CHAPTER 3

SATELLITE COMMUNICATIONS

INTRODUCTION

In the past, the Navy relied upon hf communications as its primary method of sending messages. With the overcrowding of the hf spectrum, the need for new and advanced long-range communications became apparent. Satellite communications (SATCOM) systems have shown they can provide survivable, reliable, high-capacity, secure, and cost-effective telecommunications for the military.

In this chapter, you will be introduced to satellite communications fundamentals, fleet SATCOM subsystems, shore terminals, current and future satellites, and some specific SATCOM equipment and racks. SATCOM is a natural outgrowth of modern technology and the continuing demand for greater capacity and high-quality communications. This information will be crucial to you in understanding the communications technology of both today and the future.

After completing this chapter, you should be able to:

- Recognize satellite communications fundamentals
- Identify fleet SATCOM subsystems and shore terminals
- Evaluate specific SATCOM equipment and racks

SATELLITE COMMUNICATIONS FUNDAMENTALS

A typical SATCOM link uses an active satellite that receives and retransmits, and two earth terminals. (A passive satellite simply reflects radio signals back to earth.) One station transmits to the satellite on the uplink frequency. The satellite translates the signal to the downlink frequency, amplifies the signal, then transmits it to the receiving terminal. Figure 3-1 shows

![Figure 3-1.—Satellite communications system.](image)
some of the various earth terminals and how they interface. The end use or purpose determines the system’s complexity and how the system is used.

ROLE OF SATELLITE COMMUNICATIONS

SATCOM links, one of several kinds of long-distance communications links, interconnect communications centers located strategically throughout the world. These SATCOM links are part of the Defense Satellite Communications System (DSCS) and Fleet Satellite Communications.

Satellite communications systems are very important to the worldwide military communications network for two primary reasons. First, they continue to operate under conditions that cause problems for other methods of communication. Second, they provide reliable and secure communications to previously inaccessible areas. In many cases, these communications requirements can only be satisfied by sophisticated satellite communications systems. By satisfying such needs, SATCOM makes a significant contribution to the improved reliability of naval communications.

ADVANTAGES OF SATELLITE COMMUNICATIONS

Some of the unique advantages SATCOM has over conventional long-distance communications are as follows:

- SATCOM links are unaffected by the propagation problems associated with hf radio communications.
- SATCOM links are free from the high-attenuation problems of facilities that use wire or cable for routing communications.
- SATCOM links span long distances.
- The numerous repeater stations required for line-of-sight and troposcatter systems are not needed.

As you can see, satellite links provide the required flexibility and reliability needed to support military operations. In the following paragraphs, we will look at SATCOM capacity, reliability, vulnerability, flexibility, and limitations.

Capacity

Currently, military SATCOM systems can provide communications between backpack, shore, airborne, and shipboard terminals. These SATCOM systems can handle thousands of communications channels at the same time.

Reliability

SATCOM frequencies are only slightly affected by atmospheric phenomena and do not depend on reflection or refraction. Reliability is based on the skill of operators and maintenance personnel and the condition of the satellite communications equipment.

Vulnerability

Communications satellites are relatively safe from threats of harm. Because these satellites are in such high orbits, any attempt to disable or destroy them from the Earth would be difficult and expensive. However, Earth terminals are a different story. They offer a more attractive target for destruction by conventional methods. But these terminals can be protected by the same methods taken to protect other vital installations. So overall, the satellite system is nearly free from harm by an enemy.

Operationally, highly directional earth terminal antennas provide a high degree of freedom from jamming. The wideband system can use antijamming techniques, which also reduces vulnerability.

Flexibility

Mobile military satellite earth terminals with trained crews can be deployed and put into operation anywhere in the world within hours.

Limitations

The technical characteristics of the satellite and its orbital parameters are the main limitations to a satellite communications system. Two additional limiting factors for active satellites are transmitter power and receiver sensitivity. Energy for electricity is limited to whatever can be produced by the solar cells, which limits the satellite’s output power. This problem is made worse by users who increase their output power to the satellite, causing the satellite to try to retransmit at the new power level, at the expense of reducing signals to other users.
FLEET SATELLITE COMMUNICATIONS

The Fleet Satellite Communications (FLTSATCOM) System provides communications, via satellites, between designated mobile units and shore sites. These links provide worldwide coverage between the latitudes of 70 degrees north and 70 degrees south. Three satellites are currently in use with a fourth to come online soon: GAPFILLER, LEASAT, FLTSATCOM, and UHF Follow-on (UFO).

System installations are located on ships, submarines, mobile vans, aircraft, and shore stations. Though these installations could operate separately, integrating the system provides message traffic and voice communications to all DOD long-range communications networks. In addition, certain shore stations provide a back-up capability to other users in case of an outage of any kind, which maintains net connectivity.

The Navy SATCOM system consists of information exchange subsystems that use the satellites as (1) relays for communications and control, and (2) quality monitoring subsystems that provide data required to manage satellite resources. Each subsystem is structured for specific naval communications requirements. The following subsystems make up most of the Navy’s FLTSATCOM system.

- Fleet Satellite Broadcast Subsystem. This is an expansion of the “Fleet Broadcast,” which has been the central communications medium for operating naval units.
- Common User Digital Information Exchange Subsystem (CUDIXS) and Navy Modular Automated Communications Subsystem (NAVMACS). These two installations form a communications network for transmitting general-service message traffic between ships and shore installations.
- Submarine Satellite Information Exchange Subsystem (SSIXS). This subsystem compliments other communications links between SSBN and SSN submarines and shore terminals.
- Secure Voice Subsystem. This is a narrowband uhf subsystem that links voice communications between ships and connects with wide-area shore voice networks.
- Tactical Intelligence Subsystem (TACINTEL). This subsystem is specifically designed for special intelligence communications.
- Teletypewriter Subsystem. This subsystem is an extension of terrestrial teletypewriter transmission networks.
- Tactical Data Information Exchange Subsystem (TADIXS). This is a one-way broadcast of tactical information from command centers ashore to afloat units primarily in support of over-the-horizon targeting (OTH-T).
- Officer in Tactical Command Information Exchange Subsystem (OTCIXS). This subsystem continues to provide inter-and intra-battle group communications and is now also designated as the return path for ship-to-shore OTH-T communications.
- Demand Assigned Multiple Access (DAMA) Subsystem. This subsystem was designed to multiplex several subsystems, or users, on one satellite channel, allowing more satellite circuits to use a single uhf satellite channel.
- Control Subsystem. This subsystem is a communications network that provides status reporting and management of system assets.

