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PRACTICAL CONSTRAINTS ON NETWORK ARCHITECTURE AND SIGNALLING IN THE MSAT SYSTEM

N. GEORGE DAVIES, Telesat Mobile Inc., Canada

TELESAT MOBILE INC.
P.O. Box 7800
Ottawa, Canada, K1L 8E4
(613)-746-5601

ABSTRACT

Telesat Mobile Inc. plans to provide mobile satellite communications services in Canada in 1993/4, in close co-operation with the American Mobile Satellite Consortium Inc., which will be providing services in the U.S.A. L-band frequencies will be used in multiple beams for communication with mobile terminals. Ku-band frequencies will be used for the feeder-links to fixed stations. The system will support voice and data communications. The baseline Canadian system will support approximately 450 assignable voice channels, some fraction of which will be the equivalent in data channels. The method of multiple access will be FDMA/SCPC.

The availability of frequencies, the availability of technology and the time scale for implementation all constrain the network architecture for the system. Further, it is important to have an open specification to encourage multiple equipment vendors. The interplay of these constraints is discussed.

INTRODUCTION

Telesat Mobile Inc. is planning to offer mobile satellite services in Canada using a dedicated satellite, MSAT, in 1993-94. The MSAT system is being developed in close cooperation with the American Mobile Satellite Consortium Inc. (AMSC), which will be providing services in the U.S.A. A key aspect of this cooperation is an agreement to provide mutual back-up for the space segment, thus eliminating the need for separate in-orbit back-up satellites. It is intended that the common definition of the space segment be carried forward into the definition of the ground segment, leading to economies in development and a large scale market for mobile terminal equipment manufacturers.

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DESCRIPTION OF THE MSAT SYSTEM

The MSAT system, which has been the subject of extensive studies, will use L-band frequencies for communication with mobile terminals. The first generation satellites will have nine beams to provide coverage over Canada and the continental U.S.A. Additional beams may be included to cover Mexico and the Canadian and U.S.A. controlled international flight information regions over the Atlantic and Pacific Oceans. Ku-band frequencies, in a single continental beam, will be used for feeder-links to fixed earth stations.

The satellite transponders will be designed to be capable of supporting a wide variety of communications signals in order to accommodate the provision of additional services as the system evolves over the ten year service life of the satellites. The baseline communications system is being designed to support circuit switched voice and data and packet switched data communications.

For many reasons, including limited spectrum, coordination of frequency use between systems, design simplicity, experience, desire to encourage multiple vendors, etc., the baseline system design is based upon FDMA/SCPC multiple access. However, other forms of multiple access will not be excluded by the satellite design.

The parameters of the baseline system are as listed in Table 1.

Table 1. The Parameters of the Baseline Canadian MSAT System

<u>Satellite</u>		
Orbit Location	106^{o}W to 111.1^{o}W	
Frequency Bands	L and Ku	
Payload Weight	350	kg
Payload Prime Power	2.5	kW
<u>L-Band Payload</u>		
Payload RF Power (Note 1)	450	W
Net Tx Antenna Gain (EOC)	31	dB
EIRP (EOC)	55.5	dBW
<u>Mobile Terminal</u>		
Antenna gain	8	dBic
G/T	-17.5	dB/K
Modulation	ACSSB	
Unfaded C/No Target K=10 dB with light shadowing	52.3	dB-Hz
Satellite EIRP per channel	32.3	dBW
Nominal Channel Spacing	5.0	kHz
<u>L-band System Capacity</u>		
Number of Active Carriers	209	
Voice Activation Factor	0.40	
Number of Assignable Voice Ch. (1% probability of overload)	445	
Assumed busy hour use/mobile	0.01	erlang
Number of voice mobiles (15% blocking probability)	51,700	

<u>Note 1</u>: At specified noise power ratio of 22 dB.

Table 1 illustrates the capacity of the MSAT system for circuit switched voice services using ACSSB technology and making provision for the fairly low elevation angles of 15^o - 35^o and attendant shadowing losses (mostly due to trees).

The system, of course, will not be restricted to the use of ACSSB voice modulation as there may be service providers who will wish to use other forms of voice modulation, particularly various forms of linear predictive coding (LPC) digital modulation at coding rates of 2.4, 4.8 or 9.6 kbps. The system will also be designed to support circuit switched and packet switched data transmissions. The system will require packet switched signalling channels which will be used to set up calls with mobile terminals and to assign and to control the allocation of network capacity.

