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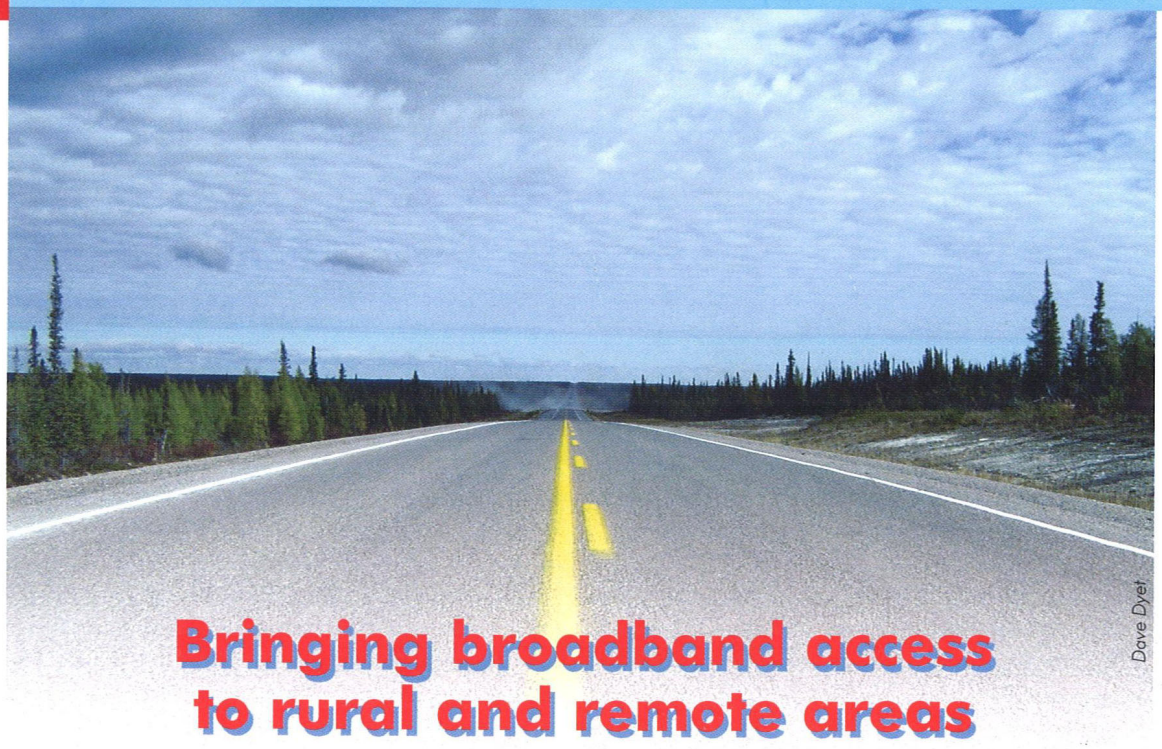

Bringing broadband access to rural and remote areas

The Canadian experience

By Gérald Chouinard

Programmes to improve access

According to ITU's *World Telecommunication /ICT Development Report 2006,* Canada is sixth in the world for broadband access penetration. However, because of the country's huge size and often sparse population, special measures need to be taken to try reaching all Canadian citizens. One third of communities (where 5 per cent of the Canadian population lives) still have no access to broadband services. And even when a community is reached, not every resident has access to broadband. This is especially true in rural areas, where the population density, beyond a central town or village, may be too low to make broadband access cost-effective using current technologies.

The Canadian government has taken steps to improve broadband access with programmes offering communities subsidies for capital investment and satellite transmission capacity, provided that they have developed plans for sustainable broadband access services. In parallel with this, the Communications Research Centre Canada (CRC), an agency of Industry Canada, launched the Rural and Remote Broadband Access (RRBA) programme in April 2002. CRC conducts research, and develops and tests innovative and cost-effective broadband access technologies and systems that should allow the private sector to develop viable business models for the provision of broadband services to Canada's under-served areas.