The installation of subsystem baseband equipment and rf terminals aboard ships is driven by communications traffic levels, type of communications, and mission requirements. For example, Fleet Broadcast, a common subsystem in naval communications, is received by many different types of ships. Atypical suite on a large ship may include Fleet Broadcast, CUDIXS, NAVMACS, Secure Voice, TADIXS, OTCIXS, Teletypewriter, and TACINTEL equipment.

Most subsystems have very rigid control and accountability of message and data-link traffic. All subsystems have some form of backup mode. Within the constraints of equipment capability, each subsystem addresses the unique requirements of the user and the environment in which the user operates. On board your ship, you may not use all these systems, but during your career you will probably come across all of them. Now that we have identified the satellite communications subsystems, we need to provide you
with a basic understanding of how they operate. But first, we need to discuss FLTSATCOM Shorebased Terminals.

**FLTSATCOM SHOREBASED TERMINALS**

SATCOM installations at shore terminals operate from existing naval communications centers and certain command operations centers. Four Naval Computer and Telecommunications Area Master Stations (NCTAMS) have primary responsibility for naval communications via satellite. They are:

- NCTAMS LANT, Norfolk, Virginia
- NCTAMS MED, Naples, Italy
- NCTAMS WESTPAC, Finegayan, Guam
- NCTAMS EASTPAC, Wahiawa, Hawaii

The Naval Computer and Telecommunications Station (NCTS), San Diego, California, as part of TADIXS, provides connectivity between NCTAMS EASTPAC and NCTAMS LANT.

Ten NCTSs are used to retransmit Fleet Broadcast message traffic via hf links. In addition, an rf terminal at Yokosuka, Japan, transmits SSIXS and Secure Voice communications to the western Pacific and Indian Oceans. Also, there is landline connection between Japan and NCTAMS WESTPAC to support TADIXS and OTCIXS transmissions.

Within these facilities, each subsystem consists of two parts: the baseband equipment (used to collect and control the transmitted or received communications) and the rf terminal (used by the baseband system to transmit and receive via satellite link). Some subsystems have the baseband equipment and rf terminals in the same building, while others have the baseband equipment installed at a remote facility located some distance from the rf terminal. Most subsystems use a common rf terminal. However, the Fleet Broadcast has an rf terminal specifically designed for that subsystem.

**FLEET SATELLITE BROADCAST SUBSYSTEM**

The Fleet Satellite Broadcast Subsystem provides the capability to transmit Fleet Broadcast message traffic in a high-level jamming environment. The subsystem has 15 subchannels of encrypted message traffic at an input data rate of 75 bps per channel. These subchannels are time-division multiplexed and are transmitted in a one-way rf transmission at 1200 bps. The shore terminal transmits this data on a direct-sequence, spread-spectrum shf signal to the satellite, where the signal is translated to uhf and down-linked to the subscriber. Figure 3-2 shows a block diagram of the Fleet Satellite Broadcast Subsystem.

The High-Speed Fleet Broadcast (HSFB) is a planned upgrade to the Fleet Satellite Broadcast Subsystem. This upgrade will improve broadcast transmission speed, information throughput (capability of equipment to process or transmit data during a specific period of time), and flexibility.

**Message Traffic Input**

The Fleet Satellite Broadcast message traffic is queued and/or channel selected by two processor-controlled message switching systems before transmission. These systems are the Naval Communications Processing and Routing System (NAVCOMPARS) for general service message traffic, and STREAMLINER for special intelligence message traffic. Fleet weather data from Naval Oceanographic Command Centers is also transmitted on nonprocessor controlled channels.

**Rf Transmission**

The FLTSATCOM satellites have two rf channels allocated for Fleet Satellite Broadcast message traffic. The primary channel is configured for an shf uplink to the satellite and for translation within the satellite for transmission as uhf in the downlink. The second rf channel is designed for backup use only.

Since two channels are available, and several different modulation techniques are used for the uplink, there are seven different modes in which the rf link can be transmitted.

In modes 1 through 6, the shf transmissions are made by the Satellite Communications Terminal AN/FSC-79. Mode 7 operates the rf uplink and downlink at ultra-high frequencies and uses the uhf transceiver AN/WSC-5(V).

**Reception**

Subscribers receive the uhf downlink signal through the AN/SSR-1 receiver system, which demodulates and demultiplexes the signal. The demuxed signal is decrypted and read into the
Figure 3-2.—Fleet Satellite Broadcast Subsystem.
NAVMACS and TACINTEL processors for message screening and printing. (Refer to the discussion of these two systems.) Weather data is sent directly to printers after decryption. Ships not equipped with one or both of these systems will normally output the broadcast to teletypewriters.

**Fleet Broadcast Retransmission**

At selected shore stations, fleet Broadcast message traffic is retransmitted on hf links. These stations receive the tdm data directly via cable or satellite.

**CUDIXS/NAVMACS**

The CUDIXS subsystem is a shore-based installation of processors and peripheral equipment that provides K link control of the network and processing at shore installations. Figure 3-3 shows a typical CUDIXS installation.

