DECLARATION OF MARK NICHOLAS CHESTON

I, Mark Nicholas Cheston, make the following Declaration pursuant to 28 U.S.C. § 1746:

1. I provide this Declaration in connection with Covered Business Method Patent Review proceedings that I understand are being requested at the United States Patent and Trademark Office by Liberty Mutual Insurance Company under 35 U.S.C. § 321. Unless otherwise stated, the facts stated in this Declaration are based on my personal knowledge.

2. From May 1986 to January 1990, I was Director of Federal Systems at Geostar Corporation. My responsibilities included, among other things, preparing material relating to marketing the Geostar system.

3. The document attached at Tab A hereto, entitled "Understanding Radio Determination Satellite Service," and dated May 1989, is a true and accurate copy of a booklet published by Geostar Corporation and publicly and widely distributed to potential Geostar system users upon its publication in May 1989. In my position at Geostar Corporation, I had personal knowledge of this attached publication and was involved in contributing some of the material included in the document.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 14, 2012

Mark Nicholas Cheston

at O'Fallon. Illinois

Liberty Mutual
Exhibit 1004

Tab A

Understanding

Radio Determination Satellite Service

GEOSTAR®

RDSS

MAY 1989

To promote a better understanding of emerging Radio Determination Satellite Service (RDSS) technology, the Geostar Corporation of Washington, DC, the U.S. developer of RDSS, is pleased to publish this descriptive primer.

Directed at the potential GEOSTAR* user community, the material is presented from a user's perspective. It addresses such questions as: What is RDSS, how did it develop, how does it work, what capabilities have been developed using the technology, and what is planned for the future?

As is the case with most evolving and developing technologies, some data presented in this document is subject to change as prototype equipment transitions to production models, and as engineering concepts solidify and emerge into operating systems and established procedures.

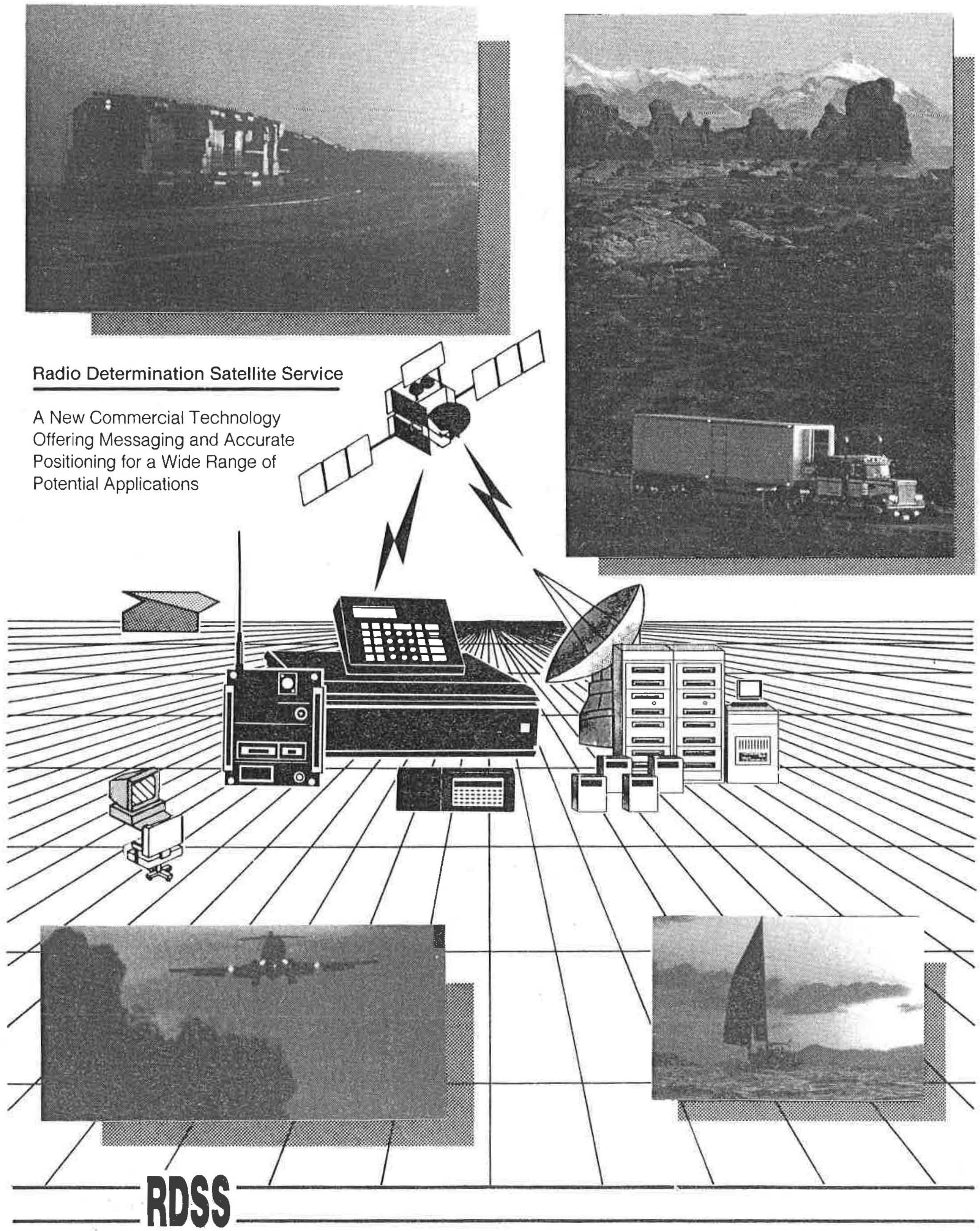
For further information, you are invited to contact the Sales and Marketing Department of the Geostar Corporation, Telephone (202) 887-0870.

*GEOSTAR is a trademark and servicemark of the Geostar Corporation.

Table of Contents

Radio Determination Satellite Service

A New Commercial Technology Offering Messaging and Accurate Positioning for a Wide Range of Potential Applications



Introducing

Radio Determination Satellite Service

WHAT IS RADIO DETERMINATION SATELLITE SERVICE?

Radio Determination Satellite Service (RDSS) is a new commercial communications technology. It offers the individual user information on location that can be supplemented with two–way digital message communication. The service employs compact, portable radio terminals for mobile platforms and, eventually will offer miniaturized handheld terminals for personal use.

Being developed initially for nation–wide service, RDSS has the potential to interoperate with other regional RDSS systems to provide nearly full global coverage serving millions of customers. Supplying the user with instant location information accurate to within 7 meters, this service can eliminate time previously wasted in search of an individual shipment or vehicle.

With the addition of a messaging capability, up to 100 characters per transmission (a single message "packet") can be readily exchanged among individuals in remote areas, a capability formerly beyond the reach of available means of communications. Multiple packets also can be linked sequentially to accommodate lengthy messages.

This flow of information allows a user to track his or her own progress, or to monitor the location and route of a train, truck, boat, car or airplane. Perhaps, a transport company needs to learn the whereabouts of a fleet of vehicles. Using

RDSS

"Worldwide communications via satellite is now available to mobile users who were previously largely excluded from the benefits of satellite technology."

Telecommunications Policy 6/87

RDSS technology, a dispatcher can immediately locate and communicate with one or all of the fleet – relaying destination changes or other important information to the drivers while en route.

Why all the excitement about RDSS? Because RDSS is a completely new communications technology, its adaptation to the contemporary communications environment will be revolutionary. Just as the applications for Alexander Graham Bell's novel new device, the telephone, became clear over the years, RDSS has the potential to make sweeping changes in the way we interact with our everyday lives.

STANDARDS SET FOR RDSS

The Federal Communications Commission and the International Telecommunications Union have established standards for radio determination satellite service. Federal Communications Commission rules define radio determination as "the determination of position, or obtaining information relating to position, by means of the propagation of radio waves."

