however, most ships can use equivalent test equipment to establish a quality monitoring test system.

SUMMARY

Your commanding officer must be able to communicate with ships and shore stations to maintain effective command and control of the situation at hand. Communications are, and always will be, the “voice of command.” In the age of nuclear weapons, guided missiles, supersonic aircraft, and high-speed ships and submarines, top performance is required of our fleet communicators. You, as an IT, along with your equipment, must always be in constant readiness to meet this formidable challenge.

Distress communications are methods that have been developed for use in times of distress. They indicate the need for immediate assistance and have priority over all other traffic. Various publications and local instructions will assist you in carrying out your required responses to these situations.

Communication systems are periodically tested to ensure that they operate efficiently and accurately. The combined tests, checks, and measurements help determine the condition of systems, subsystems, and individual equipments. Tests and measurements of communication systems and equipments range from the very simple to the very complex.

CHAPTER 2

SATELLITES AND ANTENNAS

LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

- *Identify the theory relating to satellites.*
- *Calculate azimuth and elevation using plotting guides.*
- *Identify the types, basic system and fleet broadcast subsystem equipment of communication satellites.*
- *Identify the characteristics of antennas and antenna selections.*
- *Identify the types of antennas.*
- *Explain how the distribution systems interface with antenna assignment and selections.*
- *Identify the procedures for setting up antenna couplers, multicouplers, transmitters, and transceivers.*
- *Explain how the patch panel is used in conjunction with the equipment.*
- *Identify the procedures for raising and lowering antennas.*
- *Determine the optimum reception of a directional antenna by rotation, alignment, and tuning.*
- *Identify safety precautions that should be observed when working on antennas.*

Satellite communication (SATCOM) systems satisfy many military communications requirements with reliable, high-capacity, secure, and cost-effective telecommunications. Satellites provide a solution to the problem of communicating with highly mobile forces deployed worldwide. Satellites also provide an alternative to large, fixed ground installations. They provide almost instantaneous military communications throughout the world at all but the highest latitudes (above 700).

TYPES OF SATELLITES

Three types of communications satellites are in use by the U.S. Navy today. They are GAPFILLER, Fleet Satellite Communication (FLTSATCOM), and Leased Satellite (LEASAT) (figure 2-1). These satellites are in geosynchronous orbit over the continental United States and the Atlantic, Pacific, and Indian oceans. Each satellite is described in the following paragraphs.

GAPFILLER

In 1976, three satellites, called MARISAT, were placed into orbit over the Atlantic, Pacific, and Indian oceans. Each satellite had three UHF channels for military use, one wideband 500-kHz channel, and two narrowband 25-kHz channels.

The Navy leased the UHF section of each satellite for communications purposes. To distinguish the special management and control function for communications on these UHF channels, the Navy gave the name GAPFILLER to the leased satellite assets.

GAPFILLER was intended to fill the need for a continuing satellite communications capability in support of naval tactical operations until the Navy achieved a fully operable Fleet Satellite Communications (FLTSATCOM) system.

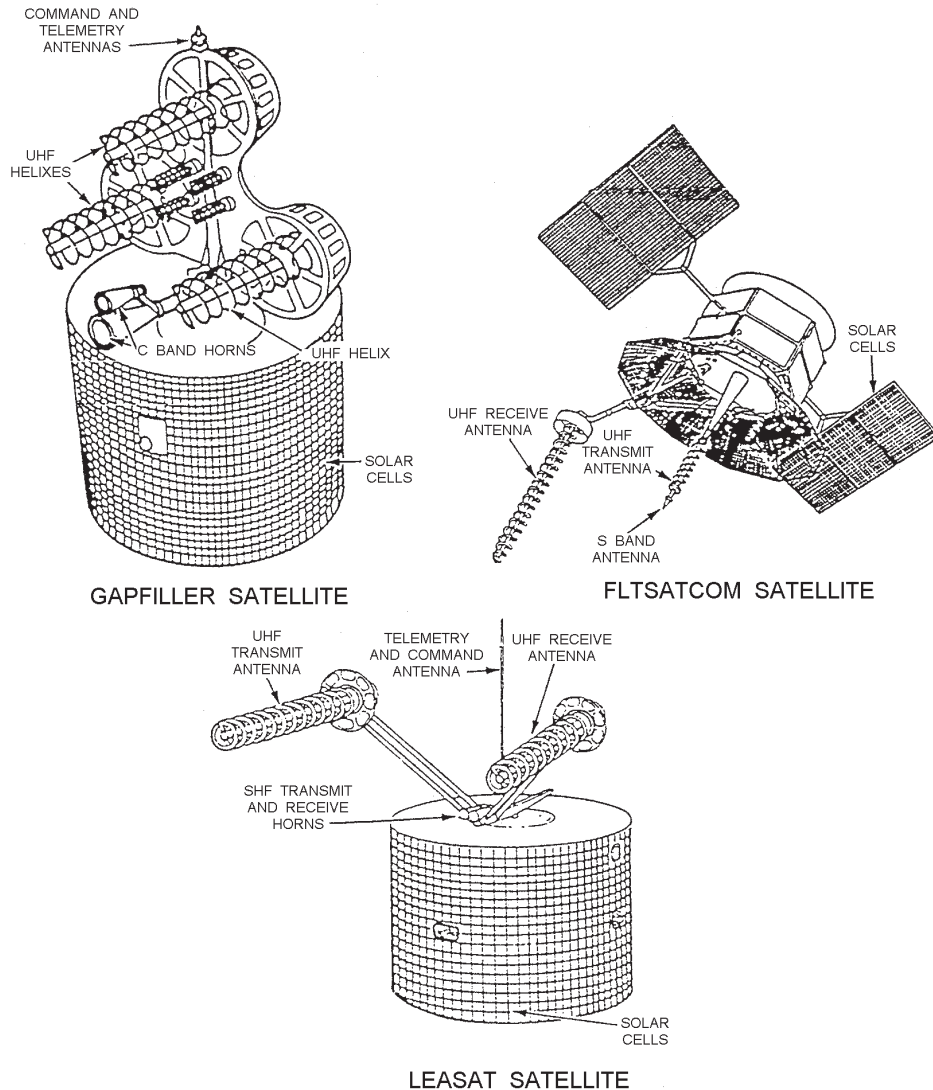


Figure 2-1.—GAPFILLER, FLTSATCOM, and LEASAT satellites.

ITf02005

The GAPFILLER satellite over the Indian Ocean is the only one still being used by the U.S. Navy. The other two GAPFILLER satellites were replaced by LEASAT. The active GAPFILLER satellite will also be replaced by LEASAT as it reaches the end of its operational life.

Within the 500-kHz band, transponders provide 20 individual 25-kHz low- and high-data-rate communications channels for 75-baud ship-shore communications and for the automated information exchange systems. The UHF receiver separates the receive band (302 to 312 MHz) from the transmit band (248 to 258 MHz).

The receiver translates the received carriers to intermediate frequencies (IFs) in the 20-MHz range and separates them into one of three channels. One channel has a 500-kHz bandwidth, and two have a bandwidth of 25 kHz each. The signals are filtered,

hard limited, amplified to an intermediate level, and up-converted to the transmit frequency. Each channel is then amplified by one of three high-power transmitters.

GAPFILLER also supports the FLTSATCOM system secure voice system and the fleet broadcast in the UHF range. The GAPFILLER communications subsystem will eventually be replaced by the FLTSATCOM system.

FLTSATCOM

There are four FLTSATCOM satellites in service. These satellites are positioned at 100° W, 72.5° E, 23° W, and 172° E longitudes. They serve the Third, Sixth, Second, and Seventh fleets and the Indian Ocean battle groups. These four satellites provide worldwide coverage between 70° N and 70° S latitudes (figure 2-2).

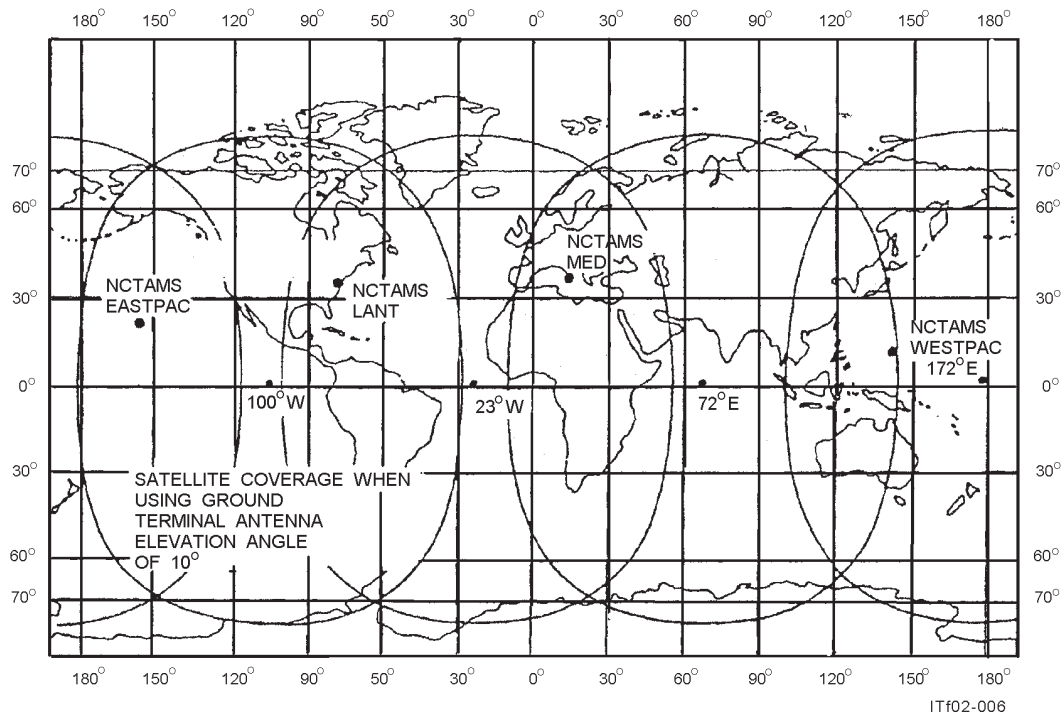


Figure 2-2.—FLTSATCOM coverage areas.

Each FLTSATCOM satellite has a 23-RF-channel capability. These include 10 25-kHz channels, 12 5-kHz channels, and 1 500-kHz channel. The 500-kHz and the 10 25-kHz channels are reserved for Navy use. Of the 10 25-kHz channels, channel 1 is used for the fleet broadcast. All channels use SHF for the uplink transmission. SHF is translated to UHF for the downlink transmission.

There is a separate UHF downlink transmitter for each channel. Each of the 23 channels has 3 different frequency plans in which the uplink or downlink may be transmitted. This capability precludes interference where satellite coverage overlaps.

LEASAT

The latest generation of Navy communications satellites is leased; hence, the program name LEASAT. As we mentioned earlier, these satellites replaced 2 of the 3 GAPFILLER satellites and augment the FLTSATCOM satellites.

CONUS LEASAT (L-3) is positioned at 105° W longitude, LANT LEASAT (L-1) is positioned at 15° W longitude, and 10 LEASAT (L-2) is positioned at 72.5° E longitude (figure 2-3).

Each LEASAT provides 13 communications channels using 9 transmitters. There are 7 25-kHz

UHF downlink channels, 1 500-kHz wideband channel, and 5 5-kHz channels. The 500-kHz channel and the 7 25-kHz channels are leased by the Navy. One of the 25-kHz UHF downlink channels is the downlink for the Fleet Satellite Broadcast.

The broadcast uplink is SHF, with translation to UHF taking place in the satellite. The remaining 625-kHz channels function as direct-relay channels with several repeaters. Currently, the LEASAT channels provide for the following subsystems:

- Channel 1 for Fleet Satellite Broadcast transmissions;
- 1 25-kHz channel for SSIXS communications;
- 1 25-kHz channel for ASWIXS communications; and
- 2 25-kHz channels for subsystems that transmit or receive via DAMA (Demand Assigned Multiple Access) (for example, CUDIXS/NAVMACS, TACINTEL, and secure voice).

SHF SATCOM

Operations Desert Shield/Desert Storm reinforced the requirement for and greatly accelerated the introduction of SHF SATCOM capability on aircraft carriers and amphibious flagships to satisfy minimum

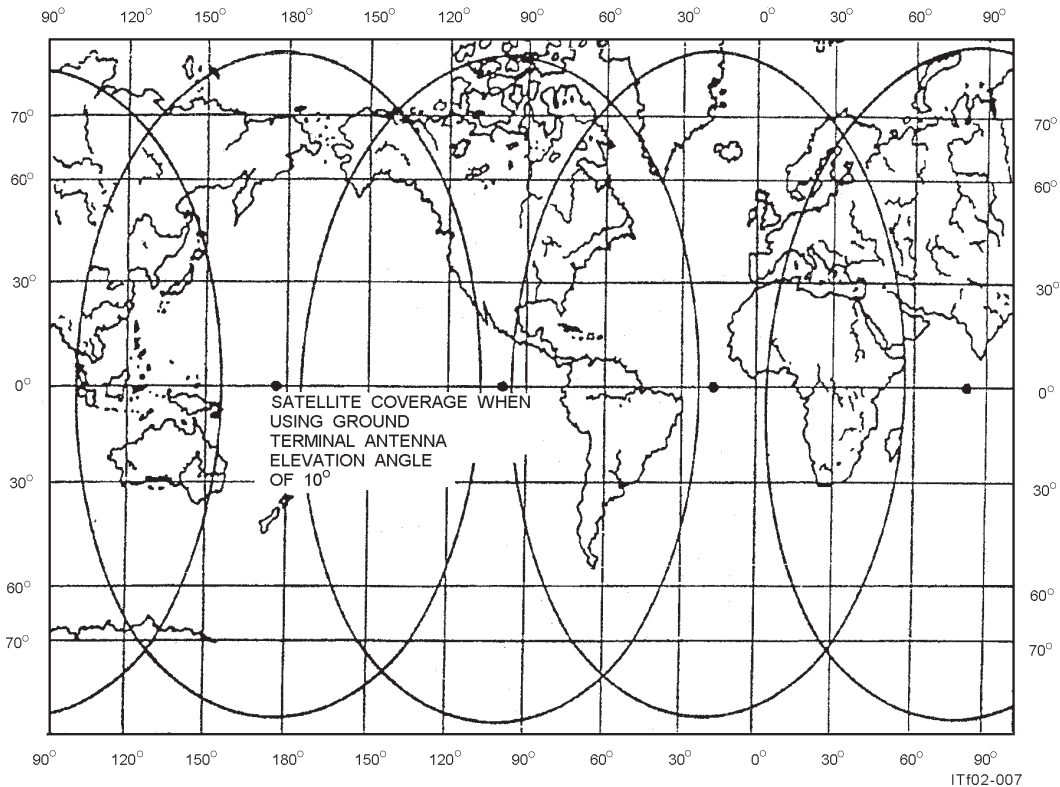


Figure 2-3.—LEASAT coverage areas.

tactical command and control (C2), intelligence and warfighting communications requirements while improving Joint and NATO/Allied communications interoperability. To meet the urgent operational requirement, the U.S. Navy obtained and modified U.S. Air Force AN/TSC-93B Ground Mobile Forces (GMF) SHF SATCOM vans for installation on aircraft carriers and amphibious flagships deploying to the Persian Gulf. The modified vans were coupled with the AN/WSC-6(V) standard U.S. Navy SHF stabilized antenna system, the SURTASS modem, 2 low-speed time division multiplexer (LSTDMs), and additional patch panels. The modified SATCOM terminals were designated “QUICKSAT.” The initial introduction of these terminals into the fleet officially marked the beginning of the U.S. Navy’s SHF SATCOM fielding plan.

The U.S. Navy also deployed an SHF Demand Assigned Multiple Access (DAMA) modem. This action replaced the QUICKSAT terminals on aircraft carriers, and adds SHF SATCOM capabilities to more ships.

In FY97, the U.S. Navy deployed the AN/WSC-6 variant. The new terminal is a modem, modular, open architecture terminal capable of providing a full

spectrum of SHF SATCOM services and greatly expands the number of installations.

The system configuration that supports Navy SHF SATCOM consists of an SHF RF terminal and supporting baseband equipment. The RF terminals for shipboard use are the AN/WSC-6(V) or AN/TSC-93B (MOD) “QUICKSAT” terminal. The terminals process and convert the RF signal transmitted to or received from the space segment. The transmit frequency range is 7.9 to 8.4 GHz, and the receive range is 7.25 to 7.75 GHz. The OM-55(V)/USC AJ modems, 1105A/1106 time division multiple access (TDMA)/DAMA modem, and the CQM-248A (phase shift keying (PSK) modems) are deployed on shipboard platforms.

The AN/WSC-6(V) and QUICKSAT configured terminals are compatible with present and future DSCS SHF satellite ground terminals and consist of an antenna group, radio set group, and modem group. The antenna group is configured as either a dual or single antenna system. The AN/WSC-6(V)1, with the MD-1030A(V) modem, is used on SURTASS ships equipped with a single antenna. The AN/WSC-6(V)2, with the OM-55(V)/USC, Frequency Division Multiple Access (FDMA) or TDMA/DAMA modems, is used on both flag and flag-capable platforms and is configured with either a single or dual antenna. The

QUICKSAT terminal is configured with an FDMA modem, single or dual antenna, and deployed on selected aircraft carriers and amphibious flagships. The AN/WSC-6(V) and QUICKSAT terminals automatically track the selected satellite, while simultaneously transmitting and receiving. An antenna control unit commands the antenna to search for tracking (beacon) signals from the satellite. Upon satellite acquisition, tracking is accomplished automatically.

BASIC SATCOM SYSTEM

A satellite communications system relays radio transmissions between Earth terminals. There are two types of communications satellites: active and passive. An active satellite acts as a repeater. It amplifies signals received and then retransmits them back to Earth. This increases the signal strength at the receiving terminal compared to that available from a passive satellite. A passive satellite, on the other hand, merely reflects radio signals back to Earth.

A typical operational link involves an active satellite and two Earth terminals. One terminal transmits to the satellite on the **uplink frequency**. The satellite amplifies the signal, translates it to the downlink frequency, and then transmits it back to Earth, where the signal is picked up by the receiving

terminal. Figure 2-4 illustrates the basic concept of satellite communications with several different Earth terminals.

The basic design of a satellite communications system depends a great deal on the parameters of the satellite orbit. Generally, an orbit is either elliptical or circular. Its inclination is referred to as *inclined*, *polar*, or *equatorial*. A special type of orbit is a synchronous orbit in which the period of the orbit is the same as that of the Earth's.

Two basic components make up a satellite communications system. The first is an installed communications receiver and transmitter. The second is two Earth terminals equipped to transmit and receive signals from the satellite. The design of the overall system determines the complexity of the components and the manner in which the system operates.

The U.S. Navy UHF/SHF/EHF combined communications solution allows each system to provide unique contributions to the overall naval communications needs.

The SHF spectrum is a highly desirable SATCOM medium because it possesses characteristics absent in lower frequency bands: wide operating bandwidth, narrow uplink beamwidth, low susceptibility to scintillation, anti-jam (AJ), and high data rates.

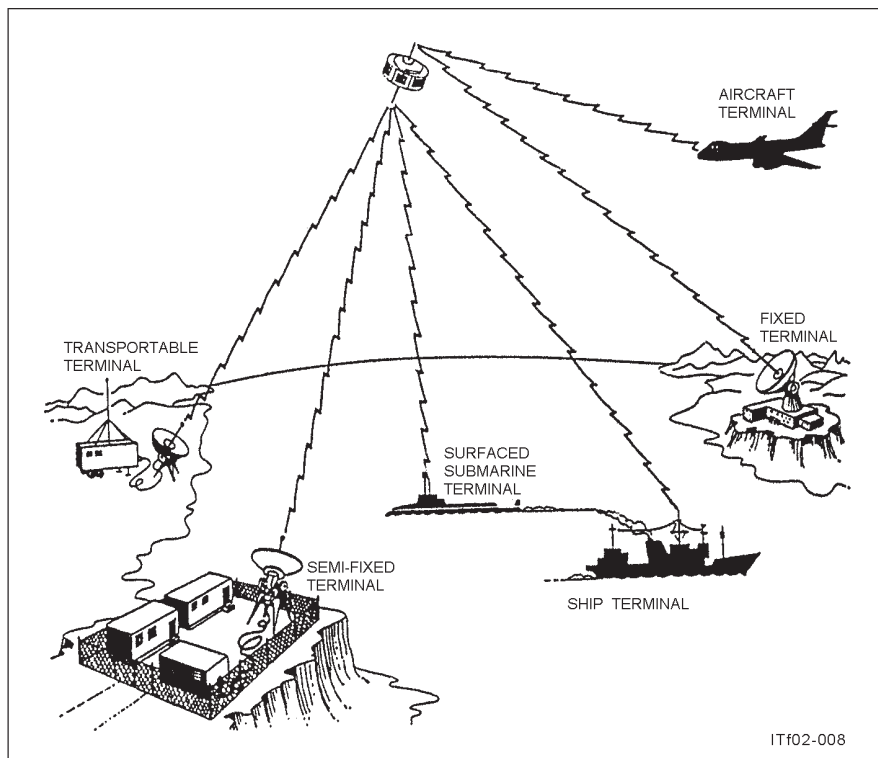


Figure 2-4.—Satellite communications systems.

