

A Land Mobile Satellite Data System

John D.B.Kent
Canadian Astronautics Limited
1050 Morrison Drive
Ottawa, Ontario K2H 8K7
Phone: 613-820-8280
FAX: 613-820-8314

ABSTRACT

The Telesat Mobile Incorporated (TMI) Mobile Data System (MDS) has been developed to apply satellite technology to the transportation industry's requirement for a fleet management system. It will provide two-way messaging and automatic position reporting capabilities between dispatch centres and customers' fleets of trucks. The design has been based on the Inmarsat L-Band space segment with system link parameters and margins adjusted to meet the land mobile satellite channel characteristics. The system interfaces with the Teleglobe Des Laurentides earth station at Weir, Quebec. The signalling protocols have been derived from the Inmarsat Standard C packet signalling system¹ with unique trucking requirements incorporated where necessary.

SYSTEM DESCRIPTION

The system topology is illustrated in Figure 1. and the HUB equipment connectivity in Figure 2. Fleets are connected to the central HUB via terrestrial (leased lines, dialup facilities or X.25 data accesses) or VSAT systems. The system connectivity maps each dispatch centre to a fleet or subfleet(s) of mobiles. Each mobile has an association with only one dispatch centre. The mobile earth terminal (MET)

identifier then becomes the only routing indicator needed to address or identify the originator or addressee of a one-to-one message.

Four classes of messages are utilized in the MDS: general messages of up to 121 bytes for outbound messages and 129 bytes for inbound messages, coded messages which are a set of 32 pre-selected messages, 32 pre-formatted message with blank fields to be filled in by the operator and broadcast messages. Fleet or subfleet broadcast messages from the dispatch centre in the outbound direction are routed to groups of METS whose association is established when the MET logs-on the system.

SYSTEM ELEMENTS

The major hardware elements in the HUB system are the STARMaster system switch (SS), redundant VAX 3300 Network Control Processors (NCP) and Single Board Computers (SBC) Satellite Protocol Processors (SPP), the PACX 200 Remote Switch and the Channel Units. Messages from dispatch centres are routed from the incoming terrestrial circuits to the on-line NCP via the SS. The NCP contains the dispatch centre records, fleet and terminal information and system configuration data. Historical records are also maintained in the

NCP for billing and network management purposes. Incoming messages are processed by the NCP and forwarded to two queues (Priority and Routine) to the SPP. The NCP also maintains the position reporting register and assigns channels, slots and slot intervals to the MET's at log-on for position reporting messages.

The two elements of the HUB are interconnected by four 9.6 kbps terrestrial routed lines, backed up by a single redundant line. The remote switch configuration is controlled by the NCP and lines and channel unit grouping are changed via a 2.4 kbps dialup orderwire.

PROPAGATION AND SYSTEM MARGIN

The land mobile satellite channel is characterized by a line-of-sight (LOS) component, a multipath-path component and shadowing or blockage of the LOS component. The LOS combined with the multi-path form the fast fading component which follows a Rician distribution and the shadowing results in a slow fading component with a log-normal distribution. Figure 2² shows the cumulative probability distribution function for typical land mobile satellite paths in the Ottawa, Ontario area.

The limited satellite EIRP available at L-Band (21.6 dBW) and the relatively wide bandwidth available per channel (5 KHz), in relation to the channel data rate, indicated that coding should be utilized to correct errors introduced by the rapidly changing channel characteristics. To improve the performance of the coding the outbound frame is interleaved in a 64x162 matrix thus spreading burst errors throughout the frame. The selected coding system was rate 1/2 convolution coding with a

constraint length of 7 with 3 bit soft decision Viterbi decoding. The inbound frame is not interleaved due to its short duration (527 ms); however, it is coded as per the outbound channel. The margin and data rates on the inbound channels are adjusted for the lack of interleaving.

FRAME STRUCTURE AND MESSAGING

The outbound and inbound channel and packet structure is shown in Figure 4. A single outbound TDM channel is used on the forward link with a frame period of 8.64 seconds. A 128 bit unique word indicates the start of frame and is followed by a 112 bit bulletin board which includes the system identifier and network information. The inbound channel descriptors (ICD) provide the acknowledgement status of the previous frame (ACK/NACK) register and the reservation status of the 14/28 slots in the position reporting and messaging channels three frames ahead. This is necessary due to the depth of interleaving and the time required for decoding and descrambling. The message packet length is established by the length of the message. In the event of a message overlapping two frames, the message is carried over to the first information packet of the next frame. If the frame has excess capacity, the unused space is padded out with dummy zeros. The outbound message includes the reservation of an inbound channel and slot on which the MET sends the message acknowledgement.

