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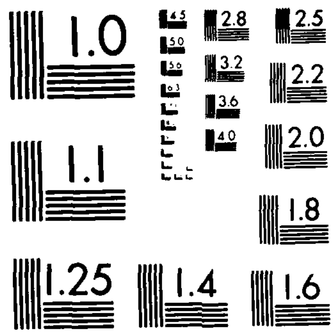

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COMMERCIAL SATCOM INTERCONNECTIVITY (CSI) SYSTEM DESCRIPTION

FINAL REPORT
November 1986

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COMMERCIAL SATCOM INTERCONNECTIVITY (CSI)

SYSTEM DESCRIPTION

November 1986

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CHAPTER 1

INTRODUCTION

The Commercial SATCOM Interconnectivity (CSI) program has been developed in response to national policy objectives, which recognize the extent to which the Federal Government relies on commercial communication capabilities in general and on commercial satellite systems specifically. The CSI System Description will describe how the CSI program responds to those national policy objectives and will present a technical description of the system that is being planned and implemented.

1.1 PURPOSE OF CSI NETWORK SYSTEM DESCRIPTION

This system description is intended to provide the top-level technical document describing the CSI system at full operational capability (FOC). The system description specifies the mission, requirements, concept of operation, overall system performance, and a description of the various elements of the CSI network. It does not address the implementation of the various stages of CSI leading to FOC, nor any CSI implementation that may come about after FOC.

1.2 BACKGROUND OF THE CSI PROGRAM

The CSI program evolved from the recommendations of the National Security Telecommunications Advisory Committee (NSTAC) and National Security Decision Directive 97 (NSDD-97).

The NSTAC was formed at the request of President Reagan and was formally announced in Executive Order 12382 on September 13, 1982. It consists of the chief executive officers of 27 of the largest telecommunications companies in the United States. The purpose of the NSTAC is to advise the President with respect to the implementation of the National Security Telecommunications

Policy as reflected in NSDD-97 (formerly Presidential Directive, PD-53).

NSDD-97, which was issued June 13, 1983, promulgates the policy that the surviving and enduring national telecommunications capability comprise Government, commercial, and private facilities, systems, and networks NSDD-97 also specifies that commercial satellite telecommunications resources be enhanced in support of the overall NSDD-97 objectives.

On May 20, 1983, the Commercial Satellite Survivability Task Force of the NSTAC issued a report [Ref. 1] that included recommendations dealing with, among other items:

- communications interoperability among commercial satellite communications networks
- telemetry, tracking and command (TT&C) interoperability among commercial satellites
- emergency plans and procedures to allow coordination of the restoration of commercial satellite communications services
- physical security of satellite control facilities and communications earth stations
- electromagnetic pulse (EMP) mitigation improvements for both satellite control facilities and communications earth stations.

The CSI program has been designed to address each of these areas.

1.3 SCOPE OF CSI PROGRAM

The CSI program is an evolutionary program that is being planned and implemented in phases. The Phase I CSI program, and the subject of this system description, is limited to C-band satellites that have CONUS coverage and that are owned and operated by U.S. companies. The associated earth terminals are limited to those owned and operated by commerical carrier companies. Phase II, which has not yet been fully defined, will encompass the impact of advanced satellite technologies (e.g., Ku- and Ka-bands) and an evolving customer base as well as changes to the Public Switched Network (PSN) and the lessons learned from the implementation of Phase I.

The Phase I program consists of three stages of implementation and a pilot implementation as defined in the CSI program plan [Ref. 2] and shown in Table 1-1. The implementation stages are:

- Pilot implementation
- Initial operational capability (IOC)
- Enhanced operational capability (EOC)
- Full operational capability (FOC).

The capabilities at each stage add to those of the previous stage until the FOC is achieved. Thus, the pilot implementation will provide two enhanced earth terminals and terrestrial connectivity to two PSN switches. The IOC stage will add six more enhanced earth terminals with associated terrestrial connectivity, one low-cost communications terminal, and an interoperable TT&C (ITT&C) site capable of controlling one of the two families of satellites (either Hughes or RCA). The EOC stage will provide five additional enhanced earth terminals with associated terrestrial connectivity. Furthermore, the EOC stage will supply the second low-cost communications terminal and the second ITT&C site capable of controlling the family of satellites not provided for during the IOC stage. Finally, five more enhanced earth terminals and terrestrial connectivity will be provided during the FOC stage. The entire Phase I implementation will remain in effect through 1994 when Phase II is expected to be operational. The extent to which Phase I capabilities will be included in Phase II is yet to be determined.

Table 1-1. Implementation Stages

	1987	1988	1989	1990
ENHANCED EARTH TERMINAL	2	6	5	5
LOW-COST TERMINAL		1	1	
TT&C TERMINAL		1	1	
IMPLEMENTATION STAGE	PILOT			
	IOC			
	IOC	EOC		
			FOC	

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CHAPTER 2

GENERAL SYSTEM DESCRIPTION

2.1 INTRODUCTION

The essential mission of the CSI network is to provide T1 (24 digitally encoded voice channels) connectivity between specific PSN switches in a post-attack environment to provide for long-haul reconstitution of the PSN Toll Network. Figure 2-1 illustrates the basic concept of the CSI network. It shows that surviving C-band commercial satellite capabilities will be used to reestablish connectivity between isolated enclaves of the PSN. This is accomplished by replacing destroyed terrestrial connectivity between PSN switches with satellite links. The C-band commercial earth terminals associated with each PSN switch will require various enhancements to provide the necessary communications interoperability. Also, terrestrial interconnect circuits will be required between the PSN switch and its associated earth terminal. The physical routing of this interconnect must be chosen to avoid areas with high probability of sustaining damage during an attack. For those PSN switch locations for which there is no feasible surviving earth terminal, low-cost communications terminals will be provided.

In order to provide the essential control functions for the satellite that is satisfying the requirement, it is necessary to provide a survivable TT&C capability. This will be accomplished by enhancing an existing TT&C location for each of the two current families of satellites (i.e., Hughes-built satellites and RCA-built satellites). The enhanced TT&C site will be capable of monitoring and controlling any one of the surviving satellites within its family.

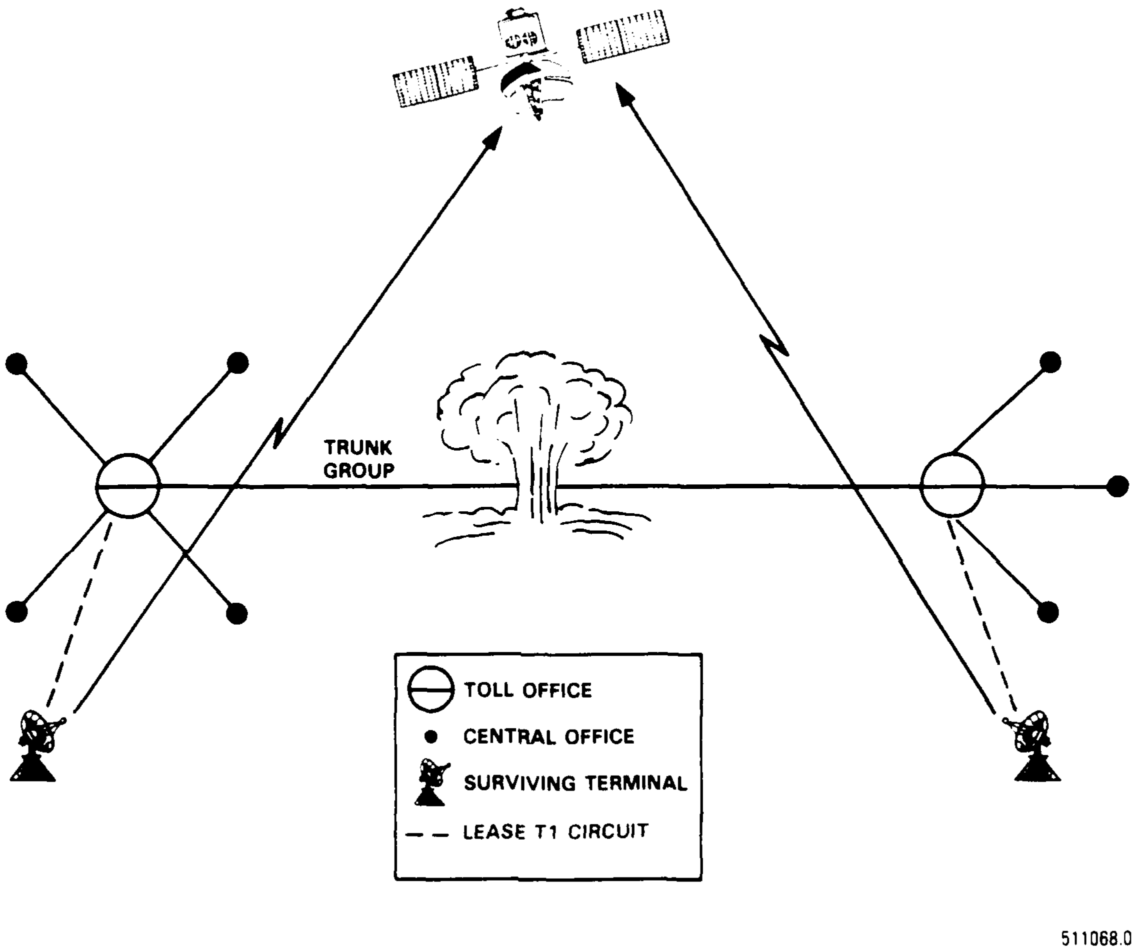

Figure 2-1. Concept of Earth Station/PSN Interconnection

As is obvious from the previous discussion, the CSI network consists of several elements that can be categorized into the following segments:

1. Space Segment - consisting of all domestic C-band satellites with CONUS coverage

2. Ground Segment - consisting of the set of enhanced surviving commercial earth terminals

3. Terrestrial Segment - consisting of the T1 links between the PSN switches and the satellite earth terminals

4. Control Segment - consisting of the set of TT&C sites and an orderwire communications capability between those sites and the earth terminals.

2.2 SPACE SEGMENT

The space segment of the CSI network consists of 18 working C-band or hybrid (C-band and Ku-band) satellites in geostationary orbit in view of CONUS as shown in Figure 2-2. These 18 satellites are owned and operated by five different companies. However, all of these satellites are manufactured by only two companies, Hughes Aircraft and RCA Astro-Electronics.

Each satellite contains a number of transponders. Each transponder acts as a repeater and will repeat any received signal the spectrum of which fits within the transponder bandwidth. Five transponders of one C-band spacecraft will be sufficient to meet the anticipated CSI trunking requirements.

The set of commercial satellites providing CONUS coverage resides in an equatorial arc bounded in the west at 146^{o}W longitude and in the east at 62^{o}W longitude. These limits are defined by the Federal Communications Commission (FCC) and result from their minimum recommended antenna elevation angle within CONUS. Each satellite occupies a slot at geosynchronous orbit (approximately 35,900 km) and is separated by a minimum

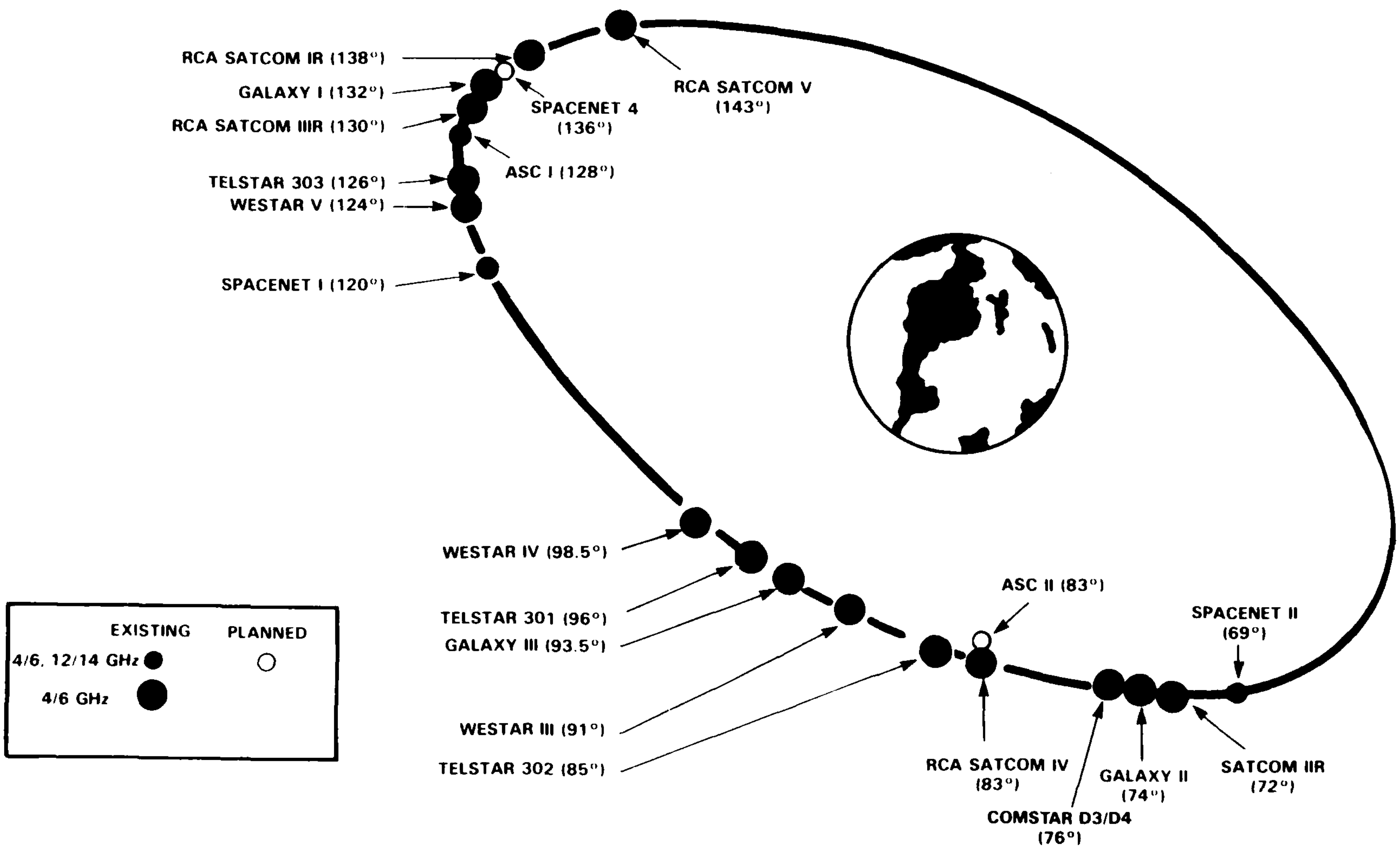

Figure 2-2. Relative Positions of Current and Planned C-Band Commercial Satellites

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arc of 2 degrees from neighboring slots. This location is typically maintained within 0.1 degree of the designated location.

Hughes and RCA currently manufacture all commercial C-band satellites. Hughes spacecraft are stabilized via spin-rotation, whereas the RCA spacecraft are three-axis stabilized. Because of their different stabilization techniques, each class of spacecraft imposes unique requirements for TT&C. Therefore, to provide TT&C interoperability between the two classes of satellites, separate TT&C resources are being provided. Furthermore, different commercial operators generally employ different frequencies and coding techniques for command and control, which impose additional requirements for TT&C interoperability among users of the same satellite class.

The commercial satellites of interest operate in the C-band with uplink and downlink carrier frequencies of approximately 6 GHz and 4 GHz, respectively. Older spacecraft contain 12 physical transponders, each providing approximately 36 MHz of usable bandwidth. Most newer spacecraft, however, employ orthogonal polarization, which effectively doubles the number of transponders that can be accommodated within the specified bandwidth. Hybrid satellites (ASC-1, SPACENET-1, and SPACENET 2) carry both C-band and Ku-band transponders. These hybrids employ 18 C-band and 6 Ku-band transponders.

2.3 GROUND SEGMENT

The CSI program focuses on the use of transmit and receive commerical carrier-owned earth terminals that operate over one of the C-band satellites identified in the previous section. In addition, each earth station must be likely to survive a nuclear attack and be within reasonable proximity to a PSN switch that is part of the CSI network.

The CSI program has established general criteria for the commerical carriers to enhance the required number of up and down chains in each earth station that will be used. The intent is to use the existing radio RF/IF equipment with few enhancements to ensure interoperability to the baseband interface level among the carriers.

