time is related to the class of user (i.e. truck, aircraft, etc.), and can be changed by either the user or GEOSTAR Central. Thus, the user can get position information at a desired rate while not wasting channel capacity.

When not inhibited, users will respond at the uplink center frequency of 1618.25 MHz with a short burst of 20–80 milliseconds depending on the size of the alphanumeric message. The user response will be a spread spectrum signal that contains the user's unique ID, protocol information, and any messages to be sent to or via GEOSTAR Central.

The user's response will be "bent–piped" (relayed with no processing) through at least two satellites to GEOSTAR Central where the roundtrip signal transit time will be calculated. The time of transmission will be measured between the Central's transmitter and the user's terminal, calculating the time for the user to respond via each of two separate satellites, plus the time required for the user's terminal to internally process the signal. GEOSTAR Central will measure the roundtrip time by comparing a local replica of the user's known code with the received code and by measuring the associated time delay. The time delay (scaled by the velocity of light) is related to the roundtrip range from GEOSTAR Central to the user's transceiver. GEOSTAR Central will determine position and may transmit it, together with outgoing messages, to the mobile user.

Benchmarks

The use of fixed "benchmark" (or reference point) transceivers at known locations will be an important contributor to RDSS position accuracy. Benchmarks will be standard terminals enclosed in an environmental shelter. Higher power output and high–gain antennas may be employed to enhance benchmark performance.

Known as "differential operation," benchmark employment will eliminate many of the ranging bias errors that plague other navigation systems, including the inherent delay characteristics of system electronics. Benchmark corrections can be implemented as either a measurement correction or as a positioning solution correction. Both methods have been demonstrated successfully in other differential navigation systems.

The first approach corrects the range measurements before the position determination is performed, with the true ranges to a benchmark calculated using the known benchmark, satellite, and Central locations. The calculated roundtrip distance is compared to the measured range to yield the range bias for that area. This bias can then be applied to the measured ranges of the user terminals in the vicinity of the benchmark before the user position calculation is performed.

The other approach, position solution correction, uses the normal positioning algorithm to calculate the position of the benchmark from uncorrected range measurements. This estimated position is then compared with the known position of the benchmark, and the difference can be applied to correct the position locations of nearby users. Propagation differences, altitude, and atmospheric delays caused by weather are also factored in.

Differential correction has been shown to compensate for range bias errors over a wide area around the benchmark. However, uncertainties in satellite ephemeris (orbital location), and ionospheric and tropospheric errors of about a meter may remain after differential correction. The atmospheric error varies with the distance between the user and the benchmark, and is due primarily to slight non–uniformities of the atmosphere above the benchmark and user sites. Summarized below are the errors and their values in meters that remain after differential correction.

In the operational concept for System 3, benchmarks will be spaced about 100 miles apart. This will provide position determination with a relative accuracy to approximately 7 meters of the actual location. Where benchmarks are not available, Geostar will use mathematical models to help offset the errors inherent in pure time difference–of–arrival measurements. Using the differential method, positioning data can be displayed in more detail with reference to the nearest benchmark; for example: "user is located 50 meters due west of the southern end of runway 4 at Miami Airport, Florida." Plans call for an initial fielding of approximately 100 benchmarks in the United States.

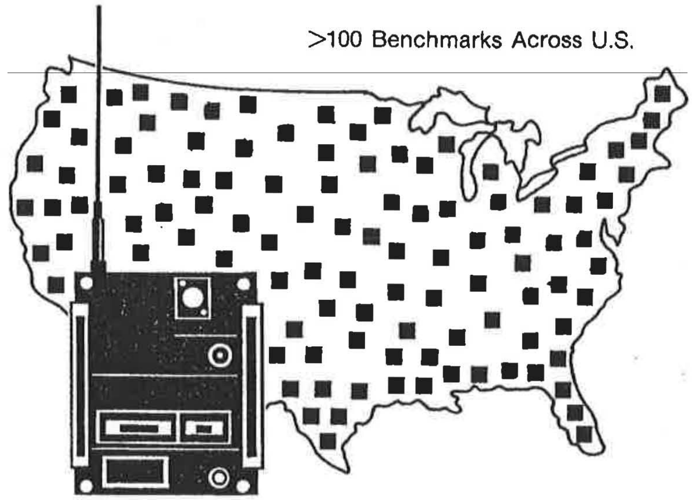
Range Errors	*Meters*
User transceiver noise	*2.8*
Benchmark transceiver noise	*1.4*
Ephemeris (satellite motion)	*0.1*
Atmospheric delay	*0.5*
Multipath (signal reflections)	*1.0*

Altitude Errors

GEOSTAR System 3 will use two range measurements combined with a terrain elevation map to locate the position of a mobile land user and altimeter information for the position of airborne users. The digital terrain elevation map is located in GEOSTAR Central computers. Altimeter information is automatically transmitted to GEOSTAR Central for airborne users.

Errors in terrain height influence the absolute positioning accuracy, but the relative accuracy of nearby users is unaffected. This is particularly true in rendezvous or homing applications. If one user is trying to reach another user (for example, rescuers trying to reach an injured hiker), any errors in the terrain map would have a diminishing effect on navigational guidance given by the GEOSTAR Central directing the rendezvous.

Benchmarks



Near-Global Access Through

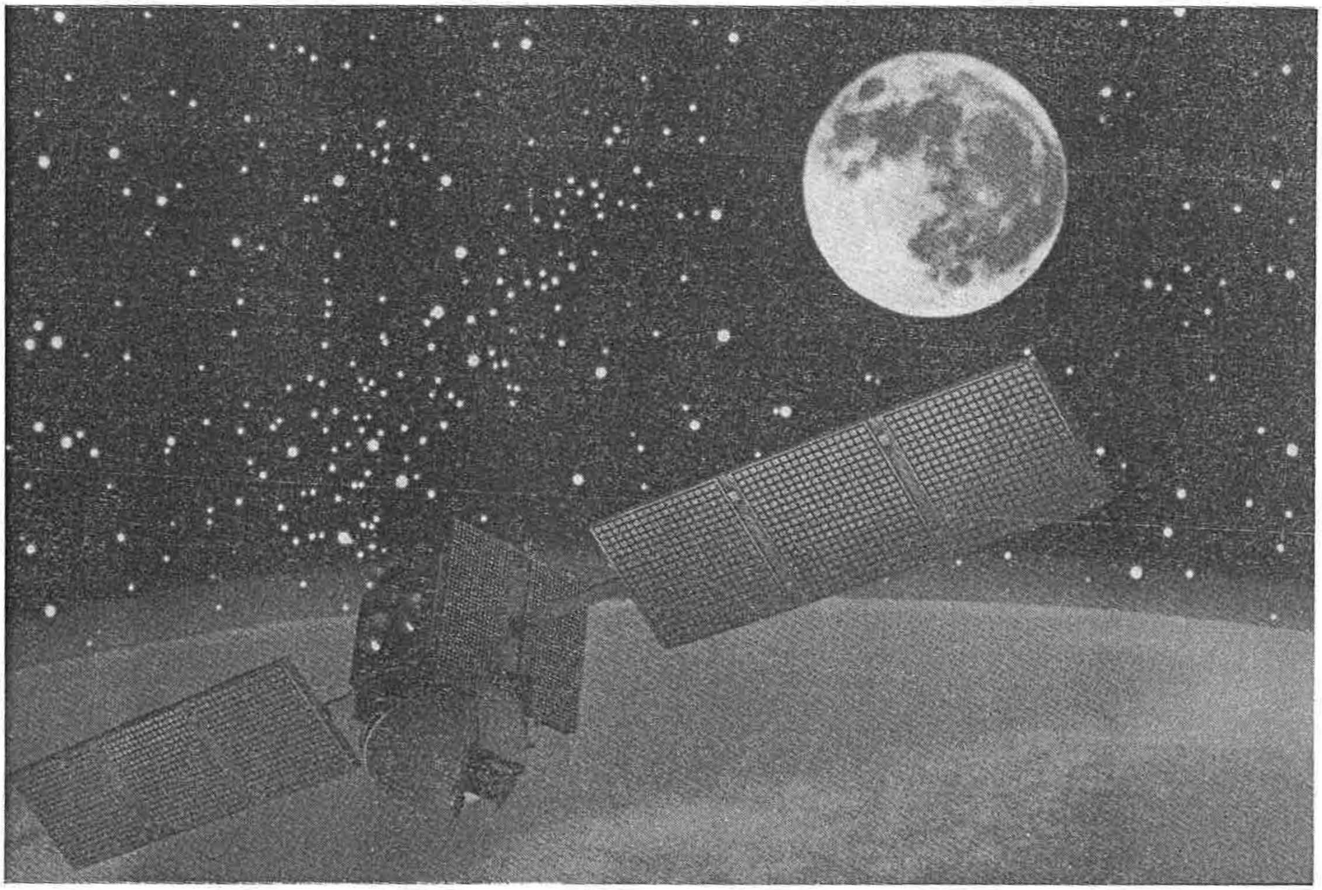
The Space Segment

WHAT SATELLITES ARE USED TO PROVIDE SERVICE?