To some extent, RDSS capabilities complement those of four other generic technologies – Mobile Satellite Service, meteor burst base radio location systems, the Long Range Aid to Navigation (LORAN) system, and radio navigation satellite systems such as the Global Positioning System (GPS) and Transit. RDSS incorporates many features of each of these complementary technologies. It does not compete with conventional voice or data systems that transmit information continuously. Instead, RDSS sends short bursts of information with accurate positioning and other services added by a central network control facility.

Definitions

Radio Determination
The determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves

Radio Navigation
Radio determination used for the purpose of navigation, including obstruction warning

Radio Location
Radio determination used for purposes other than those of radio navigation

Extracted from Radio Regulations of the International Telecommunication Union, Edition 1982

SERVICE FINDING WORLDWIDE ACCEPTANCE

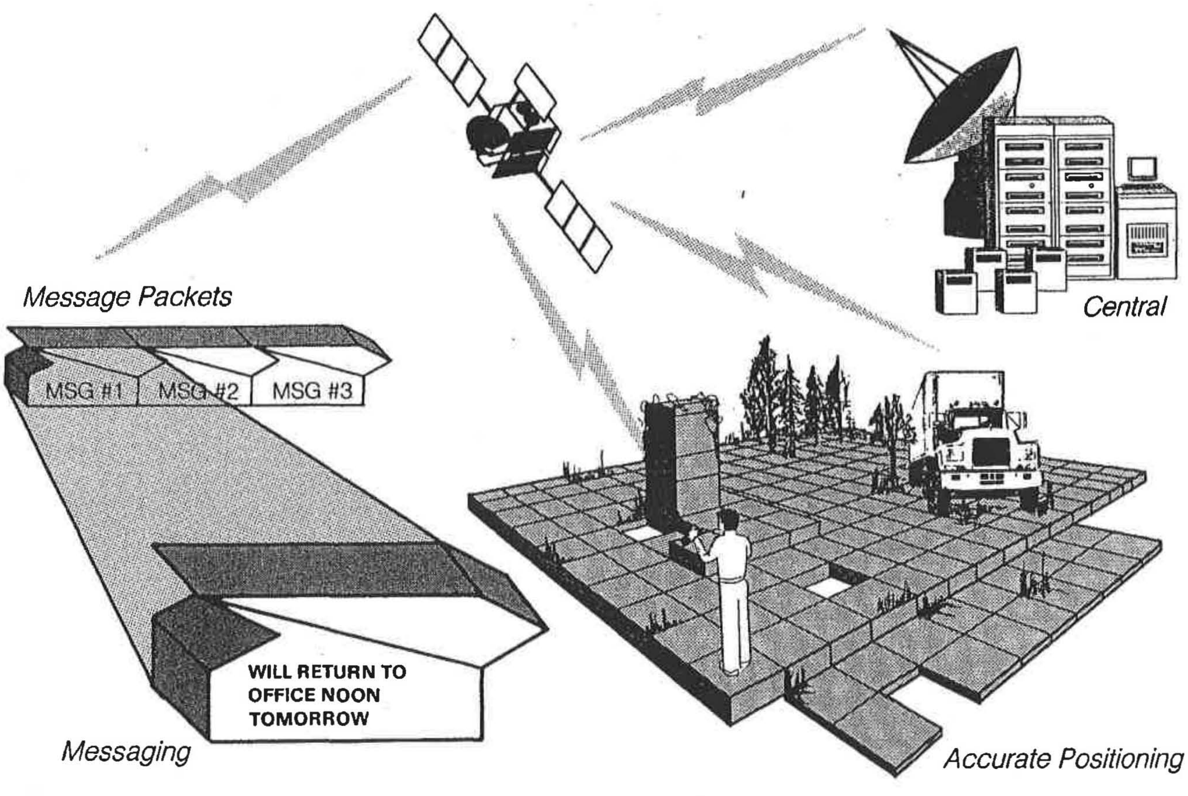
As a new commercial service with potentially widespread personal, business, and government applications in both developed and developing countries, the RDSS system is rapidly emerging as an international phenomenon. RDSS theory has undergone rigorous technical examination by many of the world's leading space and communications professionals, culminating in technology licensing arrangements with a French-led European consortium, India, and Australia. Brazil, China, and Japan have study programs underway that are aimed at possible licensing arrangements.

The technical feasibility and practicality of the RDSS concept has been ably demonstrated by the Geostar Corporation, the originator and current leader in developing an RDSS system approved by the FCC for use in the United States. Field tests have been successfully performed under U.S. Government oversight, and initial commercial service in the United States has been offered by the Geostar Corporation since June 1987.

The GEOSTAR System is presently in an early operational stage, with major capability enhancements still ahead. Initial GEOSTAR service, (Systems 1 and 2) provides a one-way flow of data, with external positioning information provided by LORAN or other navigational system. In its simplest form a user terminal broadcasts to its intended address, normally via satellite to the GEOSTAR (RDSS) Central Control Facility where the transmission is processed and forwarded to the user's organizational headquarters site or home office. This introductory capability is the initial service focused on the commercial trucking industry.

To meet popular demand, additional capabilities are being added to developing GEOSTAR systems. System 2 is being expanded in 1989 to offer an initial two-way message capability (System 2C), along with GPS (System 2G) and Transit (System 2T) positioning capabilities as options to the existing LORAN. Full GEOSTAR service (Systems 3 and 4),

What RDSS is All About



slated for implementation in the early 1990s, will provide improved two–way flow of data, plus positioning information to and from user terminals based on a signal time ranging technique (multi–lateration).

The GEOSTAR system has three components: a control segment, a family of relay satellites comprising the space segment, and user terminals. The GEOSTAR control segment, or Central, contains redundant earth stations and a set of computers for network control. The space segment consists of several satellite relays, one of which must have a transmit as well as a receive capability in order to provide two–way service. The user segment consists of compact, inexpensive radio terminals, each with a distinctive identification code. In general the user will be able to compose, store, edit, display, transmit, and receive digital messages.

Here are some of the ways that RDSS has engaged the interest of many nations of the world and which are indicative of its vast potential.

- GEOSTAR is currently operational in the U.S. with a two–way messaging and positioning service that has proven an aid to commercial truckers.
- Positioning and one–way message service will be inaugurated as early as late 1989 for the Caribbean area with two–way messaging to follow in the early 1990s and European coverage expected in 1992.
- GEOSTAR is a commercial venture that can serve its customers on an economical, pay–as–you–go basis, estimated at $45 per month per user, plus an investment or leased cost for compatible terminals.
- Small, cellular radio–sized user terminals offer superior mobility features and adaptability to numerous commercial and government applications.
- The projected capability of GEOSTAR System 3, to serve an estimated 20–30 million users per hour with rapid traffic exchange (3 seconds to 3 minutes), appears attractive for meeting a wide range of user needs.

From

A Concept To Geostar

HOW DID THE RDSS TECHNOLOGY DEVELOP?

Development of the technology for Radio Determination Satellite Service was prompted by a mid–air collision of commercial aircraft in 1978. That collision, in which more than 100 people perished because warning technology was not available, moved Dr. Gerard K. O'Neill, then a professor of physics at Princeton University, to design and patent a space based data communications and precise locating system now known as GEOSTAR. Based on spread spectrum (requiring a wide radio frequency bandwidth) and time difference–of–arrival technologies, GEOSTAR has the potential to provide radio location, radio navigation, and two–way communications from a single item of user equipment.

Dr. O'Neill founded the Geostar Corporation in 1983 to market his invention. Headquartered in Washington, D.C. with a staff of over 80 personnel, the Geostar Corporation operates and manages the system from GEOSTAR Central at this location.

