of 1,200 bps and Phase Shift Keying (PSK) at a data rate of 4,800 bps on the VHF-3 path to subscriber terminals. For the VHF-2 and VHF-4frequency bands, connecting the satellites and Regional Gateways, the transmission mode is PSK, operating at a data rate of 56 kbps. The UHF Satellite-to-Subscriber link will also use PSK, at a data rate of 4,800 bps.

The emission designators for the VHF carriers respectively are 27K00F9D and 90K00G9D, and 40K00G9D for the UHF carrier.

c. Message Processing System

The Message Processing System (MPS) in conjunction with the Network Master Control Center (NMCC) and the Regional Gateways (RG) provide the intelligence and control of the micro-messaging network.

The MPS operates as a store and forward system, receiving information at one point in time and transmitting it at a later point in time. While in view of any one of the nine Regional Gateways, the satellites will function in a virtual "bent pipe" mode with traffic processing rapidly through the MPS. Functions provided by the MPS include:

- o Messaging Processing
- o Memory/Message Storage
- o Channel Switching
- o Channel Multiplexing

In its operation, the MPS operates in three modes simultaneously:

- o Polling Mode
- o Response/Emergency Mode
- o Switching Transponder Mode

In the polling mode, the MPS receives a "polling list" from a Regional Gateway (on the VHF-2 Uplink) during its instant pass. The MPS breaks down the message into its various addresses and transmits the polled-command to the subscriber terminal(s) via their assigned VHF-3 channels. The polling command is continued (timed by a predetermined clock rate) until such time as an acknowledgement/information-dump has been received. The MPS then forwards the received information to the Regional Gateway prior to completion of its current pass.

In the response or emergency mode, the MPS receives an emergency alert ("911") on a VHF-1 channel. The alert is acknowledged (VHF-3) and subsequently forwarded to the current gateway (VHF-4). Position information is handled in the same manner.

In the switching mode, a subscriber terminal transmits a message (on a VHF-1 Uplink) through the satellite to a Regional Gateway (VHF-4). Depending on the address of the micro-message, the signal is routed via the terrestrial packet network and NMCC to the appropriate destination. The return message is routed to the Regional Gateway, uplinked to the satellite via the VHF-2 Uplink and subsequently re-routed to the appropriate subscriber terminal on a VHF-3 channel. In this manner, the MPS provides cross connect switching.

d. <u>Satellite Ephemeris Determination</u>

In order to provide "position determination" capability within the ORBCOMM system, each satellite must know accurately its inertial position at a precise time and then must transmit these data over a stable frequency to the subscriber terminal where the position of the subscriber terminal will be computed using Doppler techniques. ORBCOMM will employ an innovative approach to determine each satellite's precise position and to acquire very accurate time. ORBCOMM satellites will carry a Global Positioning Satellite (GPS) receiver that will continually compute the satellite's position and record the associated time.

The ORBCOMM GPS receiver will receive L1 signals from GPS satellites at 1,575.42 MHz. This signal is in a spread spectrum format. The signal is modulated by two codes within the GPS satellite: the C/A (coarse/acquisition) code, and the P (precise) code. These codes act as the timing signals transmitted by the GPS satellite. Each of the GPS satellites (presently there are 11 operational satellites with the twelfth just launched; it is planned to have a constellation of 22 satellites) transmit on the same frequencies but with a unique pair of codes. A 50 bps message data stream modulates both the P code and the C/A code, and in turn, these codes modulate radio frequency carriers. The 50 bit message is comprised of orbit ephemeris, satellite almanac, daily model of ionospheric delay and the health of the GPS satellite.

The P-code sequence is so long that, without precise knowledge of GPS time, acquisition is impossible. Thus, signal acquisition and lock-on is obtained using the C/A code (a 1,023 bit code which repeats every millisecond). The codes and message data bits are controlled to begin and end at the same time on every satellite. In combination, these signals define GPS time which is transferred to ORBCOMM's clock by measuring the time of arrival of the codes and compensating for the propagation delay from GPS to ORBCOMM. The GPS message also provides the difference between GPS time and Universal time.

Once on orbit, observations from four satellites are required to establish and fix ORBCOMM's position. Once fixed, data from only one GPS satellite is required to provide time and frequency update. Using GPS data, time will be determined within a range of 10 to 100 nanoseconds, thus permitting ORBCOMM's position to be fixed within 100 meters.

Given these data, the satellite Message Processing System will determine the satellite's position and attendant ephemeris. A 100 bit message formatted to contain satellite position information plus a time reference will be inserted into each of the two downlink message streams at 137 MHz and 400 MHz. The position/time data will be cyclic on the 137 MHz link, depending on message traffic loading, but comprising only two percent of the information rate. The position/time data will make up the information content of the 400 MHz link, which also will function as a highly stable reference frequency.

5. TT&C Subsystem

The TT&C subsystem will include fully redundant telemetry, tracking and command capabilities to ensure the proper positioning and operation of the spacecraft. The TT&C uplink and downlink will share the VHF-2 and VHF-4 frequency bands with the messaging functions. Two command receivers, two command decryptors and decoders and two telemetry encoders will be provided on each spacecraft.

Each TT&C uplink will be frequency modulated for spacecraft control. The satellite command receiver baseband output will be connected to the command decryption unit. This unit, in conjunction with the decoder unit, will decrypt, validate, process and provide output commands to the satellite. The satellite telemetry baseband output will be routed to the transmitter where upon ground command, the data will be modulated onto the transmitting carrier for subsequent transmission to the Satellite Control Center. The telemetry units on each spacecraft will encode, format and modulate the subcarrier with both analog and digital data. Ranging of the satellite will be determined on board the satellite utilizing GPS timing and position information. The TT&C operations will be conducted simultaneously with communications operations, with minimal degradation or interference.

6. <u>Spacecraft Description</u>

The ORBCOMM spacecraft is depicted in Figure V-5. In the stowed position, the spacecraft dimensions are 0.75 m x 1.4 m (2.5 x 4.6 feet). On orbit, the solar panels and gravity boom will be deployed, and the satellite dimensions will be extended to 4.0 m (13 feet) in the X-axis (solar panel) and 8.0 m (26 feet) in the Z-axis (boom). The estimated weight of the satellite on orbit, at beginning of life, will be 150 kg (330 lbs) including 5 kg (11 lbs) for orbit station keeping fuel. The ORBCOMM satellites will be maintained on position within +/- 2 degrees, both in-plane and out-of-plane. This small allocation of station keeping propellant reflects an important advantage of employing low earth orbits.[38]

The selected orbital altitude, 970 km, avoids any major effects of air drag. Once injected into its proper orbit and attitude, ORBCOMM will require very little fuel to maintain its position. Calculations of propellant are based on a minimum of a seven-year operational life.

The ORBCOMM satellite orientation will be maintained in three axes. This will be accomplished using a Gravity Gradient Attitude Control System to control the roll and a redundant momentum wheel to control the pitch and yaw axes.

Communications to and from the spacecraft will be accomplished via a multiple frequency quadrifilar antenna.

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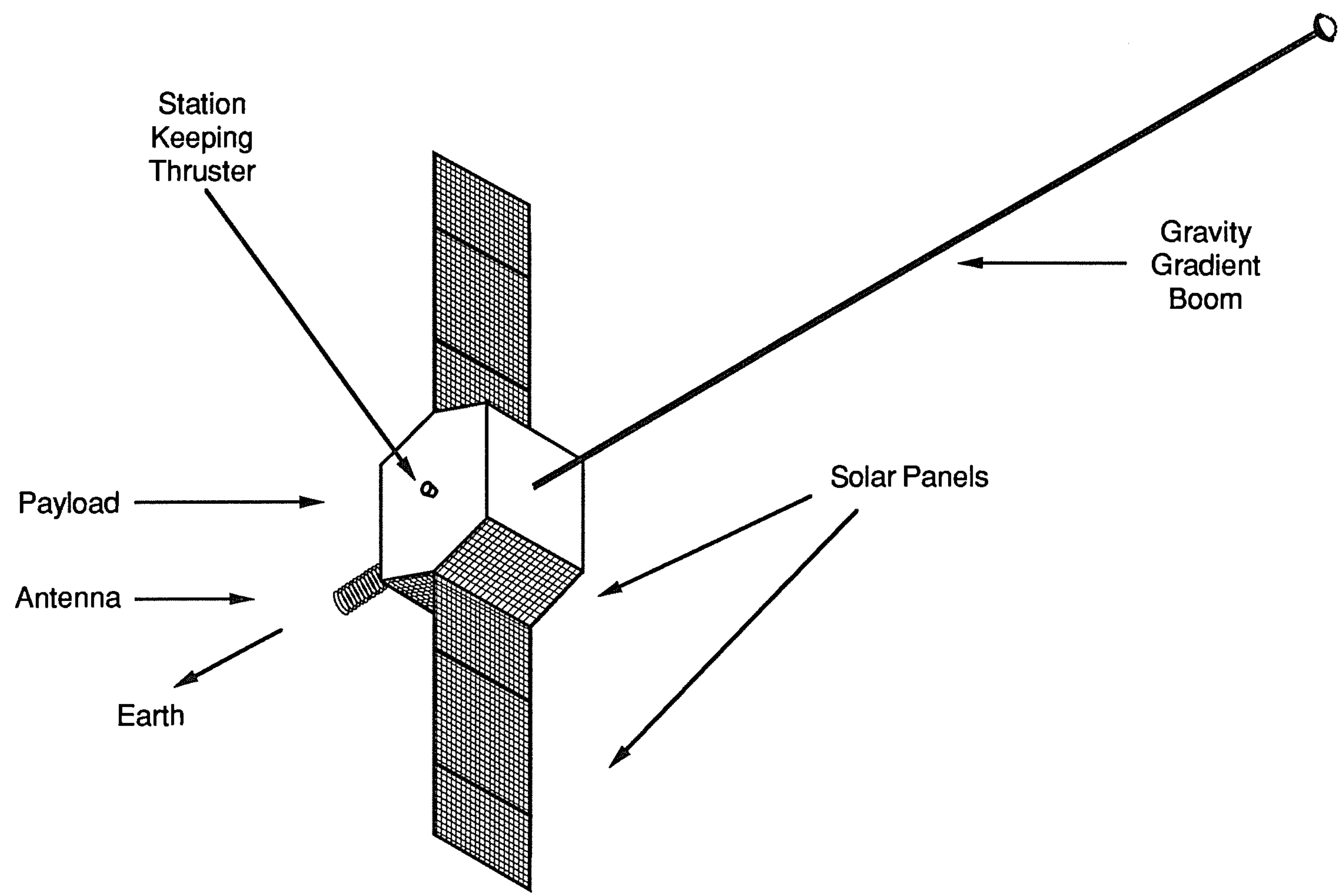
[38] Experience with the U.S. Navy's Transit NOVA satellite confirms the relative station keeping efficiency.

Figure V-5
Satellite Depiction



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B. Attitude Control And Station Keeping Subsystem

The spacecraft will employ three-axis stabilization utilizing a gravity gradient boom for roll and a momentum wheel for the remaining axis. The long term reliability and station keeping capability of this approach has been demonstrated by the NOVA series of satellites deployed in the U.S. Navy Transit program. Redundant control electronics and redundant sensors will be provided on each spacecraft. Control torques will be provided by the momentum wheel and thrusters.

Station on orbit will be maintained with in +/- 1 degrees out-of-plane and +/- 2 degrees in plane. The estimated lifetime of station-keeping fuel on the space craft will be seven years; however, ORBCOMM, during the engineering and development phase, will pursue design solutions to extend the life to ten years, if possible.

