Defense Satellite Communications System

Operations

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In the last volume, we discussed satellites as a transmission media. You will now see that it's the only system to have its own office within DCA. The system is so vast and has so many variables that it requires the management and supervision of a separate organization charged with the responsibility of ensuring that timely and correct decisions be made for control of the various aspects of the DODs satellite programs.

In this unit, we will look at the Defense Satellite Communications System (DSCS), one of its programs, the ground mobile forces (GMF) network, and an integral part of the DSCS, the Air Force Satellite Control Facility. We will also discuss the Air Force Satellite Communications System (AFSCS).

Operations

With the launching of new satellites and the modification of terminals, the Initial Defense Communications Satellite Program (IDCSP) entered a new phase and was renamed the Defense Satellite Communications System. This is a triservice program under the direction and operational control of DCA. As you read the following sections describing the DSCS, you may wish to refer back to Volume 1 of this course for a refresher on the operational characteristics of satellites.

The purpose and operational objectives of the DSCS

Purpose

The DSCS was developed to support unique and vital global communications networks for the DOD. The DSCS is an integral part of the DCS and normally supports:

a. Needs of the Worldwide Military Command and Control System (WWMCCS).

b. Establishment, extension, and upgrading of communications in direct support of combat forces.

c. Wideband communications requirements to remote locations not adequately served by other means.

d. Navy ship-to-ship, ground mobile forces, and other authorized DCS user requirements.

e. Other uses as directed by the Joint Chiefs of Staff (JCS) and/or Secretary of Defense.

A unique feature of DSCS is its ability to extend communications services to remote locations not adequately served by other means, to support Navy ship-shore-ship communications, the GMF of the Army, Marine Corps, and Air Force, and the Diplomatic Telecommunications System (DTS) of the Department of State (fig. 4–1).

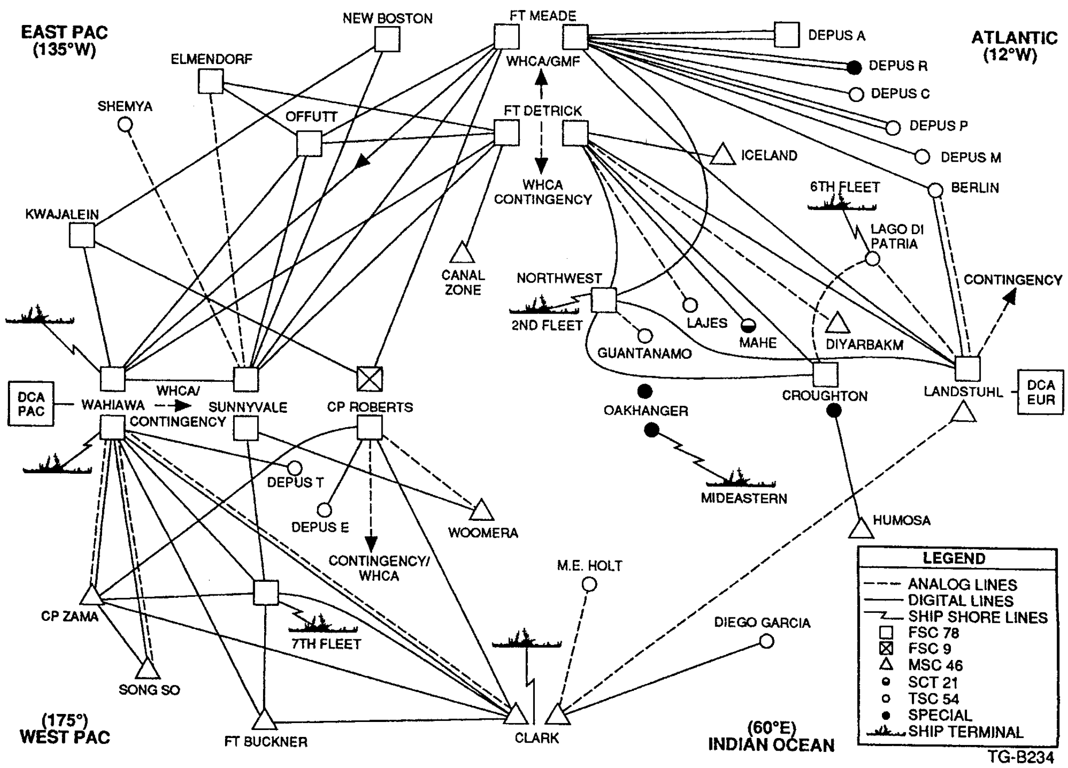

Figure 4-1. Defense Satellite Communications System (DSCS).