From its earliest days, the Geostar Corporation took steps to provide RDSS in the commercial marketplace, known as GEOSTAR nationally and by other trade names internationally. Technical development of RDSS hardware and software is conducted under license by several leading corporations in industry.

RDSS

Geostar Corporation Headquarters in Washington, D.C.

> ***"I was appalled by the circumstances of the accident and resolved to find a better way to locate aircraft, predict their paths, and warn them of probable collisions. The result was Geostar."***
>
> Gerald K. O'Neill
> Inventor of GEOSTAR
> OMNI Magazine 5/86

Geostar began interim operation of commercial service in the continental U.S. during May 1987. The initial customer base was comprised largely of members of the transportation industry.

International acceptance of RDSS technology and licensing agreements has been achieved with a number of foreign government and private agencies. In June 1987, a European RDSS consortium (LOCSTAR) signed a licensing agreement that marked the first step toward realization of a global RDSS network. Other countries reaching similar arrangements are Australia, Brazil, China, and India.

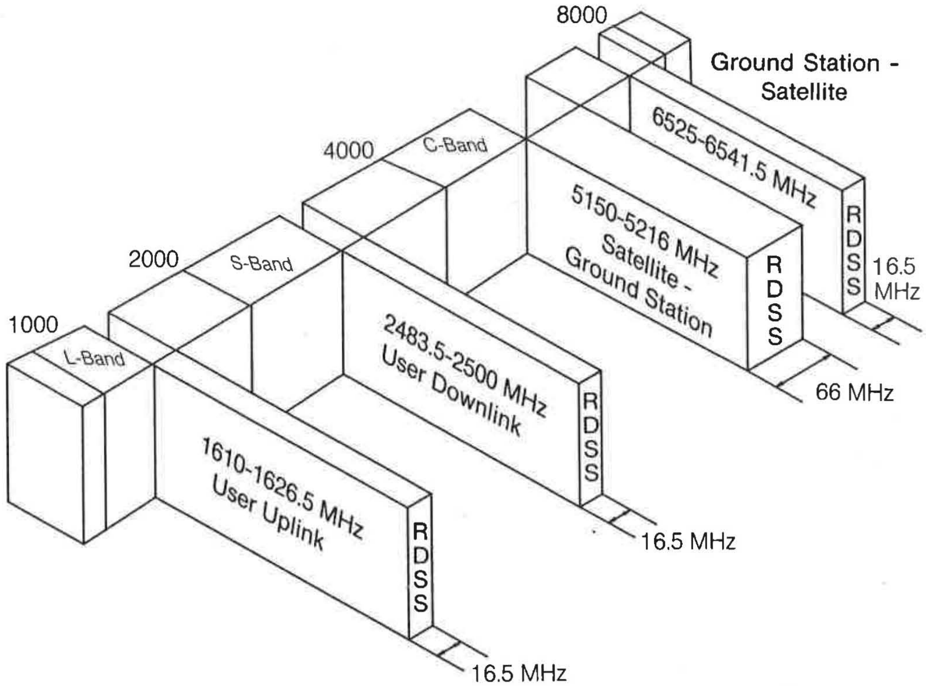
RDSS FREQUENCIES ALLOCATED

The mature configuration of RDSS known as "System 3", with its capability for two–way positioning and data communications, will operate in the L, S, and C–bands of the electromagnetic spectrum.

The fact that RDSS had been awarded the requisite frequencies on an international scale was a significant achievement. This process of acquiring worldwide frequency allocations, which normally takes 10 to 15 years, was accomplished in less than four years.

Development of the RDSS technology to a commercial operation has been rapid. In early 1983, the Corporation filed an application for license with the Federal Communications Commission to allocate a block of the frequency spectrum for RDSS usage, and sought authority to construct and launch a satellite system. In August 1986, the FCC granted Geostar Corporation a license. In 1987 the World Administrative Radio Conference for Mobile Services (Mobile WARC) of the International Telecommunications Union (ITU) held in Geneva, Switzerland, granted RDSS a total of 99 MHz for worldwide use in the following frequency bands:

- 1610–1626.5 MHz (L–Band, user uplink),
- 2483.5–2500 MHz (S–Band, user downlink),
- 5150–5216 MHz (C–Band, satellite to ground station link), and
- 6525–6541.5 MHz (C–Band, ground station to satellite link).



RDSS frequency allocations granted by the ITU carry the following conditions in the three world regions:

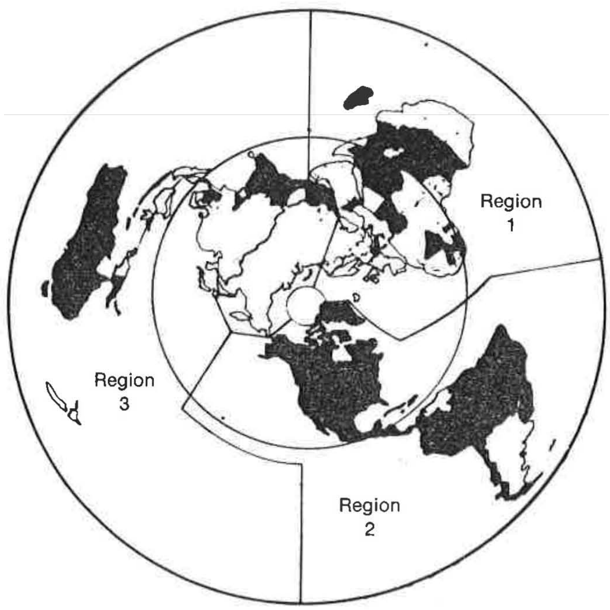
Region 1 – Europe, Africa, Mediterranean, and USSR:

Frequencies were issued generally on a Secondary allocation (non–interfering with Primary services) basis with special caution to protect aeronautical radio navigation in Sweden and defense radio location in France. Primary allocations were declared in 21 nations of Region 1, namely in Africa and the Mediterranean littoral that included Israel and Italy. Primary allocation requires that other services coordinate with RDSS operators in order to avoid harmful interference. The exception was the USSR, which took "reservation" against all RDSS allocations. This action means that the Soviet Union will not protect any RDSS system nor does an RDSS system have to protect any Soviet facility in the relevant L,S, and C band segments.

Region 2 – Western Hemisphere:

Primary allocation was granted throughout North and South

RDSS Frequency Allocations As Granted by 1987 Mobile WARC/ITU



Primary Allocation — First Priority Use

Region 2

All North America & South America
Except Argentina, Venezuela, Cuba

Region 1

Angola	Kenya	Sudan
Burundi	Lebanon	Swaziland
Ivory Coast	Liberia	Syria
Ethiopia	Libya	Tanzania
Israel	Madagascar	Togo
Italy	Mali	Zaire
Jordan	Senegal	Zambia

Region 3

Australia	Iran	Papua New Guinea
Thailand	India	Pakistan

Secondary Allocation — Non-Interfering with Primary Users

Region 2

Argentina, Venezuela

Region 1

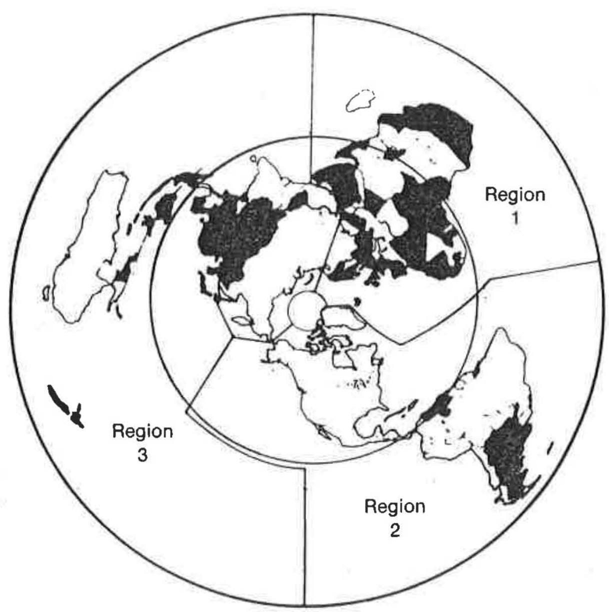
Europe, Africa
Mediterranean — Except those nations under Primary

Region 3

Asia
Pacific — Except those nations under Primary

No Allocation

USSR
Cuba



America except in Argentina and Venezuela, where it is Secondary, and in Cuba, which excluded an RDSS allocation within its territory. Cuba will, however, have to respect the Primary allocations of other Region 2 countries (e.g., the U.S.) once ITU Article II procedures have been completed.