1. Electrical Power Subsystem

The electrical power subsystem will consist of a primary and a secondary power system. Two solar array panels will provide the primary power source. Utilizing high efficiency solar cells, each of the panels will be approximately 1.2 square meters. The rotating solar arrays will be mounted on each side of the spacecraft. The combined output power of the solar arrays will be approximately 450 watts at the beginning of life and 360 watts at the end of life.

Two 10 AH nickel cadmium batteries will provide the secondary (50% eclipse) power source. The two battery sets will provide for both thermal and mass balance within the satellite. The solar cells, combined with the batteries, will provide the necessary electrical power during launch and orbital positioning, as well as during its operation. The sizing of the power system assumes global operation.

A power control unit will distribute the power to a single "power bus", operating between 24 and 36 volts, and provide the required charge control and reconditioning for the batteries.

2. Space Segment Reliability and Operational Life

The ORBCOMM satellite has been designed for maximum reliability over a seven year mission life. All hardware in the satellite will be qualified for at least a seven year mission life. Sufficient margin has been designed into the solar array power and station keeping fuel to maintain the operation of the satellite during the specified mission life.

Tables V-6 and V-7 reflect the satellite power budget and mass/size budgets respectively.

Component level redundancy will be used throughout the satellite to eliminate critical failures. Circuit stress, product design, failure modes, and effects analyses have been and will be conducted for all components of the bus and payload hardware. Performance requirements of the electronic assemblies will be satisfied for at least a ten year life under severe temperature, aging and radiation conditions. Mechanical parts subject to wear or depletion will be designed such that all performance requirements will be satisfied for at least ten years. Elements subject to cyclical operation will be designed to meet all performance requirements for at least 1.5 times the worse case number of cycles over the seven year mission life. The overall satellite design will ensure that any failure will be isolated to the individual lowest level equipment, thereby reducing the likelihood for disabling redundant functional equipment.

Thermal control of the satellite will be achieved using conventional passive techniques. The design will permit the communications equipment to be operated over a relatively smaller temperature range for the life of the satellite. This affords greater reliability for the operation of the communications equipment.

The major reliability features for the satellite include the complete redundancy of all electronic, electrical units and attitude control components.

TABLE V-6

TYPICAL ELECTRICAL SPACECRAFT POWER BUDGET

Parameter	BOL	EOL	Eclipse
Communication Subsystem	325W	325W	162W
Bus	25W	25W	25W
	----	----	----
Spacecraft Total	350W	350W	187W
Solar Array	450W	360W	0W
Battery Capacity/ Utilization	20AH	17AH	39AH (19.5% DOD)
Margin	100W	10W	1.1AH[39/]
% Margin	29%	3%	5.5%

39/ Based on allowable battery depth-of-drain of 15%.

TABLE V-7

MASS and SIZE SUMMARY

Parameter	Value kg (lbs)
EOL Satellite Mass	145 kg (320 lbs)
Propellant Budget	5 kg (11 lbs)
BOL Satellite Mass	150 kg (331 lbs)
ASE	10 kg (22 lbs)
Total Launch Mass	160 kg (353 lbs)

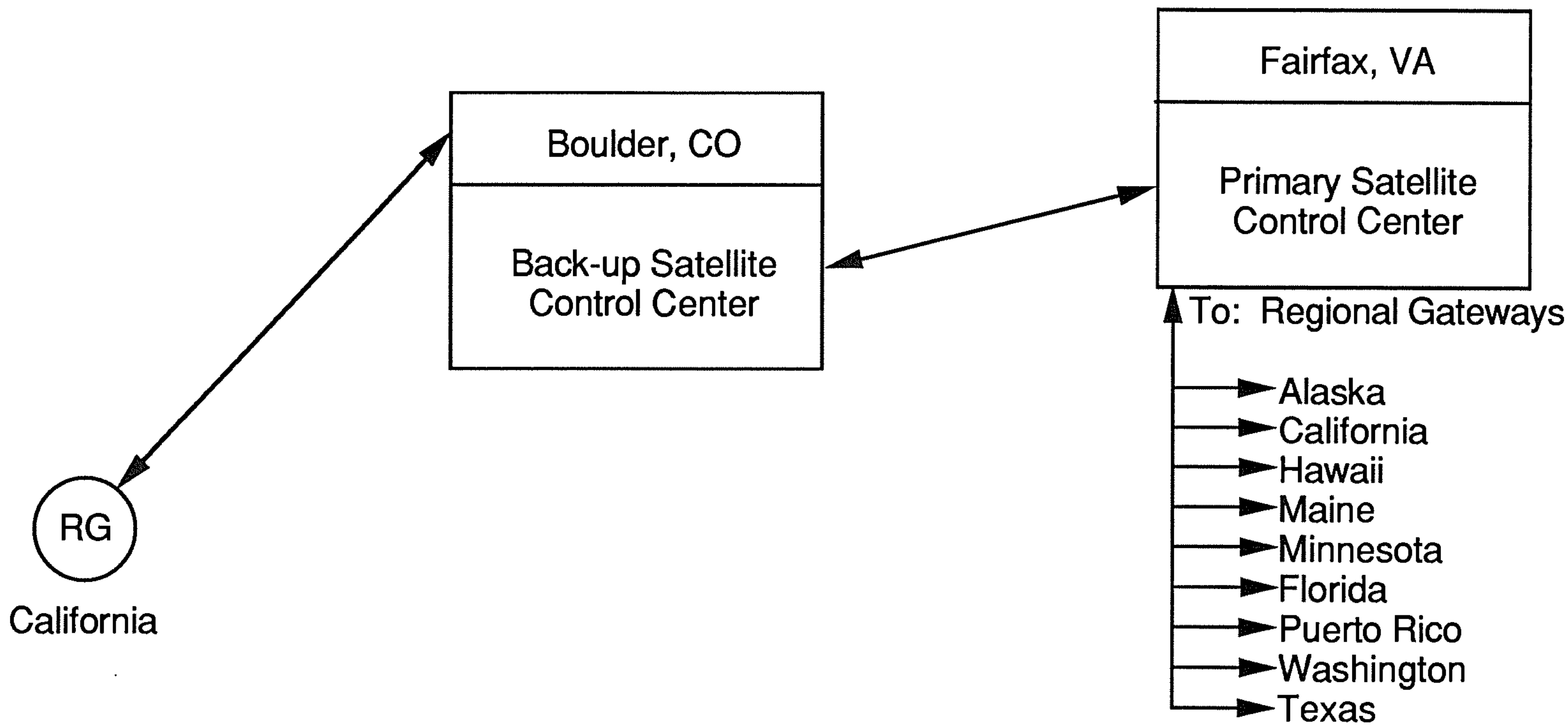
Dimensions (M/Feet)	
Diameter (stowed)	.75 Meters (2.5 feet)
Length (stowed)	1.4 Meters (4.6 feet)
Overall Length (deployed)	8.0 Meters (26 feet)

C. Launch Plan

Launch of the complete constellation of 20 satellites will be accomplished in 42 months after program inception. The satellite development effort leads to a Critical Design Review (CDR) 12 months after program inception. The first satellite will be delivered 16 months after CDR with production scheduled to deliver four satellites per quarter over five quarters. With two months for satellite integration to the first Pegasus launch vehicle (integration on subsequent launches is expected to take about two weeks), 30 months after program inception. Launches will be conducted at the rate of four per quarter over five quarters (fourth quarter 1993 through fourth quarter 1994).

Figure V-7

Telemetry, Tracking & Command Network



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A fifth flight model will be delivered in the first quarter for use as a buffer during the launch period and later as a spare.

The standard Pegasus launch service agreement requires initial installment payment at 18 months prior to launch. A single launch service agreement will be used for all launches with options for Pegasus launches available for replenishment as needed. Partial advanced payment for optional Pegasus launches can reduce to six months or less the lead-time necessary for a contingency replenishment launch.

This development and production schedule will allow a wide range of flexibility to respond to contingency situations. First, the development program will lead to a qualification article satellite which will receive thorough and rigorous qualification testing of the entire satellite design. Although flight-qualified, this satellite will not be launched as part of the basic 20 satellite constellation. Once qualification is complete, this satellite will be used in a limited engineering effort to develop an integration approach to the Pegasus launch vehicle. This effort will run in parallel with the production of the first flight unit.

The spare satellite and, if necessary, the qualification satellite, at a later date, can be made available at any point in the deployment schedule for a replenishment launch on Pegasus in response to a launch or an on-orbit satellite failure.

Finally, production of additional satellites can be initiated as a result of launch failures. This will limit the possible delay in deployment of the complete constellation to no more than six months.

D. Ground Segment

The ground segment supporting the ORBCOMM satellite system will be initially comprised of a network of Regional Gateway earth stations interconnected with the ORBCOMM Headquarters in Fairfax, Virginia. Figure V-6 depicts the network topology which will provide the Message Processing and Handling between all subscribers and the satellites, as well as all Tracking, Telemetry and Control functions. Each of the gateway earth stations will be connected to the ORBCOMM headquarters via dedicated 56 kbps duplex circuits.

Alternate routing will be provided by a ring-network connecting all of the gateway sites except for Alaska, Hawaii and Puerto Rico. These three sites with be connected to this network via the Washington, California and Florida sites respectively.

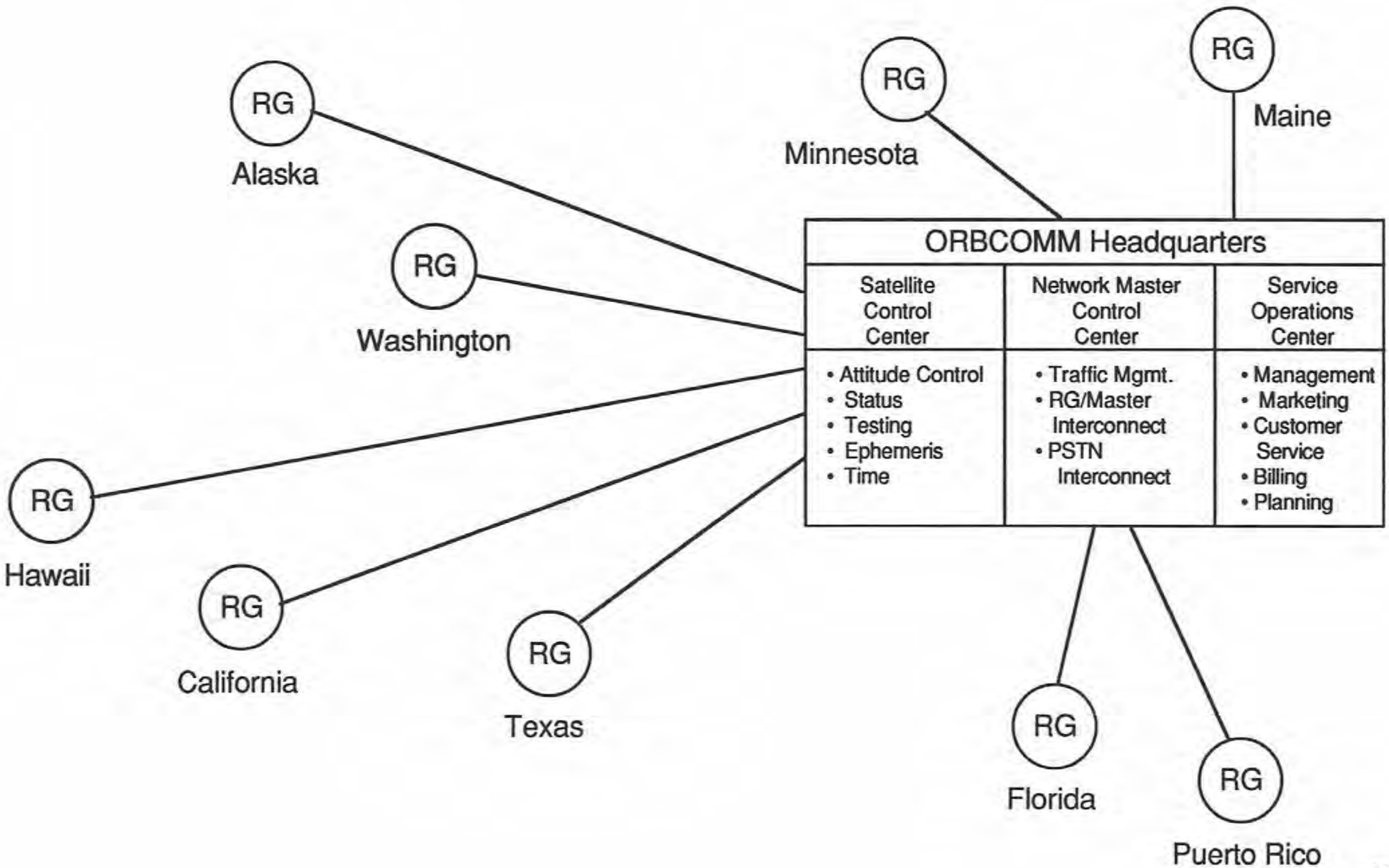
1. Regional Gateways

Nine Regional Gateways will be situated around the U.S. to provide coverage to any and all of the satellites in the ORBCOMM constellation, regardless of their orbital position while serving the U.S. These gateways will provide the communications link between the Network Master Control Center and the satellite. The gateway will provide the following functions:

- o Messaging Link between the NMCC and the satellite
- o TT&C Link between the Satellite Control Center (SCC) and the satellite.

