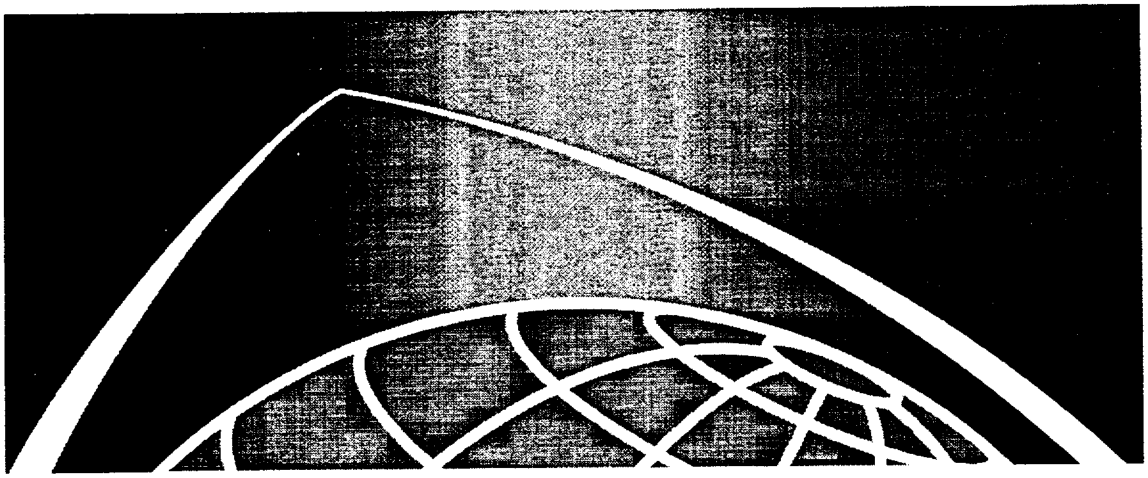
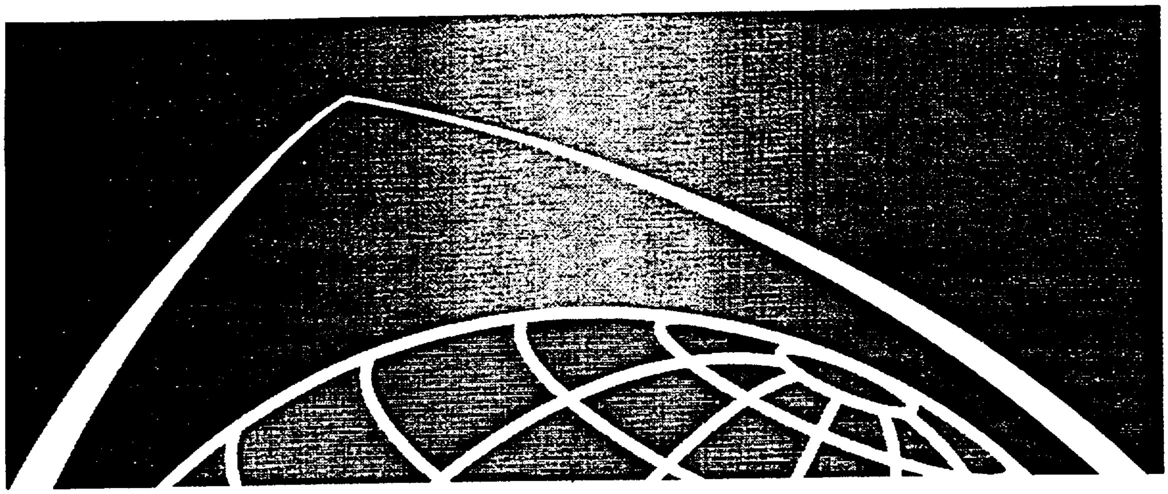
Globalstar



Description of the Globalstar System

February 24, 1997

Globalstar



Description of the Globalstar System

February 24, 1997

DOCUMENT REVISION HISTORY

Revision	Date of Issue	Scope
A	6/3/94	Incorporated QUALCOMM Comments
B	12/20/94	Updated after SRR/PDR Reviews
C	8/10/95	Updated after the HLDR Reviews
D	2/24/97	Update to incorporate design changes

Abstract

This document is written to introduce new people to Globalstar. It attempts to provide a general overview of the system and to provide some information on the design of the system. It also attempts to define how Globalstar is envisioned to operate when the system is complete. As such, this is primarily tutorial in nature. In the interests of brevity, simplifications are made in the material herein. There is no attempt to be totally complete or comprehensive for all cases.

This document should not be interpreted as a binding specification. It does not contain requirements that should be interpreted as either complete or binding. Globalstar is an evolving system. This document will be updated as the design of the system progresses. When each revision is issued there is an attempt to represent the current thinking on the system.

For binding specifications and requirements please consult the released requirements documents and the released design information.

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1. SERVICES OFFERED

1.1 Service Types

Globalstar supports two types of services. (1) The first type of service is a communications service which includes voice and data communications. (2) The second type of services are Globalstar specific services including services like position location and global roaming.

1.2 Communications Services

Three types of communications services are supported by Globalstar depending on the environment in which they operate. They are IS -41 services and GSM Services. The third type of services are those services that are related to Globalstar. These apply to both the IS-41 and the GSM domain.

1.2.1 IS-41 Services

The following IS-41-based services shall be supported directly by the gateway. The IS 41 switch is in the Gateway.

Basic Bearer Services
2.4 Kb/s: DCA, Async Data Serv (ADS)
4.8 Kb/s: DCA, Async Data Serv (ADS)
9.6 Kb/s: DCA, Async Data Serv (ADS)
Speech followed by data

Teleservices
Speech Transmission
Telephony (circuit speech)
Emergency services (911)
Lawful intercept
DTMF support

Short Message Service
Short Message Mobile Term Pt-to-Pt
Short Message Mobile Originating Pt-to-Pt
Facsimile Transmission
Alt Speech and Facsimile Group 3
Automatic Facsimile Group 3

1

Supplementary Services
Call Presentation
Calling Number ID Presentation (CNIP)
Calling Number ID Restriction (CNIR)
Call Forwarding
Call Fwd Unconditional (CFU)
Call Fwd Default (CFD)
Call Fwd on Subscriber Busy (CFB)
Call Fwd on No Reply (CFNA)
Call Offering
3-Way Calling (3WC)
Do Not Disturb (DND)
Call Transfer (CT)
Call Delivery
Call Waiting
Miscellaneous Services
Authentication
Voice Privacy
Data Privacy
Signaling Privacy
Remote Feature Control

1.2.2 GSM Services

GSM services shall be supported by a GSM - MSC connected to the gateway via the A1 interface. This section lists the bearer services and teleservices supported; supplementary services are solely provided by the GSM MSC so no requirements on these services are contained in this section.

To the extent practicable, the gateway shall appear to the GSM MSC to be a GSM BSC. Refer to the *A1 Interface Specification*, 80-25179-1 for the requirements.

Basic Bearer Services
2.4 Kb/s: DCA, 3.1kHz (ext. to the PLMN) Async Data Serv (ADS)
4.8 Kb/s: DCA, 3.1kHz (ext. to the PLMN) Async Data Serv (ADS)
9.6. Kb/s: DCA, 3.1kHz (ext. to the PLMN) Async Data Serv (ADS)
2.4 Kb/s: DCA, UDI (ext. to the PLMN) Async Data Serv (ADS)
4.8 Kb/s: DCA, UDI (ext. to the PLMN) Async Data Serv (ADS)
9.6. Kb/s: DCA, UDI (ext. to the PLMN) Async Data Serv (ADS)
Speech Followed by Data

Teleservices
Speech Transmission
Telephony (Circuit Speech)
Emergency Services
Lawful Intercept
DTMF Support
Short Message Service
Short Message Mobile Term Pt-to-Pt
Short Message Mobile Originating Pt-to-Pt
Facsimile Transmission
Alt Speech and Facsimile Group 3 (NT)
Automatic Facsimile Group 3 (NT)

1.2.3 Globalstar Specific Services and Quality

The following services and statements result from the Globalstar implementation and apply to both GSM and IS-41.

Globalstar Specific Services
Position Location (high resolution), 300 m
Position Location (low resolution), 10 km
Global Roaming
Terminal Services
CDG Sleep Mode

Throughput Rates: The data rate of the air interface plus overhead for the radio link protocol, etc. limits the effective data rate to approximately 7.2 Kb/s (if enough power has been allocated and there is no blockage of view). It is possible to interface to a higher rate service at the network interface (e.g., V.32), but the actual data rate is limited.

Short Message Service: The gateway will support interfaces to GSM and IS-41 short message service centers for SMS.

Voice Quality - Voice service is based on a Code Excited Linear Prediction (CELP) variable rate vocoder. The voice processing will incorporate a procedure to aid in cancellation of background noise. The voice quality will meet or exceed the voice quality provided by IS-96 which is the terrestrial CDMA standard. This superior voice quality can be offered at the lower data rates in large part due to the adaptable rate vocoders used in Globalstar. The voice quality cited is based on a Ricean channel model that requires a forward link Eb/No and return link Eb/No as defined in the link budget. A soft degradation is incorporated into the design. In marginal areas where the User Terminal cannot generate sufficient power to close the link, the peak data rate is reduced to 4.8 Kb/s or 2.4 Kb/s. This will provide intelligible voice communications in areas that otherwise could not be served. The Vocoders will incorporate echo cancellation which can be disabled if this function is provided by the network.

Data Quality - Data services are provided up to 7.2 Kb/s. The a Bit Error Rate contributed by Globalstar is less than 1×10^{-6}. Higher terminal rates (e.g. 9.6 Kb/s) can be processed if the equipment incorporates elastic buffers to accommodate the required flow control.

Encryption: Over the air signaling, voice and data encryption is offered.

Registration - The Gateway is capable of providing a position location function on the User Terminal with which it is communicating. The accuracy is within 10 km for registration. This is used to determine assignment of User Terminals to Gateways.

Location Service: Globalstar can locate the position of a User Terminal and provide the location as a service. Accuracy of the position location service is a function of several variables including:

a. Number of Satellites in View.

b. Position Accuracy of the Satellites

c. Geometry of the User Terminals, Satellites and Gateways.

d. The length of time that the User Terminal is connected to the Gateway.

The Gateway will also support more precise User Terminal position location as a service. With clear line of sight to at least two satellites, separated by at least 22 degrees as seen by the User Terminal, the Gateway is able to compute the User Terminal's position to within 300 meters with 95% probability in less than 10 seconds.

Location Privacy - The location of a user is protected. Only duly constituted authorities will have access to these data unless approved by the owner of the User Terminal.

Tracking Service - The Gateway is able to use sequential position locations to determine and maintain tracking services for mobile users. Offering these services is dependent upon the legality within the regions supported by the Service Providers.

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2. SYSTEM SEGMENT DESCRIPTIONS

2.1 Globalstar System

The Globalstar system consists of a Space Segment, a User Segment, a Ground Segment, and a Terrestrial Network as shown in Figure 2-1.

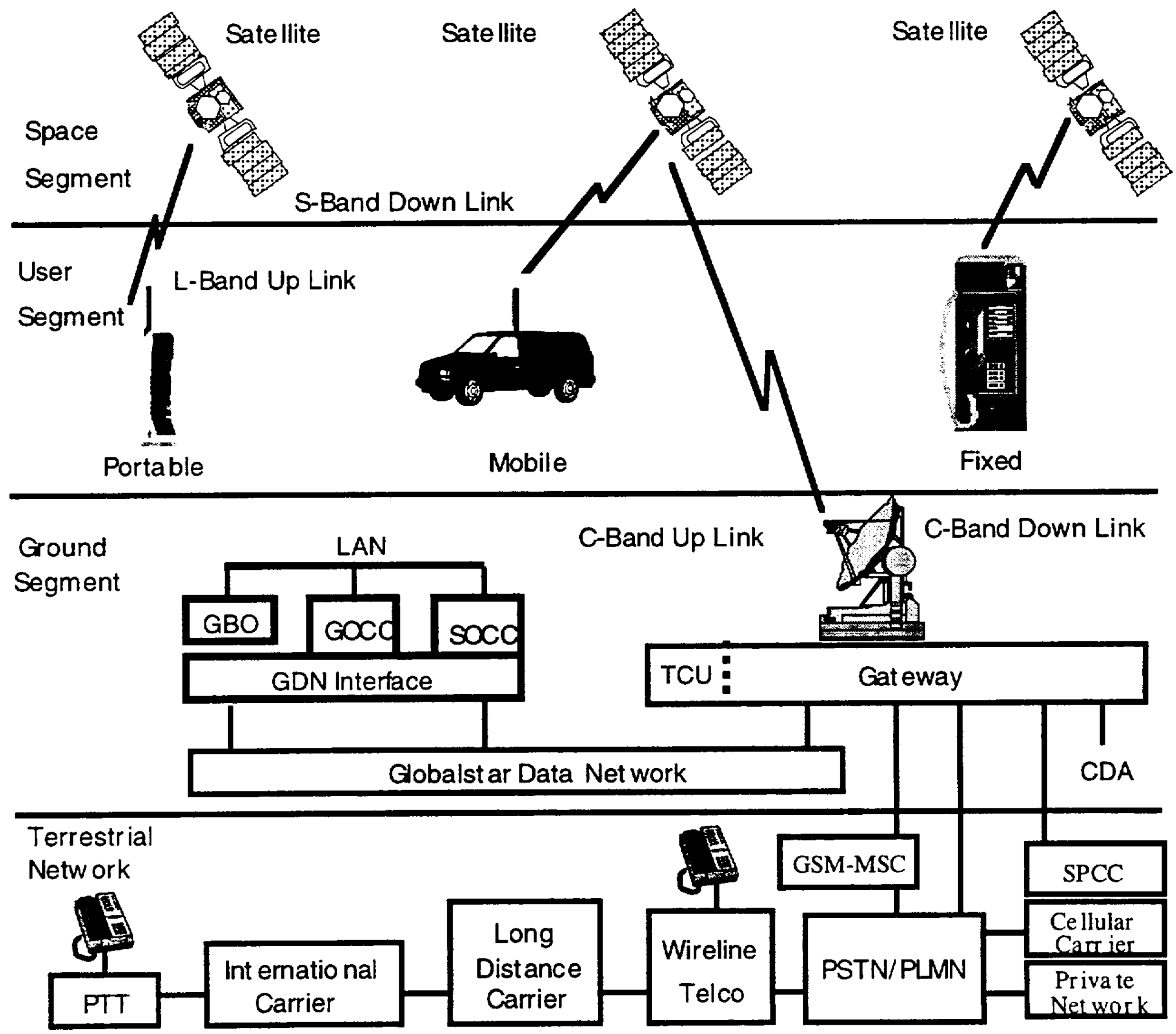

Figure 2-1 Globalstar System Integrates with Terrestrial Network

The Globalstar system provides communications from any point on the earth surface to any other point on the earth surface, exclusive of the polar regions. The satellite orbits are optimized to provide highest link availability in the area between 70 degrees south latitude and 70 degrees north latitude. Service is feasible in higher latitudes with decreased link availability.

The Globalstar space segment consists of 48 satellites in 1410 km Low Earth Orbits. The low orbits permit low power hand sets similar to cellular phones. These satellites are distributed in 8 orbital planes with 6 equally spaced satellites per orbital plane. Satellites complete an orbit every 114 minutes. User Terminals in a particular location on the surface of the earth are illuminated by a 16 beam satellite antenna as it passes over the earth as shown by the antenna footprints in Figure 2-2.

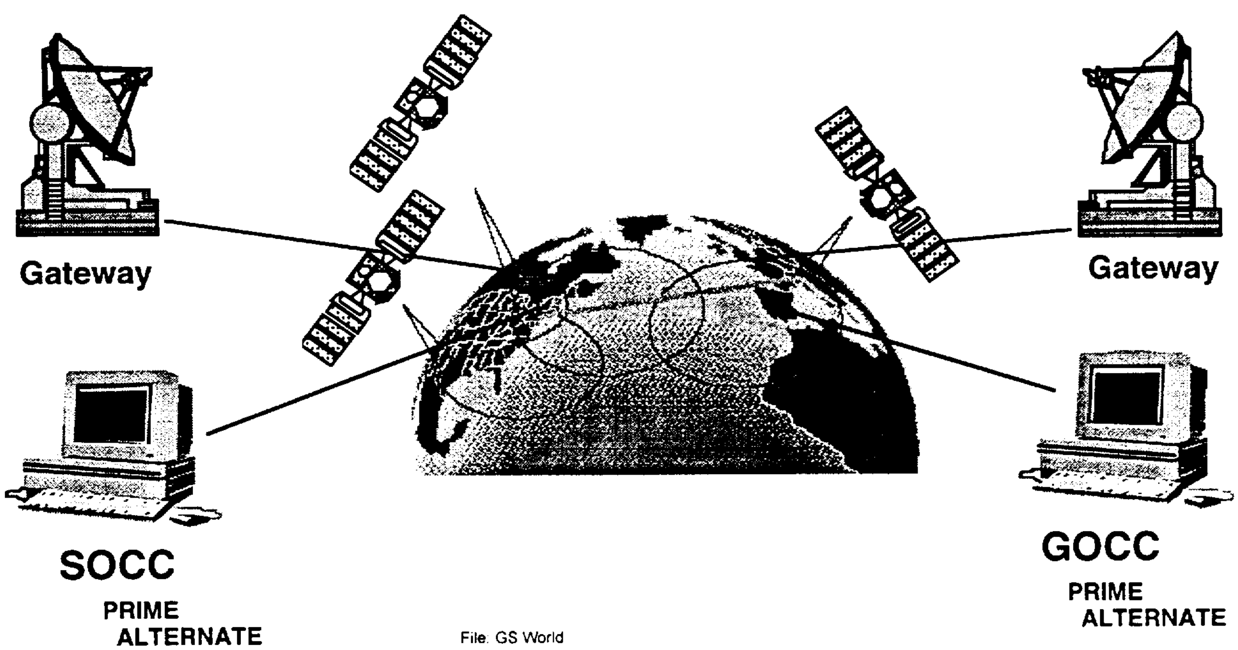

Figure 2-2 Ground Segment Accommodates Home Country Gateways

User Terminals can be served by a satellite 10 to 15 minutes out of each orbit. A smooth transfer process between beams within a satellite and between satellites provides unbroken communications for the users. The orbital planes are inclined at 52 degrees. Coverage is maximized in the temperate areas with at least two satellites in view, providing path diversity over most of the area. There is some small sacrifice in multiple satellite coverage at the equator and at latitudes above 60 degrees.

The Gateways to the terrestrial network are illuminated by an earth coverage beam. The Gateway connects the User Terminal to the terrestrial network via the Gateway. The terrestrial network is not a part of Globalstar.

2.2 User Terminal

The User Terminals come in several varieties. There are hand held units, mobile units and fixed station units. The candidate User Terminals are listed in Table 2-1

Table 2-1 Pre-Production User Terminals

Fixed Terminal	Mobile and Hand Held
Globalstar Only	Globalstar Only
	Dual Mode Globalstar & GSM
	Tri Mode Globalstar & Terrestrial CDMA & AMPS

Hand Held - A typical hand held unit is shown in Figure 2-3.

Figure 2-3 Typical Hand Held User Terminal

The radiating element of the antenna is positioned above the head of the user. The antenna is positioned vertically to effectively utilize the symmetrical radiation pattern of the hand held antenna. The area next to the head is not used for radiation. This meets the safety requirements.

Mobile - The mobile units consist of a hand held unit inserted in an adapter in the vehicle. The Mobile units typically have a higher gain antenna, a lower noise receiver and a higher RF power output. This is part of the adapter kit. The improved transmitter and receiver are mounted in the base of the antenna.

Fixed - Fixed station terminals are normally Globalstar only. The fixed User Terminals have a performance equivalent to the mobile terminal except that the antenna gain and transmitter power may be even higher. Fixed terminals do not require path diversity to combat fading and blockage. Fixed Terminals must support seamless beam to beam and satellite to satellite hand off.

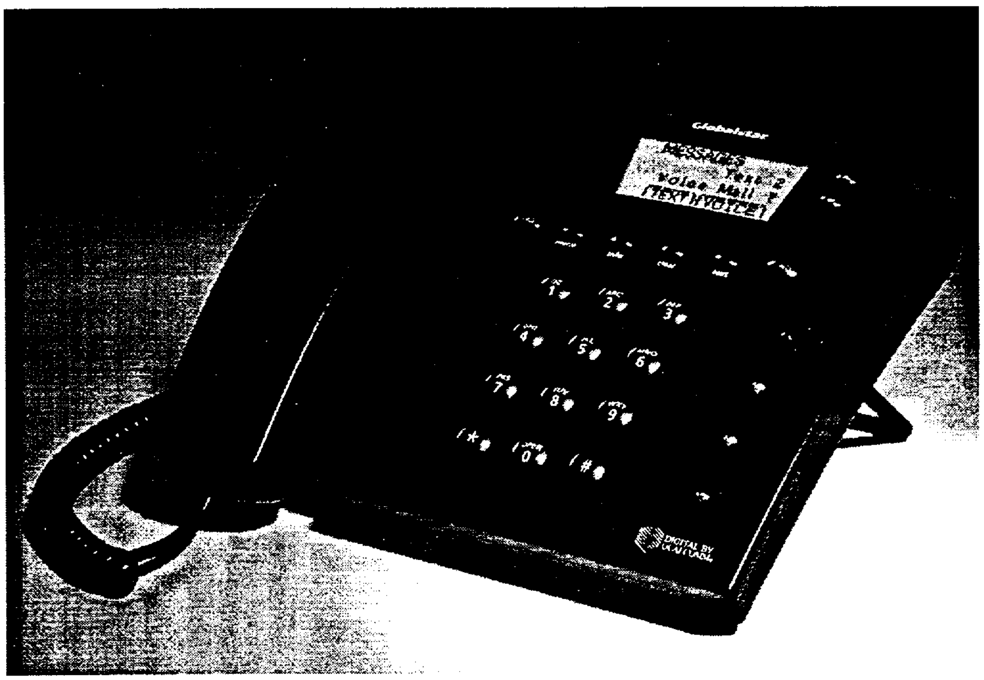

Figure 2-4 Typical Fixed Terminal Desk Set

Future User Terminals - Other User Terminals, such as Globalstar & TACS, will be developed based on market requirements.

SIM: All Hand held and Mobile User Terminals developed for Globalstar will support a Subscriber Identification Module (SIM).

Block Diagram - Figure 2-5 is a simplified block diagram of the Tri-Mode User Terminal which includes Globalstar/CDMA/AMPS.

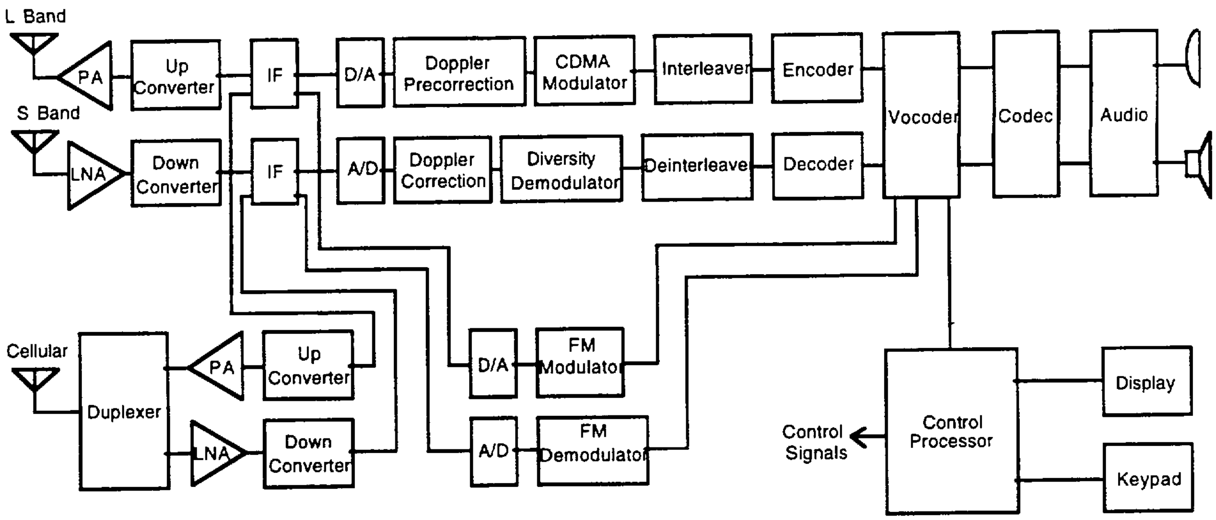

Figure 2-5 Tri-Mode User Terminal Block Diagram

Appearance : Hand held User Terminals look like a standard cellular telephone. These are multiple mode hand sets that operate with the local cellular system or Globalstar. Mobile User Terminals are functionally similar to the hand held units. A mobile consists of a hand set and a car kit. The car kit provides battery power, a higher RF power output and a higher gain antenna. There are indicators on the hand set that indicates the operational mode. Since there is no hand off between the local cellular system and Globalstar, if the user crosses a service boundary between the local cellular system and Globalstar, the call could be dropped and must be placed again. The indicators tell the operator that the mode has changed. Fixed installation User Terminals are Globalstar only. The fixed terminals are designed to serve areas that not served by cellular networks. They are fixed installations with a primary power source, higher RF power and a fixed high gain antenna.

Functions Performed : The start up functions of a User Terminal are programmable. As an example, when a dual-mode User Terminal first powers up it may attempt to log into the local cellular system. This addresses a scenario where the cellular system gets first priority to provide the service. If this fails the User Terminal then attempts to log onto the Globalstar system. Figure 2-6 illustrates a typical startup scenario within Globalstar.

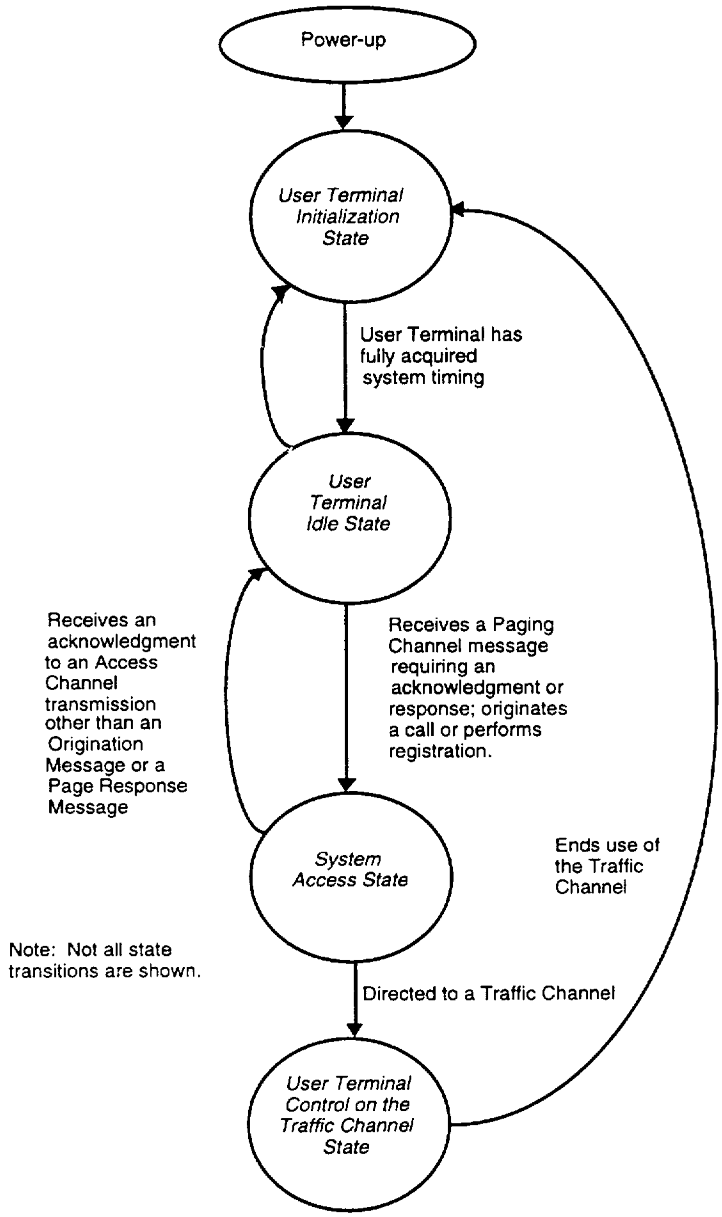

Figure 2-6 User Terminal Startup Scenario within Globalstar

The User Terminal looks for the best satellite pilot signal. When this is found it then switches to the sync channel and obtains the satellite database and other information. This database facilitates rapid acquisition of the pilot for any future calls. To place a call the user dials the number and presses "SEND". The User Terminal contacts the Gateway via the access channel. The Gateway and the User Terminal then work together to connect the call and support communications. Since the satellites are moving, the user is continuously being illuminated by different satellite beams or even different satellites. Diversity combining within the receivers supports a process of transferring traffic that is completely transparent to the user. The diversity combining process also provides better call reliability. The hand off process is accomplished without interruption to the call in process. If the user moves into an area that shadows or blocks access to one satellite, the space diversity link through a satellite that is not blocked maintains uninterrupted user communications.

