L-Band Briefcase Terminal Network Operation

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ABSTRACT

During 1989, SkyWave Electronics Ltd. developed a lightweight, battery-powered, L-band Briefcase Satellite Terminal (LBT) which is capable of providing truly portable voice and data communications on a global basis.

The LBT is designed to operate through Inmarsat's Atlantic Region Satellite MARECS B2, and Teleglobe Canada's 18-meter Laurentides Earth Station at Weir, Quebec.

A small operating network, consisting of up to 20 mobile terminals and homing on the Laurentides Earth Station, was set up in the spring of 1990 to provide commercial service to LBT users, both domestic and international.

This paper describes the briefcase terminal and the operation of the network.

BACKGROUND

The motivation for developing the LBT was two-fold.

Our first objective was to develop and evaluate new communications technology being proposed for future use in the North American MSAT system planned for 1993. This technology included new voice "modulation" techniques such as Amplitude Companded Single Sideband (ACSSB) which permits power-efficient voice communication within a 5 kHz RF channel. To support ACSSB operation, it was necessary to devise effective approaches to frequency control, signaling, linear solid state power amplifiers, as well as innovative antenna design. Development of the ACSSB itself, including the digital signal processing (DSP) implementation, had been performed earlier by Lodge[1] and others at the Canadian Department of Communications.

The second objective was to design a terminal which would be extremely portable, lightweight, and battery-powered and could be used to provide voice and data communication service, through Teleglobe Canada, within the MARECS B2 footprint. Typically users might include:

- News crews
- Disaster relief crews
- Diplomatic users
- Expeditions
- Construction project teams

From the outset it was known that there was a severe shortage of communication capacity for new services on MARECS B2 and that only a single 25 kHz, 21 dBW (C to L-band EIRP) channel could be made available by Inmarsat for the briefcase terminal network. Furthermore, this channel had to be shared between the briefcase terminals and two existing Ontario Air Ambulance Service (OAAS) aeronautical mobile terminals.

In order to permit effective time and power sharing of the allocated channel by up to 20 users (18 LBT plus 2 OAAS), it was necessary to design and implement a small network control system. The Network Controller is a PC-based system which manages power, channel allocation, access priority, and call detail recording. It is installed at the network hub in the Laurentides earth station.

NETWORK OVERVIEW

The briefcase terminal network consists of the five main elements shown if Figure 1.

The MARECS B2 satellite, stationed at 26° W covers the Atlantic Region including Europe, Africa, South America, and eastern North America. It uses L-band (1.5/1.6 GHz) for the satellite-to-mobile link and C-band (4/6 GHz) for the satellite-to-hub link.

The LBT (up to 18 units) provides voice and data communications to the user in the field. It is operated in a "stop and talk" mode.

The OAAS terminals (2 units) are used for emergency communication to ambulance aircraft used by the Ontario Ministry of Health.

The hub of the network is Teleglobe's 18-meter C-band Earth Station at Weir, Quebec, just north of Montreal.

The Network Controller, hub channel units, and PSTN interconnects are also situated at the Laurentides station.

BRIEFCASE TERMINAL DESIGN

The briefcase terminal was designed to meet the following overall requirements:

- Full duplex voice operation
- Full duplex data (2400 bps)
- Dial-up operation to the PSTN
- Weight not to exceed 32 lbs
- Deployment time 1 - 2 minutes
- 1 hour operation on internal batteries

The design approach is shown in Figure 2.

The antenna consists of two hybrid-combined, right hand circularly polarized, 16-element, microstrip patch array antennas, each with a nominal gain of 15 dBiC. The overall antenna gain is about 17 dBiC after accounting for combining and feeder losses Each panel is 17 3/4" x 14" x 5/8" and weighs under 2 lbs. The antennas attach to the LBT lid during operation and stow in the LBT carry case for transportation.

The diplexer is a low-loss (typ 0.5 dB) cavity filter design.

The 20 W SSPA uses a linear Ga As FET final device and bipolar transistor drivers.

The upconverter is synthesized in 5 kHz steps for channel selection and is of conventional design. The downconverter is synthesized in 50 Hz steps and provides both channel selection and AFC tuning capability for the demodulators.