Radio determination satellite service is provided through the use of space–based relays, with transponders that translate between user terminal operating frequencies and those of the Central. In this manner, the terminal's L–Band or S–Band transmit and receive frequencies are translated to the C–Band (or Ku–Band) uplink and downlink frequencies of the Central.

Initially, RDSS satellites are planned to cover the continental United States; then, as marketing conditions permit, the number of satellites will be expanded to include regional coverage on a near global basis. Engineering estimates envision that a minimum constellation of six to eight satellites could establish worldwide coverage, except for the polar regions. If a single satellite failed, this constellation would still provide a backup capability. Polar coverage is possible using a suitable satellite host; however, there are no plans to furnish such a capability at this time.

RDSS



Geostar satellite, 22,000 miles above the earth

Many satellite launch dates and orbital positions for the worldwide constellation remain unconfirmed because RDSS–licensed member countries and prospective member countries are still defining their specific satellite communications requirements. It is clear, however, that during the next several years a family of different RDSS satellites will be launched and operated by Geostar and other international licensees. Each satellite system will be compatible with GEOSTAR and will probably follow a similar fielding approach: initial installation of specialized digital location transmission equipment as piggyback payloads on two or three geostationary communications satellites, to be followed by a family of dedicated RDSS satellites.

Due to a setback in the U.S. space program, early GEOSTAR payloads are being launched by Arianespace, the first commercial subsidiary to market and sell French space systems and services worldwide. Rockets are launched from the European Space Agency facility in Kourou, French Guiana.

With the resumption of U.S. Space Shuttle operations, three GEOSTAR payloads are scheduled among the first launches of commercial cargo. This commitment is significant in light of the restructuring of U.S. space program and the sharp decline in its support for civilian payloads. As a result of the rescheduling of the space shuttle, GEOSTAR dedicated satellites are expected to be launched in October 1991, October 1992, and June 1993, but this is subject to change.

In the U.S., both RDSS payloads launched during 1988 were receive–only (RO) transponders riding piggyback aboard host domestic communication satellites. In 1989, the second satellite will reach geosynchronous orbit and be added to System 2 to provide an interim one–way messaging capability for the Caribbean and Central America. Beginning in 1992, both satellites will be augmented by a family of dedicated GEOSTAR satellites with an enhanced multibeam transmit–receive capability that will be the mainstay for commercial and government applications.

European Space Agency Launch Facilities in French Guiana

In addition to geosynchronous satellites, GEOSTAR is currently taking advantage of the polar–orbiting NOAA/ARGOS satellite system for an interim operational capability with limited application.

ARGOS SATELLITES

Service ARGOS, a joint U.S. and French system, began providing satellite data relay services to Geostar in May 1987. The system comprises two ARGOS satellites, identified as NOAA 9 and 10, that operate in a medium altitude, circular orbit. Historically, ARGOS has been used by the scientific community for weather observation, animal tracking, and other scientific applications. The National Weather Service had been the largest user of ARGOS; however, Geostar is currently believed to be the primary customer in terms of user terminals. As a precondition for utilizing Service ARGOS, user transmitters automatically report local temperature readings.

This introductory one–way capability for GEOSTAR is known as System 1 service. Traffic is relayed from a mobile user, through the satellite, to one of several NOAA/ARGOS ground stations located at multiple sites around the world. Despite system limitations, System 1 service will continue to be offered by Geostar after the introduction of System 2 (receive–only satellite service) as long as there is a user demand.

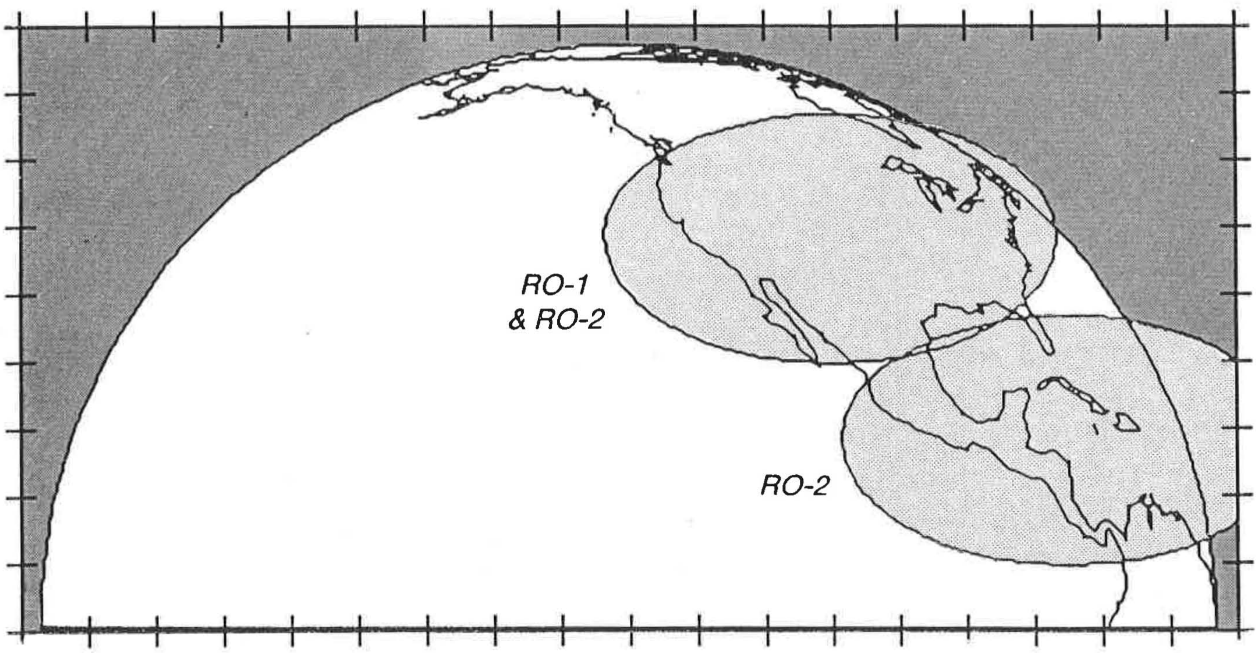
RECEIVE–ONLY SATELLITES

In 1988, two receive–only packages were orbited aboard U.S. domestic satellites launched by Ariane. Each package contains two RDSS transponders, one primary and one backup. With these packages, Geostar introduced System 2 service, a one–way messaging system with an external positioning capability. System 2 is unique in that the user utilizes an external position locating service, such as LORAN–C, to input data to the user's terminal.

The receive–only satellite is used to communicate data messages from a user's terminal to the Geostar Central. Each receive–only satellite package is relatively inexpensive and weighs approximately 36 pounds with antenna.

The dual receive–only packages will provide redundant coverage of the Continental U.S. as well as single coverage over parts of Latin America. Each receive–only package has a capacity of approximately 1,000,000 user terminals (based on an average of one transmission each per hour). Two receive–only satellites in different orbital locations are sufficient to optimize radio reception when local conditions impair line–of–sight between the user and satellite. For example, if the user terminal's view of one satellite is blocked in one direction, access can be acquired through the other satellite. Dual

GEOSTAR Receive-Only Satellite Footprints



coverage of the continental U.S. enhances system dependability and precludes a single–point failure. Because the receive–only package represents an add–on capability to the host commercial communications satellite, the possibility of antenna adjustment to alter or optimize RDSS earth coverage is very limited.