Figure V-6

ORBCOMM Ground Network Topology



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The nine locations for the gateways were chosen to provide the optimum coverage of the twenty satellites regardless of their orbital position. All sites will provide a minimum of five degrees elevation to the satellite if the satellite covers any part of the U.S. The regional gateways will be located in the following areas:

Alaska	Minnesota
California	Puerto Rico
Florida	Texas
Hawaii	Washington
Maine	

The regional gateways will consist, in part, of a fully redundant satellite earth terminal. Interfacing with the terminal will be a communications processor (also redundant), which provides the interconnection between the Satellite Control Center, the Network Master Control Center and the local computer. Each of the gateways will have the capability of managing a satellite's orbit by collecting ephemeris data, analyzing telemetry data, and providing commands to the satellite. In addition, the gateways provide the conduit for all message traffic between the NMCC and the satellite. Performance margins for the links between the satellites and the Regional Gateways are shown in Table V-8.

2. Satellite Control Center

The Satellite Control Center will be comprised of a Master Station located in Fairfax, Virginia and a backup station located in Boulder, Colorado. These facilities will each have the capability to provide:

- o Satellite Tracking
- o Telemetry Processing, Display and Analysis
- o Commanding
- o Range Determination and Orbit Control
- o In-service Monitoring and Control
- o Spot In-Orbit testing
- o Communications Interfacing and Control

Each of the regional gateways will use the VHF-2 and VHF-4 communications channels and provide the TT&C data in an encrypted format. The earth stations will share the TT&C function with the message channel. The Fairfax, Virginia center will be connected to each of the gateways via a dedicated 56 kbps duplex circuit, and also connected to the Boulder, Colorado center. The Boulder, Colorado center will also be connected to the California gateway via a 56 kbps duplex circuit, providing backup to the primary station for the TT&C function. Figure V-7 depicts the interconnection between the respective locations. In-orbit test equipment will be located at each of the two sites for precision communications measurement.

The Satellite Control Center will provide primary control for all in-orbit satellites. It will control and monitor orbit determination and prediction, power and thermal management, on-board system configuration management, and perform trend analysis and communication interfacing.

In a 970 kilometer inclined orbit each satellite will pass in view of CONUS for 3-4 consecutive orbits passing south-to-north and then have a dead-time of 4 orbits before passing in view again for 3-4 consecutive orbits passing north-to-south. The polar orbiting satellites will pass in view of CONUS 2-3 consecutive orbits and will be out of view of CONUS for 6-7 orbits. To provide continuous communications in the U.S. with all satellites, each gateway will have the capability for command and telemetry functions. Performance margins for Regional Gateway uplink and downlink, serving both the messaging and TT&C links to and from the NMCC and SCC, respectively, are shown in Table V-8.

TABLE V-8

REGIONAL GATEWAY/SPACECRAFT LINK MARGINS

Parameter	Command Uplink (148MHz VHF-2)	Telemetry DownLink (137 MHz VHF-4)
Tx Power	19.0 dBw	10.0 dBw
Antenna Gain/ Line Loss	+13.0 dB	0.0 dB
EIRP	32.0 dBw	10.0 dBw
Free Space Loss[40/]	-145.8 dB	-144.9 dB
Atmospheric Loss	-3.2 dB	-3.2 dB
Polarization Loss (Worst Case)	-3.0 dB	-3.0 dB
Receiver G/T	-28.6 dB/K	-15.7 dB/K
C/No	80.6 dBHz	71.8 dBHz
Bit Rate	56 Kbps	56 Kbps
Eb/No[41/]	33.0 dB	24.1 dB
Required Eb/No	14.5 dB	14.5 dB
Margin	18.5 dB	9.6 dB
Emission Designator	56K00G9D	56K00G9D

40/ For a 5 Degree Elevation Angle.

41/ For a BER of 10^{-6}.

3. Network Master Control Center

The Network Master Control Center is the "nerve center" of the ORBCOMM communication system, and as such, functions as the processing center for all message traffic on the system. The NMCC provides three major functions in the ORBCOMM system:

- o Traffic Management
- o Regional Gateway Interconnect
- o PSN Interconnect

The Traffic Management function is comprised of two components: the origination and composition of all outgoing polling traffic, i.e., the message structure and instructions, and the processing and routing of all incoming message traffic. The message function will be accomplished using distributed processing for each of the two functions and their attendant database management functions. The use of a distributed system will assure the highest reliability in the operation of the NMCC as well as providing maximum throughput. To distribute the polling messages, the Traffic Management System will interface with the Regional Gateway switching system that directs the polling messages to the appropriate gateway and satellite. To distribute the incoming message traffic, the Traffic Management System will interface with the PSN switching system which connects the NMCC to the commercial network and subsequently to the designated subscriber.

4. Subscriber Terminals

The key to ORBCOMM's optimism with respect to market potential is the projected low cost of the subscriber terminals. The ORBCOMM system design is driven by the goal to achieve terminals with suggested retail prices ranging from $50 to $400, depending on performance and feature level.

With few exceptions, all subscriber terminals will have both transmit and receive functions. The transceiver is the fundamental building block of the system since it enables two-way communications. The basic transceiver will have single transmit and receive channels, both built from existing, high volume components. A serial controller, ROM, RAM, A/D converter, serial input/output circuitry, a fail-safe timer, and the CPU will reside on a CMOS microprocessor equivalent to the Motorola 68HC11. The transceiver will be designed to detect "run away" transmissions and cut off the circuit to avoid flooding the uplink channel.[42/]

Power will be provided by a range of options depending on the subscriber application, including 7 volt rechargeable and replaceable batteries for portable units, 12 volt sources for mobile use, and 115 volt transformers for recharging and office use. Hybrid NiCd/air zinc batteries may be an option to extend intervals between recharge.

42/ A "run away" channel is defined as one that is "stuck" in the transmit position or exceeds traffic standards for a given service.

Antennas will also vary depending on the application. Portable units will have simple flexible or retractable antennas between 23 and 46 cm (9 and 18 inches) in length. Automotive applications will be able to share use of an antenna with AM/FM radio functions.

Various input and output devices will be available, depending on the application. In the automotive air bag installation, the unit would be triggered by activation of the air bag. Where human interaction is required, LCD screen displays, alphanumeric keyboards, and printer/computer interfaces may be required. The amount of resident memory will be designed for the specific application, with varying requirements for data acquisition or messaging.

In operation, when the ORBCOMM single transmit channel unit is activated, the unit will transmit its full message over one fixed frequency to the satellite. Should an acknowledgement not be received within about 20 milliseconds, the unit will transmit again until a slot is available. To minimize "collisions," i.e., simultaneous arrival of two or more transmissions at the satellite receiver, the 17 channels available for subscriber uplink frequencies in random access service will be randomly assigned in the manufacturing process. Traffic analyses indicate that the probability of contention for emergency services is acceptably low, even during projected busy hours. In those applications where a higher grade of service is required, subscriber terminals will have three transmit frequencies with a scanning synthesizer. Should a unit encounter a collision on a first transmission, it will scan to the next channel and so on until a connection is made. This will provide a very efficient level of circuit loading.[43]

The circuitry required for position determination will supplement the communications electronics. There will be three types of position determination terminals: single receiver channel units operating at 137 MHz (or 400 MHz), and a dual receiver unit operating at both 137 MHz and 400 MHz. In both cases, the 137 MHz receiver would serve communications and position determination functions. The 400 MHz receiver would function as a high-frequency channel to improve position resolution. The position determination electronics will include a high capacity microprocessor and additional ROM and RAM. Software built into the transceiver controller will poll the position determination memory for location computations and transmit the information along with other data to the satellite.

The position resolution provided by the one and two channel ORBCOMM electronics should be suitable for most subscriber requirements. However, should a subscriber require frequent and immediate position updates, possibly linked to a navigation system, ORBCOMM's communication transceiver can be

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[43] TDMA and Slotted Aloha techniques are not desirable for the ORBCOMM system because of the need to preserve the very small amount of bandwidth for transmission of data packets as opposed to overhead and timing information.

used to communicate position information computed by LORAN-C or GPS receivers.

Subscriber terminals will be manufactured and marketed by the consumer electronics industry. ORBCOMM will enter into development agreements in 1990 to assure that manufacturing capability will be in place by the time the service is available.

From the standpoint of the emitter, the subscriber terminals will fall into three categories: basic portable terminals, enhanced performance portable terminals, and mobile terminals (vehicle or platform mounted, which includes for this purpose fixed terminals). Transmit and receive characteristics for each of the three configurations are shown in Table V-9. Table V-10 shows typical link margins for each type.

A chart showing subscriber terminal feature by service application is included in Section III, Figure III-6.

TABLE V-9

SUBSCRIBER TERMINAL CHARACTERISTICS

Parameter	Portable Terminals Basic	Portable Terminals Enhanced	Mobile Terminals
Tx Pwr	2.0 watts	2.0 watts	5.0 watts
Antenna Gain	-1.0 dB	2.0 dB	2.0 dB
EIRP	2.0 dBw	5.0 dBw	9.0 dBw
G/T	-36.5 dB/K	-35.5 dB/K	-30.4 dB/K
Power Flux Density	-134.4[44]	-131.4[44]	-127.4[44]
Emiss Designator	15K00F1D	15K00F1D	15K00F1D

44/ $dBw/m^2/4KHz$ at the satellite at 90° elevation angle.

TABLE V-10

TYPICAL SUBSCRIBER EQUIPMENT UPLINK BUDGETS
(VHF-1, 148MHz Band)

	Personal Terminal		Mobile
Parameter	Basic	Enhanced	
Tx Pwr	3.0 dBw	3.0 dBw	7.0 dBw
Antenna Gain/Line Loss	-1.0 dB	2.0 dB	2.0 dB
EIRP	2.0 dBw	5.0 dBw	9.0 dBw
Free Space Loss[45/]	-145.7 dB	-145.7 dB	-145.7 dB
Atmospheric Loss	-3.2 dB	-3.2 dB	-3.2 dB
Polarization Loss	-3.0 dB	-3.0 dB	-3.0 dB
Data Rate	1,200 bps	1,200 bps	1,200 bps
Satellite G/T	-25.8 dB/K	-25.8 dB/K	-25.8 dB/K
Satellite G/No	30.8 dBHz	55.9 dBHz	59.9 dBHz
Satellite Eb/No	22.0 dB	25.1 dB	29.1 dB
Req'd Eb/No[46/]	17.5 dB	17.5 dB	17.5 dB
Satellite Margin	4.5 dB	7.6 dB	11.6 dB

45/ For a 5 Degree Elevation Angle.