The RRBA programme covers critical issues such as spectrum availability and interference, reach, and deployment flexibility and equipment standardization. It involves participation in international standards activities, with the aim of reducing the cost of broadband access equipment, as well as offering Canadian expertise and technologies to countries that face similar challenges.

What is the best delivery system?

Satellite communications can play a major role in reaching remote communities. Because of their large and even coverage, satellites can provide

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broadband access in various geographical settings, including rural, suburban and even urban. The only drawbacks may be the impact of the inherent 0.5 second signal propagation delay on some broadband applications and the centralized servers, and the cost of the terminals. However, CRC has worked to minimize these problems.

CRC assessed the various broadband access technologies, based on population density, and looked at their merits in relation to their perceived complexity and cost (see Figure 1). Special attention was given to the range between 1.5 person/km^2 (below which only satellite technologies make sense) and 60 person/km^2 (above which wired technologies, such as ADSL and cable, become cost-effective). Serving this range of population density begs for the development of new wireless broadband access technologies that will extend the reach to allow cost-effective coverage of rural areas. Figure 1 gives an indication of the size of this potential market in Canada, based on the 2000 census.

The most important factors to be considered when trying to extend the range of wireless technologies are depicted in Figure 2 as a function of the carrier frequency. Again, the impact of these various factors is illustrated in terms of their relative complexity and cost. The low UHF range, from 300 MHz to 1 GHz, comes out to be the best frequency range for broadband access systems in rural areas. The use of radio frequencies in this range can extend the reach of wireless broadband access systems, allowing for a larger subscriber base in sparsely populated areas and making broadband access economically sustainable. As a result of these findings, special attention has been given to this range of frequencies in the RRBA programme.

Satellite broadband access technologies

CRC's work on satellite broadband access concentrated on trying to reduce the cost and complexity of terminals operating with the new Canadian Anik-F2 satellite in the 20/30 GHz bands. The use of such high frequencies permits a reduction in terminal size and can provide an attractive solution for broadband access to remote communities, and even to individual households.

Figure 1 — Suitable broadband access technologies as a function of population density