The first operational RDSS geosynchronous package, GEOSTAR RO–1, was launched aboard the GTE communications satellite, SpaceNet 3R, by an Ariane rocket on 11 March 1988. It was placed in geosynchronous orbit at 87 degrees West longitude. Specially configured with one 2 x 4 foot flat–plate patch array antenna, the RDSS package acquires the 1618.25 MHz L–Band uplink frequency received from a user's terminal and translates it into Ku–Band (12 GHz) for downlink to the Geostar Central facility in Washington, DC.

The GEOSTAR RO–2 package was launched aboard the GTE satellite, GSTAR III, in September 1988; its operational service will begin approximately 3Q–1989. The geosynchronous orbital placement will be 126 degrees West. Equipped with two flat plate antennas, one will cover the U.S. and the other parts of Latin America. The RDSS receive–only system will serve about 1,000,000 users per hour.

TWO–WAY COMMUNICATIONS

The Geostar Corporation has accelerated plans for two–way service by more than one year (mid–1989) through the lease of an existing C–Band equipped commercial satellite, that supplements the one–way System 2 (inbound only) with an outbound messaging capability. Called System 2C, it will have the capability to service a potential 1,000,000 users by obtaining position information via LORAN—C or other radionavigation system, and providing inbound messaging on L—Band and outbound messaging on C—Band.

DEDICATED SATELLITES

Spurred by the favorable acceptance of early commercial service, the Geostar Corporation has moved directly into the acquisition of dedicated RDSS satellites. The dedicated satellite capability will provide two–way digital message exchange and geopositioning services, but with significantly greater capacity and lower user power requirements than System 2C.

In August 1986, the FCC authorized the Geostar Corporation to construct and launch a family of four dedicated satellites, including an on–ground spare. Orbital slot assignments also were authorized. The active constellation will consist of three satellites in orbit providing Western Hemisphere coverage.

In late 1987, Geostar Corporation awarded a multi–million dollar contract to GE Astro–Space Division to construct two satellites, with options for the third and fourth spacecraft. In mid– 1988, an option to develop a third dedicated satellite was exercised. The 4000–pound dedicated spacecraft, known as GEOSTAR DS–1, DS–2, and DS–3, will be configured with a parabolic dish as much as five meters in diameter. The antenna will have an electronic aiming capability that will form eight beams of overlapping coverage for North and possibly South America, depending on the final beam pattern, which remains to be determined.

RDSS Satellite Schedule Summary

Satellite	System	Coverage	Operational Status
RO-1	2	North America	In service since May 1988
RO-2	2	North America and Central South America	Estimated Sept 1989
Leased C-Band Transponder	2C	North America	Estimated June 1989
DS-1	3	Western Hemisphere	Estimated 1991
DS-2	3	Western Hemisphere	Estimated 1992
DS-3	3	Western Hemisphere	Estimated 1993

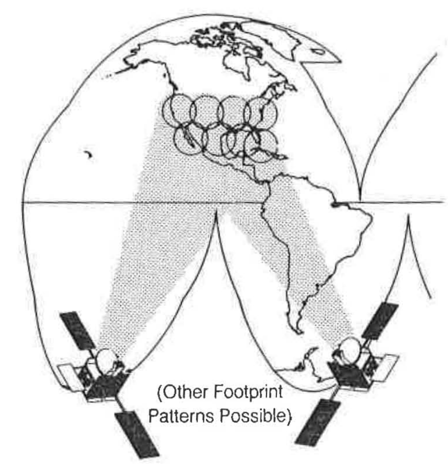
The System 3 satellite will have an L–Band uplink and S–Band downlink to and from the user, and a C–Band up and downlink to ground control at Geostar Central. The latter operates at approximately 6.5 GHz and 5.150 GHz.

Ground control of the dedicated satellites may be performed by Geostar, or GE Astro–Space may be given responsibility for tracking, telemetry, and control. Tentative plans call for a second ground control facility to be established on the West Coast.

The dedicated satellite will generate multiple overlapping beams that focus signal power into a cluster of eight footprints, each approximately 500–1000, miles in diameter on the Earth's surface. The total footprint of the eight beams is to be determined; a study is underway to optimize coverage of the first dedicated satellite over the continental U.S. and Caribbean area.

Technically, the estimated capacity for the dedicated satellite is approximately 5 million users in one spot beam. This estimate must be tempered by satellite power limitations, switching limitations, hub design, and computer memory. For eight beams, the system capacity is approximately 25 million users – nominally, overlapping beams contribute to a corresponding reduction in potential user capacity of 20–30 percent. Each beam will be assigned a unique beam number (this is transparent to the user) and each will ride a separate downlink to the Central, as necessary, to support traffic for all users of a particular beam.

Dedicated Satellite Multibeam Coverage



System capacity of the dedicated satellite is constrained by the number of transmit/receive beams formed. This limit is imposed by the channel bandwidth. Some 66 MHz of S–Band bandwidth was allocated to support four 16.5 MHz wide channels. Use of antenna polarization techniques effectively doubles the number of spot beams from four to eight, as authorized by the FCC and the ITU.

It is important to note that the ITU did not authorize or approve other techniques to expand the downlink. The System 3 dedicated satellite has more antenna gain and transmitting power than the System 2C satellite: an effective isotropic radiated power of 52 dbw versus 47 dbw. Hence, the dedicated satellite is capable of twice the data rate and double the number of potential users (per beam). This equates to many times more users than System 2C, and the dedicated satellite system will provide better performance.

RDSS INTERNATIONAL SATELLITES

In the interest of establishing a worldwide RDSS system, the Geostar Corporation is seeking to consummate licensing agreements with international clients, principally governmental and civil communications (post telephone and telegraph – PTT) organizations. More than 70 countries have been contacted in an effort to influence the integration of RDSS with the second generation of domestic and regional commercial satellites being fielded around the world. As new RDSS systems come on line, they are expected to be integrated into a global network that could begin offering international service after 1991.

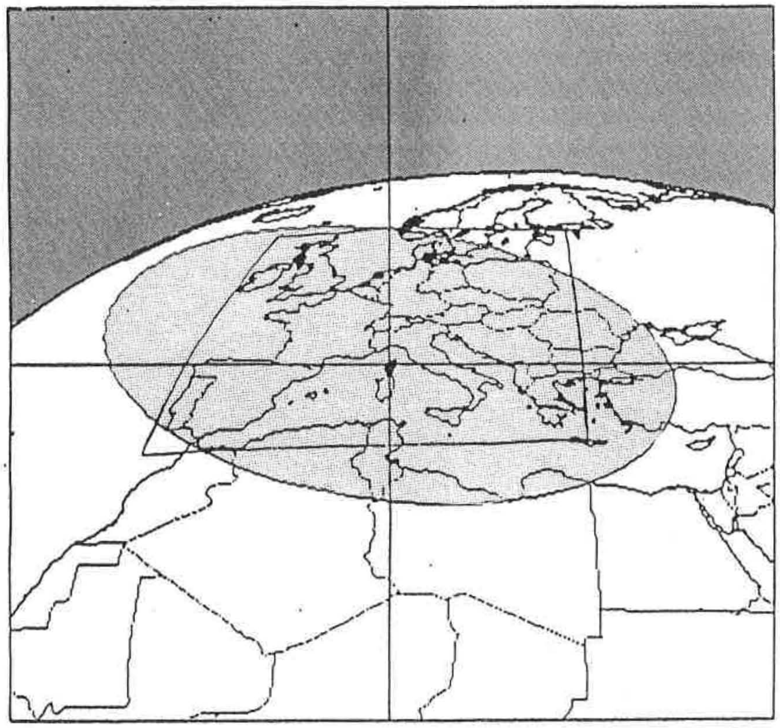
There are two broad categories of foreign interest in RDSS. The first consists of countries that would use the U.S. GEOSTAR system until their own capability could be fielded. Examples of such foreign users are Canada, Mexico, and the Caribbean Broadcast Union (a consortium of island states in the Caribbean). The second category consists of nations who wish to field their own national systems or join in a regional venture. They include Australia, Brazil, China, India, and the European LOCSTAR consortium headed by France; they are all nations whose satellite organizations are working closely with Geostar on a formal basis.