Algorithms similar to the one illustrated above for ACSSB voice channels may be employed to estimate the capacity of the system for data services and, more realistically, for a mix of services and signalling channels.

Market estimates of the requirement for services indicate that approximately half of the mobile terminals will subscribe to data services and half to voice services. Of the subscribers to voice services, approximately one quarter will require access to the public telephone network (PSTN).

The baseline design, as described, is the subject of continuing analysis as the technology for implementing the mobile terminals improves and experience is gained in mobile satellite communications. The baseline design for a mobile satellite link is conservative. Capacity estimates are very sensitive to parameters of the mobile terminal, particularly the terminal G/T and link margin. It is anticipated that the mobile terminal G/T which is economical and practical to implement will be improved by 2 dB or more over the next year or two, and may be improved further during the life of the first generation system. The results of experiments and experience with operation of the system may indicate that lower margins may be employed. The capacity of the system, in terms of voice mobile terminals (or the equivalent data mobile terminals) served by the system, over its operating life will therefore likely increase substantially over the capacity indicated in Table 1.

NETWORK ARCHITECTURE

The concept for the network architecture for MSAT is illustrated in Figure 1. This concept is derived from a key assumption that a Network Control Centre (NCC) will allocate circuit capacity on a per call or per packet basis. However, under a suitable business arrangement, the NCC may also allocate space segment resources to another entity or service provider. Such service provider could administer the capacity using a different concept.

The NCC may also interface with other users of the spectrum, such as aeronautical users, to coordinate use of the spectrum.

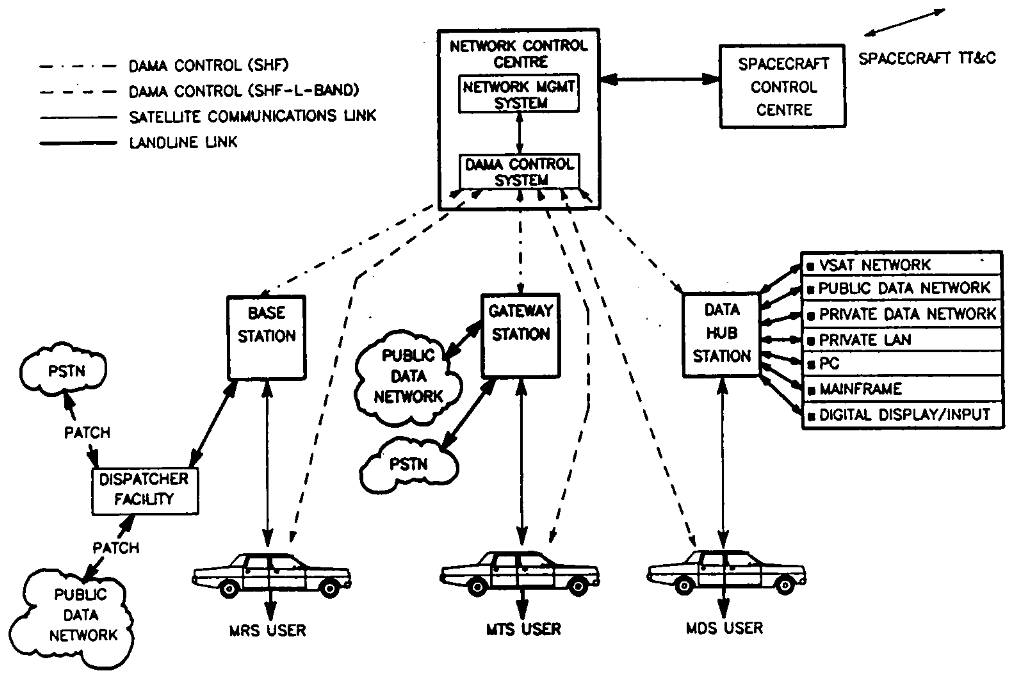

Figure 1. MSAT Network Architecture

The elements of the network architecture are:

- a Network Control Centre (NCC), which includes the:
  - Network Management System (NMS), and
  - DAMA Control System (DCS)
  - Administration System
- Data Hub Stations
- Gateway Stations
- Base Stations
- Mobile Terminals
- a signalling system to interconnect the elements of the network.

The functions of the elements of this network architecture are well understood. The most important element, in the operation and control of the network, is the NCC. The NCC will manage the network and allocate space segment capacity for communication between individual mobile terminals and fixed base, gateway and data hub stations. It may also allocate bulk capacity for a limited number of service providers who plan to operate an independent system.