NAVMACS is a shipboard message processing system that automatically guards a minimum of four broadcast channels, serves as an automated shipboard terminal for CUDIXS, and provides accountability for all incoming and outgoing message processing needs for ships of the fleet. NAVMACS subscriber terminal equipment is similar to CUDIXS terminal equipment.

The NAVMACS program is designed to address the growth requirements in existing installations and the unique requirements of ships having a high volume of message traffic. In ships that have a message processing and distribution system (MPDS), the NAVMACS processor interacts with the MPDS processor. A basic NAVMACS system is shown in figure 3-4.

NAVMACS reads the headings of incoming message traffic and separates all messages addressed to the ship or commands for which it is guarding. The system compares every addressee on each incoming first run message against entries in its command guard list (CGL). When the system finds one or more matches between addresses on the first run message and the entries of the CGL, the message is printed (copied) onto a line printer. If an emergency or Flash precedence message on a first run is received, it is printed completely, regardless of whether or not a match is found. For nonmatches of messages with precedence lower than Flash, only the heading of the message is printed.

Together, CUDIXS and NAVMACS provide improved ship-to-shore and shore-to-ship operational...
Figure 3-4.—NAVMACS (V) communications interface.
Figure 3-5.—CUDIXS/NAVMACS subsystem (non-DAMA).

1. THE ON-143 (V) 4/USQ AND ON-143 (V) 7/USQ WILL TRANSITION TO THE ON-143 (V) 0/USQ.
2. CDPS AND MPDS INTERFACE ONLY WITH THE FEW EXISTING ON-143 (V) 7/USQ OR, IN THE FUTURE, THE ON-143 (V) 9/USQ.
3. THE AN / UYK-20 (V), BASED NAVMACS SYSTEM, INTERFACES ONLY WITH EXISTING ON-143 (V) 9/USQ.
4. THE ON-143 (V) 9/USQ INTERFACES WITH ONE OF THESE SYSTEMS ACCORDING TO PLATFORM REQUIREMENTS.
communications. These improvements help increase message traffic through-put rates and traffic volume, and improve link reliability. Figure 3-5 shows both sides of the CUDIXS/NAVMACS subsystem.

**Message Traffic Input**

At shore facilities, the primary collection point for message traffic to be transmitted or received on the CUDIXS/NAVMACS rf link is NAV-COMPARS.

**Rf transmission Link Control (Non-DAMA)**

The CUDIXS baseband equipment shares a common rf terminal with other subsystems. At the shore facilities this terminal is a uhf transceiver, AN/WSC-5(V). Aboard ship, NAVMACS uses a uhf transceiver, AN/WSC-3(V). All uhf satellites have 25-kHz-wide channels allocated for CUDIXS/NAVMACS transmissions. Each channel is operated as a half-duplex uhf link, with a data transmission rate of 2400 bps. The rf modulation is differential encoded phase-shift keying (DPSK).

**SUBMARINE SATELLITE INFORMATION EXCHANGE SUBSYSTEM (NON-DAMA)**

SSIXS was designed to compliment vlf and mf/hf communication links between shorebased submarine broadcast control authorities (BCAs) and submarines. Figure 3-6 shows a SSIXS subsystem.

This subsystem provides the submarine commander the ability to receive messages transmitted via satellite at scheduled intervals ("Group Broadcasts"). Between Group Broadcasts, submarines may transmit messages to the BCA, including a request for messages held in queue. The shore terminal responds with acknowledgements for the received messages and transmits all messages addressed to that particular submarine. Two modes, Group Broadcast and Query/Response, permit the submarine to be active or passive, depending on what the submarine commander wants. One 25-kHz wideband channel on each of the four FLTSATCOM satellites has been allotted to SSIXS. A single SSIXS network may have up to 120 submarine subscribers.

![Figure 3-6.—SSIXS subsystem.](image-url)
SSIXS has undergone an upgrade (SSIXS II) that replaces the SSIXS shore equipment with new computer equipment.

Message Traffic Input

At the broadcast control authority (BCA), the console keyboard operator, high-speed paper tape reader, or Submarine Message Automated Routing Terminal (SMART) enters into the SSIXS shore terminal messages addressed to submarines that have been received from AUTODIN, NAVCOMPARS, or locally over the counter in the message center. Aboard the submarine, message traffic is input via the teletypewriter or tape reader equipment. SSN submarines that have the Data Link Control System (DLCS) installed have an additional input/output capability via the sensor interface unit (SIU) for over-the-horizon targeting (OTH-T messages.

Rf Transmission Link Control

Ashore, the SSIXS subsystem shares access to the same satellite rf terminal equipment as the other uhf SATCOM subsystems, with the exception of COMSUBGRU SEVEN, Yokosuka, Japan, which is equipped with dedicated AN/WSC-3 transceivers.

Since each BCA is located some distance away from the Naval Computer and Telecommunications Area Master Station (NCTAMS), line modems and land lines are required for interconnection. The submarine uhf rf terminal is the single-channel, half-duplex AN/WSC-3. SSIXS transmissions are at 4800 bps. The capability to operate SSIXS in the DAMA net (see the section on DAMA) has been successfully demonstrated and will be used in the future. Each subscriber to a SSIXS network is assigned a unique identification number that is used in all transmissions to or from the subscriber. The identification numbers are stored within the shore station and subscriber processors and are used for the following purposes:

- At the shore stations, the subscriber identification number, when combined with broadcasts, determines the number of times message traffic is transmitted to the subscriber.
- When a subscriber makes a transmission to the shore station, the identification number is included. The shore station will not acknowledge a transmission without receiving the identification number.
- The subscriber uses the number to screen incoming message traffic. Any data that is not addressed to that particular subscriber is discarded.