Region 3 – Asia and Pacific:

A Secondary allocation, analogous to Region 1, was granted for RDSS, with six countries declaring it Primary as follows: Australia, India, Iran, Pakistan, Papua New Guinea, and Thailand.

In summary, the needed frequency allocations in the L, S, and C–bands for RDSS technology to proceed have been awarded on either a Primary or Secondary service basis throughout the world except in the USSR and Cuba. Primary allocation assures that no one can interfere with RDSS signals, while Secondary service permits a Primary user to preempt the frequency. However, RDSS spread spectrum transmissions will not likely interfere with other users of the frequency, Secondary allocations, RDSS proponents believe, should also be integrated smoothly.

U.S. SUPPORT SPURS DEVELOPMENT

Development of the Radio Determination Satellite Service in the U.S. received widespread support. The Mobile Services Study Group of the International Radio Consultative Committee (CCIR) provided technical data in the petition for RDSS radio frequencies. The Future Air Navigation System Committee of the International Civil Aviation Organization (ICAO) included RDSS as a candidate system for global air navigation after the year 2000. And law enforcement agencies expressed interest in development of the system. All of the support helped win allocation of the necessary frequencies to allow the development of the system.

Three Segments Make Up

The Geostar System

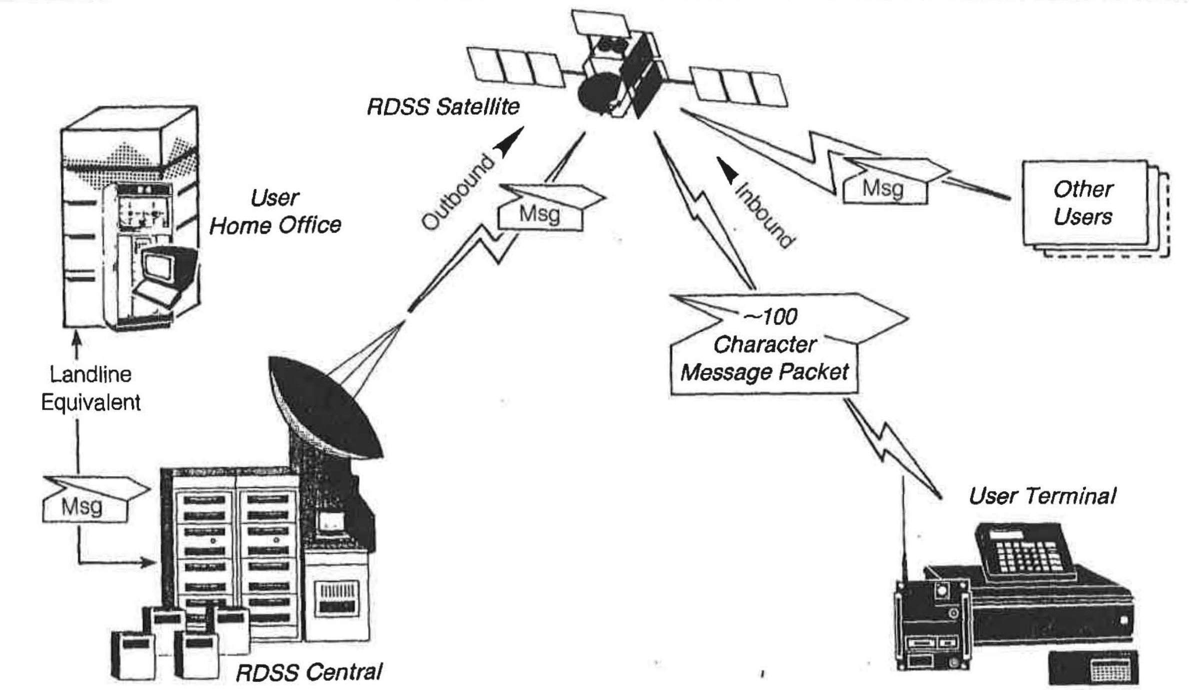
HOW DOES THE GEOSTAR SYSTEM OPERATE?

The GEOSTAR system employs two radio channels, one for carrying messages from a user to Central facility (inbound) and the other for transmitting messages from Central to the user (outbound). Each user can be addressed individually through a unique user terminal identification (ID) code, similar to a telephone number. Every message sent or received over the network includes this code, and only the addressee can receive it.

Thousands of small user terminals with built–in or external antennas communicate more or less simultaneously with a satellite in a "fixed" position over the equator (geosynchronous orbit). Spread spectrum techniques (spreading a signal over a wide frequency bandwidth) coupled with burst transmission (characters grouped as a single unit and transmitted for a very short period) of a high–power digital signal make this possible. A gain factor (increase of signal strength) of over 100–fold, or more than 20 decibels, is achieved through reversing the spreading process. Because the spreading code (analogous to a Zip Code) is known by the user terminal, the radio receiver is able to sort out the traffic from random signals and noise. Also, the receiver is cued to copy the signal at a precise time. This technique is so successful that engineering studies of the GEOSTAR radio signal acquisition capability indicate that a user has a 99 percent probability of acquiring a signal on the first try, with a 90 percent statistical confidence level.

RDSS

RDSS Two-Way Messaging Technique



Sending a message in a fraction of a second

GEOSTAR's Central facility transmits a general "interrogation" signal many times per second. It is addressed to all user terminals through a satellite relay. Each interrogation is called a frame, and there are dozens of frames per second. When the user terminal receives the signal, it responds with a unique binary sequence (an identification code or ID) together with any accompanying digital message traffic. The entire transmission takes only 10 to 40 milliseconds.

Under normal operations, the Central will acknowledge every user terminal transmission in view. To ensure the Central successfully acquires the user's signal, repeated transmissions may be commanded by the Central. After responding to the interrogation signal as many times as prescribed by the Central, each user terminal transmitter is automatically turned off.

Individual users will access the network at different intervals based on need. An aircraft may transmit every few minutes, whereas the interval may be several hours for a truck or automobile. The individual user or his or her home office may request an update, or have the Central change the reporting interval.

Taking less than one second to process a user's message packet, the Central's computers store the message and transmit a brief acknowledgment to the user. Once the message is stored, the Central can relay it to a prearranged destination or a new addressee. Messages originated by an individual user, for example, will be forwarded by the Central to the user's home office. The Central maintains a list of addressees normally accessed by the user, so that traffic can be routed quickly and easily using a technique similar to a telephone speed dialing system.