Figure 2-3 shows a simplified block diagram of a typical earth station. The number of up and down chains depends on the number of transponders that must be accessed to support emergency traffic. While each transponder can accommodate many T1 trunks, the total CSI requirement will dictate the use of multiple transponders. While most earth terminals will require access to only one transponder, terminals serving PSN gateway switches will require access to multiple transponders.

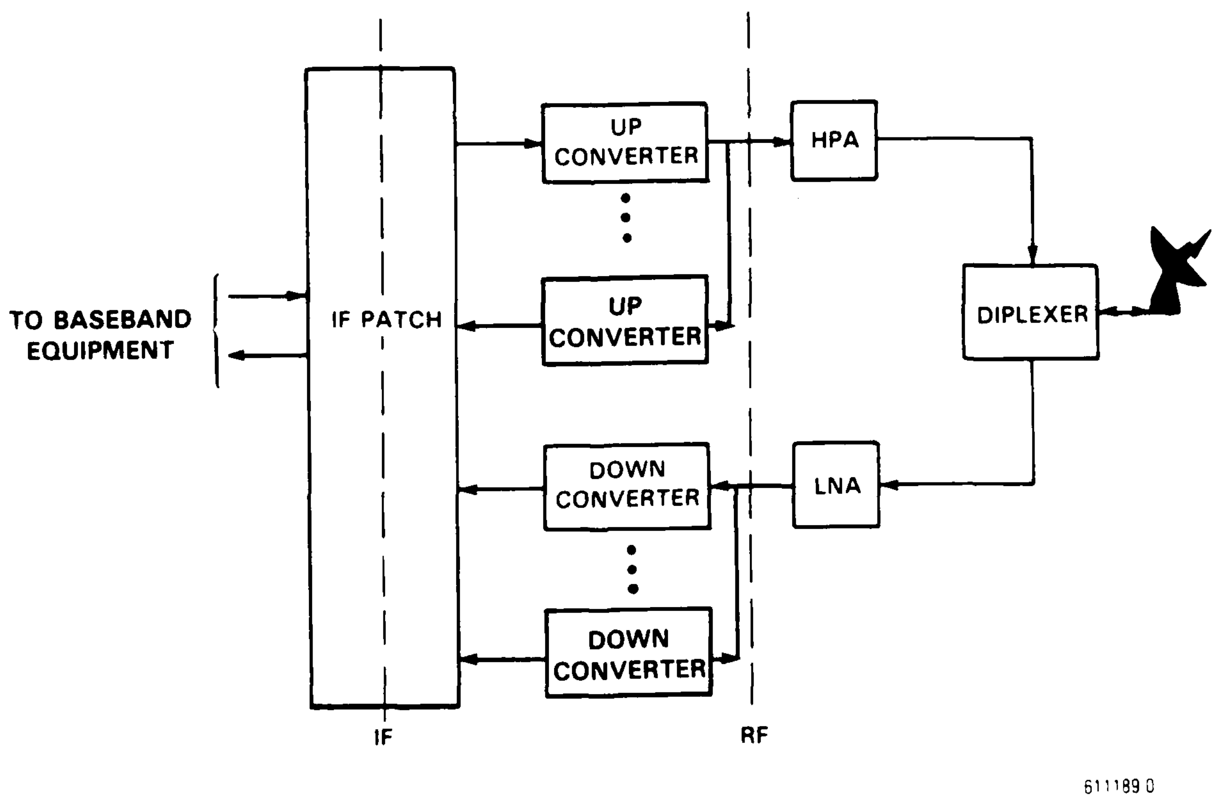


Figure 2-3. Earth Station Functional Area Design

In order to provide baseband interoperability among the earth terminals, "off-the-shelf" T1 modems will be installed. Each modem will provide one end of a full duplex channel between that terminal and a compatible terminal. The modems will be prepositioned, offline at the earth terminal, and will provide the necessary functions to interface between the DS1 signal of a T1 trunk termination and the IF converter equipment at the earth terminal. The modem will be tunable over the entire 36 MHz to cover any possible channel assignment within a given transponder.

2.4 TERRESTRIAL SEGMENT

As noted previously, the PSN switches, which are being served by the CSI network, are located at some distance (from 5 to 100 miles) from the serving earth station. The trunks will be extended from the serving earth station to the PSN switch via terrestrial T1 circuits, the routes of which circumvent areas that are within specified damage areas. Each route will be determined by the service provider and approved by the Government. Each T1 circuit will be pre-engineered and placed in an on-call status. While the circuits will be available for use by the circuit provider for other than CSI uses, they must be available for CSI use for both periodic testing and for emergency use.

2.5 CONTROL SEGMENT

The in-orbit operation of communications satellite systems requires the support of a terrestrial monitoring and control system. The monitoring and control functions can be logically divided into two categories: those relating to actual satellite control and those relating to control of the communications network. These two categories are designated as TT&C and network monitoring and control (NMC).

2.5.1 Telemetry, Tracking, and Command

As indicated in section 2.2, the commercial domestic satellites that are included in the CSI program are of two basic types: spin stabilized (Hughes) and three-axis stabilized (RCA). The control techniques for these two types of systems are not compatible. While a degree of similarity exists within each type, true interoperability does not now exist. The CSI program will provide enhancements to two TT&C earth terminals to provide intrasystem TT&C capability within each of the two families of satellites. The enhancements include both hardware and software. Each of the enhanced locations will be designated an ITT&C location.

The CSI network will include the normal TT&C locations that survive in the post-attack periods. Figures 2-4 and 2-5 show the present TT&C locations for each of the satellites currently included in the CSI network. One location from each figure will be selected as the ITT&C location for that family, while the other locations will augment the capability of the ITT&C location. All TT&C locations are expected to be members of the CSI orderwire network described below.

2.5.2 Network Monitoring and Control (NMC)

NMC for the CSI network will provide the means to assess the availability of space and ground resources and to establish an orderwire communications network among CSI participants. The orderwire system will be an autonomous system using its own earth terminals and a spread-spectrum modulation technology. The system will include up to two hub or master stations located at or in the vicinity of each of the two ITT&C facility locations. Either master station can act as the primary hub with the other as a backup. A network of remote stations will be connected to the primary hub station in a star configuration. These remote stations will be located at each of the

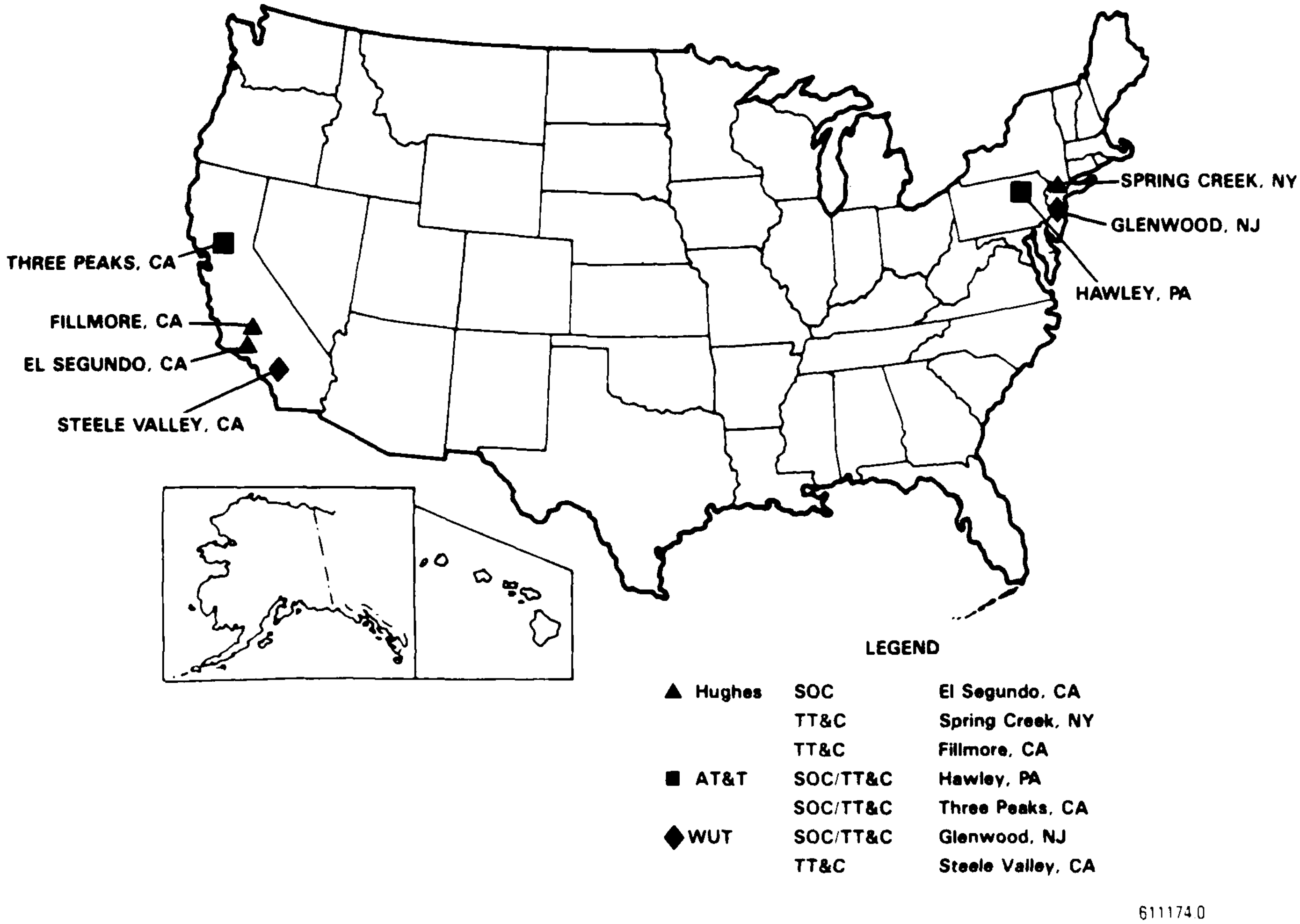
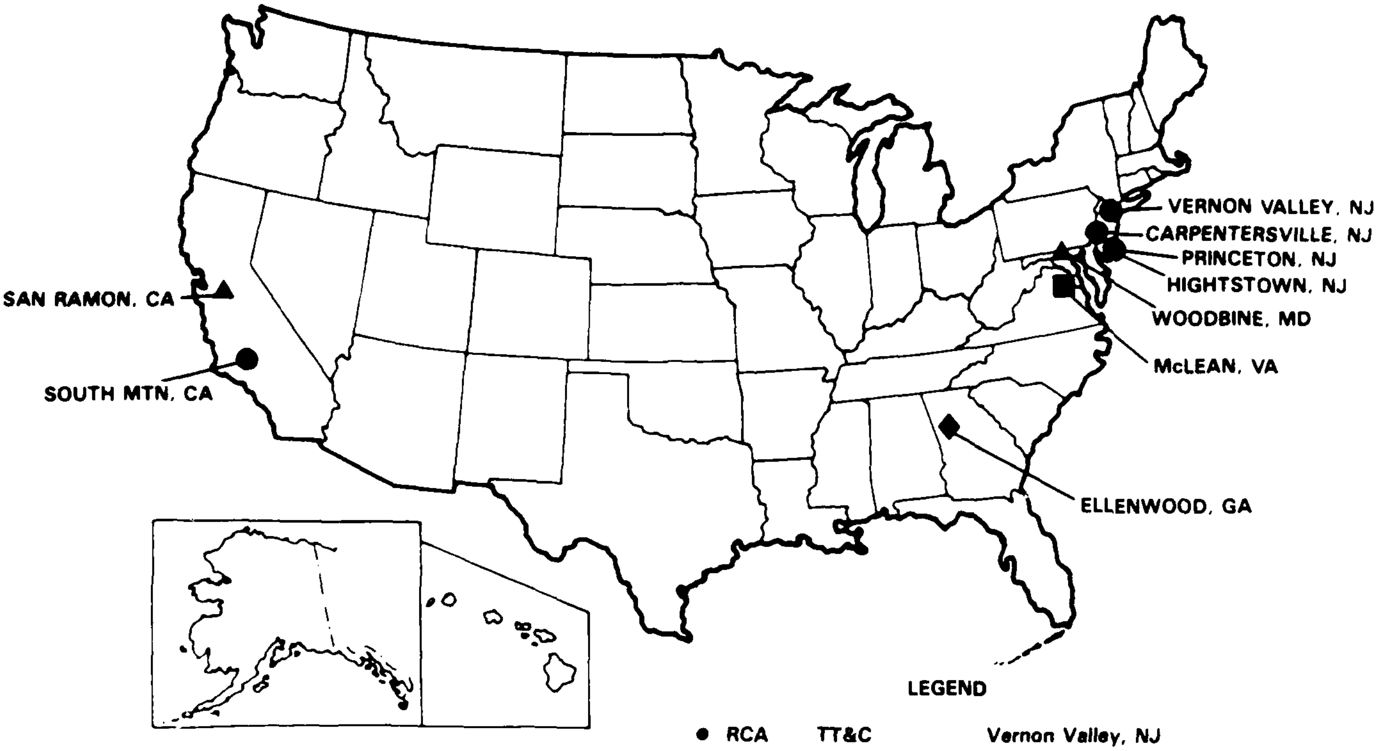


Figure 2-5. TT&C Sites for Hughes-Built Satellites



LEGEND

● RCA	TT&C	Vernon Valley, NJ
	TT&C	South Mountain, CA
	SOC	Princeton, NJ
	ASTRO TT&C	Carpentersville, NJ
	ASTRO SOC	Hightstown, NJ
▲ GTE	SOC	McLean, VA
	TT&C	Woodbine, MD
	TT&C	San Ramon, CA
◆ ASC	SOC/TT&C	Ellenwood, GA

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Figure 2-4. TT&C Sites for RCA-Built Satellites other locations that are part of the CSI network, including the CSI network control center (NCC), the commercial earth stations, and other TT&C locations considered to be survivable. The system is expected to incorporate recent advances in very small aperture terminals (VSATs) technology. The hub station antenna will be relatively large (on the order of 11 meters) with a high transmitter power. The VSATs located away from the TT&C locations will use small antennas (e.g., 1.5 meters) and very low transmitter power.

All orderwire terminals will be capable of pointing to any satellite in the domestic arc and of tuning to any C-band transponder in the satellite. This orderwire capability will be used to establish the CSI network and to coordinate its operation after it is established using a data terminal for input and output of orderwire messages and will operate with a data rate on the order of 1.2 to 9.6 kbps.

CHAPTER 3
MISSION AND REQUIREMENTS

3.1 POST-NUCLEAR ATTACK MISSION

The CSI mission exists in the post-nuclear attack environment as part of a set of national-level initiatives to satisfy National Security and Emergency Preparedness (NSEP) requirements. It relies on a Presidential declaration of a national emergency and the invocation of Section 706 of the Communications Act of 1934. These requirements will be met by establishing an emergency communications network using surviving elements of the public-switched network. The CSI network will establish connectivity between designated PSN switching nodes through the use of surviving commercial satellite spaceborne and ground assets.

3.2 NSEP REQUIREMENTS

The Office of the Manager, NCS, working with each of the organizations of the NCS, has identified the most critical NSEP telecommunications requirements of its members. Reference 3 provides a summary of the requirements data collected by the NCS for each organization. Of particular importance to the CSI program is the fact that over 5000 separate locations with over 18,000 switched voice requirements have been identified in the late trans- and early post-attack timeframe.

3.3 REQUIREMENTS

In a recent analysis of a scenario in which the PSN was damaged by a nuclear attack, 49 switches were determined to survive blast damage. Four of these surviving switches lost all long-haul connectivity to the rest of the PSN. Twelve of the surviving switches had poor connectivity (5 or fewer trunk groups) with the remainder of the toll network, and the rest of the surviving switches (33) had rich connectivity (more than 5 surviving trunk groups). The PSN augmentation concept and thus the CSI requirements provide connectivity between those switches with poor or no connectivity and those which are richly connected. A subset of the switches that survive blast damage and are still richly connected to the PSN will serve as gateway switches for the CSI program. Each disconnected switch requires a connection to each gateway switch. At the present time, it is planned to use four gateway switches, although the choice of which four requires further analysis. Each poorly connected switch will be connected to a subset of the gateways. Present planning specifies each poorly connected switch will be connected to three gateway switches. An exception to the above occurs when it is determined that no currently available satellite earth station can be associated with a particular PSN switch. The solution to this situation calls for the acquisition of a low-cost communications earth station for that switch, and the interconnection to only two gateway switches. This solution is applicable to either disconnected or poorly connected switches. Since earth stations associated with gateway switches will require access to multiple transponders on a satellite, gateway switches must be selected from those where one or more existing satellite earth stations meet the selection criteria. That is, the low-cost communications solution does not apply to gateway switches. Table 3-1 presents a typical network connectivity matrix at FOC for CSI. Figure 3-1 illustrates this matrix on a map of the United States.

