Online Journal of Space Communication

Volume 2
Issue 4 *Satellite Communication in Canada (Spring 2003)*

Article 14

May 2021

SatCom Today in Canada: Significant Research: Evolution of Portable Ka-band Terminals at CRC

Pierre Tardif

EVOLUTION OF PORTABLE KA-BAND TERMINALS AT CRC

Pierre Tardif
Communications Research Centre Canada (CRC)
3701 Carling Avenue
Ottawa Ont. Canada
Pierre.Tardif@crc.ca

Abstract

The Satellite Systems Research group (www.crc.ca/rss) of the Communications Research Centre Canada (CRC) conducts research and development on systems, concepts and technologies suitable for future generations of communication and navigation satellites. Over the past decade, R&D has been carried out in portable satellite terminals operating at Ka-Band frequencies (30/20 GHz). This paper presents the evolution and a chronological overview of the terminals' development. The three generations of prototypes are presented.

Network concept

The fundamental objective of this Ka-band R&D project is to design, develop and evaluate new technologies having the potential of leading to small multimedia terminals with the added feature of being highly portable.

The overall network concept is shown in Figure 1 where, at a remote site, a number of users, with a wired or wireless link connection, access a portable satellite terminal, which is then connected via satellite to a main network (private or Internet).

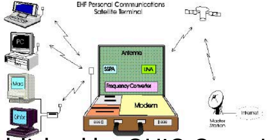

Figure 1: Network concept.

The CRC master station (or hub) consists of a 4.2m antenna equipped with an 80W TWTA, an LNA, a frequency converter for IF interface at 70MHz, a commercial QPSK modem and an Ethernet router and/or bridge. CRC also owns two smaller 1.8m Ka-Band hubs, which can be transported to accommodate different geographical network configurations. One of them was used during the field trials with Romelabs. These three hub stations are used with the three generations of terminals described below.

First generation: Suitcase terminal

The first design of the portable satellite terminal operating at Ka-Band frequencies (30/20 GHz) was initiated in 1990. This terminal, referred to as the Suitcase terminal and using mostly commercial off-the-shelf components, is shown in Figure 2a. A CRC-designed 30-cm microstrip planar array (Figure 2b) was mounted in the lid of the suitcase along with a dual-stage frequency converter and a 1W SSPA (see Figure 2c). A commercial Comstream CV101 modem was in the bottom half of the suitcase. The entire unit was mounted on a luggage carrier. The case measured 18"x24"x8" and weighed approximately 50 lbs.

Figure 2a: Original Suitcase terminal (1990).

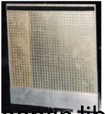

Figure 2b: 30-cm planar array used in original Suitcase terminal.

Figure 2c: Inside of Suitcase terminal showing components.

The Suitcase terminal was expected to provide a 256 kb/s link with an Eb/No = 6dB over the Olympus satellite. A 19.2 kbps link between the suitcase and CRC's 4.2m hub was demonstrated in Ottawa using Olympus but the potential of 256 kbps was not realized due to the low antenna performance. Control of the Olympus satellite was lost a few days after this experiment.

Through a partnership established between CRC and US Air Force RomeLabs Research (AFRL) laboratory, access to the Advanced Communications Technology Satellite (ACTS) was made possible to continue our investigations and experimentations. The original Suitcase terminal antenna was replaced with a 50-cm offset fed parabolic reflector. The antenna and the original 1W SSPA were fastened on the boom outside of the suitcase lid as shown in Figure 3. The same frequency conversion scheme was used as in the original design but with new oscillators to operate over ACTS. The Comstream modem was also upgraded to a CM701 with outer Reed-Solomon error correction coding. Computer and router cards were added into the unit to provide 10Mb/s wired and 2Mb/s wireless connections for data and control. A more detailed terminal description is provided in [1].