46/ For a BER of 10^{-6}; modulation is PSK.

TABLE V-10 (cont.)

TYPICAL SUBSCRIBER EQUIPMENT DOWNLINK BUDGETS
(VHF-3, 137 MHz Band -- UHF)

	Basic (137 MHz)	Mobile (137 MHz)	Time/Freq. Link (400 MHz)
Satellite Tx Pwr	10.0 Watts	10.0 Watts	20 Watts
Antenna Gain/Line Loss	0.7 dB	0.7 dB	0.0
Satellite EIRP	10.7 dBW	10.7 dBW	13 dBW
Free Space Loss[47/]	-144.9 dB	-144.9 dB	-154.19 dB
Atmospheric Loss	-3.2 dB	-3.2 dB	-0.5 dB
Polarization Loss	-3.0 dB	-3.0 dB	-3.0 dB
Data Rate	4,800.0 bps	4,800.0 bps	4,800.0 bps
Subscriber G/T	-35.5 dB/K	-32.5 dB/K	-32.5 dB/K
Subscriber G/No	52.7 dBHz	55.7 dBHz	53.4 dBHz
Subscriber Eb/No	15.9 dB	18.9 dB	16.6 dB
Req'd Eb/No	14.5 dB	14.5 dB	14.5 dB
Subscriber Margin	1.4 dB	4.4 dB	2.1 dB

47/ For a 5 Degree Elevation Angle, 137.3 MHz.

5. Service Operations Center

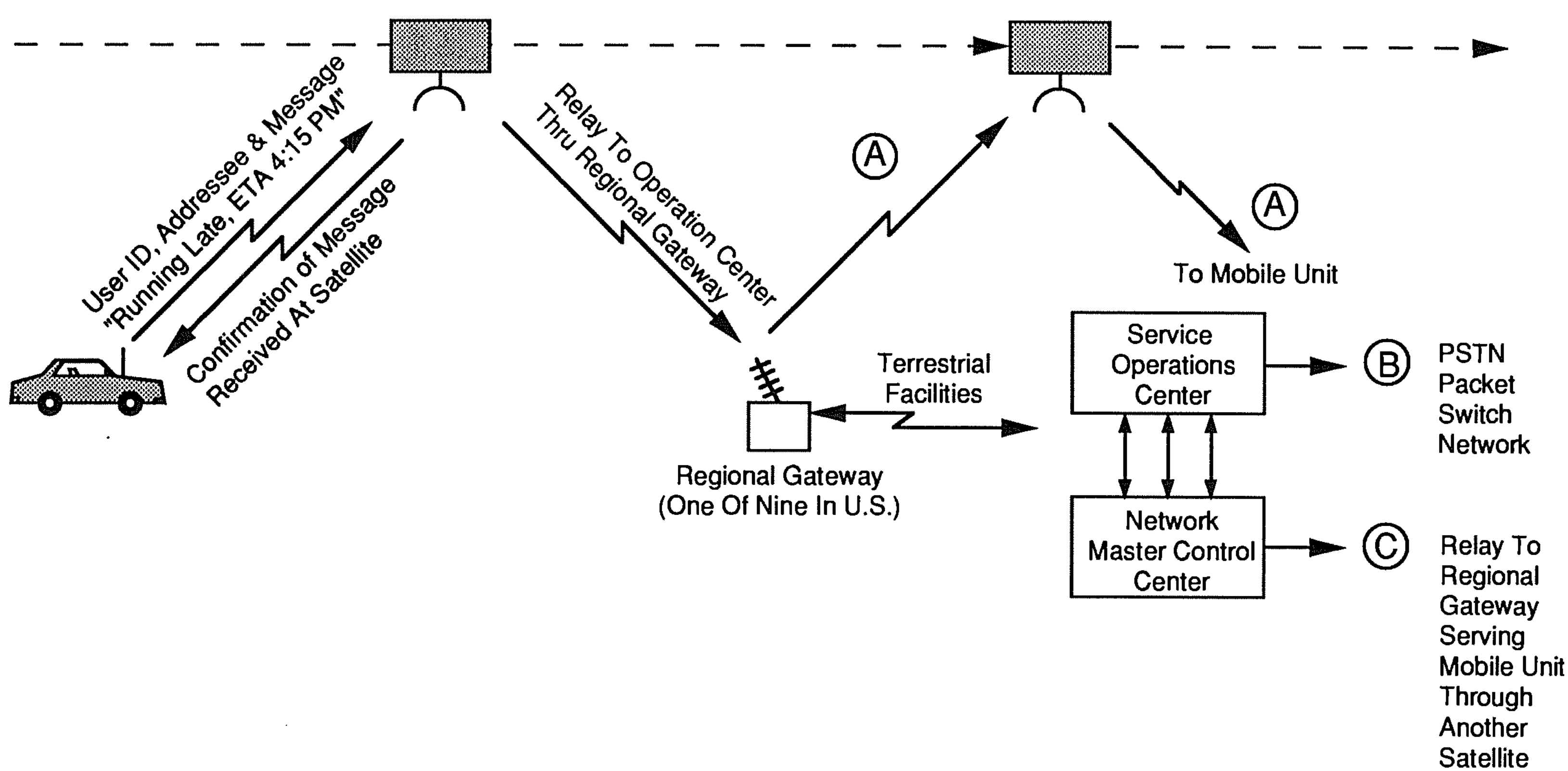
The Service Operations Center (SOC) provides the interface between the customer and the ORBCOMM system and the overall management and planning for the customer.

a. Message Handling

Figure V-8 depicts the typical routing of messages through the ORBCOMM System. There are two methods of processing messages depending on their point of origination: (i) a subscriber initiated message will flow from his or her terminal through the satellite and a Regional Gateway to the NMCC where it is either printed out for delivery by mail, or routed based on pre-determined protocols through packet switched networks. Emergency messages will be passed directly through to service providers such as automobile clubs based on subscriber identification code or to ORBCOMM's Customer Service activity where each emergency will be individually managed until confirmed as cleared. Emergency service messages will be handled on a priority basis over all other traffic; or (ii) an off-network message may enter the system through the SOC via several different media, e.g. electronically, hard copy or verbally. The SOC will enter the message into the system computers which, in turn, will forward it to the NMCC. The NMCC will then provide the proper structure and addressing and route it to the designated subscriber via the appropriate Regional Gateway and satellite based on the subscriber's last known position.

Figure V-8

Messaging Handling



- Service Operations Center Directs Messages To Mobile Units Through The Gateway And Satellite System Or Through The PSTN And Packet Switched Networks To Fixed Addresses
- A, B & C are Alternative Routes for Delivery of Messages

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b. <u>Customer Billing</u>

ORBCOMM's rate structure will be comprised of non-recurring service activation fees, monthly or annual fees, and usage fees. A matrix billing system will be established whereby customer category will be matched with the specific type of service utilized. Separate and completely automated operations will be established for the three elements of the billing structure. Sign-on and periodic billing will be handled in line with normal practices for high volume operations.

For usage billing, as each message is processed within the SOC, incoming or outgoing, the subscriber identification number will trigger a computer run against a billing algorithm for the particular class of service for that subscriber. Aggregate charges for each message processed will be established and recorded against the subscriber's account. At the end of the billing period, an automated bill will be forward for subsequent payment.

Customer billing will be on a monthly, quarterly or annual basis, depending on the category of subscriber and type of service rendered.

c. <u>Customer Service</u>

ORBCOMM will provide the highest possible level of customer service, recognizing the critical needs of all customer segments, but in particular, the importance of providing service to those in need of emergency assistance. ORBCOMM's Customer Service organization will be comprised of three principal groups:

(i) Emergency Services, (ii) Problem Resolution, and (iii) Subscriber Services. The Emergency Services Group will have operators who will process emergency requests 24 hours a day, 365 days a year on a case-by-case basis for ORBCOMM subscribers. The incoming messages will be recorded and displayed on an operator screen. The operator will have access to computers which will quickly match the incoming subscriber identification number with the subscriber data base information and the emergency service authorities in the location of the caller. The operator will place a telephone call to the authority informing them of the emergency and the position of the caller, and will document the call with a message sent through the ORBCOMM system directly to the authority's ORBCOMM terminal or through an E-mail service. The operator will follow-up with the authority until the emergency is confirmed as cleared. It is expected, however, that most emergency calls will be relayed automatically to emergency service providers such as AAA, AMOCO and Allstate based on established computer protocols. In this case, the incoming messages will be processed at the Network Master Control Center and relayed immediately over PSN facilities.

Tracking stolen automobiles or other property will be handled in much the same manner. ORBCOMM either will directly track the property until recovered, or will provide the information stream to an insurance company that will make the decisions as to what actions to take and when.

Resolution of service problems and billing will be handled to the extent possible by service operators. Customer records will be available to the operator while discussing the problem with the customer. Authority for most matters will rest with the operator. These operators also will handle requests for system checks from subscribers who only occasionally need to check their equipment. An example is the hiker who wants to be sure the SecurNet terminal is functioning properly after storing the terminal for several months. The hiker will call customer service and arrange for the unit to be addressed, and will receive confirmation of successful communications.

Subscriber services will provide information on ORBCOMM's capabilities and rates, will arrange for marketing presentations and shipment of descriptive material, and will register new customers. Customers will be able to sign-on to the new service either by mail or telephone. Subscriber equipment will included the necessary forms and instructions to receive an identification number and place the unit in service without delay.

d. Management and Planning

The Service Operations Center also will include the management, financial, system engineering, corporate development, external affairs, service planning, subscriber equipment certification, and marketing functions. ORBCOMM will operate as a stand-alone corporation dedicated to developing fully the capabilities in the U.S. and internationally. The headquarters, including management and planning functions, will be located in Fairfax, Virginia or another northern Virginia site in close proximity to OSC.

E. Position Determination Capabilities

The ORBCOMM system will provide three levels of position determination resolution to subscribers who will require this capability. These levels are differentiated by the capability and complexity of the subscriber terminal where the calculation of position will be accomplished. Determination of position at the subscriber terminal minimizes subscriber to satellite transmissions and use of the scarce spectrum.

Utilizing time and position information received from the satellite in one of three frequency plans (137 MHz only, 400 MHz only, or 137 and 400 MHz in combination), the subscriber terminal will calculate its own position using the Doppler frequency shift measurement technique. The shape of the curve of variance from the known carrier frequency is analyzed automatically to determine the most likely subscriber position.

The subscriber terminal electronics will consist of a low-cost reliable receiver operating in one of the three frequency plans plus the position determination microprocessor and memory chips. For the lowest cost, lowest performance unit, Doppler shift will be derived from the satellite's 137 MHz carrier which also serves as the messaging downlink carrier. Another single channel unit will use the 400 MHz carrier but will not have messaging capability. A number of discrete Doppler measurements must be made to calculate the user position. The time for an initial position fix, using a single frequency, will be on the order of 7 minutes. The 137 MHz unit is projected to have a single pass resolution to 3,600 feet, or about 0.7 miles for stationary or slow moving subscriber units. The 400 MHz unit is projected to provide resolution to 1,200 feet (0.2 miles) again for stationary subscribers. Resolution for both units will improve by 30% on the second satellite pass, which will occur within 24 minutes.