The heart of the terminal is the ACSSB/DMSK modem. ACSSB is used for voice communications and the co-resident DMSK (differential minimum shift keying) is used for both data communications and signaling purposes. The modulator and demodulator are implemented on two TMS 320C25 digital signal processors operating at 40 MHz clock rate.

Call setup, mode control and the user interface are managed by a CMOS V40 control processor.

The user interface consists of a sonalert, a cellular radio style handset which includes a 2 line LCD display, status indicators, and a keypad for control and call set up. The handset also contains the microphone and earpiece.

The power system includes a power conditioner, sequencer, charging circuitry, and 20 'D' size NiCad cells.

Table 1 shows a brief specification of the LBT terminal:

PARAMETER	SPECIFICATION
Voice Mode	ACSSB
Data Mode	DMSK 2400 bps, sync
G/T	-9 dB/K
EIRP	30 dBW
Transmit Band	1636.5 - 1645.0 MHz
Receive Band	1535.0 - 1543.5 MHz
Occupied BW	5 kHz
Frequency Stability	±1.6 kHz
Operating Time	1 hour
Power	12 V @ 7A 115/230 V ac
Batteries	NiCad (20 'D' cells)
Size (briefcase)	18" x 13" x 4.5"
(packed)	19" x 14" x 8.5"
Weight (batteries, case, antennas)	32 lbs

TABLE 1 : LBT Specifications

Operation

Operation of the LBT involves three steps:

- Set-up
- Peaking on the satellite
- Call establishment

First the LBT is unpacked and placed on a surface with a clear line of sight to the satellite. The two antenna panels are attached to the lid with velcro fasteners and the RF cables are connected.

The unit is then powered on and the briefcase is oriented in the general direction of the satellite. In a special antenna-pointing mode the demodulator measures the amplitude of the satellite pilot tone and modulates an audio tone in the earpiece. Peaking the antenna towards the satellite is simply a matter of adjusting the briefcase lid, in azimuth and elevation, for the highest pitch audio tone. At this point, the lid is locked in position and a call may be placed.

Placing a voice call involves entering the called party's PSTN number and pressing the call originating buttom.

For data calls, the LBT appears like a "Hayes" modem. Calls can be placed manually using the data port or with a commercial software package.

Calls can also be placed in the reverse direction (i.e., from the PSTN to the briefcase). To do this, the calling party first dials the Laurentides Earth Station's designated line and then overdials to the desired called LBT party.

Performance

Table 2 shows the ACSSB link budget.

PARAMETER	LBT TO HUB	HUB TO LBT
Uplink		
EIRP up (dBW)	24.0	59.1
FSL (dB)	189.0	200.9
Misc. Loss (dB)	0.5	1.5
G/T (dB/K)	-10.9	-14.0
C/Io (dB-Hz)	60.0	67.1
C/No th (dB-Hz)	52.2	71.3
C/No uptot (dB-Hz)	51.5	65.7
Downlink		
EIRPdn (dBW)	-16.5	18.0
G/T (dB/K)	36.3	-9.9
FSL (dB)	197.1	188.4
Misc. Loss (dB)	1.7	0.5
Boltz Const	-228.6	-228.6
C/No th (dB-Hz)	49.6	47.7
C/No dn (dB-Hz)	49.6	47.7
C/No link (dB-Hz)	47.4	47.6

Table 2 : ACSSB Link Budget

The EIRP values shown are average values and, in the LBT, correspond to between 5 and 6 dB output back off from saturation.

ACSSB voice quality is excellent at 50 dB-Hz, good at 47 dB-Hz, and intelligible down to 38 - 40 dB-Hz.

Data communications performance is excellent (BER $\leq 10^{-4}$) for C/N_0 values above 44 dB-Hz.

NETWORK OPERATION

The Briefcase Terminal Network was authorized to operate with the following constraints

- Maximum L-band EIRP of 21 dBW
- OAAS carriers require the full 21 dBW
- LBT carriers require 18 dBW each
- Occupied bandwidth 25 kHz
- Channel time/power utilization records
- Carrier down when idle operation

Under these design constraints a three-channel system and a PC-based network controller emerged. Figure 3 shows the frequency plan written for allocated 25 kHz bandwidth. The network control computer manages the hub channel units to ensure the above constraints are always met.