Optimization of the system throughput is accomplished by utilization of a combination of slotted Aloha and reservation Aloha for inbound messages. The inbound channels, up to a total of 14 messaging and position reporting channels, are divided

into 14/28 slots depending on the channel data rate of 300 or 600 bps. The channels are divided into position reporting and general messaging channels which are subdivided into retry and priority message slots. Initial log-on to the system and the first packet of a single or multi-packet message utilize a slotted Aloha protocol with subsequent packets sent in reserved slots controlled by the satellite protocol processor (SPP) through the ICD. If a fade or other loss of the inbound packet occurs, indicated by a cyclic redundancy code (CRC) error, the ICD is set to NACK and the reservation is extended for another packet by the SPP. The MET acknowledges the NACK by repeating the lost packet and continuing the message on a three frame multi-slot basis adding a slot for the lost packet. The relatively long message delay for a multi-packet inbound message is indicated in Figure 5, which assumes no CRC errors for the inbound packets. An ARQ system is used in conjunction with the FEC with the last two bytes of packets reserved for the CRC.

Position report information is forwarded from the Loran-C board (latitude and longitude to .01 degree along with a two digit relative reliability indicator) to the MET processor board on the schedule established at log-on. This information is sent in the reserved slots and channel every 104, 208, 416 or 832 frames corresponding to position information every 15, 30, 60 or 120 minutes approximately. If the position report is not received by the HUB, indicated to the MET by the ICD status the MET takes no further action. If the user has subscribed to a retry service then the HUB interrogates the MET requesting a position report and assigning one of a number of

reserved slots in a position reporting channel for the retry.

Broadcast messages to fleets and subfleets are not acknowledged by addressees to avoid congestion on the inbound channels. They are repeated at least three times in successive outbound frames to ensure reception by vehicles subject to nominal propagation conditions.

DEMODULATOR PERFORMANCE OBJECTIVES

The MET demodulator operates in a synchronous half duplex mode at 1200 sps. During transmission the MET must retain frequency and bit timing so that it can re-acquire the outbound TDM channel after the first unique word. With additive white Gaussian noise and a specified received phase noise the demodulator performance shall be:

| C/No dB-Hz | Pe xE-05 |
|---------------|-------------|
| 33.0 | 7.8 |
| 33.5 | 2.0 |

Initial acquisition of the carrier with a frequency offset at the demodulator of +/-850 Hz shall be achieved over a range of C/No of 33.0 to 35.0 dB-Hz within 25 seconds with a probability of failure not greater than 0.01.

The inbound TDMA burst demodulators will operate at 600/1200 sps (HUB selectable) with 632/316 TDM symbol periods per burst. The burst to burst frequency uncertainty after frequency correction at the Des Laurentides earth station shall not be greater than +/- 650 Hz and the maximum rate of change of frequency during a burst shall not exceed +/- 65 Hz per second for six seconds. The packet error probability (PEP) for a 15 byte packet shall be less than the

following at 300 bps:

| C/No dB-Hz | PEP |
|---------------|------|
| 32.3 | 0.1 |
| 34.6 | 0.02 |

Digital signal processing is used in all modems and provides the flexibility to rapidly reconfigure the network and reduces the hardware required for redundancy.

SUMMARY

The MDS system is currently undergoing system and acceptance tests and is scheduled to be in operational service in the Spring of 1990. The satellite link performance has proven to be quite robust and to meet the messaging

objectives even under relatively dense shadowing. The Loran-C position reporting accuracy has been excellent in rural areas and the quality indicator has alerted to possible errors in high noise environments.

Final test results will be presented at the conference and overall system performance will be discussed.

REFERENCES

1. INMARSAT, Standard-C, System Definition Manual, Release 1.3, July 1989.
2. BUTTERWORTH, J. AND MATT, E. 1983. The Characterization of Propagation Effects for Land Mobile Satellite Services. IEE Conference Publication No. 222.

