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GEOSTAR'S SYSTEM ARCHITECTURES

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ABSTRACT

Geostar is currently constructing a radiodetermination satellite system to provide position fixes and vehicle surveillance services, and has proposed a digital land mobile satellite service to provide data, facsimile and digitized voice services to low cost mobile users. This paper reviews the different system architectures for these two systems.

INTRODUCTION

Geostar is a start-up company formed in 1983 to provide radiodetermination satellite service (RDSS). The FCC has licensed its wholly owned subsidiary, Geostar Positioning Corporation, to construct and operate an RDSS system to serve the United States. Initial service began in June 1988, and Geostar is proceeding with the construction of three high capacity, spot beam RDSS satellites scheduled for launch in 1992. In 1988, Geostar formed a new subsidiary, Geostar Messaging Corporation, to develop a digital land mobile satellite system (DLMSS).

RDSS ARCHITECTURE

Geostar's RDSS system will provide radiolocation, radionavigation and ancillary two-way messaging services to mobile units with omnidirectional antennas. The system will consist of three geosynchronous satellites. The outbound and inbound links between the user terminals and the central control station utilize direct sequence spread spectrum transmission at a 8 mbps chipping rate. Table 1 presents additional details. A combination of CDMA and TDM techniques are utilized in the system to provide the capability to support over 16 million users.

In the RDSS system, a continuous outbound signal is transmitted to provide time reference marks and an outbound time division multiplex data stream. To determine the position of a mobile unit, the mobile unit retransmits one of the time reference marks, adding its unique identification code, through two or more geosynchronous RDSS satellites. The position of the mobile unit is calculated at the central earth station from the round trip propagation times through three satellites, or by the round trip propagation times through two satellites and altitude information obtained from a digitized terrain map or on-board altimeter. The relative positioning accuracy of the RDSS system is less than ten meters and the absolute ranging accuracy is under fifty meters.

	OUTBOUND	INBOUND
Information Rate	125 Kbps	15.625 Kbps
Forward Error Correction	rate -1/2, K=7 convolutional	rate -1/2, K=7 convolutional
Chip Rate	8.000 Mcps	8.000 Mcps
Technique	Direct Spread of BPSK data	Direct Spread of BPSK data
Decoding	Soft Decision MLD	Soft Decision MLD
PN Code	2^{17}-1 Mersenne	Gold Codes

TABLE 1. RDSS SIGNAL PARAMETERS

The outbound channels carry interrogation signals / time reference marks that are time division multiplexed with calculated positions and ancillary messages to the mobile terminals at the central earth station. The time reference marks are defined by the outbound channel framing structure. A separate channel is uplinked for each of the eight downlink spot beams to the mobile terminals. Each outbound channel has a bandwidth of 16.5 MHz, corresponding to the bandwidth received by the mobile terminal. Eight uplink channels are transmitted from a central earth station in the 6528 - 6607 MHz band (four channels in each of horizontal and vertical polarization.) Each of the downlink channels is transmitted at 2491.75 MHz with a nominal bandwidth of 16.5 MHz over one of the eight spot beams covering the United States. The characteristics of the PN-code allow discrimination between two outbound channels in areas where the spot beams overlap.

An inbound transmission consists of a short (20-80 millisecond) packet. The timing of the inbound transmission is synchronized to the outbound time reference marks to insure a constant mobile terminal delay for accurate ranging. The user's identification code and any ancillary message are included in the inbound packet. An inbound packet can be initiated at the request of the mobile user, at automatically preset intervals, and/or in response to an interrogation from the central earth station.

All inbound transmissions from the mobile units occur at 1618.25 MHz with a nominal bandwidth of 16.5 MHz. The transmissions from each of the eight uplink spot beams from the mobile users are frequency division multiplexed into the downlink channels to the central earth station in the 5150 - 5216 MHz band (four channels on horizontal polarization and four channels on vertical).

Table 2 presents the nominal link budget for Geostar's RDSS system. The I_0 term for RDSS accounts for interference caused by RDSS transmissions in other beams in the system and from other RDSS systems operating in the same frequency bands as Geostar.