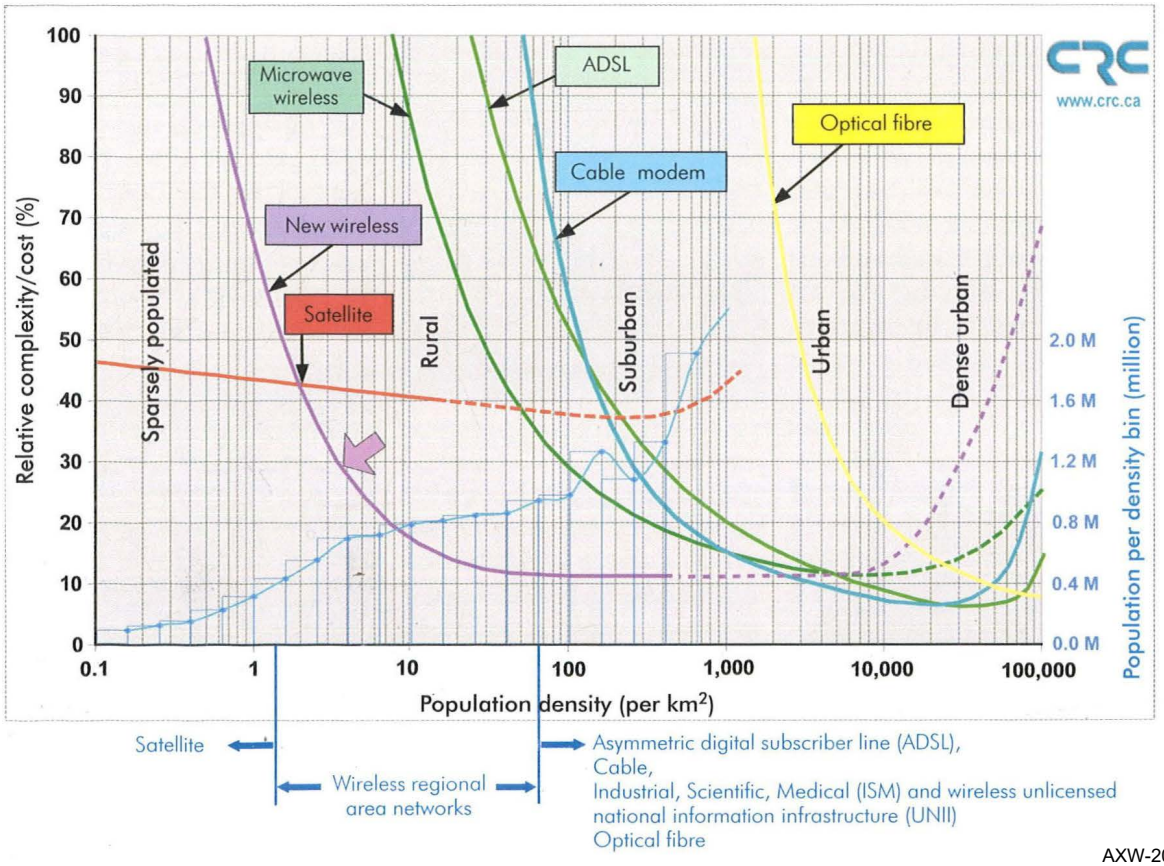

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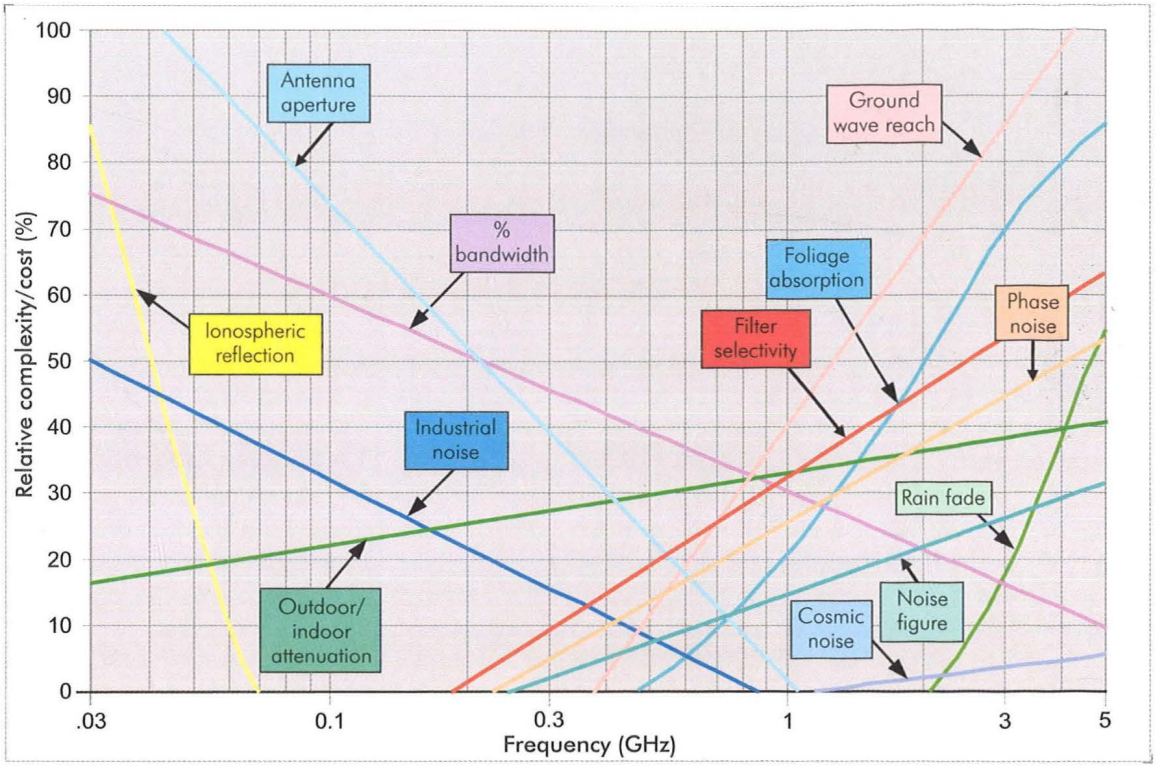
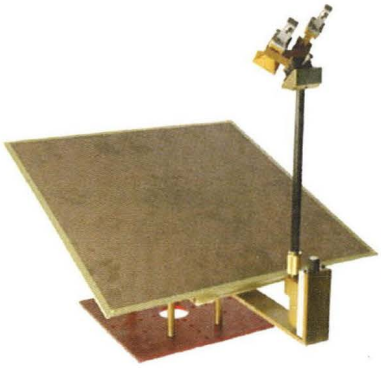
Figure 2 — Factors to be considered in the choice of the best frequency for wireless broadband access systems to serve sparsely populated rural areas