Recognizing these characteristics, the U.S. Navy developed and installed shipboard SHF terminals. These attributes are discussed in the following paragraphs.

Wide operating bandwidth permits high information transfer rates and facilitates spread spectrum modulation techniques. Spread spectrum modulation is a particularly valuable technique for lessening the effects of enemy jamming. Although wide bandwidth permits both high information transfer rates and AJ capabilities when using the OM-55(V)/USC modem, it may not permit both simultaneously in the presence of jamming. Therefore, high information transfer rates will be significantly reduced when jamming is encountered, permitting only certain predetermined critical circuits to be maintained.

Narrow uplink transmission beamwidth provides a low probability of intercept (LPI) capability. An uplink LPI capability reduces the threat of detection and subsequent location, but does not in and of itself deny enemy exploitation of those communications if detection is achieved. SHF frequencies are rarely affected by naturally occurring scintillation, making SHF SATCOM a particularly reliable form of communications.

A characteristic of SHF, favorable to flagships, is the ability to communicate critical C4I for the user information in the presence of enemy jamming and with due regard for enemy detection capabilities. SURTASS Military Sealift Command Auxiliary General Ocean Surveillance (T-AGOS) ships were initially equipped with SHF SATCOM, taking advantage of the high information transfer rate capability and LPI characteristics. Because of larger available bandwidths, inherent jam-resistance, and increasing demands on limited tactical UHF SATCOM resources, additional applications for DSCS SHF SATCOM afloat are continually being investigated for the fleet.

The radio group consists of a high-power amplifier (HPA) or medium-power amplifier (MPA), low-noise amplifier (LNA), up-converter, down-converter, and frequency standard. For transmit operations, the up-converter translates the modem's 70 or 700 megahertz (MHz) intermediate frequency (IF) to the desired radio frequency. The signal is then passed to the HPA or MPA and amplified to its authorized power level. During receive operations, the LNA amplifies the received RF signal and sends it to the tracking converter for antenna control and the down-converter

for translation to 70 or 700 MHz IF. This signal is then sent to the modem for conversion to digital data. System frequency stability is provided by a cesium or rubidium standard.

FLEET BROADCAST SUBSYSTEM EQUIPMENT

The SATCOM equipments that the Navy uses for the fleet broadcast include the SATCOM broadcast receiver (AN/SSR-1), the FLTSATCOM SHF broadcast transmitter (AN/FSC-79), the standard shipboard transceiver (AN/WSC-3), the shore station transceiver (AN/WSC-5), and the basic airborne transceiver (AN/ARC-143B). A brief description of these equipments is given in the next paragraphs.

The AN/SSR-1 is the Navy's standard SATCOM broadcast receiver system. This system consists of up to four AS-2815/SSR-1 antennas with an AM-6534/SSR-1 Amplifier-Converter for each antenna, an MD-900/SSR-1 Combiner-Demodulator, and a TD-1063/SSR-1 Demultiplexer (figure 2-5). The antennas are designed to receive transmissions at 240 to 315 MHz. The antennas and antenna converters are mounted above deck so that at least one antenna is always in view of the satellite. The combiner-demodulator and demultiplexer are mounted below deck.

The AN/FSC-79 Fleet Broadcast Terminal (figure 2-6) interfaces the communications subsystems and the satellite. The terminal provides the SHF uplink for the FLTSATCOM system and is used in particular to support the Navy Fleet Broadcast system. The AN/FSC-79 operates in the 7- to 8-GHz band and is designed for single-channel operation. The AN/FSC-79 terminal is installed at the four COMMAREA master stations and NAVCOMTELSTA Stockton, Calif.

The AN/WSC-3 Transceiver is the standard UHF SATCOM transceiver for both submarine and surface ships. The AN/WSC-3 is capable of operating in either the satellite or line-of-sight (LOS) mode and can be controlled locally or remotely.

The unit is designed for single-channel, half-duplex operations in the 224- to 400-MHz UHF band. It operates in 25-kHz increments, and has 20 preset channels. In the SATCOM mode, the AN/WSC-3 transmits (uplinks) in the 292.2- to 311.6-MHz bandwidth and receives (downlinks) in the 248.5- to 270.1-MHz band. A separate transceiver is required for each baseband or channel use.

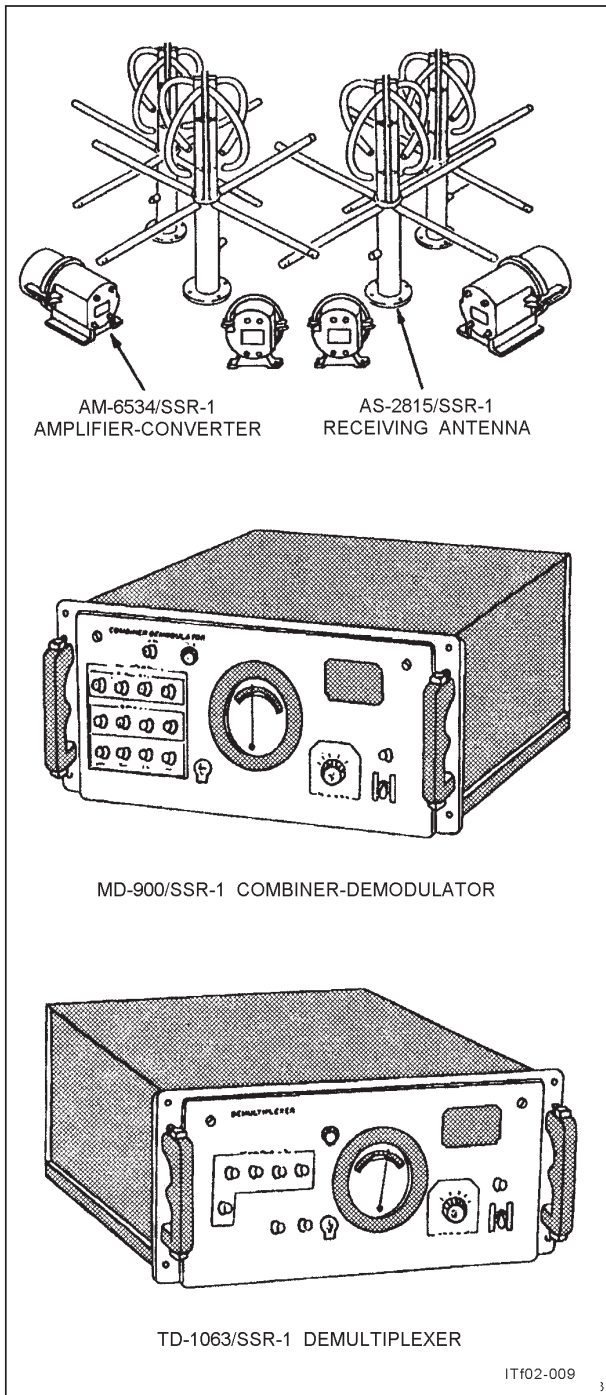


Figure 2-5.—AN/SSR-1 receiver system.

The AN/WSC-5 UHF Transceiver (figure 2-7) is the common UHF RF satellite terminal installed at NAVCOMTELSTAs for the GAPFILLER subsystem. In FLTSATCOM operations, it is used as the common RF terminal for all subsystems except the Fleet Satellite Broadcast (FSB) and the Antisubmarine Warfare information Exchange Subsystem (ASWIXS). The AN/WSC-5 can be used to back up the AN/FSC-79. The AN/WSC-5 transmits in the 248.5-

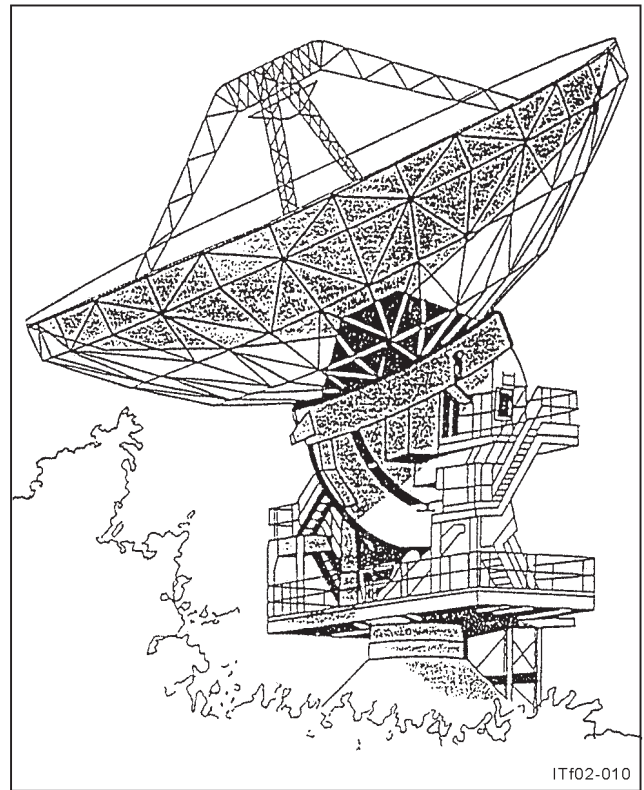


Figure 2-6.—AN/FSC-79 Fleet Broadcast Terminal.

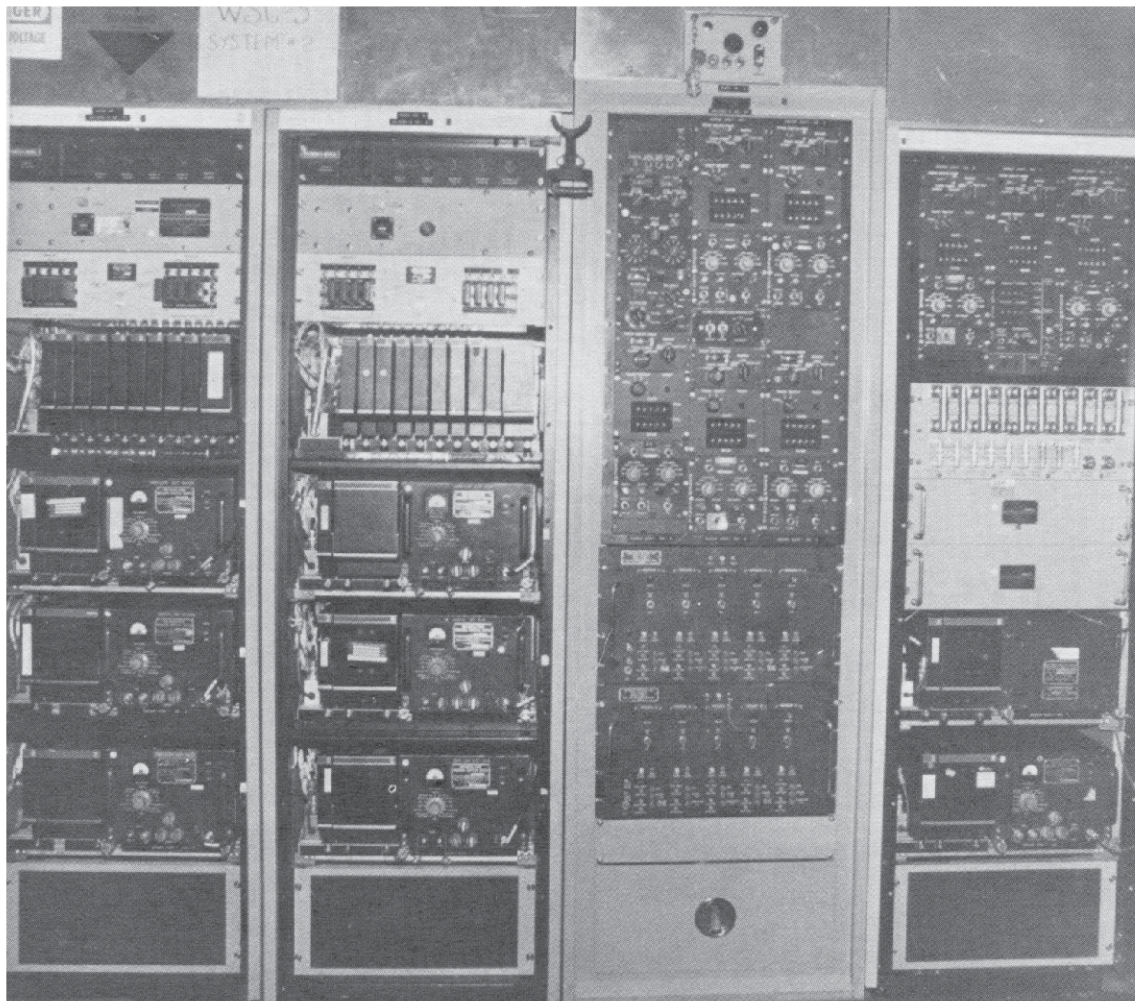
to 312-MHz range and receives in the 248.5- to 270.1-MHz range.

The AN/ARC-143 UHF Transceiver (figure 2-8) is used for ASWIXS communications and is installed at VP Antisubmarine Warfare Operation Centers and aboard P-3C aircraft. The unit has two parts: a transceiver and a radio set control. The AN/ARC-143 can be used to transmit or receive voice or data in the 255.0- to 399.99-MHz frequency range.

The systems discussed are only a few of the SATCOM equipments used by the Navy. Some of the references listed in Appendix III of this module are excellent sources for more information on satellite equipment and systems.

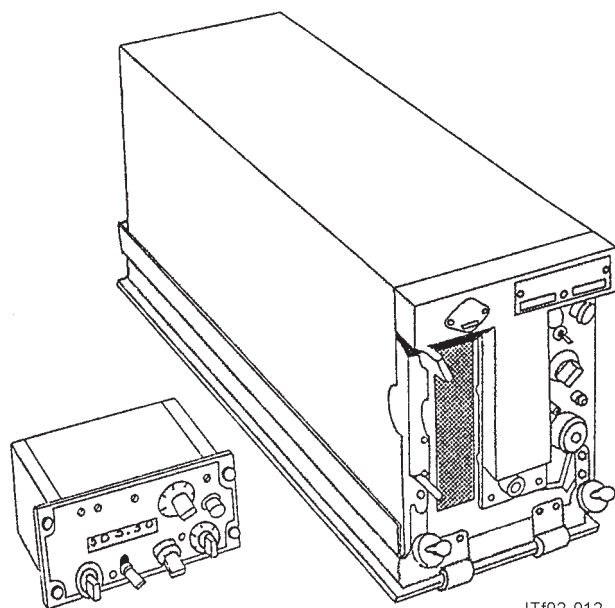
FLEET SATELLITE COMMUNICATIONS SYSTEM AND SUBSYSTEMS

The Fleet Satellite Communications (FLTSATCOM) system and subsystems provide communications links, via satellite, between shore commands and mobile units. The system includes RF terminals, subscriber subsystems, training, documentation, and logistic support. Within each satellite, the RF channels available for use have been distributed between the Navy and the Air Force.



ITf02-011

Figure 2-7.—AN/WSC-5 UHF Transceiver.



ITf02-012

Figure 2-8.—AN/AR5-143 UHF Transceiver.

Equipments in support of the FLTSATCOM system are on ships, submarines, aircraft, and at shore stations. These equipment installations vary in size and complexity. Furthermore, with the exception of voice communications, the system applies the technology of processor- (computer-) controlled RF links and uses the assistance of processors in message traffic preparation and handling.

Although any part of the FLTSATCOM system can be operated as a separate module, system integration provides connections for message traffic and voice communications to DOD communications networks.

A backup capability that can be used in the event of an outage or equipment failure is provided for both shore and afloat commands. All subsystems have some form of backup mode, either from backup equipment and/or systems, facilities, or RF channels. This capability is built in as part of the system design and

may limit the ability of selected FLTSATCOM systems to process information.

FLEET SATELLITE BROADCAST (FSB) SUBSYSTEM

The Fleet Satellite Broadcast (FSB) subsystem is an expansion of fleet broadcast transmissions that historically have been the central communications medium for operating naval units. The FSB transmits messages, weather information, and intelligence data to ships. The shore terminal transmits this data on a direct SHF signal to a satellite, where the signal is translated to UHF and downlinked. Figure 2-9 shows a standard FSB subsystem configuration.

COMMON USER DIGITAL INFORMATION EXCHANGE SYSTEM (CUDIXS) AND NAVAL MODULAR AUTOMATED COMMUNICATIONS SYSTEM (NAVMACS)

The CUDIXS/NAVMACS combine to form a communications network that is used to transmit general service (GENSER) message traffic between ships and shore installations. NAVMACS serves as an automated shipboard terminal for interfacing with CUDIXS (shore-based) and the Fleet Broadcast

System. Figure 2-10 shows a NAVMACS II configuration.

OTHER SPECIALIZED SUBSYSTEMS

The FLTSATCOM system represents a composite of information exchange subsystems that use the satellites as a relay for communications. The following subsystems satisfy the unique communication requirements for each of the different naval communities.

- **Submarine Satellite Information Exchange Subsystem (SSIXS)**

The SSIXS provides a communications system to exchange message traffic between SSBN and SSN submarines and shore stations.

- **Antisubmarine Warfare Information Exchange Subsystem (ASWIXS)**

ASWIXS is designed as a communications link for antisubmarine warfare (ASW) operations between shore stations and aircraft.

- **Tactical Data Information Exchange Subsystem (TADIXS)**

TADIXS is a direct communications link between command centers ashore and afloat.

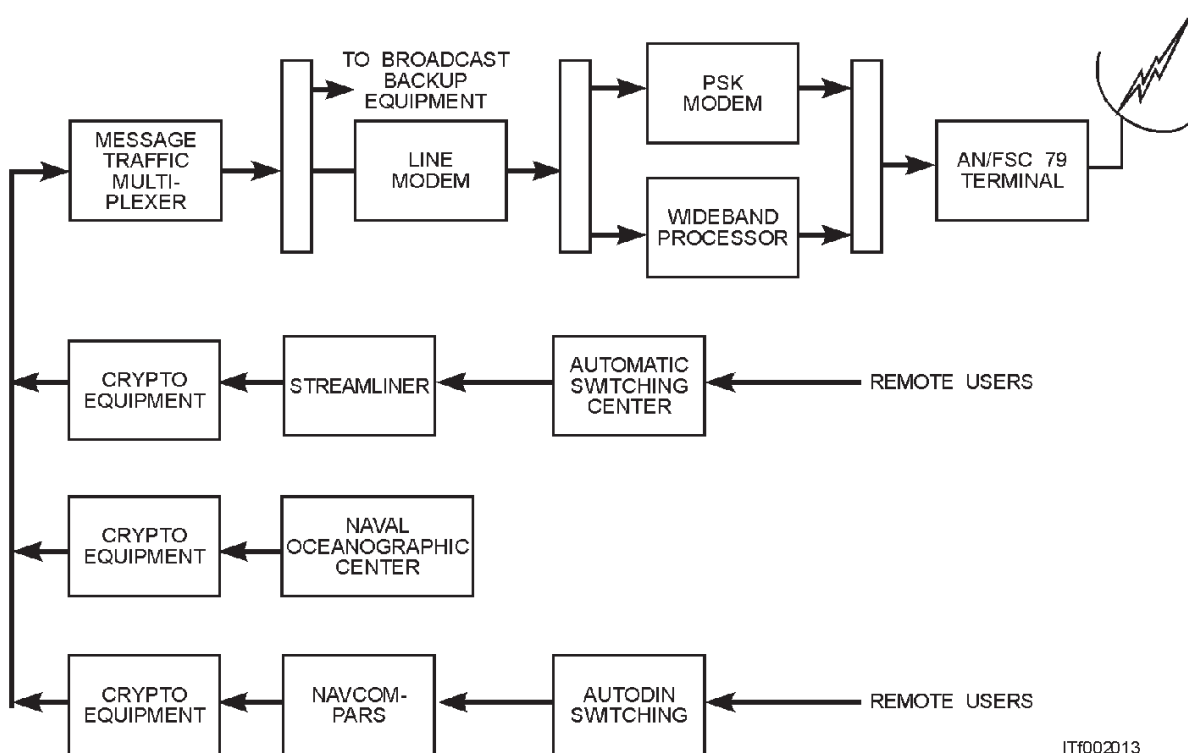


Figure 2-9.—Fleet Satellite Broadcast subsystem.