	RDSS	DLMSS	
Downlink to Mobile			
Data Rate	125 Kbps	1.2 Kbps	4.8 Kbps
Coding	rate -1/2	- -	- -
Modulation	BPSK	BPSK	BPSK
Chip rate	8.0 Mcps	N/A	N/A
Satellite EIRP	51.0 dBW	25.5 dBW	31.5 dBW
Path Loss	191.9 dB	188.2 dB	188.2 dB
Misc. Losses	0.9 dB	0.6 dB	0.6 dB
Receive G/T	-21.0 $dB(K^{-1})$	-20.8 $dB(K^{-1})$	-20.8 $dB(K^{-1})$
C/N	-5.3 dB	10.6 dB	10.6 dB
C/N_0	66.9 dBHz	44.4 dBHz	50.4 dBHz
$C/(N_0+I_0)_{tot}$	60.6 dBHz		
E_b/N_0	9.6 dB	13.6 dB	13.6 dB
Req. E_b/N_0	5.5 dB	9.6 dB	9.6 dB
Uplink from Mobile			
Data Rate	16.5 Kbps	1.2 Kbps	4.8 Kbps
Coding	rate -1/2	- -	- -
Modulation	BPSK	BPSK	BPSK
Chip rate	8.0 Mcps	N/A	N/A
Mobile EIRP	18.3 dBW	-0.2 dBW	5.9 dBW
Path Loss	188.1 dB	187.7 dB	187.7 dB
Misc. Losses	0.6 dB	0.6 dB	0.6 dB
Receive G/T	+3.0 $dB(K^{-1})$	+4.3 $dB(K^{-1})$	+4.3 $dB(K^{-1})$
C/N	-10.9 dB		
C/N_0	61.3 dBHz	44.4 dBHz	50.4 dBHz
$C/(N_0+I_0)_{tot}$	52.7 dBHz		
E_b/N_0	10.7 dB	13.6 dB	13.6 dB
Req. E_b/N_0	5.5 dB	9.6 dB	9.6 dB

TABLE 2. LINK PARAMETERS

One limitation on the inbound capacity of Geostar's RDSS system is the number of simultaneous (overlapping) transmissions that can be supported over the channel. This value can be calculated from formula (1).

$$[E_b/N_0]_{req}^{-1} = [E_b/N_0]_S^{-1} + (K-1)[E_b/N_0]_{cn}^{-1} \qquad (1)$$

where

$[E_b/N_0]_{req}$	=	required E_b/N_0 (5.5 dB for 10E-5 BER)
$[E_b/N_0]_S$	=	actual E_b/N_0 for a single packet
K	=	number of overlapping packets
$[E_b/N_0]_{cn}$	=	Code noise due to multiple access
	=	1.5*(spread ratio) = 28.8 dB

For Geostar's RDSS system, the nominal inbound E_b/N_0 is 10.7 dB at the central earth station. Inserting this value into formula (1) and solving for K yields a value of approximately 150 simultaneous (overlapping) inbound packets per beam. Assuming a system average of one transmission per hour from every mobile unit, this capacity is more than enough to support at least 16 million users of Geostar's RDSS system.

DLMSS ARCHITECTURE

A newly formed subsidiary of Geostar, Geostar Messaging Corporation, proposed its DLMSS in 1988 to operate in the bands 1530-1544 MHz and 1626.5-1645.5 MHz. These frequencies are different from the 1545-1559 MHz and 1646.5-1660.5 MHz proposed by the American Mobile Satellite Consortium for its mobile satellite system. Thus, there is no frequency overlap between these two mobile satellite systems.

Geostar's DLMSS system is based on the provision of 1200 to 4800 bps transmissions to and from user terminals with omnidirectional antennas. Each of the two DLMSS satellites will have eight spot beams covering all 50 states (six covering the continental U.S. and separate beams for Alaska and Hawaii), FDMA, and on-board signal processing and switching. The objective of this DLMSS architecture is to reduce the power requirements of the user terminals to levels that are supportable with handheld units.

Table 3 presents typical parameters for the DLMSS mobile units. The services provided to users will include data, facsimile and compressed digitized voice. Although BPSK is specified at the moment as the type of modulation due to its economy and ease of implementation, other forms of PSK modulation will be studied before a final choice is made.

Antenna Coverage	Nearly Omnidirectional
Antenna Gain	3dBi (20°-60° elevation) (0°-360° azimuth)
Transmitter Output Power	0.6-2.3 watts (at antenna)
EIRP	0.0-5.9 dBW
Data Rate	
Communications	1200-4800 bps
Outbound Orderwire	9600 bps
Modulation	BPSK

TABLE 3. DLMSS MOBILE UNIT CHARACTERISTICS

Link parameters for DLMSS are also presented in Table 2. Based on these link budgets and the characteristics of the planned DLMSS satellites, a total of 100 4800 bps and 1250 1200 bps channels can be supported simultaneously by each of these DLMSS satellites.

The Geostar DLMSS system is planned to operate in the frequency bands currently used by INMARSAT. Although conventional frequency sharing techniques, such as r.f. carrier frequency planning, may permit both systems to co-exist through the mid-1990's, Geostar has proposed reverse band operations to allow both systems to have full access to the band in later generations. This approach allows orbit and frequency re-use between INMARSAT global satellites serving ships at sea and spot beam DLMSS satellites serving land users in the United States, even if the mobile units in both systems use omnidirectional antennas. However, further study is needed of the techniques needed to avoid mutual interference when mobile units using these bands in reverse directions are operated in the same area.

CONCLUSION

This paper presents a brief description of Geostar's RDSS and DLMSS systems. Both are intended to provide digital satellite services to low cost user terminals which use omnidirectional antennas. However, the system architectures and link parameters used in each of the systems is different because of the different missions of the two systems. RDSS uses spread spectrum and CDMA techniques primarily to obtain increased precision in the time measurements needed for accurate ranging (and in part to achieve band sharing with terrestrial services and other RDSS systems). DLMSS, on the other hand, will use more conventional FDMA and BPSK techniques.

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