Hand Off: The moving satellite constellation requires hand offs to different satellites and to different beams. In general, hand off is transparent to the user. Hand off on the forward link does not imply hand off on the return link.

Forward Link: In the forward link direction (from the Gateway to the User Terminal), hand off is totally under control of the Gateway. The User Terminal finds pilots and reports quality to the Gateway. When a second pilot is seen, the quality is reported to the Gateway. If the Gateway determines that it is advisable, the Gateway will instruct the User Terminal to incorporate the signal into the diversity combiner. At all times the user terminal is using a fast algorithm to search for other pilots. Once a suspected pilot is detected, it is turned over to one of the fingers used as a clincher. So at one point in time, the User Terminal may have 3 fingers active. One is the traffic finger, one is used for diversity combing and the third finger is used as the clincher. In the forward direction the role of the User Terminal can be summed up as the proposer. The Gateway can be viewed as the disposer. The User Terminal suggests which pilots should be used. The Gateway decides.

Return Link: In the Return Link direction, the Gateway uses up to 6 fingers. Eb/No is measured. If the Eb/No is above a usable threshold it is added into the diversity combiner multiplex. New signals are added in until the Gateway runs out of fingers. A stronger signal will not cause the Gateway to take a weaker signal out of the diversity combining process as long as it is above the threshold. Once a signal drops below the acceptable threshold, it will be taken out of the diversity combining process and the finger released for assignment to other incoming User Terminal signals.

Soft Hand Off: In soft hand-off, two or more received signals through different links are simultaneously demodulated, combined, and decoded by the same entity. It is characterized by commencing communications using a new pilot on the same CDMA frequency before terminating communications with the old pilot. This is a hand off occurring while the user terminal is operating on the Traffic Channel.

Hard Hand Off: In hard hand off, the receiving entity stops demodulating and decoding information transmitted on one link and starts demodulating and decoding information transmitted on another link with possible loss of information. A hard hand off is characterized by a temporary disconnection of the Traffic Channel. Hard hand offs occur when the user terminal changes frequency or frame offsets.

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2.3 Gateway

The Gateways are geographically distributed by the service providers to serve their customer base. Figure 2-7 is an artist's concept of the Gateway.

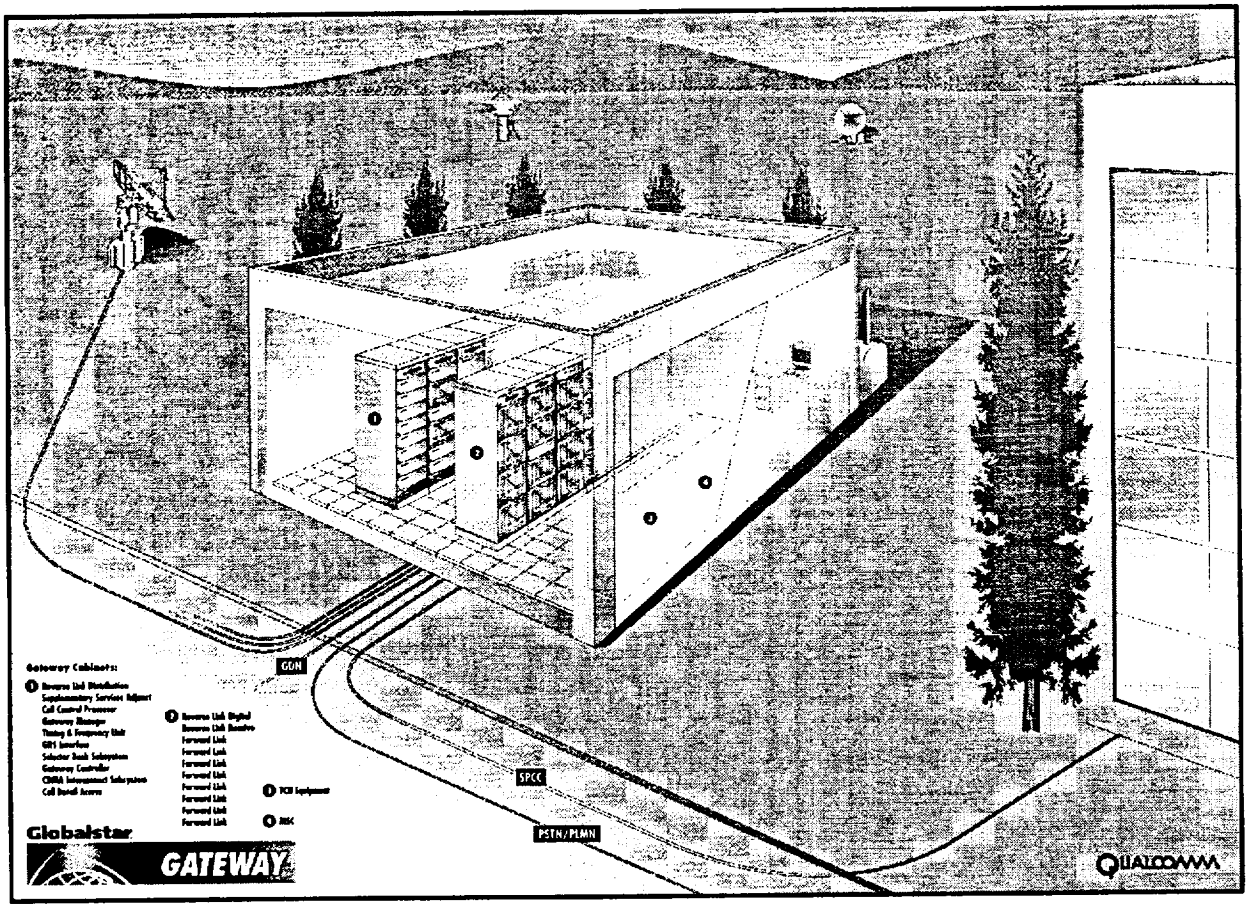

Figure 2-7 Gateway Artist Concept

Gateways are designed for unmanned operation The number of racks supplied depends upon the gateway configuration elected by the service provider. In addition to the equipment racks, the facility supplied by the Service Provider includes prime power, an Uninterrupted Power System (UPS), as well as any maintenance or office facilities. The antenna layout is flexible. The major constraint is to place the antennas so that they do not block visibility of the satellite constellation. Safety considerations for the operating area must also be observed.

Figure 2-8 is a simplified block diagram of a typical Gateway.

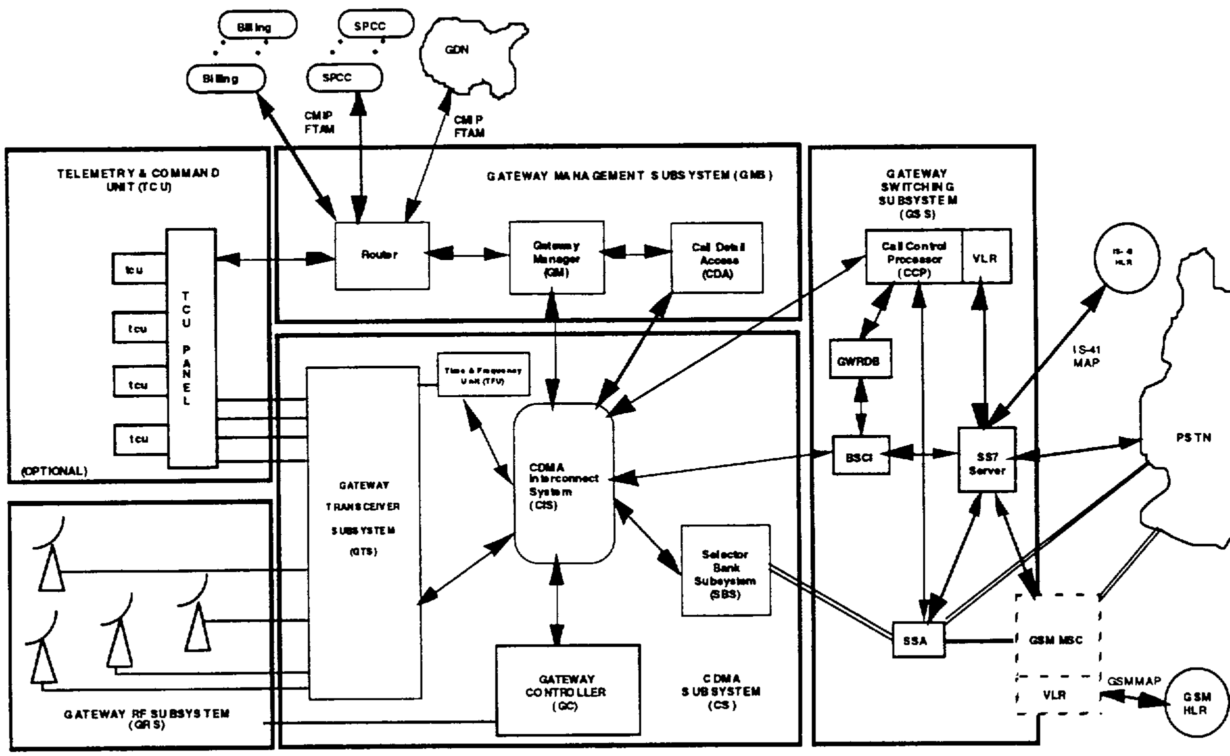

Figure 2-8 Gateway Simplified Block Diagram

Appearance : The Gateway consists of up to four identical parabolic antennas that are at least 5.5 meters in diameter. The antenna structure contains drive mechanisms for positioning the antenna, low noise receivers and high power transmitters. The antenna structure may be enclosed in a Radome to provide protection from the environment.

The antennas connect to a building that houses the electronics equipment. The Code Division Multiple Access (CDMA) equipment, PSTN interface equipment that interfaces with the terrestrial telephone network, and computer equipment to operate the Gateway and collect status and performance data are located in the electronics facility. Frequency converters may be located in the antenna structure or in the electronics facility.

Functions Performed : The Gateway supports voice communications, paging, and data transmissions. Position location services are also supported.

The Globalstar Gateway connects the Globalstar space segment to terrestrial switching equipment. The Gateway receives telephone calls from the terrestrial switching equipment and generates Code Division Multiple Access (CDMA) carriers to transmit through the satellite. The satellite then re-transmits the signal to User Terminals. These User Terminals may be either hand held, fixed or mobile and located anywhere within the satellite antenna footprint.

In the return direction, the User Terminal transmits to the satellite(s) and the satellite(s) re-transmit the signal to the Gateway. The Gateway connects the call to terrestrial switching equipment which can then connect to any subscriber using the standard telephone system.

Connections can also be made to terrestrial cellular subscribers or to other Globalstar User Terminals.

The Gateways are designed to operate without operator intervention. Maintenance is performed by service provider personnel as required. Status may be remotely monitored by the Service Provider's Control Center (SPCC).

Functions of the major elements of the Gateway are listed below.

Telemetry and Control Unit (TCU): The TCU acts as a telemetry and control interface between the satellite constellation and the SOCC. The TCU interfaces with the SOCC via the router in the GMS. The TCU interfaces with individual satellites via the GTS and the GRS.

Gateway RF Subsystem (GRS): The GRS interfaces the gateway to Globalstar users via the Globalstar satellite constellation.

Gateway Management Subsystem (GMS): The GMS interfaces the gateway with external management entities (SPCC and GOCC). The GMS performs non-real-time configuration and management of the gateway.

Call Detail Access (CDA): The Call Detail Access (CDA) is a separate, fault-tolerant workstation within the GMS, with stricter reliability requirements than the rest of the GMS. The CDA uses a confirmed-transfer protocol to retrieve accounting from the SBS, CCP and GC.

CDMA Subsystem (CS): The CS performs real-time operation of individual calls, maintaining the integrity of each physical link and performing physical layer format conversion between the CDMA wave form on the GRS side and PSTN signals on the GSS side.

Gateway Controller (GC): The GC is responsible for operation and supervision of the CS and of the GRS.

Gateway Transceiver Subsystem (GTS): The GTS is responsible for the physical layer implementation of the Globalstar Air Interface. Under the control of the GC, control elements in the GTS set up and operate overhead and traffic channels as required.

CDMA Interconnect Subsystem (CIS): The CIS provides packet-level and timing reference connectivity between all subsystems in the gateway.

Selector Bank Subsystem (SBS): The SBS provides an interface between the SSA and the CS, and performs layer two operation and radio link management of individual traffic channel circuits. The SBS also performs service option-specific processing of traffic channel data. Service options may include voice, data, and short message services.

Base Station Controller Interface (BSCI): the BSCI provides an interface between the CDMA Subsystem (CS) and the GSM MSCs. The BSCI implements the BSC side of the A1 Interface, providing the SS7 transport, the protocol discrimination function, BSSMAP processing, and passes the DTAP messaging between the GSM MSC and the CS. The BSCI can be configured to terminate multiple A1 Interface links between multiple GSM MSCs. The configuration and setup of the BSCI is controlled through the GMS interface (by way of the CS).

Time and Frequency Unit (TFU): The TFU provides a highly reliable and stable source of timing and frequency references to the CS and to the GRS. The TFU output is synchronized to the Global Positioning System (GPS).

Gateway Switching Subsystem (GSS): The GSS interfaces the gateway to the PSTN and controls the state of each call.

2.4 Ground Operations Control Center

Ground Operations Control Centers (GOCC) are responsible for planning and management of the communications resources of the Globalstar satellite constellation. This is coordinated with the Satellite Operations Control Center (SOCC). Figure 2-9 illustrates how the Ground Segment Equipment operates together to support Globalstar Communications Functions.

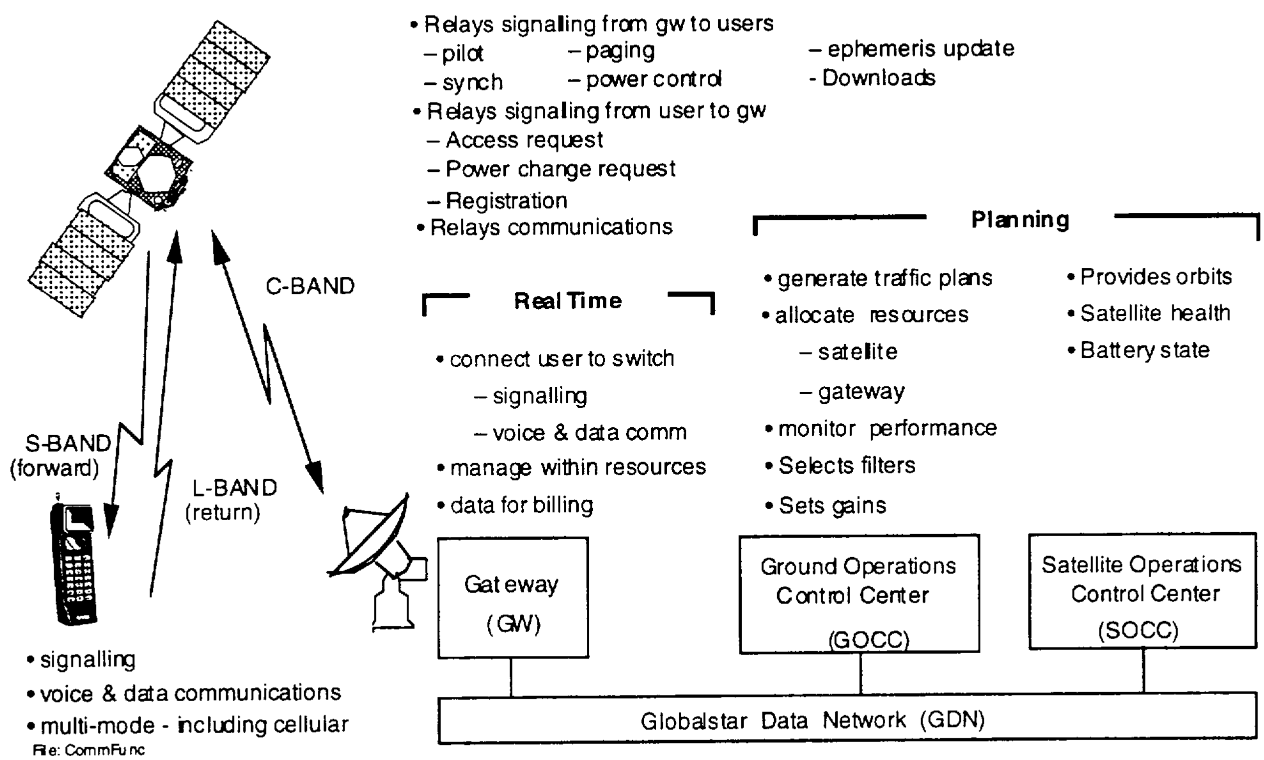

Figure 2-9 Ground Segment Support for Communications

The GOCC and the SOCC may be collocated or they may be physically separated with linkage via the Globalstar Data Network as shown in Figure 2-9. If the two are collocated, the connection will be by a Local Area Network (LAN). In either case, the GDN connections are required to accommodate failure scenarios. These collocations will reduce long term personnel costs since both the GOCC and the SOCC are manned facilities.

Figure 2-10 is a simplified block diagram of the Ground Operations Control Center (GOCC)

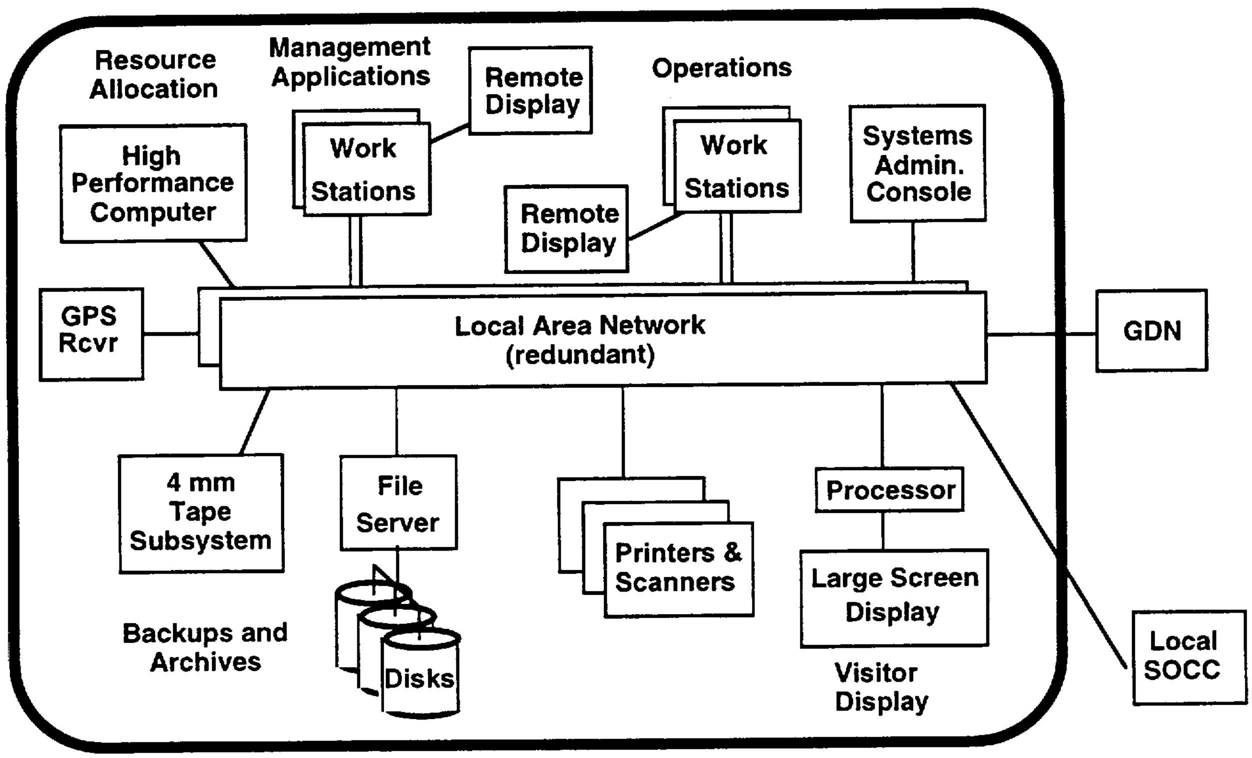

Figure 2-10 GOCC Simplified Block Diagram

In addition to the planning functions, the GOCC is responsible for monitoring performance and ensuring that the Gateways remain within the allocated satellite resources.

Appearance : The Ground Operations Control Center consists of a number of work stations in a control center environment. Besides the work stations used by the operators, there are other displays in the control center.

1. There are large screen remote displays located in the area. The computer operators can project any of the screen displays onto the large screen displays and continue operations. The large screen displays will update as the status changes.

2. There is also a large display that shows the position, coverage and status of the space segment.

3. A separate animated communications network display indicates the number of circuits flowing through Globalstar and indicates any congestion or circuit outages.

Functions Performed : The Ground Operations Control Center (GOCC) is the planning element for the Globalstar communications system. The redundant GOCCs plan the communications schedules for the Gateways and control the allocation of satellite resources to each Gateway. The Gateways process real time traffic within these assigned resources. The GOCC incorporates facilities to:

1. Generate long-range plans based on projected traffic requirements and constraints such as available frequencies, Gateway capacities, service areas, etc.

2. Monitor usage and refine plans based on measured performance of the system and constraints imposed by the SOCC.

3. Report satellite usage to the Satellite Operations Control Center.

The GOCC facilities are operated 24 hours per day.

Emergency Power : Critical elements of the ground equipment require a no-break power source or some form of backup power.

2.5 Globalstar Satellite

The Globalstar satellite is a simple low cost satellite designed to minimize both satellite costs and launch costs. A pictorial of the satellite and some of the major characteristics are shown in Figure 2-11.

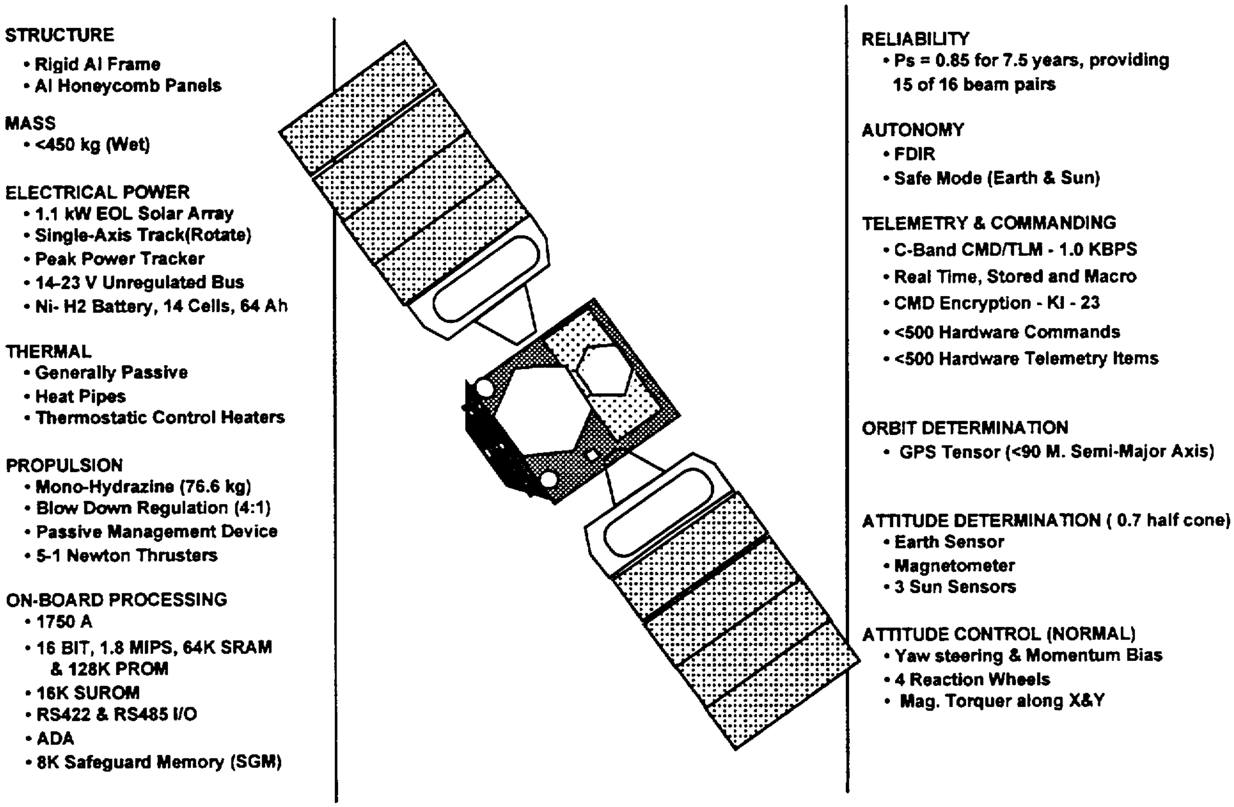

Figure 2-11 Spacecraft Bus Characteristics - Highly Autonomous

Communications Payload : A pictorial of the communications payload is shown in Figure 2-12.