[figure 4–1]

Operational objectives

The primary operational objective of the DSCS is to provide continuous high-quality communications to each validated user. In stressful environments, including trans- and postattack periods, the objective is to preserve the critical communication needs of the WWMCCS.

Operational objectives are achieved by supporting the DSCS performance criteria and its operational priority system. These objectives are met by ensuring that critical subscribers and systems maintain connectivity with the DCS; that sustained quality service is maintained through timely, effective testing and analysis in both normal and stress environments; and that efficiency is increased in the DSCS. Also, the system should remain flexible to serve the maximum number of potential users and to be tactically adaptable.

Characteristics and limitations of the DSCS

Characteristics

Due to the importance of defense satellite systems, they must have high reliability along with the basic characteristics that allow them to perform effectively. All communications systems must conform to certain basic requirements, some of which are listed below.

Reliability

Two types of reliability are of interest. The first is propagation reliability. The high-frequency (HF) band has always been subject to the irregularities of the ionospheric layers that surround the Earth. Thus, only a portion of the HF band is actually usable at any given time over a particular path.

Also, the multipath effects of ionospheric propagation seriously limit the amount of information that can be transmitted over a given channel. Added to these limitations are the "blackouts" that may result from ionospheric disturbances caused by sunspot activity. High-altitude nuclear explosions can introduce similar disturbances.

One is forced to conclude, and rightly so, that using HF frequencies and the ionosphere as a propagation medium yields less than desirable results. By contrast, a communications satellite of the active-type using line-of-sight (LOS) transmission at microwave frequencies is extremely reliable from a propagation standpoint.

A communications satellite introduces a second type of reliability problem—that of reliable unattended operation for long periods in orbit. Systems engineers have shown that a reliable communications satellite can be made with operational life expectancies of more than 1 year if the following practices are used:

- Components of proven reliability are selected.
- All components are operated within their ratings.
- The satellite design provides adequate protection during launch and while in the space environment.
- Adequate use is made of redundancy to further increase the chance of successful operation.

Capacity

Through the years, people have become dependent, almost exclusively, on frequencies in the 5- to 30-MHz range for long-range global communications. These frequencies are shared among all countries and must support both military and civilian applications. This narrow range of frequencies and the propagation characteristics discussed previously seriously limit total communications capacity.

It is not surprising that a great interest exists in techniques that open more areas of the frequency spectrum to long-range communications (e.g., ionospheric and tropospheric scatter propagation). Communications satellites use the complete range of frequencies to 10,000 MHz and higher for long-range communications, thus providing more than 1,000 times the spectrum available in the HF band.

Flexibility

One need is to provide sufficient flexibility in systems so that new or changing demands can be satisfied without major overhaul or replacement of facilities. A disadvantage of submarine cable, for instance, is lack of flexibility because it is a fixed-plant facility. Limitations on the flexibility of other systems include the physical size of equipment, criticality of the troposphere, and microwave antenna aiming points and power needs. Satellite communications systems provide a high-degree of flexibility for several reasons:

(1) They have wide bandwidths that allow versatility in traffic handling capabilities.

(2) They are flexible in positioning or location because of their compact size.

(3) By providing wide bandwidths and essentially global coverage, they place minimum restraints on the number and location of ground stations served and the volume of communications sent to each.

Also, the use of solid-state devices and modular construction places minimum power requirements on systems. Usually, all terminal power can be supplied by small, mobile power generator plants, an advantage that further broadens system flexibility.

Delay

Speed of communications is a must. All too frequently, delays are caused by poor propagation conditions. Weather, solar flares, and other atmospheric phenomena can totally disrupt normal communications links. When compounded by congested facilities, they cause delays in the transmission of urgent message.

Satellite systems designs have done much toward overcoming delay problems. Wide bandwidths have relieved traffic congestion by providing the capacity for many users simultaneously. The use of microwave frequencies and LOS principles have negated propagation problems. The ability to locate systems at sites convenient to users has ended or greatly reduced delivery delays.