Figure 3: Suitcase terminal modified for ACTS operation

This new Suitcase terminal was demonstrated at CRC in June 1995 as one of the IMSC95 exhibits using the ACTS steerable beam. The uplink from the suitcase terminal was at 512 kbps and the downlink at 1.544 Mbps with a measured Eb/No = 6.2 dB which corresponds to a margin of 2 dB @ BER = 10^{-9}. A number of computers (Sun workstation, Power Mac, Pentium and PC Laptop) with wireless LAN cards were used to demonstrate desktop video conferencing (Communique and Cu-SeeMe), Internet communication, e-mails and file transfer via the Suitcase terminal. Later in October 1995, the suitcase terminal was demonstrated at Rome Labs using the ACTS steerable beam on Ottawa and the East Sector Scan 4 beam on Rome Labs. A 2.048 Mbps full duplex satellite link (maximum data rate of suitcase Comstream CM701 modem) with an inbound link clear weather margin of 4 dB (BER = 10^{-9}) was established .

CRC has deployed the Suitcase terminal in a number of telemedicine and video-conferencing experiments and demonstrations with RomeLabs using the ACTS satellite such as Global Yankee 96, Global Apache 97, Global Patriot 98 and EFX98.

Another interesting utilisation of the Suitcase was in the Canadian arctic to provide a communication link for the Haughton-Mars Project in July 1999. The Suitcase provided two-way communication between Devon Island in the Artic and the NASA Ames Research Center (NARC). Internet, desktop videoconferencing and data collected from land survey were transferred to headquarters at NARC at a data rate of 512 kb/s with an Eb/No = 9dB.

Second generation: Briefcase terminal

The first generation served as a platform to learn and understand the required technology in terms of component specifications, integration issues and to obtain valuable field and applications experience. The design of the second generation terminal, referred to as the Briefcase terminal, resulted from R&D at CRC that focussed on innovative antennas and direct modulation techniques. 44-cm compact and flat reflector (or reflectarray) antennas with Cassegrain feeds were designed, fabricated and measured [2]. CRC also initiated work towards a direct PSK modulation at L and Ka-Band. Small single printed circuit cards (4" x 6") were designed [3][4] and integrated into the new terminal. The I&Q baseband modulator was designed according to the European Telecommunications Standards Institute (ETSI) ETS300-421 standard for digital broadcasting systems for television, sound and data services (also referred to as DVB-S). The standard specifies MPEG transport multiplex adaptation, scrambling, Reed-Solomon outer coding, convolutional inner coding and 35% roll off spectral shaping for QPSK modulation. The printed circuit board supports variable data rates up to 2 Mbps. The performance of the L-band and Ka-band modulators was as good as a typical commercial modem. The FPGA technology used in this modem board has the advantage that the software can be reconfigured and adapted to fit any user requirements and thus could be updated to meet future R&D experiment requirements.

The resulting Briefcase terminal [5] delivered the same performance but with a lighter and smaller footprint than its predecessor. The main enhancements of the new terminal were thus its reduced size and weight resulting from the new direct I&Q modulator modules and light 44-cm reflectors. The terminal consisted of a small electronics briefcase and an antenna unit/PA mounted on a tripod. Figures 4a and 4b show the Briefcase terminal with, respectively, the parabolic antenna and the reflectarray antenna mounted on the tripod. The electronics case measured 14"x18"x6" and weighed approximately 25 lbs.

Figure 4a: Briefcase terminal with 44-cm parabolic reflector

Figure 4b: Briefcase terminal with 44-cm reflectarray

The Briefcase terminal modem and the single-stage frequency converter are mounted in the bottom of the Briefcase, and a computer, Ethernet equipment (wireless card, router, bridge) and power supply are in the lid. There are three standard interfaces provided by the Briefcase for the user terminal: Ethernet wired or wireless, digital RS449 and RF at L-band. The Briefcase terminal interfaces with the SSPA and LNA/Rx filter on a tripod that has a ring on bearings to mount the antennas and to rotate the flat plate reflector for polarization alignment. The polarization of the Cassegrain parabolic antenna is set in the classical manner by rotating the orthomode coupler.

The Briefcase was first introduced while still under development in the summer 98 at the Global Patriot98. Some new 2-watt and 10-watt SSPAs were also tested during this exercise. The terminal was also utilized and setup in a tent at the EFX98 to provide two-way videoconferencing at 512 kb/s at the Eglin Air Force base. An Eb/No = 9dB was received at the 1.8m hub located in RomeLabs.