Interest in RDSS has been expressed by other countries as well. Some have deferred due to budgetary considerations, lost opportunities, or technical incompatibilities. Indonesia and the ARABSAT organization are included in this category. A number of nations are waiting to judge the effectiveness of the system.

Geostar and Embratel, the Brazilian national telecommunications company, recently signed a memorandum of understanding to cooperate in implementing RDSS in Latin America. The scope of Brazil's role in the region remains to be determined. Preliminary studies show the dedicated satellite spacecraft, with multiple beams, could provide adequate coverage. As a result, Brazil may not elect to provide service for the entire region. Technical details of Brazil's satellite system compatibility remain undetermined.

Geostar recently signed an agreement with Telefonica, the Spanish telephone and telegraph system, that now operates the Argentine telephone system and is deeply involved with other Latin countries. Under the agreement, Geostar and Telefonica will jointly develop an

LOCSTAR Service in the 1990s



RDSS structure for extending coverage to this region.

The French national scientific agency, CNES, has formed a European consortium, called LOCSTAR, to establish a regional RDSS system that would launch its first satellite relay and initiate service in 1991. The system would be owned by key European governmental and private organizations. LOCSTAR was formally incorporated in October 1988 with twenty–seven shareholders from eight different countries.

The EUTELSAT (European Telecommunications Satellite) and the ITELSAT (Italian Telecommunications Satellite) are seen as primary candidate platforms for the initial European RDSS. The system will provide mobile location and message transmission service covering Europe first, followed by coverage of Africa and the Middle East.

The Indian Space Research Organization (ISRO) signed an Memorandum of Understanding with Geostar in August 1986 to study the feasibility of implementing RDSS in the Indian Ocean region. The ISRO anticipates incorporating one–way and two–way RDSS packages in its second generation communications satellites, INSAT (Indian Satellite System) 2 series. The INSAT payloads are set for launch in the 1992–93 time frame.

The AUSSAT (Australian National Satellite System) has also signed an Memorandum of Understanding with Geostar, and issued a proposal for RDSS spacecraft relays aboard the next generation of AUSSAT 2 series of three satellites scheduled for launch in 1991/1992 and 1995. The latter satellite may provide two–way RDSS messaging service. A decision to acquire one–way service was made in 1988; two–way service will be decided in 1991. If approved, the RDSS system will be operated by AUSSAT at its Belrose earth station in Sydney. The proposed area of coverage may be confined to the continent because a larger footprint including New Zealand, for example, would impose power constraints and restrict the usefulness of small terminals.

Geostar Pacific, recently formed, will work toward implementing a Pacific Basin RDSS system that is compatible with GEOSTAR and LOCSTAR.

The Chinese Academy of Space Technology (CAST) is undertaking studies on incorporation of RDSS in their next generation of satellites planned for the early to mid–1990s. A technical feasibility study has been completed. Several options are under consideration: an application of GPS service, fielding an independent RDSS system, and providing coverage that includes Southeast Asia.

Japan has also expressed interest in using an RDSS system. Both telecommunications arms of the Japanese Government (the Ministry of Post Telecommunications and Nippon Telephone and Telegraph) are said to favor a mobile voice capability, but it may be implemented in conjunction with RDSS. A space communications committee is examining an RDSS model for possible application in Japan.

The Nerve Center

Central Control

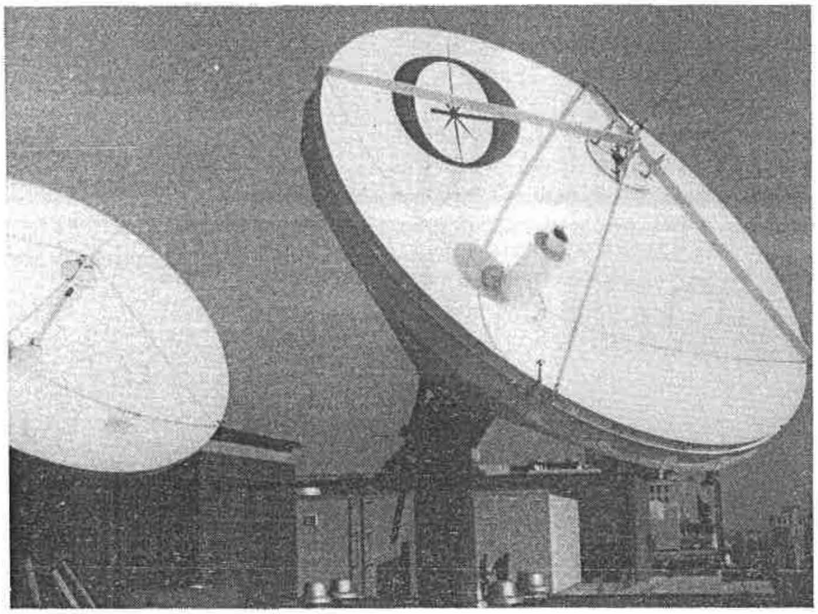
WHAT CAPABILITIES DOES CENTRAL PROVIDE?

RDSS Central is the nucleus for all functions of the network. A combination satellite earth station, network master control, and message distribution facility, the Central Control Facility is the conduit between all users and recipients of RDSS services.

The earth station portion of a Central, which is referred to as the "hub," consists of appropriate satellite communications antennas and redundant radio frequency equipment for signal acquisition and processing. Currently, GEOSTAR Central is located in downtown Washington, DC. It is configured with twin Ku–Band five–meter dishes mounted on the roof of the Geostar corporate headquarters building.

In the early 1990s, when larger C–Band antennas are required to support GEOSTAR dedicated satellites, the communications antennas and supporting equipment will be moved to new sites. Geostar has already established a hub at Woodbine, Maryland, for control of System 2C and is investigating the placement of an alternate Central in Colorado for System 3.

RDSS



Currently processing more than one and a half million messages per month

Geostar's control segment consists of Communications Satellite Corporation (COMSAT) spread spectrum modulation and demodulation equipment and network operations software under the control of a Hewlett–Packard computer system using a UNIX–based operating system. The control hub at the Central encodes and decodes spread spectrum signals, calculates position fixes, and routes traffic externally to the network as well as internally for electronic sorting and distribution. Today, at GEOSTAR Central, a network of Hewlett Packard 9000 series computers capable of supporting approximately 50,000 subscribers is on line. The system is modular to allow for growth as network traffic increases. The computers are connected in a local area network, where packet routers direct message traffic to electronic mailboxes and real–time links to customers.

The Central's message distribution function sends and stores messages, and maintains user identification data bases and traffic routing instructions. The Central, continuously staffed by two to four personnel, interacts directly with end users, providing a host of RDSS services. Individual users may deal personally with the Central, or a large consumer segment (such as the trucking industry) may have its traffic bulk–shipped to a broker for specialized processing and subsequent internal distribution.

OPERATION OF CENTRAL

The RDSS Central transmits a general interrogation signal, addressed to all user terminals, through one of the satellite relays many times per second. The outbound signal provides system wide time–synchronization for the network. Outbound traffic may include network control instructions to terminals (transparent to the user) or messages and position calculation results to end users.