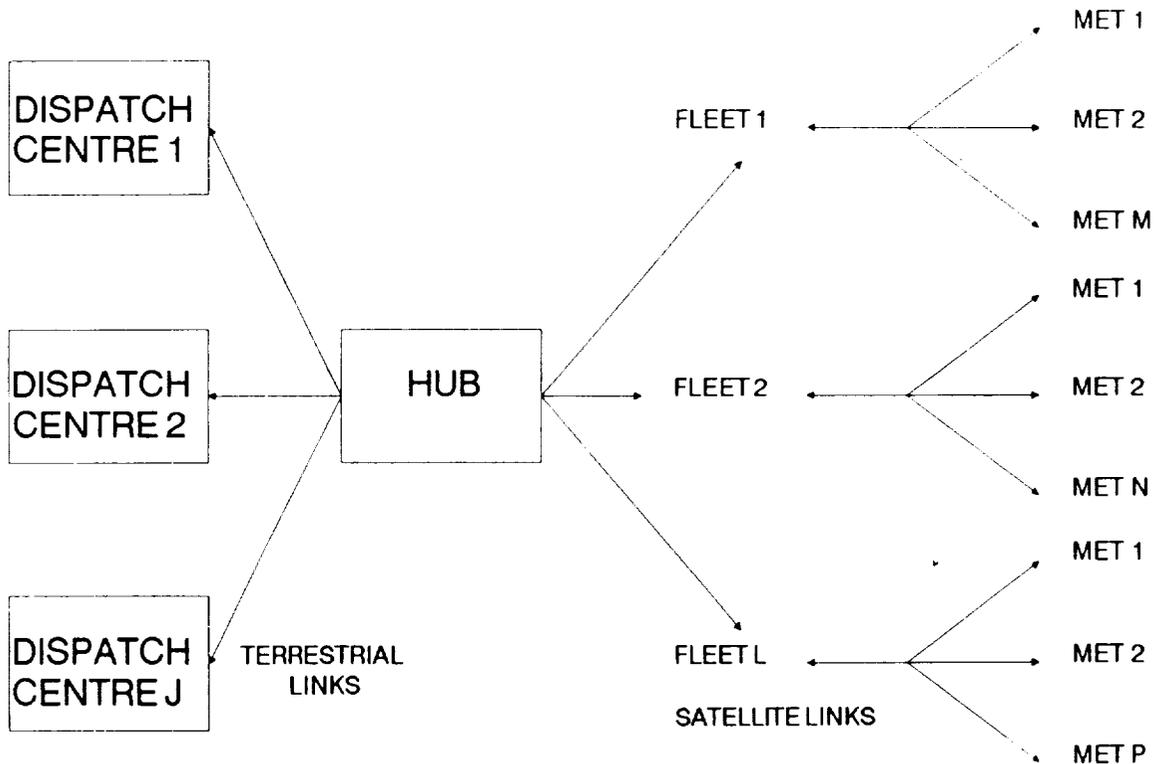


FIGURE 1 MDS NETWORK TOPOLOGY

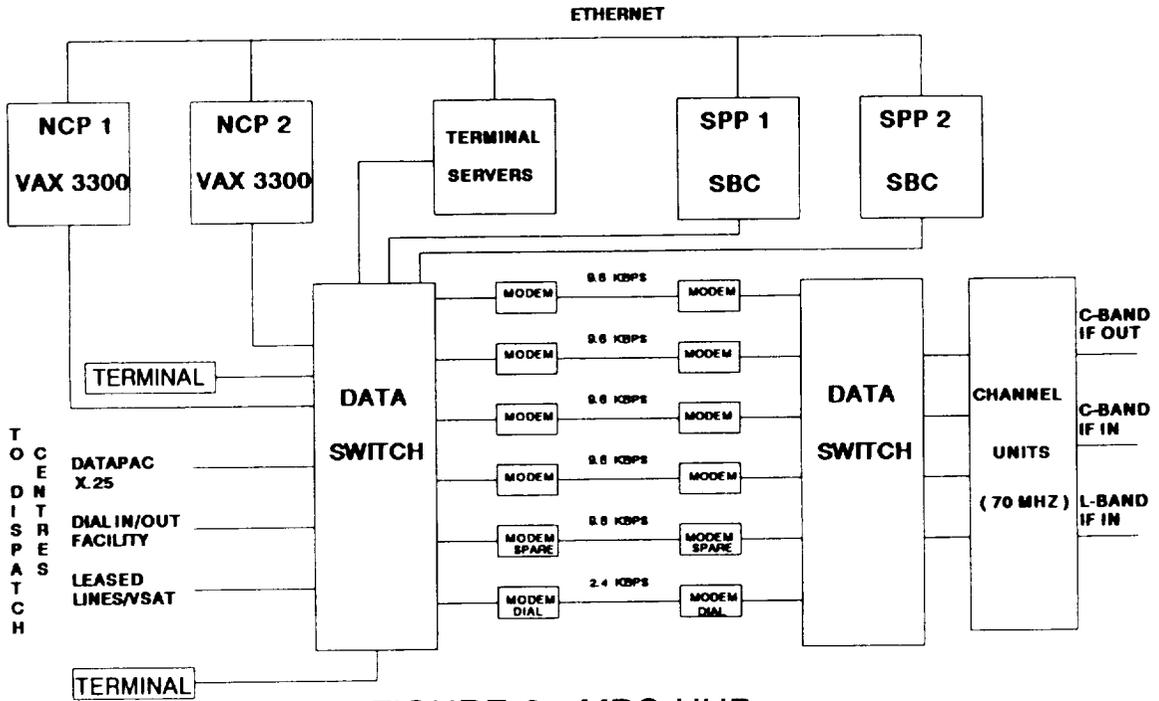