Table 3-1. Typical Network Connectivity at FOC

SWITCH	GATEWAYS			
	1	2	3	4
DISCONNECTED				
5	X	X	X	X
6 (LCT)	X	X		
7	X	X	X	X
8	X	X	X	X
9	X	X	X	X
POORLY CONNECTED				
10	X		X	X
11 (LCT)			X	X
12	X	X		X
13	X	X	X	
14	X	X	X	
15		X	X	X
16	X		X	X
17		X	X	X
18	X	X		X
19	X	X	X	
20	X	X		X

LCT-Low Cost Terminal

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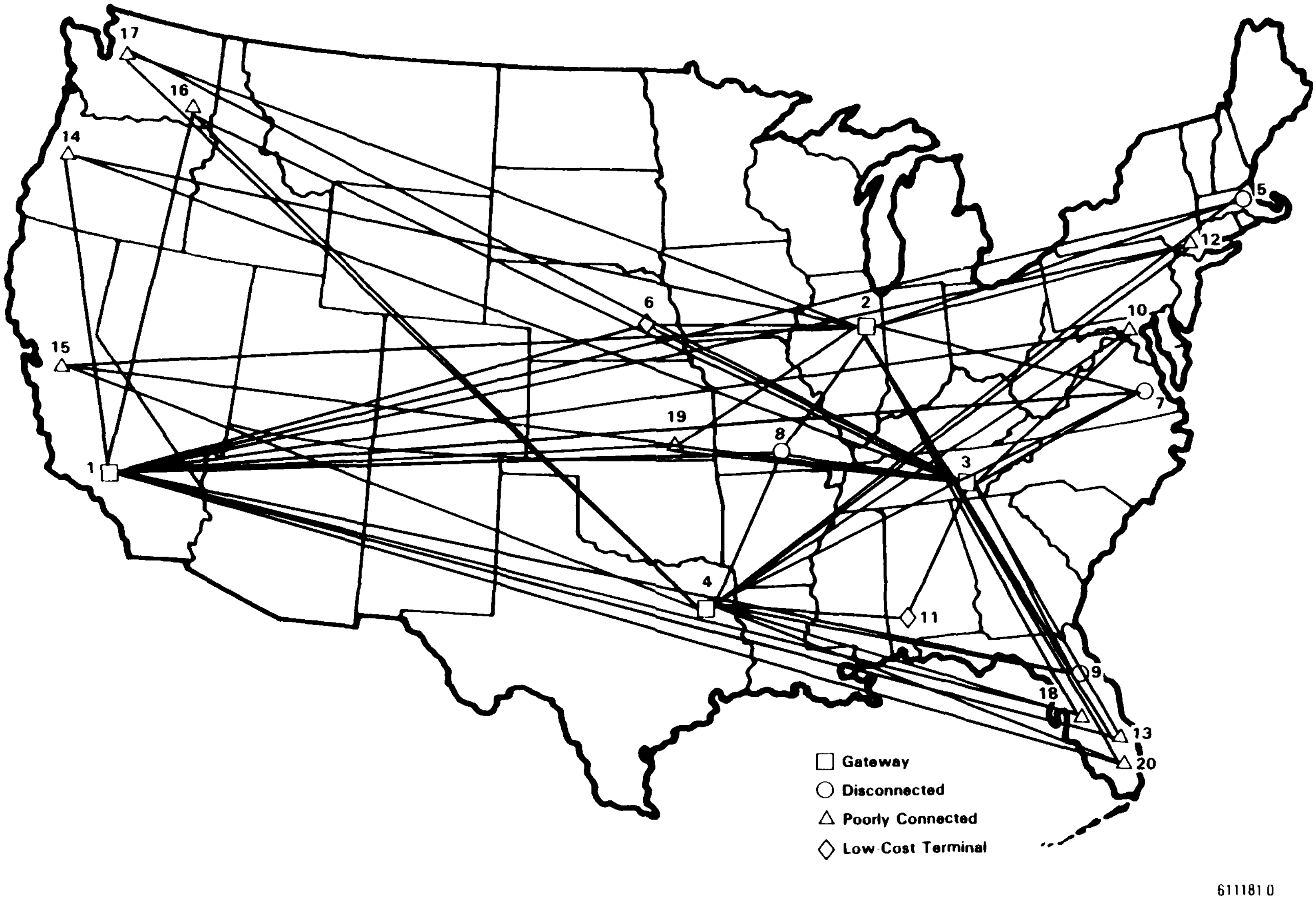

Figure 3-1. Typical Network Diagram at FOC

CHAPTER 4
CONCEPT OF OPERATION

As stated in Chapter 3, the CSI mission exists in the post-attack environment. However, it is highly desirable to conduct periodic exercises and test operations during peacetime conditions. To avoid disruption of commercial traffic during such exercises and test operations, it is necessary to define a separate concept of operations for the post-attack environment and the peacetime exercise environment. The concept defined for peacetime operation must obviously be based on the post-attack concept, with necessary modifications to minimize disruption of normal commercial operations.

In this light, the following sections will first present the basic post-attack concept of operation and then the exercise and test concept of operation.

4.1 POST-ATTACK CONCEPT OF OPERATION

The situation in the post-attack environment is expected to consist of several commercial satellites, communications earth terminals, and PSN switching nodes that have survived along with designated TT&C capabilities and a network control center (NCC) capability. Although the facilities will have survived, they will not be in a configuration that is usable to satisfy the CSI mission. It is in this worst-case configuration that the CSI network must be activated.

The decision to employ the CSI network, following declaration of a national emergency and invocation of Section 706 of the Communications Act of 1934 by the President, must be made and the participants notified. The notification will take place outside the boundaries of the CSI network, possibly through a message sent over the Emergency Broadcast System (EBS) or other means. Regardless of the means of dissemination, the personnel assigned to the facilities must be available to receive the notification and to reach the sites involved.

Once the personnel assigned are on location, each site, including TT&C and earth stations, will establish site readiness by assessing damage, determining fuel supply for emergency power, activating back-up power (if required), assessing functional capabilities of the communications equipment on the site, and following the detailed plans and procedures specified for the situation at hand.

Once operational, the two ITT&C sites will begin locating surviving satellites. The ITT&C sites will assess the health and utility of each satellite in their respective interoperable family. This will include rectifying upsets and preparing the satellite so that it is capable of supporting an orderwire communications channel. After selecting a healthy satellite, the ITT&C site will broadcast an emergency coordination message on the transponder chosen for orderwire use. The designated interoperable TT&C site will wait for responses from surviving earth stations and other TT&C sites which have survived.

The surviving earth terminals will establish their site readinesss in the same way as the TT&C site. Then, using the orderwire terminal antenna, each earth station will search for the Emergency Coordination Message (ECM) being transmitted by the TT&C site. After receiving the ECM, the earth terminal will report the fact of its survival and other pertinent status information to the TT&C site.

When instructed by the TT&C site, the earth terminal will be informed which satellite to use for establishing the CSI network. After receiving this information, the earth terminals will repoint antennas.

Once all earth terminals are pointing to the same satellite and the NCC has verified the required T1 connectivity, this information can be passed over the orderwire and T1 connectivity can be established. The concept intends that the NCC make the decision on connectivity but that the TT&C site direct the activation of the connectivity. This will free the NCC for making decisions and coordinating activities rather than handling the details of circuit activations.

Figure 4-1 depicts the CSI activation activities that will be used as the basis to develop detailed procedures for the various commercial satellite carriers involved in the program. The figure identifies seven distinct categories of actions and a set of procedures associated with each category. The details of these procedures will both affect and be affected by the actual design and capabilities of the CSI system. An iterative process will be used to refine both the operations procedures and the system requirements, particularly in the areas of orderwire communications and network monitoring.

4.2 PERIODIC EXERCISE AND TEST CONCEPT OF OPERATION

The basic concept of operation for exercise and test periods is to operate the system in functional segments rather than as a complete system. The functional segments can be actively operated while operation of the other functional segments can be simulated. The functional segments are communications interoperability, TT&C interoperability, and orderwire.

4.2.1 Communications Interoperability

The concept of operation for exercise and test of communications interoperability is to operate earth stations a pair at a time. Each terminal pair will be required to repoint an antenna to acquire and communicate through a satellite not

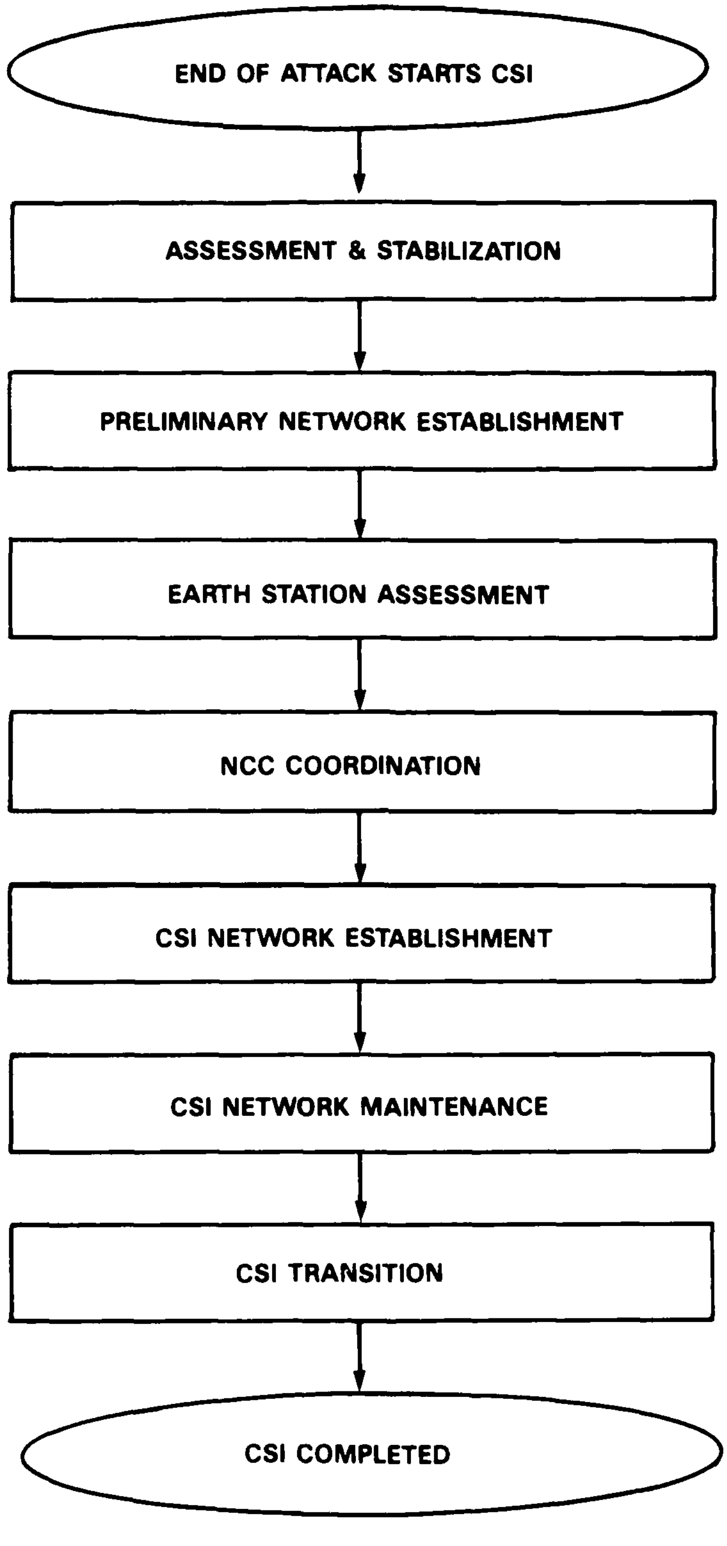

Figure 4-1. CSI Activation Activities

normally used by that terminal, thus exercising the frequency agility, antenna polarization, and antenna pointing capability of the earth station. Performing these functions during periods of scheduled maintenance at each site and coordinating these periods would avoid disruption of service to other customers.

4.2.2 TT&C Interoperability

TT&C interoperability can be demonstrated with no risk to operational satellites by including the normal control site in the process. The concept is for the interoperable TT&C site to receive telemetry and tracking information from the satellite system being tested and to determine what command signals should be sent to the satellite. However, before sending those commands, they would be verified through the normal TT&C site for that satellite. Because all satellites have two TT&C sites during normal operation, scheduling the use of the interoperable TT&C site so as not to conflict with normal satellite TT&C functions should not present a problem.

4.2.3 Orderwire

The orderwire segment is an independent system not tied to any normal commercial operation. Thus, its concept of operation for exercise and test will very closely track the concept for the post-attack environment.

CHAPTER 5
SYSTEM PERFORMANCE

System performance requirements for the CSI network are driven by its primary mission of providing voice-quality interswitch trunks to connect PSN switches in a post-attack environment. The performance specifications relate to the time necessary to establish communications and to the quality of that communications once it is established.

5.1 TIME TO ACTIVATE

As noted in Chapter 3, the CSI network is intended to function in the post-attack environment. The point in time that begins the measurement of the time required to activate the system is at the point when the President invokes section 706 of the Communications Act of 1934. In establishing the design goal for the "time-to-activate" parameter, three distinct phases can be defined: (1) the time required to notify participants that the CSI network is to be activated, (2) the time required to assess station and satellite readiness and to establish orderwire contact, and (3) the time required to actually establish the T1 network among the PSN switches.

Precise values for the parameters have not yet been established. However, based on a preliminary analysis, it has been determined that the first two phases can reasonably be accomplished in 2 to 3 days each and that it should be possible to complete the third phase within hours. Thus a reasonable preliminary value for the time required to activate the CSI system in a post-attack environment is one week.

During exercise and test operations, a different set of activity times comes into play. The first major difference is that activities must be coordinated with the carriers involved to minimize any disruption of normal commercial traffic. The second difference is that the CSI network will not be activated as a total system in this environment. This means that the various components of the system will be exercised independently of each other. The Government (NCS) will schedule a test and exercise period on a yearly basis. Contractors will be provided a minimum of 4 weeks' notification of the precise exercise period. Part of the exercise and test operation will be the demonstration of the time required to activate various components of the CSI system. For example, the time required to activate a single T1 link between two PSN switches should not exceed 4 hours. This includes activating, if necessary, the T1 terrestrial circuits connecting the PSN switch to the earth terminal, tuning modems and RF equipment and aligning and testing circuits.

Figure 5-1 shows a breakdown of the activities that compose the time-to-activate parameter for both an operational system and for exercise and test subsystems.

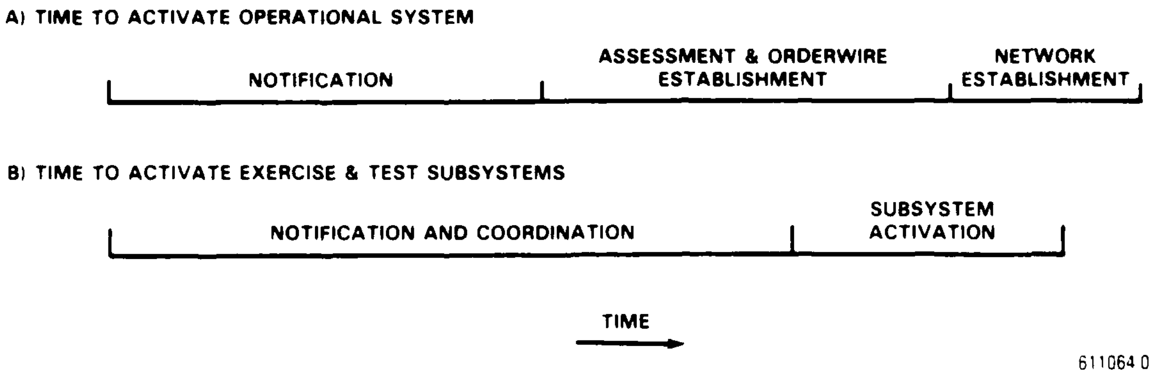

Figure 5-1. Time to Activate

5.2 PERIOD OF OPERATION

The CSI network is intended to be capable of essentially continuous operation during a post-attack emergency period for an extended period of time. Two time periods are specified.