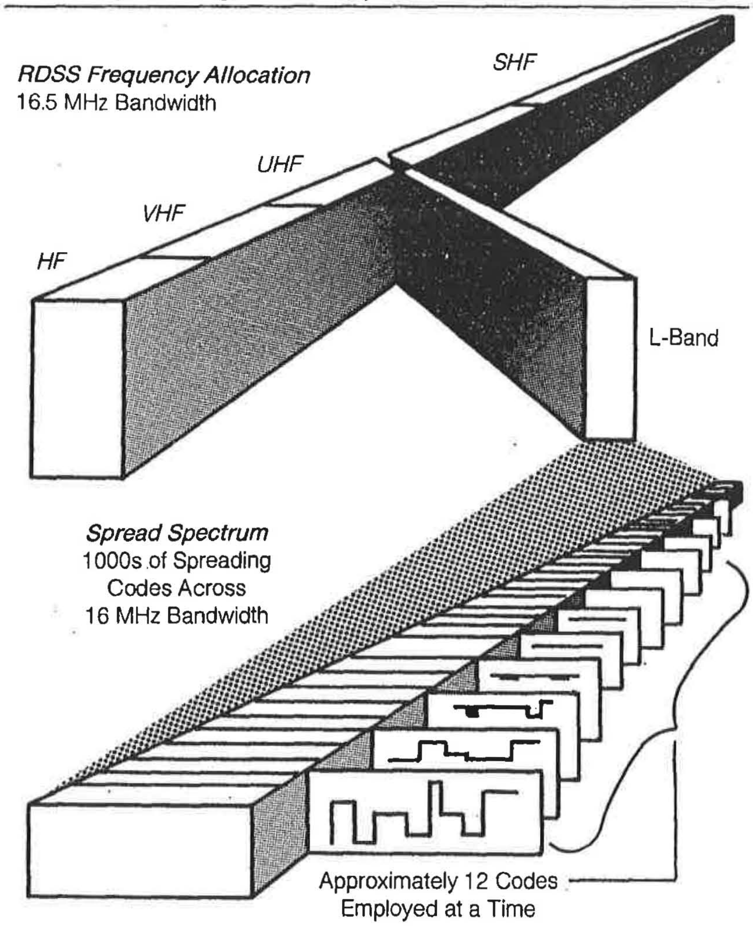
SYSTEM TECHNICAL PERFORMANCE

The GEOSTAR system architecture is based on the use of spot beams, spreading codes, and uniquely identified terminals. While multiple overlapping spot beams enhance user coverage and connectivity, and unique terminal IDs ensure proper message routing, a principal feature of RDSS technology is the employment of spreading codes which provide control over the system and its operation.

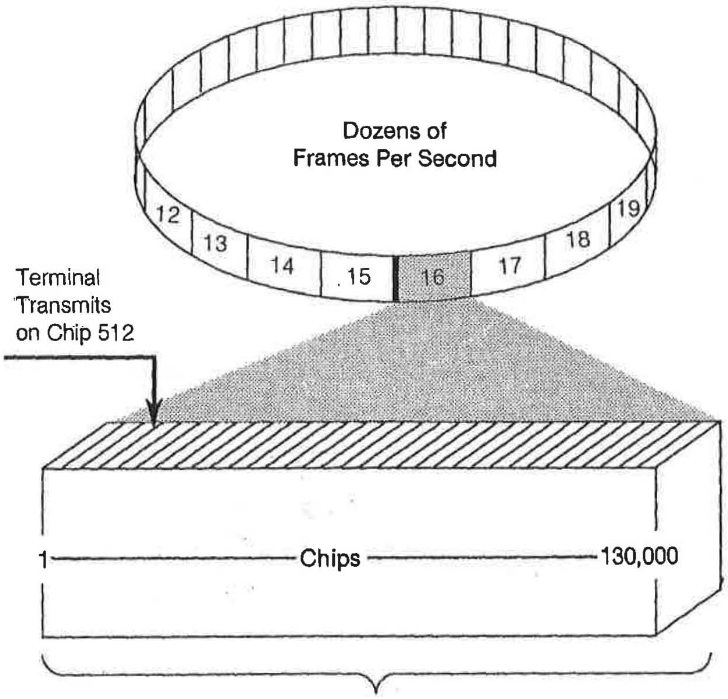
Spreading codes are the principal means for avoiding "message collision" among the various users. Terminals are routinely moved among the available spreading codes as necessary to maintain "load balancing." One code may be used for trucks, another for aircraft, etc., to help differentiate the various classes of users. GEOSTAR Central is capable of acquiring any one of these different codes upon command. For example, users with emergency traffic may be moved to a new code to ensure a better grade of service.

Of the 131,000 spreading codes available, only about 12 will be employed. This is a nominal limit that can be accommodated simultaneously in the 16 MHz bandwidth without causing self–jamming or saturation; the actual number of codes used may range between 10 and 20. The remaining codes may never be used. It is possible that the various nations licensed for RDSS may each employ a different set of codes. In this case, each nation could more effectively control authorized user access. A transient user would have to (physically) sign–in to the respective RDSS Central facility (e.g., LOCSTAR) to be provided the appropriate code. Another option under consideration might require one of twelve spreading codes to be held in common among the nations in order to allow a "visitor" to gain entry. The details of this protocol are being developed.

RDSS Spreading Code Application



RDSS Interrogation Cycle



1 Frame — 16.4 Milliseconds

A user terminal communicates on a partly random basis, consistent with the Central's frame interrogation sequence. Within each 16.4 millisecond frame which consists of about 130,000 "chips" (time slots), a user's terminal automatically begins counting at the start of the frame and, if prompted, transmits on a prearranged chip. Other competing users attempting to gain access to this frame may or may not be jammed. This is due to the difference in time delay for the signal to reach the Central, which recognizes multiple responses to the same chip, but at different relative times. This difference is attributed to the physical distance between the competing terminals, and the differences inherent in each terminal's internal processing delays. A three chip separation (512, 515, 518, etc.) is sufficient for two or more terminals to coexist on the same frame. In this fashion, many message packets can be acquired simultaneously before the system frame is saturated. In any event, if one user is blocked within that 16.4 millisecond event, a simple reentry can be initiated automatically.

SERVICES PROVIDED BY GEOSTAR

Within the United States, the GEOSTAR network will furnish four phases of customer service, Systems 1 through 4. In overseas markets, similar phases of service will evolve as future components of the RDSS system are fielded.

System 1 is an existing interim service capability that will ultimately be abandoned as the RDSS space segment achieves full operational status.

Fielded in June 1988, System 2 provided auxiliary position and one–way message transmission. It was enhanced in 1989 with the addition of a leased C–Band transponder on an existing commercial satellite to enable introduction of two–way message transmission (System 2C).

With the later launching of a dedicated satellite on the Space Shuttle, the fully operational System 3 service will enable two–way messaging and geopositioning. Internetting of various System 3 capabilities around the world is the basis of System 4, from which international RDSS service will emerge.

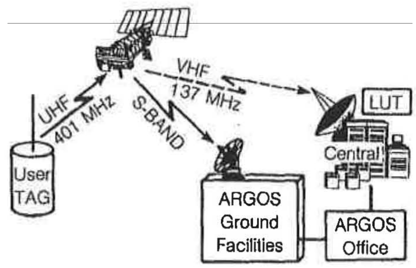
GEOSTAR RDSS Capability Development

System	Fully Protected Service	Coverage	Positioning (Accuracy)	Timeliness	Message Unit	Service Commencement
1.0	World Class	Global	Doppler (5 Mile Avg)	Hours	———	May 1987
2.0	National	North America (Including Caribbean)	Loran C (<1 Mile)	Minutes	Inbound 100 Characters	June 1988
2 Plus	Paging Add on				Variable	Nov 1988
2C	Outbound Data Add On				Outbound 100 Characters*	2Q 1989
3.0	Dedicated	North America & Europe	Satellite Ranging (5-10 Meters)	Seconds	Inbound & Outbound 100 Characters	1991/1992
4.0	Global	Worldwide By Regional System Interconnection				1992

*Maximum 24,000 Character Message Length

System 1

1987



System 1 Service

System 1 service was initiated in May 1987, using low earth orbiting ARGOS (global collection, location, weather system) satellites, a few hundred unique user terminals, and the automated control facilities of GEOSTAR Central. It provides a basic positioning information and one-way transmission capability intended for limited commercial application by the trucking industry. This service will eventually be discontinued as enhanced GEOSTAR services become widely available. Its operation has helped GEOSTAR facilitate and refine RDSS processes and procedures.