FIGURE 2 MDS HUB

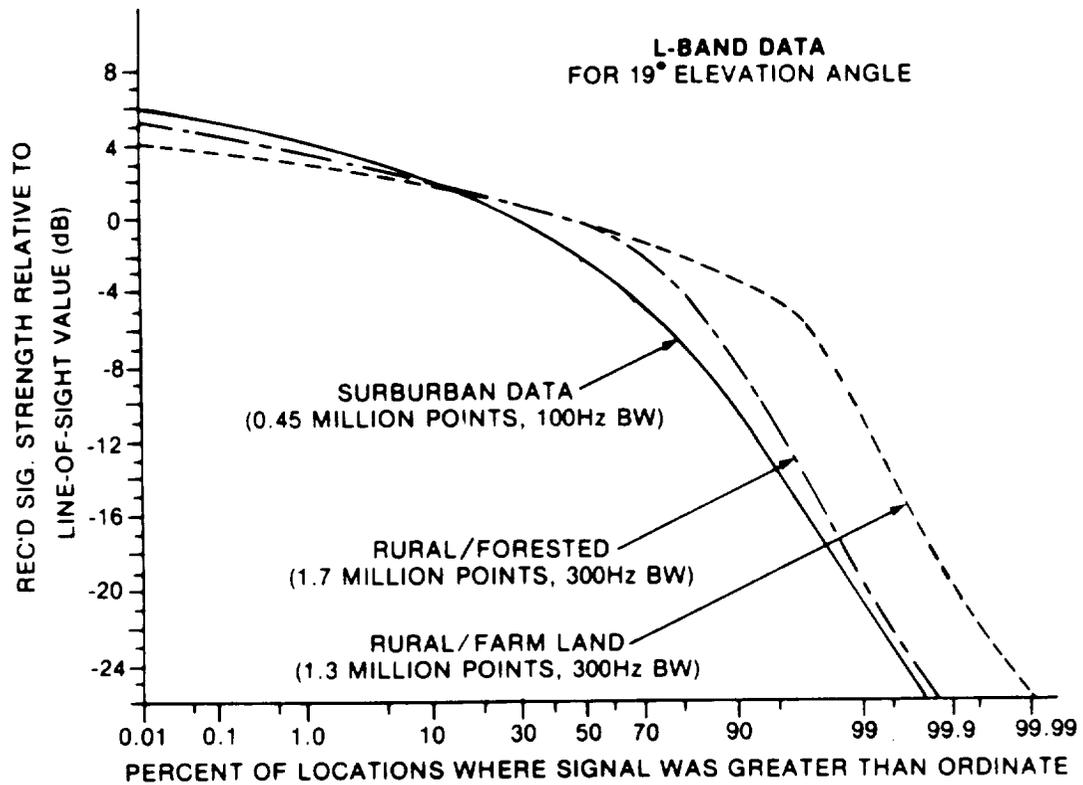
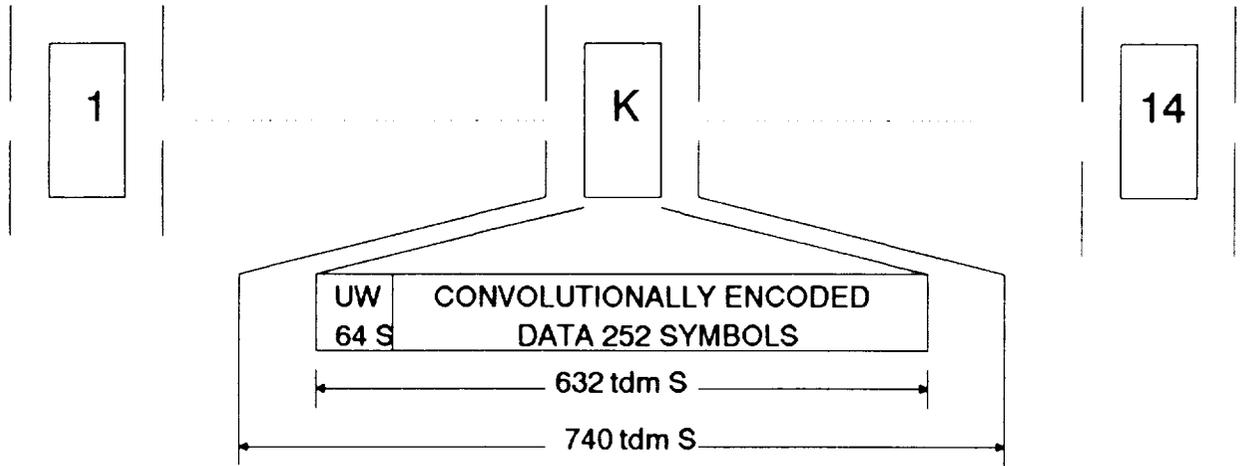