One time period is the amount of time that the CSI network is expected to operate without resupply of consumables or spare parts. This period is 10 days. The other is the amount of time that the system is expected to operate with some degree of resupply provided. This period is six months.

5.3 COMMUNICATIONS QUALITY

To be compatible with T1 trunk performance in the public switched network, the bit error rate for a nominal channel between two earth station T1 modems should be less than 10^{-6}. The error rate should also be less than 10^{-6} for a nominal channel between a PSN switch and the earth station connected to it. This will provide an adequate margin to ensure that the T1 trunk between switches does not reach the 10^{-3} error rate alarm condition, which would automatically cause the trunk to be removed from service. With this in mind, error rate performance for both the satellite link and the terrestrial link will be discussed in the following sections.

5.3.1 Satellite Link Performance

Each satellite link in the CSI network actually consists of two links in tandem: the uplink from the earth terminal to the satellite receiver and the downlink from the satellite transmitter to the earth terminal. The performance of the link is governed by the tandem operation of the uplink and the downlink. Since the objective of CSI is to be able to operate over any remaining C-band satellites, earth station performance must be specified to allow acceptable performance over the worst-case satellite scenario. Thus, it is necessary to determine a minimum required earth station receiver performance and transmitted power for earth stations that will become a part of the CSI network.

5.3.2 Downlink Performance

Since the downlink from the satellite will be power limited due to factors such as available power from space-qualified high-power amplifiers (HPAs) and satellite antenna gain, the earth terminal receiver figure of merit, G/T, becomes the primary variable governing the acceptable performance of the downlink. The minimum figure of merit for the earth terminal receive system can be determined using the following equation:

$$G/T = M + B_o + f + L_{DN} + k + R + E_b/N_o - EIRP_{SAT}$$

where:

M	= margin for losses other than free space loss
B_o	= backoff of transponder needed for linearity (6 dB)
f	= fraction of transponder power allocated to each carrier = 10 log (no. of carriers) = 13.8 dB for 24 carriers
L_{DN}	= nominal free space path loss at 4 GHz (196.3 dB)
k	= Boltzmann's constant (-228.6 dBW/K-Hz)
R	= 10 log (bit rate) = 61.9 dB for 1.544 Mbps
E_b/N_o	= minimum specified for interoperable modem is 7.0 dB
$EIRP_{SAT}$	= satellite effective isotropic radiated power has a nominal value of 34 dBW (Westar, Telstar) or 33 dBW (Comstar and SATCOM)

Substitution of these values into the above equation yields:

$$G/T = M + 6 + 13.8 + 196.3 - 228.6 + 61.9 + 7 - 33$$
$$G/T = M + 23.4$$

A margin of 5 dB or greater indicates acceptable performance. Therefore, G/T must be greater than or equal to 28.4 dB/K for any earth terminal to be considered for CSI.

5.3.3 Uplink Performance

The primary consideration in determining acceptable uplink performance for an existing commercial earth terminal is the availability of adequate transmitter power to provide the required carrier to noise power ratio at the satellite. The transmitter power required at the earth terminal is also related to the effective antenna gain at the earth station. Thus, effective isotropic radiated power (EIRP) is a better measure of performance.

In order to determine the total required EIRP of the earth terminal, it is necessary to first determine the required uplink carrier to thermal noise density, $(C/kT)_{UP}$. The following equations are applicable for determining the required $(C/kT)_{UP}$.

The C/kT required for the total system is:

$$(C/kT)_{TOT} = R + E_b/N_o = 61.9 + 7 = 68.9 \text{ dB}$$

$$(C/kT)_{DN} = (C/kT)_{TOT} + M_{DN} = 68.9 + 6 = 74.9 \text{ dB}$$

For a satellite with a repeater transponder, the $(C/kT)_{TOT}$ can be calculated as follows:

$$(C/kT)_{TOT} = \left[\left(\frac{1}{C/kT}\right)_{UP} + \left(\frac{1}{C/kT}\right)_{DN} \right]^{-1}$$

In order for the uplink C/kT not to degrade $(C/kT)_{TOT}$, a good rule of thumb is: $(C/kT)_{UP}$ must be at least 10 dB greater than $(C/kT)_{DN}$.

$$\text{Thus, } (C/kT)_{UP} = (C/kT)_{DN} + 10 = 74.9 + 10 = 84.9 \text{ dB}$$

The required earth station EIRP depends on the number of carriers that are to be transmitted. It can be calculated from the following equation:

$$EIRP_{ET,\ MIN} = (C/kT)_{UP} + L_{UP} + M_{UP} + k - G/T_{SAT} + B_o + f$$

where:

$(C/kT)_{UP}$ = uplink carrier to thermal noise density
L_{UP} = nominal free space loss at 6 GHz (199.9 dB)
M_{UP} = uplink margin (assumed = 0 dB)
k = Boltzmann's constant (-228.6 dBW/K-Hz)
G/T_{SAT} = nominal value for the satellite receive system figure of merit. Typical values are -5 dB/K (for Satcom, Westar, and Telstar) and -7 dB/K (Comstar)
B_o = transponder backoff (6 dB)
f = 10 log (no. of carriers)

Substituting the above values into the above equation yields:

$$EIRP_{ET,MIN} = 84.9 + 199.9 + 0 - 228.6 - G/T_{SAT} + 6 + f$$

Assuming $M_{up} = 0$ dB, $EIRP_{ET,MIN} = 62.2-(G/T)_{SAT} + f$

Thus, for the worst case satellite (i.e., $G/T_{SAT} = -7$ dB/K), an earth terminal required to transmit 13 carriers would require an EIRP of 80.3 dBW.

5.4 ITT&C PERFORMANCE

The basic performance requirement of the ITT&C subsystem of CSI is that it be capable of operating all of the Hughes and RCA C-band commercial communications satellites. This will be accomplished by designing an add-on capability at each of two survivable TT&C locations, one for each family of spacecraft. Each site must be capable of performing all of the possible actions necessary to meet the following objectives for each satellite that has survived:

1. Establish and maintain a stable operating condition for essential spacecraft bus systems.

2. Test the spacecraft payload to determine which of the transponders are in a usable condition.

3. Configure the spacecraft payload so that it may be used for its intended purposes with minimal degradation.

4. Maintain spacecraft payload so that it may be used for its intended purposes with minimal degradation.

5. Minimize potential damage to the spacecraft in carrying out the basic mission of the system when operated by personnel with minimal training in system operation.

In a normal communications satellite system, the TT&C facility controls a limited set of satellites. Command and telemetry frequencies are consistent with the earth station hardware. Ground hardware is dedicated to each of the satellites in the system. Data bases and command/telemetry lists are limited to the covered spacecraft. Operational procedures cover the specific system requirements. The ITT&C system must perform these functions for all satellites in a given family. The requirements resulting from this increased scope are:

- Each implementation of the ITT&C system must be capable of controlling all covered commercial communications satellites of a particular family. Data bases and command/telemetry lists must be provided and maintained for all covered spacecraft. Operator control inputs and displays must be designed to emphasize the common, functional aspects of spacecraft operation and to minimize focus on the detailed, spacecraft-unique implementation details.
- Hardware, software, and procedure designs for the control of the covered spacecraft must be based on the time-shared use of the ITT&C system hardware.
- ITT&C system hardware must be capable of covering the command and telemetry frequencies of all covered satellites.

In accomplishing the above, the ITT&C system will use existing hardware and software designs to the maximum extent practical. In so doing, there are two key areas where performance requirements must be established. The first area deals with the basic ability of the ITT&C system to communicate with each satellite in a given family. The second area deals with the degree and scope of the automated support provided to exercise actual satellite control.

5.4.1 ITT&C Communications Performance

In order to perform the above functions, the ITT&C terminal must be able to communicate with the TT&C subsystem of each satellite in its family. The system performance requirements listed in Table 5-1 are the minimum requirements needed to assure that each ITT&C site can point to each satellite and have adequate transmitter power and receiver performance to communicate with it.

5.4.2 ITT&C Computer System Performance

The ITT&C System must provide a semiautomated control function. This function should recommend to the operator a

Table 5-1. ITTAC System Performance Requirements

Facilities	
Existing Earth Station	Diesel fuel, food, and potable water self-sufficient for 10 days; all other supplies self-sufficient for 6 months
Activation Time	< 2 days
Earth Station Minimum RF Performance	
G/T	
RCA	31 dB/K (Horizontal and vertical polarization)
Hughes	16 dB/K (Horizontal and vertical polarization)
EIRP	
RCA	87 dBW (Horizontal and vertical polarization)
Hughes	72 dBW (Horizontal and vertical polarization)
Ground Antenna Pointing/Tracking	
Autotracking of spacecraft	Within 0.3 (1σ rms)
Pointing accuracy	±0.03°
Frequency Range	Shall be capable of send/receive at all spacecraft frequencies
Orbital Arc Coverage	
Span	134° W to 74° W
Time to Move Across Arc	10 min
Minimum Elevation Angle	Adequate to view all covered spacecraft
Spacecraft Stationkeeping Accuracy	Shall maintain all covered spacecraft within ±0.15° latitude and ±0.15° longitude

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procedure that will accomplish the system goals. Following operator approval, the control function shall be capable of initiating all other system functions needed to carry out these goals. The initial system implementation should provide the functional capability for semiautomated execution of control procedures. Provision should be made for creating the actual procedures and entering them into the system.

The system must provide a data collection function capable of performing the standard set of basic TT&C data collection operations for all covered spacecraft. This function should provide hardware interface software, tracking data collection (range, azimuth, and elevation), telemetry data collection (bus and attitude data), and payload test data collection. CRT display and hard copy of all data will be provided. The data collection functions must also provide the real-time telemetry signals needed by the spacecraft command function for synchronous jet fire commands.

The ITT&C system must provide a spacecraft status evaluation function that can evaluate the current spacecraft orbit, attitude, and configuration. Based on the current status, this function should return an appropriate course of action to the control function. The status evaluation function shall contain a data base for all status data not obtainable from the spacecraft telemetry. Provisions must be made for updating this data base during peacetime on a regular basis so that the ITT&C location will have the most current data available if it is called upon to exercise control.

The system must include a spacecraft command function capable of generating and transmitting all spacecraft commands and verifying their execution. Command verification information will be obtained from the data collection function.

The system should have a station control function that provides control of the earth station hardware under the direction of the semiautomated control function. Station control shall be able to point the antenna to the desired satellite, select the desired polarization, tune upconverters and downconverters, tune receivers, etc.

5.5 NETWORK MONITORING AND CONTROL

The purpose of the network monitoring and control capability within the CSI network is to provide the means to assess the availability of the space and ground resources and to coordinate the activation and configuration of the network. In order to accomplish these functions, various testing and monitoring capabilities will be required at each location and a means of communications among the locations is required. The CSI orderwire subsystem will provide the coordination capability required and each location will be equipped with test and monitor capabilities. The following subsections discuss the performance requirements for these two areas.

5.5.1 Network Orderwire

A CSI network orderwire will be established using a spread-spectrum signal on a 36-MHz-wide C-band satellite transponder. The key advantage of using a spread-spectrum technique is the flexibility of establishing contact regardless of whether the satellite transponder is occupied by other users.

One potential spread-spectrum network orderwire implementation consists of a surviving TT&C site that would function as a master site (hub) for multiple spokes terminals (i.e., the potentially survivable commercial carrier earth stations and the PSN switches enhanced with low-cost terminals). The hub stations would use a single carrier in a broadcast mode to poll each of the other earth stations for transmission. All spoke terminals could use the same spoke-to-hub carrier.

A typical link budget (shown below) for the network orderwire implementation consisting of a single hub-to-spoke carrier shows a maximum bit rate of approximately 3.4 Mbps can be achieved using a hub station with a 1.8M antenna and multiple spoke stations with 1.2M antennas.

$$R = G/T - L_{DN} - K - E_b/N_o + EIRP_{SAT} =$$
$$9 - 196.3 - (-228,6) - 9 + 33 = 3.4 \text{ Mbps}$$

where:

- G/T = earth station receive system figure of merit, 9 dB/K for 1.2M antenna
- L_{DN} = free space loss at 4GHz = 196.3
- K = Boltzmann's constant (-228.6 dBW/K-Hz)
- E_b/N_o = 9.0 dB for a typical spread spectrum modem
- $EIRP_{SAT}$ = satellite effective isotropic radiated power (33 dBW).

As shown by the equation below, the maximum achievable data rate for spoke-to-hub is 7.2 Mbps assuming all spoke stations transmit on a single carrier.

$$R = R/T - L_{DN} - k - E_B/N_o + EIRP_{SAT} =$$
$$12.3 - 196.3 - (-228.6) - 9 + 33 = 7.2\text{Mbps}.$$

These results were obtained assuming the CSI user was the only user on the transponder. An uncoded BER of 10^{-4} is considered acceptable for the CSI orderwire user.

When commercial users are occupying the same transponder, their effect can be viewed as jamming from the CSI orderwire user's standpoint. The following equation can be used to calculate the tolerable ratio (J/S) of commercial user to CSI orderwire user power in a 10-MHz spread-spectrum bandwidth such that the CSI user can achieve a data rate of 2400 bps.

$$J/S = W_{ss}R_d - E_b/N_o - L$$

where:

W_{ss} = spread spectrum BW - 10 MHZ
R_d = CSI user data rate = 2400 bps
Eb/No =
E_b/N_o = 9.0 dB for a typical spread spectrum modem
J/S = jammer-to-signal ratio
L = system losses, assumed to be 0 dB.

Substituting the values into the above equation, the CSI orderwire user can tolerate a jamming signal up to 27.2 dB greater than its own signal while achieving a data rate of 2400 bps.

Another spread-spectrum network orderwire implementation consists of a single hub-to-spoke carrier with individual spoke-to-hub carriers. Detailed studies are needed to assess the trade-offs and to determine which approach is most desirable.

5.5.2 Testing and Monitoring Performance

Testing and monitoring performance requirements consist of two areas. The first deals with the requirement to closely monitor and control the power transmitted to the satellite by each earth station in the network to assure satellite transponder operation in its linear range. The second deals with the testing and monitoring of the T1 trunks themselves to maintain acceptable error rate performance.

5.5.2.1 Link Power Control

The ITT&C site will be responsible for determining and monitoring the allowable power to be transmitted by each CSI earth station. This requires that the ITT&C site be able to measure the relative power of each carrier. This typically employs a spectrum analyzer capable of tuning to each transponder frequency and displaying the relative carrier power level of each carrier within that transponder. The CSI NMC system should be capable of measuring and controlling transmitted power within 1 dB. Control of transmitted power will actually rest with each earth station; however, it will be the responsibility of the ITT&C location to advise each earth station of the correct transmit power level.

5.5.2.2 T1 Circuit Testing and Monitoring

In order to assure acceptable T1 circuit performance and to correct problems when performance becomes degraded, T1 circuit testing and monitoring capabilities are required at each CSI earth station.

Monitoring is an in-service function that involves observing the T1 circuit while traffic is being carried. Testing is typically an out-of-service function requiring that traffic be removed from the circuit and test data substituted for the traffic. The T1 signal format lends itself to both in-service monitoring and out-of-service testing. The channel service unit (CSU) used to terminate the T1 circuit at the earth station contains certain monitoring capabilities (see section 6.3). Additional monitoring and testing capabilities are required. The precise set of capabilities has not yet been determined. However, Table 5-2 lists a candidate set of requirements.

Table 5-2. Candidate T1 Test Requirements

IN-SERVICE MONITORING	OUT-OF-SERVICE TESTING
Bipolar Violations Analysis ● Bipolar Violations Count ● Violation Seconds ● Percent Violation-Free Seconds ● BPV Rate	Bit Error Analysis ● Bit Errors Count ● Errored Seconds ● Percent Error-Free Seconds ● Bit Error Rate
Signal Quality Analysis ● Excess Zeros Detection ● T1 Frequency (Hz or kHz) ● T1 Signal Level (dBdsx) ● All-Ones Detection ● Jitter Analysis	Timing Analysis ● Clock (Timing) Slip Detection ● Frame Loss Detection Parametric Testing ● Multiple Fixed Patterns ● Multiple Pseudorandom Patterns ● Frequency Variation
Framing Analysis ● D4 Framing Capability ● Frame Errors Count ● Frame Error Rate ● D4 Yellow Alarm Detection ● F_e (ESF) Framing Capability ● CRC-6 Errors Count ● CRC-6 Errored Seconds ● CRC-6 Error Rate ● F_e (ESF) Yellow Alarm Detection ● Frame Loss Detection	

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The most critical factor for out-of-service testing is test equipment compatibility between the two sites performing the test, particularly when fixed or pseudorandom signal patterns sent by one site must be known by the other site in order to perform the specific measurement. For this reason, specific test equipment compatibility requirements will be imposed once specific testing requirements have been determined.