SECURE VOICE SUBSYSTEM

The Secure Voice subsystem enables the transmission of ship-to-ship, ship-to-shore, and shore-to-ship voice communications via satellite relay. Figure 3-7 shows a Secure Voice subsystem. AUTOSEVOCOM has been replaced by radio wireline interface (RWI) at all NCTAMS shore activities.) The subsystem transmits and/or receives secure voice communications via a half-duplex, push-to-talk satellite link. Channels on each of the four FLTSATCOM satellites have been allocated for use by the Secure Voice subsystem. Control of the voice channels is maintained by the Secure Voice controller at the responsible NCTAMS/NCTS.

The subsystem uses digitized voice at a data rate low enough to be compatible with a 3-kHz voice channel and is considered narrowband. The sound of Narrowband Secure Voice is very distinctive. Once you hear it, you won’t forget it. The system uses special analog-to-digital processing of the speech signal at the handset terminal and the rf transmission rate is 2400 bps.

The Secure Voice subsystem has dedicated rf channels on the uhf SATCOM satellites as well as dedicated DAMA time slots where DAMA nets have been established.

Voice Transmission

The rf terminal installations on mobile platforms determine the manner in which a Secure Voice transmission is made. These mobile platforms maybe categorized into two types:

- The small ship/submarine that share a single-channel AN/WSC-3(V) uhf transceiver and cryptographic equipment between NAVMACS or SSIXS and a Secure Voice terminal.
- Larger ships that have two or more AN/ WSC-3(V) uhf transceivers and cryptographic equipment between NAVMACS or SSIXS and a Secure Voice terminal.

Secure Voice use is accomplished by either of two methods. In the first method, ships access a Secure Voice channel if the channel is not in use. The ship contacts another ship directly by using the available channel. When coordination of voice communications with shore commands is required, the ship contacts the voice controller who, in turn, tells the recipient(s) of an incoming voice transmission.
The second method requires a different process and is used if the channels are busy or if procedures require this method. For the small ship or submarine, a voice transmission request must be sent by message to the Secure Voice controller. A small ship uses the CUDIXS/NAVMACS network for the message. The submarine may transmit a voice-channel request during a random-access time period in the SSIXS. In both cases, the request is passed from the reception point ashore to the voice controller. The voice controller coordinates the voice transmission by assigning a voice channel, contacting the unit that will receive the voice transmission, and following through with the transmission.

**Radio Wireline Interface**

The Radio Wireline Interface (RWI) was developed to access and interconnect existing and future Secure Voice subsystems and equipment. It provides the capability to connect shorebased worldwide
Figure 3-8.—DAMA-configured TACINTEL subsystem.
terrestrial (wireline) systems with the SATCOM, Defense Satellite Communications Systems, and alternate hf systems. This system extends shore communications seaward and gives commands at sea the same Secure Voice telephone communications currently provided to the worldwide shore establishment. The RWI provides interconnection among the Secure Voice Improvement Program (SVIP) channels (STU-III units), a RED telephone bus, the Advanced Narrowband Digital Voice Terminal, SATCOM radio terminals (uhf, shf, and in the future, ehf), and hf radio links.

**TACTICAL INTELLIGENCE SUBSYSTEM**

The Tactical Intelligence subsystem (TACINTEL) is used to transmit special-intelligence communications. A link-control protocol has been adapted to a format required for communication across a DAMA-supported channel using a polling scheme that can support a net membership of 23 subscribers. A portion of a DAMA 25-kHz channel on each of the FLTSATCOM satellites has been allocated for TACINTEL. A TACINTEL subsystem is shown in [figure 3-8](#).

TACINTEL also processes time-sensitive sensor data and other data essential to Indications and Warnings and OTH-Targeting. In addition, this system, unlike CUDIXS/NAVMACS, can be used for direct ship-to-ship interchange of this data.

**Rf Transmission**

TACINTEL baseband equipment uses an rf terminal in common with other subsystems at both shore facilities and subscriber terminals. Shore facilities use an AN/WSC-5(V); subscribers use an AN/WSC-3(V). The TACINTEL channel operates as a half-duplex uhf link at 1200, 2400, or 4800 bps. Modulation is DPSK.

**Subscriber Reception**

Each subscriber has an identification number recognized by the subscriber processor. This number serves as the initial basis for incoming message screening. Screened message traffic is sent to the TACINTEL peripheral equipment (printer) or the interfacing systems. The remaining message traffic is discarded without release.

**Future TACINTEL**

The TACINTEL II program will upgrade the existing TACINTEL and incorporate state-of-the-art hardware and software. It will be a computer-based message communications system, enabling automatic receipt and transmission of Special Intelligence communications for both ashore and afloat users. During the transition, it will be compatible with the present TACINTEL.

**TELETEYPETRITER SUBSYSTEM**

The Teletypewriter Subsystem expands existing teletypewriter communications networks by using satellites as relay stations.

The Navy continues to have numerous uses for the 75-bps tty. These include dedicated full-time terminations for beyond-line-of-sight tactical and report-back circuits and as backup connectivity for networks such as CUDIXS/NAVMACS and TACINTEL. A non-DAMA-configured teletypewriter subsystem is shown in [figure 3-9](#).

![Figure 3-9.—Teletypewriter subsystem-non DAMA.](#)
TADIXS supports the exchange of Over-the-Horizon Targeting (OTH-T) information between shore and fleet-based computer systems that support Navy cruise missile operations. Surface ships and submarines operate in a TADIXS receive-only mode. OTH-T data from the fleet destined for shore or other fleet users is sent by the afloat Tactical Data Processors (TDPs) through the TADIXS ON-143(V)6/USQ to the OTCIXS ON-143 (V)6/USQ for transmission over the OTCIXS satellite. A TADIXS surface ship installation is shown in Figure 3-10. Each OTCIXS-equipped surface ship or submarine can enter both out-going teletype and TDP traffic simultaneously.

**RF Transmission Link Control**

The TADIXS satellite link network operates in a half-duplex manner at a data rate of 2400 bps in a permanently assigned time slot of a uhf DAMA channel. Control of message traffic transmission is...
achieved by a polling and controlled access protocol installed in the TADIXS radio controller (shore) software and the TADIXS satellite link controller (afloat) software.