System 2 Service

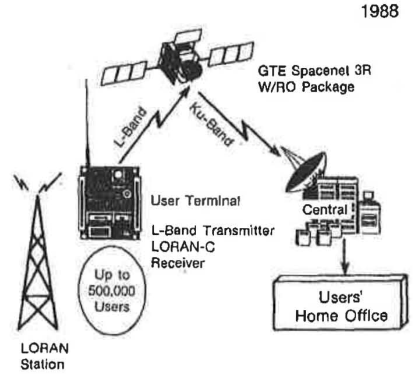
Transmission of positioning information and short, digital one-way messages via satellite constitutes System 2 service. Inaugurated first within the continental United States, it will be expanded in 1989 to Latin America. Operation is supported by a Hughes or Sony user transmitter, the Federal Government's LORAN-C navigation network, and GEOSTAR's satellite relays and Central earth station.

Designed for installation in trucks, trains and other mobile units, compact radio terminals located inside a vehicle can send position data, status or alarms, and messages to GEOSTAR Central in Washington, DC. Data is continually received and processed at the Geostar computer facility and delivered to the users' headquarters locations, using standard commercial communications links. The entire process takes only a few seconds.

In actual operation, the user terminal automatically transmits a short message containing longitude and latitude data as reported by an integral LORAN-C receiver. With an optional keyboard and display unit, the user can prepare messages of up to 100 characters in length. The inbound data is processed by the Central and delivered to a computer mailbox, from

System 2

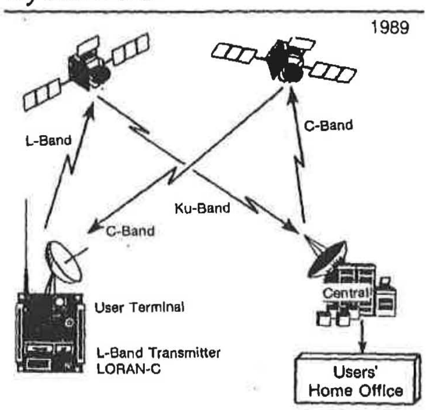
1988



which the user can arrange dial–in or dial–out connections or real–time continuous links for retrieval.

Enhancements to System 2 include the addition of a second satellite to provide a C–Band outbound message transmission capability at 100 characters per packet (System 2C) to complement the L–Band inbound existing feature of the basic System 2. GPS or Transit positioning services also will be offered as options to LORAN–C, for improved accuracy or coverage in future Systems 2G and 2T, respectively. Geostar System 2C, introduced in mid–1989, features two–way messaging between the mobile user and Central/home office using a commercial communications satellite outbound link, a compatible C–Band radio receiver, and a small hand–sized satellite dish antenna. An optional voice synthesizer is also being offered to translate messages into spoken words. When the user's home office sends a message, the terminal will display the message on a small computer screen in the vehicle equipped with an RS–232 port for an optional printer if hardcopy is desired. All inbound traffic will be automatically acknowledged. The user or driver will be able to send a message to the home office in the normal manner. This introductory two–way service is currently being implemented by many commercial trucking firms.

System 2C



Additional enhancements include System 2–Plus and the Geostar/ARGOS Integrated Terminal Service (GAITS), both of which have been activated. System 2–Plus incorporates a pocket pager in the user terminal for receiving brief messages in selected urban areas. GAITS provides a System 1/2 crossover capability in the Caribbean area to enable extended coverage to vessels entering and leaving alternate GEOSTAR satellite coverage.

System 3

When fielded, System 3 service will offer a two–way transmission capability and will identify locations accurately within approximately 7 meters. This enhanced GEOSTAR service should become available starting in 1992. However, the availability of System 3 service depends upon the launch schedule and the viability of new satellites to provide coverage over much of the Western hemisphere.

When System 3 service is fielded, each transmission will be relayed through a Central in a dual hop mode. The Central interrogates, and the user responds. Central is capable of accommodating multiple frames per second for time division multiple access, and of using code division multiple access spread spectrum techniques. It is estimated the system can ac-

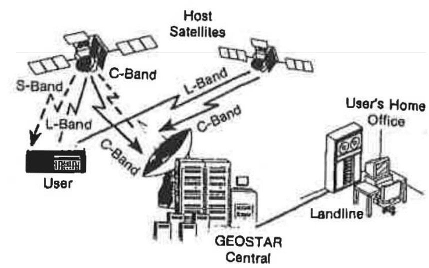
> *"...it is possible to envisage a new age of mobile communications ... operated as part of a worldwide network."*
>
> Martin Rothblatt, Geostar President
> Satellite News 10/31/88

cept more than 100 packets per frame, or nearly five million messages per hour in one spot beam. The fielding of a dedicated satellite, with its 8 spot beams, will permit the System 3 inbound capacity to increase to 20–30 million packets per hour.

In System 3, position information will be obtained through a signal time ranging technique integral to the system, rather than relying upon external sources such as LORAN, GPS, or Transit.

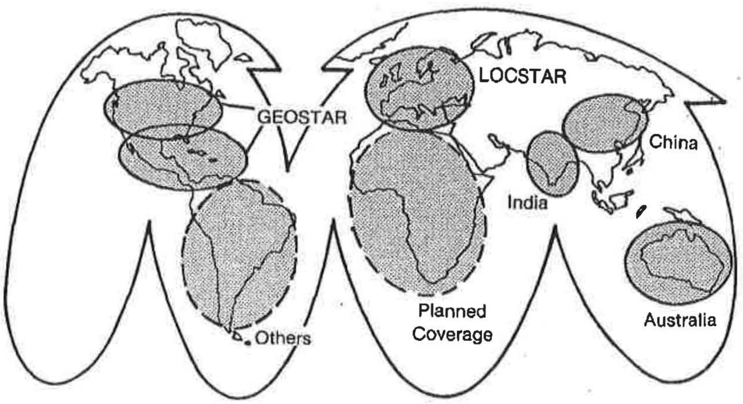
System 3

1991



- Two-Way Messaging
- RDSS Geolocation
- 30 Million Packets Per Hour

System 4



- Internetting of Regional RDSS Systems
- International Standards
- Evolving Participation

System 4

Internetworking of regional RDSS System 3 coverages forms the basis of a System 4 service. International standards are being developed to ensure worldwide system compatibility, including standard protocols, message formats, and spread spectrum techniques. Efforts are underway to define employment concepts that will accommodate internetworking of national RDSS systems. A number of different spreading codes may be employed in the worldwide system and between potential RDSS competitors. To be determined is the way a user will be able to transition between these national or regional user communities and the speed of service to process and disseminate traffic across international RDSS boundaries. System 4 service is envisioned to become operational in 1992 with the inauguration of the LOCSTAR European RDSS service.

SENDING MESSAGES

In North America, GEOSTAR System 2 initiated the sending of one–way messages (user–to–Central) in 1988; System 2C introduced limited two–way messaging in 1989; and System 3 is scheduled to offer full two–way messaging in 1992. In Europe, the LOCSTAR RDSS system is expected to be capable of one–way message service in 1991 and two–way service beginning in 1992. Subsequently, two–way message communications is planned on an international (Western Hemisphere and Europe) basis and ultimately worldwide, employing six or more satellites.

The estimated time for a message to transit the system is expected to range from three seconds (priority) to three minutes (routine), based on calculated engineering analyses and design criteria. Data transmitted through the system may be archived in GEOSTAR Central for a nominal 30 days, or as specified by the user for retrieval purposes. Message traffic can be received, processed, and stored at the user's home office or the Central.