5.6 ELECTROMAGNETIC PULSE PROTECTION

The CSI network is not required to operate through periods of electromagnetic pulse (EMP) disturbances. It is, however, required to operate after EMP resulting from high-altitude nuclear explosion. The precise EMP environment is not specified and, therefore, specific EMP performance criteria have not been specified. However, certain EMP mitigation measures are suggested. A cost analysis on a site-by-site basis is required to determine specific mitigation measures.

The EMP protection enhancements to be provided are not EMP hardening measures. They will, however, result in a higher probability that circuits and functions necessary to support the desired level of operation in a post-attack environment will survive at the TT&C facilities and the fixed earth terminal facilities.

Four primary measures will be used. First, equipment added by the CSI program that is not part of daily facility operation will be maintained in an off-line condition and in a powered-down state. This will provide a high level of protection against EMP-induced damage. The second measure will involve protecting equipment that cannot be maintained in a powered-down state or with all long lines disconnected. The protection measures to be considered include:

- Surge arrestors and/or filters for signal lines
- Filters and isolation transformers on power lines
- Waveguides flanges and RF seals at building waveguide penetrations.

The application of these measures is depicted in Figure 5-2. The third measure is to consider limited separation of selected cables from large cable bundles to reduce electro-magnetic coupling. The fourth measure will involve creating an effective ground plane for each of the facilities. This will reduce the common mode voltage between equipments.

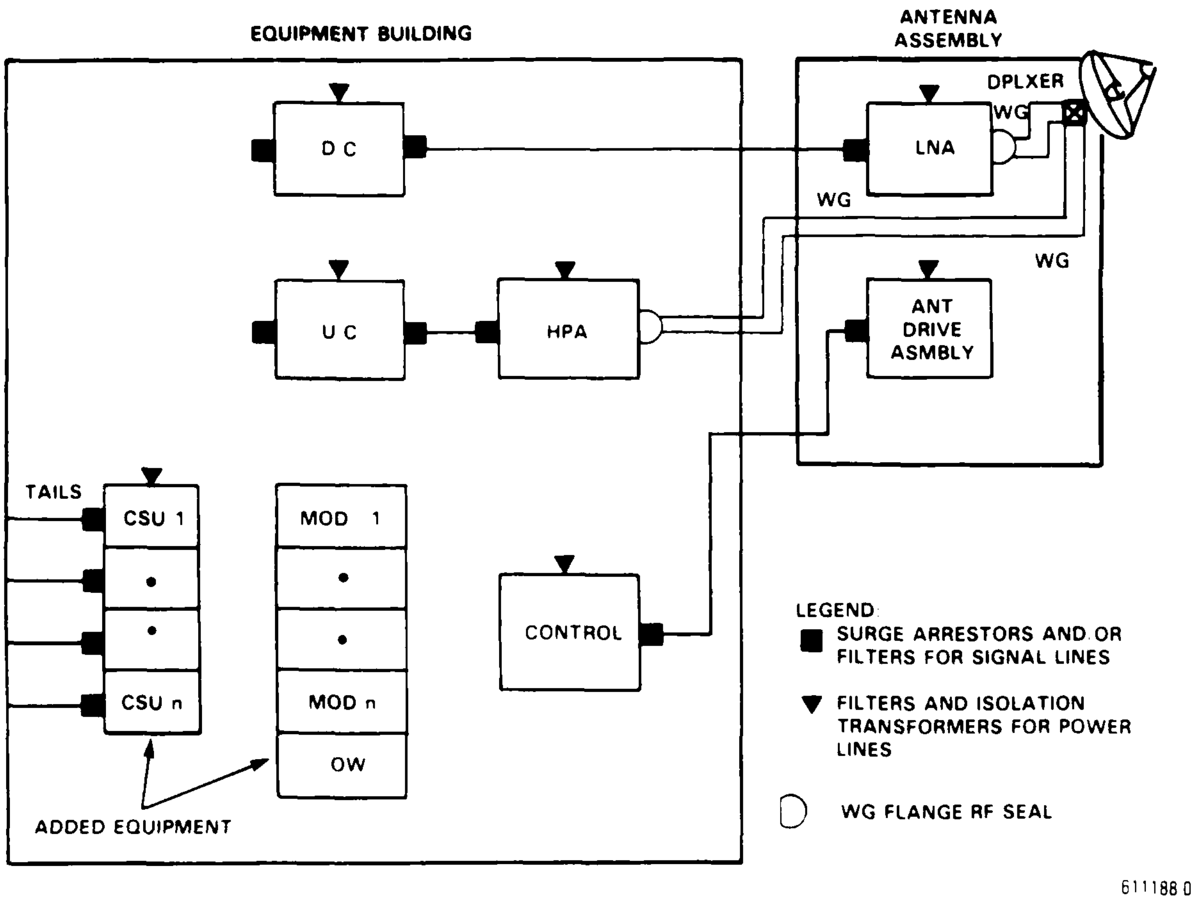


Figure 5-2. EMP Considerations

5.7 PHYSICAL SECURITY

Physical security for commercial satellite communications systems comprises the prevention of disruption or destruction of communications earth stations and satellite control facilities and the unauthorized access to, and control of, satellite systems.

Specific physical security performance criteria have not been established for the CSI program. However, many protective measures are available to implement physical security techniques. All provide varying degrees of physical protection depending on the individual sites they are applied to, and upon which combination of measures are selected for implementation. Although the following list is not all inclusive it displays a sampling of the physical security measures that can be applied to CSI facilities:

- Perimeter and inner fences
- Gates, doors, locks, and other access control devices
- Warning signs
- Sensors
- Guards/patrols
- Security lighting
- Closed circuit television
- Obstacles/barriers
- Waveguide and antenna feed obscurants
- Procedures
- Protective enclosures
- Relocation of equipment.

In addition to these measures, the CSI Program Manager is pursuing measures to include the CSI facilities under either the Federal Emergency Management Agency (FEMA) "National Asset Protection Program" or the U.S. Army Forces Command "Key Asset Protection Program."

The emphasis for the CSI program will be on the ITT&C facilities. Each contractor for each ITT&C location will be asked to identify a comprehensive plan combining physical security procedures and protective measures and to provide cost estimates for varying degrees of protection.

CHAPTER 6
DESCRIPTION OF SYSTEM ELEMENTS

In its FOC configuration, the CSI network will include all U.S. commercial C-band satellites, 18 enhanced commercial C-band earth terminals, 2 low-cost fixed C-band terminals, terrestrial circuit connectivity to 20 selected PSN switches, 2 ITT&C locations and an orderwire and network management capability to control the network. Figure 6-1 depicts these system elements and the following sections describe each element.

6.1 SATELLITES

The satellite to be used during CSI operation will be selected from surviving C-band (3700- to 4200-MHz downlink and 5925- to 6425-MHz uplink) commerical-carrier-owned communications satellites. These satellites are located in a circular orbit above the earth's equator at an altitude of 22,300 miles (35,860 km). Relative to the earth, these satellites appear stationary. Their locations are typically specified by indicating the longitude of the point on the equator directly below the satellite. For CSI purposes (i.e., CONUS coverage), satellites located between 62^{o}W and 146^{o}W longitude are included.

The communications payload aboard these satellites consists of a set of transponders that acts as a simple frequency-translating repeater as shown in Figure 6-2. A typical C-band satellite will contain 24 such transponders, each having 36-MHz bandwidth separated by 4 MHz and using orthogonal polarizations. Some hybrid satellites exist that contain both C-band and Ku-band transponders. A hybrid satellite typically contains 18 C-band and 6 Ku-band transponders. In addition to the primary components of the transponder, the satellite contains additional spare components that can be switched into operation if failure occurs.

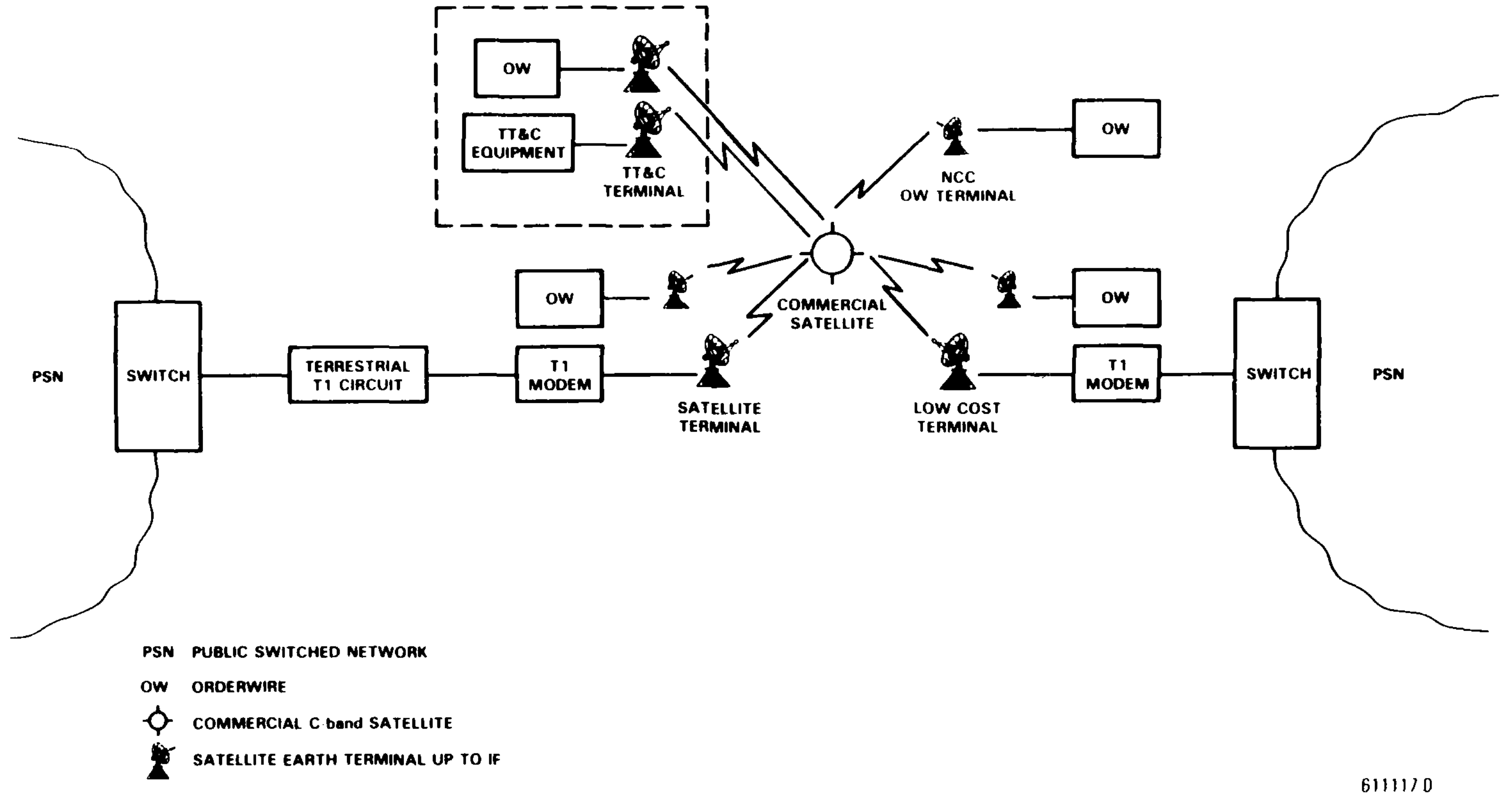


Figure 6-1. CSI System Elements

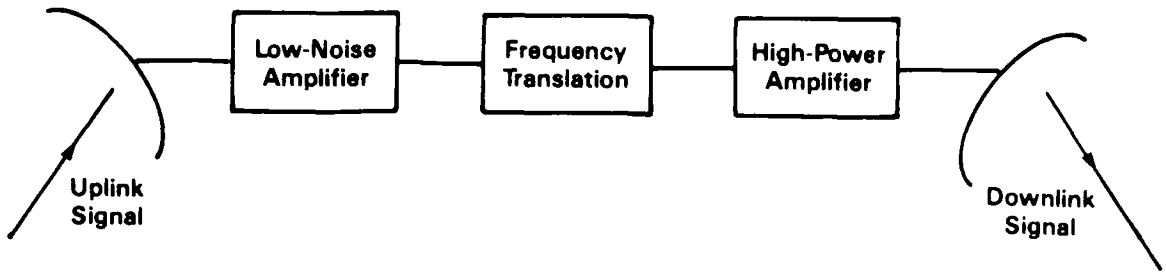


Figure 6-2. Frequency-Translating Repeater

All currently existing commercial C-band transponders (with the exception of Spacenet and ASC) have similar bandwidths (36 MHz usable) and center frequencies. Figure 6-3 shows a typical C-band transponder frequency and polarization plan. Frequency reuse is made practical by using linear polarization separation and by staggering the carriers of the odd and even channels so that only sideband energies overlap. The carriers are staggered to minimize the system noise caused by co-channel transmissions.

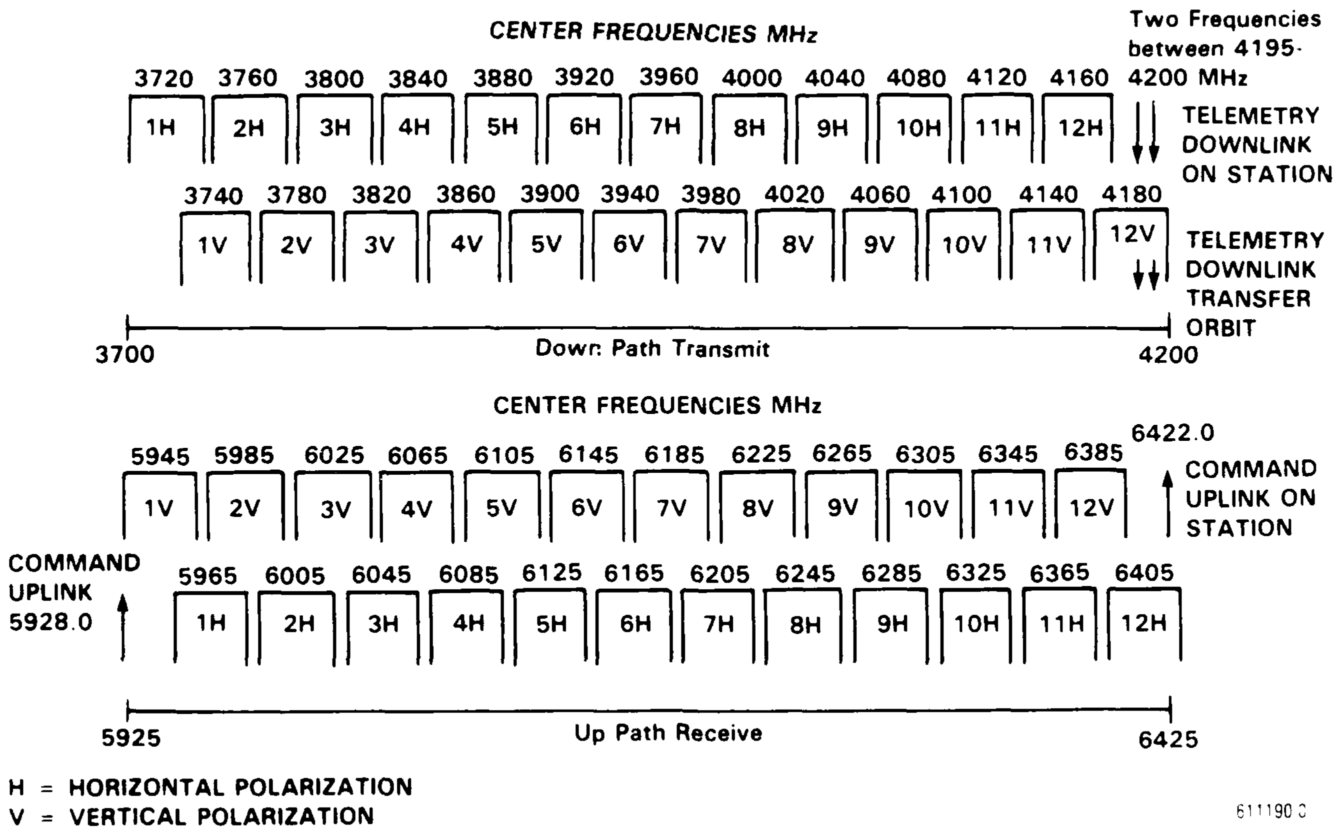
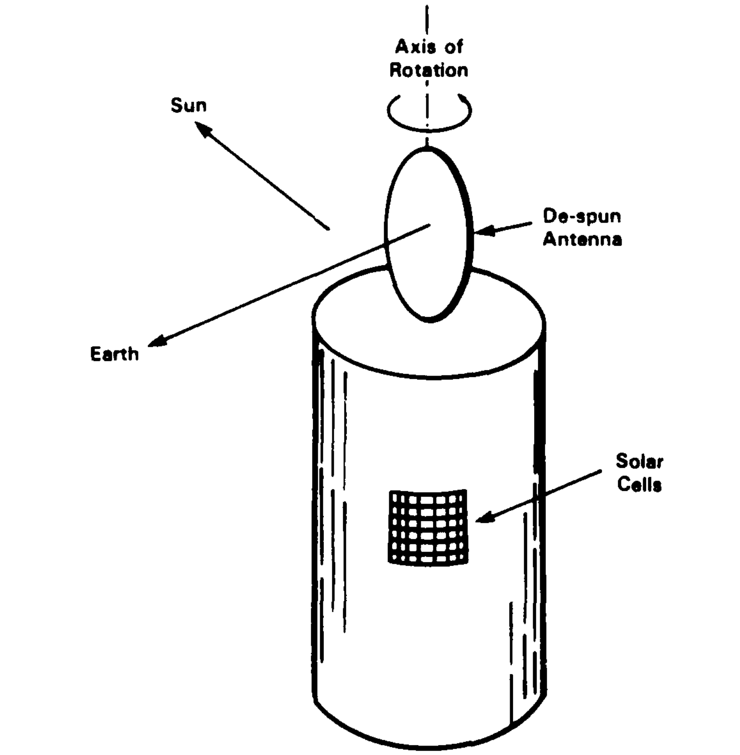