Another important function of the NCC will be to link the systems of Telesat Mobile and AMSC to provide back-up space segment capacity. Provided there is sufficient commonality in system design, and suitable business arrangements are made, the linkage between the NCCs will provide for efficient servicing of cross-border mobile terminals.

The Data Hub Stations will support a packet switched mobile data service. The Gateway Stations will provide an interconnection to the public telephone and data networks for circuit switched services. The Base Stations will support private circuit switched voice and data services.

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SIGNALLING

At this time, the signalling system is the least well defined element of the network architecture. However, a number of boundary conditions are known:

- The signalling channels will be packet switched, probably based on TDM outbound channels and Slotted Aloha random access and assigned access inbound channels.
- The signalling channels will support, principally, the circuit switched services, but could also form the basis for the packet switched data service.
- One or more signalling channels will be needed in each beam.
- The signalling channels will have to be capable of supporting the number of mobile terminals operating within any beam.
- The mobile terminals will have to be capable of locating the signalling channels and identifying the best ones to use.
- The signalling system should be layered in accordance with the OSI model in order to ease the problems of adaptation to different applications, and the incorporation of improvements.
- The signalling system should, to the greatest extent possible, be standardized in order that economies of scale in mobile terminal hardware may be realized, and to reduce NRE costs in the NCC.

The signalling plays a key role in providing efficient access to the network, in the speed of response of the network and in other performance aspects of the system. To date, in other satellite mobile systems, a unique signalling (and access control) system has been designed for each new mobile satellite service. It would be very attractive, for reasons of mobile terminal commonality and to reduce NRE costs, to standardize the signalling.

Current designs of signalling systems for mobile satellite services are:

Inmarsat Standard-A
Inmarsat Standard-B
Inmarsat Standard-M
Inmarsat Standard-C
Inmarsat/AEEC 741 Aeronautical
Aussat Mobilsat
Telesat MSAT (not fully defined)

Only the Inmarsat Standard-A is in operation. Inmarsat Standard-C will be in operation in 1989/90, as will Telesat Mobile's early entry Mobile Data Service, which is derived from Standard-C signalling. Inmarsat's Standard-B and Standard-M and Aussat's Mobilsat system are targeted for operation in 1992. There are plans for the implementation of the Aeronautical system in the early 1990s.

The signalling system that will be employed must support the system into the middle of the first decade of the 21st century, fifteen years from now. During this period, common channel signalling, with all its attendant advantages, will be deployed in the terrestrial network and likely in the cellular network. Telesat Mobile is giving consideration to common channel signalling in the MSAT system for the following reasons:

1. Positive and continuous control of all mobile terminals in the system. A mobile terminal will not be allowed to transmit unless it is receiving a signalling access control channel, and therefore it can be controlled at all times.
2. Positive derivation of frequency from a common frequency reference as is the usual practice for SCPC operation.
3. Common channel signalling to support network features (display of calling number, call waiting, voice/data operation, etc.).
4. Availability of a continuous signal for antenna tracking in the mobile terminal.

The disadvantage of common channel signalling is that the mobile terminals will be required to receive an outbound access control channel signal at all times. This will require, as a minimum, an additional frequency synthesizer and a demodulator. The potential cost impact on the mobile terminals must be explored, bearing in mind that these terminals will not reach the market in significant quantities until 1994, when we may expect that the technologies of frequency synthesizers and DSP demodulators will have advanced significantly and could be expected to be much cheaper than they are at present.

CONCLUDING REMARKS

The baseline design of the MSAT system is based upon a DAMA FDMA/SCPC approach. This approach has been chosen for the following reasons:

- The frequency allocation for mobile satellite services is very limited and must be shared and coordinated among a wide variety of organizations. A FDMA approach is the most practicable.
- The wide variety of services planned, which may be offered by different service providers.
- The base of technological experience is quite deep for FDMA, but is quite limited for other technologies such as TDMA and CDMA.
- The time scale for implementation of five years to a fully installed system is very short.
- The desire to have an open system specification which will provide for multiple vendor participation in production of mobile terminals.

The current plans of Telesat Mobile call for technical specifications for the ground segment to be available early in 1990 and for Telesat Mobile to have contracted for all elements of the ground segment by the end of 1990. These plans match the plans for the procurement of the space segment procurement, which call for a contract by the end of 1989.

At Telesat Mobile, we look forward to entering into a joint agreement with AMSC in order to define a common, flexible, first generation system which will serve mobile satellite users in North America through the year 2005 with a first generation system, and subsequently through future generations of the system.