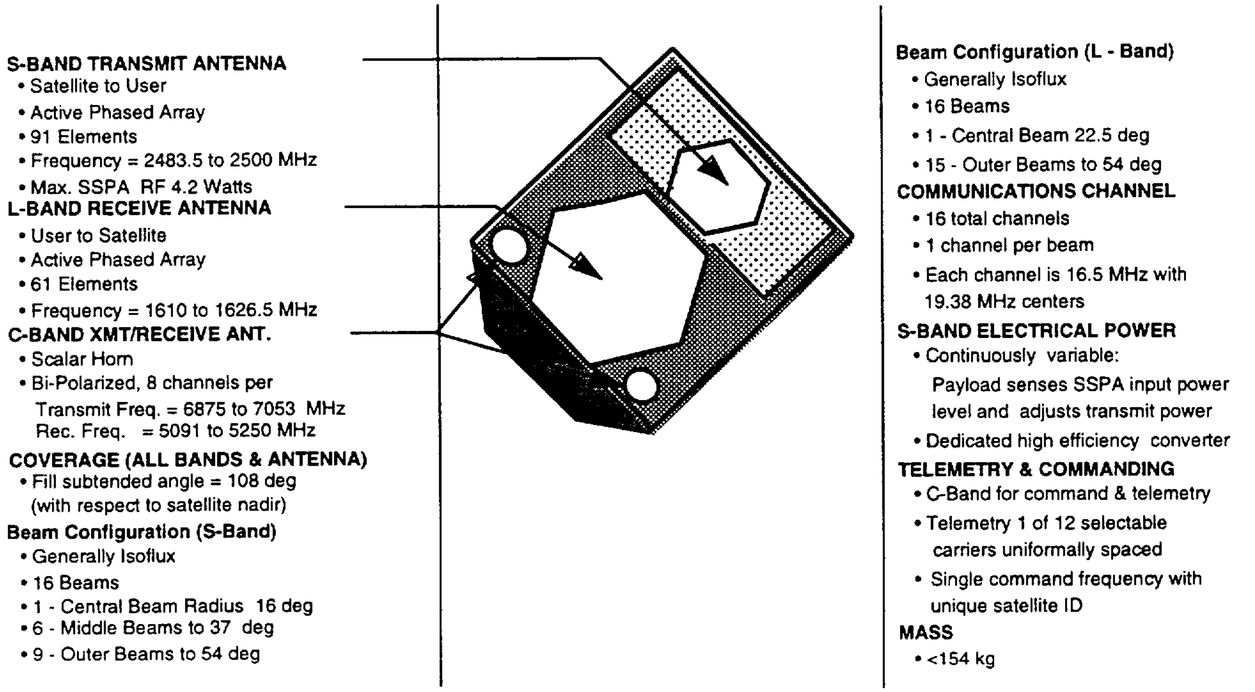

Figure 2-12 Communications Payload Pictorial

The communications payload is a simple bent pipe communications package as shown in Figure 2-13.

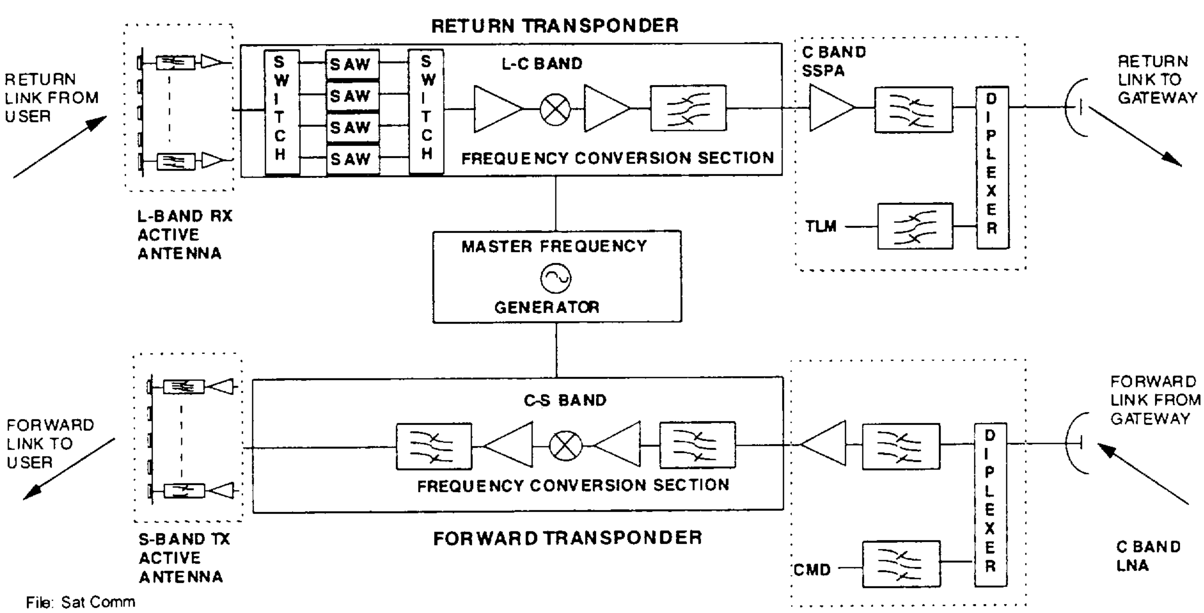

Figure 2-13 Communications Payload Simplified Block

Functions Performed : A User Terminal transmits to the satellite by L-Band. The signal enters the satellite through the L-Band low noise amplifier. It is amplified and then converted into a C-Band signal after which it is further amplified. This is radiated to the Gateway. The Gateway receives the signal and block down converts to an intermediate frequency. A sample of the intermediate frequency is provided to the TCU for processing. The communications traffic is presented to the CDMA equipment for demodulation.

In the forward link direction, the Gateway combines the up link CDMA signals with the signal from the command transmitter and radiates it at C-Band up to the satellite. The satellite then down converts the signal and radiates an S-Band down link signal to the User Terminals.

Telemetry & Command : The Telemetry and Command carriers share the C-Band with the communications feeder links. Figure 2-14 is a simplified block diagram of the T&C package on the satellite.

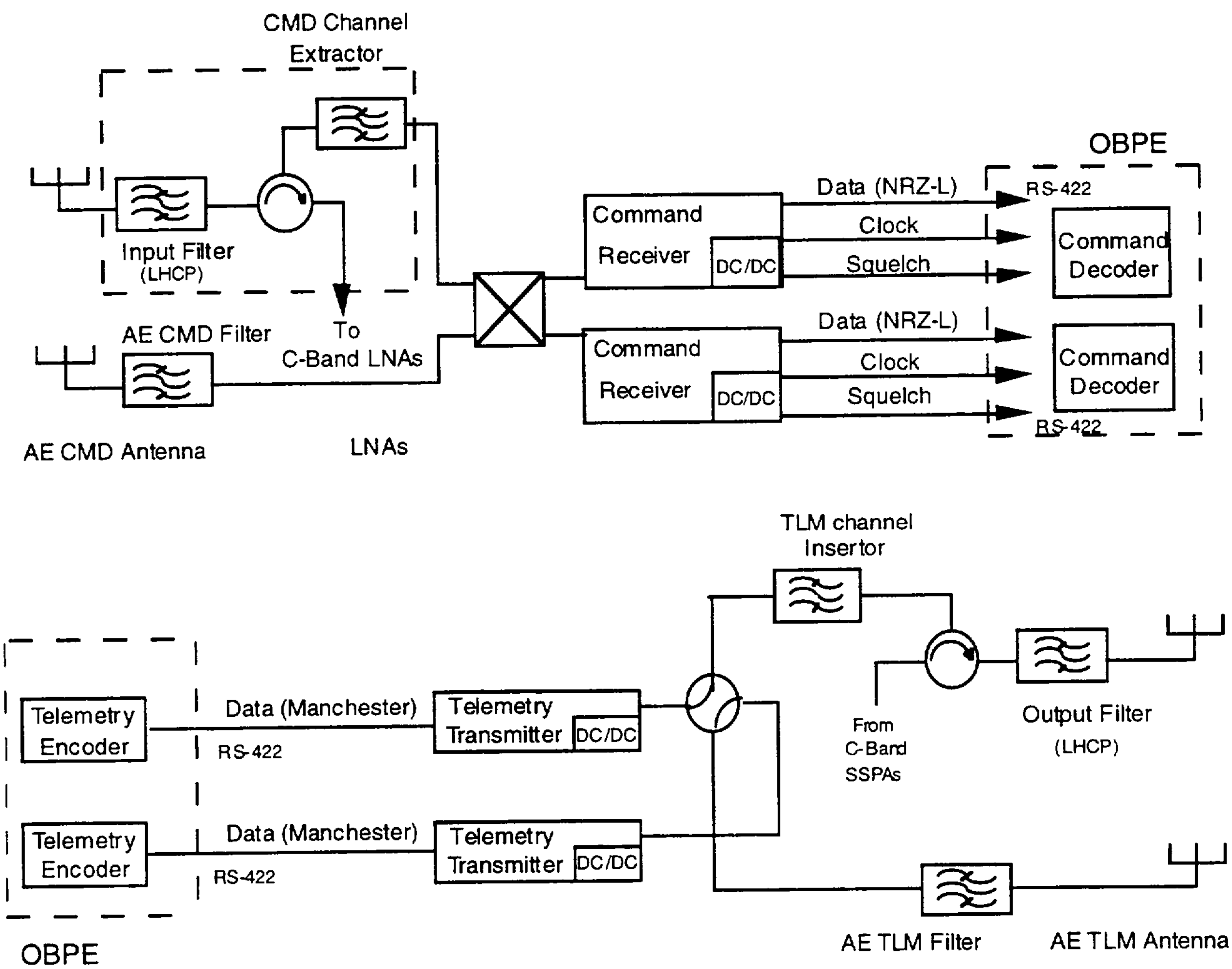

Figure 2-14 Satellite T&C - Compatible with Communications

The T&C connects to the normal C-Band communications antenna for on-orbit operations. There is also a T&C antenna on the anti-earth face of the satellite. This antenna functions when the satellite is not oriented correctly or when there are problems. The anti-earth antenna is to ensure that telemetry can be obtained and commands entered under all recoverable contingencies. Note that the anti-earth antenna bypasses the Low Noise Amplifier. This means that the transmitted power from the commanding earth terminal will have to be higher than the normal power required for commanding. This can be accommodated because there is no communications traffic when the satellite is not oriented correctly.

Yaw Steering: The satellite is steered in yaw to keep the solar panels oriented toward the sun to extract the maximum energy. This increases the communications capacity of the Globalstar System. There are some minor penalties that cause a slightly slower acquisition time and may cause more hand offs than would be otherwise required.

2.6 Satellite Operations Control Center

The Satellite Operations Control Center (SOCC) manages the satellites. Redundant SOCCs control the orbits and provide Telemetry and Command (T&C) services for the satellite constellation. In order to accomplish this function on a worldwide basis, the SOCC communicates with T&C units collocated at selected Gateways. The T&C units share the RF links with the Gateway communications equipment to relay commands and to receive telemetry. Figure 2-15 illustrates how the various elements of the Globalstar Ground Segment operate together to support the command and telemetry functions.

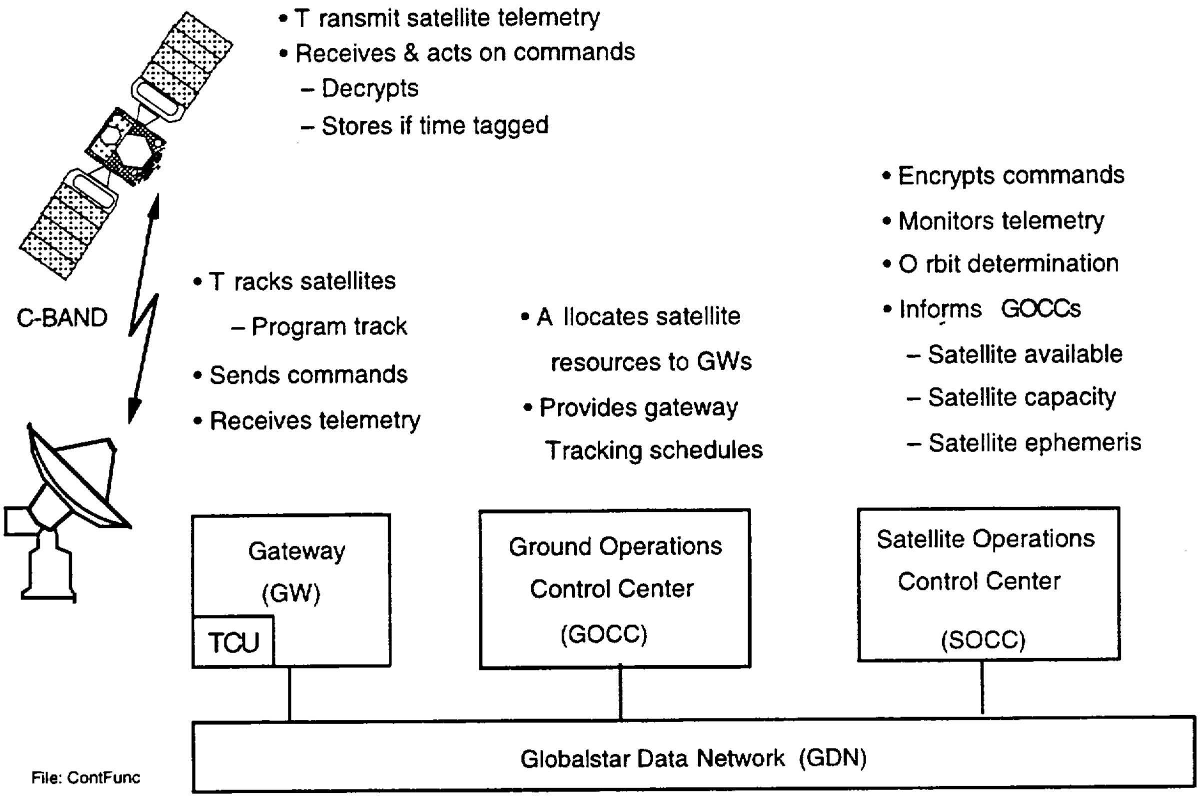

Figure 2-15 Ground Equipment Support for T&C Functions

Telemetry Down link and Command Up link : Globalstar satellites continuously transmit telemetry data which contains orbit position data and measurements of current on-board health and status of the spacecraft. Because both the telemetry stream and the communications payload feeder links will utilize C-band communications, T&C operations utilize antennas and RF-equipment at selected communications Gateways. Since only selected Gateways have T&C units, telemetry is available only when the satellite is being tracked by an antenna with a T&C Unit. All Gateways equipped with T&C Units have the ability to command the satellite. The T&C unit consists of special purpose RF cards and a DSP controlled by a Pentium based Personal Computer. A single self contained rack will accommodate up to 5 T&C Units (1 spare). The T&C units are designed to run automatically, with control from the SOCC No routine staffing is required. Any maintenance will be provided by service provider personnel dispatched on call from the Globalstar Control Center (GCC).

Telemetry Reception: Telemetry from each satellite will be received at the T&C Gateway that have an antenna trained on that satellite. The T&C unit will be able to either directly send the demodulated data (bent-pipe mode) or store it for later transmission (store and forward mode). Stored data will be sent to the SOCC upon SOCC request, typically during a period of lower system utilization or lower communications network costs. The SOCC will coordinate the T&C data transmission to avoid receiving identical data sets from multiple T&C sites. The telemetry data sent from the T&C site is routed to the SOCC as packet messages on the Globalstar Data

Network (GDN). Should more than one SOCC be providing support, the T&C equipment will route the data to multiple destinations.

Command Transmission: Commands received from the SOCC are immediately transmitted to the satellite (bent pipe mode only). Depending upon the command, the satellite can execute the command immediately or store the command for execution at a later time. The TCU does not incorporate a command storage facility. The SOCC is responsible for directing the command message to the proper T&C at the correct time for transmission.

SOCC Operations : The SOCC will receive minor frames over the Globalstar Data Network. Data received in the telemetry bent-pipe mode is immediately routed to the user workstations assigned to monitor or control the specific satellite. At any one time, all satellites in contact are automatically monitored by the software, with only selected satellites directly monitored by a member of the flight operations team. A single workstation can monitor up to 6 satellites. An operations controller may have asked for up to 6 specific satellites to monitor or may have defined the criteria by which the system can automatically determine which satellites are to be monitored. For example, the controller could request to see all satellites for which real-time data is being received for which the power subsystem monitoring software detects a possible area of concern.

Because of the very low telemetry rates, it is possible to have remotely located workstations, connected to the SOCC via using simple modem or ISDN communications. A workstation at the satellite manufacturer's facility, for example, could routinely be used to monitor a single satellite to support problem investigation, routine monitoring, or analysis.

The SOCC is also responsible for coordinating activities with the GOCC. The three primary interface functions are:

a. Orbit position information : The SOCC will provide information to the GOCC so that each Gateway can accurately track each satellite. The data will consist of data tables sufficient to allow the Gateway software to generate its own contact lists.

b. Utilization statistics : The GOCC will provide statistics to the SOCC pertaining to the actual communications quality and utilization (Gateway assessment) of each satellite. This information will be correlated with satellite telemetry to distinguish between expected and anomalous behavior.

c. Spacecraft status : The SOCC will report to the GOCC spacecraft/transponder availability. This data will include limitations associated with any satellite which may constrain or preclude its use for communications.

Use of Multiple SOCCs : Two SOCCs are planned. The San Jose, California location will support primary operations and a second one in El Dorado Hills, California serves as a backup to the prime. Both SOCCs will be able to receive telemetry data from the same satellites so that dual-site monitoring and "hot backup" functions could be supported; however, the baseline is a single string SOCC operation.

The main reason for the second SOCC is to create a backup operational facility in case of a catastrophic failure (fire, etc.) at the primary site. The two SOCCs, however, could be used routinely to share the load between two sites, to conduct training and to support development and test of software upgrades.

2.7 Globalstar Business Office

To support the Globalstar Business Office (GBO), the Globalstar Accounting & Billing System (GABS) is collocated with the GOCC and the SOCC. The GABS is responsible for all financial activities associated with Globalstar.

Appearance: The GABS is a client/server system with many work stations and the requisite office facilities required to support the assigned accounting and billing activities. The server for the primary GABS is located in the GCC. A back-up GABS server is located in the alternate GCC. Multi-platform client support is provided.

Functions: The GABS provides basic accounting and billing functions for GLP. The accounting functions are provided by a Commercial - Off - The - Shelf (COTS) package, ORACLE Financial, and include accounts payable, accounts receivable, general ledger, purchasing , and financial planning software. The wholesale billing function, provided by custom developed software, receives data from both the Gateways and the Service Providers. These data, call usage summaries, subscriber counts, etc. are used to calculate charges for usage of the Globalstar system and to generate bills which are sent to the service providers monthly.

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3. FREQUENCIES AND COVERAGE ANALYSIS

3.1 Frequency Plans

Globalstar uses C-Band between the Gateway and the Satellites as shown in Figure 3-1.

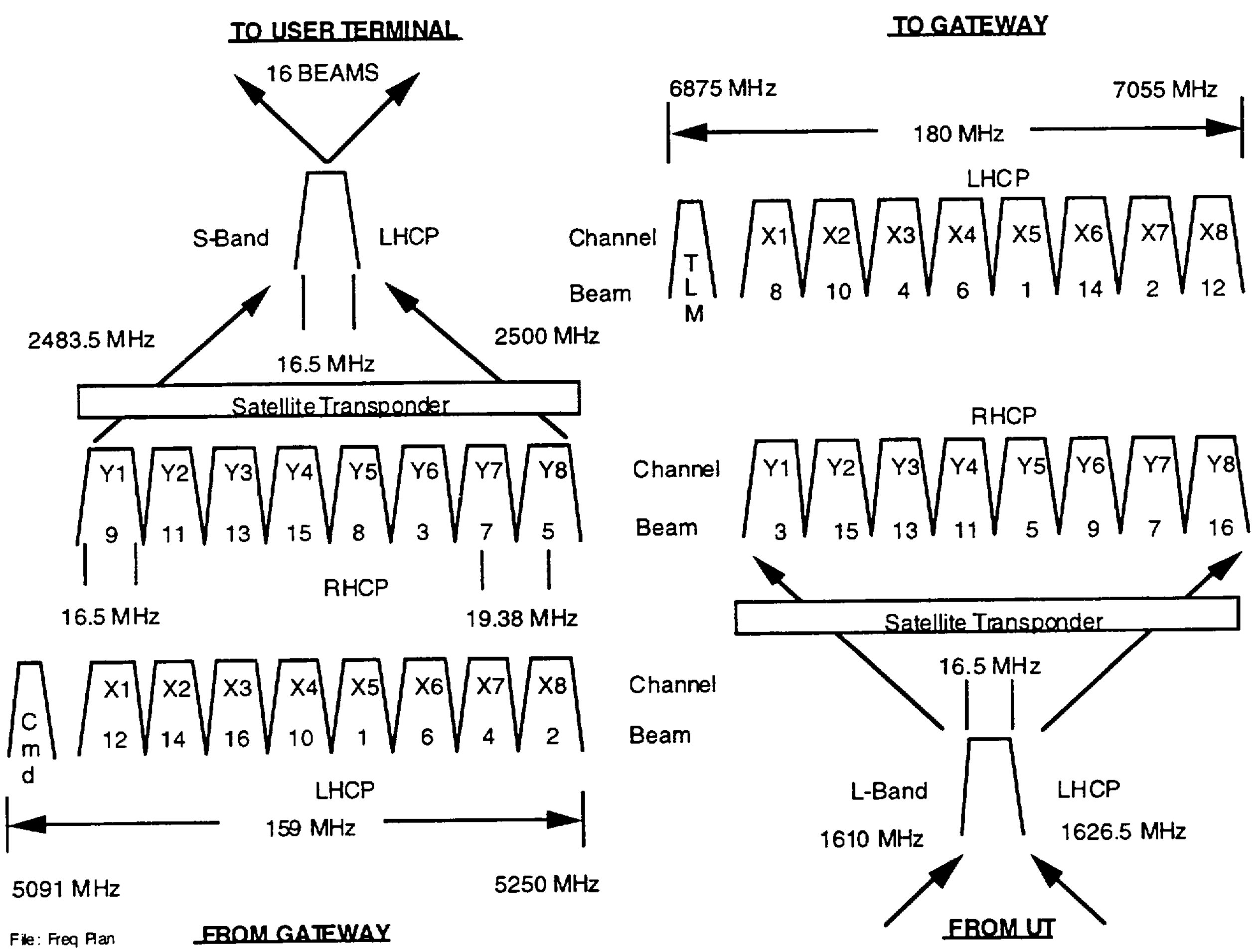

Figure 3-1 Frequency Plan - Emphasizes Conservation of Spectrum

The C-Band antennas on the satellite use an earth coverage beam. The Gateways use a parabolic antenna and program track the satellites. Program tracking uses the orbital data provided by the Satellite Operation Control Center to position the Gateway antenna.

Efficient Spectrum Utilization - The spectrum is used efficiently by incorporating frequency reuse and spread spectrum into the design. Both Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP) are used for C-Band. This allows 8 frequencies to connect to 16 beams on the satellite. The beam numbers shown in Figure 3-1 map to the S-Band beams shown in Figure 3-2 and the L-Band beams in Figure 3-3 which follows. The alpha characters used within the spectrum blocks and on the following diagram indicate polarization.

X= Left Hand Circular Polarization

Y= Right Hand Circular Polarization

3.2 Satellite Antenna Beam Configuration

The S-Band antennas on the satellite are configured to produce 16 beams as shown in Figure 3-2.

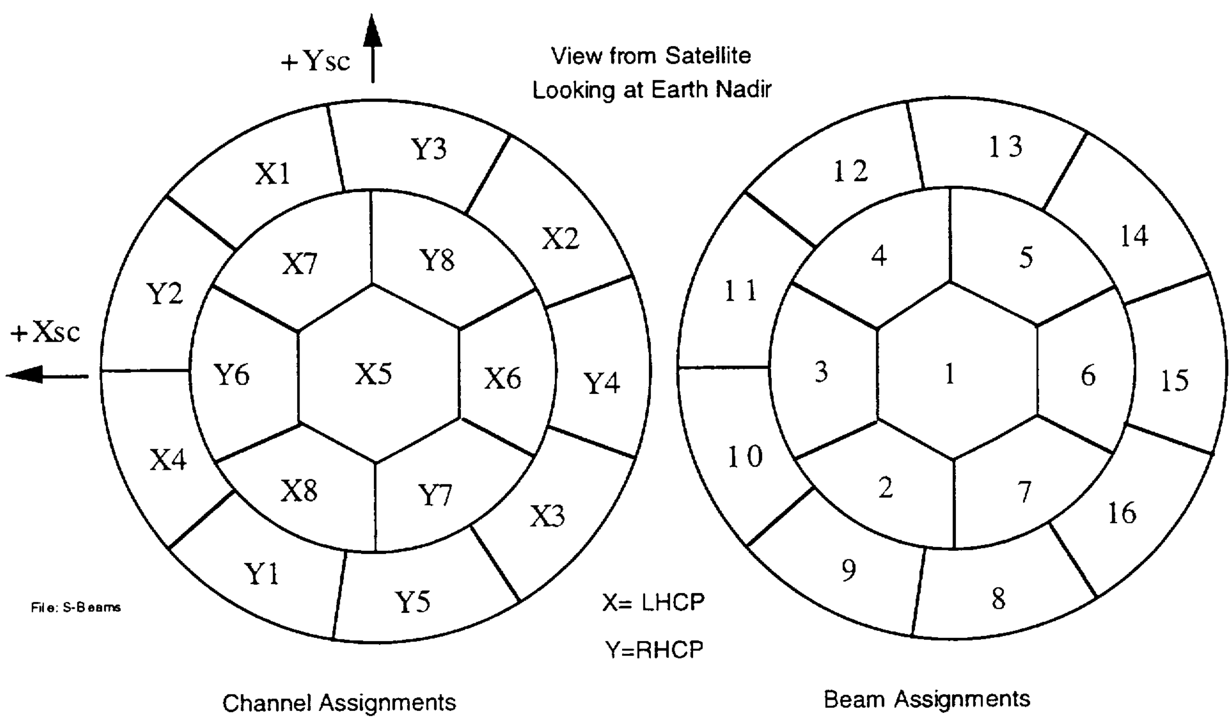

Figure 3-2 S - Band Beams

The antennas are multiple beam antennas designed to provide an isoflux pattern on the earth in the service region. The isoflux pattern is obtained by shaping the beam so that the gain at the edge of coverage is higher than at the beam center. This compensates for the difference in losses due to the longer slant range at the beam edges.

L-Band Pattern: The L-Band pattern consists of 16 beams. Beam 1 is in the center. The remaining 15 beams are arranged in an annular ring around the center beam as shown in Figure 3-3.

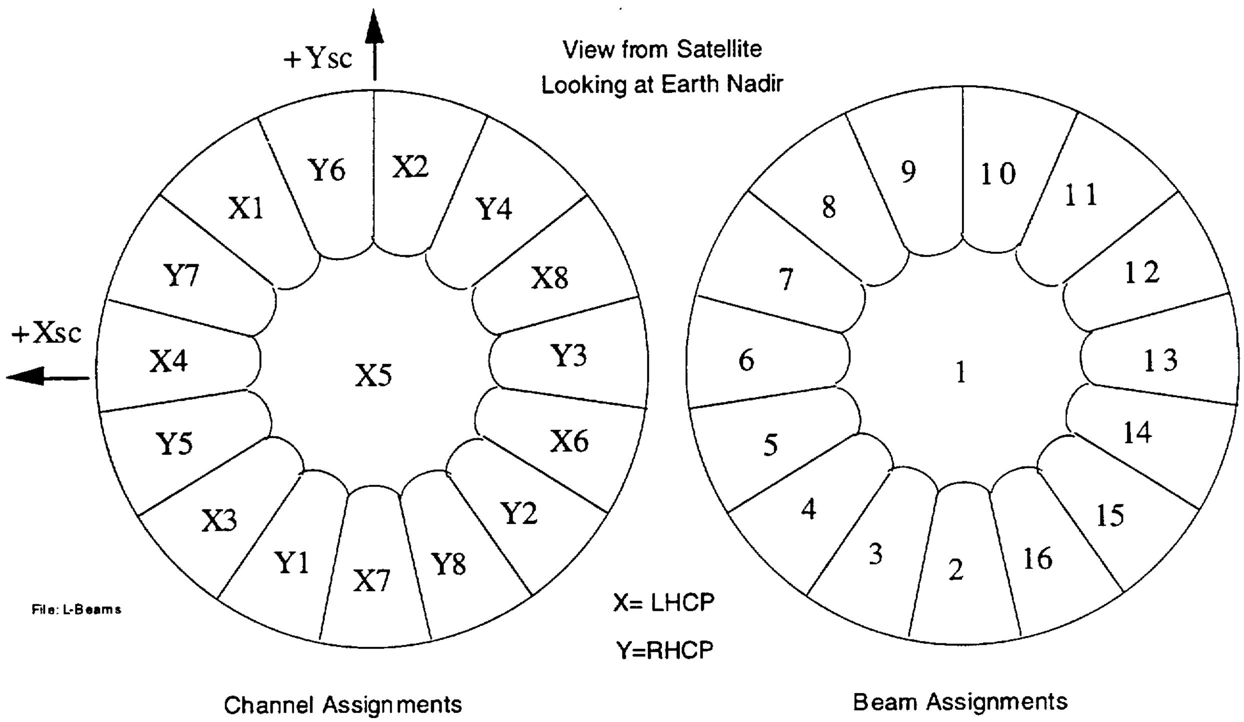

Figure 3-3 L- Band Beams

This configuration provides better coverage on the earth to reduce the power requirements on the L-Band transmitters in the User Terminals.