Limitations

To understand the capabilities of space communications more fully, we must consider certain constraints and design limitations.

Natural constraints

The natural constraints that must be considered in space communications systems are listed below:

a. Path profile. An LOS path must be established between the transmitter and receiver.

b. Free space loss. Power radiated from a transmitting antenna is distributed over an everexpanding portion of the Earth’s spherical surface. The resulting decrease in power density (power per unit area) reduces the energy “captured” by the receiving antenna and is known as free space loss. This is the most serious loss in satellite communications.

c. Noise. Noise is introduced at each stage of the communications process. The most significant contributions are from the medium through which communications are sent and from within the receiver itself. Noise reduces the ability of a receiver to detect weak signals.

Design limitations

Some design limitations that must be considered are as follows:

a. Transmitter power. This is a measure of the minimum signal strength with which a receiver can be gainfully operated.

b. Receiver noise figure. The inherent noise injected into a system by the receiver itself constitutes a basic limit on the minimum detectable signal.

c. Bandwith. The bandwidth of a system is limited by many considerations, most important of which is the capacity of a system to transmit data directly proportional to its usable bandwidth.

d. Data processing. Transmitting data into space does not necessarily mean that effective communication will be the result because all data does not represent information. One can find out the effective capacity of a system only by measuring how well transmitted data represents information. In other words, if data is transmitted with errors, there will be wasted energy, therefore, the system will not work as efficiently as it should.

e. Modulation. The effectiveness of a communications system varies greatly with the modulation technique used.

Systems Control and Terminal Equipment

There are several types of terminals in use in the DSCS, each with its own operational characteristics, but they all must adhere to certain operational guidelines. In this section, we will discuss the operational control of the DSCS, the control system of the DSCS, and then take a look at the various terminals the system uses.

Control elements of the DSCS operations control system

DOCS is the system of operational control used in the DSCS. This control system is exercised by the DCA satellite operations division, the area communications operations centers, the DSCS operations centers, technical control facilities, and DSCS Earth terminals. This structure can be seen in figure 4–2.

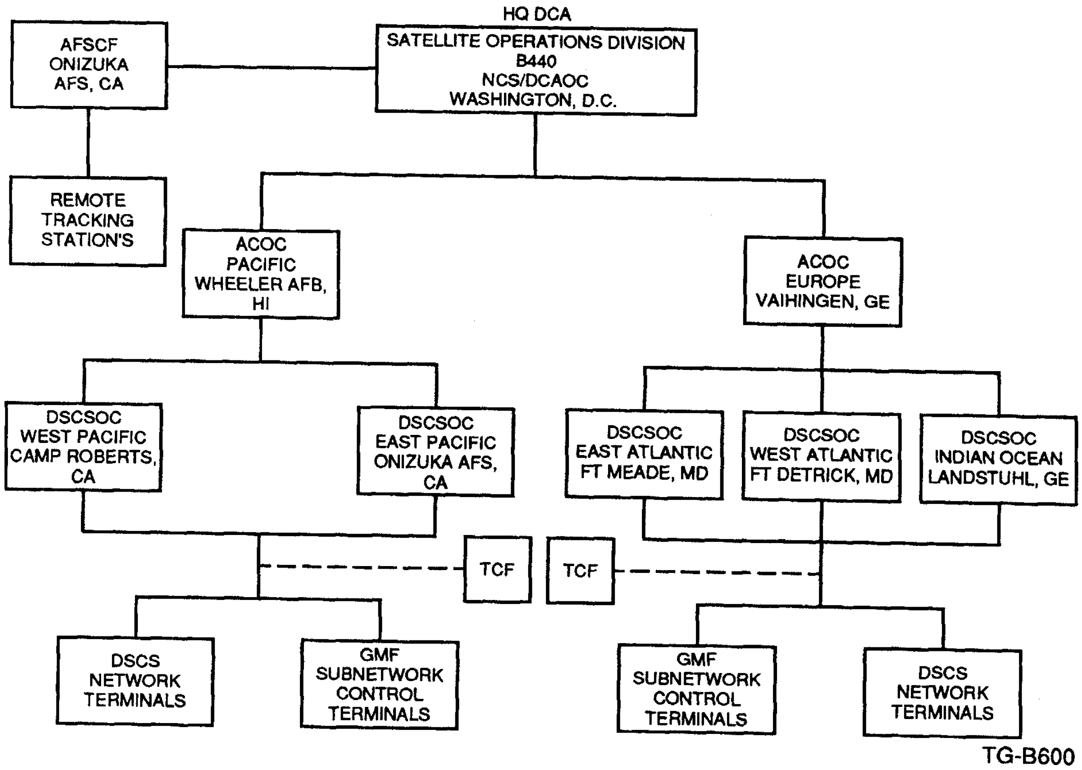

Figure 4-2. DSCS Operations Control System (DOCS).