In the non-DAMA mode, OTCIXS operates in a half-duplex manner at a data rate of 2400 bps using a dedicated uhf channel. When functioning in the DAMA mode, OTCIXS operates at a data rate of 1200 or 2400 bps in a permanently assigned time slot of a uhf DAMA channel. Control of message traffic transmission is achieved by a demand-assigned access protocol installed in the OTCIXS radio controller (shore) and satellite link controller (afloat) software.

**Message Traffic Reception**

Each subscriber in the TADIXS network has a unique identification number recognized by the subscriber processor. This number serves as the initial basis for incoming message traffic screening. TADIXS or OTCIXS satellite link controllers (on afloat units) compare redundant receptions for accuracy and form the most accurate composite of the traffic received.

For surface ship and submarine users, screened message traffic is sent to the teletypewriter or TDP system, as applicable. The rest of the traffic is discarded. The reception of traffic does not make the satellite link controller send an acknowledgement. This allows afloat platforms to receive traffic while operating in an emission control (EMCON) environment.

**DEMAND-ASSIGNED MULTIPLE ACCESS (DAMA) SUBSYSTEM**

The uhf DAMA subsystem was developed to multiplex several baseband systems or users on one 25-kHz satellite channel. This had the effect of adding more satellite circuits per channel to the uhf Satellite Communications System. Without uhf DAMA, each satellite communications subsystem requires a separate satellite channel.

DAMA equipment accepts encrypted data streams from independent baseband sources and combines them into one continuous serial output data stream. DAMA interfaces the Navy uhf SATCOM subsystems and the AN/WSC-5(V) and DAMA-compatible AN/WSC-3(V) transceivers. The DAMA unit (TD-1271B/U multiplexer) includes a modem, eliminating the need to use a separate modem at the AN/WSC-5(V) or the modem within the AN/WSC-3(V). The baseband equipment input or output (I/O) data rate with DAMA equipment can be 75, 300, 600, 1200, 2400, 4800, or 16,000 bps. The DAMA transmission rate on the satellite link (burst rate) can be 2400,9600, 19,200, or 32,000 symbols per second (sps). CUDIXS/NAVMACS, Secure Voice, and OTCIXS currently use 2400 bps. TACINTEL operates at 2400 or 4800 bps, depending upon the ocean area.

The DAMA multiplexed data stream is divided into frames, with each frame being 1,386 seconds long. Each frame is subdivided into time slots as shown in figure 3-11. Most of the DAMA frame formats are derived from this basic format. In the following paragraphs, we will name and describe the purpose of each slot.

**Channel Control Order Wire (CCOW) Slot**

This slot is used to transmit system timing and control information from the channel controller to subscriber units only. It provides subscriber units with system timing, configuration, and satellite rf control information. It occurs at the beginning of each frame.

**Return Channel Control Order Wire (RCCOW) Slot**

This time slot provides limited order wire capability for DAMA-related subscriber-to-channel controller communications. It is used for transmission from the subscriber to the channel controller.

**Ranging Time Slot**

This is the time slot during which the user’s TD-1271B/U determines the range between the user terminal and the satellite to set the transmitter synchronization required for timing. All DAMA multiplexer transmit times are referenced to the satellite.

**Link Test Slot**

The link test slot is used to evaluate the performance of the satellite link. Each subscriber is able to transmit a fixed data stream through the satellite, receive that bit stream, and then perform error analysis automatically.

![Figure 3-11.—Basic DAMA frame format.](image)
Data Time Slots

These are the time slots during which users transmit or receive data. There are three segments of time slots in each frame, designated A, B, and C. Segment A may contain from one to five circuits; B may contain from one to eleven circuits; and C may contain from one to six circuits. The number of circuits in each group depends on the baseband data rate, the forward correction rate, and the transmission burst rate, as influenced by the radio frequency interference (RFI) environment.

Current Operation

For communications on the eastern Pacific satellite, a master control station is installed at NCTAMS EASTPAC. This same pattern of DAMA equipment installations has been followed at NCTAMS LANT, MED, WESTPAC, and NTCS. Each master control station has multiple multiplexer installed, and each TD-1271B/U multiplexer can accommodate up to four circuits. The number of multiplexer installed aboard each ship varies according to platform requirements.

Any DAMA-equipped platform with full-duplex capability can be designated a channel controller. This capability provides an emergency backup for the shorebased master controller terminals. A DAMA subscriber who is designated a channel controller will provide all the required CCOW functions for DAMA system control of a particular rf channel.

Operationally, the user terminal will have its baseband port automatically connected to a data time slot when the proper slot number is keyed into the multiplexer front panel keyboard. Each SATCOM subsystem that uses DAMA will have a specific slot number. Circuits will normally be operated on a netted basis, and circuit numbers will be assigned by COMNAVTELCOM and/or FLTCINC.

Transition

Transition to DAMA is taking place in a manner that allows subscribers converted to DAMA to communicate with those who have not been converted. During the transition period, equipment installed at shorebased master stations will form gateways between DAMA and non-DAMA circuits. In the following paragraphs, we will discuss subsystems that are either currently undergoing conversion to DAMA or are planned for conversion, so you will know what to expect in the future.

Secure Voice — DAMA is now being phased into the Secure Voice Subsystem. A DAMA-configured Secure Voice Subsystem is shown in figure 3-12.

CUDIXS/NAVMACS — NAVMACS platforms will be gradually transitioned to DAMA. This transition will start when CUDIXS shore and CUDIXS/NAVMACS ship hardware and software have been modified for compatibility with DAMA. At that time, a transition will begin allowing DAMA or non-DAMA ships to communicate with the CUDIXS shore terminal. A DAMA-configured CUDIXS/NAVMACS subsystem is shown in figure 3-13.