Channel Assignment

Each of the three channels was assigned a specific purpose. Channel 1 was assigned for OAAS-1 calls, OAAS-2 call requests and potentially LBT preemptive requests. No LBT calls are allowed on this channel, keeping it free for OAAS call setups. OAAS-2 shares its call channel with one of the LBT groups so that it does not interfere with the OAAS-1 air unit.

Channels 2 and 3 remain for use by the LBTs. A circuit sharing algorithm was developed that allowed a hub channel unit to uniquely address a LBT within its own group. This algorithm allows a number of LBTs to share a single hub channel unit. It supports calls both into and out of the hub. Idle LBTs can detect when their hub channel unit is busy. When its hub channel unit is busy the LBT will block any further call setup attempts until the channel becomes free.

The system design assumes that OAAS is inactive a large percentage of the time since the LBT user is generally not informed of OAAS call activity and if an LBT user makes a call request while OAAS is active, the request will not be answered.

Call Authorization/Billing

The network controller continually monitors the call state of each hub channel unit. It uses state transitions and their associated parameters to build call detail records. At the end of a call the call detail record is sent to disk and optionally to a printer. The PC clock is used for logging all call start and end times. Each call detail record contains the remote user identification number and the dialled PSTN number if it was an inbound call.

All outgoing and incoming call requests block the hub channel unit until it gets authorization from the network controller to transmit. Depending on the network's current status and the call request's status, the network controller either authorizes or terminates the call request. Before a call is authorized the network controller will allocate any network resources the pending call will require.

Resource Management

The network configuration is defined in a database created by a separate setup program. Three parameters are stored for each hub in the data base

- Group number
- Priority
- EIRP allocation

All hub channel units with the same call channel share a common group. In no case will the network controller authorize two hub channel units within the same group. Groups allow different services and different hub channel units to share a common frequency. In the system, for example, one group will have a hub channel unit connected to the PSTN while another hub channel unit will connect to a dedicated line.

Each hub channel unit is assigned a priority level. The network controller will terminate any existing calls when a higher priority call request arrives.

EIRP allocation presently is quite simple but adequate for the three channel system. Only two EIRP settings are possible: either the hub requires all the EIRP or it shares the EIRP. If it requires the entire EIRP it must be the only hub transmitting. The network controller assumes that total EIRP of all groups with hubs sharing EIRP does not exceed the total allocated EIRP. In this network all LBT hub channel units must be set for a maximum EIRP of 18 dBW.

Preemption

The network controller supports preemptive LBT calls. A preemptive call allows a LBT to terminate the call current within its group and subsequently place its own call. In order to provide a preemptive capability, the network requires a dedicated hub channel unit in the LBT's call group that listens to a separate channel. Like all hub channel units, the preemptive hub channel unit must first get authorization before it completes the call. The call setup always proceeds on the group call channel.

A "type of service" parameter is included in the configuration database. This parameter allows the network controller to move preemptive hub channel units to a second channel to listen for call requests.

Table 3 summarizes the configuration parameters for the hub channel units in the network.

HUB	GROUP	PRIORITY	EIRP	SERVICE
OAAS-1	1	1	All	Normal
OAAS-2	3	1	All	Normal
PSTN	2	3	Share	Normal
PSTN	3	3	Share	Normal
DATA	3	3	Share	Normal
Preempt	3	2	Share	Preempt

Table 3 : Hub Configuration Parameters

CONCLUSION

The paper has presented details of the L-band Briefcase Terminal and its associated Network Control System.

SkyWave wishes to thank DOC, Teleglobe, and Inmarsat for their support in this activity.

REFERENCES

(1) Lodge, J and Boudreau, D. "The Implementation and Performance of Narrow Band Modulation Techniques for Mobile Satellite Application". IEEE International Conference on Communications, Toronto 1986, Conference Record.