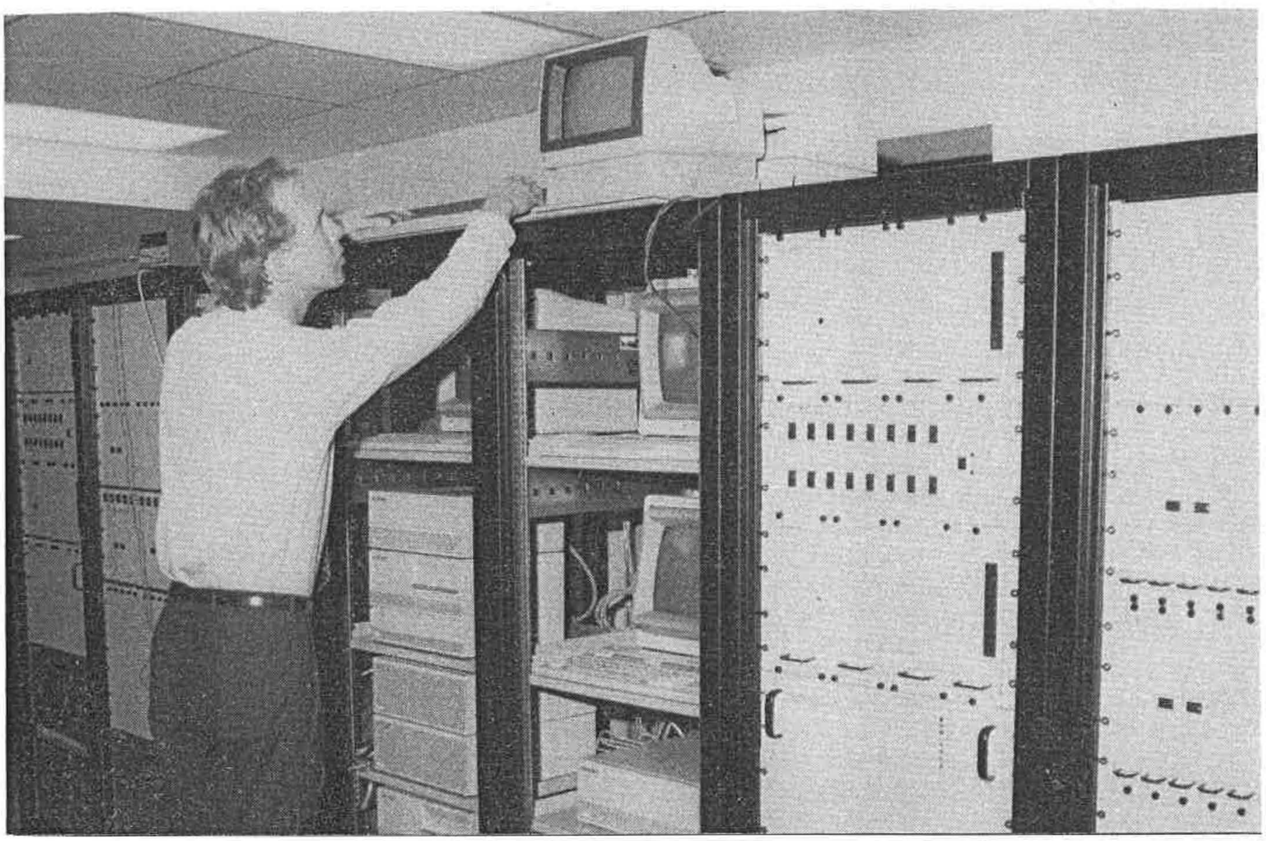
Inbound signals (messages) from user terminals provide ranging data crucial for locating positions. The signals are detected, verified, and identified as to individual user terminal through the use of unique identification codes. As required, the Central can compute the user's position, and process and route message traffic to an electronic mail box, to the user's home office, or other destinations as specified.

The Central maintains a master system clock for network reference. It also maintains automated files and storage facilities for all user identifications, and for cross–correlation with physical identifications and traffic routing instructions.

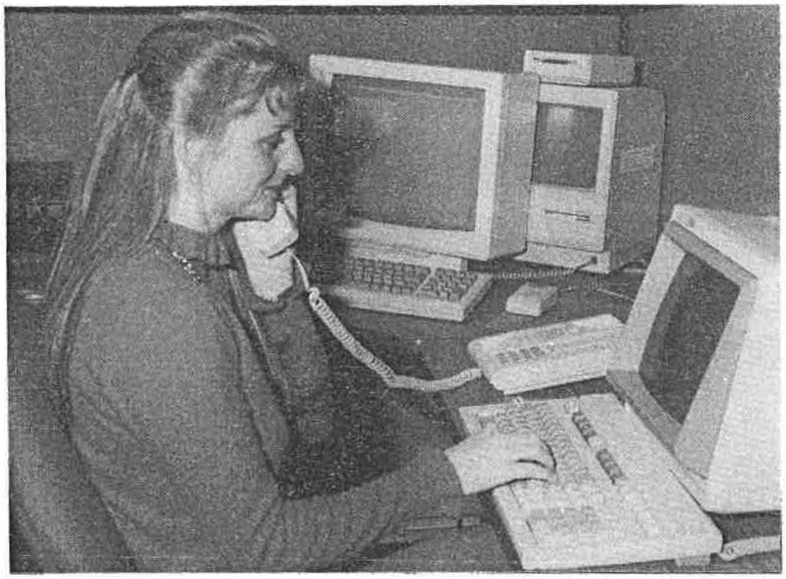
In maintaining network operation, approximately a dozen spreading codes may be employed by RDSS Central to help differentiate among the various classes and densities of users. For example, one code may be allocated for trucks, another for aircraft, and perhaps a third for emergency vehicles. Should saturation, conflict, or contingency arise, the Central can shift users to other spreading codes. The flexibility to move a user or a class of users at will among a number of codes is essential for efficient operation.

Electronic Mailbox Service

When processing traffic, the RDSS Central identifies the user, screens portions of messages for special routing instructions, and distributes traffic to a user addressee, a home office, or mailbox. The Central can store and forward message traffic intended for a user who may be temporarily unavailable. The Central may forward all unanswered traffic to a mailbox and, upon detecting the next transmission of a given user terminal, relay any



Geostar Central Accesses, Stores and Routes Message Traffic



GEOSTAR Customer Service Representative

stored traffic at that time. Normally, traffic will be retained for up to three months. The user may arrange for messages to be retained for a longer period.

Recognizing the need to maintain the confidentiality of user traffic and positioning data, the RDSS system is designed to protect customer privacy. A user will never have his position reported or a message sent to another without his permission. Because network functioning is fully automated, most user transactions are transparent to Central operating personnel, although specific files and mailboxes can be accessed by the Central's staff on demand. In fact, as a service to the trucking industry, GEOSTAR Central maintains a display of vehicle movements and can recall historical files that depict individual truck routes.

A customer home office can access its mailbox at Central in one of several ways. The three most common methods are:

- Conventional dial–up telephone
- Leased line (using X.25 message packet protocol)
- Small–scale earth station (VSAT)

Customers may access mailboxes themselves, or they may arrange for RDSS Central to notify them when traffic is available. This interaction can occur as often as every 10–15 seconds; however, hourly or daily retrieval may be the norm. Additionally, users can redirect or preempt the normal process by attaching a special code to a message that will specify one of the four traffic priorities or precedences. For example, an emergency precedence will prompt Central to initiate immediate connection with the user's home office, or other persons or agencies, as appropriate. For emergency traffic, a standard procedure adopted by the Central requires the initiation of both an electrical contact and a voice acknowledgement with the customer's home office.

Growing Capability of the Central

Beginning with System 3 service, the Central will be capable of geolocating every transmission; however, this calculation generally will not be performed routinely unless the customer requests the service.

The RDSS Central is expected to offer a variety of "value added services" to meet users' special needs. For example, as the user population expands, the Central will be able to "observe" local vehicle traffic patterns across the nation based on timely analysis of position reports from like users such as automobiles, commercial trucks, or emergency vehicles. The Central also could provide users with rerouting or other instructions, thus allowing them to avoid congested areas.