IT002D13

NAVMACS II
(TYPICAL LARGE DECK CONFIGURATION)

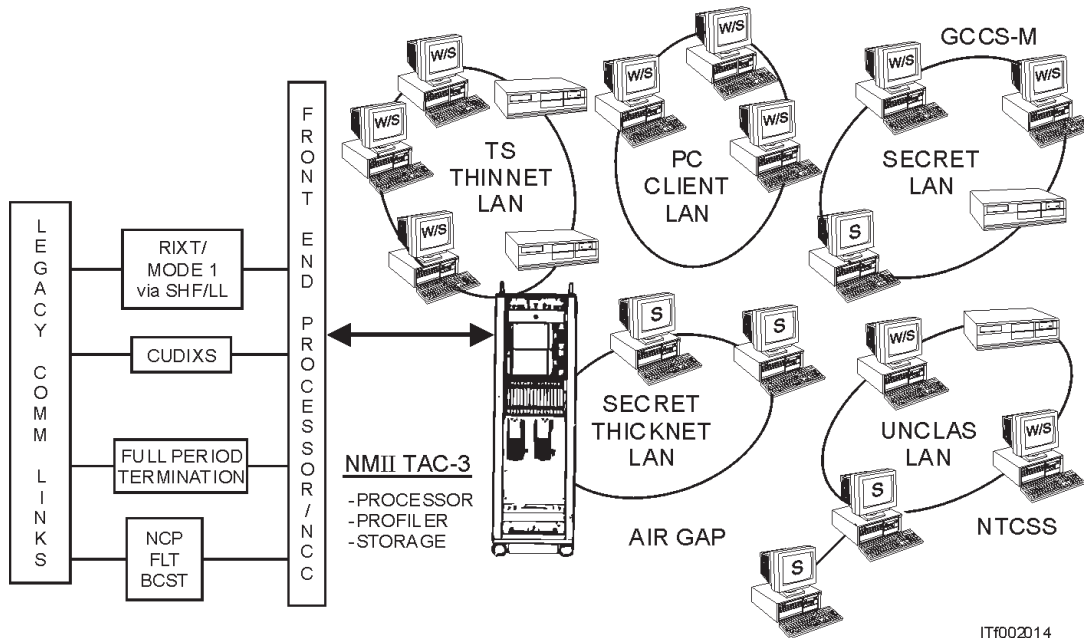


Figure 2-10.—NAVMACS (V) communications interface.

TADIXS provides one-way transmission of data link communications.

- **Secure Voice Subsystem**

The secure voice subsystem is a narrowband UHF link that enables secure voice communications between ships. It also allows connection with wide-area voice networks ashore.

- **Tactical Intelligence (TACINTEL) Subsystem**

TACINTEL is specifically designed for special intelligence communications.

- **Control Subsystem**

The Control subsystem is a communications network that facilitates status reporting and management of FLTSATCOM system assets.

- **Officer in Tactical Command Information Exchange Subsystem (OTCIXS)**

OTCIXS is designed as a communications link for battle group tactical operations.

- **Teleprinter Subsystem (ORESTES)**

ORESTES is an expansion of the existing teleprinter transmission network.

LEASAT TELEMETRY TRACKING AND COMMAND SUBSYSTEM

The LEASAT Telemetry Tracking and Command subsystem is a joint operation between the U.S. Navy and contractors for controlling LEASATS. The installation of subsystem baseband equipment and RF terminals aboard ships and aircraft is determined by communications traffic levels, types of communications, and operational missions.

Since Fleet Satellite Broadcast message traffic is a common denominator for naval communications, it is received by numerous types of ships. In some installations, such as large ships, the fleet broadcast receiver represents one part of the FLTSATCOM equipment suite. A typical configuration on a large ship would include fleet broadcast, CUDIXS/NAVMACS, secure voice, OTCIXS, TADIXS, teleprinter, and TACINTEL equipment.

The FLTSATCOM subsystems apply some form of automated control to the communications being transmitted with the exception of the secure voice and control subsystems. This includes message or data link processing before and after transmittal and control of the RF network (link control) in which the messages are being transmitted. The automation of these functions is handled by a processor.

Much of the message processing before transmission and after receipt is fully automatic and does not require operator intervention. The actual message or data link transmission is fully automated and under the control of a processor. Within the limitations of equipment capability, each subsystem addresses the unique requirements of the user and the environment in which the user operates.

DEMAND ASSIGNED MULTIPLE ACCESS (DAMA)

The Demand Assigned Multiple Access (DAMA) was developed to multiplex several subsystems or users on one satellite channel. This arrangement allows more satellite circuits to use each UHF satellite channel.

Multiplexing

The number of communications networks being used is constantly increasing. As a result, all areas of the RF spectrum have become congested. Multiplexing is a method of increasing the number of transmissions taking place in the radio spectrum per unit of time.

Multiplexing involves the simultaneous transmission of a number of intelligible signals using only a single transmitting path. As we mentioned earlier, the Navy uses two multiplexing methods: time-division multiplexing (TDM) and frequency-division multiplexing (FDM). We have already discussed FDM with the AN/UCC-1. Additional information concerning both methods can be found in *Radio-Frequency Communication Principles*, NEETS, Module 17.

A UHF DAMA subsystem, the TD-1271/U Multiplexer, was developed to provide adequate capacity for the Navy and other DOD users. This subsystem was developed to multiplex (increase) the number of subsystems, or users, on 1 25-kHz satellite channel by a factor of 4.

This factor can be further increased by multiples of 4 by patching 2 or more TD-1271's together. This method increases the number of satellite circuits per channel on the UHF satellite communications system. Without this system, each satellite communications subsystem would require a separate satellite channel.

Transmission Rates

The DAMA equipment accepts encrypted data streams from independent baseband sources and combines them into one continuous serial output data stream. DAMA was designed to interface the Navy UHF SATCOM baseband subsystem and the AN/WSC-5 and AN/WSC-3 transceivers.

The TD-1271/U Multiplexer includes a modem integral to the transceiver. The baseband equipment input or output data rate with DAMA equipment can be 75, 300, 600, 1,200, 2,400, 4,800, or 16,000 bits per second (bps). The DAMA transmission rate on the satellite link (referred to as "burst rate") can be 2,400, 9,600, 19,200, or 32,000 symbols per second.

Circuit Restoral/Coordination

When a termination is lost in either or both directions, communications personnel must observe special guidelines. During marginal or poor periods of communications, the supervisors should assign a dedicated operator to the circuit if possible.

When normal circuit restoration procedures are unsuccessful and/or a complete loss of communications exists, an IMMEDIATE precedence COMMSPOT message should be transmitted (discussed earlier). Every means available must be used to re-establish the circuit, including messages, support from other ships or NAVCOMTELSTAs, or coordination via DAMA if available.

The guidelines established in NTP 4, CIBs, and local SOPs are not intended to suppress individual initiative in re-establishing lost communications. Circuit restoral is dependent upon timely action, quick decisions, and the ability of personnel to use any means available to restore communications in the shortest possible time.

SPECIAL CIRCUITS

During certain communications operations, you may be required to activate and operate special circuits. Some of the most common special circuits are discussed next.

UHF AUTOCAT/SATCAT/MIDDLEMAN RELAY CIRCUITS

Shipboard HERO conditions and emission control (EMCON) restrictions often prohibit transmission of RF below 30 MHz.

To provide an uninterrupted flow of essential communications without violating HERO and EMCON restrictions, AUTOCAT, SATCAT, and MIDDLEMAN were developed. With these techniques, the range of tactical UHF circuits (voice or teleprinter) can be extended by relay of AM UHF transmissions via HF or satellite. AUTOCAT accomplishes this using a ship; whereas SATCAT uses an airborne platform for automatically relaying UHF transmissions. MIDDLEMAN requires an operator to copy the messages with subsequent manual retransmission.

The three techniques just discussed use three different types of circuit for reception and relay of UHF transmissions. These circuits are as follows:

- A voice circuit where some units send and receive on one frequency, and other units send and receive on any other frequency;
- A voice circuit where all units transmit on one frequency and receive on another frequency; and
- A RATT circuit where all units transmit on one frequency and receive on another frequency.

FLEET FLASH NET

The Fleet Flash Net (FFN) is composed of senior operational staffs and other designated subscribers. The purpose of the FFN is to distribute high-precedence or highly sensitive traffic among subscribers. A receipt on the net constitutes firm delivery, and the message need not be retransmitted over other circuits to receipting stations. The FFN is explained in more detail in *Mission Communications*, NTP 11.

ANTENNA SYSTEMS

Operation of communication equipment over the entire range of the RF spectrum requires many types of antennas. You will need to know the basic type of antennas available to you operationally, their characteristics, and their uses. Very often, you, the operator, can mean the difference between efficient and inefficient communications. You will have a choice of many antennas and must select the one most suitable for the task at hand. Your operational training will acquaint you with the knowledge necessary to properly use the antennas at your disposal. However, your operational training WILL NOT acquaint you with the WHY of antennas, in other words, basic antenna theory. The following topics are intended to

familiarize you with basic antenna terminology, definitions, and characteristics.

ANTENNA CHARACTERISTICS

As you will learn in this section, all antennas exhibit common characteristics. The study of antennas involves the following terms with which you must become familiar:

Antenna Reciprocity

The ability of an antenna to both transmit and receive electromagnetic energy is known as its **reciprocity**. Antenna reciprocity is possible because antenna characteristics are essentially the same for sending and receiving electromagnetic energy.

Even though an antenna can be used to transmit or receive, it cannot be used for both functions at the same time. The antenna must be connected to either a transmitter or a receiver.

Antenna Feed Point

Feed point is the point on an antenna where the RF cable is attached. If the RF transmission line is attached to the base of an antenna, the antenna is **end-fed**. If the RF transmission line is connected at the center of an antenna, the antenna is **mid-fed** or **center-fed**.

Directivity

The **directivity** of an antenna refers to the width of the radiation beam pattern. A directional antenna concentrates its radiation in a relatively narrow beam. If the beam is narrow in either the horizontal or vertical plane, the antenna will have a high degree of directivity in that plane. An antenna can be highly directive in one plane only or in both planes, depending upon its use.

In general, we use three terms to describe the type of directional qualities associated with an antenna: **omnidirectional**, **bidirectional**, and **unidirectional**. Omnidirectional antennas radiate and receive equally well in all directions, except off the ends. Bidirectional antennas radiate or receive efficiently in only two directions. Unidirectional antennas radiate or receive efficiently in only one direction.

Most antennas used in naval communications are either omnidirectional or unidirectional. Bidirectional antennas are rarely used. Omnidirectional antennas are used to transmit fleet broadcasts and are used aboard ship for medium-to-high frequencies. A parabolic, or

dish, antenna (figure 2-11) is an example of a unidirectional antenna. As you can see in the figure, an antenna (normally a half wave) is placed at the “focal” point and radiates the signal back into a large reflecting surface (the dish). The effect is to transmit a very narrow beam of energy that is essentially unidirectional. Figure 2-12 shows a large, unidirectional parabolic antenna. Directional antennas are commonly used at shore installations.

Wave Polarization

Polarization of a radio wave is a major consideration in the efficient transmission and reception of radio signals. If a single-wire antenna is used to extract energy from a passing radio wave, maximum signal pickup results when the antenna is placed physically in the same direction as the electric

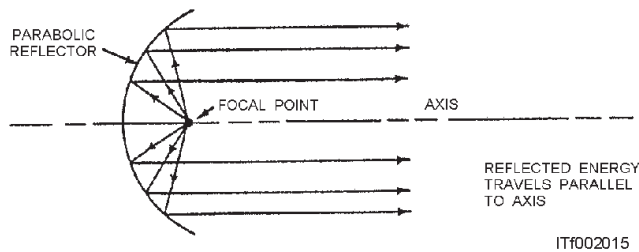


Figure 2-11.—Principle of parabolic reflection.

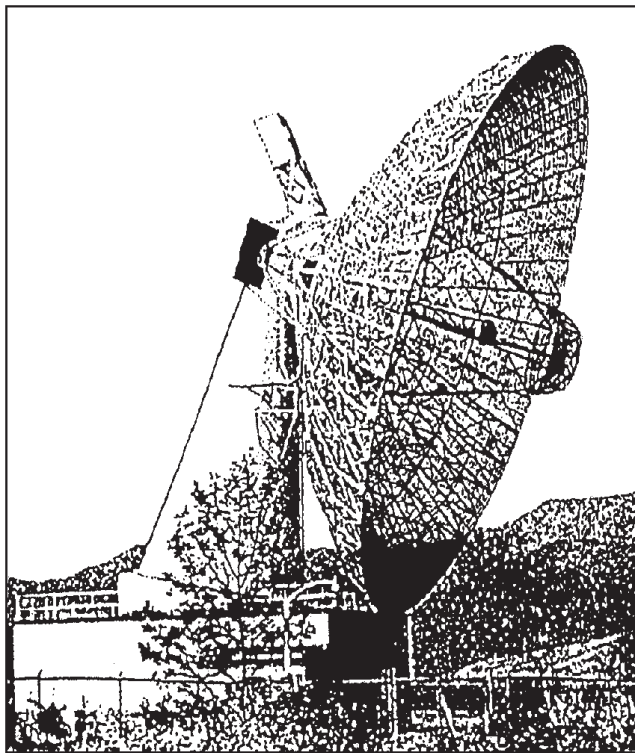


Figure 2-12.—Unidirectional parabolic antenna.

field component. For this reason, a vertical antenna is used to receive vertically polarized waves, and a horizontal antenna is used to receive horizontally polarized waves.

At lower frequencies, wave polarization remains fairly constant as it travels through space. At higher frequencies, the polarization usually varies, sometimes quite rapidly. This is because the wave front splits into several components, and these components follow different propagation paths.

When antennas are close to the ground, vertically polarized radio waves yield a stronger signal close to the Earth than do those that are horizontally polarized. When the transmitting and receiving antennas are at least one wavelength above the surface, the two types of polarization are approximately the same in field intensity near the surface of the Earth. When the transmitting antenna is several wavelengths above the surface, horizontally polarized waves result in a stronger signal close to the Earth than is possible with vertical polarization.

Most shipboard communication antennas are vertically polarized. This type of polarization allows the antenna configuration to be more easily accommodated in the limited space allocated to shipboard communications installations. Vertical antenna installations often make use of the topside structure to support the antenna elements. In some cases, to obtain the required impedance match between the antenna base terminal and transmission line, the structure acts as part of the antenna.

VHF and UHF antennas used for ship-to-aircraft communications use both vertical and circular polarization. Because aircraft maneuvers cause cross-polarization effects, circularly polarized shipboard antennas frequently offer considerable signal improvements over vertically polarized antennas.

Circularly polarized antennas are also used for ship-to-satellite communications because these antennas offer the same improvement as VHF/UHF ship-to-aircraft communications operations. Except for the higher altitudes, satellite antenna problems are similar to those experienced with aircraft antenna operations.

Incident Waves

Various factors in the antenna circuit affect the radiation of RF energy. When we energize or feed an

antenna with an alternating current (ac) signal, waves of energy are created along the length of the antenna. These waves, which travel from a transmitter to the end of the antenna, are the incident waves.

Let's look at figure 2-13. If we feed an ac signal at point A, energy waves will travel along the antenna until they reach the end (point B). Since the B end is free, an open circuit exists and the waves cannot travel farther. This is the **point of high impedance**. The energy waves bounce back (reflect) from this point of high impedance and travel toward the feed point, where they are again reflected.

Reflected Waves

We call the energy reflected back to the feed point the **reflected wave**. The resistance of the wire gradually decreases the energy of the waves in this back-and-forth motion (oscillation). However, each time the waves reach the feed point (point A of figure 2-13), they are reinforced by enough power to replace the lost energy. This results in continuous oscillations of energy along the wire and a high voltage at point A on the end of the wire. These oscillations are applied to the antenna at a rate equal to the frequency of the RF voltage.

In a perfect antenna system, all the energy supplied to the antenna would be radiated into space. In an imperfect system, which we use, some portion of the energy is reflected back to the source with a resultant decrease in radiated energy. The more energy reflected back, the more inefficient the antenna. The condition of most antennas can be determined by measuring the power being supplied to the antenna (forward power) and the power being reflected back to the source (reflected power). These two measurements determine the voltage standing wave ratio (VSWR), which indicates antenna performance.

If an antenna is resonant to the frequency supplied by the transmitter, the reflected waves and the incident waves are in phase along the length of the antenna and tend to reinforce each other. It is at this point that

radiation is maximum, and the SWR is best. When the antenna is not resonant at the frequency supplied by the transmitter, the incident and reflected waves are out of phase along the length of the antenna and tend to cancel out each other. These cancellations are called power losses and occur when the SWR is poor, such as 6:1 or 5:1.

Most transmitters have a long productive life and require only periodic adjustment and routine maintenance to provide maximum operating efficiency and reliable communications. Experience has shown that many of the problems associated with unreliable radio communication and transmitter failures can be attributed to high antenna VSWR.

Dummy Loads

Under radio silence conditions, placing a carrier on the air during transmitter tuning would give an enemy the opportunity to take direction-finding bearings and determine the location of the ship. Even during normal periods of operation, transmitters should be tuned by methods that do not require radiation from the antenna. This precaution minimizes interference with other stations using the circuit.

A dummy load (also called dummy antenna) can be used to tune a transmitter without causing unwanted radiation. Dummy loads have resistors that dissipate the RF energy in the form of heat and prevent radiation by the transmitter during the tuning operation. The dummy load, instead of the antenna, is connected to the output of the transmitter, and the normal transmitter tuning procedure is followed.

Most Navy transmitters have a built-in dummy load. This permits you to switch between the dummy load or the actual antenna, using a switch. For transmitters that do not have such a switch, the transmission line at the transmitter is disconnected and connected to the dummy load (figure 2-14). When transmitter tuning is complete, the dummy load is disconnected and the antenna transmission line is again connected to the transmitter.

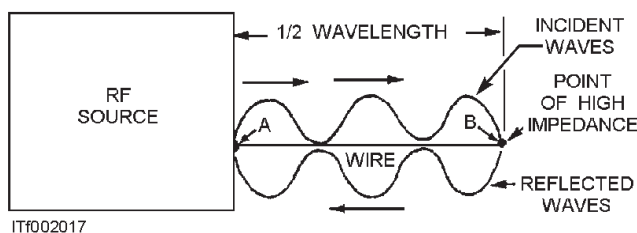


Figure 2-13.—Incident and reflected waves on an antenna.

ELECTROMAGNETIC WAVELENGTH

Electromagnetic waves travel through free space at 186,000 miles per second. But, because of resistance, the travel rate of these waves along a wire is slightly slower. An antenna must be an appropriate length so that a wave will travel from one end to the other and return to complete one cycle of the RF voltage. A wavelength is the distance traveled by a radio wave in

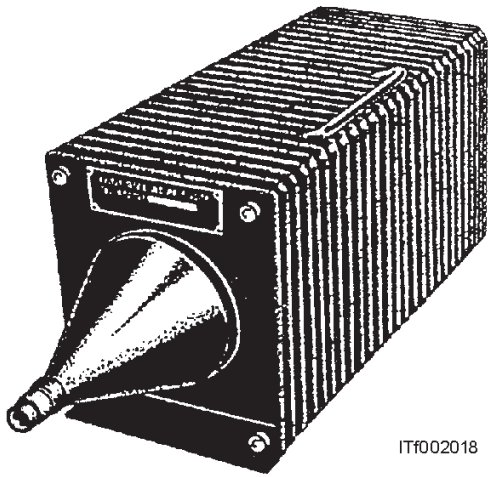


Figure 2-14.—DA-91/U dummy load.

one cycle. This means that wavelength will vary with frequency.