FIGURE 3 L-BAND PROPAGATION

8.64 secs
10368 tdm symbols



OUTBOUND TDM CHANNEL



INBOUND TDMA CHANNEL (300 BPS)

FIGURE 4 CHANNEL AND PACKET STRUCTURE

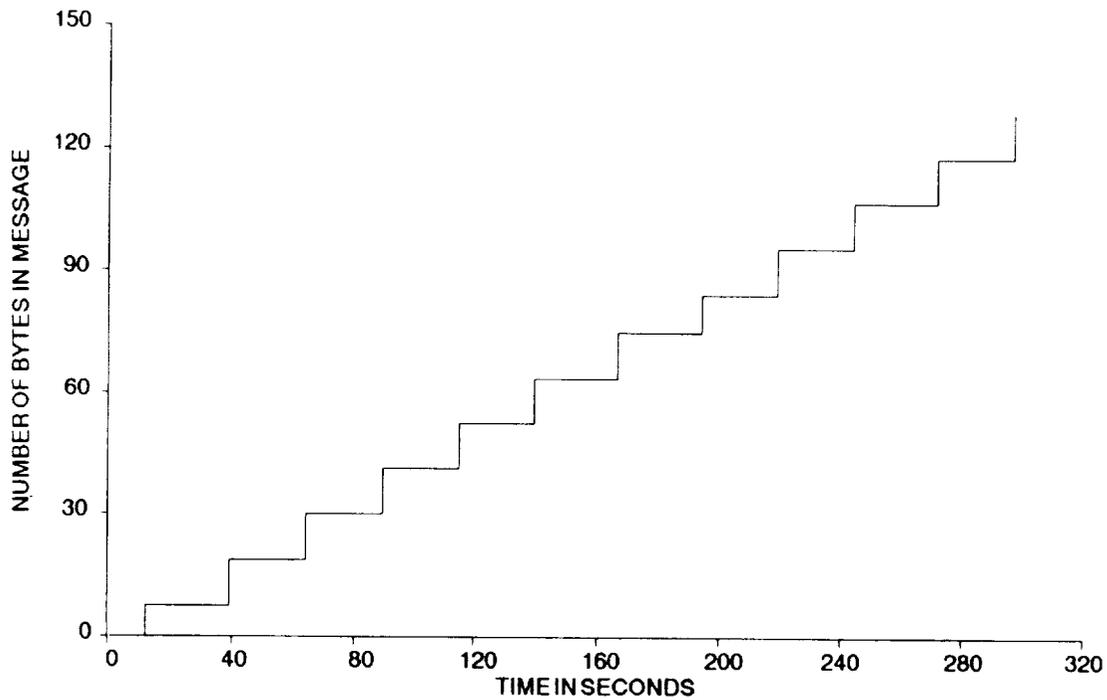


FIGURE 5 INBOUND PACKET TRANSFER TIME