Figure 6-3. An Example of Frequency and Polarization Plan

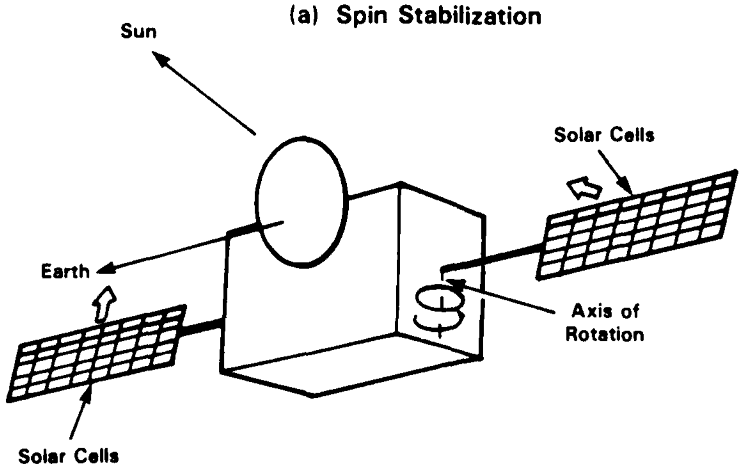
In addition to its communications payload, satellites must provide other functions such as power, stabilization, propulsion, stationkeeping altitude control, and TT&C. Satellite power is derived from arrays of photovoltaic solar cells and rechargeable batteries. Typical power generation onboard the satellite is 1 to 2 kw. A satellite also contains a propulsion system to allow the satellite to move to its assigned position in orbit and to maintain orbit in that position. The propulsion system usually consists of a supply of hydrazine gas with properly placed jets to develop thrust impulses of the necessary size and direction.

The satellite must maintain a precise orientation in space in order for its antennas to be directed toward intended areas on earth and for its solar arrays to be pointed at the sun. The space platform is oriented by defining an axis in space that is established by a rotational motion about the axis. The rotational movement is accomplished by using one or two different types of spacecraft, each produced by one of two U.S. manufacturers: Hughes Aircraft Company and RCA Astro-Electronics. Hughes produces the spin-stabilized type, and RCA manufactures the three-axis stabilized type. Figure 6-4 depicts both types. In a spin-stabilized satellite, the main body of the satellite is cylindrical and spins about the axis. Solar cells cover the cylindrical surface and antennas are mounted on a de-spun platform. The platform maintains an earth-facing orientation that is derived from earth-seeking sensors. In a three-axis stabilized satellite, a spinning momentum wheel within the satellite establishes the same frame of reference as the spinning cylinder, however, the entire spacecraft is effectively the de-spun platform. In this type of satellite the solar cells are mounted on panels external to the spacecraft body allowing them to be oriented toward the sun.

Control of the position, attitude, transponder configuration, etc., is provided by the TT&C subsystem of the satellite. The



(a) Spin Stabilization



b) Three-Axis Stabilization

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Figure 6-4. Satellite Stabilization

telemetry portion of the subsystem provides a data stream to the ground that reports on each of the satellite subsystems, independent of any other communications link. For example, if a transponder has failed, the telemetry data contains information that permits diagnosis of the cause of the failure. The command portion permits the satellite configuration to be modified or the satellite position to be altered. The satellite contains both a transmitter for telemetry only and a receiver for command only. The designated TT&C earth station contains the necessary equipment to insert commands, receive and interpret telemetry, and compute orbital parameters. It can track the position of the satellite either by using a special beacon signal on the spacecraft or by inserting tracking tones through the main communications system.

The following satellite systems use spin-stabilized spacecraft: Comstar, Galaxy, Telstar, and Westar. The Comstar satellite system was developed by COMSAT General Corporation and leased by AT&T and GTE Corporation. Telstar, developed and operated by AT&T, is a replacement for the Comstar system for AT&T long-line satellite communications services. The Galaxy spacecraft are owned and operated by Hughes Communications, Inc. The Westar domestic communications satellite system is owned jointly by Western Union Telegraph Company and American Satellite Company; Western Union is the system manager. These systems operate in the C-band frequency range (6/4 GHz).

Satcom, Spacenet, and ASC are three-axis stabilized satellite systems. Satcom is a C-band system owned and operated by RCA Americom. Spacenet is owned and managed by GTE Spacenet Corporation. It is a hybrid system with spacecraft that operate in both C-band and Ku-band (14/12 GHz). ASC is a hybrid satellite system intended to augment the communications service provided to American Satellite Company by the Westar satellites. Table 6-1 is a summary of the current C-band satellite systems.

Table 6-1. Current C-band Satellites

SATELLITE	FCC CALL SIGN	LOCATION (LONGITUDE, DEG. W)	NUMBER OF TRANSPONDERS	EIRP	LAUNCH DATE	LIFETIME
WESTAR III	KS22	91 (NEAR END OF LIFE)	12			
IV	KS58	98.5	24	34	1982	10
V	KS59	124	24	34	1982	10
SATCOM IIIR	KS42	130	24	32, 34	1981	10
IV	KS40	83 (81)	24	32	1982	10
IR	KS43	138	24	36	1983	10
IIR	KS44	72	24	34-35	1983	10
V	KS45	143	24	35	1982	10
COMSTAR D3/D4	KS29	127 (NEAR END OF LIFE)	24	33	1981	7
TELSTAR 301	KS60	96	24	32-34	1984	10
302	KS61	85	24	32-34	1984	10
303	KS62	126	24	32-34	1985	10
GALAXY 1	KS50	132	24	37	1983	10
2	KS51	74	24	34	1983	9
3	KS52	93.5	24	34	1985	9
SPACENET 1	KS46	120	24**	34, 36 AND 39	1984	10
2	KS47	69	24**	34, 36 AND 39	1984	10
4	KS49	(136)	24**	34, 36 AND 39	TO BE LAUNCHED	10
ASC 1	KS69	128	24**	34, 37 AND 42	1985	7.5
2	KS70	(83)	24**	34, 37 AND 42	TO BE LAUNCHED	7.5

*( ) INDICATES FUTURE PLANNED LOCATIONS

**18 TRANSPONDERS ARE C-BAND, SIX ARE Ku-BAND.

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6.1.1 Westar Satellite Parameters

Three operational spacecraft (located at 91°, 98.5°, and 124°W longitude) compose the current Westar satellite constellation, which operates in the C-band to provide telephone, data, and television service to the 50 United States and Puerto Rico. Westar III has 12 transponders, which receive vertically and transmit horizontally, while the Westar IV and V satellites employ dual polarization and frequency reuse to achieve 24 channels, each having a 34-MHz usable bandwidth within the 500-MHz allocation. The odd-numbered channels receive vertically polarized signals and transmit horizontally polarized signals; the even-numbered channels operate with a reversed polarization. Each satellite is equipped with six spare TWTAs and has a design life of 10 years. Table 6-2 provides a listing of Westar satellite parameters.

Table 6-2. Westar Satellite Parameters

PARAMETER	WESTAR
STABILIZATION	SPIN
STATIONKEEPING	
N-S	±0.1 deg
E-W	±0.1 deg
RECEIVE FREQUENCIES	5.927 TO 6.403 GHz
TRANSMIT FREQUENCIES	3.702 TO 4.178 GHz
COMMAND FREQUENCIES	
UPLINK	6420 MHz (H)
DOWNLINK	4198.25 (V), 4198.75 (V), 4199.25 MHz (V)
EIRP/CHANNEL (CONUS)	33 dBW
RECEIVER G/T (CONUS)	-7 dB/K
POLARIZATION	H, V; V, H

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6.1.2 Satcom Satellite Parameters

Currently, there are five geosynchronous satellites (72°, 83°, 130°, 138°, and 143°W longitude) in the SATCOM satellite system providing voice-grade, data, and television transmission circuits for both commercial and Government users. Each Satcom satellite has a 10-year mission life and employs frequency reuse to provide 24 C-band transponder channels. Each channel has a 34-MHz usable bandwidth within the 500-MHz allocation. The odd numbered channels receive horizontally and transmit vertically. Even-numbered channels receive vertically and transmit horizontally.

The 24 channels are configured into four groups of six channels each. Satellites III-R and IV are powered by six 8.5-W TWTAs and 18 5.5-W TWTAs plus one spare for each group of six channels (7-for-6 redundancy). The transponder channel groups are fed by four receivers configured into two redundant receiver chains, one set serving each polarity. Beginning with Satcom V, each satellite will be equipped with 28 8.5-W solid-state HPAs, providing 7-for-6 redundancy. Table 6-3 presents key parameters of the Satcom satellites.

6.1.3 Comstar/Telstar Satellite Parameters

AT&T and GTE, who have jointly used Comstar for communications service, have each deployed independent satellite systems to meet their own specific needs. AT&T has deployed three Telstar spacecraft (85°, 96°, and 126°W longitude), which operate in the C-band (6/4 GHz), while a GTE subsidiary, GTE Satellite Corporation (GSAT), has deployed the Gstar spacecraft, which operate in the Ku-band (14/12 GHz).

In 1983, Telstar 301 replaced the Comstar D1/D2 combination, which was colocated at 95°W longitude. In 1984, Comstar D3 was replaced by Telstar 302. Comstar D4, launched in 1981, remains operational and is located at 127°W longitude. Telstar 303 was launched in 1985 and is positioned at 126°W longitude.

Table 6-3. Satcom Satellite Parameters

PARAMETER	I-R, IIR, III-R, IV	V
STABILIZATION	3-AXIS	3-AXIS
STATIONKEEPING		
N-S	±0.2 deg	±0.1 deg
E-W	±0.2 deg	±0.1 deg
RECEIVE FREQUENCIES	5.925 TO 6.425 GHz	5.925 TO 6.425 GHz
TRANSMIT FREQUENCIES	3.700 TO 4.200 GHz	3.700 TO 4.200 GHz
TT&C FREQUENCIES		
UPLINK	6423.5 MHz (H)	6423.5 MHz (H)
DOWNLINK	3700.5 MHz (H) 4199.5 MHz (V)	3700.5 MHz (H) 4199.5 MHz (V)
EIRP/CHANNEL (CONUS)	31 dBW	35 dBW
RECEIVER G/T (CONUS)	-6 dB/K	-3 dB/K
POLARIZATION	H, V; V, H	H, V; V, H

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Comstar D4 (near end of life) has a 500-MHz bandwidth with each of 24 individual channels having a 34-MHz usable bandwidth. The channels are configured in four groups of six channels each. Each horizontally polarized channel employs a 5-W TWTA, and each vertically polarized channel employs a 5.5-W TWTA. No redundancy of HPAs is provided.

The transponder channel groups are fed by four switched receivers providing redundancy for both the horizontal and vertical polarization. This configuration also allows for the switching of polarities between the received signals and the transmitted signals. In normal operation, 12 transponders employ vertical polarization transmission and reception, and the other 12 transponders employ horizontal polarization transmission and reception.

Each Telstar spacecraft has 24 C-band transponders. The system provides AT&T users with telephone, data, and television service to the 50 United States and Puerto Rico. The Telstar satellites use the same polarization scheme as Comstar D4.

Satellite parameters for Comstar D4 and the Telstar spacecraft are presented in Table 6-4.

Table 6-4. Comstar and Telstar Satellite Parameters

PARAMETER	COMSTAR D3/D4	TELSTAR 301, 302, 303
STABILIZATION	SPIN	SPIN
STATIONKEEPING		
N-S	±0.1 deg	±0.1 deg
E-W ±	0.1 deg	±0.1 deg
RECEIVE FREQUENCIES	5.925 TO 6.425 GHz	5.925 TO 6.425 GHz
TRANSMIT FREQUENCIES	3.700 TO 4.200 GHz	3.700 TO 4.200 GHz
TT&C FREQUENCIES		
UPLINK	5927 MHz (H)	6422 MHz (H)
DOWNLINK	3700.5 MHz (H) 4198.0 MHz (V)	301: 3701.75 (H) 302: 3702.75 (H) 303: 3702.25 (H)
EIRP/CHANNEL	33 dBW	34 dBW
RECEIVER G/T	-8.8 dB/K	-5 dB/K
POLARIZATION	V, V; H, H	V, V; H, H

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6.1.4 Galaxy Satellite Parameters

The three operational Galaxy satellites (located at 132°, 74°, and 93.5°W longitude) employ orthogonal linear polarization to provide frequency reuse on the uplinks and downlinks. Twelve transponders receive vertically and transmit horizontally, while the other 12 receive horizontally and transmit vertically. Four receivers and a 1-for-4 TWTA redundancy are provided to meet a 10-year satellite mission life. Table 6-5 lists the Galaxy satellite parameters.

Table 6-5. Galaxy Satellite Parameters

PARAMETER	GALAXY
STABILIZATION	SPIN
STATIONKEEPING	
N-S	±0.1 deg
E-W	±0.1 deg
RECEIVE FREQUENCIES	5.9 TO 6.4 GHz
TRANSMIT FREQUENCIES	3.7 TO 4.2 GHz
TT&C FREQUENCIES	
UPLINK	5927.5 MHz (V)
DOWNLINK	4197.5 MHz (V)
	3702.5 MHz (H)
EIRP/CHANNEL (CONUS)	34 dBW
RECEIVER G/T (CONUS)	-7 dB/K
POLARIZATION	H, V; V, H

6.1.5 Spacenet Satellite Parameters

Two RCA-built Spacenet satellites were placed in geosynchronous orbit in 1984 at orbital positions of 69° and 120°W longitude. The Spacenet satellite system operates at 6/4 GHz (C-band) and 14/12 GHz (Ku-band). It has a communications subsystem that provides simultaneous operation of both wideband and narrowband communications by the use of horizontally and vertically polarized signals operating with 24 transponders. The C-band payload consists of 12 (narrowband) channels with 8.5-watt solid-state amplifers and six 72-MHz-wide (wideband) channels with 16-watt TWTAs. The six 72-MHz-wide Ku-band channels consist of six 16-watt TWTAs. The C-band narrowband and Ku-band wideband transponders receive on the vertical polarity and transmit on the horizontal polarity; the C-band wideband transponders receive on the horizontal polarity and transmit on the vertical polarity. A 7-for-6 redundancy of HPAs and a 2-for-1 redundancy of receivers is provided to meet a 10-year satellite mission life.

Table 6-6 summarizes the key parameters of the Spacenet satellites.