Billing

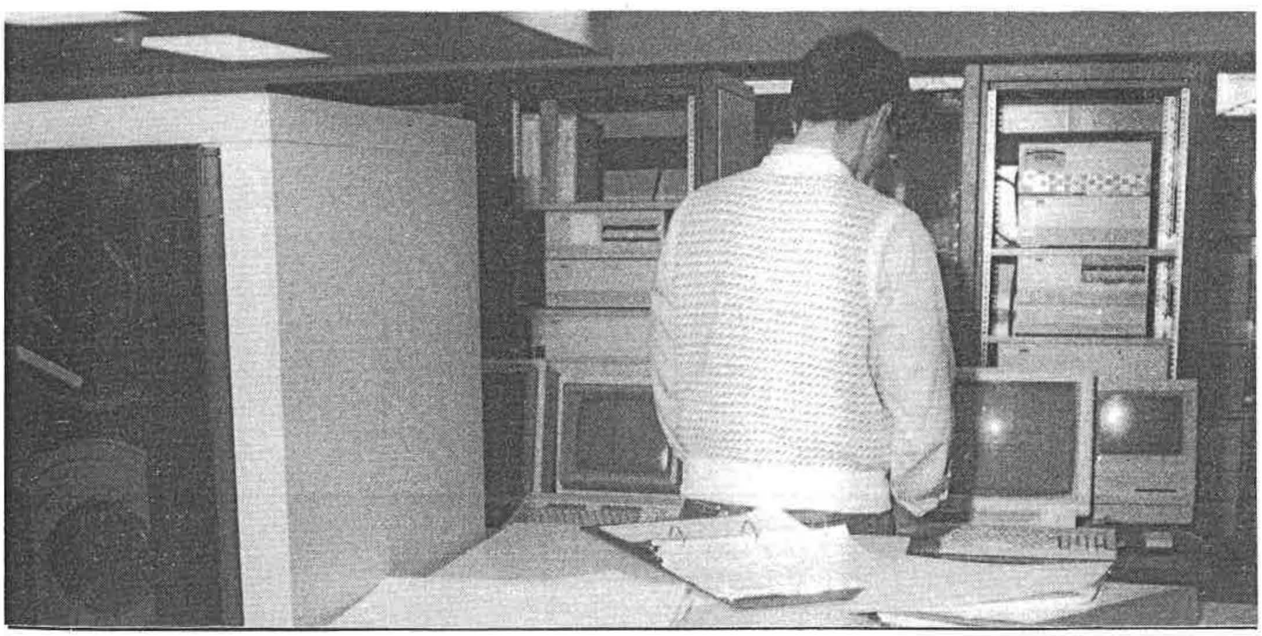
The Central maintains a record of all message transactions. Administrative data reflecting user traffic volume, by time of day, is made available to billing and accounting personnel. The billing system and specific customer charges are evolving as the range of RDSS service expands.

Presently, one billing unit equates to one Standard Inbound Packet (SIP), a single message of approximately 100 characters. The minimum information required by the Central for billing must include the user's identification code and the number of total transmissions. It is also possible to inform customers as to when the transaction took place. The actual customer billing format to emerge will likely reflect specific customer needs and budget.

The initial commercial charge for basic RDSS service is $45 dollars per month per user terminal. Basic service has been defined as 720 transmissions per month, the equivalent of one standard message per hour, 24 hours per day for 30 days. Transmissions in excess of this number in a single month will be charged at five cents each.

Net Management Duties

When performing its network management duties, the Central routinely interacts with any or all active user



Central — Directing Message Packets to Electronic Mailboxes terminals in the system. Each transaction may or may not be displayed on the user's terminal. The user may be unaware that his transmissions have increased in power or repetitions. For instance, RDSS Central is able to command a user terminal to change response rates to better control traffic flow and priorities. For example, a conifer pine needle forest tends to attenuate L–Band (user transmission) frequencies; therefore, the Central may direct terminals operating in this environment to increase the number of transmission repetitions to enhance signal reception.

Regional RDSS Centrals

To establish a global RDSS network, several RDSS Centrals will be required. Each regional RDSS Central will operate its own independent constellation of satellites. Regional Centrals are expected to be interconnected by alternate communications means, possibly by commercial satellite links. The specific procedures to be employed in servicing a transient user are undetermined.

One plan for coordinating international service envisions each regional RDSS Central maintaining its own master listing of "foreign" identifiers: a user terminal or router ID, an organizational or physical ID, and pertinent user–unique protocols. The regional RDSS Central, such as LOCSTAR Central in Europe, would have a master lookup file reflecting only the terminal or router ID for all RDSS users assigned to a particular sister RDSS Central, such as GEOSTAR Central in North America. This file would permit LOCSTAR or other regional systems to route traffic along with billing data to GEOSTAR, unless other arrangements are made by the user.

Friendly and Portable

User Terminals

WHAT'S AVAILABLE FOR THE USER?

By the time RDSS System 3 becomes operational, user terminals are expected to consist of compact, relatively inexpensive radios that can be hand-carried or mounted, as appropriate, for a particular application. Most user terminals will be capable of message display and composition, storage of multiple messages, monitoring of external sensors, automated reporting, and performing a variety of other unique functions.

In the United States, three electronics manufacturers are producing RDSS terminals. They are Hughes Network Systems, Motorola Government Electronics Group, and The Sony Corporation of America. Sony and Hughes have been producing and selling commercial radios providing one-way service since early 1988, and they are developing radios that provide two-way service for delivery in early 1989. Thousands of terminals already have been placed in service by the trucking and railroad industries. Motorola is developing a miniaturized handheld terminal design to provide future two-way service. Depending on market conditions, all three vendors may eventually elect to produce a low-cost miniaturized radio for commercial application. Overseas, other licensing arrangements will be consummated independently between the vendor and the host nation involved.

RDSS

The design goal is to manufacture a production model user terminal for under $3,000. RDSS radios have a basic core specification, with specific models differing in size, weight, power options, and special user features. Operations requiring extensive processing are performed at GEOSTAR Central, reducing the sophistication and cost of the terminal.

The number of commercial one–way and two–way terminals that will be fielded worldwide in the next several years may be in the millions, based on studies of market potential. For example, the French space agency (CNES) has recently sponsored seven independent marketing surveys of 2,000 companies projecting RDSS utilization in the European community. The potential market for LOCSTAR in Western Europe is estimated at between 120,000 and 210,000 users after one year and 400,000 to 800,000 users after six years.

"...(Geostar) provides a much simpler and more cost-effective method for monitoring remote pipeline locations."

Pipeline & Gas Journal 10/88

TERMINAL CONFIGURATIONS

In addition to the terminals currently in production, plans are underway to provide a terminal interface port for optional Global Positioning System and Transit radionavigation receivers; integrated with one–way RDSS units, these support Systems 2G and 2T. Each user terminal will have a unique digital identification code and will be able to transmit a coded digital burst through the satellite to GEOSTAR Central. The System 2G or 2T terminal will be composed of the following subsystems: positioning, transmitter, and baseband processor. Operational procedures for System 2G or 2T terminals will be the same as those for System 2.

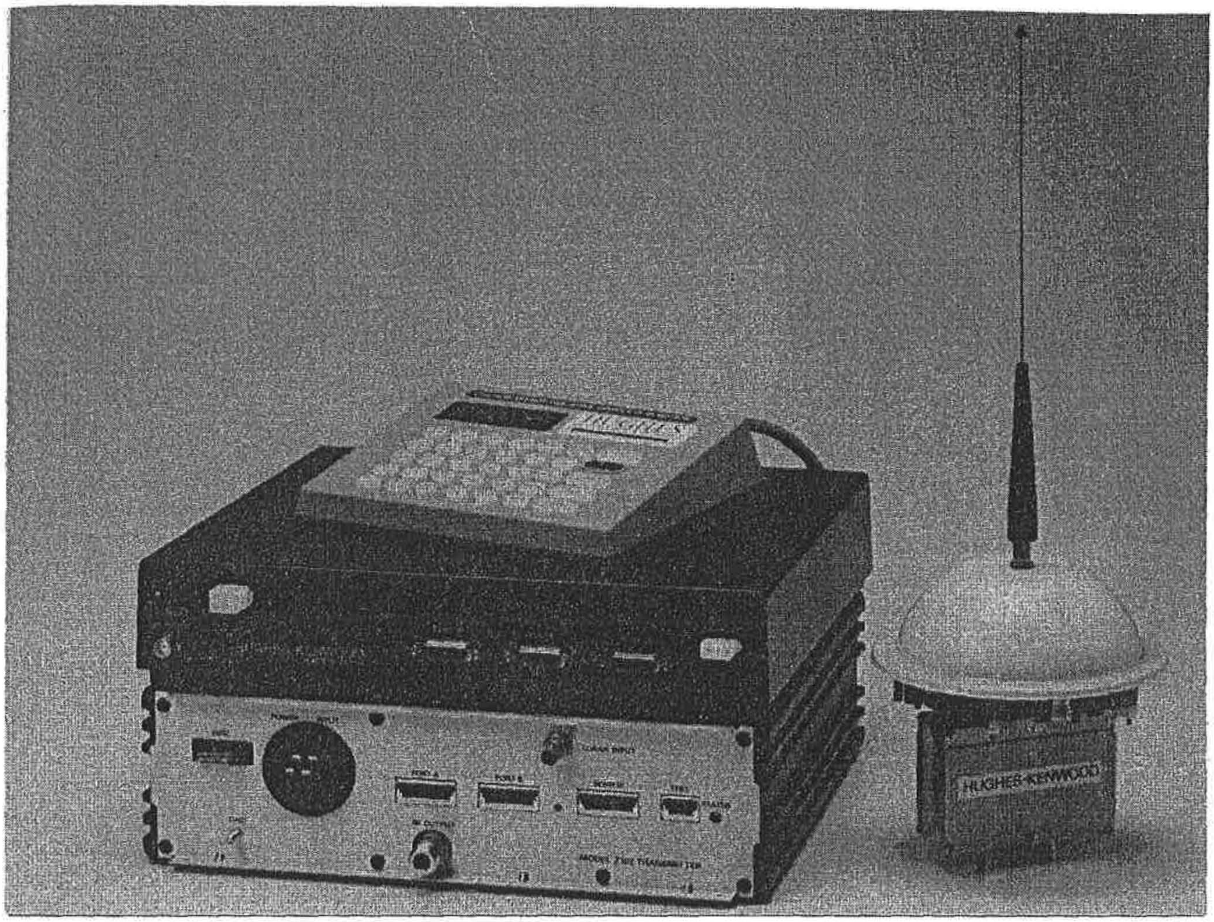
The System 2C terminal will include a C–Band radio receiver to complement its L–Band transmitter, providing a two–way messaging capability with Central and then to the user's home office. Outbound message packets of up to 100 characters may be read by the user upon receipt on his terminal keyboard display.