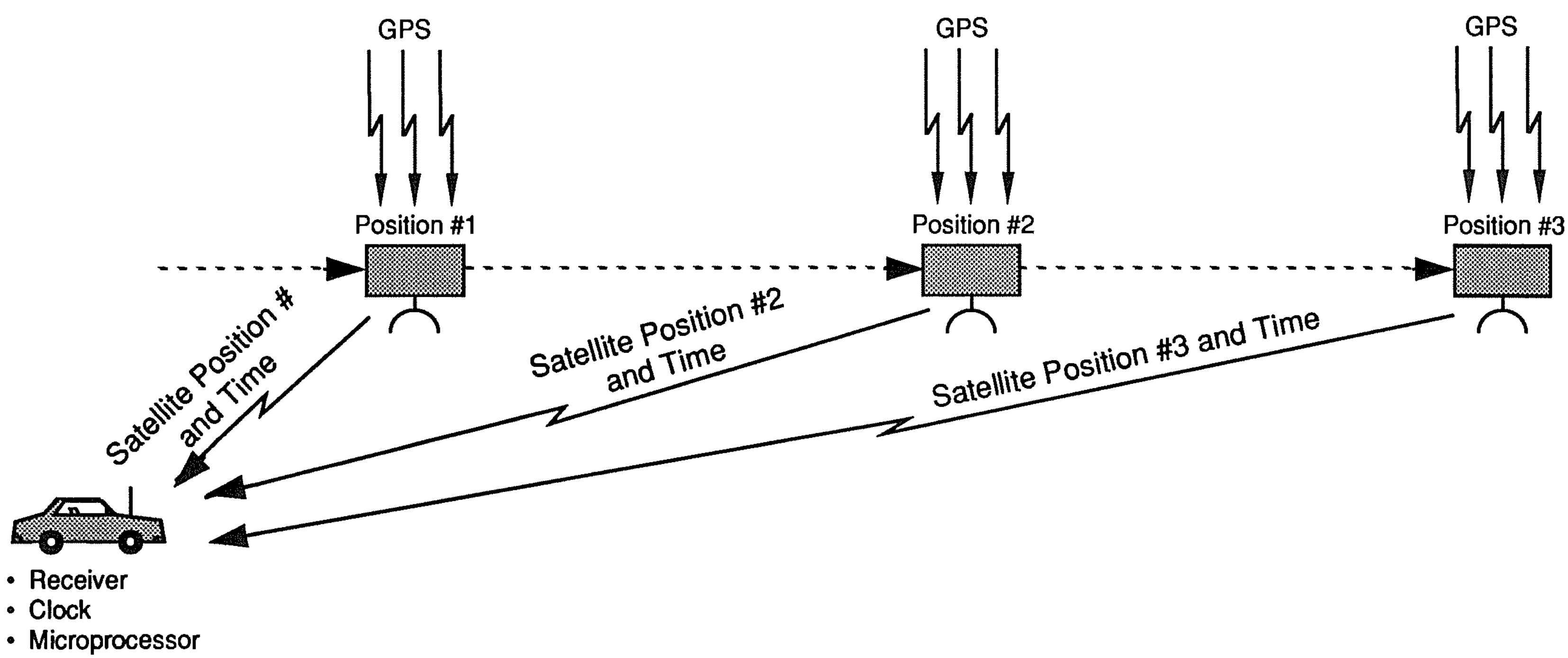
For the dual carrier receiver unit, the Doppler shift will be measured from a signal derived from a combination of the satellite's 137 MHz and the 400 MHz carriers. Utilizing this system, the subscriber terminal is able to remove the propagation path errors caused by ionospheric refraction of the radio waves, and provide a significant improvement in the position resolution. The single pass projected resolution for this unit is 120 feet. Second and third pass resolution will improve to 85 feet and 70 feet respectively. Figure V-9 depicts the position determination concept.

For mobile applications, the subscriber terminal, enhanced with navigational aides such as compass and odometer, can provide limited navigational capability.

For both terminal configurations (single and dual carrier receivers), resolution accuracy will also be a function of equipment performance, e.g. oscillator stability and the

Figure V-9

Position Determination Process



- Distance Of Vehicle From Satellite Caculated Based On Doppler Frequency Shift
- Vehicle Position Determined By Using Known Satellite Positions and Calculated Distance Of Vehicle From Multiple Satellite Positions
- Accuracy Improves With Multiple Satellite Passes

91220.09 b

TABLE V-11
POSITION DETERMINATION ACCURACIES (1)

Terminal Configuration	Satellite Passes One Pass (7-Minutes)	Two Passes (24-Minutes)	Three Passes (41-Minutes)	Four Passes (58-Minutes)
Single Frequency				
137 MHz	**1,100 m (3,600 Ft)**	**775 m (2,500 Ft)**	**650 m (2,100 Ft)**	**550 m (1,800 Ft)**
400 MHz	**371 m (1,200 Ft)**	**262 m (850 Ft)**	**214 m (700 Ft)**	**185 m (600 Ft)**
Dual Frequencies				
138 MHz & 400 MHz	**37 m (120 Ft)**	**26 m (85 Ft)**	**21 m (70 Ft)**	**19 m (60 Ft)**

(1) Nominal 45 Degree elevation Angle during Daylight for stationary subscribers. Resolution degrades at higher and lower elevation angles due to ionospheric effects and angle of approach. Night time performance for single frequency units will approximately double the daytime performance. Worst case timing between consecutive satellite passes will add 17 minutes delay to complete the above calculations.

APPENDIX E

DataSat-X EXPERIMENTAL SATELLITE PROGRAM

I. Introduction

In March 1989, following completion of initial market and technical studies of a low-earth orbit data communications and position determination system, OSC had sufficient confidence in the potential of the system to proceed with a test, demonstration, and development program with one experimental satellite to be launched on one of the initial flights of Pegasus. With the support and partial funding from the Virginia Center of Innovative Technology, OSC filed applications with the Commission for experimental radio licenses. The Commission granted licenses for experimental use as follows:

- Spacecraft
  - 42.010 MHz, 20 watts, 12 KHz B/W
  - 423.500 MHz, 2 watts, 100 KHz B/W
- Earth Stations (two Fairfax, VA and Boulder, CO)
  - 5 channels (35 to 39 MHz), 1,585 watts, 12 KHz B/W
- Remote Terminals (Unlimited)
  - 5 channels (35 to 39 MHz), 1 watt, 12 KHz B/W

The satellite, named DataSat-X, will be launched on one the first Pegasus vehicles into a circular polar orbit. Exhibit 1 includes a copy of the experimental licenses and the narrative that was included with the application for the licenses.

signal-to-noise ratio of the radio links with the satellite. The ORBCOMM satellite will incorporate sufficient on-board computing and memory capability to assure the determination of an accurate satellite ephemeris. The subscriber terminal will incorporate oscillators with excellent short term stability. Finally the ORBCOMM system design assures sufficient link margin to provide highly reliable communications to the terminal. Collectively these factors will provide a good single-pass position determination whose error will become smaller as additional positions are calculated and accumulated from multiple satellite passes. Table V-11 provides a summary of the position accuracies expected with the ORBCOMM system.

In those applications requiring frequent, immediate, and highly position determination, ORBCOMM communications terminals could be used in conjunction with LORAN-C or GPS receivers to transmit position information.

VI. LEGAL, FINANCIAL AND TECHNICAL QUALIFICATIONS

A. Legal Qualifications

ORBCOMM was organized under the laws of Delaware for the primary purpose of entering the U.S. and international satellite communications and position determination services business. ORBCOMM is a wholly-owned subsidiary of Orbital Sciences Corporation. OSC also is a Delaware corporation primarily engaged in the business of developing, manufacturing, and marketing space transportation systems, space support systems, and satellite systems and services, including spacecraft and associated ground systems.

ORBCOMM's legal qualifications are demonstrated in the FCC Form 430, "Common Carrier and Satellite Radio License Qualification Report," submitted with this application as Appendix B.

B. Financial Qualifications

1. Construction and Launch Schedules

ORBCOMM will purchase its satellites from a satellite manufacturer based on responses to a request for proposals. We anticipate that a U.S. manufacturer will be selected, given the number of qualified domestic manufacturers. Potential satellite sources include, in alphabetical order, Ball Aerospace, Fairchild Space & Defense, Ford Aerospace, General Electric Astro, Hughes Aircraft Company, Martin Marietta, Rockwell and TRW. Selected portions of the satellite system may be provided by OSC.

ORBCOMM will purchase launch services from OSC based on a negotiated fixed price contract. ORBCOMM plans to use Pegasus as the launch vehicle. Pegasus launches typically will be conducted over the Atlantic Ocean.

ORBCOMM will take delivery of the first operational spacecraft from the satellite manufacturer beginning 28 months after the contract is signed. Launch of the first five spacecraft to the three orbital planes will take place over the subsequent three months. Following two months of spacecraft and ground system checkout, initial service will be inaugurated 32 months after placement of the order for satellites.

The contract for launch services will be executed 12 months after the contract for the satellites is signed, and the first launches will take place 18 months later. All 20 spacecraft will be launched over a fifteen month period (four launches per quarter).

One spacecraft built for test purposes will be refurbished to serve as a ground spare to be launched in the event of in-orbit failures. A second spare satellite will be delivered at the end of the production run. The proposed schedule launches by type and number are shown in the table below. In the event any of the operational launches fail to insert usable spacecraft into the required orbit, replacement spacecraft and launch services will be ordered following the failure.

LAUNCH AND OPERATIONAL SCHEDULE

Launch Quarter	Number of Satellites	Launch Date	Operational Date
1st Quarter	4	10/93-12/93	12/93- 2/94
2nd Quarter	4	1/94- 3/94	3/94- 5/94
3rd Quarter	4	4/94- 6/94	6/94- 8/94
4th Quarter	4	7/94- 9/94	9/94-11/94
5th Quarter	4	10/94-12/94	12/94- 2/95

ORBCOMM will contract for design and construction of the Satellite Control Center, Network Master Control Center, Service Operations Center, and Gateways shortly after the satellites are under contract. To assure that subscriber terminals are available at the time the first spacecraft are launched, ORBCOMM will enter into Joint Development Agreements with selected suppliers in the second and third quarters of 1990.[48/] Concurrent with the filing of this application, ORBCOMM is requesting a Section 319(d) waiver to begin the initial phases of design and development of its satellites and the operations centers by April 1990. Assuming receipt from the Commission of authority to construct, launch, and operate the ORBCOMM system in the U.S. one year from the date of this application, it is necessary to proceed with engineering and development as early as possible in order to be prepared to enter into contracts for the satellites and control centers soon after receiving authority. Under this timing plan, ORBCOMM service could be inaugurated by the end of 1993. This schedule may be accelerated somewhat if construction is allowed to proceed immediately under a Section 319(d) waiver.

48/ Given the number of potential qualified U.S. manufacturers, we expect to sign agreements with domestic companies. ORBCOMM intends to enter initial Joint Development Agreements with foreign manufacturers only if qualified domestic manufacturers prove unavailable.