The GEOSTAR system has been designed to accommodate four levels of message precedence, or priority. The precedence levels are:

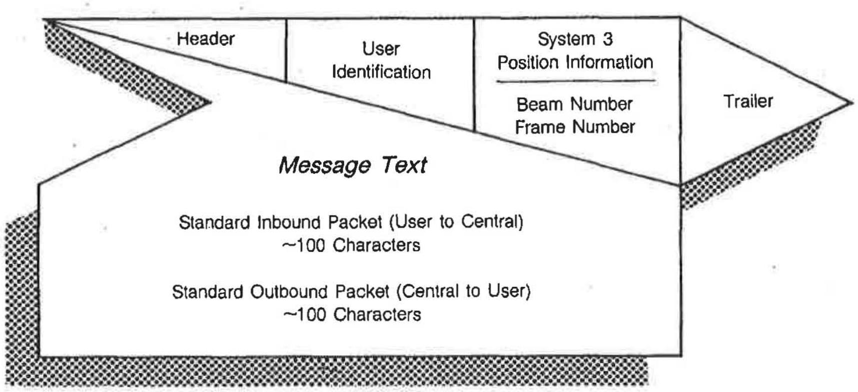
0 – Low
1 – Normal
2 – Immediate
3 – Emergency

User Identification

For message routing purposes, each terminal has a unique digital identification code. The ID block consists of a 48–bit digital sequence that is assigned permanently to each user terminal. This block identifies unit type (System 2 or 3) and manufacturer as well as the model number, lot number, and unit serial number that is unique to each terminal.

The initial System 2C and the full two–way System 3 will permit a message to be

Message Packet Format



"... we can tell our customers ... where their shipments are with precision."

Mayflower Spokesperson
Transport Topics 5/25/87

sent from any user to any other user within the coverage area, whether the addressee's terminal ID is known to the sender or not. The Central maintains a "look-up" table that equates a terminal physical ID to the user's actual identification.

Formats

Message traffic within RDSS technology is formatted digitally into message packets, which contain a total of 1,024 bits each, (with the actual message occupying up to 105 characters or bytes at eight bits each). At a transmission rate approximating 16 Kilobits per second, the average (50-character) packet length can be transmitted in approximately 25 milliseconds. In System 2, message transmissions are repeated usually twice with a one-minute separation between bursts. The actual number of repeats and length of separation between transmissions are selectable. In Systems 2C and 3, the terminal exchanges acknowledgments with the Central.

In the GEOSTAR system, a typical message format in simplified terms would appear as follows:

- Header
- Addressee(s)
- Text (free narrative up to 100 characters)
- Header repeat verification or CRC cyclic redundancy check for error detection
- Trailer

There are, however, slightly different formats specified for inbound messages from a user to Central and outbound messages from Central to user as well as between the Central and the user's home office. Using High-level Data Link Control (HDLC), these format variances are employed principally for the purposes of network management, service efficiency, and user accommodation.

A comparison of message packet formats is illustrated graphically in the accompanying figure, which depicts in simplified terms the typical format for a message in free text and the three types of packet formats: inbound, Central to or from home office, and outbound. The user is concerned only with the message portion of the packet consisting of the designated addressee(s) and text. The remainder of the packet is overhead, which is transparent to the user but essential for network management.

When the subscriber packet is processed and relayed by Central to the user's home office, its original format is altered including a header to announce what is coming, the transmitter's ID to identify the sender, the block sequence number, hardware and port status, an added date-time stamp, the user's position (which is optional), message priority, and the text. The time required by the Central to receive and process a subscriber packet for transmission to the home office is approximately one second.

The standard inbound packet consists of the following: a route identification used to distinguish system type and path routing; a physical ID that denotes the user's call sign or radio address; a block sequence number for message accountability; and a status indicator of the terminal hardware operating condition. In addition, an indicator is used to designate the serial port for peripherals. In the positioning field, the packet contains information

Typical Message Format:

Header	Addressee(s)	Text	CRC	Trailer

Subscriber Inbound Packet (User to Central):

Route Identification	Physical Identification	Block Sequence #	Status	Positioning Data	Text	Timing Data

Central to User Home Office Packet:

Header	Transmitter's Identification	Block Sequence #	Status	Date Time Stamp	Position (Optional)	Priority	Text

Standard Outbound Packet (Central to User):

Beam Number	Frame Number	Address	Protocol	Data/Text	CRC

on the user's location. For System 2, this will reflect LORAN or GPS or Transit data, but for System 3 it will specify the frame number and beam number for the transmission and path, with timing data added by the Central. The actual message text is called the applications packet.

The standard outbound packet from Central to user will consist of the following: the beam and frame number as needed to establish the path via the satellite to the user's location, the address, a protocol field, the message text, and the header repeat confirmation or cyclic redundancy check for error detection.

Capacity

The messaging capacity of the system is measured in terms of user population. This capacity varies directly with the capability of the satellite and the computing power of the Central. The number of messages that can be processed by the system (information throughput) is difficult to quantify. Several factors must be taken into consideration including the number of addressees to be reached and the number of characters per transmission. Also, inbound and outbound traffic flows at different speeds, and the physical protocol that is established between the Central and the home office further determines the speed of service.

RDSS technology appears to offer an excellent potential capacity for messaging. The capacity of a single receive only spot beam on the one–way satellite is ultimately limited by code interference and can accommodate an estimated 160 near–simultaneous users, with an average packet duration of approximately 25 milliseconds. Thus, after "contention" reduction by a factor of two, the calculated capacity of System 2 is approximately 5 million messages per hour per single spot beam. This figure would increase four to six–fold using eight spot beams on a satellite, the increase being mathematically limited due to beam overlap. For System 2C, which employs two one–way transponders on separate satellites (L–Band inbound and C–Band outbound), each with a single spot beam, the outbound capacity will be limited to approximately 500,000 messages per hour at 2400 bps transmission rate. For the RDSS System 3 dedicated satellite using eight spot beams at 125 Kbps, the theoretical capacity is calculated to be 4 million outbound messages per hour and 20–30 million inbound messages per hour.

Between the Central and the user's home office, the capacity is dependent upon the specific technical interface and the type of landline utilized. This is a nominal 2.4 Kbps, but can be higher when needed to meet user requirements.