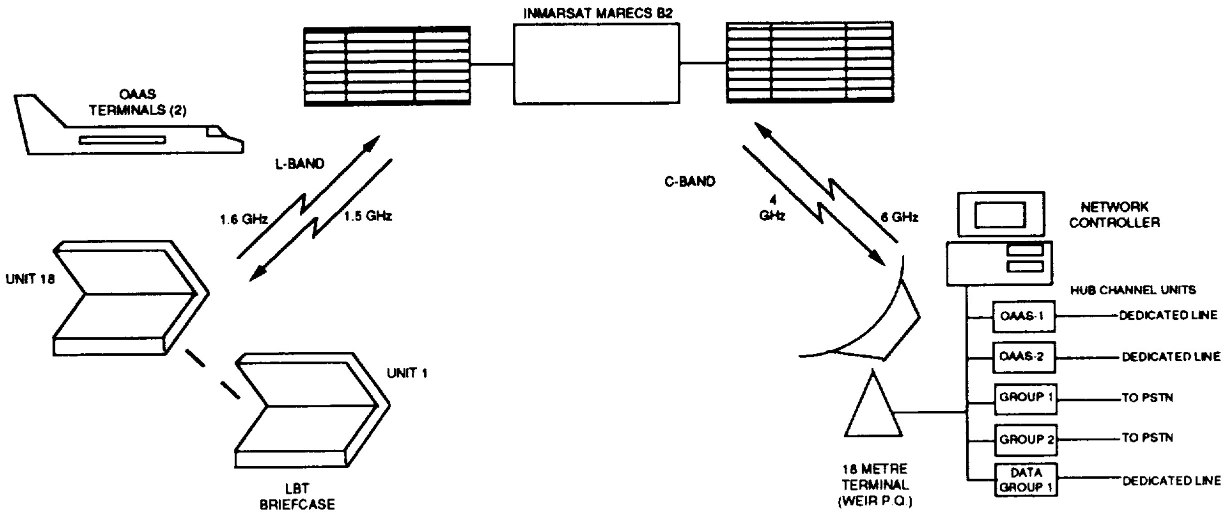

Figure 1 BRIEFCASE TERMINAL NETWORK

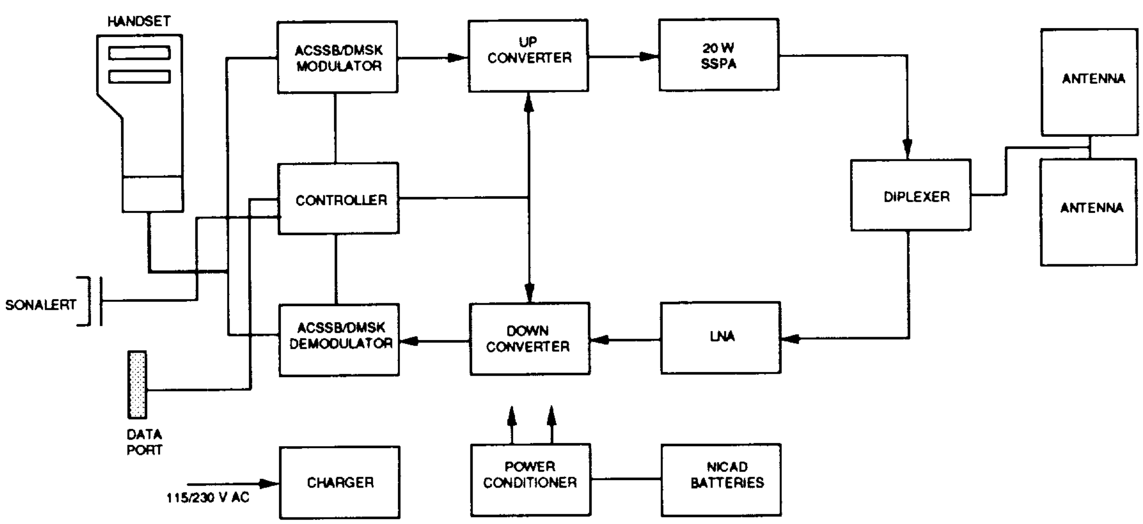

Figure 2 BRIEFCASE TERMINAL DESIGN APPROACH

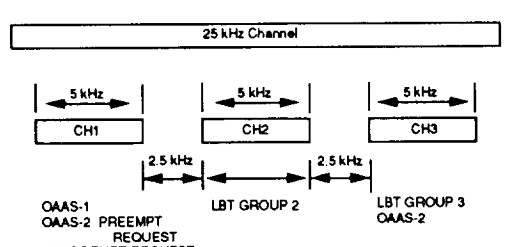

Figure 3 FREQUENCY ALLOCATIONS