2. Total System Cost

The total projected investment cost, including pre-operational expenses for the ORBCOMM satellite system, is approximately $283 million, plus $37 million in capitalized interest. ORBCOMM's space segment is comprised of 20 operational satellites plus two ground spares. The proposed ground system will consist of a Satellite Control Center in Fairfax, Virginia, a back-up Satellite Control Center in Boulder, Colorado, and nine Regional Gateway stations located throughout the U.S. and Puerto Rico. Pre-operational and administrative expenses will consist of system engineering, software development, general and administrative expenses, and legal expenses incurred prior to the launch of the satellites. ORBCOMM's total investment requirements are itemized in the table below:

TOTAL INVESTMENT REQUIREMENTS
$ Millions

Spacecraft & Mission Operations (20)	$ 67.7
Launch Services (20)	104.9
Total Space Segment Cost	$171.6
NMCC Stations (2)	$ 20.0
SCC	15.0
SOC	20.0
Regional Gateways (9)	18.0
Total Ground Segment Cost	$ 73.0
Total Capital Expenditures	$244.6
Total Pre-operational Expenses	38.3
Capitalized Interest	36.9
Total Investment	$319.8

a. Pre-operational Expenses

ORBCOMM has established its headquarters offices in Fairfax, Virginia, collocated with OSC. OSC has a professional staff fully experienced at satellite and launch system design. During the past year, extensive business and technical studies have taken place between OSC's planning staff and major prospective users of ORBCOMM's capacity. OSC has entered into Joint Research Agreements with several major organizations including the State of Virginia and the National Park Service. The Agreements provide for test and evaluation of DataSat-X capabilities in specific applications and joint evaluation of market potential. The DataSat-X project is described in detail in Appendix E. The overall objective of the Joint Research Agreement program is to assure that ORBCOMM system design will meet fully the market requirements with respect to performance, cost, and feature. ORBCOMM will assume responsibility for these activities and will add permanent staff to market and develop the system.

In total, the capitalized pre-operational expenses, with interest, included in the total system cost are projected to be $41.6 million.

b. Research and Development Costs

During 1989, OSC independently spent several million on research and development and facilities directly related to the ORBCOMM system. This does not include the $40 million investment made by OSC and Hercules in development and construction of

Pegasus. OSC has invested $1.5 million in designing and building the DataSat-X experimental satellite and has budgeted substantial amounts in 1990 for system engineering and development, DataSat-X operations, ground terminal development and test, and support for the Joint Research Agreements -- all of which represent investment in the ORBCOMM System.

OSC also has spent substantial amounts on market research, planning, and the Joint Research Agreement program to quantify the potential market, to define subscriber operational requirements, and to complete the necessary spectrum analyses in preparation for the submission of this application.

c. Satellite Construction and Launch Service Investment

Satellite construction and launch service costs on an annual basis are set forth in detail in the table on the next page. ORBCOMM's spacecraft contract will be on a fixed price basis. Incentives will be included in the contract to encourage on time delivery and performance in orbit. ORBCOMM intends to employ a warranty payback approach in the event of in-orbit failures.

SPACE SEGMENT ANNUAL EXPENDITURES
$ Millions

	1991	1992	1993	1994
Spacecraft (22)	$ 8.1	$16.2	$25.5	$18.0
Launch Services (20)	0.2	22.8	48.5	33.3
Interest	0.5	2.6	8.7	14.4
Total Expenditures	$ 8.8	$41.6	$82.7	$65.7

d. Ground Segment Investment

At facilities in or near Fairfax, Virginia, ORBCOMM will construct the Satellite Control Center, the Network Master Control Center, and the Service Operations Center. The management, planning, marketing, and administrative functions also will be located at this headquarters facility. A back-up Satellite Control Center will be located at OSC's Space Technology Laboratory in Boulder, Colorado. Each facility will have the capability to provide tracking, telemetry, and control functions. A remote tandem back-up computer center with emergency operations capability will be maintained to provide service should the master facility be disabled.

U.S. Regional Gateways will be placed in nine locations: Alaska, California, Florida, Hawaii, Maine, Minnesota, Puerto Rico, Texas, and Washington State. This network will permit continuous communications with a satellite whenever its footprint is over any part of the U.S. The Regional Gateways will operate unattended in secure facilities and will have fully redundant equipment. Each Gateway will be connected to the Network Master Control Center by dedicated terrestrial communications facilities, primary and back-up, acquired from a nationwide interconnect company. Subscriber terminals will be provided by traditional manufacturers and distributors of this type of equipment, and their costs will be borne by subscribers. A summary of ORBCOMM's ground segment investment is shown below:

GROUND SEGMENT INVESTMENT
$ Millions

	1991	1992	1993
Network Master Control Center	$ 4.4	$10.2	$11.8
Service Operations Center	4.0	8.0	8.0
Satellite Control Centers	-0-	7.5	7.5
Regional Gateways	-0-	9.0	9.0
Total Ground Segment Invest.	$ 8.4	$34.7	$36.3

For a summary of all the investment costs by year, refer to Table VI-5.

e. Operating Expenses

ORBCOMM will own and operate the satellite constellation and ground system throughout its life. Usage must be carefully controlled at all times. All traffic to and from subscribers will be processed through the Network Master Control Center. Accordingly, sale or lease of transponders is not possible. The Center will provide the interface with the PSN. International Control Centers, linked to and coordinated by the U.S. master station, will be established as the service becomes available in foreign countries.

The Service Operations Center will be responsible for providing customer service, including emergency case handling, and billing. This organization also will incur ongoing operation and maintenance expenses throughout the life of the system, as well as marketing, general, administrative and legal expenses.

TABLE VI-5

Schedule of Investment Costs

($ in Thousands)

	1990	1991	1992	1993	1994	Total
Satellite Costs :						
Hardware	0	8,100	16,200	24,750	16,950	66,000
Mission Operations	0	0	0	700	1,000	1,700
Launch Services	0	240	22,849	47,896	32,340	103,325
Payload Adapters	0	0	0	600	1,000	1,600
Capitalized Interest	0	453	2,625	8,739	14,376	26,193
Total Space Segment	0	8,793	41,673	82,685	65,666	198,818
Ground Segment Costs :						
Network Management	0	4,000	8,000	8,000	0	20,000
Satellite Control	0	0	7,500	7,500	0	15,000
Satellite Operations	0	4,000	8,000	8,000	0	20,000
Gateways	0	0	9,000	9,000	0	18,000
Capitalized Interest	0	435	2,184	3,841	0	6,460
Total Ground Segment	0	8,435	34,684	36,341	0	79,460
Pre-ops Capital	3,700	5,922	11,760	16,919	0	38,301
Capitalized Interest	149	322	790	2,000	0	3,261
Total Pre-ops Capital	3,849	6,244	12,551	18,918	0	41,562
Total Investment	3,849	23,472	88,909	137,945	65,666	319,840
Cumulative Investment	3,849	27,321	116,230	254,174	319,840	
Cumulative Debt Financing	2,628	18,754	80,170	177,404	235,119	
Cumulative Equity Investm	1,221	8,567	36,059	76,770	84,721	

Tables VI-6, VI-7, and VI-8 have been omitted in public copies based on a request for confidential treatment for a limited time filed pursuant to 47 C.F.R. § 0.459.

f. Net Income

ORBCOMM has projected a potential net income on the basis of calculated revenue, investment and expenses, as depicted in Table VI-6. The service is projected to yield a return on investment as shown on that Table. In order to estimate revenues, we assumed rates ranging from $5 to $30 for non-recurring sign on fees; recurring annual charges of $30 to $50, or in some cases monthly charges of $20 to $30; and per message or per emergency usage charges.[49/]

3. Investment Cost Per Potential Subscriber

Based on traffic studies and system capacity analyses, we calculate that the ORBCOMM system will be capable of supporting up to 20 million subscribers in the U.S., depending on subscriber mix by service type. Thus, the capital investment per potential subscriber will be about $15, or a little over $2 per year assuming a system life of seven years.[50/]

If ORBCOMM is successful in providing service through licensees in foreign markets, because the space segment is completely reusable the incremental investment per potential international subscriber will be significantly less than 10% of

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49/ All of the rates that were used for financial analysis are preliminary. The actual rates will be set shortly before service is initiated, and will depend on the final costs of the system, additional marketing analysis and the level of competition. Any necessary tariffs will also be filed at that time.

50/ While direct comparisons with the investment per subscriber for cable TV admittedly are not totally relevant, it is interesting to note that cable systems cost about $1,000--or one-hundred times more per potential subscriber--to build than ORBCOMM.

the initial system investment. The ORBCOMM satellite constellation, which represents the largest part of the total U.S. investment, will be used throughout the world as the satellites circle the globe. Foreign affiliates will become operational with the construction of ground facilities only, at a relatively small cost.

4. Source of Funds

OSC is prepared to finance the ORBCOMM program described in this application. OSC has previously demonstrated its ability to raise capital required for its existing businesses. Since its founding in 1982, OSC has raised over $125 million in equity and debt. OSC's sales revenues were $80 million in 1989. OSC has been identified as one of the fastest growing high technology companies in America. Based on the increased financial resources, OSC has the capital to proceed as requested over the next year. Future funding would be obtained through a combination of debt, public offerings, and/or joint venture arrangements with major strategic partners.

Appendix F contains a letter from one of OSC's investment bankers, Alex. Brown & Sons Incorporated, which indicates that, in its opinion, it is reasonable to expect that ORBCOMM will be able to raise the required capital through a combination of debt and equity financing.

5. Revenue Requirements

Table VI-7 shows the rate of return calculation, and Table VI-8 shows the revenues associated with the projected return.

C. Technical Qualifications

OSC and ORBCOMM have the required management and professional staff to design, plan, and launch the proposed satellite system. OSC has some 200 engineers, 100 technicians and managers who have accumulated hundreds of years of hands-on space and communications experience. ORBCOMM is in the process of adding senior management with satellite service, mobile telecommunications, and/or telephone system experience to its staff. OSC is building the Pegasus launch vehicles required for the ORBCOMM program. The company has produced and launched over 600 suborbital boosters weighing up to 70,000 pounds, and has built over 200,000 sounding rockets. In the next few years, OSC's Transfer Orbit Stage (TOS) will boost NASA's Advanced Communications Technology Satellite (ACTS) to geostationary orbit and the NASA's Mars Observer satellite to the planet of Mars.

ORBCOMM will acquire other critical skills and experience needed for the program by contracting out to fully qualified vendors and by entering into joint venture arrangements with strategic partners.

CONCLUSION

In this application and the petition for rulemaking filed concurrently, ORBCOMM seeks Commission authorization for a pioneering, low-earth orbit mobile satellite system operating in the VHF and UHF bands. ORBCOMM has demonstrated that it is qualified to construct the satellites and operate the system. ORBCOMM waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests an authorization in accordance with this application.

ORBCOMM has shown that the proposed low-earth orbit system will provide much needed services to unserved and underserved consumers. By operating in low orbit and in the VHF and UHF bands, subscribers will be able to use low-power, low-cost terminals for two-way data and position determination. ORBCOMM will be able to provide these services to millions of subscribers using only 898 KHz of spectrum. Moreover, by granting ORBCOMM a "modified primary" status, it will not be necessary to displace any currently authorized licensees in the requested frequency bands in order to bring this service to the public. Finally, prompt action by the Commission will allow ORBCOMM to exploit its current technological lead and the ability to reuse the space segment as the satellites circle the globe, thereby exporting service to the rest of the world and helping reduce the telecommunications trade deficit. In sum, the public interest would be well served by Commission grant of the authority to construct the ORBCOMM low-earth orbit satellite system.

Dated this 28th day of February, 1990

By: ______________________________

Alan L. Parker
President
Orbital Communications
Corporation
12500 Fair Lakes Circle
Fairfax, Virginia 22033

Albert Halprin
Stephen L. Goodman
Verner, Liipfert, Bernhard
McPherson and Hand, Chartered
Suite 700
901 15th Street, N.W.
Washington, D.C. 20005-2301
(202) 371-6009

ENGINEERING CERTIFICATE

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in these applications, that I am familiar with Part 25 of the Commission's Rules and Regulations, that I have reviewed the engineering information submitted in these applications, and that it is complete and accurate to the best of my knowledge.