[figure 4–2]

DCA satellite operations division (Code B440)

B440 is the operations manager of the DSCS within the DCA directorate. One of their responsibilities is to develop and manage a control system (DOCS) that makes sure the DSCS mission and operational objectives are met. The DSCS control authority goes from B440 through the control hierarchy of the NCS/DCAOC and ACOCs to the DSCS operations centers.

DSCS Operations Center (DSCSOC)

The DSCSOCs, colocated with dual-headed Earth terminals, perform satellite communications (SATCOM) network and satellite control. They conduct the daily operation and control of networks associated with chosen satellites under the authority of their ACOC. The DSCSOCs also provide operational direction of Earth terminals and satellite payloads by using DOCS equipment to maintain correct network parameters.

DSCS earth terminals

Earth terminals, or network control terminals (NCT), are operated and maintained by the military departments (MILDEP) and are a key element in the control process. NCT personnel perform the DOCS function by monitoring, measuring, and maintaining performance standards of terminal equipment, and by reconfiguring and adjusting operating parameters in response to direction from the DSCSOCs. Execution of all terminal operations is coordinated with the local TCF and/or the DSCSOC, as appropriate.

Technical control facility

TCFs support the DOCS by coordinating with NCTs and the DSCSOCs for channel fault isolation, corrective action, and channel activation or deactivation.

DSCS systems control

DSCS systems control

DSCS system control is an inherent part of the DCS control structure (fig. 4–2). Systems control will be exercised at the lowest level consistent with authority and resources. It is the means by which DSCS assets are used to maintain and restore maximum DSCS performance under changing traffic conditions, natural or manmade stresses, disturbances, and equipment disruptions.

The basic aspects of systems control include the timely acquisition of systems performance data, facility and satellite load status, and service quality indications. It also includes rapid analysis and processing and display of information to include real-time data base management. Decisionmaking and control execution are a major emphasis of systems control. It takes into consideration the support of long-range systems management and engineering objectives.

Planned and reactive changes

The DSCS has two methods for making changes to the systems it manages: planned and reactive. Planned changes are caused by management decisions on reconfiguration of DSCS subsystems and are based on a variety of engineering factors or on operational performance analysis indicators. Reactive changes are in response to disturbances, such as equipment failures, system outages, circuit degradation, or unusual traffic demands.

The systems control design supports DCA and the MILDEPs in the performance of their DSCS activities. Also, it builds on the inherent monitoring and control features of major satellite facilities to help DCA in the execution of its network administration and management activities.

Systems control objectives

The primary objectives for DSCS systems control are to:

a. Make sure of critical subscriber and system connectivity.

b. Make sure that systems control reacts quickly and flexibly, but in such a way as to impose no operational constraints on the system.

c. Incorporate a level of control and systems management survivability consistent with the survivability of the DSCS.

d. Make sure of sustained quality service through timely, effective testing and analysis in both normal and stressed environments.

e. Make sure of interoperability or compatibility with the control systems associated with other communications systems.

f. Increase DSCS efficiency.

g. Improve management visibility of availability status, quality of service, and performance of the DSCS.

h. Make operation and maintenance activities easier at DSCS stations.

i. Decrease manpower resources and support information required for control.

The Air Force satellite control facility

Air Force Satellite Control Facility (AFSCF)

The Air Force has responsibility for launching DSCS satellites and, as mentioned in Volume 1 of this course, the AFSCF is under the operational direction of the Department of the Air Force and performs telemetry, tracking, and control of all satellites in the DSCS. It has the responsibility of keeping satellites in their assigned orbital positions, maintaining the prescribed altitude relative to Earth, and supporting the housekeeping functions necessary to make sure of optimum operations.