Teletypewriter — Teletypewriter capability via DAMA becomes available as DAMA is installed on each platform. To provide maximum flexibility during the transition, capability is provided at the shorebased master control stations to interface non-DAMA and DAMA users. Figure 3-14 shows a DAMA-configured teletypewriter subsystem.

CONTROL SUBSYSTEM

The Control Subsystem is structured to perform the following tasks:

- Sense and collect system status information in a defined geographical area and on a worldwide scale.
- Control system resources and the degradation of system capability.

The Control Subsystem is a combination of several areas and levels of command. The major players are listed below:

- The Chief of Naval Operations is the executive authority for all SATCOM system.
- The Commander, Naval Space Command is responsible for the operational control and management of these systems and for the effective operation and maintenance of assigned Navy resources for the Department of Defense.
- The Naval Computer and Telecommunications Command performs the required functions to provide day-to-day control and operation of naval satellite communications assets. With coordination, system resources can be adjusted to meet operational needs.
Supporting the control subsystem are NCTAMS, NCTS, the USAF Satellite Operations Center, and contractor-operated control facilities.

The key to controllability lies in having many points for sensing the status of subsystems and equipment operation. Status data may be collected by operators or by special facilities or equipment. There are many points within each subsystem where subsystem and equipment operational status is collected. Also, several subsystems/systems have the ability to provide a printout of status information.

Transmission of status data from the NCTAMS, NCTS, and USAF Satellite Operations Center is via teletypewriter order wire. The Naval Computer and Telecommunications Command maintains a substantial quantity of updated status data in computer files. A diagram of the Control Subsystem is shown in figure 3-15.
Figure 3-13.—DAMA-configured CUDIXS/NAVMACS subsystem.
Figure 3-14.—DAMA-configured teletypewriter subsystem.

Figure 3-15.—Control Subsystem functional diagram.
Figure 3-16.—Uhf satellite coverage areas.
In 1976, three satellites were placed into orbit over the Atlantic, Pacific, and Indian Oceans. These satellites, called **MARISATs**, were procured by and are managed by the COMSAT General Corporation. Each satellite has three uhf channels for military use (one wideband 500-kHz channel and two narrowband 25-kHz channels). The uhf section of each satellite is leased to the Navy for communications. To distinguish the special management and control functions for communications on these uhf channels, the Navy has given the leased MARISAT satellite assets the name **GAPFILLER**.

Current planning calls for no Navy use of GAPFILLER satellites after the mid-1990’s. Satellite coverage will then be provided by a combination of **FLTSAT** and **LEASAT** until the new **UHF FOLLOW-ON** (UFO) satellites are placed into service. The Navy plans to have two operational satellites in each of four satellite coverage areas. Each satellite coverage area can be terminated in at least two NCTAMS, allowing around-the-world connectivity. You can see this connectivity in the figure 3-16.

**FLTSATCOM SATELLITE**

The FLTSATCOM satellite consists of two major parts: a payload module that includes the antennas and a space craft module with a solar array. The payload module contains the uhf, shf, and S-band (tracking, telemetry, and command) communications equipment antennas. The communications equipment is mounted internally on side panels that cover this section of the satellite.

The space craft module contains nearly all other subsystem equipment, including sensors, attitude and velocity control, telemetry, tracking and command, and electrical power distribution. The spacecraft is stabilized on three axes, and the body-fixed antennas are kept pointing at the sun by a clock drive. A FLTSATCOM satellite is shown in figure 3-17.

Each FLTSATCOM satellite can relay communications on 23 separate uhf channels. Of the 23 channels, 10 are 25-kHz channels, 12 are 5-kHz channels, and one is a 500-kHz channel. The ten 25-kHz channels are dedicated for Navy use. Each 25-kHz uhf down-link channel has a separate transmitter. Channel one, used in primary mode for Fleet Broadcast transmissions, incorporates signal processing within the satellite (the shf up-link signal is translated to uhf for down-link transmission). In addition, two of the FLTSATCOM satellites have ehf packages attached.

**FLTSAT Extremely-High-Frequency Package (FEP)**

The Fleet Satellite (FLTSAT) Extremely-High-Frequency (EHF) Package (FEP) provides ehf communications capability for Army, Navy, and Air Force ground, airborne, and ocean-going terminals. Two FEPs are currently in orbit, carried aboard two modified uhf FLTSATs, numbers seven and eight.

FEP operates at ehf frequencies of approximately 20-GHz on the down-link and 44-GHz on the up-link. It has two antenna beams: (1) a dual-frequency spot beam steerable by ground command, and (2) an earth coverage beam that uses separate horn antennas for transmit and receive.

**LEASAT SATELLITE**

The LEASAT satellite has seven 25-kHz uhf down-link channels, one 500-kHz wide-band channel, and five 5-kHz channels. One of the seven 25-kHz down-link channels is used for Fleet Broadcast. The broadcast up-link is shf, with translation to uhf taking place in the satellite. The remaining
six channels function as direct relay channels with separate repeaters. A LEASAT satellite is shown in Figure 3-18.

Compared to FLTSATCOM satellites, LEASAT satellites have a reduced number of 25-kHz channels. However, they can still serve expanding Navy SATCOM requirements by using the ground-based DAMA technique, effectively using each satellite channel more efficiently.

UHF FOLLOW-ON SATELLITE

The purpose of the Ultra-High-Frequency Follow-On Satellite System (UHF F/O) is to provide satellite communications for DOD and other government agencies through satellites in geosynchronous orbit. The current satellites, GAPFILLER, FLTSATCOM, and LEASAT are approaching the end of their normal mission life. UHF F/O will provide the needed replenishment satellites. The strategy for replacement is to use existing FLTSATCOM and LEASAT assets fully, while deploying the UHF F/O satellites to minimize communications disruptions as the FLTSATCOM and LEASAT satellites fail or reach the end of their useful life. An exploded view of a UHF F/O satellite is shown in Figure 3-19.