Efficient Spectrum Utilization - As shown in Figure 3-4 and Figure 3-5, only 16.5 MHz of L-Band and S-Band spectrum are used. The same set of frequencies are reused in each of the 16 beams. Note that C-Band frequencies are assigned to beams to minimize interference. The Globalstar approach is very efficient in its use of the valuable L-Band and S-Band spectrum. L-Band is used to communicate from the User Terminal to the satellite and S-Band is used to communicate from the Satellite to the User Terminal. Within each of the beams, there are 13 FDM channels.

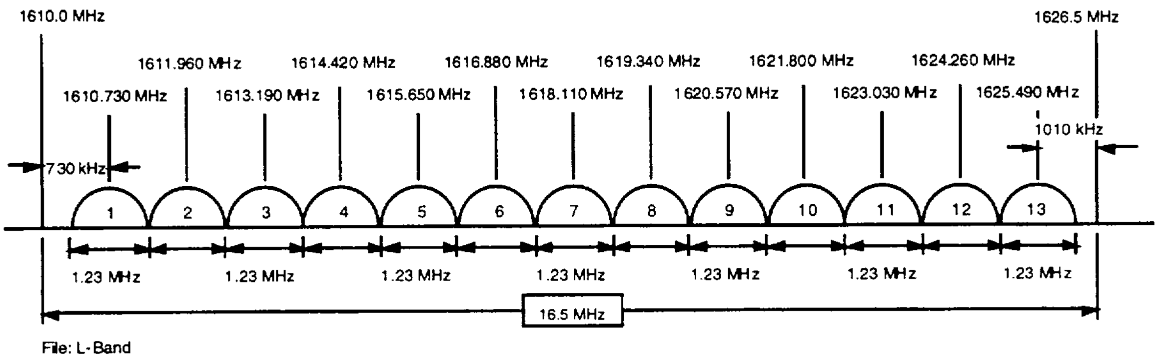

Figure 3-4 L - Band Channel Frequencies

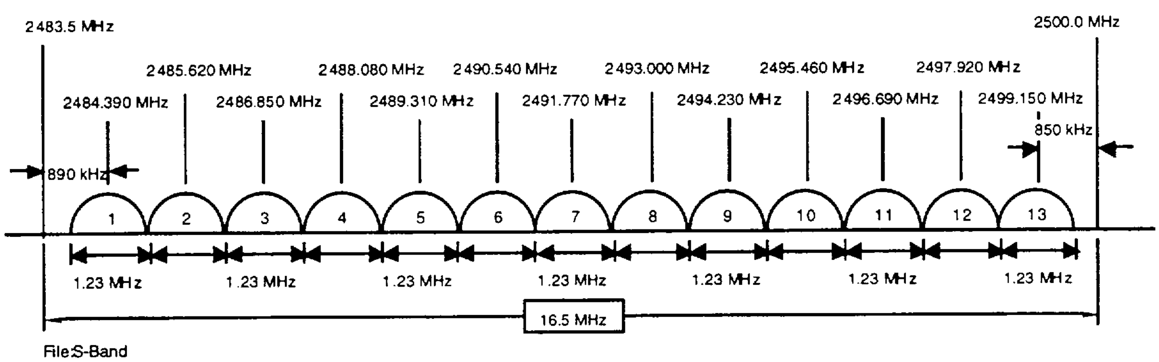

Figure 3-5 S - Band Channel Frequencies

Spectrum Sharing - Within a channel, spread spectrum is used to convey the voice or data intelligence. Multiple voice or data circuits may be carried within a single 1.23 MHz FDM channel. The circuit data is separated by unique PN spreading sequences. This allows the same spectrum to be shared by other CDMA users.

Satellite Frequency Plan: Table 3-1 illustrates how the C-Band up link signals are converted to S-Band down link signals and indicates how the signals are connected to down link beams. The table shows the assigned C-Band Frequencies.

Table 3-1 Satellite C-Band to S-Band

C-Band Frequencies		S-Band LHCP		S-Band RHCP	
RF Freq.(MHz)	**L.O. Freq (MHz)**	**Chan**	**Beam**	**Chan**	**Beam**
5105.21	7596.96	X1	12	Y1	9
5124.59	7616.34	X2	14	Y2	11
5143.97	7635.72	X3	16	Y3	13
5163.35	7655.10	X4	10	Y4	15
5182.73	7674.48	X5	1	Y5	8
5202.11	7693.86	X6	6	Y6	3
5221.49	7713.24	X7	4	Y7	7
5240.87	7732.62	X8	2	Y8	5
5091.50		CMD			

Table 3-2 illustrates the how the Return link is processed in the Satellite. The table shows the assigned C-Band Frequencies.

Table 3-2 Satellite L-Band to C-Band

L-Band to C-Band		L-Band LHCP		L-Band RHCP	
RF Freq(MHz)	**L.O. Freq (MHz)**	**Chan**	**Beam**	**Chan**	**Beam**
6908.99	5290.74	X1	8	Y1	3
6928.37	5310.12	X2	10	Y2	15
6947.75	5329.50	X3	4	Y3	13
6967.13	5348.88	X4	6	Y4	11
6986.51	5368.26	X5	1	Y5	5
7005.89	5387.64	X6	14	Y6	9
7025.27	5407.02	X7	2	Y7	7
7044.65	5426.40	X8	12	Y8	16
6876.0-6877.1 (12 ea.)		TLM			

Command and Telemetry Frequencies: The telemetry frequencies are listed in Table 3-3

Table 3-3 Satellite Telemetry & Command Frequencies

Command Channel Bandwidth	No. of Channels		Channel Width(s)	Frequency Center(s)
5091 to 5092 (*)	1		240 KHz	5091.5
Telemetry Channel Bandwidth	**No. of Channels**	**Chnl No.**	**Channel Width(s)**	**Frequency Center(s)**
6875.95 to 6877.15	12	1	100 KHz	6876.0
		2		6876.1
		3		6876.2
		4		6876.3
		5		6876.4
		6		6876.5
		7		6876.6
		8		6876.7
		9		6876.8
		10		6876.9
		11		6877.0
		12		6877.1

Doppler: The Frequencies that appear at the Globalstar nodes (Gateway, Satellite, UT) differ from the assigned frequencies. Doppler is one of the primary contributors. Doppler can be computed and the nodes can compensate for the differences in frequency. Table 3-4 indicates the magnitude of the Doppler components.

Table 3-4 Worst Case Doppler

Path Name	From	To	Frequency (MHz)	Doppler (KHz)	Rate Hz/sec
Forward Uplink	Gateway	Satellite	5250	97.2	468.8
Fwd Downlink	Satellite	UT	2500	46.5	224.3
Return Uplink	UT	Satellite	1626.5	30.2	146.0
Return Downlink	Satellite	Gateway	7052.9	131.6	634.9

3.3 Earth Surface Coverage

The surface of the earth, with the exception of the polar regions, is covered with multiple overlapping satellite beams as shown in Figure 3-6.

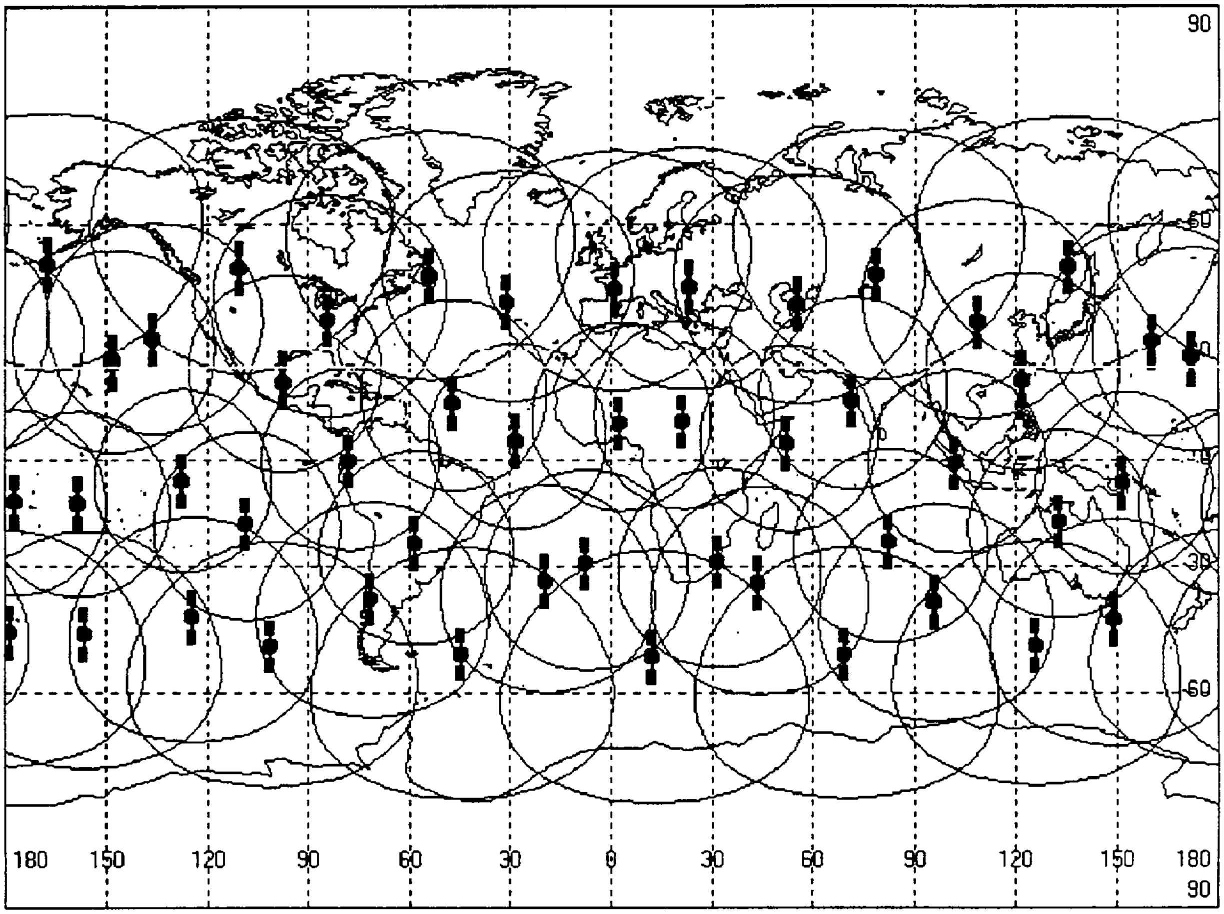

Figure 3-6 Full Earth Coverage-Except Polar Regions

The contours shown indicate that a User Terminal within the contour can communicate with the satellite at an elevation angle above 10 degrees.

Constraining the User Terminals to operate with satellites that have higher elevation angles referred to the User Terminal will reduce the overlapping coverage but would provide an advantage in that it would reduce the power demands placed on the User Terminal to close the link. This would result in longer battery life for the User Terminal.

Conversely, lowering the angle to the satellite will increase the overlapping coverage. Small changes dramatically increase the coverage area. This is particularly apparent in the polar regions. If operated at low elevation angles, polar areas that otherwise could not be covered can receive service. In polar areas, overlapping coverage would be increased and power demands may be increased. In this region the look angle to the satellite is limited. High gain directional antennas become practical for fixed and even portable installations. The pay back is that Globalstar could now serve areas that otherwise might be unserviceable.

To a degree, some of these same considerations discussed for polar areas apply to equatorial areas where the overlapping coverage is less than 100%.

Satellites in View as a Function of Latitude: Figure 3-7 illustrates the multiple satellite coverage more clearly.

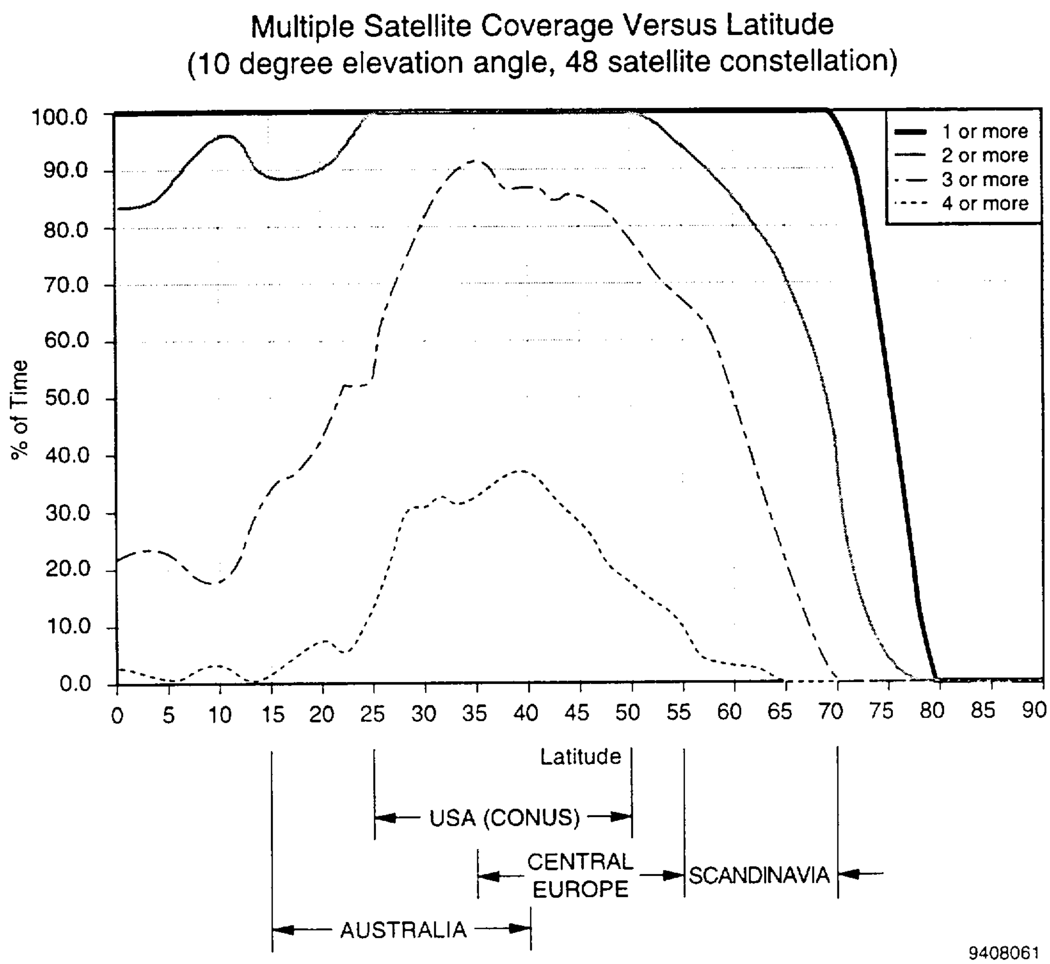

Figure 3-7 Enhanced Coverage for Temperate Regions

Note that the coverage is optimized to provide multiple coverage in the temperate regions. In areas within this temperate region, the User Terminal can communicate via multiple satellites. This enhances the link availability and allows the User Terminal to operate with nominal link margins.

Orbital Parameters: The orbital parameters for the initial injection orbit and for the final on station orbit are shown in Figure 3-8.

	On Station		Phasing Orbit	
Parameter	Mean	Tol (3 σ)	Mean	Tol (3 σ)
Radius (km)	7778	+/- 0.1	7298	+/- 20
Orbit Period-Nodal	114 min	+/- 0.13 sec	103.35	+/-0.4
Eccentricity	0.000	+ 0.008	0.000	+ 0.01
Inclination (Degrees)	52	+/- 0.01	52	+/- 0.6
RAAN Spacing for plane J=1...8 (Degrees)	45	+/- 1.0		
Relative Phasing between satellites in a plane (Degrees)	60	+/- 1		
Relative Phasing between adjacent planes (Degrees)	7.5	+/- 1		File: Orbitp Rev 11/06/96

Figure 3-8 Orbital Parameters for Globalstar Satellites

3.4 Position Determination

The location of the User Terminal is determined by Globalstar and used for several purposes. Any position location services that may be provided should be considered a by product of the Globalstar System. The primary purpose of Globalstar is to provide communications. It should not be considered as a competitor or replacement for GPS or GLONASS. Two basic accuracy are supported.

Low Accuracy: The user terminal is located to within 10 km for purposes of National Sovereignty, to assign the user to a gateway, and to support registration. This accuracy is sufficient for the gateway to determine which satellite/beam should be used for phone paging. This avoids having to page on multiple satellites/beams at the cost of capacity.

High Accuracy: A higher accuracy on the order of 300 meters is feasible in under some conditions. This may be attractive as a service. This high accuracy results from the high degree of precision with which the position and velocity of the satellite constellation is know. Each satellite incorporates a GPS receiver to determine position and rate of change of position. When this data is processed with other data at the SOCC the precision of the orbit becomes quite good. The CDMA, for its own purposes, needs to align chips within 1/8 of a chip. Potential for high positioning accuracy is inherent.

The User Terminal may determine its position with the assistance of the Gateway or it may determine its position autonomously. In all cases, determination of position is based on determining the intersection of three or more spheres in 3-dimensional space. The surface of the earth can be used as one of the spheres. The Gateway has the processing power to make active determination attractive. This must be traded for additional messaging that will be required to support active determination of position.

Active Determination: The Gateway calculates range based on time delay between the User Terminal and the Gateway through a satellite. The phone transmission can be an access probe or an ongoing call, but it must be synchronized in some fashion to the forward link signal. When this accomplished through two satellites with the proper geometry, excellent positioning accuracy can be achieved.

Passive Determination: The User Terminal can determine its location without the assistance of the Gateway. In this mode, since time is not known very well this means the system has an extra degree of freedom. The phone measures a ΔT between two different satellites, and another ΔT using a third satellite. Three 3 satellites are required, to solve for the phone's clock offset. An additional form of passive position determination incorporates measurements of the satellite velocities relative to the phone, instead of or in addition to the satellite ranges to the phone. This is done by measuring the received Doppler shift of the satellite signal.

Any of the techniques must incorporate the following generic considerations.

Geometric Dilution Of Precision (GDOP): This is a phenomenon that affects all forms of position determination. It is due to the orientation of the satellites from the phone's perspective. When the geometry is good, precision is good. When poor, the accuracy degrades very quickly.

Time to Position: Time to achieve an accurate position depends on the time. In simple forms, the more time the more precise the location.

Geographical Constraints: Position determination becomes more difficult when the User Terminals are on the equator or at high latitudes. In these cases, only one satellite may be visible. This means that range must be determined at one point in time and the range determined again at another point in time. Under these conditions the geometry is less than optimal, resulting in a long time to achieve a valid position determination and an inaccurate determination of position.

Terrain Maps: For the surface of the earth to be used as one of the intersecting spheres, a terrain map must be used to determine altitude above the mean surface of the earth. The degree of granularity of this map will impact the accuracy that can be achieved and will impact the time to achieve a position indication.

3.5 Channel Characteristics

Figure 3-9 illustrates the orientation of a User Terminal in a typical temperate climate scenario with multiple satellite coverage.

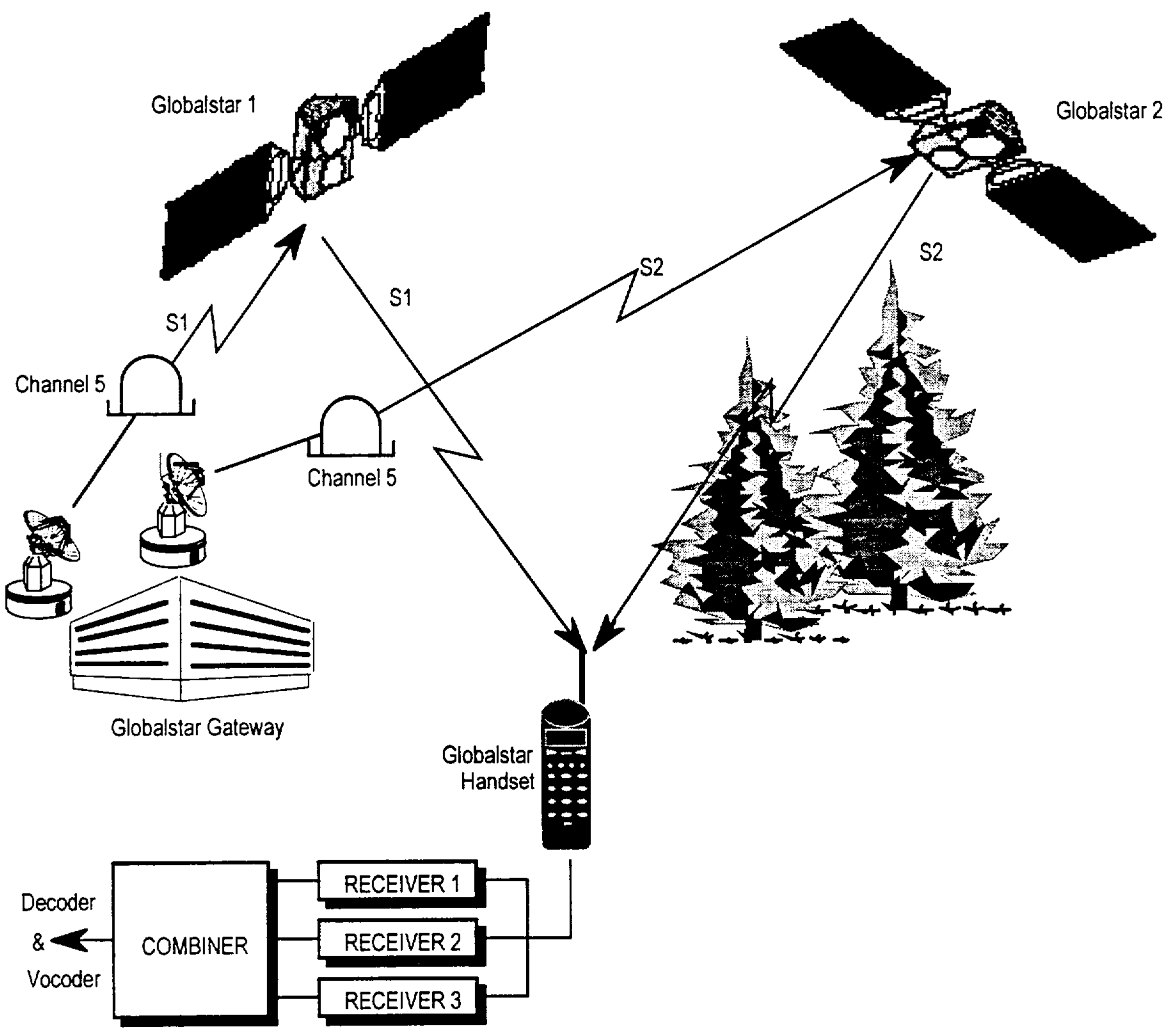

Figure 3-9 Channel Characteristics Considerations

Line of Sight: For the Globalstar system, many of the obstructions in the direct line of sight do not completely block the line of sight, but rather simply attenuate the signal. Given two satellites in view at the same time, the probability of signal blockage or shadowing to both satellites is significantly less than the probability of blockage to a single satellite.

Specular Reflection: The specular reflection component is the signal reflected off the surface of the earth. The magnitude of the reflected signal can be large if the surface is relatively smooth and flat at the point of reflection. The specular component will prove to be an insidious problem for the hand held antennas. It can either add to or subtract from the signal received from the direct line of sight. This problem can be managed effectively for the mobile and the fixed station antennas.

Diffuse Reflection: The diffuse component is composed of a sum of a large number of individual terrain scatter from outside the first Fresnel zone. This diffuse component is characterized by phase incoherent multi-path with a uniform phase distribution and a Rayleigh amplitude distribution. The signal fading associated with the diffuse component combining with the direct component produces the fast-fading characteristics of the propagation channel.

Building Penetration: Globalstar has limited ability to penetrate buildings. Operation is possible in wood frame buildings or near windows with a wide angle view of the sky. The best locations within building results in 6 to 13 dB added insertion loss. There is a high degree of sensitivity to antenna location within the building. A change in lateral position of 20 to 30 centimeters can produce a 30-dB variation in signal power.

In Pocket: With the antenna extended, operation depends on orientation. Body blockage can insert attenuation in excess of 15 dB. If the antenna is stowed, operation is not considered feasible.

Interference: User Terminal receivers may experience interference when operating in close proximity to microwave ovens, plywood plants or hospitals. The transmitters are frequency coordinated for operation with Radio Astronomy sites, for operation with GPS, and with GLONASS. The Gateway site locations are selected to avoid interference with the Microwave Landing Systems (MLS) associated with airports.

Conclusions: Several Conclusions can be drawn for Globalstar operations.

1. Operation at higher elevation angles is preferred.

2. Mobile will suffer less from specular. Power control may be less effective at some operating speeds.

3. Fixed terminals will suffer less degradation from all sources.

4. Forward and Return link behavior are not correlated. Conclusions from one direction cannot be used to derive control information for the other direction.

3.6 Link Analysis

The Globalstar system provides spatial diversity to overcome shadowing and blocking. The link analysis in this section is based on the current FCC filing which assumes nominal 5.5 meter antennas at the Gateways. There are 3 cases that are presented.

Case 1: This is a detailed link budget. This case considers the forward and return links between the Gateway to the User Terminal. The up link from the Gateway to the satellite is C-Band. The down link from the satellite to the User Terminal is S-Band. The Return Link is L-Band from the User Terminal to the Satellite and C-Band from the satellite to the Gateway. There is no shadowing or blocking and diversity is used.

Case 2: This is an abbreviated link budget that shows only the differences from case 1. One path is blocked. Only the C-Band or the S-Band can be blocked; since, the Gateway will be in one location.

Case 3: This is a rare case where both links are shadowed or faded by 10 dB.