Hughes Terminals

Hughes RDSS System 2 (one–way) terminals are currently installed and operating on trucks and railroad trains across the United States. Their initial Model 2101 was produced in a limited quantity of only 500 units, while their improved Model 2102 began testing in December 1988 with plans to produce at least 3,800 units in 1989. The cost will be approximately $3,100 per terminal including antenna, plus $350 for the optional keyboard display.

The Hughes Network Systems Model 2102 Mobile Satellite Terminal (MST) is a compact unit designed for RDSS System 2 operation from trucks, trains, buses, aircraft, ships, and fixed site remote locations. The fully equipped MST is composed of a Model 2102 transmitter with integrated antenna and a companion Mobile Data Terminal (MDT) Model 2901 keyboard and display unit.

Principal features of the MST include: transmittal of data containing position, remote sensor status, messages, or emergency information; fully automatic, "hands–off" operation; advanced technology integrated LORAN–C receiver for position determination accuracy within a fraction of a mile; full continental U.S. coverage with no mid–continent gap; a ruggedized enclosure to permit operation under extreme environmental conditions;



Hughes Model 2902 2-Way Satellite Terminal

a tamper–proof security cover to seal and conceal connections and interfaces; low power consumption at 12 VDC; and ease of installation and maintenance. In addition, the Hughes MST provides two RS–232C interfaces for optional keyboard display and external computer, as well as eight parallel inputs for alarm and sensor contacts.

The companion Hughes Model 2901 Mobile Data Terminal enables the operator to recall preset messages from memory, edit free–form variable messages, and select different message precedences for transmissions to the user's home office.

The keyboard may be either handheld or mounted in a bracket attached to the dashboard or control panel of the operator's vehicle. The unit has a 4–line–by–20–character alphanumeric liquid crystal display (LCD). Electro-luminescent lighting allows the keypad and display to be easily seen at night. Interface ports permit connection to the 2102 MST. A supplied pouch allows storage while the vehicle is in motion.

The MDT has 30 multifunction buttons that allow the operator to compose and transmit messages of nearly 100 characters in length. For example, a typical message might be:

```
"EN ROUTE HEADING
EAST ON I-40...84 MILES
FROM MEMPHIS...ETA
4 PM."
```

A full-size tactile keypad assures ease of use even with a gloved hand.

Hughes/Kenwood 2902 Keyboard and Display Unit

Ten user-defined messages enable the operator to precompose standard messages into memory for later recall and transmission to dispatch operators. Special editing and control keys allow messages to be formatted and viewed before transmission and easily corrected for accuracy.

The MDT keyboard and display unit is compact, lightweight, and measures 6 x 8 x 2". Its information rate is 1200 baud, using asynchronous serial data and standard RS-232C protocol. It has an operating temperature range from -22° to 140°F.

For the two-way RDSS System 2C, Hughes Network Systems is developing a companion C-Band receiver for their MST that will enable the user to receive messages transmitted from his home office or from another user terminal via GEOSTAR Central. The C-Band receiver comprises an integrated, multipurpose external antenna unit and an indoor unit, which mounts inside a vehicle and is connected to the Model 2102 MST. The companion receiver has essentially the same technical characteristics (e.g., environmental and power source) as the MST, but operates at a nominal frequency of 4.184 GHz with an information bit rate of 1200 baud, and has two RS-232C ports for an MDT and an ancillary device.

Motorola Terminals

To date and under contract to Geostar and the United States Customs Service, Motorola Inc. has focused its total RDSS terminal development effort on the two-way GEOSTAR System 3 and, as a result, offers no product to interoperate with the one-way System 2 or the interim two-way System 2C. Concentrating on a

Miniaturized Handheld Radio Under Development by Motorola

two–way terminal of handheld size with integrated flat (conformal) antenna array, multiple power sources (AC, DC, or battery), and an optional message encryption capability; the Motorola System 3 terminal will be composed of an L–Band transmitter, S–Band receiver, internal processor module, and optional keyboard and display. The small terminal can be configured with an external AC or DC power source, an optional external antenna, an ancillary personal or laptop computer (via RS–232C port), and up to eight sensors.

The terminal measures 5.6 x 3.1 x 1.6 inches and weighs 22 ounces. With the battery pack attached, its overall dimensions are nearly double. The integral keyboard display contains a 2–line by 39 character LCD and a 3–row by 10 column alphanumeric keypad. The transmitter and the receiver can accommodate multiple data rates. The terminal has an operating temperature range of –30° to 60°C.

Motorola terminals are being designed in four different models as shown, all of which are hand held. Two models will have a built–in keyboard and display and antenna, while the other two will have provisions for mounting those devices externally; all will have a serial port for remotely operated peripherals such as a personal computer terminal or printer. Scheduled delivery of the initial Motorola models is expected in mid-1990.

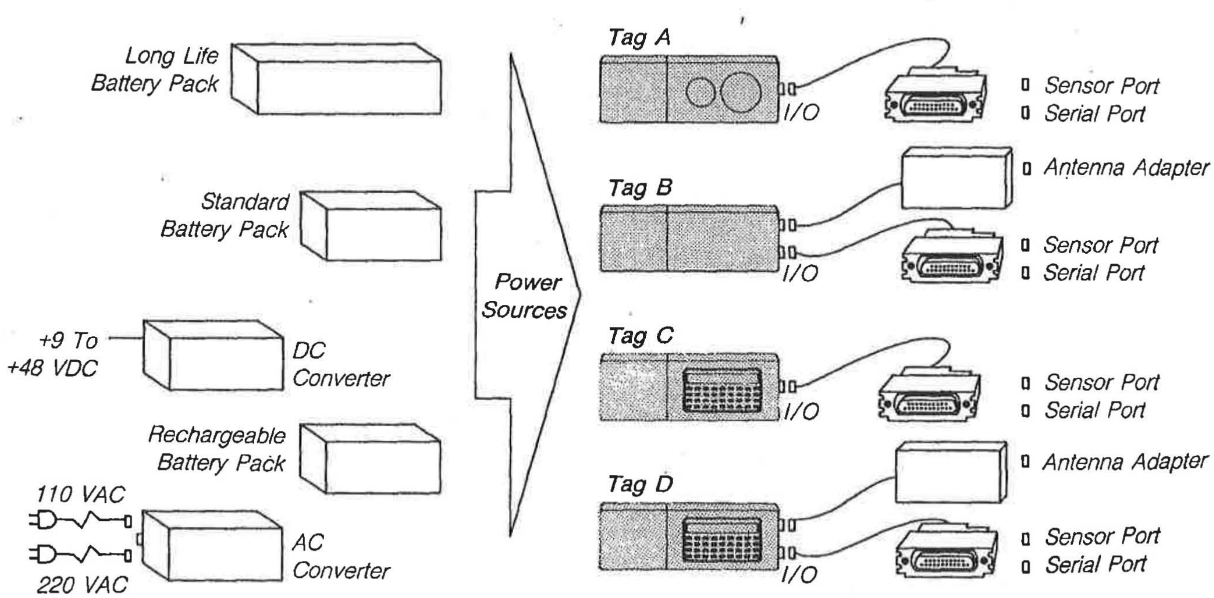
The following graphic summarizes the configuration of each Motorola miniaturized RDSS terminal and depicts the various power options. The eight-hour battery pack is the design standard for the handheld terminal, while a long-life battery and AC and DC power sources are optional. The B and D models come with an external antenna adapter module with a built-in low noise amplifier to accommodate a user-provided antenna.