Dated this 28th day of February, 1990

By: Antonio L. Elias

Dr. Antonio L. Elias
Vice President, Engineering
Orbital Communications Corporation

APPENDICES

APPENDIX A

INTERFERENCE ANALYSIS

A.1 Introduction

ORBCOMM is concurrently requesting the Commission to institute a Rule Making to allocate radio spectrum in the VHF and UHF frequency bands for low-earth orbit, mobile satellite services. To demonstrate the compatibility of the ORBCOMM system with the proposed electromagnetic environment, on a global basis, an interference analysis has been performed. This appendix describes the methodology and the results of this analysis. As demonstrated herein, the ORBCOMM system will not cause (or receive) harmful interference to (or from) any space station or terrestrial system authorized by an appropriate regulatory agency, domestically or internationally.

A.1.1 Approach

ORBCOMM's approach to this analysis was first to identify, (i) all regulatory issues associated with the use of these frequency bands, (ii) the user community within these bands, and (iii) the potential for interference to/from the ORBCOMM system.

A comprehensive study was then conducted with respect to the rules and regulations governing these bands. Table A-1 summarizes those aspects pertinent to their use as shown in the National Table of Frequency Allocations, NTIA, May 1989. The predominant use of the requested spectrum is divided into two areas: Space Operations in the 137-138 MHz band and Mobile

Operations in the 148-149.9 MHz band. There is presently no use of the proposed 400.1 MHz frequency.

With respect to the user community, ORBCOMM focused its research on the U.S. user population; however, international usage is addressed. The U.S. community included both government and non-government users. Sources of data included publicly available sources as well as the National Telecommunications and Information Administration. Table A-2 provides a summary of the identified users in these bands.

A.1.2 Methodology

ORBCOMM has adopted separate methodologies for the analysis of interference within the proposed frequency bands.

Within the 137-138 MHz band, we determined that the community of users is extremely small, thus the interference analysis was best handled on a case-by-case basis.

The principal potential interference to/from the ORBCOMM system will result from operation in the 148-149.9 MHz frequency band. This particular band is allocated almost exclusively, on a world-wide basis, to land mobile communications; however, as such, the range of operation for any particular system is confined to an area of between 5 and 75 square miles.

While there are reported to be 4,000 radios in use in the 148-149.9 MHz band in the U.S., the potential for interference to/from the ORBCOMM system is very small. Utilizing the latest FCC and CCIR data for frequencies in the 150 MHz range, separation contours can be established for providing general guidance in the usage of specific frequencies in a specific geographic location. (See Figure A-1.) Thus, the analysis for this particular frequency band can be handled on a class basis.

A.2 Analysis

A.2.1 General

This section summarizes the analysis performed for each of the three frequency bands. The analysis includes interference to/from the ORBCOMM space segment as well as to/from the ORBCOMM ground segment and is addressed on a frequency band basis.

A.2.2 Frequency Band 137-138 MHz

The 137-138 MHz frequency band is shared between Government and Non-government users. The Government allocations are for Meteorological Satellite, Space Operations and the Space Research Services space-to-earth. They are used by the National Oceanographic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA).

NOAA currently maintains three low-earth orbit satellites (nominal 824-864 km near circular orbits) providing weather data information. Such information is transmitted at 137.5 MHz via a 30 KHz bandwidth. The TT&C command link for these satellites operates at 148.56 MHz also via a 30 KHz bandwidth.

Except for the weather satellite usage, NASA has phased out its use of the 137-138 MHz band although short-lived missions such as PEGSAT will temporarily occupy a small portion of the band. This satellite is in a circular polar orbit with an altitude of 556 km. PEGSAT's telemetry link operates at 137.92 MHz via a 20 KHz bandwidth. (The command link operates at 149.2 MHz via a corresponding bandwidth.) There is no other known current government use of this frequency band.

Non-government allocation in the subject frequency band covers specialized services such as Experimental Research and Development, Local Government, Special Emergency, and Telephone Maintenance. At present, there are no licenses for these services.

Based upon the available information, the above entities represent the sum total of the user community in the 137-138 frequency band.

ORBCOMM has developed a frequency plan for its satellite system that uses a part of the 137-138 MHz frequency band and avoids specific frequencies used by NOAA and NASA, thereby precluding precludes any interference to or from current user systems.

A.2.3 Frequency Band 148-149.9 MHz

The 148-149.9 MHz frequency band is shared between Government and Non-Government users with the latter being comprised of experimental licenses. The Government allocations are for fixed and mobile communications; however, the band also is allocated to earth-to-space communications as stated in Paragraph A.2.2. The principal users of the mobile communications in this band are the military services for mobile radio with miscellaneous applications, such as training, base security, search and rescue operations, and maintenance functions. These radios are employed within military installations in the United States. The number of current assignments is reported to be less than 4,000 in the geographic areas indicated and is being reduced. Table A-3 reflects the typical characteristic of the equipment used in these applications. ORBCOMM's equipment characteristics are summarized in Table A-4.

Non-government allocations in the subject frequency band includes specialized services such as Experimental Research, Local Government, Special Emergency, and Telephone Maintenance. At the present time there are five experimental licenses for these services.

Based upon available information, the above represent the total user community in the 148-149.9 frequency band.

As stated in Paragraph A.1.2, the principal potential interference to/from the ORBCOMM system is anticipated in the 148-149.9 MHz frequency band. The potential for interference would be ORBCOMM's gateway stations interfering with the mobile terrestrial users, and the existing mobile base stations may interfere with the various ORBCOMM ground segment components.

However, the operating characteristics of the ORBCOMM system and its subscriber profile will serve to obviate interference:

- ORBCOMM subscribers will be very widely dispersed and will tend to use the system in rural or remote areas where access to the PSN is not available.
- Due to the normal restrictions associated with the perimeters of military installations, the probability of an emergency service requirement near a base is very small and occasional only.
- The nature of the ORBCOMM equipment is such that it will operate in a burst mode, therefore, a very low duty cycle would be typical. On average, the subscriber terminal will transmit for a period of 500 milliseconds and at low power levels (2-5 watts).

Considering these operating characteristics, the given equipment characteristics, the geographic dispersion of the mobile users, and the nature of propagation at these frequencies, mutual interference is virtually precluded. Further, isolation between the ORBCOMM System and the mobile user community in general will be achieved by the antenna characteristics employed within the two systems. In mobile communication systems the antenna configuration is such that the energy radiated is predominantly in the horizontal plane, while that for the ORBCOMM System will be in the vertical plane.[51/]

Regional Gateways will be located and shielded to preclude interference to and from military mobile radio users.

[51/] Should harmful interference occur despite our analysis and coordination, then ORBCOMM would bear the reasonable costs of locating the current authorized users to another part of the spectrum.

A.3 International

The basis for ORBCOMM's analysis of the international usage of the proposed frequency bands is the ITU Table of Frequency Allocations and the International Radio Regulations. The most recent information available from U.S. government sources is dated October 1981. These sources indicate the following:

- International use of the 137-138 MHz frequency band is consistent with the U.S. use of this band -- namely for Worldwide Tracking Facilities for Scientific and Weather Satellites. The Soviet Union operates a series of Meteor satellites in this band. As a consequence of the establishment of NASA's Tracking and Data Relay Satellite (TDRSS) now in orbit, many of the allocations have been rendered unnecessary and have been vacated. There is light usage currently of this frequency band, and the frequency assignments for these services is in the upper half of the band. Therefore, existing assignments lie outside the range proposed by ORBCOMM.

- The International use of the 148-149.9 MHz frequency band is consistent with the use of this band in Region 2 and the U.S. In Regions 1 (Europe and Africa) and Region 3 (Asia and Australia), these frequencies are allocated to mobile communications. ORBCOMM believes that the current and planned international use of this spectrum is such that it can be utilized on a shared basis, particularly in the highest priority markets.

A.4 Results/Conclusions

ORBCOMM has conducted an investigation into the U.S. domestic and international user community of the frequency bands proposed. This investigation and the analysis which was performed as to the potential for interference to/from the ORBCOMM System has concluded the following:

A.4.1 Frequency Band 137-138 MHz

ORBCOMM's proposed frequency plan will preclude any interference with the users of this frequency band.

A.4.2 Frequency Band 148-149.9 MHz

ORBCOMM's proposed frequency plan will preclude interference into all space applications employing this frequency band. We also is conclude that ORBCOMM will not cause harmful interference into the mobile users of this band. ORBCOMM recognizes that a conclusive interference analysis, within this frequency band, cannot be accomplished without specific information on all users. It will continue its interference analysis and in the event is able to identify specific interference problems, proposes to effect a coordination process, based upon the channelization employed. Where necessary, ORBCOMM is committed to developing sharing criteria to enable the joint use of this frequency band.

A.4.3 Frequency 400.1 MHz

There are presently no identified users of this frequency band, therefore interference to or from another use is not possible.

TABLE A-1

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
137-138	SPACE OPERATION (Space-to-Earth) METEOROLOGICAL-SATELLITE (Space-to-Earth) SPACE RESEARCH (Space-to-Earth) Fixed Mobile except aeronautical mobile (R) 596 597 598 599		137-138		METEOROLOGICAL-SATELLITE (Space-to-Earth) SPACE OPERATION (Space-to-Earth) SPACE RESEARCH (Space-to-Earth)	METEOROLOGICAL-SATELLITE (Space-to-Earth) SPACE OPERATION (Space-to-Earth) SPACE RESEARCH (Space-to-Earth)	

596--Different category of service: in Afghanistan, Saudi Arabia, Bahrain, Brunei, China, the United Arab Emirates, India, Indonesia, Iran, Iraq, Kuwait, Malaysia, Oman, Pakistan, Qatar, Singapore, Thailand, Yeman A. R. and Yeman (P.D.R. of), the allocation of the band 137-138 MHz to the fixed and mobile, except aeronautical mobile (R), services is on a primary basis (see No. 425).

597--Different category of service: in Israel, Jordan and Syria, the allocation of the band 137-138 MHz to the fixed and mobile, except aeronautical mobile, services is on a primary basis (see No. 425).

598--Different category of service: in Austria, Bulgaria, Egypt, Finland, Greece, Hungary, the Lebanon, Mongolia, Poland, the German Democratic Republic, Roumania, Czechoslovakia, the U.S.S.R. and Yugoslavia, the allocation of the band 137-138 MHz to the aeronautical mobile (OR) service is on a primary basis (see No. 425).

599--Additional allocation: in Australia, the band 137-144 MHz is also allocated to the broadcasting service on a primary basis until that service can be accommodated within regional broadcasting allocations.

425 (6) Where a band is indicated in a footnote of the Table as allocated to a service "on a primary basis", or "on a permitted basis" in an area smaller than a Region, or in a particular country, this is a primary service or a permitted service only in that area or country (see No. 419).

419 (3) Permitted and primary services have equal rights, except that, in the preparation of frequency plans, the primary service, as compared with the permitted service, shall have prior choice of frequencies.

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
146-149.9 FIXED MOBILE except aeronautical mobile (R) 608	148-149.9 FIXED MOBILE 608		148-149.9	US10 608	FIXED MOBILE G30		148.15 Civil air patrol land; Civil air patrol mobile.

608--Subject to agreement obtained under the procedure set forth in Article 14, the band 148-149.9 MHz may be used by the space operation service (Earth-to-space). The bandwidth of an individual transmission shall not exceed ±25 kHz.

G30--In the bands 138-144, 148-149.9, 150.05-150.8, 1427-1429 and 1429-1435 MHz, the fixed and mobile services are limited primarily to operations by the military services.

US10--The use of the frequencies 26.62, 143.90 and 148.15 MHz may be authorized to Civil Air Patrol land stations and Civil Air Patrol mobile stations.