If we increase the frequency, the time required to complete one cycle of alternating current (ac) is naturally less; therefore, the wavelength is less. If we decrease the frequency, the time required to complete one cycle of ac is longer; therefore, the wavelength is longer. Another word used to represent wavelength is LAMBDA (designated by the symbol λ).

The term “wavelength” also refers to the length of an antenna. Antennas are often referred to as **half wave**, **quarter wave**, or **full wave**. These terms describe the relative length of an antenna, whether that length is electrical or physical. Figure 2-15 shows a theoretical half-wave antenna with a center feed point. Both sections of the antenna relative length of an antenna, whether that length is electrical or physical.

Earlier, we said that when tuning an antenna, we are electrically lengthening or shortening the antenna to achieve resonance at that frequency. We are actually changing the wavelength of the antenna. The electrical length of an antenna may not be the same as its physical length.

You know that RF energy travels through space at the speed of light. However, because of resistance, RF energy on an antenna travels at slightly less than the

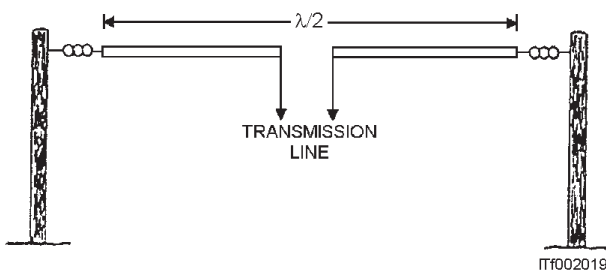


Figure 2-15.—Half-wave antenna with center feed point.

speed of light. Because of this difference in velocity, the physical length no longer corresponds to the electrical length of an antenna. Therefore, an antenna may be a half-wave antenna electrically, but it is physically somewhat shorter. For information on how to compute wavelengths for different frequencies, consult NEETS, Module 12, *Modulation Principles*.

BASIC ANTENNAS

Many types and variations of antenna design are used in the fleet to achieve a particular directive radiation pattern or a certain vertical radiation angle. However, all antennas are derived from two basic types: the half wave and the quarter wave.

HALF-WAVE ANTENNA

An antenna that is one-half wavelength long is the shortest antenna that can be used to radiate radio signals into free space. The most widely used antenna is the half-wave antenna, commonly called a dipole, or hertz, antenna. This antenna consists of two lengths of wire rod, or tubing, each one-fourth wavelength long at a certain frequency.

Many complex antennas are constructed from this basic antenna design. This type of antenna will not function efficiently unless its length is one-half wavelength of the frequency radiated or received.

Figure 2-15 shows a theoretical half-wave antenna with a center feed point. Both sections of the antenna are $\lambda/4$ (one-fourth wavelength) at the operating frequency. Together, of course, the sections make the effective length of the antenna $\lambda/2$ (one-half wavelength) at the operating frequency.

One feature of the dipole antenna is that it does not need to be connected to the ground like other antennas. Antennas shorter than a half wavelength must use the ground to achieve half-wave characteristics. The half-wave antenna is already long enough to radiate the signal properly.

Because of sophisticated antenna systems and tuning processes, half-wave antennas can be electrically achieved aboard ship. Therefore wavelength is becoming less and less the criteria for determining the types of antennas to be used on ships. Dipole antennas can be mounted horizontally or vertically, depending upon the desired polarization, and can be fed at the center or at the ends. Because it is ungrounded, the dipole antenna can be installed above energy-absorbing structures.

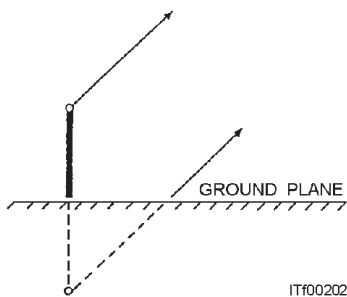
QUARTER-WAVE ANTENNA

A quarter-wave antenna is a grounded antenna that is one-fourth wavelength of the transmitted or received frequency. You will hear the quarter-wave antenna referred to as a “Marconi antenna.” The quarter-wave antenna is also omnidirectional.

As we mentioned earlier, a half-wave antenna is the shortest practical length that can be effectively used to radiate radio signals into free space. The natural question, then is, “How do we use a quarter-wavelength antenna if a half-wavelength is the shortest length that can be used?” The answer is simple.

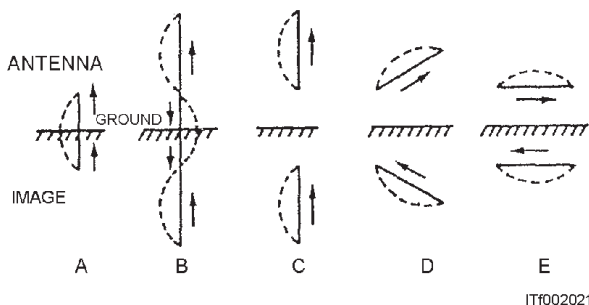
Two components make up the total radiation from an antenna. One component is the part of the radiated signal that leaves the antenna directly. The other is a **ground reflection** that appears to come from an underground image of the real antenna (figure 2-16). This image is sometimes called the **mirror image** and is considered to be as far below the ground as the real antenna is above it.

Figure 2-17 shows basic current distribution in a real and image antenna. There are certain directions in which the direct wave from the real antenna and the reflected wave from the image are exactly equal in amplitude but opposite in phase. Conversely, there are other directions in which the direct and reflected waves are equal in amplitude and in phase. Therefore,



ITF002020

Figure 2-16.—Direct and image signal of a quarter-wave antenna.



ITF002021

Figure 2-17.—Current distribution in a real antenna and its image.

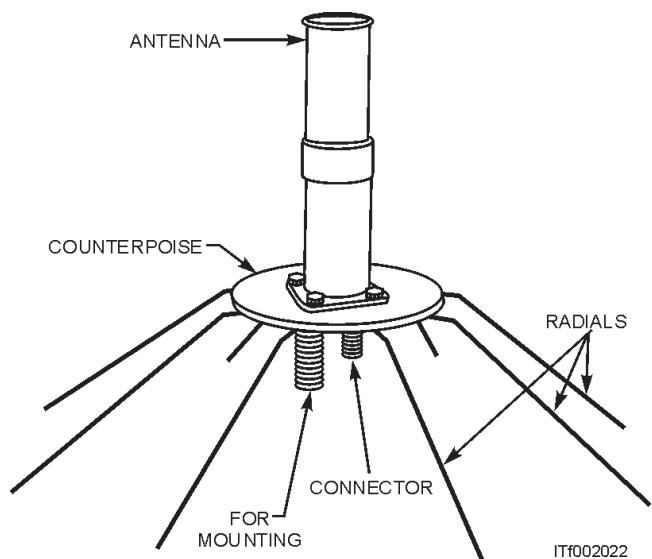
depending on the direction and location of the point at which the field strength is measured, the actual field strength may be (1) twice the field strength from the real antenna alone, (2) zero field strength, or (3) some intermediate value between maximum and minimum. It is this “real” and “image” radiated field that forms the basis for using quarter-wavelength antennas.

This reflected-energy principle is very useful in the lower frequency ranges, although ground reflections occur in the high-frequency range as well.

The antenna does not always need to be placed at the Earth’s surface to produce an image. Another method of achieving reflected images is through the use of ground planes. This means that a large reflecting metallic surface is used as a substitute for the ground or Earth. This method is frequently used in the VHF/UHF frequency ranges. Figure 2-18 shows a commonly used UHF antenna (AS-390/SRC), which uses this principle. The ground plane is sometimes referred to as a “counterpoise,” as shown in the figure. Together, the counterpoise and the radials form the reflecting surface, which provides the reflected image.

TYPES OF SHIPBOARD ANTENNAS

Figure 2-19 shows various shipboard antennas and their placements. The complex structures of modern ships and their operational requirements require the use of many types of antenna. These types include wire rope fans, whips, cages, dipoles, probes, trussed monopoles, and bow stubs. The selection and use of different types is often governed by the limited space available.



ITF002022

Figure 2-18.—AS-390/SRC UHF antenna with counterpoise, or ground plane.

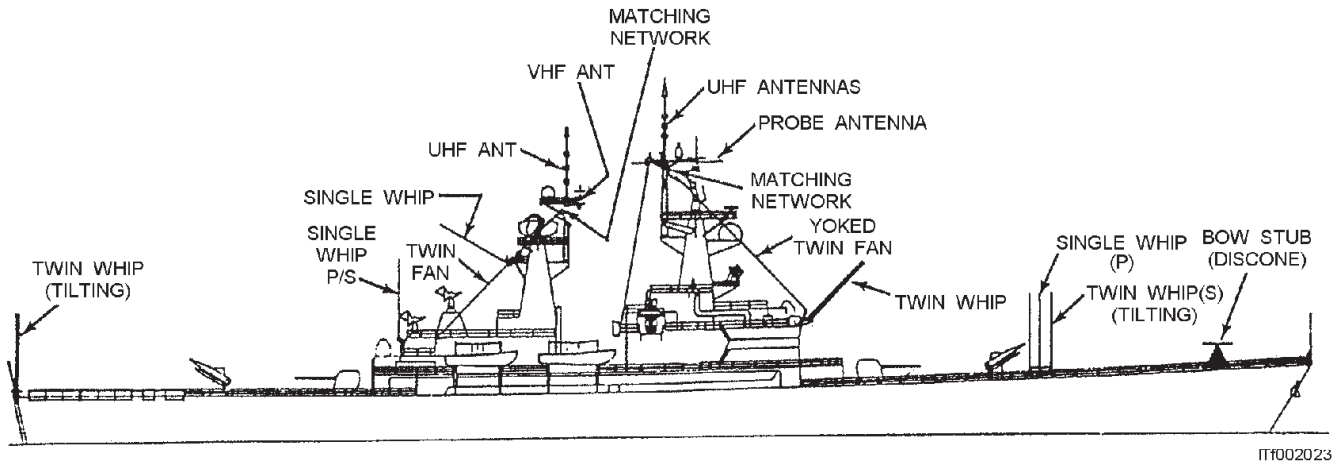


Figure 2-19.—Shipboard antenna systems.

WIRE ROPE ANTENNAS

Wire rope antennas are installed aboard ship for medium- and high-frequency (300 kHz to 30 MHz) coverage. A wire rope antenna (figure 2-20) consists of one or more lengths of flexible wire rigged from two or more points on the ship's superstructure. A wire rope antenna is strung either vertically or horizontally from a yardarm or mast to outriggers, another mast, or to the superstructure. If used for transmitting, the wire antenna is tuned electrically to the desired frequency.

Receiving wire antennas are normally installed forward on the ship, rising nearly vertically from the

pilothouse top to brackets on the mast or yardarm. Receiving antennas are located as far as possible from the transmitting antennas so that a minimum of energy is picked up from local transmitters.

Because of the characteristics of the frequency range in which wire antennas are used, the ship's superstructure and other nearby structures become an electronically integral part of the antenna. As a result, wire rope antennas are usually designed or adapted specifically for a particular ship.

WHIP ANTENNAS

Whip antennas are used for medium- and high-frequency transmitting and receiving systems. For low-frequency systems, whip antennas are used only for receiving. Essentially self-supporting, whip antennas may be deck-mounted or mounted on brackets on the stacks or superstructure. The self-supporting feature of the whip makes it particularly useful where space is limited and in locations not suitable for other types of antennas. Whip antennas can be tilted, a design feature that makes them suited for use along the edges of aircraft carrier flight decks. Aboard submarines, they can be retracted into the sail structure.

Whip antennas commonly used aboard ship are 25, 28, or 35 feet long and consist of several sections. The 35-foot whip is most commonly used. If these antennas are mounted less than 25 feet apart, they are usually connected with a crossbar with the feed point at its center. The twin whip antenna (figure 2-21) is not broadband and is generally equipped with a base tuning unit.

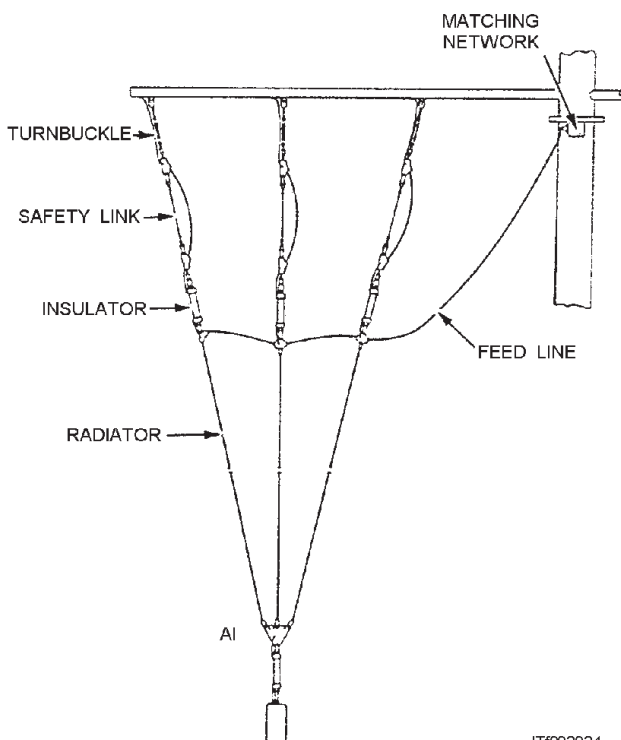


Figure 2-20.—Wire rope fan antenna.

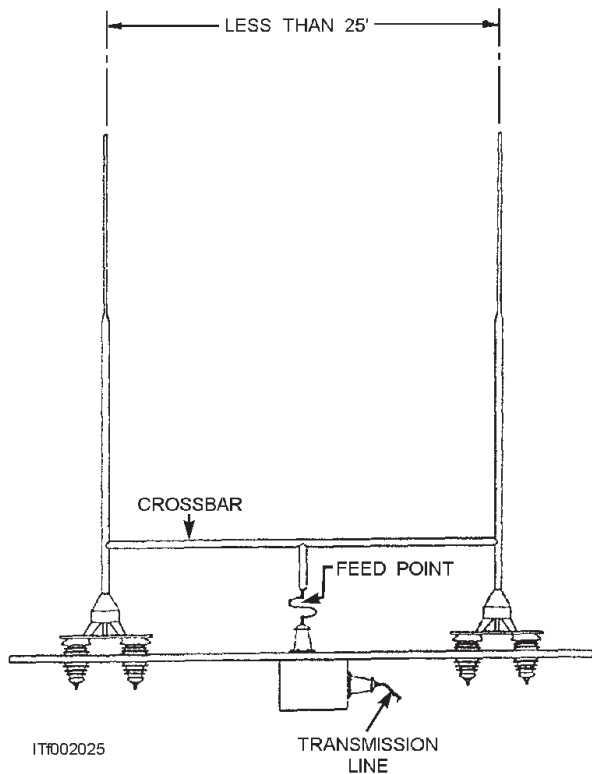


Figure 2-21.—Twin whip antenna with crowbar.

VHF AND UHF ANTENNAS

The physical size of VHF and UHF antennas is relatively small because of the short wavelengths at these frequencies. Aboard ship, these antennas are installed as high and as much in the clear as possible. Since VHF and UHF antennas are line-of-sight systems, they require a clear area at an optimum height on the ship structure or mast. Unfortunately, this area is also needed for various

radars and UHF direction-finding and navigational aid systems.

VHF and UHF antennas are usually installed on stub masts above the foremast and below the UHF direction finder. UHF antennas are often located on the outboard ends of the yardarms and on other structures that offer a clear area.

For best results in the VHF and UHF ranges, both transmitting and receiving antennas must have the same polarization. Vertically polarized antennas are used for all ship-to-ship, ship-to-shore, and ground-to-air VHF/UHF communications. Usually, either a vertical half-wave dipole or a vertical quarter-wave antenna with ground plane is used. An example of a UHF half-wave (dipole) antenna is the AT-150/SRC, shown in figure 2-22. This antenna is normally mounted horizontally.

BROADBAND ANTENNAS

Broadband antennas for HF and UHF bands have been developed for use with antenna multicouplers. Therefore, several circuits may be operated with a single antenna. Broadband antennas must be able to transmit or receive over a wide frequency band.

HF broadband antennas include the 35-foot twin and trussed whips, half-cone, cage, and a variety of fan-designed antennas. The AT-150/SRC UHF antenna in figure 2-22 is an example of a broadband antenna.

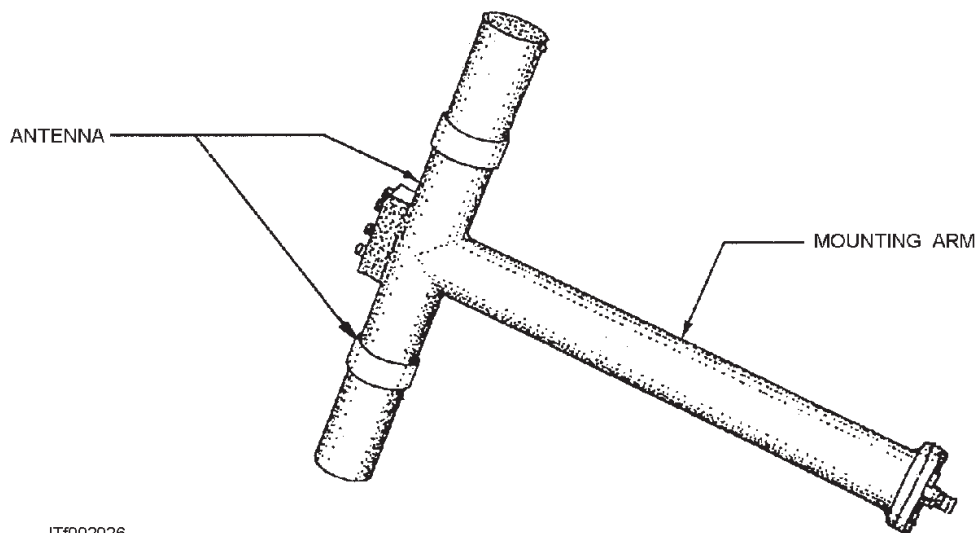
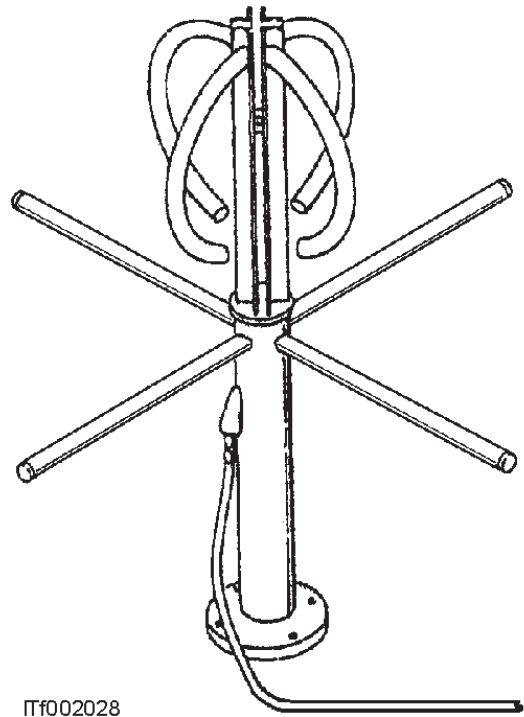


Figure 2-22.—AT-150/SRC UHF antenna.

SATCOM ANTENNAS

The antennas shown in figures 2-23 and 2-24 are used for satellite communications. The OE-82C/WSC-1(V) antenna (figure 2-23) is used with the AN/WSC-3 transceiver (figure 2-25) and designed primarily for shipboard installation. Depending upon requirements, one or two antennas may be installed to provide a view of the satellite at all times. The antenna is attached to a pedestal. This permits the antenna to rotate so that it is always in view of the satellite. The frequency band for receiving is 248 to 272 MHz and for transmitting is 292 to 312 MHz.

The AN/SRR-1 receiver system consists of up to four AS-2815/SSR-1 antennas (figure 2-24) with an amplifier-converter AM-6534/SSR-1 for each antenna. The antennas are used to receive satellite fleet broadcasts at frequencies of 240 to 315 MHz. The antenna and converters are mounted above deck so that at least one antenna is always in view of the satellite.



ITf002028

Figure 2-24.—AS-2815/SSR-1 antenna physical configuration.