Communications Capability

The uhf communications subsystem consists of receive and transmit antennas, a low-noise pre-amplifier, 25- and 5-kHz channel receivers and transmitters, and an output multiplexer. The shf communications subsystem provides shf anti-jam up-link capability for Fleet Broadcast (which is down-linked as uhf) and consists of receive and transmit antennas, the receiver, a dual channel processor, and the beacon transmitter. Signals received by the shf receive antenna are fed to the shf receiver. In turn, the processor provides Fleet Broadcast outputs that are fed to uhf communications subsystem for down-link. The multiplexed anti-jam broadcast capability of the UHF F/O permits up to three broadcast channels to be up-linked and down-linked simultaneously.

On the fourth and subsequent satellites deployed, an ehf communications subsystem will provide three ehf broadcast channel up-links and seven ehf communications channel up-links. Each of these ehf up-links will be capable of being down-linked as ehf only, uhf only, or simultaneously as uhf and ehf. UHF F/O will also have the capability of transmitting and receiving ehf telemetry and command data.

User interfaces for UHF F/O are identical to those of the current FLTSATCOM and LEASAT constellation. The uhf portion of the UHF F/O system is compatible with all existing Navy uhf terminals except those using frequency-hopping techniques.

Channel Allocations

The UHF F/O satellite channels are allocated and grouped as follows:

- Group I has a single 25-kHz bandwidth channel with a variable satellite translation frequency and a jam resistant shf up-link.
- Group II has nine 25-kHz bandwidth channels with a satellite translation frequency of 41 MHz.
- Group III has eight 25-kHz bandwidth channels with a satellite translation frequency of 33.6 MHz.
- Group IV has eight 5-kHz bandwidth channels with a satellite translation frequency of 73.1 MHz.
- Group V has thirteen 5-kHz bandwidth channels with a satellite translation frequency of 53.6 MHz.

MILSTAR

MILSTAR is a new generation Satellite Communications (SATCOM) system being developed by the Navy, Army, and Air Force for two primary purposes. First, it will provide a survivable

Figure 3-18.—LEASAT satellite.
communications capability to the National Command Authority (NCA). Second, it will provide sufficient communications support for both strategic and tactical missions. The primary objective of the MILSTAR program is to develop and deploy an affordable, jam-resistant SATCOM system that will meet both long-haul and local communications needs.

MILSTAR will use communications terminals that will provide Secure Voice (SV), Teletype (TTY), data, and facsimile EHF SATCOM. MILSTAR terminals will be installed on aircraft, in fixed telecommunications centers, landbased tactical elements, shorebased telecommunications centers, surface ships, and submarines.

In the following paragraphs, we will look at some of the equipment associated with satellite communications.

**SATELLITE EQUIPMENT**

The equipment used in Navy SATCOM subsystems can be divided into two general groups, rf terminals and the baseband equipment common to a processor installation. The selection of specific equipment is determined by the operating environment—whether installation is to be aboard a ship, submarine, aircraft, or shore installation. In this chapter, we will limit our discussion primarily to commonly used shipboard and shore equipment.

**Satellite Communications Terminal AN/FSC-79**

The AN/FSC-79 terminal processes and converts 70-MHz signals to X-band (shf) transmitted signals. It also converts received signals from X-band to 70 MHz. This terminal can simultaneously transmit a spread spectrum carrier and receive a satellite beacon signal. The design of the terminal provides redundancy in many components to ensure a high degree of availability. The terminals are installed at NCTAMS LANT, MED, WESTPAC, EASTPAC, and NCTS, Stockton (contractor operated).

**Uhf Transceiver AN/WSC-5(V)**

The AN/WSC-5(V) transceiver provides an eight-circuit, full-duplex data operation or, as an alternative, six full-duplex data circuits and two FM audio or tone-group circuits. It also provides an interface for connectivity to the uhf DAMA
Figure 3-20.—Uhf transceiver AN/WSC-5(V).

This transceiver is capable of three types of modulation/demodulation:

- Frequency modulation/demodulation with pre-emphasis/de-emphasis for voice transmission/reception.

- Frequency modulation/demodulation without pre-emphasis/de-emphasis for tone-group transmission/reception.

- Differentially encoded phase-shift keying using the OM-43A/USC modem. The transceiver has a 70-MHz interface for connection to either the modem or the TD-1271B/U DAMA multiplexer.

All four NCTAMS have AN/WSC-5(V) transceivers installed.

The C-11330/WSC-5(V) shown in Figure 3-21 provides for remote control of the AN/WSC-5(V) for teletype operation. The C-11330/WSC-5(V) is similar to the C-9899/WSC-3, except that it uses +6 Vdc for the keyline signal and indicator lamps. Both units have identical front panels.

**Transceiver AN/WSC-3(V)**

To be consistent in this discussion, we will refer to both the AN/WSC-3 and AN/WSC-3(V) transceivers.
as AN/WSC-3. A single AN/WSC-3 (RT-1107/WSC-3) is shown in Figure 3-22.

The AN/WSC-3 transceiver is used primarily aboard ship, at Marine Corps terminals, and at selected shore installations. It has various configurations designed to meet the particular requirements of these platforms. The configuration differences are identified in the AN/WSC-3 variations table (table 3-1).

The transceiver can be operated in either satellite or line-of-sight mode, either locally or remotely. A modulation control permits selection of PSK data rates from 75 to 9600 bps, FSK modulation at 75 bps, and FM or AM modulation for voice. The rf output is 30 watts AM and 100 watts for FM, PSK, and FSK.

The AN/WSC-3A, AN/WSC-3A(V)2 and (V)3 have been modified for use with the DAMA subsystem. The AN/WSC-3(V)15, (V)17, and (V)19 are manufactured as DAMA-capable.