Though the AFSCF is not really a part of the DSCS control structure, it must coordinate all of its actions with the right DSCSOCs, as well as with B440. As you can see in figure 4–2, the AFSCF has a worldwide network of remote tracking stations (RTS), which supply a constant status of all DSCS satellites. The AFSCF is located in Onizuka AFS, California.

Terminals used in the DSCS

At present, four types of terminals are used in the DSCS:

(1) AN/FSC–9.

(2) AN/MSC–46.

(3) AN/FSC–78.

(4) AN/GSC–39.

AN/FCS–9

The AN/FSC–9 is a fixed terminal maintained by the Army. There is one located at Ft. Dix, New Jersey, and one at Camp Roberts, California. They are the primary entry points to the continental United States for the Pacific and European satellite communications links. They are both nodal stations.

AN/MSC–46

The AN/MSC–46 has a misleading nomenclature. It is a heavy air transportable terminal, not a mobile terminal as the “M” (in MSC–46) would lead you to believe. This system is an SHF system with most of its equipment sheltered in vans. Five vans make up the system (fig. 4–3):

(1) Operations control van (OCV).

(2) Maintenance van.

(3) Transmitter van.

(4) Storage van.

(5) Multiplexer van.

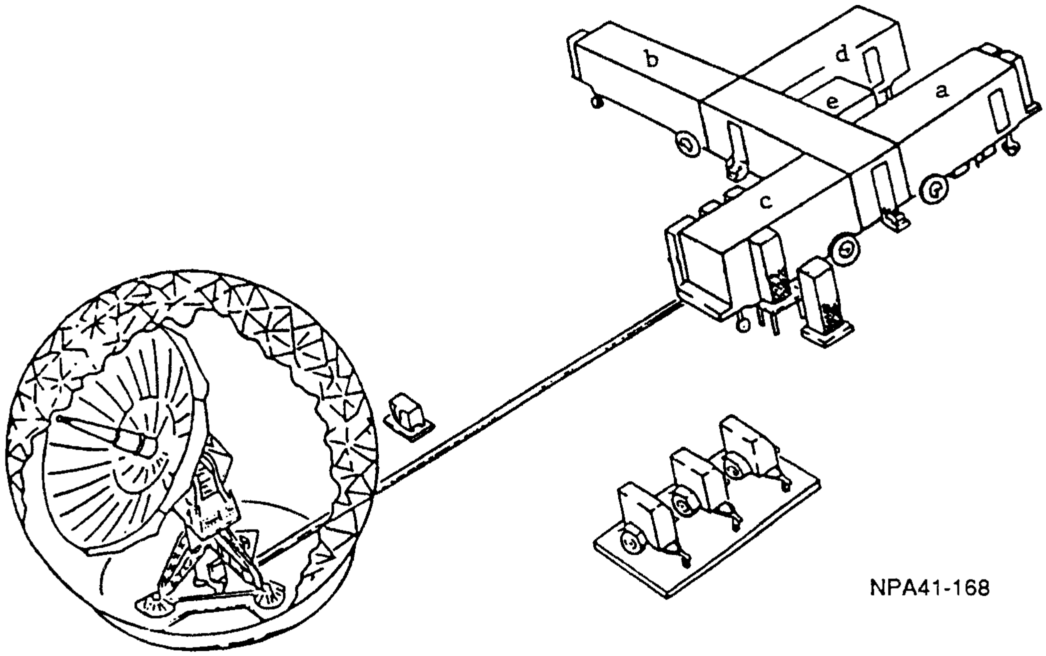

Figure 4-3. AN/MSC-46.

[figure 4–3]
The antenna is transportable on an antenna trailer, often called a “bogey.” Most installations have a radome surrounding the antenna to protect it from the weather.

Frequency range

The terminal has two power amplifiers. The high-power amplifier is a klystron with a maximum power output of 10kW (70 dBm). The low-power amplifier uses a traveling wave tube (TWT) and has a maximum power output of 2.5kW. Only one may be selected at a time.

Antenna system

The AN/MSC–46 uses a 40-foot paraboloid reflector for its antenna. Gain is approximately 57 dB at 8 GHz.

Tracking

This system tracks satellites manually, through the use of elevation and/or azimuth handwheels, or automatically. In the manual method, the operator/maintenance technician uses inputs to a servosystem to adjust the antenna position for maximum signal strength from the satellite. In the “autotrack” (automatic tracking) mode, the terminal will use the satellite’s beacon frequency to fine-tune the antenna position.