During the spring 2000, the Briefcase terminal was used in a mobile application [6]. A commercial "KVH TracVision 3" Ku-band marine system with a 45-cm antenna was modified to operate over ACTS. A new Ka-band feed was designed by Infomagnetics to replace the initial Ku feed. The original electronics and tracking algorithm were used to point the antenna at the satellite based on a received pilot. The algorithm was designed for marine applications whereas this modified Ka-band land-mobile experiment gave extreme motion and signal level variations. The Briefcase terminal was used in a van to provide the majority of the communication functions. The RF electronics (frequency converter, 2-watt SSPA and LNA) were removed from the Briefcase and mounted inside the KVH pedestal on the roof of the vehicle (see Figure 5). Videoconferencing, Web browsing and emails applications were run while travelling.

Figure 5: Mobile Briefcase terminal with KVH.

Third generation: Ka-Pak terminal

The Ka-Pak terminal is the third and latest generation of transportable satellite terminals operating at Ka-Band resulting from CRC's R&D work. Cost, size and weight reduction remaining a main objective, we focused on designing this new terminal to be a single-piece unit (no-assembly) for easy transportation and quick deployment. We targeted broadband multimedia applications such as emergency/disaster management and recovery, newsgathering, medical and educational services, etc. where frequent transportation and fast deployment are required. To achieve this objective, the new technologies developed at CRC were integrated in this new terminal including the DVB direct L-band modulator card and the flat plate reflector. Figure 6 shows a typical setup of the Ka-Pak terminal operating from a car battery and providing Internet access to the laptop at 512 kb/s with an Eb/No=9 dB over the streerable beam on ACTS. Refer to [7] and to the Ka-Pak terminal link for more details or to its specifications.

Figure 6: Ka-Pak terminal – Typical setup.

Conclusion

CRC initiated work on the highly portable terminals in the early 1990's to demonstrate broadband capability and new applications offered by this new frequency band. The project turned out to be a good vehicle to promote Ka-Band applications and technologies for upcoming satcom terminals. The Ka-Pak terminal development is essentially complete but more advanced technologies such as direct transmitter self-calibration [8] and SSPA linearization [9] are currently being incorporated. The reflectarray is being redesigned to fit the circular polarization of a new generation of satellites such as NIMIQ-II and Anik-F2. It is planned to carry out more demonstrations of applications and technologies in the future using satellites of opportunity.

References

[1] C.J. Pike, P. Tardif, W. Janssen, E.K. Chan, G. Bivens, " Ka-band (29/19 GHz) Suitcase Satellite Terminal " , MILCOM 96, 21-24 Oct 1996, McLean, Virginia - pp. 341-346

[2] A. Petosa, D.J. Roscoe, A. Ittipiboon, M. Cuhaci, " Antenna Research at the Communications Research Centre ", Antennas and Propagation Magazine, Oct 1996

[3] C. Pike, P. Tardif, D. Drolet, W. Janssen, A, Webb, "Direct I&Q to Ka-band PSK Modem", 3rd Ka-band Utilization Conference, Sorrento, Italy, 15-18 Sept 1997, pp. 331-337

[4] D. Drolet, C. Pike, P. Tardif, W. Janssen, C.J. Verver, "Direct Ka-band Modulator for Multimedia Applications", Wireless 99, 12-14 July 1999, Calgary, Alberta, pp. 466-472

[5] C. Pike, P. Tardif, D. Drolet, W. Janssen, "Ka-band (29/19 GHz) Briefcase Satellite Terminal", 5th Ka-band Utilization Conference, Sicily, Italy, 1999.

[6] C. Pike, C. Desormeaux, "Ka-Band Land-Mobile Satellite Communications using ACTS", 7th Ka-band Utilization Conference, Genoa, Italy, 2001.

[7] P. Tardif, R. Bérubé, S. Morris, "A Very Small Ka-Band Satellite Terminal for Multimedia Applications", CIIT2002, St-Thomas USVI, USA, 2002.

[8] Huang X. and Caron M., "Gain/phase Imbalance and DC Offset Compensation in Quadrature Modulators", 2002 IEEE International Symposium on Circuit and Systems., Phoenix, USA, 2002.

[9] Huang X. and Caron M., "A Novel Adaptive Type-Based Baseband Predistorter for Solid State Power Amplifiers", 20th AIAA International Communications Satellite Systems Conference and Exhibit, Montréal, Canada, 2002.