The transceiver has two control indicators for remote operations. The C-9351/WSC-3, shown in Figure 3-23, provides for remote control of the AN/WSC-3 as described in the table 3-1 description. As we mentioned before, the C-9899/WSC-3 provides for remote teletype operation. Two built-in modems are included with the transceiver.

**Receiver Systems AN/SSR-1 and 1A**

You have probably seen this receiver since it is installed aboard most naval surface vessels. It enables ships to receive Fleet Satellite Broadcast. The received carrier may contain either FM or PSK modulation; the preferred demodulation is selected manually with a switch associated with the receiving set. The AN/SSR-1 can drive high-level teletype equipment. The AN/SSR-1A can drive both high- and
<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Description</th>
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<tbody>
<tr>
<td>AN/WSC-3</td>
<td>AM Voice, AM Secure Voice, FM Voice, PSK Data at 75, 300, 1200, 2400, 4800, 9600 bps. FSK Data at 75 bps via satellite or LOS, selectable.</td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td>Similar to (V)1 with FM Vinson S/V and Link 11 modules added. Standard Interface Module.</td>
</tr>
<tr>
<td>AN/WSC-3(V)2</td>
<td>Similar to (V)2 but with SAS module.</td>
</tr>
<tr>
<td><strong>• RT-1107(V)2/WSC-3(V)</strong></td>
<td>None produced.</td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td>None produced.</td>
</tr>
<tr>
<td>AN/WSC-3(V)6</td>
<td>Similar to (V)5. FM Vinson S/V, standard interface and Link 11 modules added.</td>
</tr>
<tr>
<td><strong>• RT-1107(V)6/WSC-3(V)</strong></td>
<td>Similar to (V)6, but with SAS I/O module</td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td>Similar to (V)7 with computer-compatible serial frequency and mode control. (USCG)</td>
</tr>
<tr>
<td>AN/WSC-3(V)8</td>
<td>Similar to (V)3. Modified for 5-kHz channels vce 25 kHz. Provide 34,995 channels vce 7000.</td>
</tr>
<tr>
<td><strong>• RT-1107(V)8/WSC-3(V)</strong></td>
<td>Similar to (V)6 with AJ capability.</td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td>Similar to (V)7 with AJ capability.</td>
</tr>
<tr>
<td>AN/WSC-3(V)10</td>
<td>Similar to (V)3 but modified for Trident SSBN IRR. Blower flow altered.</td>
</tr>
<tr>
<td><strong>• RT-1107(V)10/WSC-3(V)</strong></td>
<td>Similar to (V)2. Modified to operate from 400-Hz primary power.</td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td>Similar to (V)7 but uses a bidirectional MIL-STD-1553B bus interfaced to an external controller.</td>
</tr>
<tr>
<td>AN/WSC-3(V)11</td>
<td></td>
</tr>
<tr>
<td><strong>• RT-1107(V)11/WSC-3(V)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td></td>
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<tr>
<td>AN/WSC-3(V)12</td>
<td></td>
</tr>
<tr>
<td><strong>• RT-1107(V)12/WSC-3(V)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td></td>
</tr>
<tr>
<td>AN/WSC-3(V)13</td>
<td></td>
</tr>
<tr>
<td><strong>• RT-1107(V)13/WSC-3(V)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>• C-9351/WSC-3</strong></td>
<td></td>
</tr>
<tr>
<td>AN/WSC-3(V)14</td>
<td></td>
</tr>
<tr>
<td><strong>• RT-1107(V)14/WSC-3(V)</strong></td>
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3-26
<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Description</th>
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<tbody>
<tr>
<td>AN/WSC-3(V)15&lt;br&gt; • RT-1107(V)15/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Similar to (V)2 or (V)3 but is DAMA compatible. Has a switchable audio interface module and can be switched from standard interface or SAS.</td>
</tr>
<tr>
<td>AN/WSC-3(V)16&lt;br&gt; • RT-1107(V)16/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Similar to (V)2 but has an SSN AFSA1COM system (SAFS) interface drawer (A20) instead of the preset channel.</td>
</tr>
<tr>
<td>AN/WSC-3(V)17&lt;br&gt; • RT-1107(V)17/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Similar to (V)15 but has modified transmit signal transient and preamble characteristics. (MTSC)</td>
</tr>
<tr>
<td>AN/WSC-3(V)18&lt;br&gt; • RT-1107(V)18/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Similar to (V)12 but has modified transmit signal transient and preamble characteristics. (MTSC)</td>
</tr>
<tr>
<td>AN/WSC-3(V)19&lt;br&gt; • RT-1107(V)19/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Similar to (V)17 but has the SAFS A20 drawer installed.</td>
</tr>
<tr>
<td>AN/WSC-3A&lt;br&gt; • RT-1107A/WSC-3&lt;br&gt; • C-9351/WSC-3</td>
<td>Same as AN/WSC-3 but modified for use with UHF DAMA.</td>
</tr>
<tr>
<td>AN/WSC-3A(V)2&lt;br&gt; • RT-1107A(V)2/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Modified for use with UHF DAMA.</td>
</tr>
<tr>
<td>AN/WSC-3A(V)3&lt;br&gt; • RT-1107A(V)3/WSC-3(V)&lt;br&gt; • C-9351/WSC-3</td>
<td>Modified for use with UHF DAMA.</td>
</tr>
<tr>
<td>C-9351/WSC-3</td>
<td>Remote control for RT-1107. Contains preset channel control, modulation select, handset control, RT indicator lamps, and RT mode controls.</td>
</tr>
<tr>
<td>C-9351A/WSC-3</td>
<td>Similar to C-9351 and allows use of longer interface cables.</td>
</tr>
<tr>
<td>C-9899/WSC-3</td>
<td>Remote control for RT-1107/WSC-3, has a keyline switch, transmit and receive indicators. It is used for teletype circuit control: requires 28 volts dc for indicator lamps and provides a ground keyline.</td>
</tr>
</tbody>
</table>