Motorola is developing two types of antennas, a built-in patch array and the external antenna adapter module. Both types will support L-Band transmit and S-Band receive signals.

Sony Terminals

The RDSS System 2 terminal manufactured by the Sony Information Systems Company, a division of Sony Corporation of America, is called the Wayfarer Mobile Communications Unit. It consists of four components: the main unit, a keyboard/display, a LORAN-C receive antenna, and a transmit L-Band antenna. The main unit, which weighs 10.8 pounds and measures 5.8 x 9.8 x 7.2 inches, contains all of the positioning, transmitting, and computing electronics. It features a built-in diagnostics program for maintenance troubleshooting and can be attached to vehicle sensors (to transmit such on/off data as: engine overheat, oil low, door open, refrigeration temperature too high, and burglar alarms).

Motorola Tag Configurations



The Wayfarer keyboard/display measures 8.8 x 4.4 x 1.2 inches and includes function keys in addition to the standard alphanumeric keys. The back–lit LCD display can accommodate 40 characters x 2 lines, which is being increased to 40 x 4 lines, and allows the user to edit a message before sending. The unit is designed for operator simplicity and speed, and can transmit position and sensor readings automatically.

The Wayfarer's two antennas are small and connect to the main unit. The L–Band helical transmit antenna has a built–in power amplifier. The LORAN–C receive antenna resembles a short CB aerial, 16.5 inches high, and contains a preamplifier to pick up radionavigation signals from LORAN–C transmitters located in the U.S. These signals are fed to a computer in the main unit that calculates position to within a nominal accuracy of 1/4 mile.

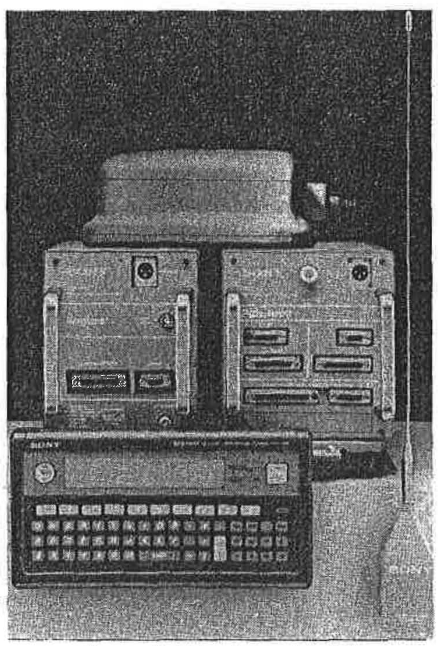
The Wayfarer can operate at an altitude of up to 10,000 feet and over temperature ranges of –22° to 140°F (main unit) and 14° to 140°F (keyboard/display).

Sony also plans to develop a two–way RDSS terminal that will add a C–Band receiver to their Wayfarer's configuration for operation in GEOSTAR System 2C. Costs estimated for the Sony Wayfarer series of products are:

System 2 one–way terminal	–$3,300
System 2 upgrade to System 2C	–$1,800
System 2C two–way terminal	–$4,800

Positioning Displays

In addition to RDSS terminals, two software vendors offer map display packages for those users who prefer vehicle positioning data portrayed on a map rather than in terms of degrees latitude and longitude. Techwest (a division of Fleet Aerospace Corporation) produces FLEETVIEW, and ComGrafix Corporation offers Mapstar. FLEETVIEW requires a properly configured IBM Personal Computer/AT in the user's home office, and Mapstar requires an Apple Macintosh Plus, SE, or Macintosh II. Both map display systems are designed primarily for the trucking industry to provide an "electronic atlas" on the computer screen as an aid to dispatchers, managers, and maintenance/customer service representatives for better operational control over truck fleets.



Sony 2-Wayfarer Mobile Communications Unit

Geostar transfers data between portable "go anywhere" terminals

Key Terms

A

AC
Alternating current

ANSS
Australian National Science System

ARABSAT
Arabian Satellite Organization

Ariane
Mainly French space launcher and/or European Space Agency Program

ARGOS
Global collection, location, weather satellite system

AUSSAT
Australian National Satellite System

B

Benchmark
Calibrated transceiver at known location

C

CAST
Chinese Academy of Space Technology

C–Band
4 – 6 GHz frequency range

CCIR
International Radio Consultative Committee

CDMA
Code division multiple access (spread spectrum technology)

Chip
time slot

CNES
French national space agency, Centre Nationale d'Etudes Spaciales

COMSAT
Communications Satellite Corporation (U.S. affiliate of INTELSAT)

CRC
Cyclic redundancy check for error detection/correction

D

db
decibel

DC
direct current

DS
Dedicated satellite

E

EIRP
Effective isotropic radiated power (antenna gain) in dbw

EMBRATEL
Brazilian National Telecommunications Company

ESA
European Space Agency

EUTELSAT
European Telecommunications Satellite

F

FANS
Future Air Navigation Systems (Committee of ICAO)

FCC
Federal Communications Commission

FEC
Forward error correction

G

GEOSTAR
RDSS trademark of Geostar Corporation

GHz
One billion Hertz (10^9)

GPS
Global Positioning System

GSTAR
GTE Spacenet satellite (series)

H

HDLC
High Level Data Link Control

Hertz (Hz)
Equivalent to cycles per second

Hub
RDSS Central Earth Station

I

ICAO
International Civil Aviation Organization

ID
Identification

INMARSAT
International Maritime Satellite (System)

INSAT
Indian Satellite System

INTELSAT
International Telecommunications Satellite (Consortium)

I/O
Input/Output

ISRO
Indian Space Research Organization

ITCC
International Technical Coordinating Committee

ITELSAT
Italian Telecommunications Satellite

ITU
International Telecommunications Union

K

Kbps
Kilobits per second

Ku–Band
11–17 GHz frequency range

L

LCD
Liquid crystal display

LOCSTAR
European RDSS Consortium

LORAN
Long Range Aid to Navigation

LUT
Local user terminal (ARGOS)

L–Band
1 – 2 GHz frequency range

M

MDT
Mobile Data Terminal

MHz
One million Hertz (10^6)

MOPT
Ministry of Post Telecommunications (Japan)

Msg
Message

MSS
Mobile Satellite Service

MST
Mobile Satellite Terminal

N

NASA
National Aeronautics and Space Administration

NOAA
National Oceanic and Atmospheric Administration

NTT
Nippon Telephone and Telegraph (Japan)

P

PN
Pseudo–noise (spreading sequence)

PTT
Post Telephone and Telegraph

R

RDSS
Radio Determination Satellite Service

RO
Receive only (satellite)

S

SIP
Standard inbound packet

S–Band
2 – 4 GHz frequency range

T

Tag
RDSS terminal nickname

TDMA
Time division multiple access

Telefonica
Spanish Post Telephone and Graphic

U

UHF
Ultra high frequency

V

VAC
Volts, alternating current

VHF
Very high frequency

VDC
Volts, direct current

VSAT
Very small aperture terminal

W

WARC
World Administrative Radio Conference

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