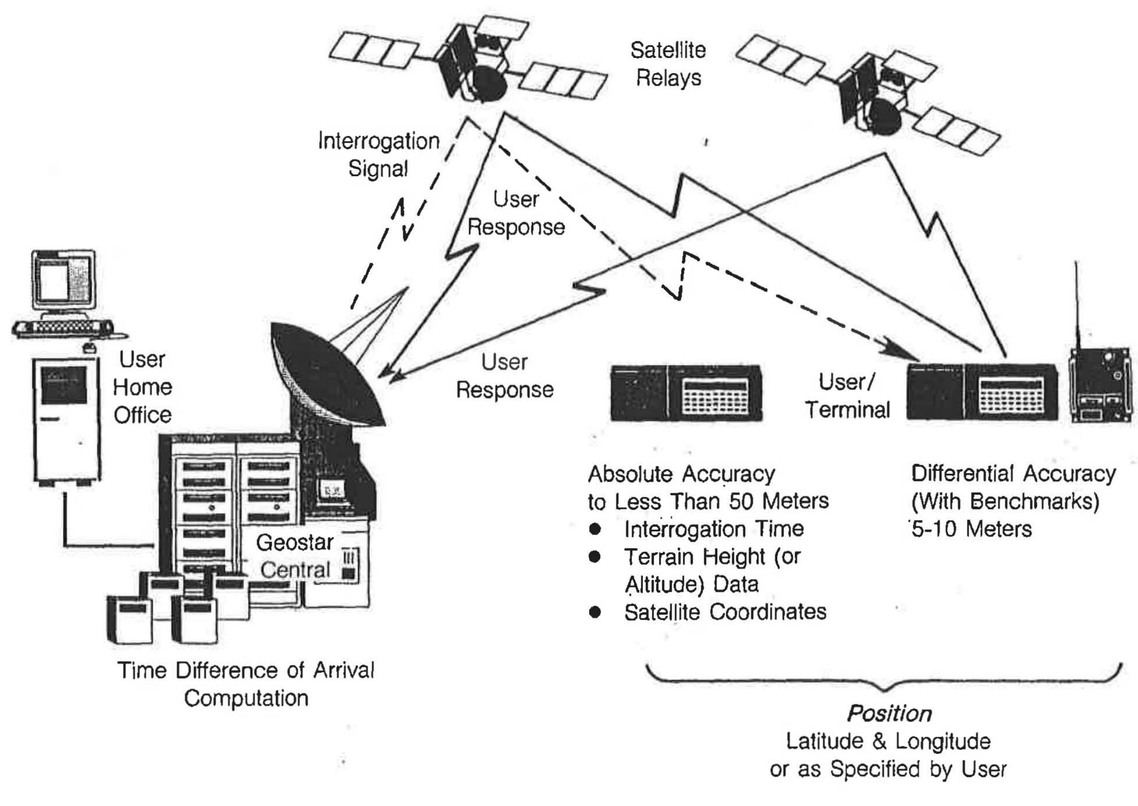
From an individual user's perspective, the inbound capacity may be constrained principally by battery performance, or by heat build–up in the small terminal caused by transmitter power. However, this is not considered serious for normal utilization, as the GEOSTAR system is designed to handle large volumes of traffic. Traffic forecasts by system developers are based on the premise that the typical user will transmit an average of one message packet per hour.

POSITIONING

The RDSS positioning capability and technique varies with system configuration. In Systems 2, 2C, 2G, and 2T, position information is derived from external sources, namely LORAN, GPS, or Transit. In Systems 3 and 4, position information will be obtained through a signal time ranging technique integral to the system. Only Systems 3 and 4 will provide a positioning capability based exclusively on RDSS technology.

The position location process for System 3 and 4 begins with a timing marker signal that is sent out to all users many times per second. The user's response will pass through two relays on separate geosychronous satellites, causing the return signal to arrive at the Central at slightly different times. These two times are then compared with the initial interrogation signal to determine round–trip range from the Central to the user. The two range measurements are combined with altitude information from a digital terrain map located at the Central. Aircraft

System 3 Positioning Technique



"Dispatchers can see just where their trucks are by glancing at a map on a IBM or Apple personal computer screen."

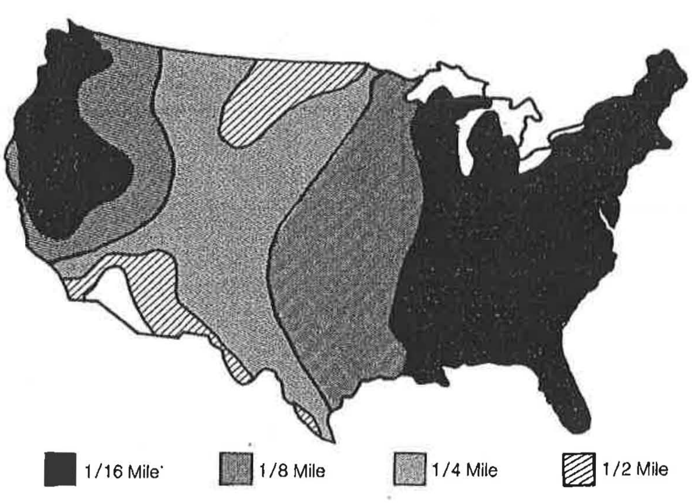
U.S. News & World Report 3/21/88

users may provide barometric altimeter readings to Central for use in position calculations in lieu of the terrain map.

After the position calculation is performed at Central, it may be passed to the user's home office or transmitted back to the user as an addressed digital message. Position data can be displayed in terms of latitude and longitude, relative distances from a reference point, or be shown on a map. The complete transaction, from the time that the initial interrogation signal is transmitted through relay to the user/home office, can occur as rapidly as one second.

Position interrogation and response will be conducted directly between the RDSS Central and the user. This method provides position accuracy to approximately 30–50 meters of the user's actual location in potentially all areas of the globe, but with "benchmarking" techniques described later, resolution is expected to be 5 to 10 meters. Near the equator (within 2 degrees north or south) geometry causes the accuracy to degrad to approximately 100 meters.

LORAN-C Coverage



Initial RDSS Positioning

In System 1, signals are relayed fror the remote user through a National Oce anic and Atmospheric Administratio (NOAA)/ARGOS satellite ground statio to GEOSTAR Central. The Central dete mines, through doppler sampling tech niques, the position of a mobile user within an average of 5 miles. Due to th small number of demodulators on th ARGOS satellite, service is limited about 250 users on System 1, providir five to seven position fixes per day f each user.

In System 2, user terminals have a on–board LORAN–C capability for pos tioning. Self–generated latitude–lonç tude data is transmitted to a geostationa satellite over North America. The satelli downlinks the data directly to GEOSTA Central for relay to the user's home offic Recent tests have shown System 2 pos tioning accuracy of approximately 2 meters for a moving boat in high seas.

The LORAN–C system used by Sy tem 2 provides regional coverage over a proximately 10 percent of the wor LORAN–C covers most of North Ameri and the surrounding waters and, as illu trated, provides positioning with an acc racy that varies between 1/16 and 1/2 m (nominally 300 meters), depending up the user's distance from the LOR broadcast station. With LORAN static located along the Continental Unit States east coast, and to a lesser ext on the west coast, coverage/accuracy generally best in the seaboard areas a worse inland and in the southern Car bean reaches.

Two other geopositioning systems that are planned as options to LORAN are the government's Global Positioning System (GPS) and the older Transit Satellite Navigation System. The NAVSTAR GPS utilizes spread spectrum signals to transmit time and position data from a multi–satellite network. GPS will have a total of 21 satellites in orbits of over 13,000 miles altitude to provide eventual worldwide coverage. GPS orbits are configured to allow four or more satellites to be visible to a receiver at any point at or near the earth's surface, which will provide sufficient signal data to determine the three–dimensional position and velocity of the user's receiver. Launched in the 1960s, Transit has demonstrated the practicality of employing radio satellites to provide a universal, all–weather, common–grid positioning reference. Transit has a half–dozen satellites orbiting at an altitude of 672 miles and coordinated by a complex of ground control stations. A comparison of the three navigation/position location systems is shown below.

RDSS Positioning Technique

When System 3 becomes operational, system–wide interrogation, transmitted simultaneously with outbound messages, will be sent every 16.4 milliseconds to all users from GEOSTAR Central through one of the relay satellites. The general interrogation and outbound messages addressed to users will be modulated with an 8 mega–chip pseudo-noise (PN) direct spreading sequence or, modulated into a 16 MHz PN spread spectrum signal. All user transceivers in line of sight of the transmitting satellite will remain locked on to this outbound PN stream of interrogations and messages.

To increase system capacity, users will not be interrogated individually, but will respond to one of many system–wide interrogations. The rate of response will be determined by an internal inhibit time stored in the memory of the user transceiver. The nominal value for the inhibit

Navigation System Comparison

System	Position Accuracy (m)	Velocity Accuracy (m/sec)	Range of Operation	Operation
GPS	16 3 Dimensions	0.1	Worldwide	Operational worldwide with 24-hour, all-weather coverage
LORAN-C	300	——	U.S. coast, continental U.S., and selected overseas areas.	Operational with localized coverage. Limited by skywave interference.
Transit	200	——	Worldwide	Approximate interval between position fixes is hourly. Not useful for high speed vehicles.