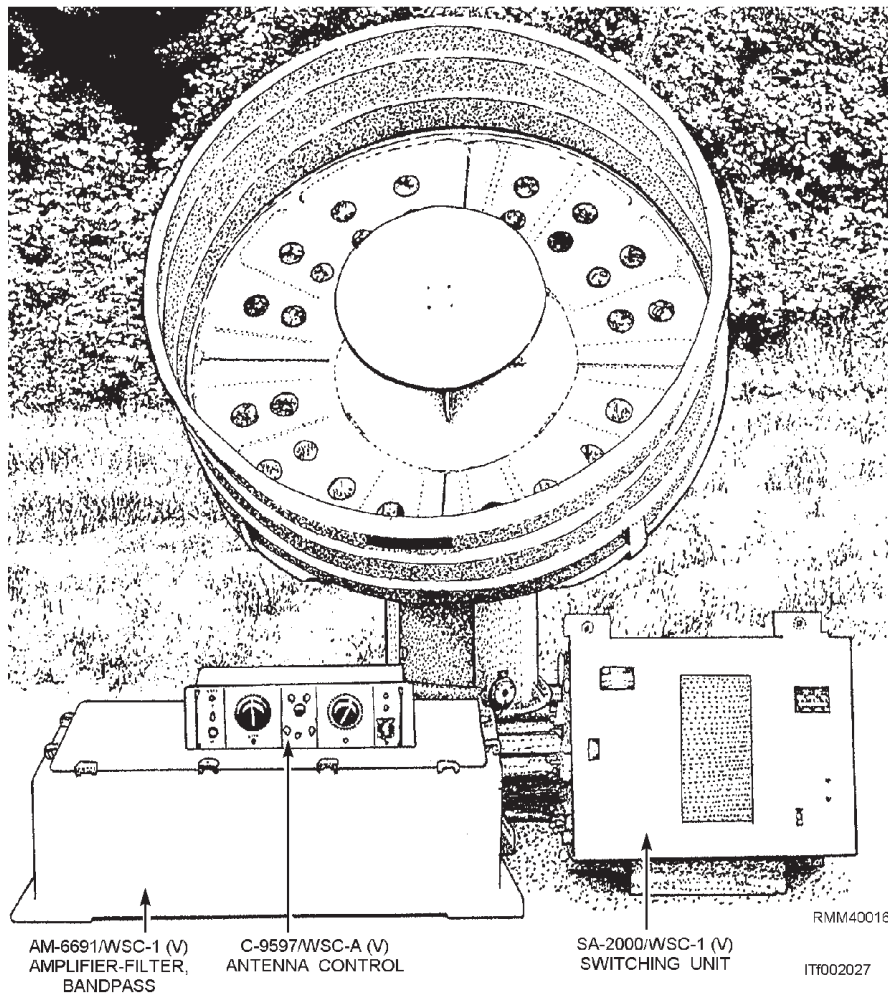


Figure 2-23.—OE-82C/WSC-1(V) antenna group.



ITF02-001

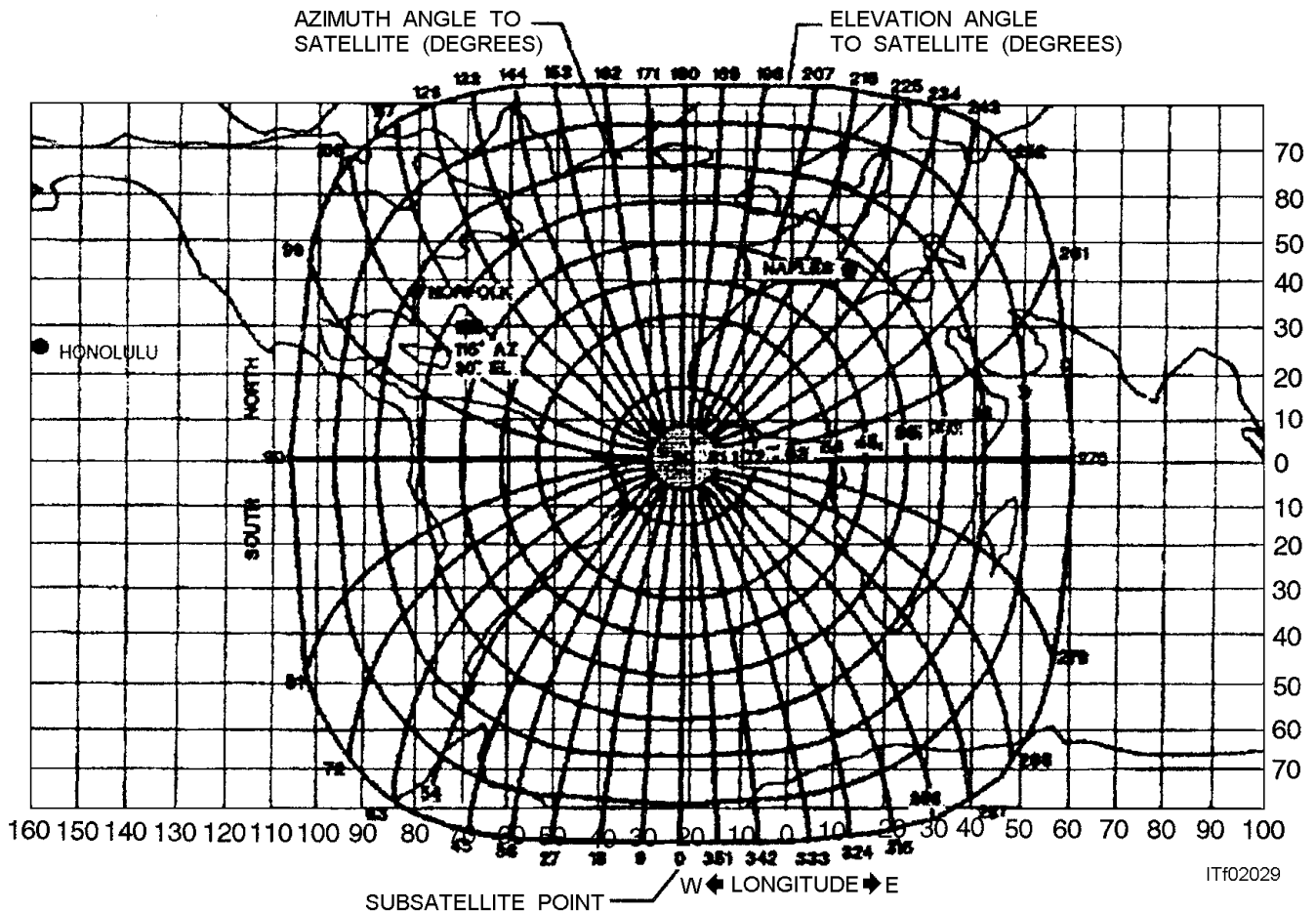
Figure 2-25.—AN/WSSC-3 UHF transceiver.

The newer satellite systems use the SHF band. One of the major advantages of these systems is that they use a very small parabolic antenna measuring only 12 inches in diameter.

A satellite antenna must be pointed at the satellite to communicate. We must first determine the azimuth (AZ) and elevation (EL) angles from a fixed location. Figure 2-26 illustrates how these angles are derived,

using a pointing guide called the Equatorial Satellite Antenna Pointing Guide. This guide is normally available through the Navy Supply System.

The antenna pointing guide is a clear plastic overlay, which slides across a stationary map. It indicates AZ and EL angles in degrees to the satellite. The values obtained are useful to the operator in setting up the antenna control unit of a satellite system.



ITF02029

Figure 2-26.—Equatorial Satellite Antenna Pointing Guide.

To use the guide, follow these procedures:

- Center the overlay directly over the desired satellite position on the stationary map.
- Mark the latitude and longitude of the ship on the plastic antenna pointing guide with a grease pencil.
- Determine the approximate azimuth angle from the ship to the satellite.
- Locate the closest dotted line radiating outward from the center of the graph on the overlay in relation to the grease dot representing the ship's location. This dotted line represents degrees of azimuth as printed on the end of the line. Some approximation will be required for ship positions not falling on the dotted line.
- Determine the degrees of elevation by locating the solid concentric line closest to the ship's marked position. Again, approximation will be required for positions not falling directly on the solid elevation line. Degrees of elevation are marked on each concentric line.

Example: Assume that your ship is located at 30° north and 70° west. You want to access FLTSAT 8 at 23° west. When we apply the procedures above, we can determine an azimuth value of 115° and an elevation angle of 30°.

TYPES OF SHOREBASED ANTENNAS

There is a variety of shorebased antennas just as shipbased antennas. In the following paragraphs we will acquaint you with some of the shorebased.

RHOMBIC ANTENNA

The rhombic antenna, usually used at receiver sites, is a unidirectional antenna. This antenna consists of four long wires, positioned in a diamond shape. Horizontal rhombic antennas are the most commonly used antennas for point-to-point HF naval communications. The main disadvantage of this antenna is that it requires a relatively large area.

MULTIWIRE RHOMBIC

A rhombic antenna improves in performance if each leg is made up of more than one wire. An

improved antenna, known as a curtain rhombic, uses three wires spaced 5 to 7 feet apart for each leg and connected to a common point (figure 2-27).

SLEEVE ANTENNA

The sleeve antenna is used primarily as a receiving antenna. It is a broadband, vertically polarized, omnidirectional antenna. Its primary uses are in broadcast, ship-to-shore, and ground-to-air communications. Although originally developed for shore stations, there is a modified version for shipboard use. Figure 2-28 shows a sleeve antenna for shore stations.

Sleeve antennas are especially helpful in reducing the total number of conventional narrowband antennas that otherwise would be required to meet the requirements of shore stations. With the use of multicouplers, one sleeve antenna can serve several receivers operating over a wide range of frequencies. This feature also makes the sleeve antenna ideal for small antenna sites.

CONICAL MONOPOLE ANTENNA

The conical monopole antenna (figure 2-29) is used in HF communications. It is a broadband, vertically polarized, compact omnidirectional antenna. This antenna is adaptable to ship-to-shore, broadcast, and ground-to-air communications. It is used both ashore and aboard ship.

When operating at frequencies near the lower limit of the HF band, the conical radiates in much the same manner as a regular vertical antenna. At the higher frequencies, the lower cone section radiates, and the top section pushes the signal out at a low angle as a sky wave. This low angle of radiation causes the sky wave to return to the Earth at great distances from the antenna. Therefore, this antenna is well suited for long-distance communications in the HF band.

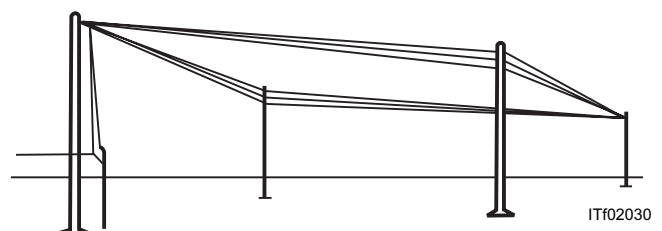


Figure 2-27.—Three-wire rhombic antenna.

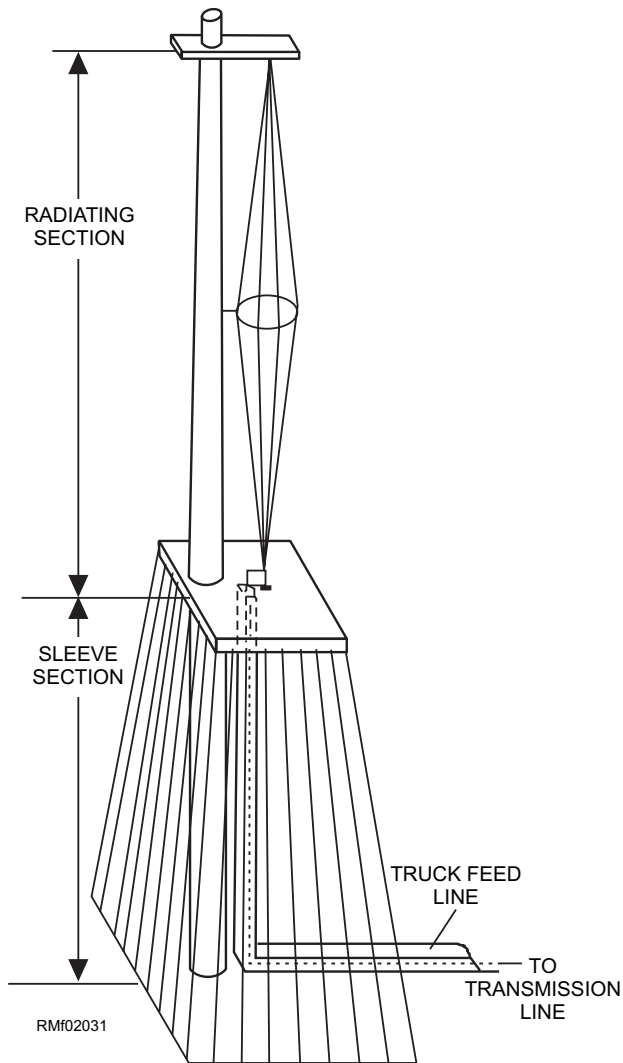


Figure 2-28.—Sleeve antenna (shore stations).

INVERTED CONE ANTENNA

The inverted cone antenna (figure 2-30) is vertically polarized, omnidirectional, and very broadband. It is used for HF communications in ship-to-shore, broadcast, and ground-to-air applications. The radial ground plane that forms the ground system for inverted cones is typical of the requirement for vertically polarized, ground-mounted antennas. The radial wires are one-quarter-wavelength long at the lowest designed frequency.

LOG-PERIODIC ANTENNA

The log-periodic (LP) antenna operates over an extremely-wide frequency range in the HF and VHF bands. Figure 2-31 shows a typical LP antenna designed for extremely broadbanded, VHF communications. The LP antenna can be mounted on steel towers or utility poles that incorporate rotating

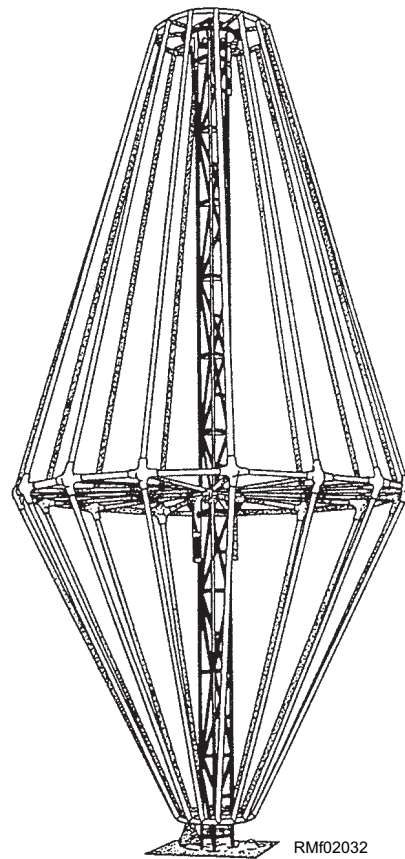


Figure 2-29.—Conical monopole antenna.

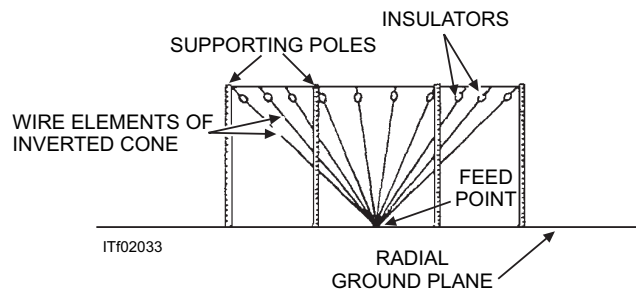


Figure 2-30.—Inverted cone antenna.

mechanisms. This antenna is particularly useful where antenna area is limited. A rotatable LP antenna, known as an RLP antenna (figure 2-32), possesses essentially the same characteristics as the fixed LP antenna but has a different physical form. The RLP antenna is commonly used in ship-shore-ship and in point-to-point communications.

EMERGENCY ANTENNAS

Damage to an antenna from heavy seas, violent winds, or enemy action can cause serious disruption of communications. Sections of a whip antenna can be carried away, insulators can be damaged, or a wire

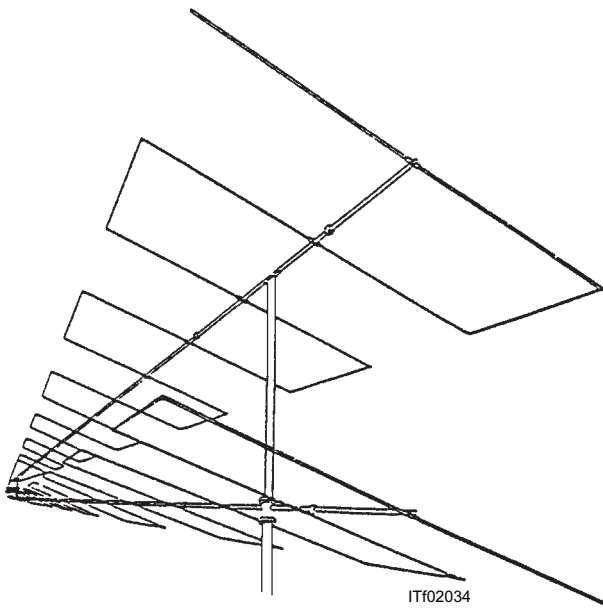


Figure 2-31.—Log-periodic antenna.

antenna can snap loose from its moorings or break. If loss or damage should happen when all available equipment is needed, you may have to rig, or assist in rigging an emergency antenna to temporarily restore communications until the regular antenna can be repaired.

The simplest emergency antenna consists of a length of wire rope to which a high-voltage insulator is

attached to one end and a heavy alligator clip, or lug, is soldered to the other. The end with the insulator is hoisted to the nearest structure and secured. The end with the alligator clip (or lug) is attached to the equipment transmission line. To radiate effectively, the antenna must be sufficiently clear of all grounded objects.

ANTENNA DISTRIBUTION SYSTEMS

In figure 2-33, we see a distribution system with one antenna that can be connected (patched) to one of several receivers or transmitters by way of a multicoupler. In this system, you can patch the antenna to only one receiver or transmitter at a time. However, some distribution systems are more complex, such as the one shown in figure 2-34. In this system, you can patch four antennas to four receivers, or you can patch one antenna to more than one receiver via the multicoupler. In either system, we need a way to connect the antenna to the receiver or transmitter that we want to use.

Figure 2-35 shows a receiver antenna filter patch panel, AN/SRA-12, with a receiver patch panel. The AN/SRA-12 provides seven radio-frequency channels in the 14-kHz to 32-MHz range. Any or all of these channels can be used independently of any other channel, or they can operate simultaneously.

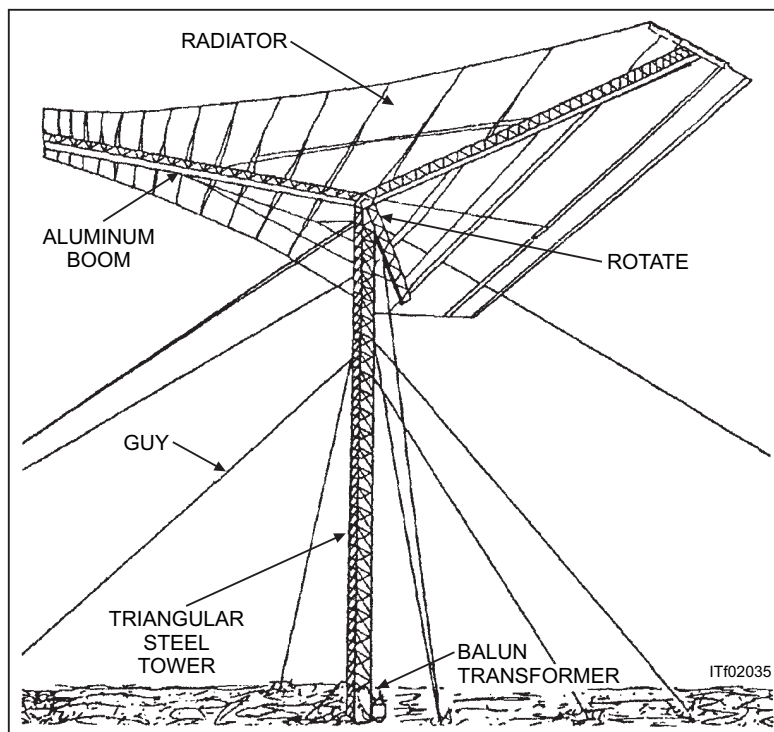


Figure 2-32.—Rotatable log-periodic antenna.