Table 6-6. Spacenet Satellite Parameters

PARAMETER	SPACENET
STABILIZATION	3-AXIS
STATIONKEEPING	
N-S	±0.05 deg
E-W	±0.05 deg
RECEIVE FREQUENCIES	5.925 TO 6.425 GHz
TRANSMIT FREQUENCIES	3.700 TO 4.200 GHz
COMMAND FREQUENCIES	
UPLINK	6422.0 MHz (V)
DOWNLINK	3700.5 MHz (H) 4199.5 MHz (V)
EIRP/CHANNEL (CONUS)	34 dBW (C-Band, 36 MHz) 36 dBW (C-Band, 72 MHz)
RECEIVER G/T (CONUS)	-5 dB/K (C-Band, 36 MHz) -2 dB/K (C-Band, 72 MHz)
POLARIZATION	H, V; V, H

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6.1.6 ASC Satellite Parameters

The ASC satellite system was built by RCA for American Satellite Company. The ASC constellation consists of three dual-band satellites (two in orbit and one ground spare) having 18 cross-polarized C-band channels and six Ku-band channels. ASC-1 was placed in geosynchronous orbit in 1985 at 128^{o}W longitude. ASC-2 has not been launched to date. The C-band payload onboard each spacecraft contains 12 narrowband channels with 8.5-W solid-state amplifiers providing an EIRP of 34 dBW and six wideband channels with 16.2-W TWTAs providing an EIRP of 37 dBW. The six Ku-band channels contain 16.2-W TWTAs that supply an EIRP of 42 dBW. A 7-for-6 redundancy of RF power amplifiers exists for the C-band narrowband and Ku-band channels while a 4-for-3 redundancy of power amplifiers exists for the C-band wideband channels. Table 6-7 provides a listing of ASC satellite parameters.

6.2 EARTH TERMINALS

A typical satellite earth station contains the elements shown in Figure 6-5. Since a satellite generally serves many earth stations, each station generally does not require the full bandwidth capability. However, for flexibility purposes, it is desirable for an earth station to have tuning capability over the entire bandwidth of the satellite even though it will not be using all of the bandwidth at any one time. The fundamental operations are similar to those in space. The signal to be transmitted is converted to the uplink frequency before being amplified and directed to the appropriate polarization part of the antenna feed. The signal received from the satellite is amplified by a low noise amplifier (LNA) before being down-converted from the downlink frequency. If an earth station is required to operate over two or more separate transponders, then a separate upconverter and downconverter chain is required for each transponder. For CSI purposes, it

Table 6-7. ASC Satellite Parameters

PARAMETER	ASC
STABILIZATION	3-AXIS
STATIONKEEPING	
N-S	±0.05 deg
E-W	±0.05 deg
RECEIVE FREQUENCIES	5.925 TO 6.425 GHz
TRANSMIT FREQUENCIES	3.7 TO 4.2 GHz
TT&C FREQUENCIES	
UPLINK	NOT AVAILABLE
DOWNLINK	NOT AVAILABLE
EIRP/CHANNEL (CONUS)	34 dBW (C-BAND, 36 MHz) 37 dBW (C-BAND, 72 MHz)
RECEIVER G/T (CONUS)	-4 dB/K
POLARIZATION	H, V; V, H

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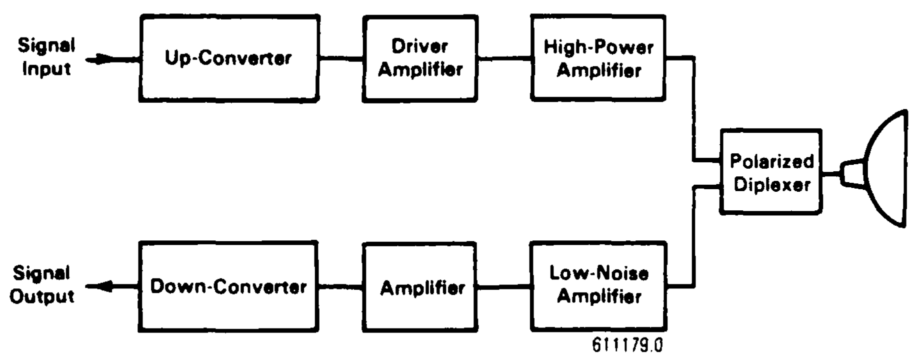

Figure 6-5. Elements of an Earth Station

is essential that the chosen earth stations be capable not only of pointing their antenna at any satellite selected for use but also that they be able to tune to any transponder on that satellite. This requires both frequency and polarization agility for the upconverter and downconverter chain.

6.2.1 Commercial Earth Stations

The networks of the commercial satellite carriers include three types of communications earth stations: general service (GS), dedicated Government service (DGS), and dedicated private service (DPS).

The GS earth stations handle large numbers of circuits and are normally connected to the public switched services. Furthermore, significant RF and IF interoperability capabilities exist among GS terminals. For these reasons, they are likely candidates for enhancements under the CSI program.

While the DGS earth stations outnumber GS earth stations and carry the bulk of Government circuits during normal operations, these terminals are smaller and generally require more enhancements for provision of interoperability than GS terminals. They are also more likely than GS terminals to be located in proximity to targeted areas. The potential for communications interoperability of most commercial terminals is impaired by lack of both polarization and frequency agility. Most DPS terminals have limited pointing capabilities as well.

Virtually all commercial earth station antennas have the capability to be pointed throughout the domestic orbital arc.

The communications services offered by commercial terminals consist of multiple access, modulation schemes, coding (if digital modulation), and multiplexing. The predominantly used multiple access technique is frequency division multiple access

(FDMA). Smaller dedicated terminals use single channel per carrier as a form of FDMA.

Trunking terminals generally use frequency modulation (FM) modulation schemes in conjunction with FDMA. Dedicated terminals use a variety of quadrature phase shift keying (QPSK), binary phase shift keying (BPSK), and companded FM. For QPSK and BPSK modulations, FEC coding is used with different code rates based on power and bandwidth tradeoff studies.

Baseband signal multiplexing also can be either frequency division multiplexing or time division multiplexing.

The result of the variety of modulation, coding, and multiplexing techniques used at these earth stations is an inherent lack of interoperability among stations that do not normally communicate with each other. To overcome this lack of interoperability and to meet the basic CSI requirement for providing T1 connectivity between PSN switches, each CSI earth station will be equipped with a standard T1 modem. Multiple modems will be provided depending on the number of T1 circuits required at a particular earth station.

6.2.2 Earth Terminal Selection Criteria

Three primary factors will be used to select the candidate set of commercial earth terminals associated with each PSN switch. They are: distance from the PSN switch, likelihood of surviving the threat, and performance capability of the terminal.

The first step in determining the candidate set of earth terminals is to identify all commercial C-band terminals within 250 miles of the PSN switch in question. Then, these terminals identified are tested against the threat scenario being used for network design. Obviously, a terminal must survive to be considered for CSI. The third criterion, terminal performance, is then applied based on the performance criteria specified in Chapter 5. The candidate earth stations must have adequate transmitter power (EIRP) and receiver performance (G/T) to provide the T1 trunks specified.

Those terminals that meet all of the above criteria are then candidates to be selected for the CSI system. A competitive acquisition will be used to determine the actual terminal to be included.

6.2.3 Low-Cost Earth Terminals

Based on the earth terminal selection criteria presented in the previous section, it appears that two PSN switch locations will not be served by an existing commercial earth terminal. In order to provide the necessary network connectivity for these switches, two low-cost dedicated C-band terminals will be provided at or near the PSN switch location. These terminals will be interoperable with all other commercial earth terminals and satellites within the CSI system, but will only be configured to provide two T1 trunks. The resulting terminal block diagram is shown in Figure 6-6.

6.3 TERRESTRIAL CIRCUITS

From the viewpoint of radiowave propagation C-band has been the band of choice because rain attenuation is minimal in this band. However, this same frequency band is shared with terrestrial microwave systems. Since C-band terrestrial microwave and satellite links interfere with one another; obtaining frequency authorization for satellite earth stations in populated areas is a severe problem--so severe that it is almost impossible to clear a wide bandwidth in an urban area for satellite use. For this reason, commercial earth stations serving major cities are typically located outside the city and are connected to their urban users by microwave relay or cable systems. The PSN switches, on the other hand, are located closer to their user population. This fact requires that provisions be made to provide survivable terrestrial connectivity between the PSN switch and the satellite earth station. This connectivity will be provided by T1 circuits between the PSN switch and the satellite earth station. The physical routing of these circuits is important in assuring the survivability of the link.

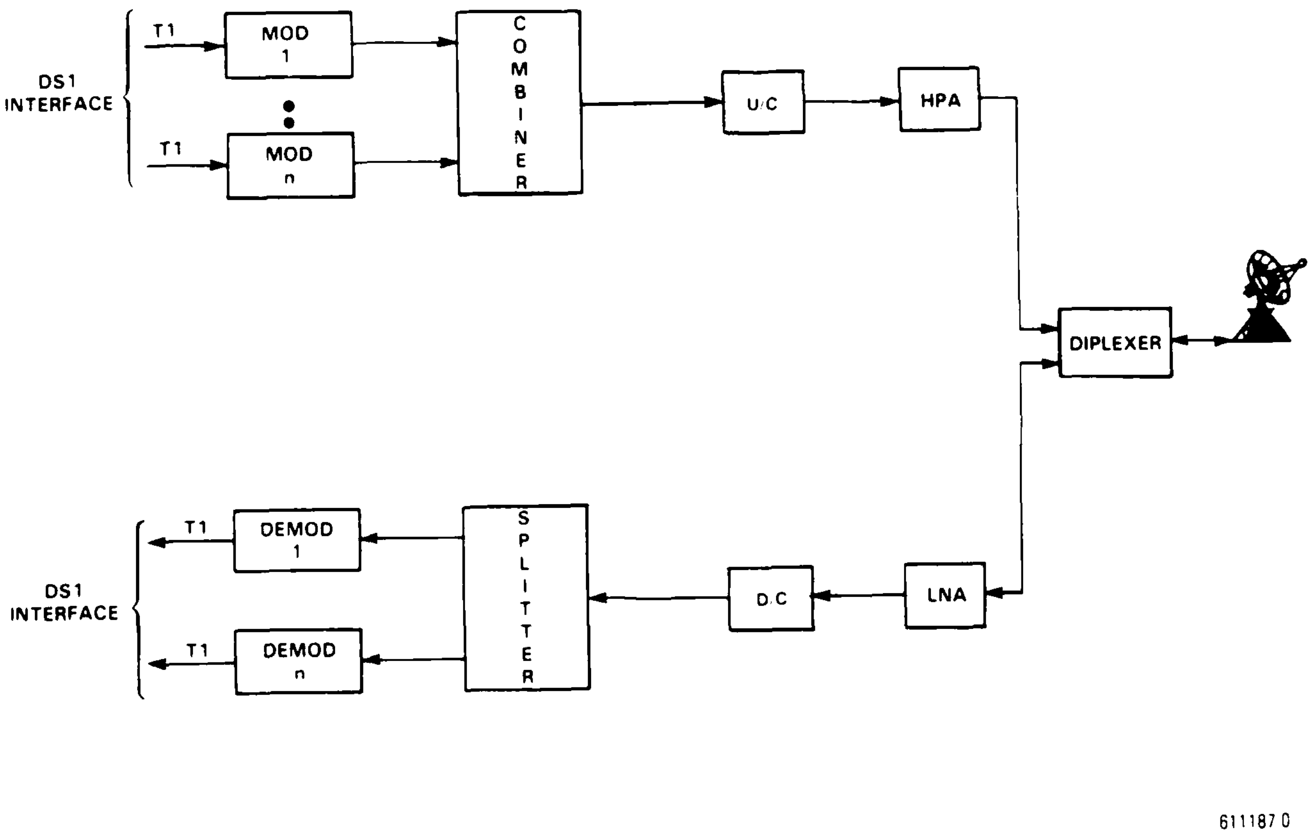

Figure 6-6. Low-Cost Terminal Diagram

At the satellite earth station, the T1 circuits will be terminated in a terminal protective device (TPD) and a channel service unit (CSU).

The TPD is essentially a surge protector that will prevent electromagnetic pulses from damaging equipment within the earth terminal.

The CSU is a device used to terminate leased T1 channels and provides additional circuit isolation and various monitor and control functions. It responds to test signal commands from the PSN switch site, such as loopback, and ensures that all signals reaching the switch have the proper bipolar format so that one-bits alternate in polarity and that there are never more than 15 consecutive zeroes and an average of at least one 1-bit for every seven zeroes. It also provides extensive on-site diagnostic capabilities in the form of jacks, lamp displays, and loopback switches.

6.4 TT&C EARTH STATIONS

All satellite communications systems require a set of procedures, hardware, and software to control the satellites in the system. This set of facilities is referred to as the TT&C system. At present, each carrier maintains its own ground facilities for this purpose. While, in principle, the two families of domestic satellites (Hughes and RCA Astro built satellites) can be controlled by any TT&C facility capable of controlling a satellite in the given family, interoperable TT&C between families is not possible without extensive modification. CSI has initiated development of an interoperable TT&C capability for one station in each family. The two interoperable TT&C stations will have enhancements giving them the capability to control satellites within their respective families.

A typical ground control network consists of a Satellite Control Center (SCC) and two TT&C stations. The TT&C terminals are usually widely separated to maximize system availability.

The SCC is responsible for planning satellite operations, generating command lists to implement these plans, and processing satellite telemetry data to monitor the health and configuration of the satellite.

In the normal configuration, TT&C stations operate as terrestrial relay terminals between the spacecraft and the SCC. Commands are developed at the SCC and are transmitted to the TT&C station for relay to the satellite. The TT&C station collects and monitors satellite telemetry data and forwards it to the SCC for storage and analysis. However, in case of major SCC equipment failure or loss of data lines, a TT&C station may be used to originate spacecraft commands and to receive and process telemetry.

While the SCC may be collocated with a TT&C station, many systems employ separately located facilities. Connectivity is usually provided through dual, redundant, dedicated terrestrial circuits. RCA and Western Union use satellite links as well as terrestrial links to provide communications between SCC and TT&C sites.

Figure 6-7 depicts a typical TT&C ground segment. The real-time control computer performs all the telemetry processing functions (including averaging and archiving data in files for the orbital operations computer and for updating CRT displays), performs the spacecraft command functions of formulating commands and verifying execution, and interfaces the spacecraft controller and the earth station hardware.

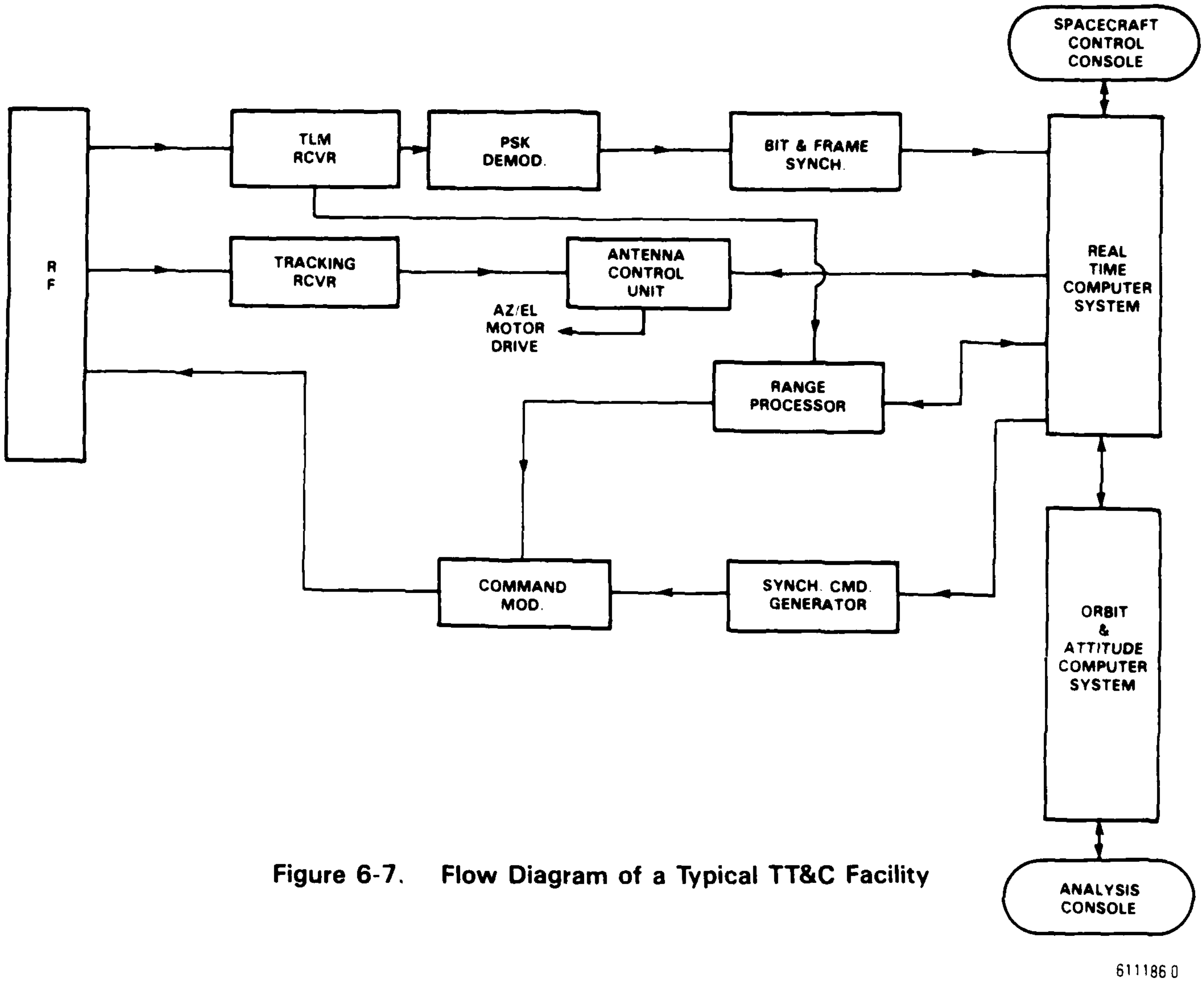

Figure 6-7. Flow Diagram of a Typical TT&C Facility

The telemetry processing subsystem includes the receiver to convert the IF telemetry/ranging output to baseband for input to the range tone processor, or to the subcarrier demodulator where the telemetry bit stream is recovered from its subcarrier. The telemetry bit stream is bit synchronized and frame synchronized for input to the real-time computer system where the data can then be displayed.