Table 3-5 Forward Link C-Band - Case 1 - Detailed Budget

Up Link Gateway to Satellite C-Band		
Frequency	5125.0	MHz
Nominal EIRP per user	26.8	dBW
Path loss(40 degree. GW elev.)	-172.5	dB
Polarization & Tracking. Loss	-1.1	dB
Satellite Antenna gain (incl. line loss)	3.1	dB
Receive power/user at LNA	-143.7	dBW
Average User Data Rate	2400.0	b/s
System Noise Temperature	549.5	K
Thermal Noise Density, No	-201.2	dBW/Hz
Estimate Interference Density	-198.5	dBW/Hz
Up link Eb/(No+Io)	19.1	dB

1 **Table 3-6 Forward Link S-Band - Case 1 - Detailed Budget**

Down Link Satellite to User Terminal		
Frequency	2495.0	MHz
Nominal EIRP per user	-2.9	dBWi
Satellite Altitude	1414.0	km
Typical Elevation Angle	50.0	degrees
Range	1740.5	km
Free Space Loss	-165.2	dB
Polarization & Tracking. Loss	-1.0	dB
Shadowing Loss	0.0	dB
Receive Signal Strength /user/sat.	-169.1	dBWi
User Antenna Gain(incl. line loss)	2.6	dBi
User Signal at antenna output	-166.5	dBW
System Noise Temperature	293.7	K
Thermal Noise Density, No	-203.9	dBW/Hz
Average Data Rate, Rb	2400.0	b/s
Down link Eb/No	3.6	dB
Interference per Channel	-148.6	dBW
Spreading Bandwidth	1.23	MHz
-10*log(spreading BW)	-60.9	dB/Hz
Interference Density, Io	-209.5	dBW/Hz
Down link Eb/(No+Io)	2.6	dB
Coherent combining gain	2.5	dB
Overall Eb/(No+Io) (up&dn)	5.0	dB
Operating Eb/No	5.0	dB

2

3

Table 3-7 Forward Link - Case 2 - Link Blockage

C-Band Up Link and S-Band Down Link		
Up link		
EIRP per user	28.8	dBW
Up link Eb/(No+Io)	21.1	dB
Down link		
EIRP per user	-0.4	dBW
Down link Eb/(No+Io)	5.1	dB
Coherent combining gain	0.0	dB
Overall Eb/(No+Io)	5.0	dB

Table 3-8 Forward Link - Case 3 - Rare Two Link Fade

C-Band Up Link and S-Band Down Link		
Up link		
EIRP per user	36.3	dBW
Up link Eb/(No+Io)	28.6	dB
Down link		
EIRP per user	7.1	dBW
Shadowing loss	-10.0	dB
Down link Eb/(No+Io)	2.6	dB
Coherent combining gain	2.5	dB
Overall Eb/(No+Io)	5.0	dB

1 ### *Table 3-9 Return Link L-Band - Case 1 - Detailed Budget*

Up Link User Terminal to Satellite		
Frequency	1615.0	MHz
Nominal EIRP per user	-11.2	dBWi
Satellite Altitude	1414.0	km
Typical elevation angle	70.0	degrees
Range	1487.1	km
Free Space Loss	-160.1	dB
Polarization & Tracking. Loss	-1.0	dB
Shadowing loss	0.0	dB
S/C Receive Signal Strength	-172.3	dBWi
S/C Antenna Gain (incl. line loss)	11.5	dBi
User Signal at antenna output	-160.8	dBW
System Noise Temperature	500.0	K
Thermal Noise Density, No	-201.6	dBW/Hz
Average data rate, Rb	2400.0	b/s
Up link Eb/No	7.0	dB
Interference per channel	-142.2	dBW
Spreading bandwidth	1.23	MHz
Interference Density	-203.1	dBW/Hz
Up link Eb/(No+Io)	4.7	dB

2

1 **Table 3-10 Return Link C-Band - Case 1 - Detailed Budget**

Down Link Satellite to Gateway		
Frequency	6975.0	MHz
Nominal EIRP per user	-27.7	dBW
Path loss (40 degree GW elev.)	-175.2	dB
Polarization & Tracking. loss	-1.1	dB
GW antenna gain	49.4	dB
Receive power/user	-154.5	dBW
System noise temp.	127.7	K
Thermal noise density, No	-207.5	dBW/Hz
Interference Density, Io	-212.3	dBW/Hz
Down link Eb/(No+Io)	18.0	dB
Combining gain	1.8	dB
Overall Eb/(No+Io)(up&dn)	6.3	dB
Operating Eb/No	6.3	dB

2

3 **Table 3-11 Return Link - Case 2 - Link Blockage**

L-Band Up Link and C- Band Down Link		
Up link		
EIRP per user	-9.4	dBW
Up link Eb/(No+Io)	6.5	dB
Down link		
EIRP per user	-25.9	dBW
Down link Eb/(No+Io)	19.8	dB
Combining gain	0.0	dB
Overall Eb/(No+Io)(up&dn)	6.3	dB

4

Table 3-12 Return Link - Case 3 - Rare Two Link Fade

L- Band Up Link and C- Band Down Link		
Up link		
EIRP per user	-1.2	dBW
Shadowing loss	-10.0	dB
Up link Eb/(No+Io)	4.7	dB
Down link		
EIRP per user	-27.7	dBW
Down link Eb/(No+Io)	18.0	dBW
Combining gain	1.8	dB
Overall Eb/(No+Io)(up&dn)	6.3	dB

Forward Link: The link from the Gateway to the User Terminal reduces self interference within an FDM channel by coherent transmissions and by using CDMA Walsh codes which are orthogonal.

Return Link: The Return link uses paths through multiple satellites to combat the effects of shadowing, blockage and multi-path.

4. CODE DIVISION MULTIPLE ACCESS (CDMA)

4.1 Introduction

The Globalstar Air Interface uses a modified form of IS-95 to support Code Division Multiple Access. CDMA was selected for Globalstar because it represents a proven technology that can provide a bandwidth efficient modulation scheme for satellite communications. It is relatively interference tolerant, both from the standpoint of generation of interference to other services and tolerating outside interference. As a bonus, there is a level of security inherent in the modulation scheme. It is difficult to listen into conversations or to pirate services from the system. CDMA is able to provide good voice quality while operating at relatively low RF power levels. The Globalstar CDMA is based on the existing QUALCOMM CDMA product line used for terrestrial cellular communications.

Path Diversity combats fades and blockage - Probably one of the most important aspects of CDMA is associated with the way Globalstar uses CDMA. Diversity combining is used to provide continuous communications even under conditions where a path to one satellite is totally blocked. The Globalstar system can operate with relatively low link margins and still provide a high link availability.

CDMA supports spectrum sharing - There are other useful and interesting aspects of CDMA. In CDMA two or more systems can occupy the same frequency-power space. Separation of the intelligence is accomplished by demodulating the PN spreading sequence. This supports band sharing by more than one system.

Soft Capacity Limit: There is another useful aspect of CDMA. Since CDMA is basically a system whose capacity is limited by self generated interference, the limit is a soft limit. Unlike bandwidth limited systems like Time Division Multiple Access (TDMA) or Frequency Division Multiple Access (FDMA), CDMA allows the predicted capacity limit to be exceeded with soft degradation occurring.

4.2 Diversity Combining

Diversity combining is used to mitigate the effects of link phenomena. In a simple form, diversity combining uses the signal with the best signal to noise ratio. Rake receivers are used to receive and combine the signals from multiple sources. As an example, the User Terminal will provide diversity combining for the forward link signals received through up to two different links simultaneously.

Diversity increases Availability - The performance in the diversity mode will always exceed the performance that would be achieved with communications via a single string link. Diversity combining is continuous. There is no break in service if one or more of the diversity links is lost.

Multiple Satellite - Forward Link: In the forward direction, the use of diversity brings substantial gain if one of the satellites is obstructed and is break even for unobstructed operation without multi-path. With multi-path fading (typically with high values of Ricean k) the diversity also provides benefit.

Multiple Satellite - Return Link: In the reverse direction, there is a clear advantage because gain results even with no obstruction. Because this is non coherent diversity combining, the gain is not quite as much as with coherent operation.

Multiple Beam - Forward Link: There is no diversity advantage for using multiple beams. All beams come from precisely the same point in the sky and are at the same sub-channel frequency. Whatever shadowing or multi-path occurs for one beam occurs for the other.

Multiple Beam - Return Link: On the Return Channel the signals the gateway sees through the different beams are, of course, the same; they fade in exactly the same way. But the noise backgrounds in which they are received are essentially independent. There is some advantage to using diversity.

4.3 Fade Mitigation

The Gateway will support power control to address slow fades and interleaving to address medium to fast fades. Power control is implemented on both the forward and return links.

Power Control: To support forward link power control, the user terminal reports pilot quality statistics to the gateway. For return link power control, the Gateway measures frame error rate. The response time of the power control is adjusted to accommodate the satellite round trip time delays. Average round trip delay is on the order of 30 ms.

> **Forward Link**: Forward link power control is closed loop under control of the Gateway. The dynamic range of the forward link power control is at least 20 dB.

> **Return Link**: The return link is operated open loop when a fade is first sensed, then closed loop under control of the Gateway. The dynamic range of the return link power

control is a maximum of 20 dB with a 0.5 dB step size. The User Terminal will limit the integrated transmitted power to conform with regulatory requirements.

Interleaver: The Interleavers will operate over a 20 ms vocoder packet frame which will effectively address medium and fast fades.

4.4 Acquisition

Search to Acquire: When a Globalstar phone hunts for a pilot channel it must search through a multi-dimensional space. Three of the more obvious dimensions are illustrated in Figure 4-1.

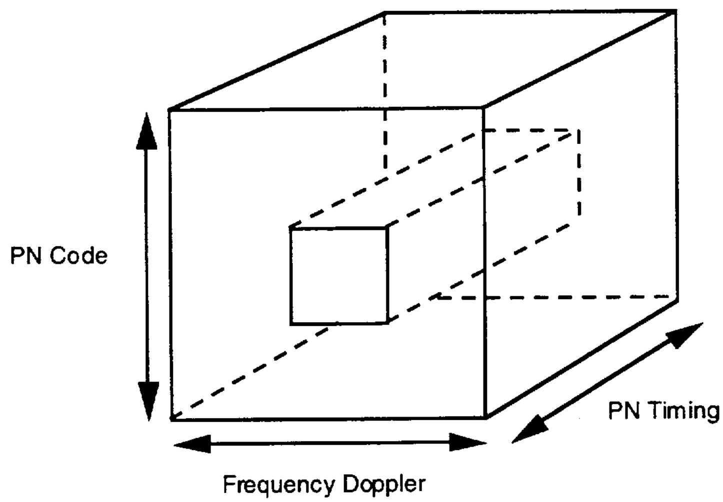

Figure 4-1 Acquisition Search Space

The goal is to reduce the search volumes by all means practical. Given that the search volume is decreased; then parallel processing can be used to speed the search process without compromise to the probability of a correct acquisition.

Latitude Dependence: The acquisition time is also a function of other variables such as latitude as shown in Figure 4-2.

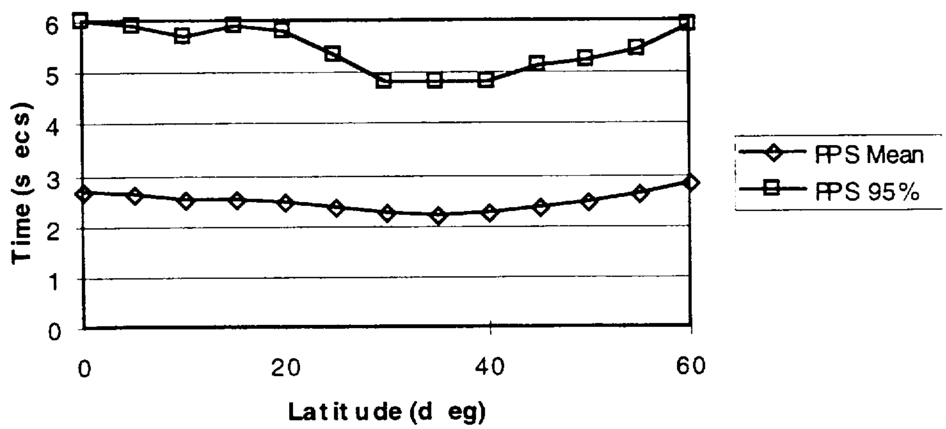

Figure 4-2 Acquisition Time as a function of Latitude

The Search is latitude dependent due to the orbital geometry. Less satellites are visible at high latitudes.

Several approaches are used to attain this apparent rapid response. Parallel searching speeds the search process materially. The Ground Operations Control Center (GOCC) is also involved in speed up of the search process. The search times shown in Figure 4-2 apply if the pilot frequency is known. The GOCC can help by assigning the pilot frequencies near the center of the band in a given geographical area. This basically collapses the search frequency dimension shown in Figure 4-1 to the uncertainty due to Doppler.

Summary: This means that if the User Terminal stays in its home gateway area the acquisition process can be very quick. If the pilot frequency is unknown due either to poor assignment by the GOCC or due to the User Terminal roaming to another gateway area, the search time can extend. Basically the maximum search time is the number of pilots that must be searched times the time to acquire as shown in Figure 4-2. The mean time to acquire is roughly half of the maximum time to acquire.

4.5 Forward CDMA Channel

An example assignment of the code channels transmitted by a gateway is shown in Figure 4-3. Out of the 128 code channels available for use, the example depicts the Pilot Channel (always required), one Sync Channel, seven Paging Channels (the maximum number allowed), and 119 Traffic Channels of Rate Set 1. Another possible configuration could replace all the Paging Channels and the Sync Channel one for one with Traffic Channels of Rate Set 1, for a maximum of one Pilot Channel, zero Paging Channels, zero Sync Channels, and 127 Traffic Channels of Rate Set 1.

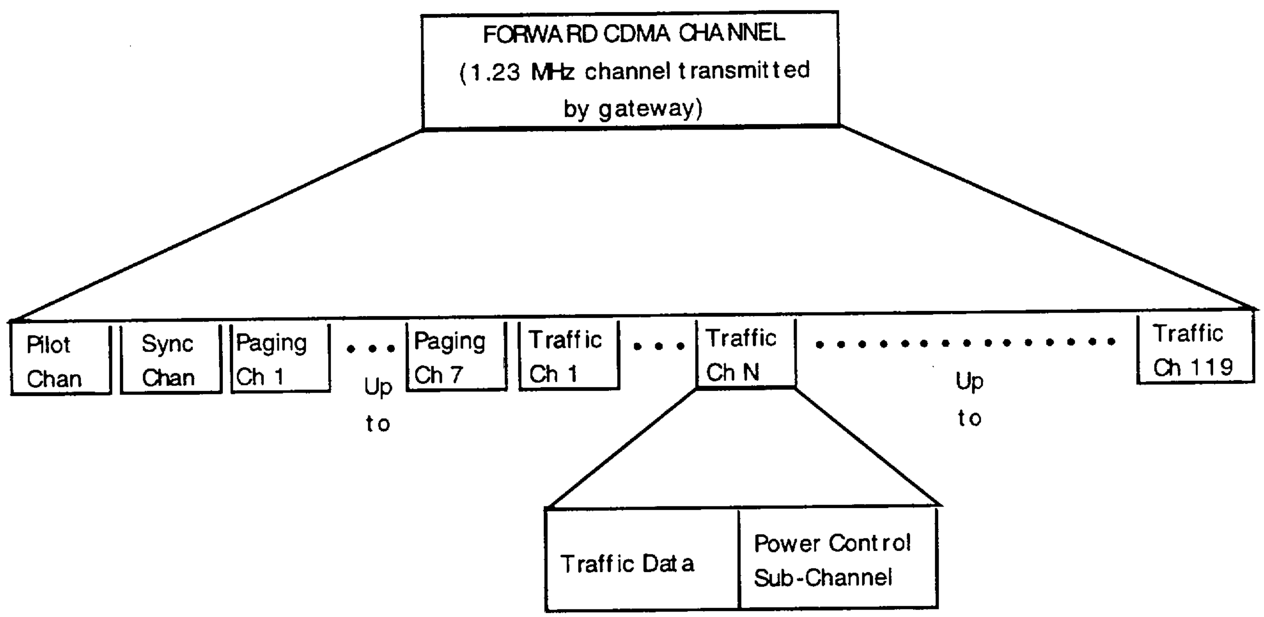

Figure 4-3 Forward CDMA Channel Transmitted by a Gateway

The forward CDMA channel consists of the Pilot Channel, one Sync Channel, up to seven Paging Channels, and a number of Forward Traffic Channels. Multiple Forward Channels are used in a Gateway by placing each Forward Channel on a different frequency.

The forward link Pilot, Sync and Paging Channel is generated as shown in Figure 4-4.

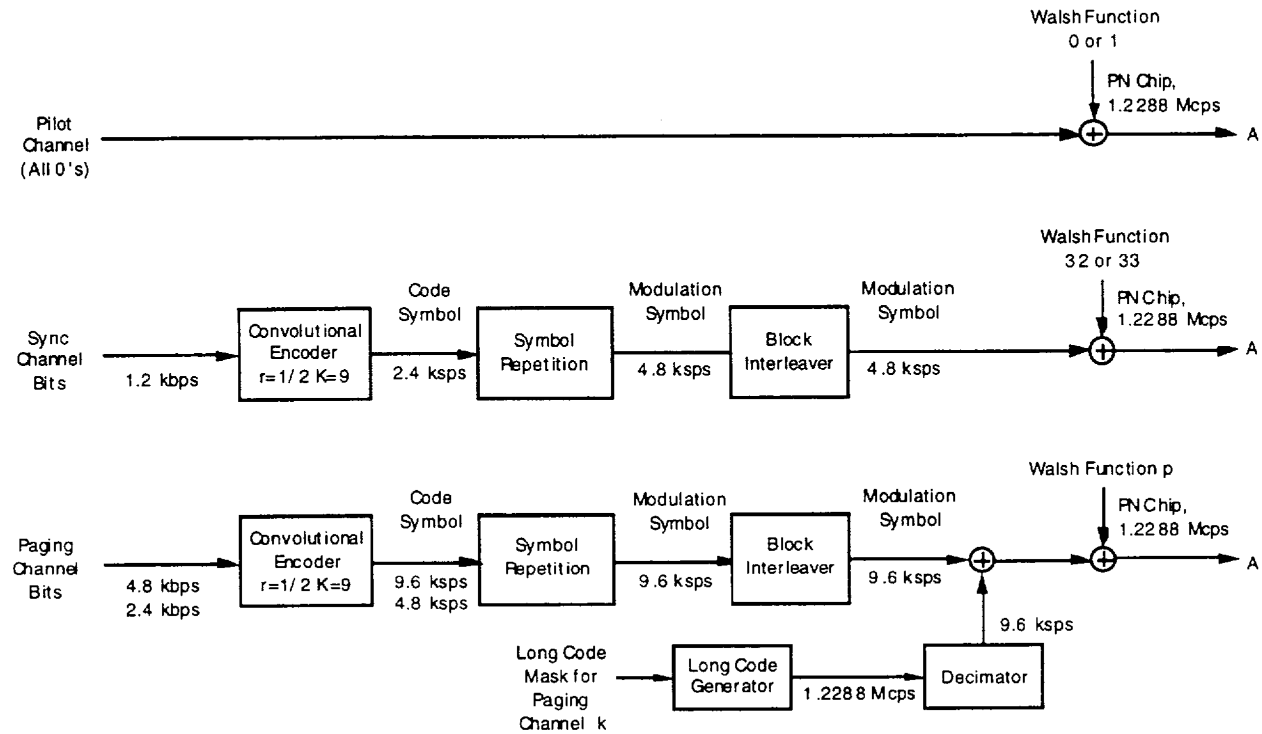

Figure 4-4 Forward Link Pilot, Sync and Paging Channel

The forward link is modulated as follows.

Pilot Channel: The Pilot Channel is transmitted continuously by the Gateway and is utilized by the User Terminals operating within the coverage area of the Gateway to acquire timing on the forward channel, to provide a phase reference for coherent demodulation and to provide signal strength comparisons that govern when to do hand offs. The Pilot channel will generate an all zeros Walsh Code. This is combined with the short code used to separate signals from different Gateways and different satellites. The pilot channel is modulo 2 added to the 1.2288 Mc/s short code and is then QPSK spread across the 1.23 MHz CDMA bandwidth. The User Terminal monitors the pilot channel and assesses its signal strength at all times except when it is operating in the slotted mode.

Sync channel: The Sync Channel is an encoded, interleaved, spread and modulated spread spectrum signal that is used by the User Terminals operating within the gateway coverage area to acquire initial time synchronization. The Sync channel will generate a 1200 b/s data stream that includes (1) time, (2) transmitting Gateway identification, (3) assigned paging channel. This is convolutionally encoded and Block Interleaved to combat fast fades. The resulting 4800 symbols per second data stream is modulo two added to the sync Walsh code at 1.2288 Mc/s and the short code. It is then QPSK spread across the 1.23 MHz CDMA bandwidth.

Paging Channel: The Paging Channel is used for transmission of control information and pages from a gateway to a user terminal. The paging channel is convolutionally encoded at Rate = 1/2, Constraint length K = 9 and block interleaved. The resulting symbol rate is combined with the long code. The paging channel and the long code are modulo two added and provided to the symbol cover where the resulting signal is modulo two added to the 1.2288 Mc/s Walsh Code and the short code. The results are then QPSK spread across the 1.23 MHz CDMA bandwidth.

Forward Traffic Channel: The Forward Link Traffic Channel - Rate Set 1 is generated as shown in Figure 4-5.

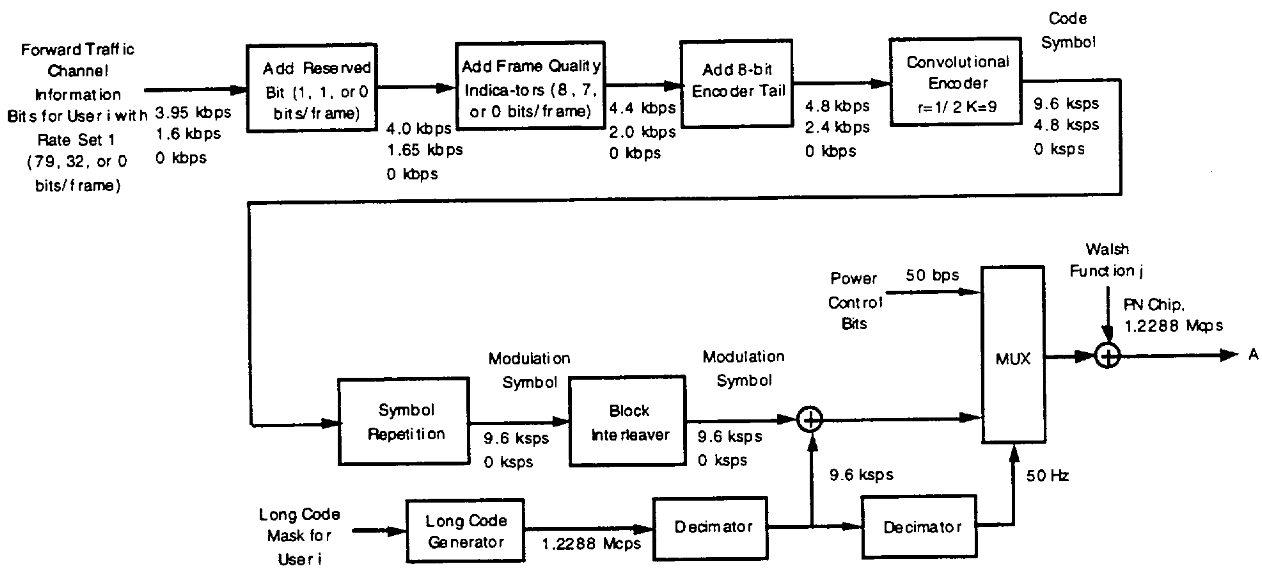

Figure 4-5 Forward Link Traffic Channel - Rate Set 1

The Forward Link Traffic Channel - Rate Set 2 is generated as shown in Figure 4-6.

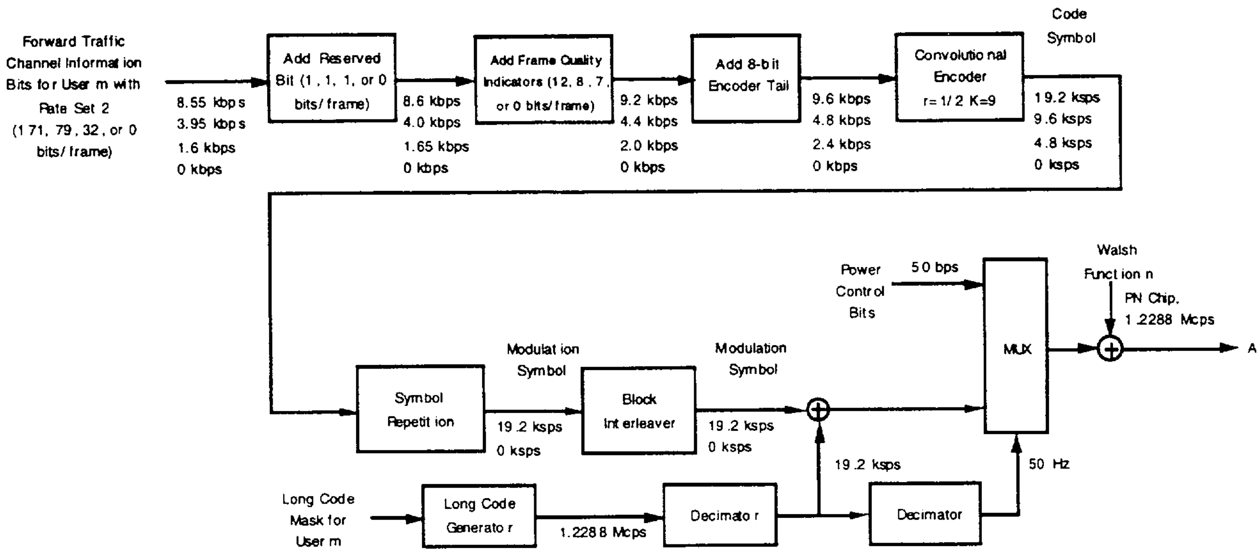

Figure 4-6 Forward Link Traffic Channel - Rate Set 2

The Vocoder encodes the voice into a PCM data stream. The data stream is the processed as shown in Figure 4-5. The resulting data stream is then power controlled and modulo two added to the 1.2288 Mc/s Walsh code and the short code. The results is then QPSK Spread across the 1.23 MHz CDMA communication channel bandwidth. The Globalstar Air Interface will support two different rate sets from the Gateway. Within a rate set, the Globalstar Air Interface (GAI) will support variable data rate operation. When the high rate shown in Figure 4-5 is used, two Walsh codes are required.

Modulation and Spreading: Modulation and spreading is applied as shown in Figure 4-7.

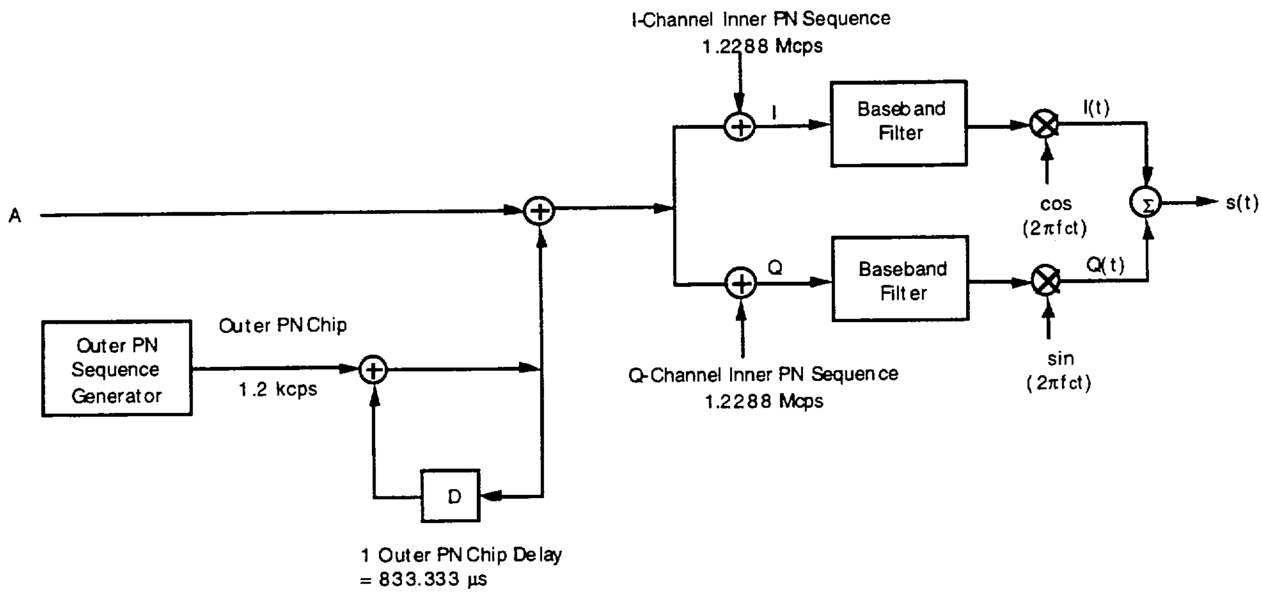

Figure 4-7 Forward Link Modulation and Spreading

The spreading sequence structure for a given Globalstar CDMA channel is comprised of an inner PN sequence pair and a single outer PN sequence. The inner PN sequence has a chip rate of 1.2288 Mcps and a length of 1024, while the outer PN sequence has an outer chip rate of 1200 outer chips per second and a length of 288; the outer PN sequence modulates the inner PN sequence to produce the actual spreading sequence, lasting exactly 240 msec. Exactly one inner PN period is contained within a single outer PN chip. The spreading and modulation process applies to all forward link channels.