Link and channel capability

AN/MSC–46 terminals consist of a maximum of 9 uplinks (transmit) and 15 downlinks (receive). They were originally configured to be either nodal or nonnodal systems with different FDM multiplexer vans; however, most have been reconfigured to use a digital subsystem van.

There are several MSC–46 terminals located around the world being operated and maintained by the using service. Presently, the Air Force has MSC–46 terminals at Diyabakir, Turkey; Humosa, Spain; and Misawa, Japan. These can be used in either a nodal or nonodal configuration, depending on the requirements of the communications link.

AN/FSC–78

AN/FSC–78 terminals are an updated version of the AN/MSC–46. It is a fixed SHF system using phase II and III satellite repeaters.

A typical layout of an AN/FSC–78 consists of an antenna group, a communication/transmitter (C/T) equipment building, and an interfacility line trench connecting the two structures.

Frequency range

The frequency range of the AN/FSC–78 terminal is identical to that of the AN/MSC–46: receive frequencies are 7.25 to 7.75 GHz, and transmit frequencies are from 7.9 to 8.4 GHz.

Output power

The terminal has two 5kW TWT power amplifiers.

Antenna system

The AN/FSC–78 has a 60-foot parabolic reflector that works with a 7-foot hyperbolic reflector to form a Cassegrain feed system. Gain is approximately 60 dB at 8 GHz.

Tracking

Satellites may be tracked manually, through the use of elevation and/or azimuth handwheels, or automatically. In the manual mode, the operator/maintenance technician uses the inputs to a servo system to adjust antenna position for maximum signal strength from the satellite. In the autotrack mode, the terminal uses a satellite beacon frequency to fine tune antenna position.

Link and channel capability

AN/FSC–78 terminals consist of a maximum of 9 uplinks (transmit) and 15 downlinks (receive).

These terminals are located at the following sites:

a. RAF Croughton, England.

b. Elmendorf AFB, Alaska.

c. New Boston, New Hampshire.

d. Onizuka AFS, California.

e. Offutt AFB, Nebraska.

AN/GSC–39

The AN/GSC–39 is a medium-traffic, fixed terminal. It is made up to two major equipment groups: an antenna group and a communications equipment group. The communications equipment group is contained in two vans, the transmitter and operations vans that, along with a maintenance and supply van, provide all terminal support.

Frequency range

Frequency range for this system is the same as for the MSC–46 and FSC–78.

Output power

This terminal has two 5kW TWT power amplifiers.

Antenna system

A 38-foot parabolic main reflector provides high-gain, narrow-beam radiation of RF energy.

Tracking

The antenna has an autotrack capability that enables it to move from <196>2.5 to +92° in elevation.

All terminals in the DSCS have spread spectrum and antijam capabilities. Multiple access of satellites is done using frequency division techniques.

Associated Networks

There are many networks that use the satellites of the DSCS. Some of them are under the direct control and operational direction of DCA, and others are operated by the military departments. We will discuss two of these, the ground mobile forces network and the Air Force Satellite Communications System.

Ground mobile forces

Purpose and applicability of ground mobile forces

The US Army first made satellite terminals for its GMF to provide access into the DSCS. As the name implies, GMF terminals were designed specifically for military use in tactical communications. These terminals are capable of entry into the DCS during crises through a network of DSCS gateways. They augment other mobile communications systems and provide the quick reaction ability needed to support tactical mission.

Gateway station

Gateway stations provide the deployed tactical community with the ability to extend their communications capabilities from a point-to-point mode to an intratheater or intertheater mode. There are 15-gateway stations.

Terminals

All GMF terminals operate in the same frequency range as the four DSCS terminals, and all include an automatic tracking 8-foot diameter antenna mounted as an integral part of the equipment enclosure. They are completely self-contained and designed to provide a full communications ability within 20 minutes of arrival at a deployed location. There are two terminals being used by the Air Force: the AN/TSC–94 and the AN/TSC–100.

AN/TSC–94

The AN/TSC–94 has all equipment necessary for the reception, transmission, and processing of multiplexed voice channels. It is used for point-to-point operation in tactical communications systems and is capable of simultaneous transmission and reception of a single high-rate carrier. The terminal consists of receive, transmit, antenna, power, and distribution groups. Also, it has an environmental control unit (heating and air-conditioning) for personnel comfort.