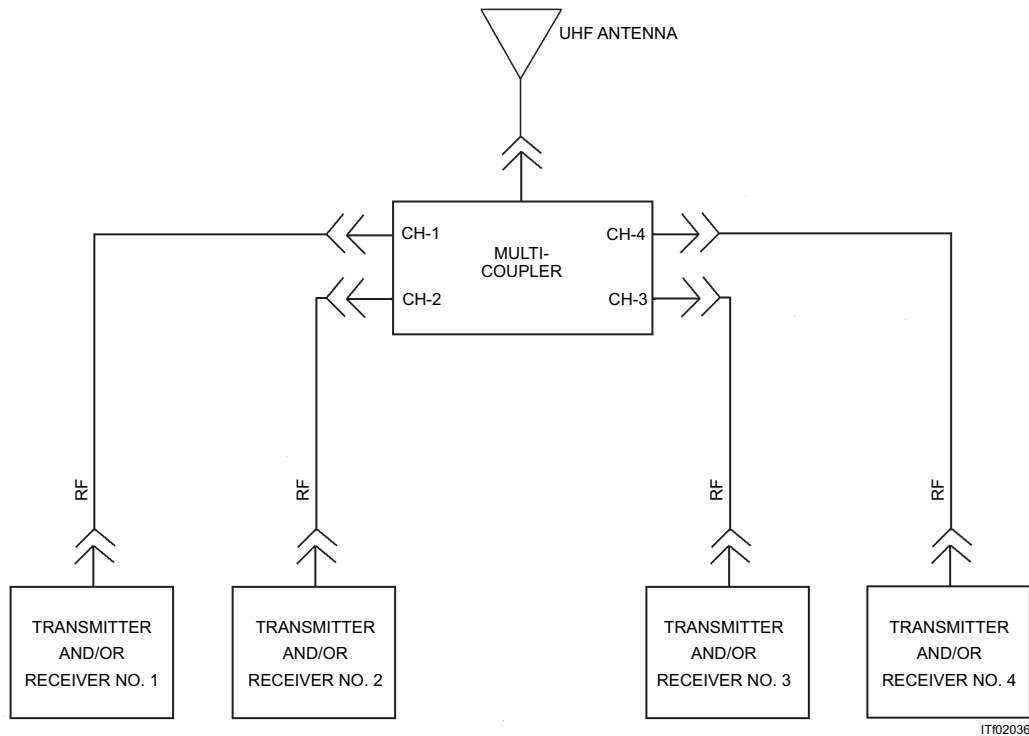


Figure 2-33.—Antenna multicoupler interconnection diagram.

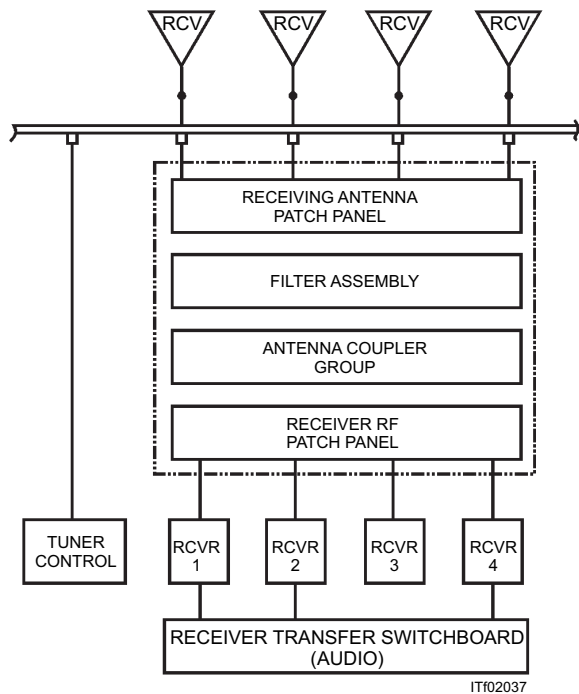


Figure 2-34.—Complex distribution system.

On the receiver patch panel, a receiver is hardwired to each jack. With the use of patchcords, you can connect a receiver, tuned to a particular frequency, to the antenna by connecting the receiver to the proper jack on the AN/SRA-12. Figure 2-35 shows how the filter assembly is used in combination with other units

to pass an RF signal from an antenna to one or more receivers.

Transmitting antenna distribution systems perform the same functions as receiving distribution systems.

ANTENNA POSITIONING

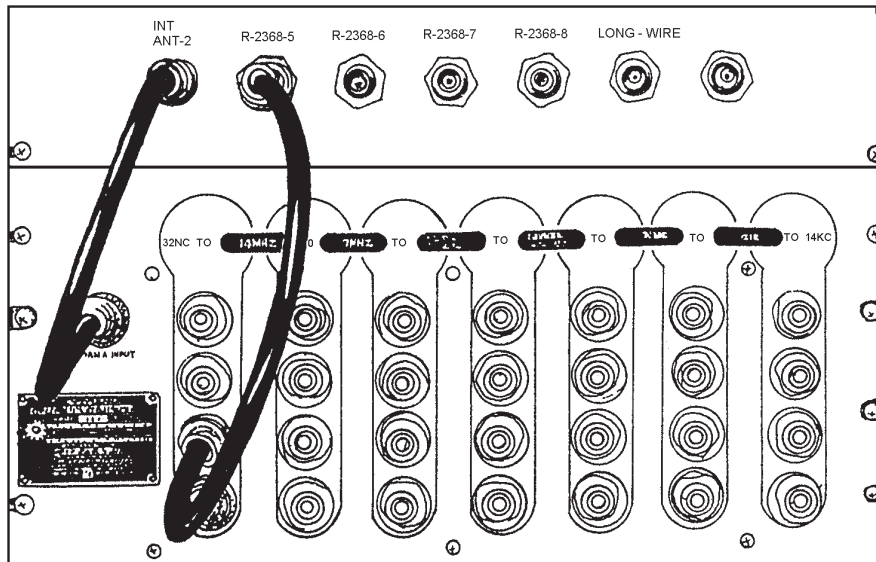
The raising and lowering of antennas is associated with flight quarter refueling or PMS operations. Extreme care should be taken that all moving parts are in correct operating conditions; also the Officer of the Deck and Communications Watch Officer must be informed before physical movement of the antennas.

USE DIRECTIONAL ANTENNAS

Reception is defined as when an electromagnetic wave passes through a receiver antenna and induces a voltage in that antenna. Further detailed information on antennas, antenna use, wave propagation and wave generation can be found in NEETS MODULES 9, 10, and 17.

Rotate For Optimum Reception

Rotating for optimum reception is accomplished by both physical and mechanical means of moving the antenna(s) to properly align and tune the antenna.



ITf02038

Figure 2-35.—AN/SRA-12 antenna filter patch panel with receiver antenna patch panel.

Align For Optimum Reception

Using the correct antenna location (by rotation) and the correct equipment for the system, you will bring the antenna into alignment and be ready for the final step, which is tuning.

ANTENNA COUPLING

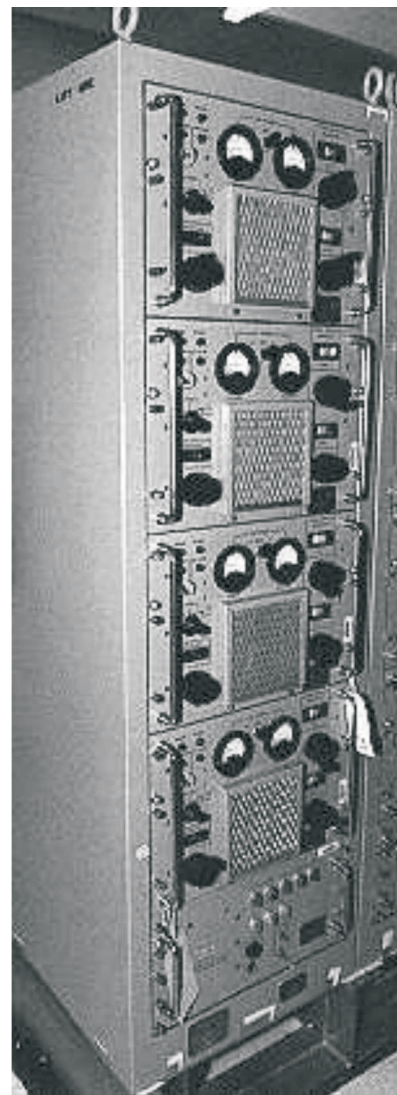
Antenna couplers (fig. 2-36) are used to connect one antenna to a transmitter or receiver and “electronically tunes” the signal to the antenna. An antenna multicoupler (fig. 2-37) connects one antenna to several transmitters or receivers and permits simultaneous operation of transmitter. An antenna filter connects one or more HF receivers to a single antenna.

Tune For Optimum Reception

There are two objectives of antenna tuning: (1) to tune out the various impedances and (2) to match the length of the antenna to the frequency radiated at its characteristic impedance.

- **Impedance:** everything exhibits some impedance. Even a straight piece of copper wire 3 inches long will offer some resistance to current flow, however small. The characteristic impedance of this same piece of copper wire is its overall resistance to a signal.

The transmission line between an antenna and a transmitter has a certain amount of characteristic impedance. The antenna also has a certain



ITf02039

Figure 2-36.—SRA-56, 57, 58 antenna coupler.



ITf02040

Figure 2-37.—OA-9123 antenna multicoupler.

amount of characteristic impedance. This basic mismatch in impedance between the transmitter and the antenna makes antenna tuning necessary. Naturally, as transmitters, transmission lines, and antennas become more complex, antenna tuning becomes more critical.

- **Antenna tuning:** Transmit antenna tuning is the electrical shortening or lengthening of the antenna to a desired frequency. Electrical changing of an antenna's length does not physically change the length of the antenna. A coupler performs the tuning process. When the antenna is tuned to the desired operating frequency, it is said to be "RESONANT." Receive antenna tuning uses band pass filtering to pass the frequency selected to the receiver.

You will find that the better the ability of the receiver to reject unwanted signals, the better its selectivity. The degree of selection is determined by the sharpness of resonance to which the frequency-determining circuits have been engineered and tuned. You usually measure selectivity by taking a series of sensitivity readings. As you take the readings, you step the input signal along a band of frequencies above and below the circuit resonance of the receiver; for example, 100 kilohertz below to 100 kilohertz above the tuned frequency. As you

approach the tuned frequency, the input level required to maintain a given output level will fall. As you pass the tuned frequency, the required input level will rise. Input voltage levels are then compared with frequency. They can be plotted on paper, or you can view them on an oscilloscope. They appear in the form of a response curve. The steepness of the response curve at the tuned frequency indicates the selectivity of the receiver, thus allowing for the optimum reception.

RF SAFETY PRECAUTIONS

Although electromagnetic radiation from transmission lines and antennas is usually of insufficient strength to electrocute personnel, it can lead to other accidents and compound injuries. Voltages may be inducted in ungrounded metal objects, such as wire guys, wire cable (hawser), hand rails, or ladders. If you should come in contact with these objects, you could receive a shock or RF burn. This shock can cause you to jump or fall into nearby mechanical equipment or, when working aloft, to fall from an elevated work area. Take care to ensure that all transmission lines or antennas are deenergized before working near or on them.

Guys, cables, rails and ladders should be checked for RF shock dangers. Working aloft "chits" and safety harnesses should be used for your safety. Signing a "working aloft chit" signifies that all equipment is in a nonradiating status (the equipment is not moving). The person who signs the chit should ensure that no RF danger exists in areas where personnel are working.

Nearby ships or parked aircraft are another source of RF energy that must be considered when checking work areas for safety. Combustible materials can be ignited and cause severe fires from arcs or heat generated by RF energy. RF radiation can detonate ordnance devices by inducing currents in the internal wiring of the device or in the external test equipment, or leads connected to the device.

You should always obey RF radiation warning signs and keep a safe distance from radiating antennas. The six types of warning signs for RF radiation hazard are shown in figure 2-38.

RF BURNS

Close or direct contact with RF transmission lines or antennas may result in RF burns. These are usually

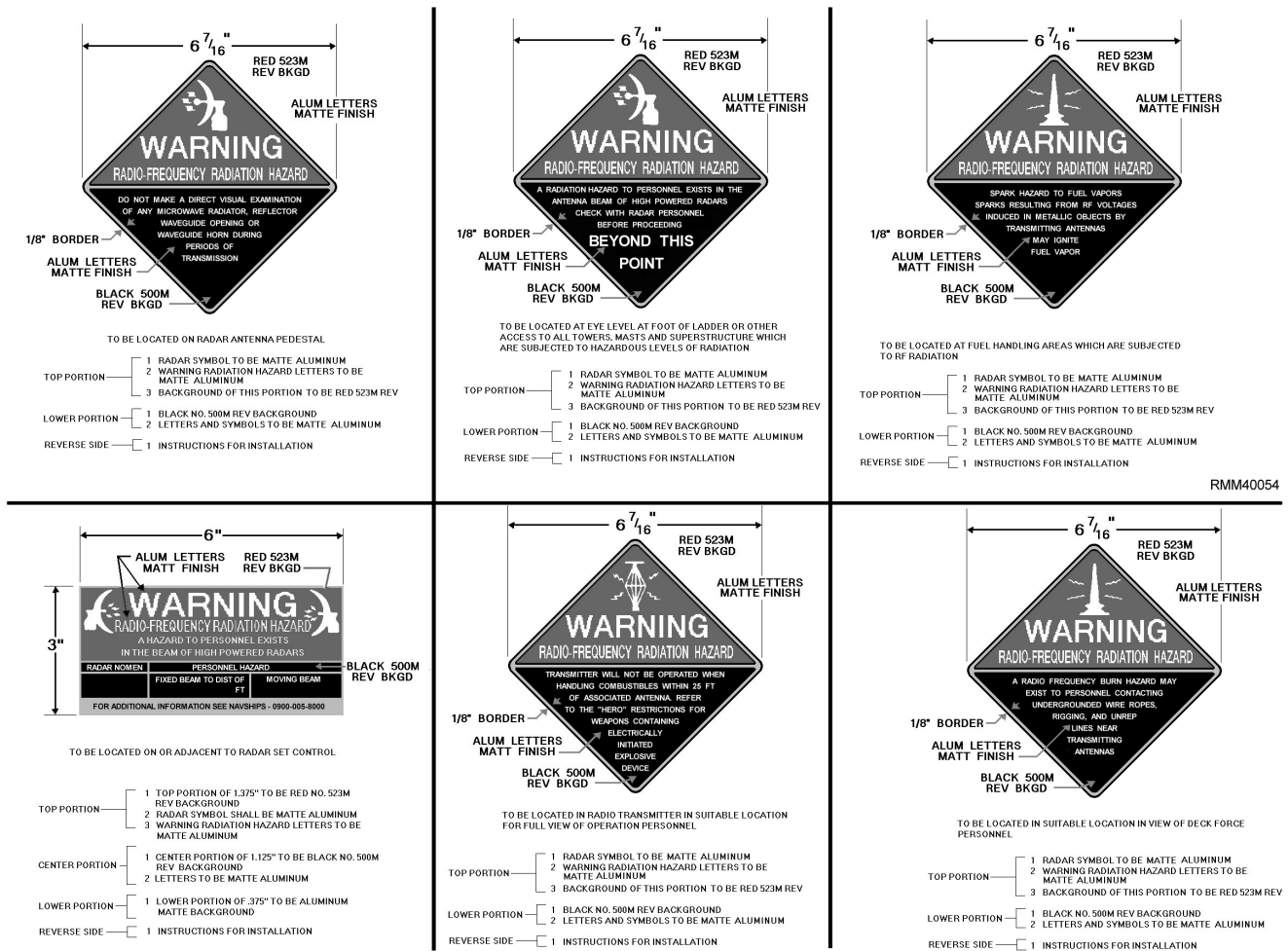


Figure 2-38.—Examples of RF radiation warning signs.

deep, penetrating, third-degree burns. To heal properly, these burns must heal from the inside to the skin surface. To prevent infection, you must give proper medical attention to all RF burns, including the small “pinhole” burns. Petrolatum gauze can be used to cover burns temporarily before the injured person reports to medical facilities for further treatment.

DIELECTRIC HEATING

Dielectric heating is the heating of an insulating material by placing it in a high-frequency electric field. The heat results from internal losses during the rapid reversal of polarization of molecules in the dielectric material.

In the case of a person in an RF field, the body acts as a dielectric. If the power in the RF field exceeds 10 milliwatts per centimeter, a person in that field will have noticeable rise in body temperature. The eyes are highly susceptible to dielectric heating. For this reason, you should not look directly into devices

radiating RF energy. The vital organs of the body are also susceptible to dielectric heating. For your own safety, you must not stand directly in the path of RF radiating devices.

PRECAUTIONS WHEN WORKING ALOFT

Before going aloft, you must follow all NAVOSH and local requirements such as wearing a harness and a hard hat. You must have a safety observer and meet all other requirements.

When radio or radar antennas are energized by transmitters, you must not go aloft unless advance tests show that little or no danger exists. A casualty can occur from even a small spark drawn from a charged piece of metal or rigging. Although the spark itself may be harmless, the “surprise” may cause you to let go of the antenna involuntarily, and you may fall. There is also a shock hazard if nearby antennas are energized.

Rotating antennas also may cause you to fall when you are working aloft. Motor safety switches

controlling the motion of rotating antennas must be tagged and locked opened before you go aloft near such antennas.

When working near a stack, you should draw and wear the recommended oxygen breathing apparatus. Among other toxic substances, stack gas contains carbon monoxide. Carbon monoxide is too unstable to build up to a high concentration in the open, but prolonged exposure to even small quantities is dangerous.

SUMMARY

Naval communications using satellite and various antennas types must always be ready to shift from

peacetime to wartime requirements. To this end, the diversity of fleet communication operations has given the Navy an expanded capability to meet ever-increasing command, control, and support requirements by use of satellites and assorted antennas.

Additionally, this variety of communications technology has increased the requirements for greater proficiency from all operating personnel. As an IT, you will be tasked with higher levels of performance in an increasingly technical Navy.

APPENDIX I

GLOSSARY

A

ANTENNA—A device used to radiate or receive radio waves.

ANTENNA COUPLER—A device used for impedance matching (tuning) between an antenna and a transmitter or receiver.

ANTENNA RECIPROCITY—The ability of an antenna to both transmit and receive electromagnetic energy.

ANTENNA TUNING—The process where an antenna is electrically “matched” to the output frequency and impedance of the transmitter.

ATTENUATION—A deliberate reduction or an unintended loss in RF signal strength.

B

BANDWIDTH—Any section of the frequency spectrum occupied by specific signals.

BIDIRECTIONAL ANTENNA—An antenna that radiates in or receives most of its energy from only two directions.

BLACK—Cipher text or encrypted text or information.

C

CARRIER—The unmodulated signal originally produced in the oscillator section of a transmitter.

CARRIER FREQUENCY—The final RF output without modulation. The assigned transmitter frequency.

CHANNEL—A carrier frequency assignment, usually with a fixed bandwidth.

COMPLEX WAVE—A transmitted radio signal composed of different frequencies.

COUNTERPOISE—The ground plane, or reflective surface, comprising an antenna’s reflected image at a given wavelength.

CRITICAL FREQUENCY—The highest transmitted frequency that can be propagated

directly upward and still be bent, or “refracted,” back to Earth.

CYCLE—Two complete alternations of alternating current, or one complete revolution in any period of time, equal to 360°.

D

DAMA—(DEMAND ASSIGNED MULTIPLE ACCESS SUBSYSTEM)—Subsystem that multiplexes several subsystems on one satellite channel.

DIFFRACTION—The bending of radio waves around the edges of a solid object or dense mass.

DIRECTIONAL ANTENNA—An antenna that radiates or receives radio waves more effectively in some directions than in others.

DIRECTIVITY—The sharpness or narrowness of an antenna’s radiation pattern in a given plan.

DIRECT WAVE—A radio signal that travels in a direct line-of-sight path from the transmitting antenna to the receiving antenna.

DUMMY LOAD—A nonradiating device used at the end of a transmission line in place of an antenna for tuning a transmitter. The dummy load converts transmitted energy into heat so that no energy is radiated outward or reflected back.