Path Identification: It is necessary to know the path that a signal has taken in order to facilitate gateway sharing of a forward CDMA channel and to support diversity combining. Path information is derived from the pilot signal.

Gateway: Two gateways can share a forward CDMA channel. Pilot channel 0 is assigned to the first gateway can be allocated more power and serve as a beacon pilot within the beam to increase acquisition speed of the User Terminals in the beam.

Orbital Plane: The inner PN sequence is used to identify the orbital plane. The length of the sequence is 2^{10} chips at a chip rate of 1.2288 mcps. there are 24 repetitions every 20 ms.

Satellite: Each satellite is identified by a pilot PN sequence.

Beam: Each Satellite Beam has a unique outer PN sequence offset.

Beam Juxtaposition: Each Adjacent beam within a satellite is identified by a unique inner PN sequence offset. Inner PN offsets are reused among non adjacent beams of a satellite.

Sharing of Forward CDMA Channel: It is also possible for two gateways to share a single subbeam. This mode is used when a gateway's traffic needs only a fraction of a subbeam and each gateway must supply a separate pilot. In particular, this mode is useful when a satellite beam is moving from gateway service area A to gateway service area B. Gateways A and B can then share a subbeam as the traffic from A is ramping down and the traffic from B is ramping up. When sharing the first gateway will use all even-numbered code channels, and the second gateway will use all odd-numbered code channels.

The Pilot Channel of the first gateway is transmitted on code channel 0. The Sync Channel associated with this Pilot Channel, if it exists, is transmitted on code channel 32. The Primary Paging Channel (Paging Channel number 1) of the first gateway, if it exists, is transmitted on code channel 64. Paging Channel numbers 2, 3, 4, 5, 6, and 7, if they exist, are transmitted on code channels 2, 66, 4, 68, 6, and 70, respectively.

The Pilot Channel of the second gateway is transmitted on code channel 1. The Sync Channel associated with this Pilot Channel, if it exists, is transmitted on code channel 33. The Primary Paging Channel (Paging Channel number 1) of the second gateway, if it exists, is transmitted on code channel 65. Paging Channel numbers 2, 3, 4, 5, 6, and 7, if they exist, are transmitted on code channels 3, 67, 5, 69, 7, and 71, respectively.

4.6 Return Link CDMA Channel

The Reverse CDMA Channel is composed of Access Channels and Reverse Traffic Channels as shown in Figure 4-8.

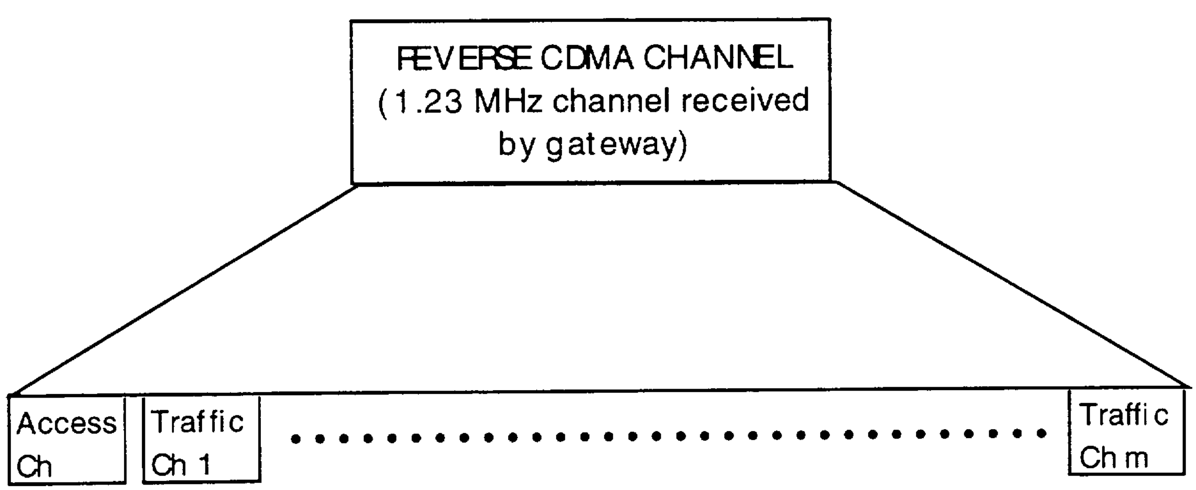

Figure 4-8. Reverse CDMA Channels Received at a Gateway

Figure 4-8 shows an example of all of the signals received by a gateway on the Reverse CDMA Channel. These channels share the same CDMA frequency assignment using direct-sequence CDMA. Each Traffic Channel is identified by a distinct user long code sequence. Each Access Channel is identified by its quadrature spreading codes and the gateway identification in the long code mask. Multiple Reverse CDMA Channels on different frequencies may be used by a gateway.

The Reverse CDMA Channel has the overall structure shown in Figure 4-9 and Figure 4-10. Data transmitted on the Reverse CDMA Channel is grouped into 20 ms frames. All data transmitted on the Reverse CDMA Channel is convolutionally encoded, block interleaved, modulated by the 64-ary orthogonal modulation, and direct-sequence spread prior to transmission.

Access Channel: The Access Channel is used by the User Terminal for communicating to the Gateway. It is used for short signaling message exchanges such as call origination, response to pages, and registrations. The Access channel is a slotted random access channel. Each Access Channel, as shown in Figure 4-9, is identified by a distinct Access Channel long code sequence.

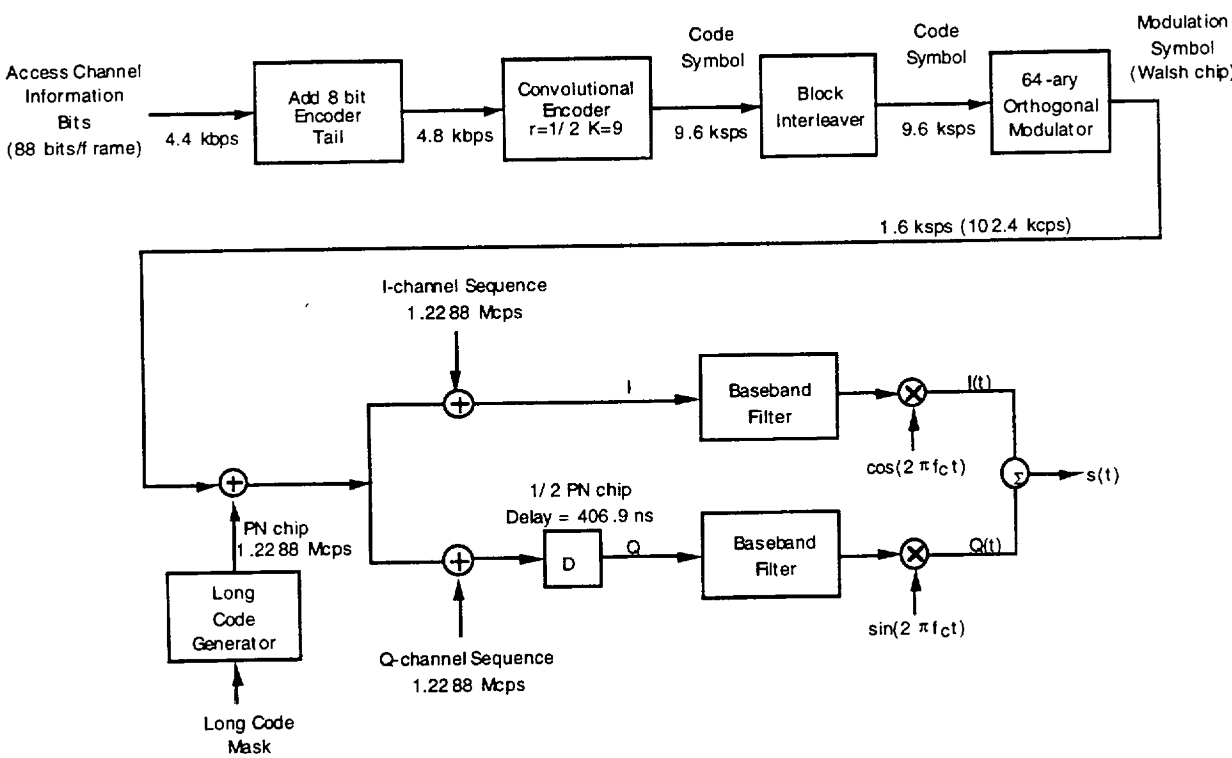

Figure 4-9 Return Link Access Channel

Return Link Traffic Channel: Each Traffic Channel is identified by a distinct user long code sequence as shown in Figure 4-10.

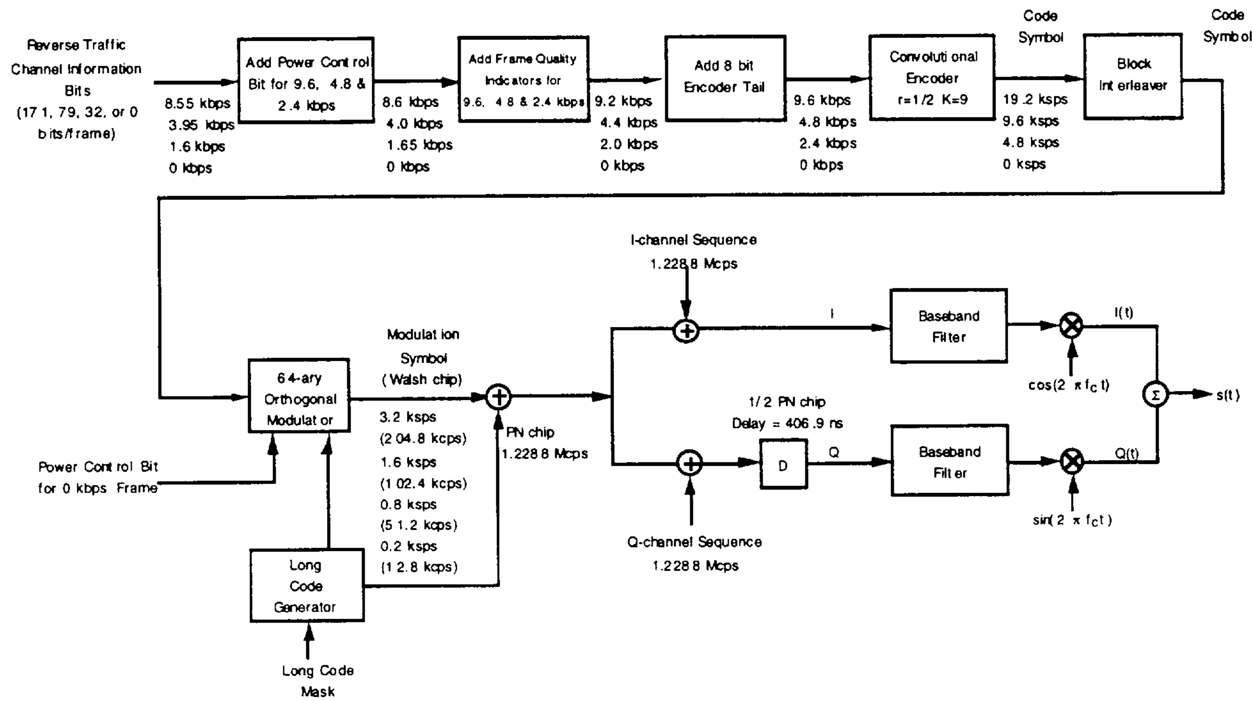

Figure 4-10 Return Link Traffic Channel

The rate 1/2 code used for the Globalstar return link takes advantage of longer coherence times for the channel and will perform better in the Additive White Gaussian Noise (AWGN) channel typical of Globalstar. The rate 1/3 code, typically used in terrestrial CDMA, performs better in a Rayleigh channel because it offers greater diversity. The return link does not use the randomizer used in cellular CDMA. It uses a continuous transmission with code symbol repetition to maintain the same rate.

4.7 CDMA End to End Performance

There are a number of other CDMA topics that span both the forward and return links.

Time: All gateway digital transmissions are referenced to a common CDMA system-wide time scale that uses the Global Positioning System (GPS) time scale, which is traceable to and synchronous with Universal Coordinated Time (UTC). GPS and UTC differ by an integer number of seconds, specifically the number of leap second corrections added to UTC since January 6, 1980. The start of CDMA System Time is January 6, 1980 00:00:00 UTC, which coincides with the start of GPS time. System Time keeps track of leap second corrections to UTC but does not use these corrections for physical adjustments to the System Time clocks.

When receiving the paging channel, the User Terminal is within 1.0 microseconds of the earliest arriving signal used for demodulation.

Link Delay: Delay through a link is an important end to end parameter. It becomes particularly important in conversations when one party attempts to interrupt the other. The LEO orbit satellites will provide a much more benign delay than the more common synchronous orbit satellites. Delay is held to 150 ms in each direction. There is a design margin, of course. Figure 4-11 summarizes the delay for the forward link.

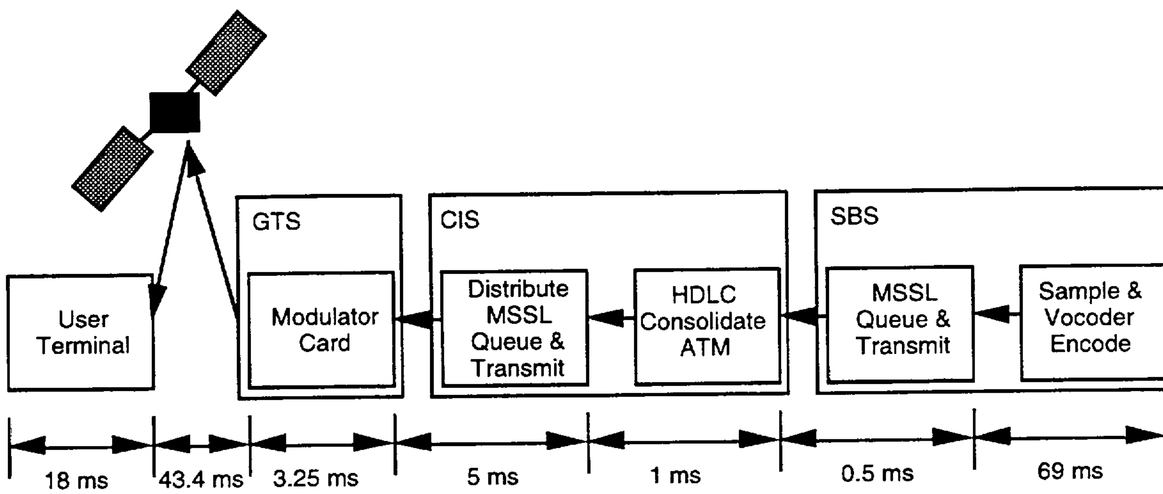

Figure 4-11 Forward Link Delay Budget

Figure 4-12 illustrates the delay budget for the return link.

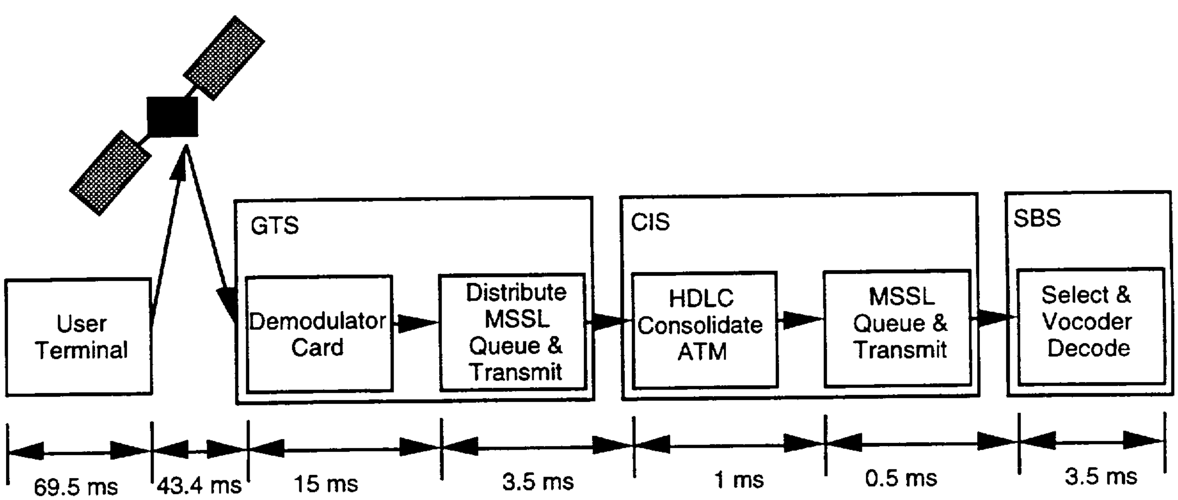

Figure 4-12 Reverse Link Delay Budget

Tradeoffs are possible to improve voice quality, improve capacity or other system level parameters at the expense of end to end delay.

Vocoder: The Globalstar vocoder is uses a Code Excited Linear Prediction (CELP) algorithm with a structure similar to that used by the IS-96 coder but with several improvements. The percentage of time between rates of 0 b/s and 8,550 can be adjusted. Voice quality can be traded for capacity. Voice quality can also be traded for signal delay. The Globalstar design will operate with high voice quality when the capacity is not stressed and when the links can be closed. If the links cannot be closed or if the capacity is being stressed, voice quality can be sacrificed. Vocoder rates and resulting channel rates are shown in Table 4-1.

Table 4-1 Vocoder and Channel Rates

Configuration	Vocoder Rate	Channel Rate	Purposes
Rate 1	8,550	9,600	High Quality Option
Rate 1/2	3,950	4,800	Baseline Voiced
Rate 1/4	1,750	2,400	Baseline Unvoiced
Rate 1/8	800	1,200	Baseline Pauses/Background

Some improvements are envisioned that may increase capacity. In the forward direction, a zero rate can be used. Since this is the coherent direction, the User Terminals can stay locked on by using the pilot. This is the direction that constrains capacity. In the return direction, some energy must be transmitted to keep the receiver locked since the return direction is not coherent.

Power Control: The objective of power control is to transmit the minimum power necessary in order to achieve a given quality of service. Quality of service could be specified in terms of the Frame Error Rate (FER) and the probability of outage. Accurate power control reduces the transmit power needed to achieve a given quality of service objective, thereby prolonging battery life of portable phones. In addition, it also enhances capacity. Figure 4-13 is a simplified end to end diagram to support the description of power control.

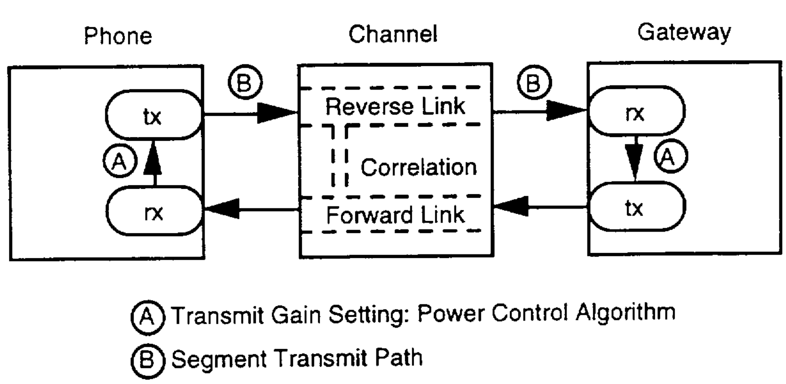

Figure 4-13 Power Control Simplified Diagram

Power Control and time to acquire are intimately related as shown in Figure 4-14.

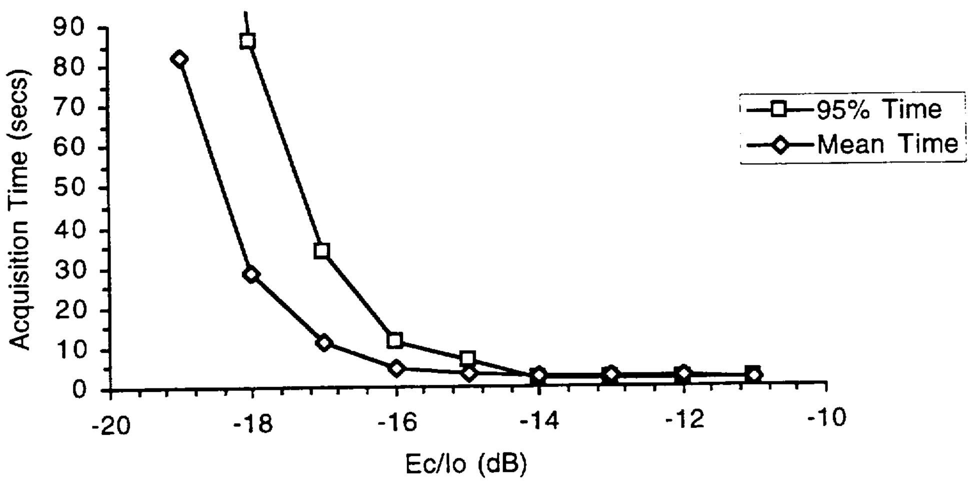

Figure 4-14 Acquisition Time as a function of Eb/No

Once the target for Eb/No is established, the task of power control is to maintain the desired Eb/No. Acquisition time will extend if the Eb/No is not well established correctly or controlled to the desired value. In order to achieve the power control there are two loops.

Inner Loop: The inner loop controls to the target Eb/No on a one bit per frame basis.

Outer Loop: The outer loop adjusts the target Eb/No based on the measured Frame Error Rate.

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5. TERRESTRIAL INTERFACE

5.1 Telecommunication Network Interface

The Gateway Architecture emphasizing the terrestrial interface is shown in Figure 5-1.

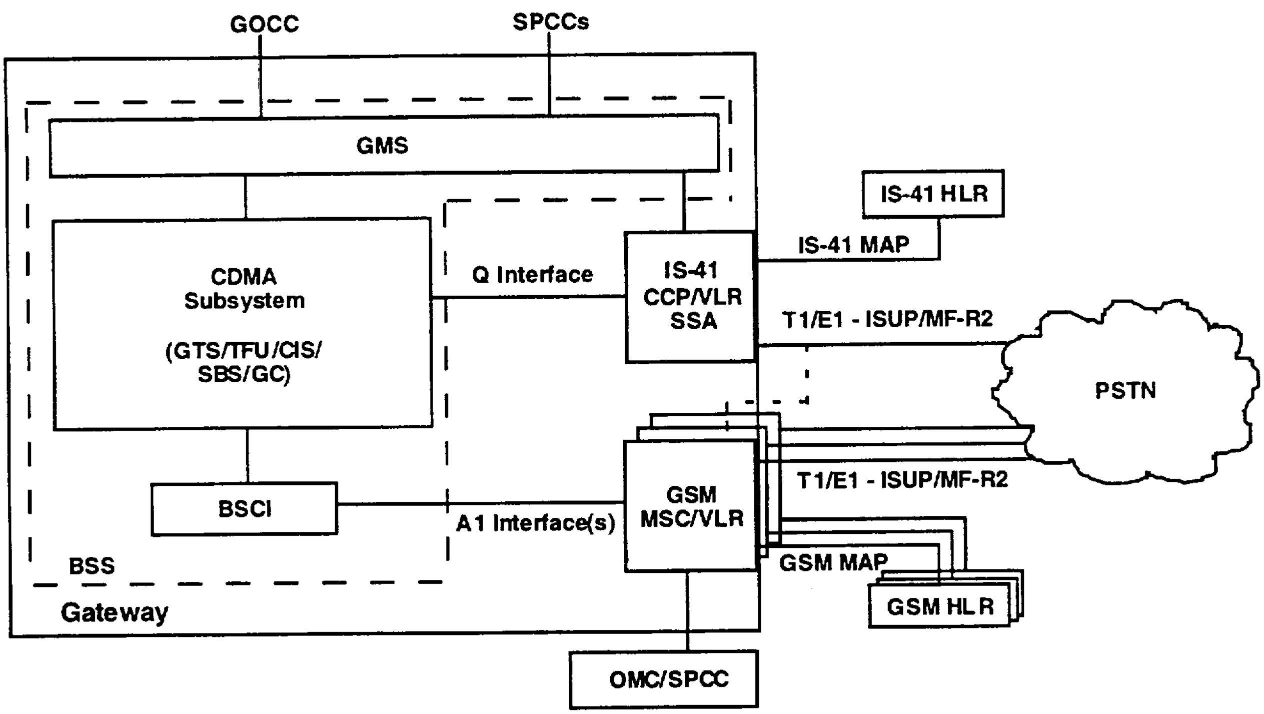


Figure 5-1 Gateway Architecture

The Gateway can operate in territories with terrestrial systems which are predominately GSM based or IS-41 C based.

GSM: In a GSM environment, the GSM-MSC can either be incorporated in the Gateway or it can be external. If external, it can be directly associated with the Gateway or shared with other terrestrial cellular systems. A protocol conversion process may be required to support IS-41 roamers whose home networks use ANSI SS-7 for MAP signaling rather than ITU SS-7. Protocol conversion may be performed by the international SS-7 carrier or by a separate device. GSM roamers whose home networks comply with ITU SS-7 do not require protocol conversion support.

IS-41: In an IS-41 network, a GSM-MSC must be available to provide GSM roaming services. The switch can either be in the gateway or can be back hauled to a GSM-MSC in another location. Protocol conversion may be required to convert between ITU SS-7 and ANSI SS-7 for mobility signaling to support international roamers with different home signaling protocols.

Flexible Interface: In areas where there is no infrastructure or where there is an infrastructure other than GSM or IS-41, the Gateway can interface directly to the PSTN. The Gateway has a built in switch than can be adapted to a variety of PSTNs. This, of course, does not address type qualification which may or may not be a large problem depending on the specific country and situation involved.

The entities associated with the terrestrial network of primary interest include:

GSM MSC/VLR: The GSM Mobile Switching Center (MSC) and Visitor Location Register (VLR) provide the call control and mobility management functions for GSM based users in the GW coverage area. The GSM MSC terminates one end of the A1 Interface, processing the BSSMAP and DTAP messages carried on this interface. The GSM VLR maintains the subscriber records for GSM based UTs operating on the GW. In addition, the GSM VLR interfaces to the existing GSM terrestrial cellular mobile Home Location Register (HLR) network. The GSM MSC also provides an interface to the local PSTN via standard signaling protocols (ISUP, MF-R1, MF-R2, etc.).

GSM HLR/AuC: The GSM HLRs that are accessible from the GW are new or existing terrestrial cellular HLRs in the GSM MAP network. These HLRs contain the home subscriber records for GSM based GW UT subscribers.