The command processing subsystem includes a synchronous command generator (SCG) to convert computer commands into the spacecraft command format. The command modulator is driven by the range processor and the SCG, for which it routes commands to the upconverter at IF.

The ranging subsystem consists of the range tone processor and the ranging software that measures the phase delay of the timed sequence of tones looped through the satellite.

The orbit and attitude computer system computes spacecraft orbit and attitude based on data received from the real-time computer.

The RF subsystem contains the upconverters, downconverters, low noise amplifiers and high-power amplifiers. The command upconverter is normally required to generate a unique tracking signal used by the spacecraft for phase locking the command receivers and for antenna pointing.

6.4.1 Functions

The basic operational and performance requirements of the ITT&C system include performing the following functions for all spacecraft in a given family which are visible from the implementation site:

- Establishing and maintaining a stable operating condition for spacecraft bus subsystems
- Testing the spacecraft payload to determine which of the transponders are in a usable condition
- Configuring the spacecraft payload so that it may be used as intended with minimal degradation
- Maintaining spacecraft orbital position and attitude with sufficient accuracy.

6.4.2 Locations of Existing Sites

Table 6-8 is a summary of the domestic satellite SCC and TT&C systems; it lists the satellite names, the system manager, the SCC, and TT&C earth station locations, and the number and size of antennas at each of these earth stations. The ITT&C sites will be selected from the TT&C earth stations listed.

6.5 ORDERWIRE NETWORK

The orderwire network for CSI will be a medium-speed (e.g., 1200 to 9600 bps) data orderwire providing duplex telecommunications between the primary interoperable TT&C location and any one of the other CSI system locations, thus forming a star configuration as shown in Figure 6-8. A hub station will be located at or in proximity to each of the two interoperable TT&C facilities. A network of spoke stations will communicate with the primary hub. A spoke terminal will be located at each of the other facilities that participate in the CSI network, i.e., the NCC, the 20 communications earth stations and approximately 10 potentially surviving TT&C locations.

The use of spread-spectrum modulation equipment offers a relatively inexpensive alternative to standard FDMA or TDMA systems for low-bit-rate applications such as the CSI orderwire.

Table 6-8. Domestic Satellite SCC and TT&C Systems

SATELLITE SYSTEM	SYSTEM MANAGER	SCC	TT&C	ANTENNAS: TT&C Only (no.) Diameter	ANTENNAS: Communications and TT&C (no.) Diameter
GALAXY	Hughes Communications, Inc	El Segundo, CA	Fillmore, CA (E2178) Spring Creek, NY (E3943)		(2) 13 m, (2) 10.3 m (2) 10.3 m
TELSTAR	AT&T	Bedminster NJ	Three Peaks, CA (KB31) Hawley, PA (WB30)	(1) 13 m (1) 13 m	(3) 30 m (3) 30 m
WESTAR	WESTERN UNION TELEGRAPH	Glenwood, NJ	Glenwood, NJ (WB20) Steele Valley, CA (KB22) Estill Fork, AL (WB24)	(1) 10 m (1) 11 m	(3) 15 m, (1) 11 m (3) 15 m, (1) 13 m (2) 15 m
SATCOM	RCA American	Vernon Valley, NJ	South Mountain, CA (KB27) Vernon Valley, NJ (WB81)	(1) 13 m (1) 13 m	(4) 11 m, (1) 10 m (2) 13 m, (1) 12 m, (2) 11 m
SPACENET*	GTE Spacenet Corporation	McLean, VA	Woodbine, MD (E2037) San Ramon, CA (E6241)	C-band: (1) 13 m Ku-band: C-band: Ku-band:	(3) 13 m (2) 9.2 m (3) 13 m (2) 9.2 m
ASC*	American Satellite Company	Ellenwood, GA	Ellenwood, GA (E7465)		

*Hybrid Using C and Ku Band

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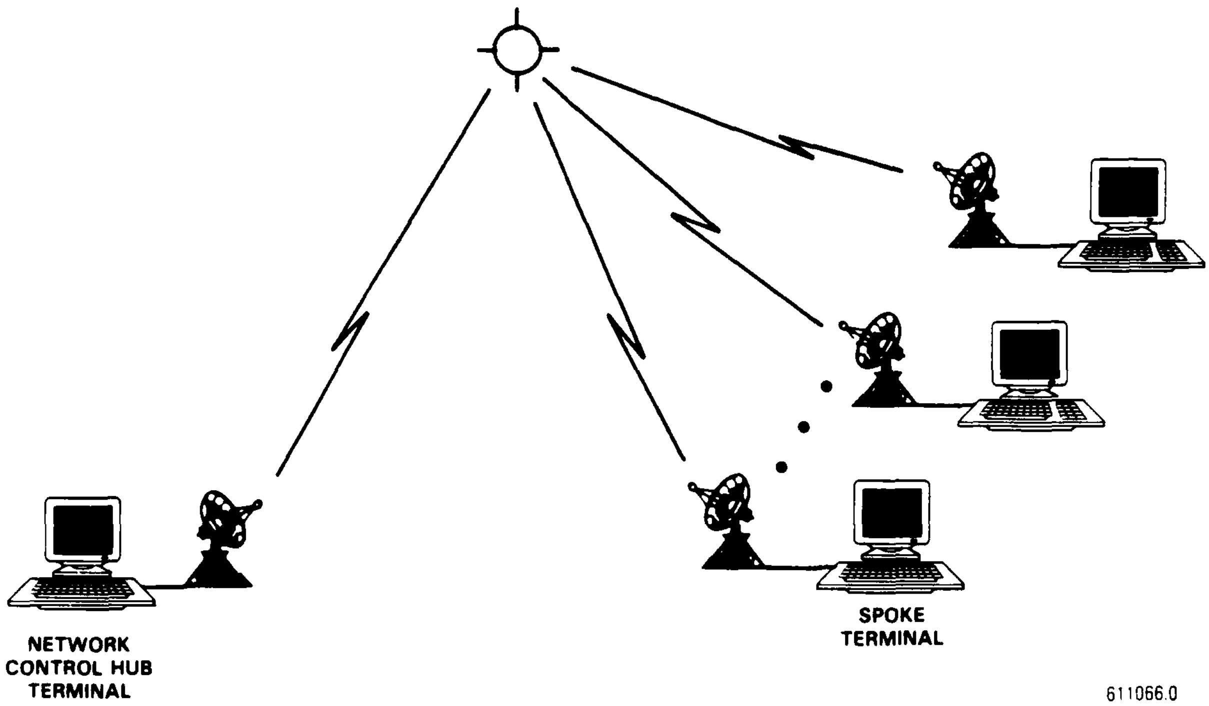

Figure 6-8. CSI Orderwire System

The most logical candidate for spread spectrum modulation is direct sequence coding in which a long pseudorandom noise sequence of symbols, called chips, is used to represent a bit of information. The number of chips per bit can vary from a few tens to a few thousands depending on the size of the receiving antenna and the amount of satellite power allocated. In general, the lower the power and/or the smaller the receiving antenna, the larger the number of chips that must be used per data bit. The receiver, knowing the PN sequences involved, performs a pattern-recognition analysis to determine whether the binary information was a one bit or a zero bit. Theoretically, by using enough PN chips per bit, a particular level of noise and interference can be overcome within fixed levels of available power. This permits power versus bandwidth tradeoffs to achieve efficient communications results within constrained resources.

A block diagram of a direct-sequence (DS) coded, spread-spectrum system using coherent PSK as carrier modulation is shown in Figure 6-9. The PSK carrier at the modulator output is spread in frequency band by multiplying it by another carrier that has been modulation by a pseudorandom or pseudonoise (PN) sequence at a much higher rate than the information rate. At the receiver, the information is recovered by multiplying the channel waveform by a synchronized replica of the PN sequence.

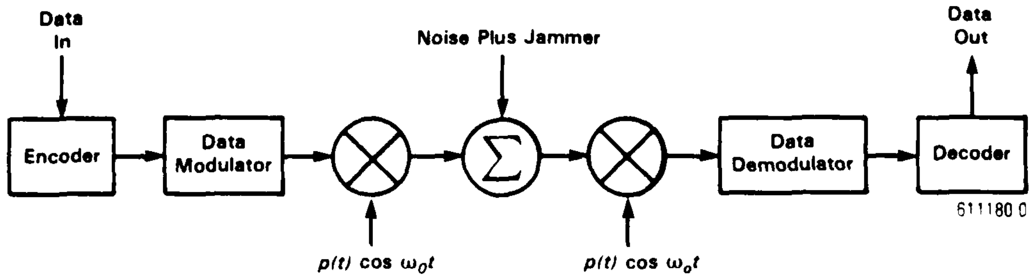

Figure 6-9. A Coded PSK-DS Spread Spectrum Modulator and Demodulator

To demodulate the data contained in a DS spread-spectrum signal, the receiver must correlate the received signal with a generated replica of the PN sequence so that the phases of the received PN sequence and its replica are synchronized to despread the spread signal. The process of initial searching through all possible phases until the received sequence phase is essentially the same as the generated sequence phase is called acquisition. The acquisition time is directly related to the PN sequence length, the bit rate of the information signal, the detection probability, and the false alarm probability.

6.6 NETWORK MANAGEMENT

Network management of the CSI network begins with the decision to activate the CSI network and the dissemination of that decision to those required to act on it. Since many different organizational entities are involved with the network, the management of a coordinated set of activities by diverse groups of people is necessary.

The user of the CSI network is the PSN; specifically, that surviving subset of the PSN serving certain high-priority Government users. Thus, the requirements for PSN switch connectivity must be driven by the needs of the PSN. For this reason, network management of the CSI network is inextricably tied to network management of the PSN subnetwork.

The design of the CSI network is driven by this connectivity requirements of the PSN and the threat scenario used to determine which facilities (switches and earth stations) will likely survive a nuclear attack on the U.S.

It is conceivable, even likely, that these connectivity requirements could change based on the actual situation at the time activation is required. The process by which the new requirements are generated, analyzed, and satisfied is also part of network management. The assumption within the CSI program is that the National Coordinating Mechanism embodied in a survivable NCC will be responsible for coordinating the requirements specified by the PSN network management center. The selected ITT&C site will be in charge of configuring the CSI network in accordance with instructions from the NCC.

Furthermore, the TT&C site will be responsible for coordinating network monitor and control activities of the earth stations. These functions include:

- Frequency assignment
- Carrier power monitoring
- Error performance monitoring
- Fault detection and isolation.

Thus, the Network Management Structure for the CSI network is shown in Figure 6-10. The primary tool to be used in exercising network management is the CSI orderwire.

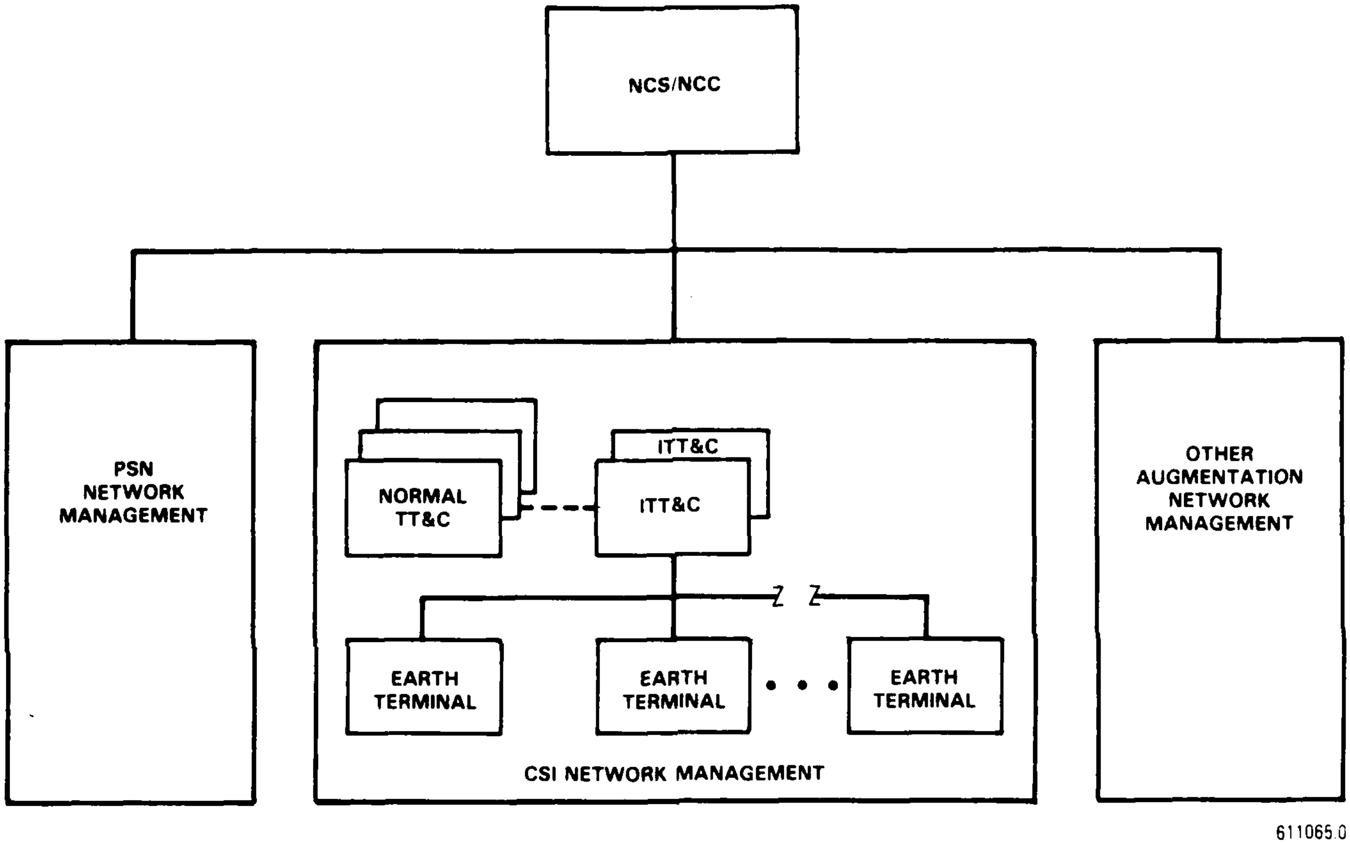

Figure 6-10. CSI Network Management Relationships

REFERENCES

1. NSTAC CSS Task Force Resource Enhancements Working Group Report, Commercial Satellite Communications Survivability Report (U), May 1983 (UNCLASSIFIED).

2. Commercial SATCOM Interconnectivity CSI Program Plan (U), November 1985 (SECRET).

3. NSEP Telecommunications Requirements Analysis (U), September 27, 1985 (SECRET).

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