The AN/TSC–94s 8-foot dish must be built on-arrival at the deployed location. It can then manually track satellites using switches on the antenna control panel, or track automatically through a method known as random step scan. This terminal can track either the satellite beacon or the communications signal. However, because the autotrack system can adjust the antenna only +12.5°, antenna movement is limited.

There is an output power capability of 500 watts through one klystron. The terminal has a single uplink and downlink, providing a total of 12-voice channels and 1-voice orderwire.

AN/TSC–100

The AN/TSC–100 is picked for single- or multiple-carrier service with single- or dual-tracking antenna. The terminal is composed of three major components (fig. 4–4). They include an S–280-type shelter, housing all of the terminal electronics except for the receiver low-noise front end, an 8-foot ground-mounted parabolic antenna system, and a diesel-powered generator and associated switch gear to provide primary power. The terminal can also operate with a 20-foot antenna.

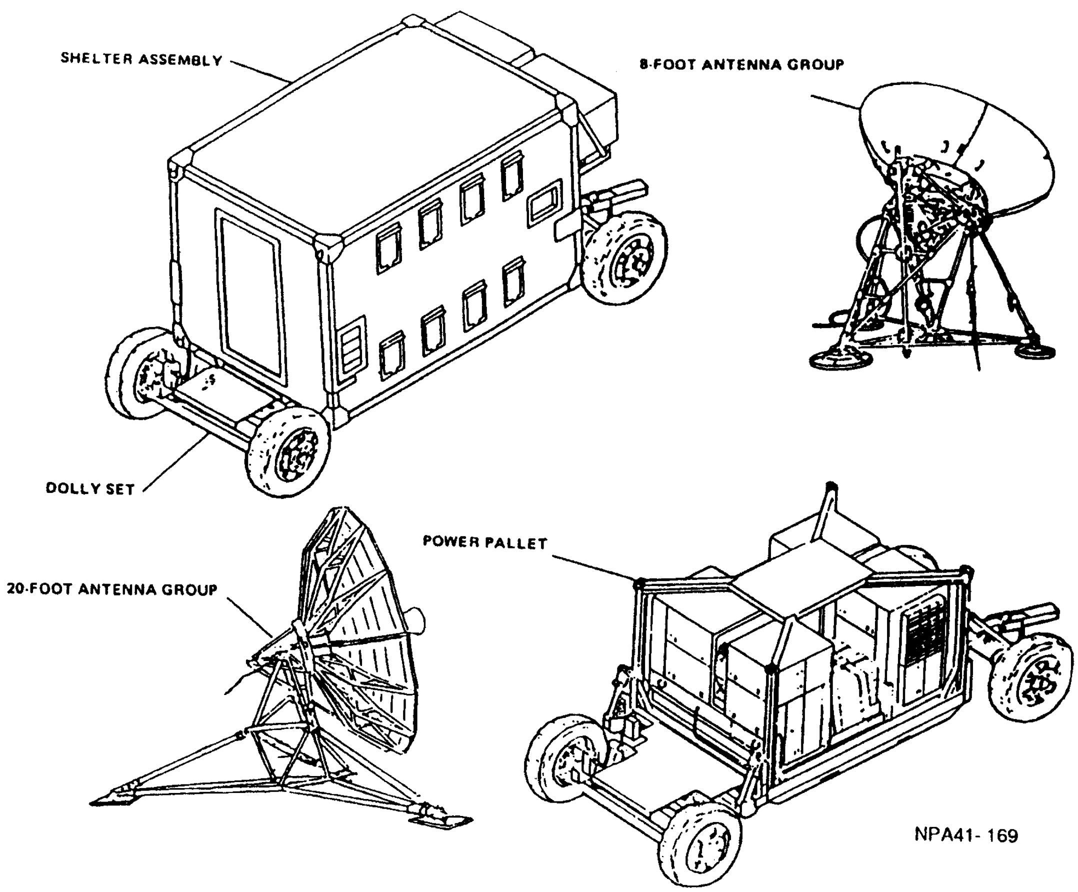

Figure 4-4. AN/TSC-100.

[figure 4–4]