IS-41 CCP/VLR/SSA: For IS-41 based users in the GW, the IS-41 based call control and mobility management functions are processed by the IS-41 CCP/VLR/SSA entity. The IS-41 VLR maintains the subscriber records for IS-41 based UTs operating on the GW. In addition, the VLR interfaces to the existing IS-41 terrestrial cellular mobile Home Location Register (HLR) network. The SSA interfaces the GW to the local PSTN via standard signaling protocols (ISUP, MF-R1, MF-R2, etc.). The GW can also be configured in such a manner where the SSA can directly interface to one or more of the GW GSM MSCs if desired.

IS-41 HLR/AuC: The IS-41 HLRs that are accessible from the GW are existing terrestrial cellular HLRs in the IS-41 MAP network. These HLRs contain the home subscriber records for IS-41 based GW UT subscribers. The IS 41 C Authentication Center provides authentication for its IS-41 C based Globlastar Subscribers.

Figure 5-2 provides more details on what is inside the Globalstar Gateway.

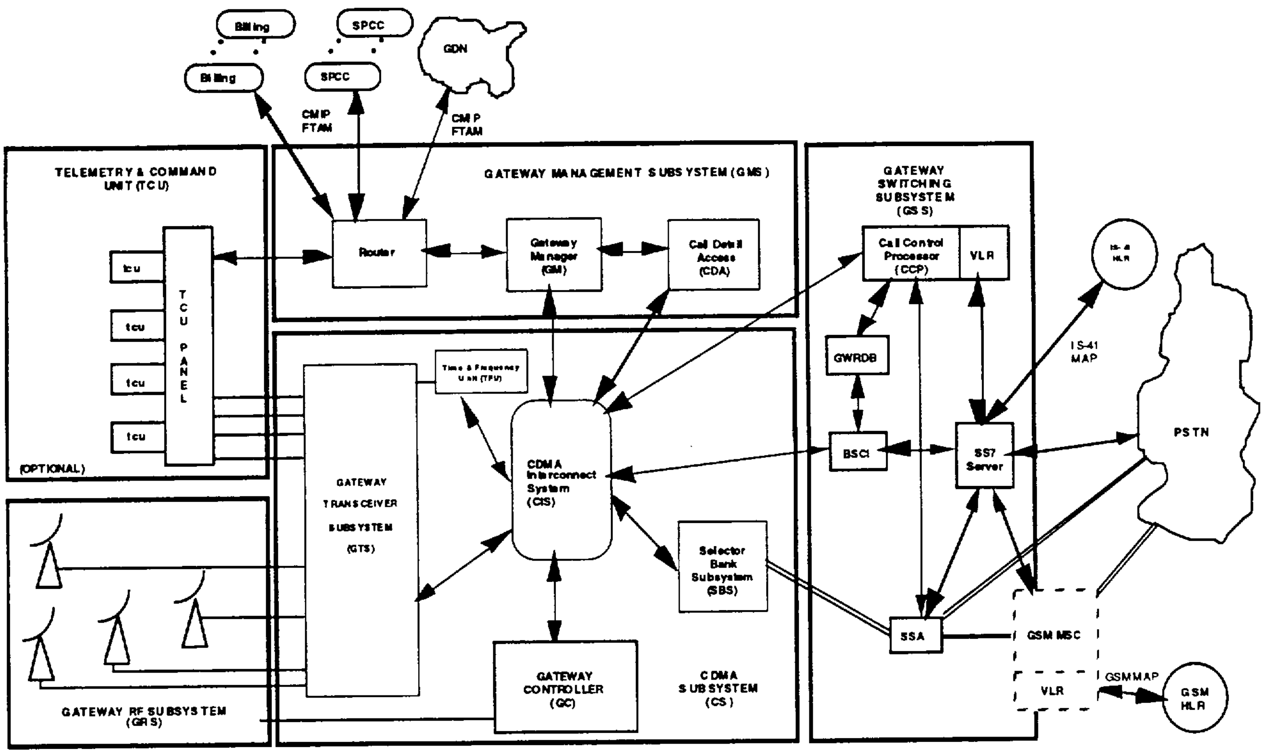


Figure 5-2 Gateway Connections to the PSTN - Flexible Interface

Physical Interface: The Gateway will connect to telecommunications networks via standard T1/E1. This is accomplished by the Service Switching Adjunct (SSA) shown in the upper right of Figure 5.1-2. This is also called Service Switching Point (SSP) in intelligent networks.

PSTN Interface Protocols: The Gateway provides an Integrated Service Digital Network (ISDN) interface and will connect to the PSTN via Primary Rate Interface (PRI).

5.2 Registration Process

Registration is the process by which the User Terminal notifies the Gateway of its location, status, identification, User Terminal type, and paging slot being monitored. Under normal circumstances, the Globalstar Gateway only contains a Visitor Location Register which is used in conjunction with external GSM or IS-41 Home Location Registers. Registration with an external HLR will be supported through the Gateway VLR. Registration while roaming involves the exchange of information between system types (GSM to IS-41 or visa versa). The messages and procedures for exchange of authentication data with the AuC/HLR is currently being reviewed by TIA for inclusion in IS-41D, and is summarized in TSB-51, Cellular Radio Telecommunications Inter systems Operation: Authentication, Signaling Message Encryption and Voice Privacy.

There are two registration processes that will be supported.

User Terminal	User ID	HLR	VLR
IS-95 Modified	ESN/MIN	IS-41	Globalstar
IS-95 Modified	GSM/IMSI	GSM	Globalstar

IS-41 HLR Registration: Figure 5-3 illustrates the process of registration of an IS-95 User Terminal within an IS-41 HLR.

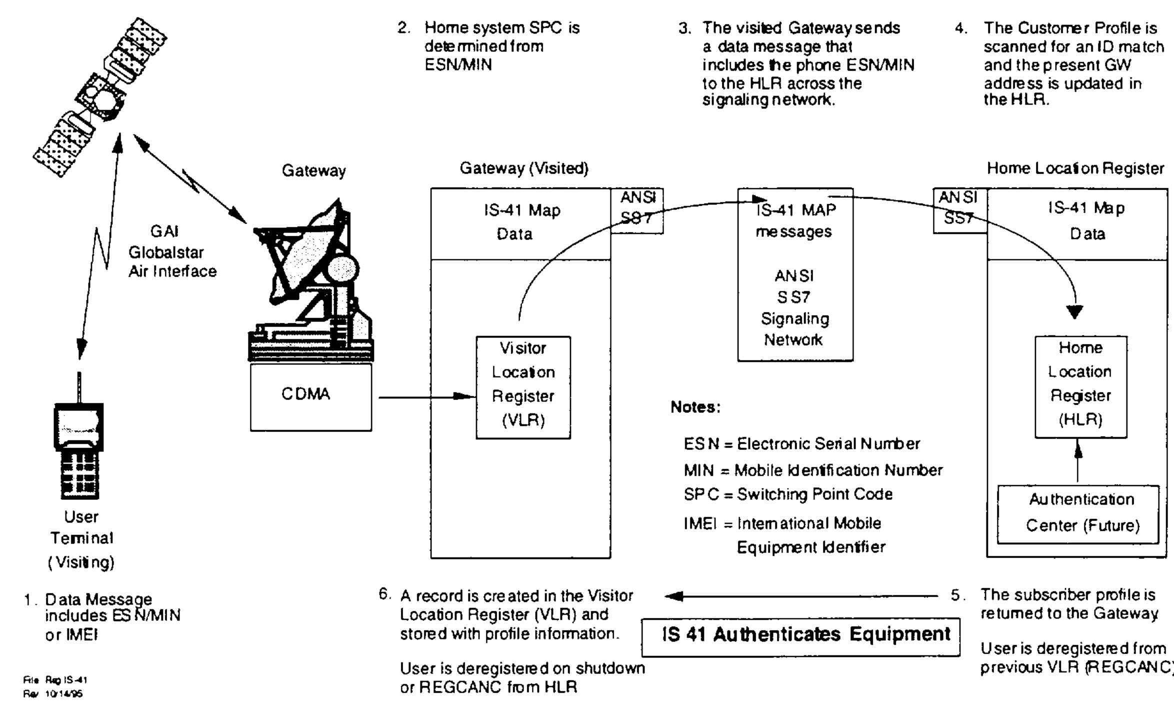


Figure 5-3 Registration of a U.S. based User with an IS-41 HLR

If IMEI are used in the User Terminals, ESN will not be stored. ESN is computed from the IMEI. The IMEI also incorporates the type approval code.

GSM HLR Registration: Here, all of the network components (MSC, HLR, VLR and AuC) should be able to communicate as in the normal system. The challenge is reduced to a protocol inter working task on the Gateway-VLR and Gateway-MSC interfaces, and transport of GSM authentication data to and from the SIM. Figure 5-4 illustrates the registration process.

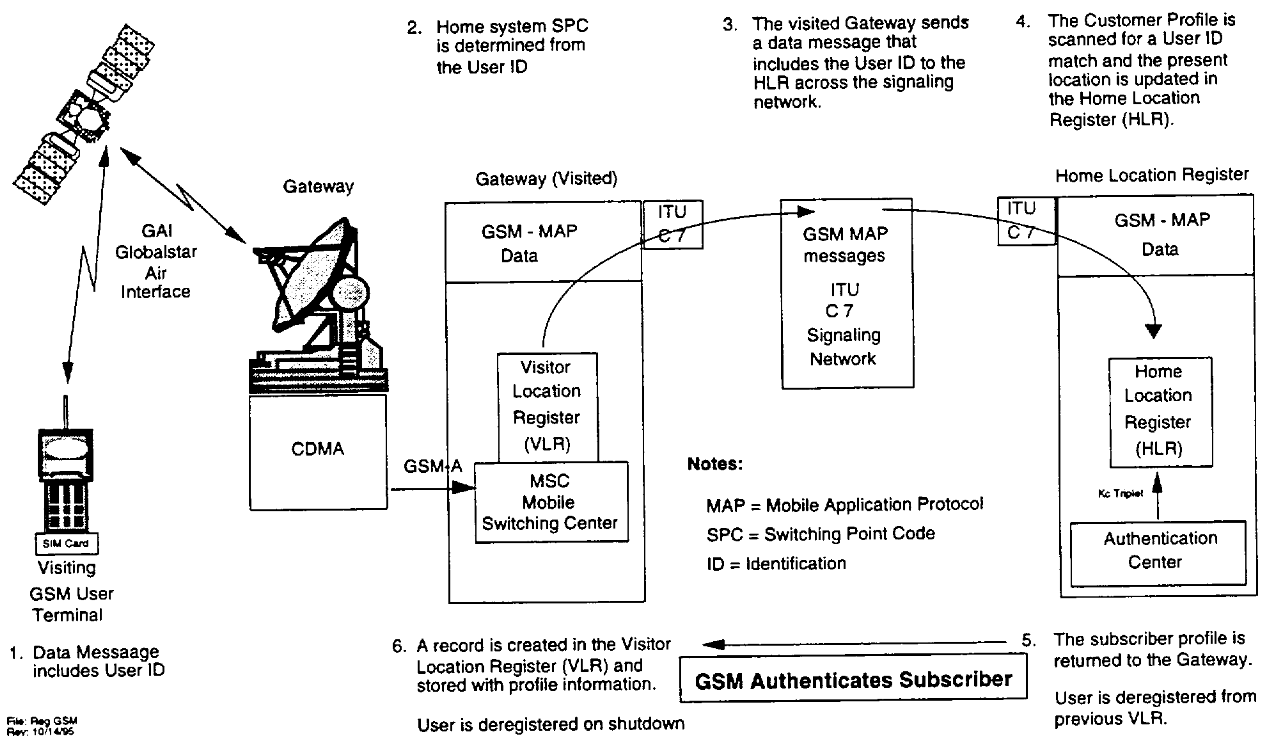


Figure 5-4 Registration of a European User in a GSM HLR

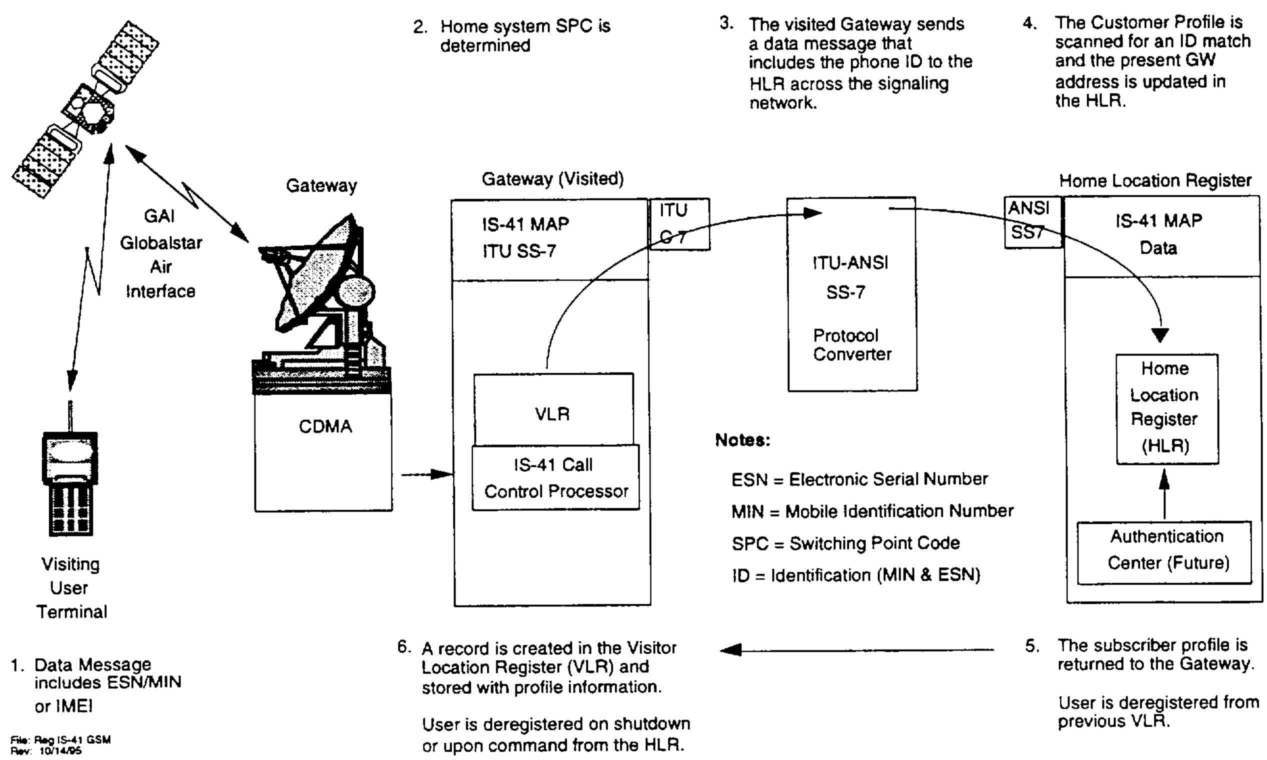


Figure 5-5 Registration of a U.S. User in a GSM Environment

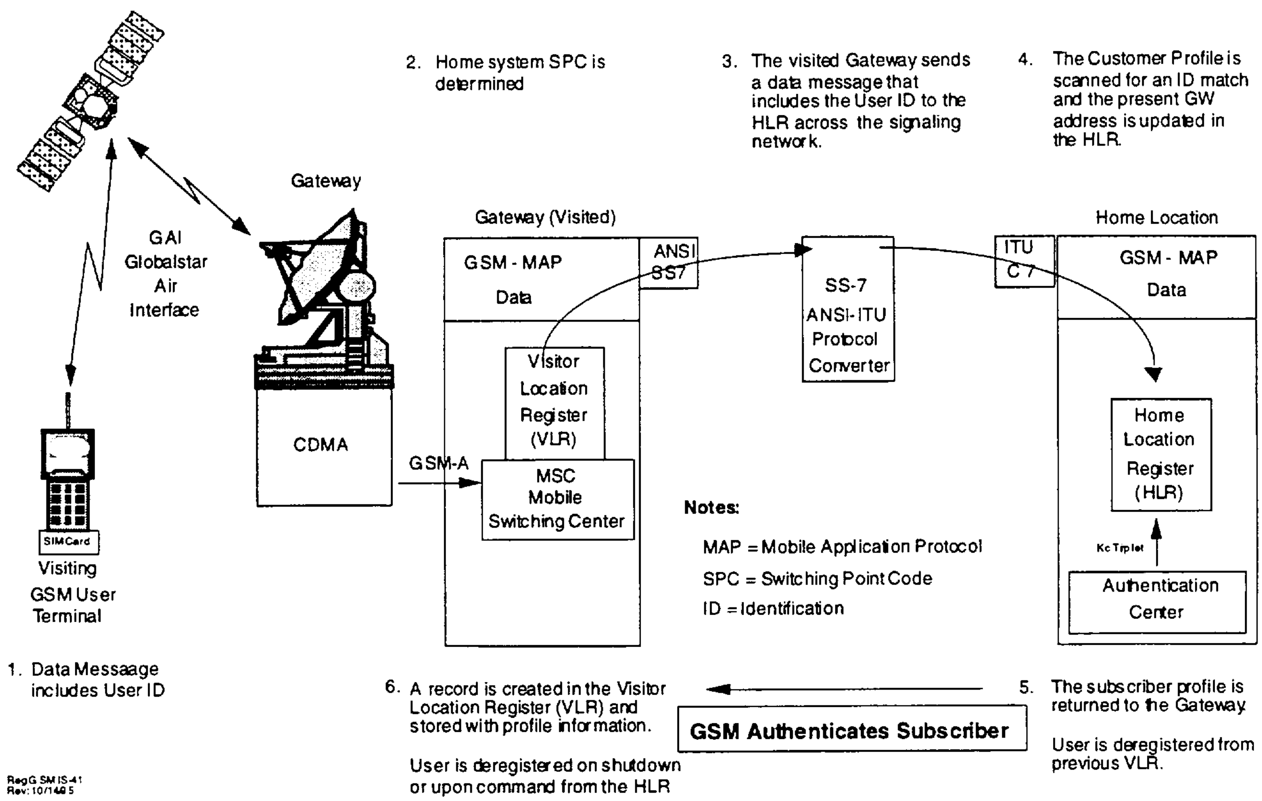


Figure 5-6 Registration of a European User in an IS-41 Environment

5.3 Authentication Process

Authentication verifies that the User Terminal is authorized to use the Globalstar resources. The Gateway will support authentication of the User Terminals; but, authentication is the responsibility of the home PLMN operator. The Gateway will transport authentication messages in the form required by the home PLMN operator. The Gateway will incorporate facilities to challenge, examine and update the authentication signature in the User Terminals.

To achieve a consistent authentication scheme, the system adopted must be able to deal with each of the following situations:

a. GSM User in GSM System

b. IS-41 User in IS-41 System

c. GSM User in IS-41 System

d. IS-41 User in GSM System

Where IS-41 User indicates a user whose Home system is based upon the IS-41 model and protocols (i.e. AMPS, IS-54, IS-95 and PSTN systems), and a GSM or IS-41 System indicates a serving Globalstar system where the mobility management facilities (HLR, VLR etc.) are GSM or IS-41-based, respectively.

GSM User in GSM System: Here, all of the network components (MSC, HLR, VLR and AuC) should be able to communicate as in the standard GSM system. The challenge is reduced to a protocol inter working task on the Gateway-VLR and Gateway-MSC interfaces, and transport of GSM authentication data to and from the SIM. GSM roamers do not require a protocol converter. GSM uses the same SS-7 as the international signaling.

IS-95 user in IS-95 (IS-41) System: All of the network components and protocols will operate in an IS-41 system. IS-41D supports and authentication center. Some networks may not support authentication.

GSM User in IS-95 (IS-41) System: In this scenario, the various network components belong to different systems, as summarized in the following table:

Component	System
SIM	GSM
Gateway/MSC	IS-41
VLR	IS-41
HLR/AuC	GSM

The task that needs to be solved in this scenario is the retrieval and storage of authentication data from the HLR/AuC. For example, the triplets could be both requested and stored by the Gateway and the RAND and SRES parameters carried on the air interface to/from the SIM.

The general message exchange is illustrated in Figure 5-7:

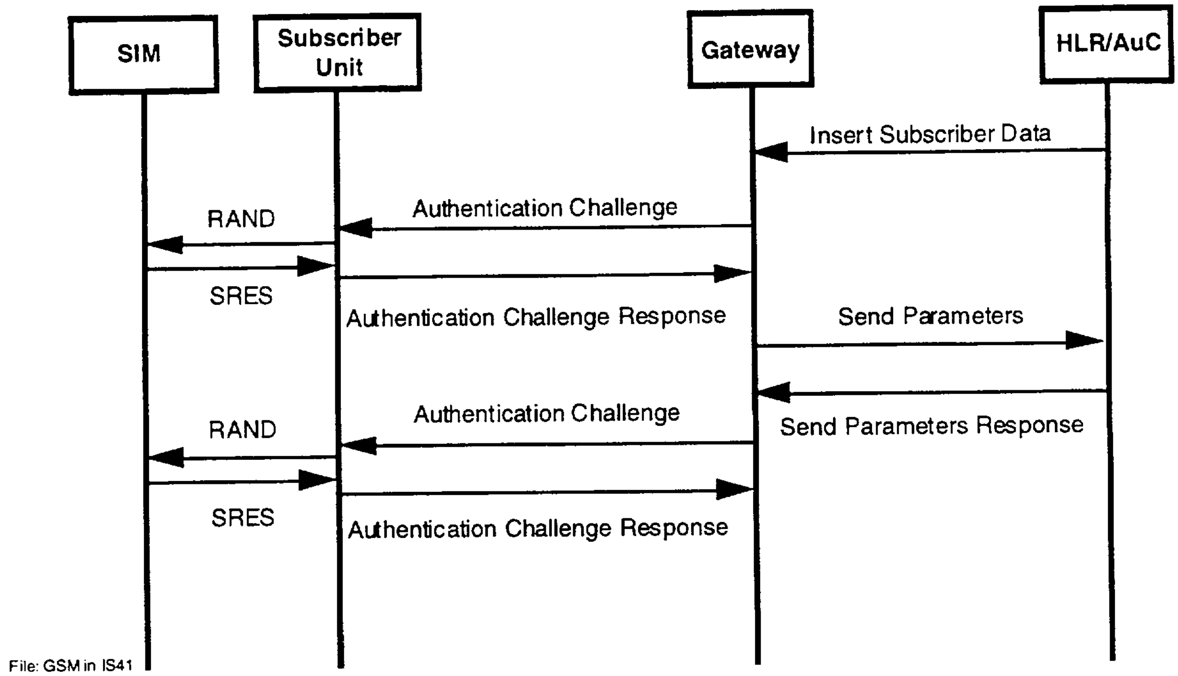


Figure 5-7 Authentication for a GSM User in IS-41 System

IS-95 User in GSM System: In this scenario, the various network components belong to different systems, as summarized in the following table:

Component	System
User Terminal	IS-95/Globalstar
Gateway/MSC	GSM
VLR	GSM
HLR/AuC	IS-41

In the IS-41 system, authentication is done mainly by the Gateway, with updates to authentication parameters periodically being retrieved from the AuC. The Gateway just has to recognize that the user understands IS-41 authentication, and not GSM and process messages appropriately.

The messages and procedures for exchange of authentication data with the AuC/HLR is currently being reviewed by TIA for inclusion in IS-41C, and is summarized in TSB-51, Cellular Radio Telecommunications Inter systems Operation: Authentication, Signaling Message Encryption and Voice Privacy.

5.4 GSM - A Interface in Globalstar

The Globalstar Gateway will interface with and MSC in the GSM environment in much the same way that any base station interfaces with the MSC. Figure 5-8 illustrates a typical GSM DTAP on Mobile Terminated Calls.

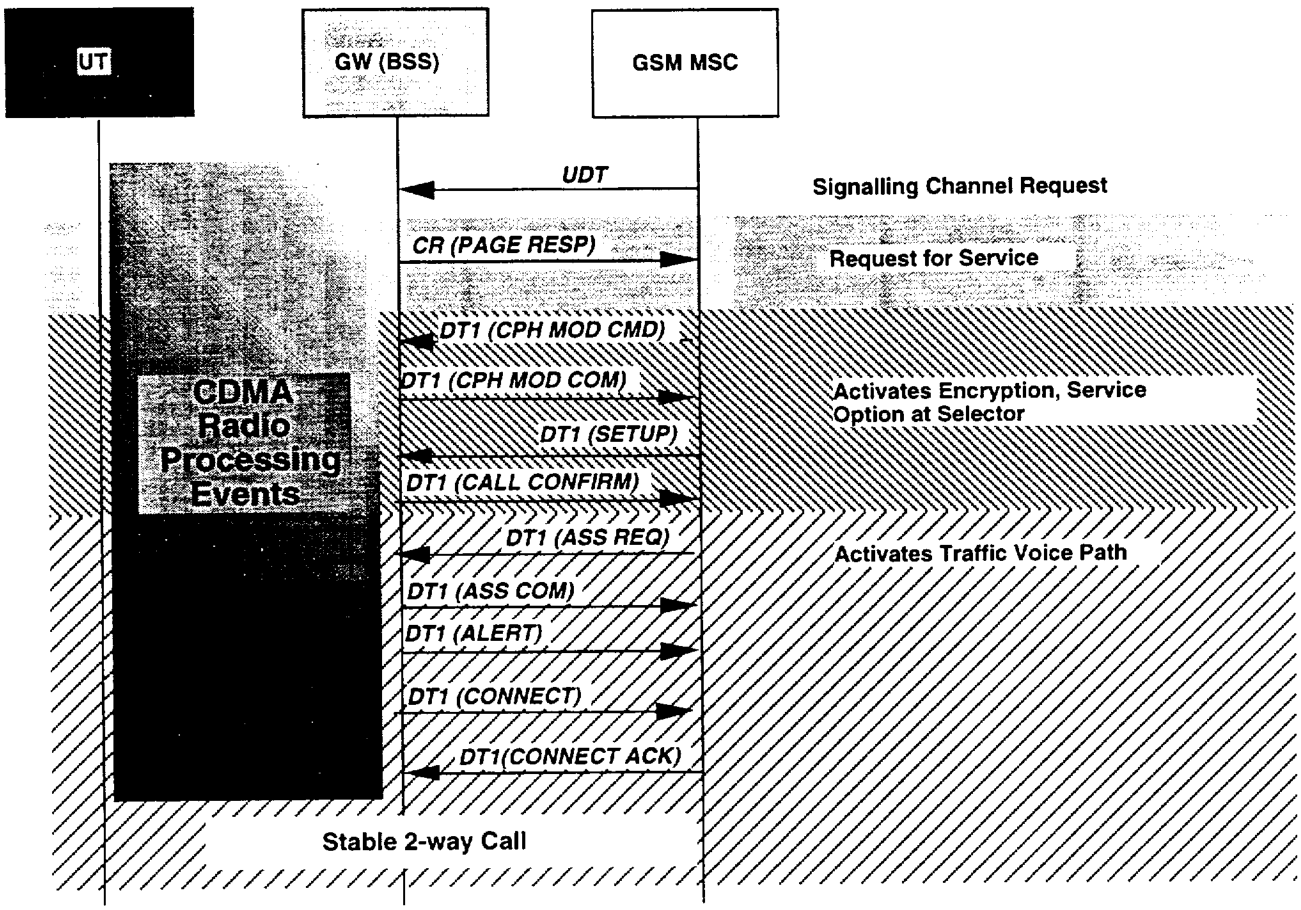
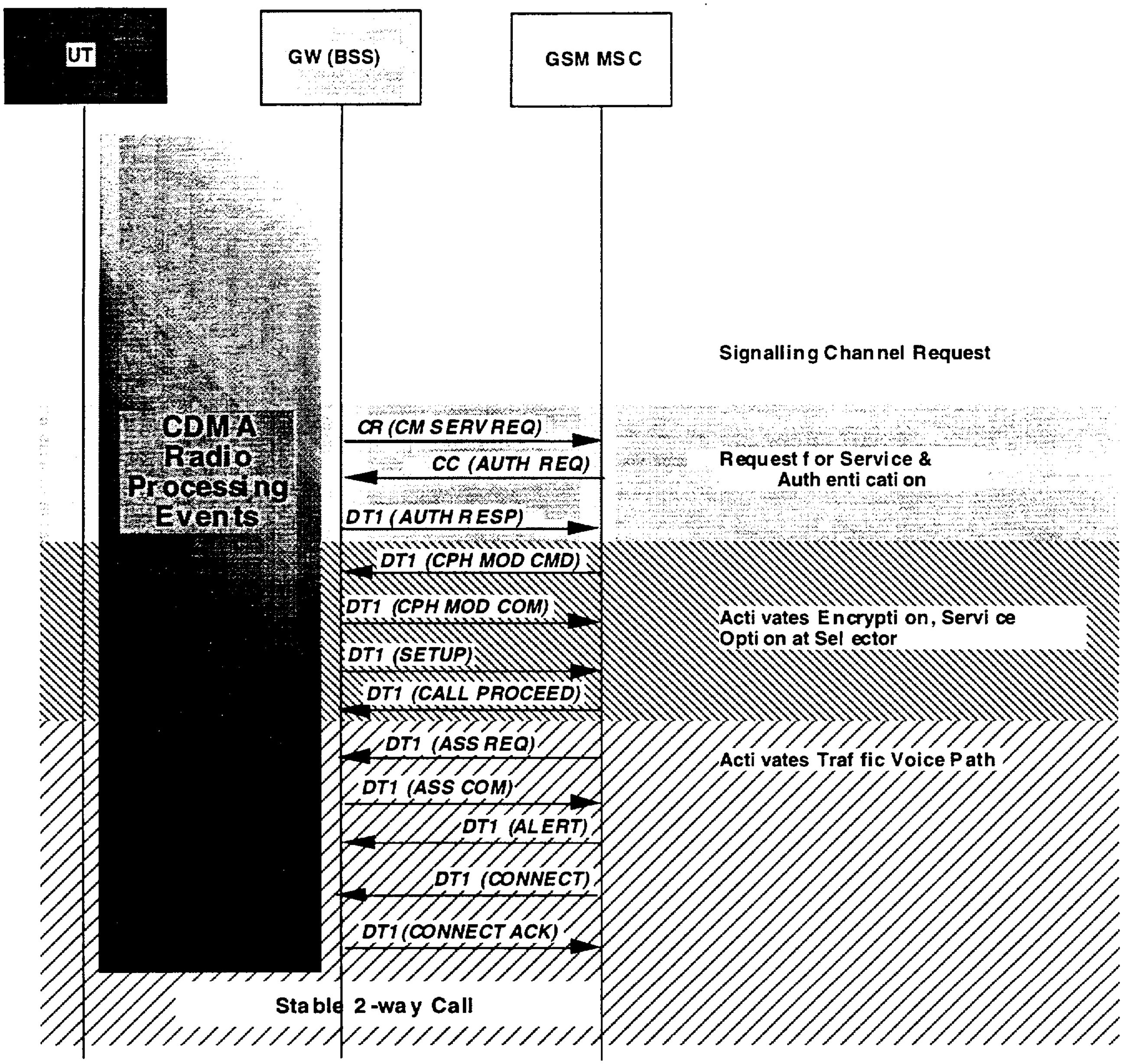


Figure 5-8 GSM DTAP on Mobile Terminated Call

Figure 5-9 Illustrates GSM DTAP on a typical mobile originated call in Globalstar.