E

EHF (EXTREMELY-HIGH FREQUENCY)—The band of frequencies from 30 GHz to 300 GHz.

ELECTRIC FIELD—A field produced as a result of a voltage charge on an antenna.

ELECTROMAGNETIC ENERGY—An RF source composed of both an electric and a magnetic field.

ELECTROMAGNETIC WAVES—Energy produced at the output of a transmitter; also called radio waves.

- F**
- FADING**—Variation, usually gradual, in the field strength of a radio signal that is caused by changes in the transmission path or medium.
- FEED POINT**—The point on an antenna at which the RF cable that carries the signal from the transmitter is connected.
- FOT (FREQUENCY OF OPTIMUM TRANSMISSION)**—The most reliable frequency for propagation at a specific time.
- FREQUENCY**—The number of complete cycles per unit of time.
- FREQUENCY DIVERSITY**—The method in which the information signal is transmitted and received on two separate radio frequencies simultaneously to take advantage of the fact that fading does not occur simultaneously on different frequencies.
- FSK (FREQUENCY-SHIFT KEYING)**—The process of shifting the incident carrier above and below the carrier frequency to correspond to the marks and spaces of a teleprinter signal.
- G**
- GAIN**—An increase in signal strength.
- GIGAHERTZ (GHz)**—A unit of frequency equal to 1000 megahertz.
- GROUND**—A term used to denote a common electrical point of zero potential.
- GROUND-PLANE ANTENNA**—A type of antenna that uses a ground plane (a metallic surface) as a simulated ground to produce low-angle radiation.
- H**
- HALF-WAVE DIPOLE ANTENNA**—A common type of half-wave antenna made from a straight piece of wire cut in half. Each half operates at a quarter of the wavelength. It is normally omnidirectional with no gain.
- HERTZ (Hz)**—A unit of frequency equal to one cycle per second.
- HERTZ ANTENNA**—An ungrounded half-wave antenna that is installed some distance above ground and positioned either vertically or horizontally.
- HF (HIGH FREQUENCY)**—The band of frequencies from 3MHz to 30MHz.
- I**
- IMPEDANCE**—The total opposition to the flow of alternating current.
- INCIDENT WAVE**—The RF energy that travels from the transmitter to the antenna for radiation.
- INDUCTION FIELD**—The electromagnetic field produced around an antenna when current and voltage are present on the antenna.
- K**
- KILOHERTZ (kHz)**—A unit of frequency equal to 1000 hertz.
- L**
- LEASAT**—Leased satellite.
- LF (LOW FREQUENCY)**—The band of frequencies from 30kHz to 300kHz.
- LUF (LOWEST USABLE FREQUENCY)**—The lowest frequency that can be used at a specific time for ionospheric propagation of radio waves between two specified points.
- M**
- MAGNETIC FIELD**—One of the fields produced when current flows through a conductor or an antenna.
- MARCONI ANTENNA**—A quarter-wave antenna that is operated with one end grounded; it is positioned perpendicular to the Earth.
- MEGAHERTZ (MHz)**—A unit of frequency equal to 1,000,000 hertz.
- MF (MEDIUM FREQUENCY)**—The band of frequencies from 300kHz to 3MHz.
- MIRROR IMAGE**—The part of the radiated signal of a quarter-wave antenna (Marconi antenna) appearing to come from an underground image of the real antenna. This image is also called ground reflection.
- MODULATED WAVE**—The wave that results after the information from the modulating signal is impressed onto the carrier signal. The wave that is transmitted.
- MODULATION**—The process of adding, or superimposing, information on an RF carrier wave.

MUF (MAXIMUM USABLE FREQUENCY)—The highest operating frequency that can be used at a specific time for successful radio communications between two points.

O

OMNIDIRECTIONAL ANTENNA—An antenna that radiates or receives equally well in all directions, except directly off the ends.

OSCILLATOR—An electrical circuit that generates alternating current at a particular frequency.

P

PARABOLIC ANTENNA—An antenna that radiates its signal back into a large reflecting surface (called the dish) for radiation.

PERIOD (of a wave)—The time required to complete one cycle of a waveform.

POLARIZATION (of antennas)—The plane (horizontal or vertical) of the electric field as radiated from a transmitting antenna.

R

RADHAZ (RADIATION HAZARD)—Electromagnetic radiation hazard generated from electronic equipment.

RADIATION FIELD—The electromagnetic field that radiates from an antenna and travels through space.

RADIATION RESISTANCE—The resistance that, if inserted in place of an antenna, would consume the same amount of power that is radiated by the antenna.

RECIPROCITY—See antenna reciprocity.

RED—Plain text or unencrypted information.

REFLECTED WAVE—An electromagnetic wave that travels back toward the transmitter from the antenna because of a mismatch in impedance between the two.

REFLECTION—Occurs when a radio wave strikes the Earth's surface at some distance from the transmitting antenna and is returned upward toward the atmosphere.

RF (RADIO FREQUENCY)—A frequency in the range within which radio waves can be transmitted. Frequencies used for radio communication fall between 3kHz and 300GHz.

RF ENERGY—Radio frequency energy. Energy produced at the output of a transmitter.

S

SATELLITE COMMUNICATION (SATCOM)—A type of worldwide, reliable, high-capacity, secure, and cost-effective telecommunications system using satellites.

SHF (SUPER-HIGH FREQUENCY)—The band of frequencies from 3 GHz to 30 GHz.

SIGNAL—Detectable transmitted energy that can be used to carry information.

SWITCHBOARD—Device that connects receiver outputs to numerous pieces of equipment.

T

TRANSMISSION LINE—A device designed to guide electrical or electromagnetic energy from one point to another.

U

UHF (ULTRA HIGH FREQUENCY)—The band of frequencies from 300 MHz to 3 GHz.

UNIDIRECTIONAL ANTENNA—An antenna that radiates in only one direction.

V

VHF (VERY-HIGH FREQUENCY)—The band of frequencies from 30 MHz to 300 MHz.

VLF (VERY-LOW FREQUENCY)—The band of frequencies from 3 kHz to 30 kHz.

W

WAVEFORM—The shape of an electromagnetic wave.

WAVELENGTH—The distance traveled, in feet or meters, by a radio wave in the time required for one cycle.

APPENDIX II

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

A

ASWIXS—Antisubmarine Warfare Information Exchange Subsystem.

ASWOC—Antisubmarine Warfare Operations Center.

AZ—Azimuth.

C

CAT—Communications assistance team.

CONUS—Continental United States.

CUDIXS—Common User Digital Information Exchange System.

CW—Continuous wave (Morse code).

D

DAMA—Demand Assigned Multiple Access Subsystem.

dc—Direct current.

DSB—Double-side band.

DSCS—Defense Satellite Communications System.

E

EHF—Extremely-high frequency.

EL—Elevation.

EMCON—Emission control.

F

FDM—Frequency division multiplexing.

FDMA—Frequency division multiple access.

FDX—Full duplex.

FFN—Fleet flash net.

FLTCINC—Fleet Commander-in-Chief.

FLTSATCOM—FM satellite communications.

FOT—Frequency of optimum transmission.

FSB—Fleet satellite broadcast.

FSK—Frequency-shift keying.

G

GHz—Gigahertz.

H

HDX—Half duplex.

HERO—Hazardous electromagnetic radiation.

HF—High frequency.

HPA—High-power amplifier.

Hz—Hertz.

I

IF—Intermediate frequency.

K

kHz—Kilohertz.

L

LEASAT—Leased satellite.

LF—Low frequency.

LNA—Low-noise amplifier.

LOS—Line of sight.

LP—Log-periodic antenna.

LPI—Low probability of intercept.

LSTDMs—Low-speed time division multiplexer.

LUF—Lowest usable frequency.

M

MHz—Megahertz.

MF—Medium frequency.

MPA—Medium power amplifier.

MUF—Maximum usable frequency.

N

NATO—North Atlantic Treaty Organization.

NAVCOMTELSTA—Naval Computer and Telecommunications station.

NAVMACS—Naval Modular Automated Communications System.

NCTAMS—Naval Computer and
Telecommunications Area Master Station.

NCTS—Naval Computer and Telecommunications
stations.

NECOS—Net control station.

O

ORESTES—Teleprinter subsystem.

OTAR—Over-the-air relay.

OTAT—Over-the-air transfer.

OTC—Officer in tactical command.

OTCIXS—Officer in Tactical Command Information
Exchange Subsystem.

P

PRIS/S—Primary ship-shore.

PSK—Phase shift keying.

R

RADHAZ—Radiation hazard.

RF—Radio frequency.

RLP—Rotatable log-periodic antenna.

S

SAR—Search and air rescue.

SATCOM—Satellite communication.

SECVOX—Secure voice.

SHF—Super-high frequency.

SSB—Single-sideband.

SSIXS—Submarine Satellite Information Exchange
Subsystem.

T

TACINTEL—Tactical intelligence system.

TADIXS—Tactical Data Information Exchange
Subsystem.

TDM—Time division multiplexing.

TDMA—Time division multiple access.

U

UHF—Ultra-high frequency.

V

VHF—Very-high frequency.

VLFF—Very-low frequency.

APPENDIX III

REFERENCES USED TO DEVELOP THIS NRTC

- Basic Operational Communications Doctrine (U)*, NWP 4(B), Chief of Naval Operations, Washington, D.C., Sep. 1989.
- Communication Instructions—General (U)*, ACP 121(F), Joint Chiefs of Staff, Washington, D.C., Apr. 1983.
- Communications Instructions—General*, ACP 121 US SUPP-1(F), Joint Chiefs of Staff, Washington, D.C., June 1981.
- Communications Instructions—Teletypewriter (Teleprinter) Procedures*, ACP 126(C), Joint Chiefs of Staff, Washington, D.C., May 1989.
- Communications Security Material System (CMS) Policy and Procedures Manual*, CMS 21, Department of the Navy, Washington, D.C., June 2000.
- Fleet Communications (U)*, NTP 4(D), Commander, Naval Telecommunications Command, Washington, D.C., Feb. 1995.
- Naval Telecommunications Procedures, Recommended Frequency Bands and Frequency Guide*, NTP 6 Supp-1(S), Commander, Naval Computer and Telecommunications Command, Washington, D.C., 1993.
- Naval Telecommunications Procedures, Spectrum Management Manual*, NTP 6(D), Commander, Naval Telecommunications Command, Washington, D.C., Aug. 1992.
- Naval Warfare Documentation Guide*, NWJP 0 (Rev. P)/NWP 1-01, Chief of Naval Operations, Washington, D.C., Jan. 1990.
- Navy Electricity and Electronics Training Series, Module 1, *Introduction to Matter, Energy, and Direct Current*, NAVEDTRA 14173, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 2003.
- Navy Electricity and Electronics Training Series, Module 2, *Introduction to Alternating Current and Transformers*, NAVEDTRA 14174, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 2003.
- Navy Electricity and Electronics Training Series, Module 8, *Introduction to Amplifiers*, NAVEDTRA 14180, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 1998.
- Navy Electricity and Electronics Training Series, Module 9, *Introduction to Wave-Generation and Wave-Shaping Circuits*, NAVEDTRA 14181, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 1998.
- Navy Electricity and Electronics Training Series, Module 10, *Introduction to Wave Propagation, Transmission Lines, and Antennas*, NAVEDTRA 14182, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 1998.
- Navy Electricity and Electronics Training Series, Module 12, *Modulation Principles*, NAVEDTRA 14184, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 1998.

Navy Electricity and Electronics Training Series, Module 17, *Radio-Frequency Communications Principles*, NAVEDTRA 14189, Naval Education and Training Professional Development and Technology Center, Pensacola, Fla., 1998.

Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat, Vols I, II, and III, OPNAVINST 5100.19D, Chief of Naval Operations, Washington, D.C., Aug. 2001.

Navy Super-High Frequency Satellite Communications, NTP 2, Section 1 (E), Naval Computer and Telecommunications Command, Washington, D.C., Jan. 2001.

Navy UHF Satellite Communication System Description, IWCS-200-83-1, Commander, Naval Ocean Systems Center, San Diego, Calif., 1991.

Navy UHF Satellite Communication System—Shipboard, EE130-PL-OMI-010/W142-UHF SATCOM, Space and Naval Warfare Systems Command, Washington, D.C., Aug. 1986.

Navy Ultra-High Frequency Satellite Communications (U), NTP 2, Section 2 (E), Naval Computer and Telecommunications Command, Washington, D.C., July 1992.

Operational Reports, NWP 1-03.1, Chief of Naval Operations, Washington, D.C., Nov. 1987.

Secure Telephone Unit Third Generation (STU-III) COMSEC Material Management Manual, CMS 6, Director, Communications Security Material System, Washington, D.C., Oct. 1990.

Shipboard Antenna Systems, Volume 1, Communications Antenna Fundamentals, NAVSHIPS 0967-17-3010, Naval Ship Systems Command, Washington, D.C., Sep. 1972.

Shipboard Antenna Systems, Volume 3, Antenna Couplers, Communications Antenna Systems, NAVSHIPS 0967-177-3030, Naval Ship Systems Command, Washington, D.C., Jan. 1973.

Shipboard Antenna Systems, Volume 5, Antenna Data Sheets, SPAWAR 0967-LP-177-3050, Space and Naval Warfare Systems Command, Washington, D.C., May 1973.

Ships' Maintenance and Material Management (3-M) Manual, OPNAVINST 4790.4C, Chief of Naval Operations, Washington, D.C., Nov. 1994.

Telecommunications Users Manual, NTP 3(I), Commander, Naval Telecommunications Command, Washington, D.C., Jan. 1990.

INDEX

A

- Antennas, 2-15
 - broadband, 2-18
 - conical monopole, 2-21
 - emergency, 2-22
 - inverted cone, 2-22
 - log-periodic, 2-22
 - multiwire rhombic, 2-21
 - quarter-wave, 2-16
 - rhombic, 2-21
 - SATCOM, 2-19
 - sleeve, 2-21
 - tuning, 2-14, 2-15, 2-17, 2-25
 - UHF, 2-18
 - VHF, 2-18
 - whip, 2-17
 - wire rope, 2-17
- Antenna coupling, 2-25
- Antenna distribution system, 2-23
- Antenna positioning, 2-24
 - align for optimum reception, 2-25
 - rotate for optimum reception, 2-24
 - tune for optimum reception, 2-25
 - use, 2-24
- Antenna systems, 2-12
 - ASWIXS, 2-10
 - AUTOCAT, 2-12
 - bidirectional, 2-12
 - characteristics, 2-12
 - directivity, 2-12
 - dummy load, 2-14
 - feed point, 2-12
 - incident waves, 2-14
 - omnidirectional, 2-12
 - reciprocity, 2-12
 - reflected waves, 2-14
 - unidirectional, 2-12
 - wave polarization, 2-13

C

- COMMSPOT reports, 1-6
- Cryptographic equipment, 1-4
 - frequency-shift keying (FSK), 1-4
- CUDIXS, 1-6, 2-13

D

- DAMA, 2-11

- Distress communications, 1-7
 - emergency, 2-26
 - frequencies, 1-7
 - OTC, 1-15
 - SAR frequencies, 1-7
 - watches, 1-7
- Dummy load, 2-14

E

- EHF, 2-5
- Electromagnetic wavelength, 2-15
 - full wave, 2-16
 - half wave, 2-15
 - quarter wave, 2-16

F

- FDMA, 2-5
- Feed point, 2-12
 - center-fed, 2-12
 - end-fed, 2-12
 - mid-fed, 2-12
- FFN, 2-12
- Fleet broadcast system, 2-9
- Fleet broadcast system equipment, 2-9
 - AM-6534/SSR-1 amplifier-converter, 2-6
 - AN/ARC-143 UHF transceiver, 2-6
 - AN/FSC-79 Fleet Broadcast terminal, 2-6
 - AN/SSR-1 receiver, 2-6
 - AN/WSC-3 (UHF) transceiver, 2-6
 - AN/WSC-5 (UHF) transceiver, 2-6
 - Antisubmarine Warfare Information Exchange
 - Subsystem (ASWIXS), 2-7
 - Fleet Satellite Broadcast (FSB), 2-9
 - MD-900/SSR-1 combiner-demodulator, 2-6
 - TD-1063/SSR-1 demultiplexer, 2-6
- Fleet Satellite Communications (FLTSATCOM), 2-5
 - Antisubmarine Warfare Information Exchange
 - Subsystem (ASWIXS), 2-7
 - circuit restoral/coordination, 2-11
 - Common User Digital Information Exchange
 - System (CUDIXS), 2-9
 - Control subsystem, 2-10
 - Demand Assigned Multiple Access (DAMA), 2-11
 - Fleet Flash Net (FFN), 2-12
 - Fleet Satellite Broadcast, (FSB), 2-9
 - LEASAT telemetry tracking and command
 - subsystem, 2-10

Naval Modular Automated Communications System (NAVMACS), 2-10
 Officer in Tactical Command Information Exchange Subsystem (OTCIXS), 2-10
 Secure voice, 2-10
 special circuits, 2-11
 Submarine Satellite Information Exchange Subsystem (SSIXS), 2-9
 Tactical Data Information Exchange Subsystem, (TADIXS), 2-10
 Tactical Intelligence subsystem, 2-10
 Teleprinter Subsystem (ORESTES), 2-10
 FLTSATCOM, 2-10
 Frequency-shift keying (FSK), 1-4
 FSB, 2-9
 Full-period terminations, 1-5
 CUDIXS, 1-6
 equipment tests, 1-6
 NAVMACS, 1-6
 TACINTEL, 1-6
 termination requests, 1-5
 termination types, 1-6

G

GPS, 1-5

H

Hazardous electromagnetic radiation (HERO), 1-5
 High-frequency receive system, 1-2
 High-frequency transmit systems, 1-2
 HPA, 2-6

L

LNA, 2-6
 Low-frequency systems, 1-2
 LPI, 2-6

M

MARCONI antenna, 2-19
 MIDDLEMAN, 2-12
 MPA, 2-6
 low-speed time division multiplexer (LSTDMS), 2-6

N

NAVMACS, 2-9, 2-10

O

Optimum reception, 2-25
 tuning, 2-25
 ORESTES, 2-10
 OTAT/OTAR, 1-6
 OTCIXS, 2-10
 Over-the-air rekey, 1-6
 Over-the-air transfer, 1-6

P

Patch panels, 1-3
 Primary ship-shore circuits, 1-6
 FSK, 1-6
 PSK, 1-6, 2-7

Q

Quality monitoring, 1-8
 AN/SSQ-88 equipment, 1-10
 AN/SSQ-88 quality monitoring set, 1-9
 program, 1-8
 system, 1-8

R

RF safety precautions, 2-26
 burns, 2-25
 dielectric heating, 2-27
 precautions, 2-27
 warning signs, 2-27

S

SATCAT, 2-14
 SATCOM antennas, 2-1
 AS-29151SSR-1, 2-19
 DAMA, 2-11
 frequency division multiple access (FDMA), 2-5
 FLTSATCOM, 2-2
 GAPFILLER, 2-1
 LEASAT, 2-3
 low-speed time division multiplexer (LSTDMS), 2-6
 OE-83C/WSC-1(V) group, 2-19
 phase shift keying (PSK), 2-7
 pointing guide, 2-3
 time division multiple access (TDMA), 2-5
 types, 2-1
 SATCOM system, 2-5

- Fleet Broadcast System, 2-9
- Fleet Satellite Communications, 2-7
 - high-power amplifier (HPA), 2-6
 - low-noise amplifier (LNA), 2-6
 - low-probability of intercept (LPI), 2-6
 - medium-power amplifier (MPA), 2-6
 - secure voice worldwide voice network, 1-5
 - net membership, 1-5
 - satellite system control, 1-5
- Ship-shore circuits, 1-4
 - duplex, 1-4
 - full duplex (FDX), 1-4
 - half duplex (HDX), 1-4
 - methods, 1-10
 - semiduplex, 1-4
 - simplex, 1-4
- Special circuits, 2-11
 - AUTOCAT, 2-12
 - MIDDLEMAN, 2-12
 - SATCAT, 2-12
- SSIXS, 2-9

- Status board, 1-7
- Super-high frequency systems, 1-3

T

- TACINTEL, 1-6, 2-13
- TADIXS, 2-12
- TDMA, 2-5

U

- Ultra-high frequency systems, 1-2
- Ultra-high frequency receive system, 1-2
- Ultra-high frequency transmit system, 1-5
- Underway preparation, 1-1
 - predeployment check-off sheet, 1-1

V

- Very-high frequency systems, 1-2

ASSIGNMENT 1

Textbook Assignment: "Communications Hardware," chapter 1, pages 1-1 through 1-10.