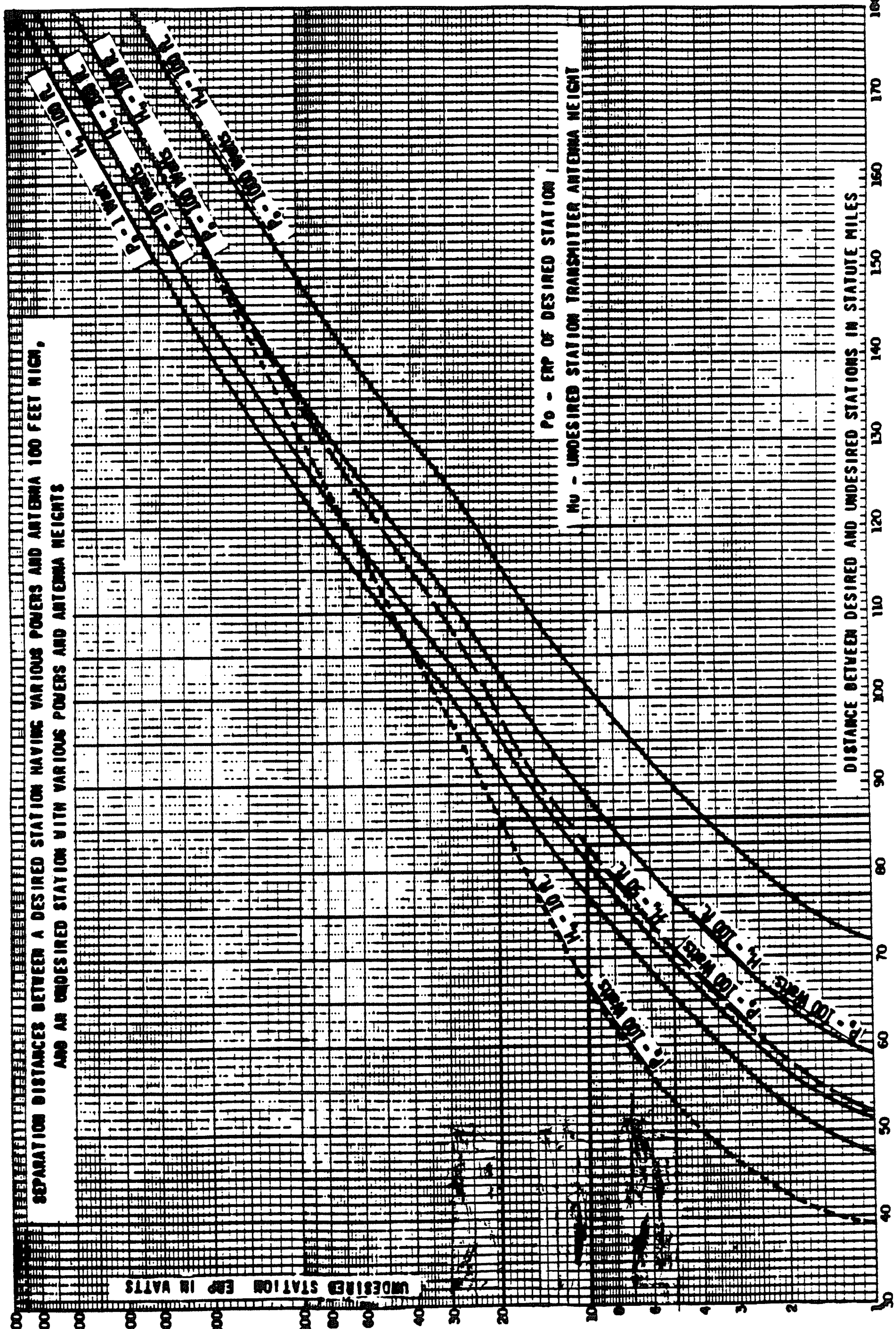
INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
400.05-400.15	STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE (400.1 MHz) 646 647		400.05-400.15	646	STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE (400.1 MHz)	STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE (400.1 MHz)	

646--Emissions shall be confined in a band of ±25 kHz about the standard frequency 400.1 MHz.

647--Additional allocation: in Afghanistan, Saudi Arabia, Bahrain, Bulgaria, Colombia, Costa Rica, Cuba, Egypt, the United Arab Emirates, Ecuador, Hungary, Indonesia, Iran, Iraq, Israel, Kuwait, Liberia, Malaysia, Nigeria, Oman, Pakistan, the Philippines, Poland, Qatar, Syria, the German Democratic Republic, Roumania, Singapore, Somalia, Sri Lanka, Czechoslovakia, Thailand, the U.S.S.R. and Yugoslavia, the band 400.05-401 MHz is also allocated to the fixed and mobile services on a primary basis.

FREQENCY BAND 25-470 MHZ

FIGURE A-1



UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

January 12, 1990

Mr. Donald M. Jansky
President
Jansky/Barmat Telecommunications, Inc.
1899 L Street, NW
Suite 1010
Washington, DC 20036

Dear Mr. Jansky:

I would like to acknowledge your letter of December 21, 1989, requesting data on the Government's radiocommunication uses in the 137-138, 148.0-149.9 and 400.05-400.15 MHz frequency bands.

I have enclosed standard data summaries for the frequency bands 137-138, 148.0-149.9 and 400.05-400.15 MHz. There are less than 100 Government assignments in the 137-138 MHz band, less than 4000 Government assignments in the 148-149.9 MHz band, and none in the 400.05-400.15 MHz band. The summaries characterize current major Government applications. There may also be other authorized Government applications of the bands that are not included in the summaries. We did not provide complete listings of all uses since we have characterized those applications that have the greatest likelihood of causing interference, and as you are aware such a list is classified. It should be recognized that new uses of the spectrum may be implemented, by the Government, in these bands under the National Rules and Regulations as requirements change.

This response by NTIA does not change the "non-interference basis" for devices that operate under Part 15, FCC Rules and Regulations. Part 15 specifically states that if harmful interference is experienced from authorized radio services, the interference must be accepted as a condition for unlicensed operation.

We believe that voluntary industry action, taken to reduce the susceptibility during the design stages of a product, will be an effective way of dealing with the problem. Hopefully, through our cooperative efforts, the incidence of interference will be reduced and the public interest will be served.

Sincerely,

Robert J. Mayher
Director
Spectrum Plans and Policies

Enclosure

SUMMARY CHARACTERIZATION OF THE 148-149.9 MHz FREQUENCY BAND

Band (MHz) and National Provisions	Government Allocation	Non-Government Allocation	Major Government Use	Power (dBm)	Modulation Type and Necessary Bandwidth	Antenna Gain (dBi)		Receiver Sensitivity (dBm)
						TX	RX	
148-149.9	FIXED MOBILE		Fixed and Land Mobile Operations by the Military Services	Fixed: 33-54 (48 Predominate)	Fixed: Frequency; 100 Hz-36 kHz (16 kHz Predominate)	Fixed: (1-12 6 predominate	Fixed: (1-12 6 predominate	Fixed: -110 to -120
US10 608	G30			Land Mobile: 24-50 (44 Predominate)	Land Mobile: Frequency; 5-36 kHz (16 kHz Predominate)	Land Mobile: (1-9 6 predominate	Land Mobile: (1-12 6 predominate	Land Mobile: -110 to -120

Areas of Deployment: Fixed and land mobile operations occur within a 1 to 10 mile radius of military installations throughout the United States.

Typical Operation: This band is used mainly by the military services for miscellaneous purposes such as training, base security, search and rescue operations and maintenance functions.

The following footnotes to the National Table of Allocations apply to the 148-149.9 MHz frequency band:

This footnote denotes a stipulation applicable only to the Government.

G30----In the bands 138-144, 148-149.9, 150.05-150.8, 1427-1429 and 1429-1435 MHz, the fixed and mobile services are limited primarily to operations by the military services.

This footnote denotes a stipulation applicable to both Government and non-Government.

US10---The use of the frequencies 26.62, 143.90 and 148.15 MHz may be authorized to Civil Air Patrol land stations and Civil Air Patrol mobile stations.

This footnote comes from the Radio Regulations, Geneva 1982.

608----Subject to agreement obtained under the procedure set forth in Article 14, the band 148-149.9 MHz may be used by the space operation service (Earth-to-space). The bandwidth of an individual transmission shall not exceed ± 25 kHz.

SUMMARY CHARACTERIZATION OF THE 137-138 MHz FREQUENCY BAND

Band (MHz) and National Provisions	Government Allocation	Non-Government Allocation	Major Government Use	Power (dBm)	Modulation Type and Necessary Bandwidth	Antenna Gain (dBi)		Receiver Sensitivity (dBm)
						TX	RX	
137-138	METEOROLOGICAL SATELLITE (Space-to-Earth)	METEOROLOGICAL SATELLITE (Space-to-Earth)	Meteorological Data Transmission from Space to Earth.	20-24	Amplitude, Frequency; 30 kHz	<1	20-28	For Earth Stations: -110
	SPACE OPERATION (Space-to-Earth)	SPACE OPERATION (Space-to-Earth)		29-33	Frequency; 40-200 kHz	<2	17-21	
	SPACE RESEARCH (Space-to-Earth)	SPACE RESEARCH (Space-to-Earth)	Sonobuoy Data relay to Ships and Aircraft.	35-41	Frequency; 30 kHz	<2	N/A	For Sonobuoys: -100

Areas of Deployment: NOAA operates several non-geostationary orbiting meteorological satellites in this band. NASA operates several tracking and telemetry space stations in both geostationary and non-geostationary orbits. The Navy provides sonobuoy data to ships and aircraft deployed mainly in the Atlantic.

Typical Operation: Weather satellites update and provide data required for long and short range forecasts. Data from NASA satellites are received at earth stations located in Alaska, North Carolina, Maryland and Florida. Sonobuoys are devices released from ships or aircraft and are used to detect submerged vessels.

SUMMARY CHARACTERIZATION OF THE 400.05-400.15 MHz FREQUENCY BAND

Band (MHz) and National Provisions	Government Allocation	Non-Government Allocation	Major Government Use	Power (dBm)	Modulation Type and Necessary Bandwidth	Antenna Gain (dBi)		Receiver Sensitivity (dBm)
						TX	RX	
400.05-400.15	STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE	STANDARD FREQUENCY AND TIME SIGNAL-SATELLITE	No Operational Use of this band.					

TABLE A-2

U.S. DOMESTIC USERS

FREQUENCY BAND	GOVERNMENT USERS[1/]	NON-GOVERNMENT USERS	
137-138 MHz	NOAA[2/]	None	
148-149.9 MHz	NOAA[2/] DOD[3/]	Deere & Co. McDonnell Douglas Radio Serv. Metme Communications New York State Dept. Environ. Radiation Systems Corporation	Experimental
400.1 MHz	None	None	

1/ Refer to Exhibit A-1

2/ Space Operations

3/ Mobile Operations

TABLE A-3

MOBILE EQUIPMENT CHARACTERISTICS (148-149.9 MHz)

APPLICATION	ERP	MODULATION	BANDWIDTH	RX SENSITIVITY
Fixed Stations	3 to 24 dBw 18 dBw[4/]	FM	100 Hz to 36 KHz 16 KHz[4/]	-140 dBw
Mobile Stations	-6 to 20 dBw 14 dBw[4/]	FM	5 KHz to 36 KHz 16 KHz[4/]	-140 dBw

4/ Predominant Use

TABLE A-4

ORBCOMM EQUIPMENT CHARACTERISTICS

TERMINAL	ERP	MODULATION	BANDWIDTH	RX SENSITIVITY
Subscriber	2 to 9 dBw 2 dBw[5/]	Frequency Shift Keying	15 KHz	-128 dB/K
Gateway	32 dBw	Phase Shift Keying	90 KHz	-158 dB/K

5/ Predominant Use