1

2 ***Figure 5-9 GSM DTAP on Mobile Originated Call***

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6. CALL PROCESSING

6.1 Call Processing between Globalstar and PLMN

This section discusses call processing between Globalstar and other PLMN systems. In Globalstar all User Terminals are treated as roaming from their terrestrial PLMN home system.

Globalstar Only User Terminals: There are a series of User Terminals that are Globalstar Only. In these cases the service provider will incorporate the Globalstar Only User Terminals in the local Home Location Register (HLR). This applies to GSM or IS-41 HLRs. The Gateway will treat Globalstar Only UTs as Roamers.

No Existing HLRs: In areas where there is no existing HLR, Globalstar may set up an HLR and function as the Service Provider.

Emergency Calls: Globalstar will comply with the regulations for delivery of emergency calls.

Mobile Originated Call: Figure 6-1 illustrates how a mobile originated call is processed.

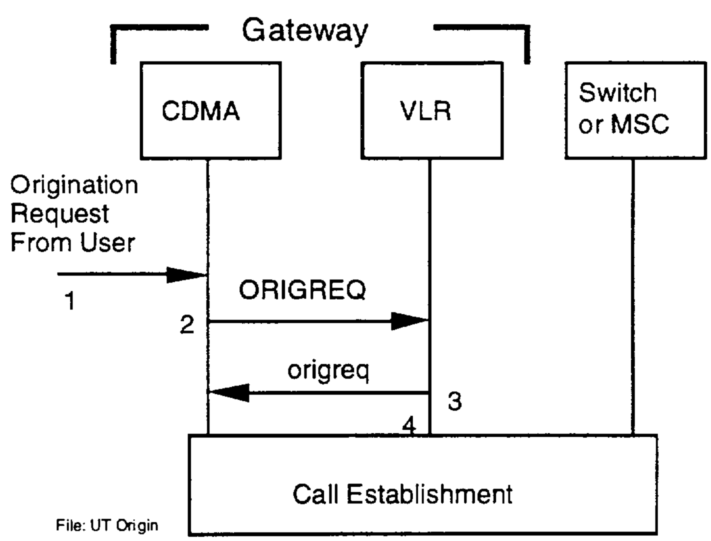

Figure 6-1 Mobile Originated Call

The following steps are performed:

1. An Origination Request (ORIGREQ) is received from a User Terminal.

2. An Origination Request INVOKE is sent from the Gateway (GW) to the VLR.

3. The Mobile is currently registered in this Visitor Location Register (VLR). The VLR responds with the Origination Request RETURN RESULT parameters.

4. The call is established with the terrestrial system.

Mobile Terminated: There are two scenarios for roaming call delivery. The first one is for a successful call (i.e. the user is idle). In the second case, the user is busy - this case is used to illustrate the possible invocation of a supplementary service such as Call Forward on Subscriber Busy.

Roaming Call Delivery - Idle Case: Figure 6-2 illustrates a successful call connection.

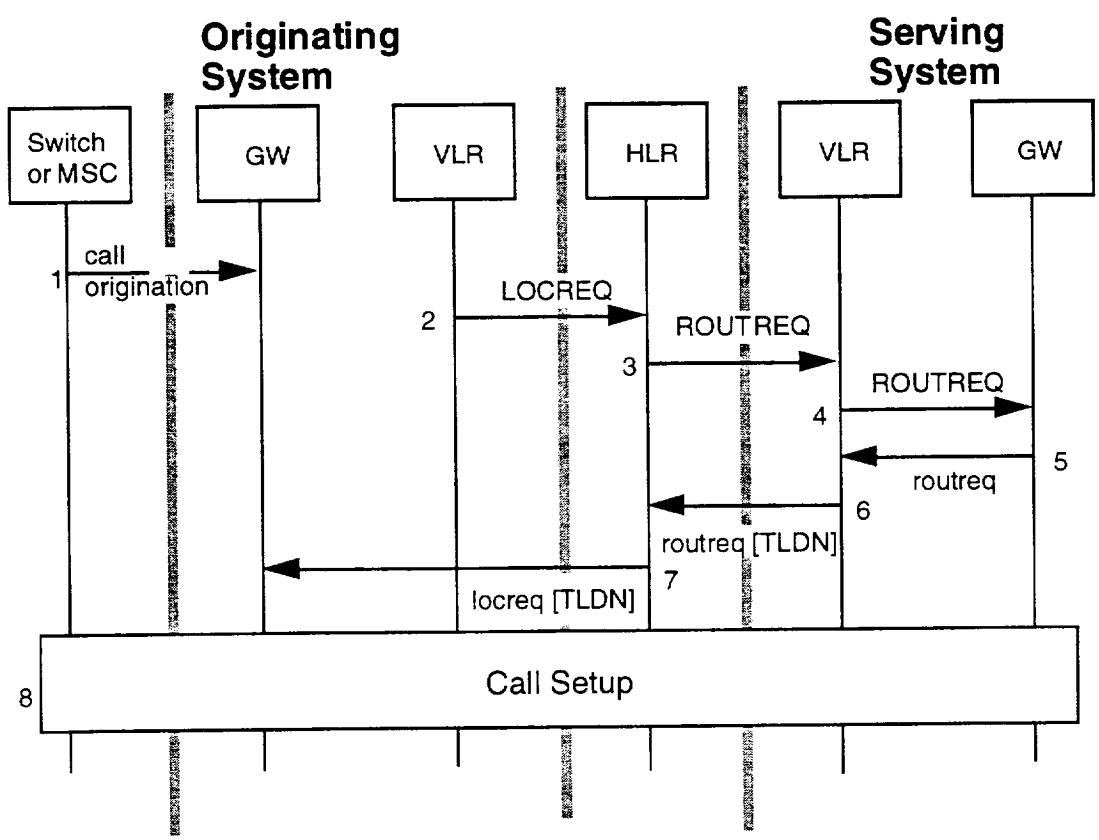

Figure 6-2 Roaming Call Delivery - Successful

The following steps are performed:

1. The switch attempts to deliver a call to the home Gateway of a mobile. In this scenario, the mobile is roaming, and so is not registered at the VLR of the home system.

2. The VLR sends a Locate Request (LOCREQ) INVOKE to the Home Location Register (HLR) requesting the location of the mobile.

3. The HLR determines the serving system for the User Terminal and sends a Routing Request INVOKE to the serving VLR.

4. The VLR sends a Routing Request (ROUTREQ) INVOKE to the Gateway to request the allocation of a Temporary Local Directory Number (TLDN) for the mobile.

5. The Gateway allocates a TLDN and returns the result in a Routing Request RETURN RESULT.

6. The VLR returns this TLDN to the HLR in the Routing Request RETURN RESULT.

7. The HLR sends the TLDN to the originating VLR via Locate Request RETURN RESULT.

8. The Gateway forwards the call to the destination Gateway (using the TLDN) and call setup is initiated with the serving Gateway.

Roaming Call Delivery - Busy Case: This scenario illustrates the case where the called number is busy in a roaming system. The message exchange would be similar if features such as call forwarding were activated. Figure 6-3 is a case where the called number is busy.

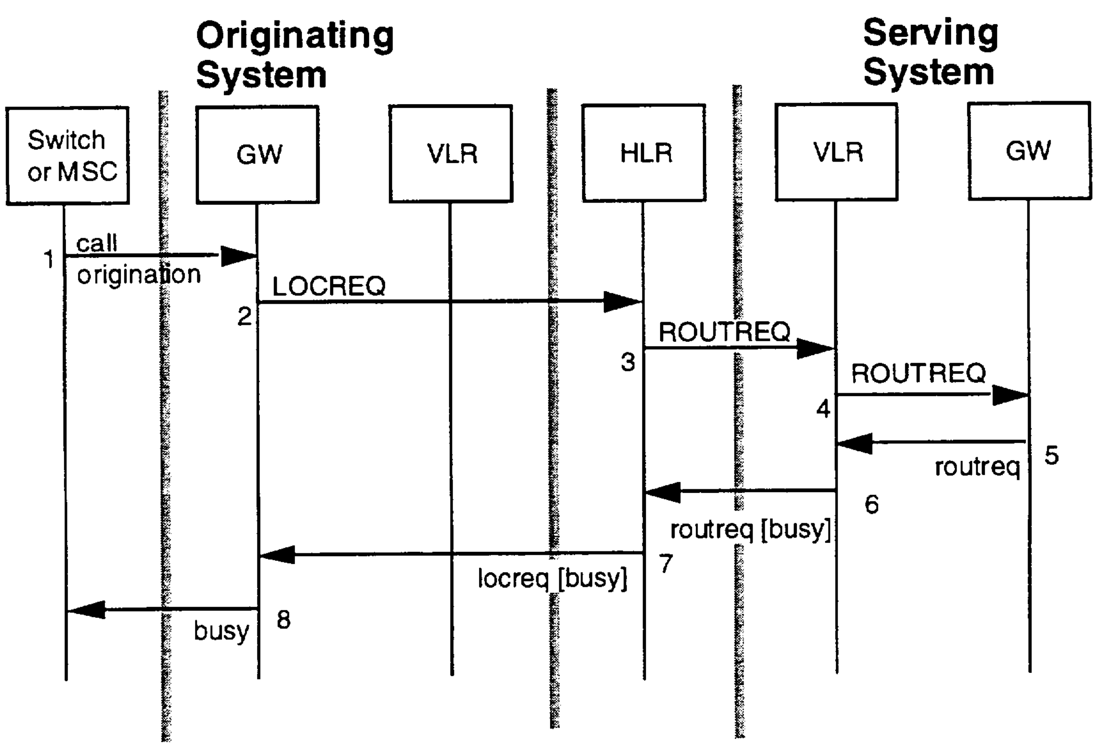

Figure 6-3 Roaming Call Delivery - Subscriber Busy

The following steps are performed:

1. The switch attempts to deliver a call to the home Gateway of a mobile. In this scenario, the mobile is roaming, and so is not registered at the VLR of the home system.

2. The VLR sends a Locate Request (LOCREQ) INVOKE to the HLR requesting the location of the mobile.

3. The HLR determines the serving system for the User Terminal and sends a Routing Request INVOKE to the serving VLR.

4. The VLR sends a Routing Request INVOKE to the Gateway to request the allocation of a Temporary Local Directory Number (TLDN) for the mobile.

6. The Gateway determines that the mobile is busy in another call and returns the result in a Routing Request RETURN RESULT.

6. The VLR returns this notification to the HLR in the Routing Request RETURN RESULT.

7. The HLR sends the result to the originating VLR via Locate Request RETURN RESULT, and the VLR forwards the result to the Gateway.

8. The Gateway returns a busy indication to the network.

Note that in the case of other call setup failures e.g. if Call Forwarding has been activated, the same scenario applies in principle, but the indication contained within the messages are different.

6.2 TIA and ETSI Call Flow Examples

This is an informative appendix which contains examples of call flows. The diagrams follow these conventions:

- All messages are received without error
- Receipt of messages is not shown except in the handoff examples
- Acknowledgments are not shown
- Authentication procedures are not shown
- Encryption mode transitions are not shown

User Terminal				Gateway
• Detects user-initiated call				
• Sends *Origination Message*	>	Access Channel	>	• Sets up Traffic Channel
				• Begins sending null Traffic Channel data
• Sets up Traffic Channel	<	Paging Channel	<	• Sends *Channel Assignment Message*
• Receives N_{5m} consecutive valid frames				
• Begins sending the Traffic Channel preamble				• Acquires the Reverse Traffic Channel
• Begins transmitting null Traffic Channel data	<	Forward Traffic Channel	<	• Sends *Gateway Acknowledgment Order*
• Sends *Service Request Message* for Service Option 1	>	Reverse Traffic Channel	>	• Allocates resources for Service Option 1
• Begins processing primary traffic in accordance with Service Option 1	<	Forward Traffic Channel	<	• Sends *Service Connect Message*
• Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
Optional				Optional
• Sends *Origination Continuation Message*	>	Reverse Traffic Channel	>	
Optional				Optional
• Applies ring back in audio path	<	Forward Traffic Channel	<	• Sends *Alert With Information Message* (ring back tone)
Optional				Optional
• Removes ring back from audio path	<	Forward Traffic Channel	<	• Sends *Alert With Information Message* (tones off)
(User conversation)				*(User conversation)*

Figure 6-4 Simple Call Flow, User Terminal Origination Example Using Service Option 1 (TIA Call Control Procedures)

(Part 1 of 2)

User Terminal				Gateway
• Detects user-initiated call				
• Sends *Channel Request Message* indicating call origination and service option requested	>	Access Channel	>	• Sets up Traffic Channel • Begins sending null Traffic Channel data
• Sets up Traffic Channel	<	Paging Channel	<	• Sends *Channel Assignment Message*
• Receives N_{5m} consecutive valid frames				
• Begins sending the Traffic Channel preamble				• Acquires the Reverse Traffic Channel
• Begins transmitting null Traffic Channel data	<	Forward Traffic Channel	<	• Sends *Gateway Acknowledgment Order*
• Sends *ETSI Layer 3 Transport Message* containing CC *Setup* message	>	Reverse Traffic Channel	>	• Starts setting up a call
• See the note below	<	Forward Traffic Channel	<	• Sends *ETSI Layer 3 Transport Message* containing CC *Call-Proceeding* message

Note: The gateway and the user terminal follow the call establishment procedures as defined in section 5.2.1 of ETS 300 557, GSM 04.08.

User Terminal				Gateway
• Begins processing primary traffic in accordance with Service Option 1	<	Forward Traffic Channel	<	• Sends *Service Connect Message*
• Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
(User conversation)				*(User conversation)*

Figure 6-5 Simple Call Flow, User Terminal Origination Example Using Service Option 1 (ETSI Call Control Procedures) (Part 2 of 2)

User Terminal				Gateway
	<	Paging Channel	<	• Sends *General Page Message*
• Sends *Page Response Message*	>	Access Channel	>	• Sets up Traffic Channel
				• Begins sending null Traffic Channel data
• Sets up Traffic Channel	<	Paging Channel	<	• Sends *Channel Assignment Message*
• Receives N_{5m} consecutive valid frames				
• Begins sending the Traffic Channel preamble				• Acquires the Reverse Traffic Channel
• Begins transmitting null Traffic Channel data	<	Forward Traffic Channel	<	• Sends *Gateway Acknowledgment Order*
• Allocates resources for Service Option 1	<	Forward Traffic Channel	<	• Sends *Service Request Message* for Service Option 1
• Sends *Service Response Message* accepting Service Option 1	>	Reverse Traffic Channel	>	
• Begins processing primary traffic in accordance with Service Option 1	<	Forward Traffic Channel	<	• Sends *Service Connect Message*
• Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
• Starts ringing	<	Forward Traffic Channel	<	• Sends *Alert With Information Message* (ring)
• User answers call				
• Stops ringing				
• Sends *Connect Order*	>	Reverse Traffic Channel	>	
• Begins sending primary traffic packets from the Service Option 1 application				
(User conversation)				*(User conversation)*

Figure 6-6. Simple Call Flow, User Terminal Termination Example Using Service Option 1 (TIA Call Control Procedures)
(Part 1 of 2)

User Terminal				Gateway
	<	Paging Channel	<	• Sends *General Page Message* with service option requested
• Sends *Channel Request Message* indicating paging response	>	Access Channel	>	• Sets up Traffic Channel • Begins sending null Traffic Channel data
• Sets up Traffic Channel	<	Paging Channel	<	• Sends *Channel Assignment Message*
• Receives N_{5m} consecutive valid frames				
• Begins sending the Traffic Channel preamble				• Acquires the Reverse Traffic Channel
• Begins transmitting null Traffic Channel data	<	Forward Traffic Channel	<	• Sends *Gateway Acknowledgment Order*
• Sends *ETSI Layer 3 Transport Message* containing RR *Paging Response* message	>	Reverse Traffic Channel	>	
• Starts alerting	<	Forward Traffic Channel	<	• Sends *ETSI Layer 3 Transport Message* containing CC *Setup* message
• Sends *ETSI Layer 3 Transport Message* containing CC *Call_Confirmed* message	>	Reverse Traffic Channel	>	• See note below
Note: The gateway and the user terminal follow the call establishment procedures as defined in section 5.2.2 of ETS 300 557, GSM 04.08.				
• Begins processing primary traffic in accordance with Service Option 1	<	Forward Traffic Channel	<	• Sends *Service Connect Message*
• Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
(User conversation)				*(User conversation)*

Figure 6-7 Simple Call Flow, User Terminal Termination Example Using Service Option 1 (ETSI Call Control Procedures) (Part 2 of 2)

User Terminal		Gateway
• Detects user-initiated disconnect • Sends *Release Order*	> Reverse Traffic Channel >	
	< Forward Traffic Channel <	• Sends *Release Order*
• Enters the *System Determination Substate* of the *User Terminal Initialization State*		

Figure 6-8. Simple Call Flow, User Terminal Initiated Call Disconnect Example (TIA Call Control Procedures)
(Part 1 of 2)

User Terminal		Gateway
• Detects user-initiated disconnect • Sends *ETSI Layer 3 Transport Message containing* CC *Disconnect* message	> Reverse Traffic Channel >	• Initiates procedures to clear the network connection
• Releases the MM connection	< Forward Traffic Channel <	• Sends *ETSI Layer 3 Transport Message* containing CC *Release* message
• Sends *ETSI Layer 3 Transport Message* containing CC *Release Complete* message[1]	> Reverse Traffic Channel >	• Releases the MM connection
• Releases the RR connection (Traffic Channel) • Enters the *System Determination Substate* of the *User Terminal Initialization State*	< Forward Traffic Channel <	• Sends *Release Order*

Figure 6-9 Simple Call Flow, User Terminal Initiated Call Disconnect Example (ETSI Call Control Procedure)
(Part 2 of 2)

[1]For more details see call release procedures defined in section 5.4.3 of ETS 300 557, GSM 04.08.

User Terminal		Gateway
	< Forward Traffic Channel <	• Detects call disconnect • Sends *Release Order*
• Sends *Release Order*	> Reverse Traffic Channel >	
• Enters the *System Determination Substate* of the *User Terminal Initialization State*		

Figure 6-10. Simple Call Flow, Gateway Initiated Call Disconnect Example (TIA Call Control Procedures)
(Part 1 of 2)

User Terminal				Gateway
				• Detects call disconnect
	<	Forward Traffic Channel	<	• Sends *ETSI Layer 3 Transport Message* containing CC *Disconnect* message
• Sends *ETSI Layer 3 Transport Message* containing CC *Release* message	>	Reverse Traffic Channel	>	• Releases the MM connection
• Releases the MM connection	<	Forward Traffic Channel	<	• Sends *ETSI Layer 3 Transport Message* containing CC *Release*[2] Complete message
• Releases the RR connection (Traffic Channel) • Enters the *System Determination Substate* of the *User Terminal Initialization State*	<	Forward Traffic Channel	<	• Sends *Release Order*

Figure 6-11 Simple Call Flow, Gateway Initiated Call Disconnect Example (ETSI Call Control Procedure) (Part 2 of 2)

[2] For more details see the call release procedures as defined in section 5.4.4 of ETS 300 557, GSM 04.08.

User Terminal				Gateway
(User conversation) • Detects request for third party to be added to conversation • Sends *Flash With Information Message* (dialed digits)	>	Reverse Traffic Channel	>	*(User conversation)* • Mutes speech
Optional • Applies ring back in audio path	<	Forward Traffic Channel	<	Optional • Sends *Alert With Information Message* (ring back tone) *(Called party answers)*
Optional • Removes ring back tone from audio path	<	Forward Traffic Channel	<	Optional • Sends *Alert With Information Message* (tones off) • Unmutes speech from added party
(Two-way conversation with added party; original party held) • Detects user request to establish three-way conversation • Sends *Flash With Information Message* *(Three-way conversation)*	>	Reverse Traffic Channel	>	*(Two-way conversation with added party; original party held)* • Reconnects original party *(Three-way conversation)*

Figure 6-12. Simple Call Flow, Three-Party Calling Example (TIA Call Control Procedures)

User Terminal				Gateway
(User conversation with first party)				*(User conversation with first party)* • Detects incoming call
<u>Optional</u> • Applies call waiting tone in audio path	<	Forward Traffic Channel	<	<u>Optional</u> • Sends *Alert With Information Message* (call waiting tone)
• Detects user request to change parties • Sends *Flash With Information Message*	>	Reverse Traffic Channel	>	• Mutes speech path to first party, connects second party
(User conversation with second party; first party held) • Detects user request to change parties • Sends *Flash With Information Message*	>	Reverse Traffic Channel	>	*(User conversation with second party; first party held)* • Mutes speech path to second party, connects first party
(User conversation with first party; second party held)				*(User conversation with first party; second party held)*

Figure 6-13. Simple Call Flow, Call-Waiting Example (TIA Call Control Procedures)

Figure 6-14 illustrates call processing operations during a soft handoff from pilot A to pilot B. Figure 6-15 illustrates call processing operations during a sequential soft handoff in which the user terminal is transferred from a pair of pilots A and B through a pair of pilots A and C to pilot C. All the handoff call processing procedures described below are the same for both the TIA and the ETSI call control and mobility management procedures.

User Terminal				Gateway
(User conversation using A)				*(User conversation using A)*
• Sends *Pilot Strength Measurement Message*	>	Reverse Traffic Channel	>	• Receives *Pilot Strength Measurement Message*
				GW decides to begin handoff to channel B.
				• Begins transmitting traffic on the Forward Traffic Channel on B
• Receives *Handoff Direction Message*	<	Forward Traffic Channel	<	• Sends *Handoff Direction Message* to use A and B
• Acquires B; begins using Active Set {A,B}				
• Sends *Handoff Completion Message*	>	Reverse Traffic Channel	>	• Receives *Handoff Completion Message*
• Handoff drop timer of pilot A expires				
• Sends *Pilot Strength Measurement Message*	>	Reverse Traffic Channel	>	• Receives *Pilot Strength Measurement Message*
				GW decided to cancel channel A
• Receives *Handoff Direction Message*	<	Forward Traffic Channel	<	• Sends *Handoff Direction Message* to use B only
• Stops diversity combining; begins using Active Set {B}				
• Sends *Handoff Completion Message*	>	Reverse Traffic Channel	>	• Receives *Handoff Completion Message*
				• Stops transmitting on the Forward Traffic Channel using A
(User conversation using B)				*(User conversation using B)*

Figure 6-14. Call Processing During Soft Handoff

User Terminal				Gateway
(User conversation using A and B)				*(User conversation using A and B)*
• Sends *Pilot Strength Measurement Message*	>	Reverse Traffic Channel	>	• Receives *Pilot Strength Measurement Message,* determines that new Active Set should contain B and C
				• Begins transmitting traffic on the Forward Traffic Channel using C
• Receives *Handoff Direction Message*	<	Forward Traffic Channel	<	• Sends *Handoff Direction Message* to use B and C
• Stops diversity combining A and B; starts diversity combining B and C				
• Sends *Handoff Completion Message*	>	Reverse Traffic Channel	>	• Receives *Handoff Completion Message*
				• Stops transmitting on the Forward Traffic Channel using A
• Sends *Pilot Strength Measurement Message*	>	Reverse Traffic Channel	>	• Receives *Pilot Strength Measurement Message*
(Continues)				*(Continues)*

Figure 6-15. Call Processing During Sequential Soft Handoff
(Part 1 of 2)

User Terminal				Gateway
(Continues)				*(Continues)*
• Receives *Handoff Direction Message*	<	Forward Traffic Channel	<	• Sends *Handoff Direction Message* to use C only
• Stops diversity combining; begins using Active Set {C}				
• Sends *Handoff Completion Message*	>	Reverse Traffic Channel	>	• Receives *Handoff Completion Message*
				• Stops transmitting on the Forward Traffic Channel using B
(User conversation using C)				*(User conversation using C)*

Figure 6-16 Call Processing During Sequential Soft Handoff (Part 2 of 2)

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