- 1-1. A lot of communications failures are ascribed to which of the following areas?
1. Equipment failure
 2. Poor administration
 3. Technical problems
 4. Operator error
- 1-2. The level of readiness and preparation that a deploying ship should maintain is determined by what individual?
1. The commanding officer
 2. The executive officer
 3. The type commander
 4. The fleet commander in chief
- 1-3. The most efficient method of ensuring that all step-by-step preparations are completed before deploying can be accomplished by using which of the following procedures?
1. A check-off list
 2. A visual check of all stores
 3. A review of all locally produced SOPs
 4. A review of all inventory lists
- 1-4. What publication provides the minimum number of check-off sheets?
1. NTP 4
 2. NWP 4
 3. CMS 1
 4. CMS 5
- 1-5. For long-range direction finding, medium-range communications and navigation communications, which of the following frequencies is normally used?
1. VLF
 2. UHF
 3. SHF
 4. LF
- 1-6. What frequency band is used as a backup system for satellite communication systems?
1. 30-300 kHz
 2. 3-30 MHz
 3. 30-300 MHz
 4. 300 Mhz to 3 GHz
- 1-7. What frequency band is used strictly for line-of-sight communications?
1. SHF
 2. EHF
 3. LF
 4. HF
- 1-8. What is the difference, if any, between a black dc patch panel and a red dc patch panel?
1. The black dc patch panel is located closer to the antenna multicoupler than the red dc patch panel
 2. The black dc patch panel allows the operator to patch the signal to any crypto equipment, and the red dc patch panel restricts the printer selected to plain readable text or language
 3. The black dc patch panel allows for patching the signal into any crypto equipment, and the red dc patch panel completes the loop for a single feedback circuit
 4. None
- 1-9. What frequency range is primarily for mobile and maritime units?
1. UHF
 2. SHF
 3. HF
 4. VLF
- 1-10. Aeronautical radio navigation, mobile communications, boat crews, and radar use which of the following frequency bands?
1. ELF
 2. HF
 3. VLF
 4. VHF
- 1-11. Which of the following satellite system segments has been designed to counter spoofing?
1. Space
 2. Terminal
 3. Control
 4. Each of the above

- 1-12. The UHF band is located in what frequency range?
1. 30 - 300 GHz
 2. 300 MHz to 3 GHz
 3. 3 - 30 MHz
 4. 300 kHz to 3 MHz
- 1-13. Which of the following patch panel colors indicates classified material is being passed through the panel?
1. Black
 2. Blue
 3. Red
 4. Green
- 1-14. "A sequence of random binary bits used to initially set and periodically change permutations in crypto equipment for decrypting electronic signals" defines what term?
1. Key
 2. Cipher text
 3. Secure system process
 4. Enciphered signal
- 1-15. Information pertaining to the Navy's SHF satellite system can be found in what section of NTP 2?
1. One
 2. Two
 3. Three
 4. Four
- 1-16. What is/are the warning sign(s), if any, that are attached to black patch panels?
1. UNCLAS ONLY
 2. ENCRYPTED TRAFFIC ONLY
 3. BLACK PATCH PANEL and UNCLAS ONLY
 4. None
- 1-17. Equipment permanently wired together and used in conjunction with each other is known by which of the following terms?
1. Normal-through
 2. Wired
 3. Tied
 4. Junctions
- 1-18. The Navy's primary means of delivering message traffic to afloat commands is accomplished through use of which of the following ship-shore circuits?
1. Full period terminations
 2. SSIXS
 3. Fleet broadcast
 4. OTIXS
- 1-19. What term used in the call-up indicates that a ship cannot transmit and receive simultaneously?
1. Duplex
 2. Simplex
 3. Semiduplex
 4. Voice only
- 1-20. What type of publications contain information and instructions on the use of crypto equipment?
1. KAOs
 2. NTPs
 3. NWP's
 4. ACPs
- 1-21. Under HERO conditions, the affected ship communicates to other ships using what frequency band?
1. HF
 2. SHF
 3. UHF
 4. EHF
- 1-22. Which of the following is NOT a requirement when on a secure voice net?
1. Paper logs must be used
 2. HF transmitter tuning is prohibited
 3. Dummy load calibrations must be used
 4. Actual time of significant transmissions must be logged
- 1-23. On a secure voice net, the NECOS normally ensures proper circuit discipline.
1. True
 2. False
- 1-24. What are the different methods of operation in ship-shore mode?
1. Duplex, simplex, and semiduplex
 2. Simplex, semiduplex, and triplex
 3. Duplex, semiduplex, and quadplex
 4. Simplex, duplex, triplex, and quadplex

- 1-25. When you can use a communications equipment to both transmit and receive simultaneously, this is known by which of the following terms?
1. FSK (phase shift keying)
 2. TDM (time-division multiplexing)
 3. FDX (full duplex)
 4. HFX (half duplex)
- 1-26. What is the normal reason that a ship would use the simplex method?
1. Equipment casualties
 2. Not ample equipment onboard
 3. Abundance of circuits online
 4. Transmission by NECOS of a SAR request
- 1-27. A ship using a simplex system has to call up the shore station to pass message traffic. If the ship cannot raise the shore station after the second attempt, what is the usual procedure?
1. Check the equipment
 2. Repeat the call-up
 3. Try standby frequency
 4. Attempt to contact another station
- 1-28. What is the purpose of the secure voice worldwide voice network?
1. To be able to communicate anywhere in the world by voice
 2. For ships to be able to talk to shore stations
 3. To hook together all types of commands into one voice network
 4. To provide secure real-time, voice communications between both afloat commands and operational commanders using HF or satellite connectivity
- 1-29. What is the total number of FLTCINCs that control the network of secure voice area control stations?
1. One
 2. Two
 3. Three
 4. Four
- 1-30. What does a full-period termination accomplish?
1. Provides communications between shore stations and afloat commands
 2. Allows a ship to send traffic to any shore station along its track for retransmission
 3. Provides exercise control over a ship for a greater period of time
 4. Allows a ship and an aircraft to communicate over greater distances
- 1-31. What is the normal lead time that a termination request must be submitted for a full-period termination?
1. 12 hours
 2. 24 hours
 3. 36 hours
 4. 48 hours
- 1-32. Details that must be included in a termination request message are in what publication?
1. NTP 3
 2. NTP 4
 3. NWP 4
 4. NWP 6
- 1-33. Once the full-period termination period is secured, what type of message must be sent to cancel the termination?
1. TSR
 2. COMMSPOOT
 3. COMMSHIFT
 4. Off-the-air
- 1-34. System back-to-back off-the-air testing must be completed what total number of hours before a termination activation?
1. 12 hrs
 2. 24 hrs
 3. 48 hrs
 4. 72 hrs
- 1-35. For what reason will a COMMSPOOT report be submitted?
1. Any time unusual communications difficulties are encountered
 2. When a ship is having problems passing traffic to a shore station
 3. When a shore station cannot raise a ship for a channel check
 4. When an aircraft wishes to pass vital message traffic for a Task Force

- 1-36. To prepare a JINTACCS formatted COMMSPOUT message, you should refer to what publication for instructions?
1. NTP 4
 2. CMS 6
 3. NWP 1-03, Supp-1
 4. NWP 10-10-10 (NWP 1-03.1)
- 1-37. Primary ship-shore circuits use what type of encrypted teleprinter nets?
1. TDM/TDK
 2. FDX/HDX
 3. ARK/MRK
 4. PSK/FSK
- 1-38. Where are the frequencies for PRI S/S circuits listed?
1. CIBs
 2. TSRs
 3. NAVADMINs
 4. Local SOPs
- 1-39. What does the use of OTAT/OTAR procedures allow a command to do?
1. Not carry any crypto keying material
 2. Reduce the amount of paper keying material on board
 3. Relieve the operator of ever using SF-153 forms
 4. Reduce the number of CMS custodians required
- 1-40. In what publication do you find detailed OTAT/OTAR procedures?
1. CMS 1
 2. CMS 6
 3. NAG 16
 4. NTP 4
- 1-41. Where were the use and verification of OTAT/OTAR procedures first used?
1. Desert Shield/Storm
 2. Vietnam
 3. Bosnia
 4. Cuba
- 1-42. What type of message traffic takes priority over all other types?
1. Immediate
 2. AMCROSS
 3. Distress
 4. SOSUS
- 1-43. Who may authorize the transmission of unclassified distress messages on national or international distress frequencies?
1. The commanding officer
 2. The officer in tactical control
 3. The communications officer
 4. The communications watch officer
- 1-44. If your ship is in distress and traveling with others, to whom will you transmit your distress message?
1. FLTCINC
 2. OTC
 3. NECOS
 4. CNO
- 1-45. If you are in a lifeboat, which of the following frequencies will you use?
1. 500 kHz
 2. 2182 kHz
 3. 8364 kHz
 4. 121.5 MHz
- 1-46. What is the international worldwide SAR frequency for voice?
1. 138.78 MHz
 2. 123.1 MHz
 3. 282.8 MHz
 4. 172.5 MHz
- 1-47. Navy ASW aircraft assigned to a SAR mission monitor on what frequency?
1. 138.78 MHz
 2. 123.1 MHz
 3. 282.8 MHz
 4. 172.5 MHz
- 1-48. During an emergency, which of the following organizations/officers is in control of the distress message traffic frequency?
1. The station in distress
 2. The first ship on the scene
 3. The first aircraft on the scene
 4. The senior international officer at the scene
- 1-49. When equipment and manpower will allow, what frequencies does a watch station normally listen to?
1. Worldwide timing
 2. GMT
 3. Distress
 4. Secvox

1-50. What is the usual cause of system degradation?

1. Dirty jacks
2. Small contributing factors
3. Power outages
4. Degraded patch cords

1-51. What is the primary function of the quality monitoring program?

1. To ensure that all PMS checks are completed on line
2. To monitor the end results from all QC jobs
3. To verify all paper work associated with levels, signals, and analysis forms
4. To direct measurement of signal quality characteristics

1-52. What is the nomenclature of the Quality Monitoring set?

1. AN/SSQ-88
2. AN/QMS-23
3. Spectrum Analyzer 134
4. Spectrum Monitor 143

ASSIGNMENT 2

Textbook Assignment: "Satellites and Antennas," chapter 2, pages 2-1 through 2-28.

- 2-1. What was the reason for the development of the satellite communication (SATCOM) system?
1. Provides a long range, jam-proof communication system
 2. Fulfills the military requirements for reliable, high-capacity, secure and cost-effective telecommunications
 3. Is line-of-sight and EMCON proof
 4. Replaces all baseband frequencies during HERO and AUTOCAT
- 2-2. Satellites provide an alternative to which of the following facilities?
1. Fixed ground installations
 2. Airborne command posts
 3. GPS
 4. AMCC vans
- 2-3. What are the three types of U.S. Navy communications satellites?
1. MARISAT, RCA, and ATT
 2. GAPFILLER, FLTSATCOM, and LEASAT
 3. ORION, EROS and ZEUS
 4. DANTE, ORION, and HERMES
- 2-4. What type of orbits do U.S. Navy satellites use?
1. Geostationary
 2. Geosynchronous
 3. Polar
 4. Random
- 2-5. MARISAT channels are broken down into three UHF channels, two narrowband channels, and what total number of wideband channels?
1. One
 2. Five
 3. Three
 4. Six
- 2-6. The 500-kHz band GAPFILLER satellites provide what number of 75-baud ship-shore communications channels?
1. 15
 2. 20
 3. 35
 4. 50
- 2-7. What does the UHF receiver separate on the GAPFILLER satellite?
1. The receiver and transmitter band
 2. Intermediate frequencies and low frequencies
 3. Secure voice and non-secure voice channels
 4. Red and Black channels
- 2-8. What are the FLTSATCOM satellites' longitudinal positions?
1. 95° W, 65° E, and 150° E
 2. 25° E, 35° W, 05° N, and 55° E
 3. 100° W, 72.5° E, 23° W, and 172° E
 4. 22° W, 152° E, 06° E, and 21° N
- 2-9. What is the maximum RF-channel capability on the FLTSATCOM satellite?
1. 10
 2. 15
 3. 23
 4. 35
- 2-10. On the FLTSATCOM satellite, channel 1 of the 25-kHz channels is used for what purpose?
1. Timing
 2. Fleet broadcast
 3. Weather
 4. DSN
- 2-11. What is the position of the LANT (L-1) LEASAT?
1. 15° W
 2. 105° W
 3. 72.5° E
 4. 53° E

- 2-12. Each LEASAT provides what total number of (a) communications channels and (b) transmitters?
1. (a) 10 (b) 4
 2. (a) 11 (b) 6
 3. (a) 13 (b) 9
 4. (a) 15 (b) 11
- 2-13. One of the UHF downlink channels is used for the Fleet Satellite Broadcast downlink. What is its frequency?
1. 10 kHz
 2. 15 kHz
 3. 20 kHz
 4. 25 kHz
- 2-14. A Demand Assigned Multiple Access (DAMA) modem replaced which of the following terminals on aircraft carriers?
1. TADIX
 2. QUICKSAT
 3. SUBSAT
 4. FSC-78
- 2-15. What are the two types of communication satellites?
1. Active and passive
 2. Passive and module
 3. Active and repeater
 4. Repeater and passive
- 2-16. An active satellite and two Earth terminals are considered what type of operational link?
1. Standard
 2. Optimal
 3. Universal
 4. Typical
- 2-17. Normally, a satellite's orbit is elliptical or circular, while its incline is polar, equatorial, or which of the following?
1. Angle
 2. Attitude
 3. Inclined
 4. Slant
- 2-18. A satellite communications system includes installed communications receivers and transmitters and what other components?
1. Two Earth terminals ready to transmit and receive satellite signals
 2. Two Earth terminals equipped with receiver and satellite transceivers
 3. Three Earth terminals, two with receivers and one with transceivers
 4. Three Earth terminals, one with receivers and two with UHF transmitters
- 2-19. What capability does a narrow uplink transmission beamwidth provide?
1. High intercept problems (HIP)
 2. Low probability of intercept (LPI)
 3. High detection rates (HDR)
 4. Exploitation, detection, and location (EDL)
- 2-20. An HPA or MPA, LNA, up and down converters, and a frequency standard are known by what name?
1. Power group
 2. Digital set
 3. Binary set
 4. Radio group
- 2-21. What is the Navy's standard SATCOM broadcast receiver system?
1. AN/FSC-79
 2. AN/SSR-1
 3. CV-123
 4. ARC-143B
- 2-22. Communications subsystems and satellites are interfaces using which of the following equipments?
1. AM-6534
 2. TD-1063
 3. AN/FSC-79
 4. CV-123
- 2-23. What is the operating bandwidth of the AN/FSC-79?
1. 7 to 8 GHz
 2. 9 to 11 GHz
 3. 10 to 12 GHz
 4. 11 to 15 GHz

- 2-24. When it uplinks in the 292.2- to 311.6 MHz bandwidth and downlinks in the 248.5- to 270.1 MHz band, the AN/WSC-3 is in what mode of operation?
1. TDM
 2. Fleet communication
 3. SATCOM
 4. Remote
- 2-25. The AN/ARC-143 UHF Transceiver, used for ASWIXS communications, has how many parts?
1. Five
 2. Two
 3. Three
 4. Four
- 2-26. What type of system provides communications links, via satellite, between mobile units and shore commands?
1. FLTSATCOM
 2. LEASAT
 3. NOVEMBER
 4. DELTA
- 2-27. What network/terminal is used as the interface between CUDIXS (shore-based) and the Fleet Broadcast System?
1. SNAP III
 2. NAVMACS
 3. GLOBAL HICOM
 4. DAMA
- 2-28. SSIIXS is used to transmit and receive message traffic between what two types of users?
1. VP aircraft and ASCOMMs
 2. Fleet Marine Forces and attack helos
 3. SSN/SSBN submarines and shore stations
 4. SSN/SSBN submarines and Battle Group commanders
- 2-29. ASWIXS is used as a communications link between ASW planes during operations and what other type of commands?
1. Shore stations
 2. Battle Group commanders
 3. Senior officer present afloat
 4. SPECOMMs
- 2-30. The subsystem that expedites status reporting and management of FLTSATCOM system assets is known by what name?
1. TACINTEL
 2. NECOS
 3. Control
 4. Fleet Flash Net
- 2-31. DAMA was developed for what purpose?
1. To break out the secure voice circuit from all other transmissions
 2. To remove all residue traces that allow for jamming
 3. To fully automate and link data systems with the net
 4. To multiplex several subsystems onto one satellite channel
- 2-32. What other multiplexing method, if any, does the Navy use besides frequency-division?
1. Time-division
 2. Shift-division
 3. Split time-division
 4. None
- 2-33. When HERO condition and EMCON restrictions are set, what are the radio frequencies (RFs) that are prohibited from use?
1. 2 - 3 GHz
 2. Below 30 MHz
 3. 300 - 2568 kHz
 4. Above 3000 kHz
- 2-34. Who are the major participants on the FFN?
1. Senior operational staffs only
 2. Senior operational staffs and designated subscribers
 3. NATO and CINCs only
 4. The Joint Chiefs of Staff and their Force Commanders
- 2-35. An antenna can both transmit and receive energy. This ability is known by what term?
1. Reciprocity
 2. Feed point
 3. Transducance
 4. Stagnation

- 2-36. The point on an antenna where the RF cable is attached is known by what term?
1. Focal point
 2. Dummy point
 3. Feed point
 4. Center point
- 2-37. What type of antenna radiates efficiently in only one direction?
1. Bidirectional
 2. Omnidirectional
 3. Polarized
 4. Unidirectional
- 2-38. Energy reflected back to the feed point is known by which of the following terms?
1. Impedance point
 2. Reflected waves
 3. Oscillation point
 4. Deflected waves
- 2-39. Electromagnetic waves travel in free space at what rate?
1. 1,324,000 miles per second
 2. 946,000 miles per second
 3. 518,000 miles per second
 4. 186,000 miles per second
- 2-40. Antennas are referred to in lengths. There is full quarter, and which of the following other lengths?
1. Half
 2. Eighth
 3. Third
 4. Sixteenth
- 2-41. Wire rope (fan) antennas are used for what range of frequency coverage?
1. 30 kHz to 299 kHz
 2. 300 kHz to 30 MHz
 3. 2 - 20 GHz
 4. 3 - 30 kHz
- 2-42. What antenna is used with the AN/WSC-3 transceiver and is employed primarily onboard ships?
1. AN/SSR-1
 2. OE-82C/WSC-1(V)
 3. Whip
 4. Quarter-wave
- 2-43. Where is the OE-82/WSC-1(V) mounted?
1. Main stack
 2. Fore mast
 3. On a pedestal
 4. To the skin of the ship
- 2-44. What is the receiving frequency band for the OE-82C/WSC-1(V)?
1. 248 - 272 MHz
 2. 275 - 300 MHz
 3. 310 - 315 MHz
 4. 2 - 4 GHz
- 2-45. What is the total number of AS-2815/SSR-1 antennas in an AN/SRR-1 receiver system?
1. One
 2. Two
 3. Three
 4. Four
- 2-46. The AS-2815/SSR-1 antennas employed in the 240- to 315-MHz frequency range are used to receive what type of broadcasts?
1. CUDIXS
 2. Common Channel
 3. FFN
 4. Fleet
- 2-47. What is the physical size of the newer satellite parabolic antennas?
1. 6 in
 2. 8 in
 3. 12 in
 4. 18 in
- 2-48. The conical monopole antenna is used in what type of communications?
1. LF
 2. MF
 3. HF
 4. VHF
- 2-49. The AN/SRA-12 allows for what total number of RF channels in the 14-kHz to 32-MHz range?
1. Five
 2. Two
 3. Seven
 4. Four

- 2-50. What is/are the objectives of tuning an antenna?
1. Tune out impedances and match length to frequency radiated
 2. Physically or mechanically move the antenna
 3. Exhibit and multiplex its impedance
 4. Clean up the wave generation and use wave propagation

- 2-51. Which Navy standards, if any, have control over the safety of personnel going aloft?
1. NAVSAFCEN instructions
 2. NAVOSH requirements
 3. MILSTDs
 4. None