A 45-cm circularly-polarized reflect-array antenna was developed, with an offset feed with different focal points at 20 GHz and 30 GHz to avoid the need for a complex waveguide orthomode transducer. This design meets the gain mask recommended by ITU's Radiocommunication Sector (ITU–R) with respect to discriminating among geostationary satellites if the size of the antenna is greater than 70 cm.



Offset-fed 30/20 GHz reflect-array

Direct transceiver architecture is used for the terminals, so as to simplify the hardware needed. Work was done on the miniaturization of a 30 GHz vector modulator with a coupler, amplifiers, and an envelope detector in a single package, in order to improve overall performance and reduce the cost of direct transceiver terminals.

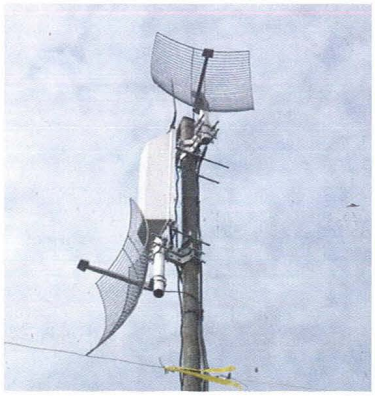
CRC developed compensation techniques for receiver gain/phase balance, as well as for power amplifier linearization. A frequency synthesizer was developed, and meets the stringent requirements needed for systems operating with DVB-RCS (digital video broadcasting — return channel satellite) open standard. DVB-RCS was selected in order to use the Anik-F2 satellite capacity credit (in the 20/30 GHz band) for Northern Canada.

CRC completed a study on innovative transport, network and link protocols for the transmission of internet protocol (IP)-based broadband services over satellite circuits. The satellite transmission capacity is maximized through the concerted use of a link performance enhancer replacing the usual transmission control protocol (TCP) to reduce the link latency and dynamic satellite bandwidth allocation, while meeting specified levels of quality-of-service (QoS). It was found that the service latency could be cut by more than 70 per cent and the end-user traffic throughput could be increased by a factor of five. These improvements can be added through either an upgrade to current open-standard DVB-RCS terminals, or through a more optimized upgrade to future DVB-RCS terminals.

Panorama from a communications tower at Penticton, British Columbia, Canada

Wireless broadband access using frequencies below 1 GHz

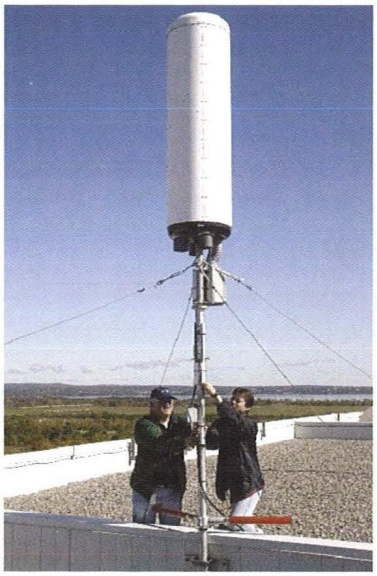
Investigations of the use of frequencies below 1 GHz for future broadband access systems were carried out, with the aim of enhancing the coverage range at low cost. CRC developed prototypes of a duplex frequency converter between the 2.4 GHz band and 700 MHz. These prototypes were successfully used in a field trial with simple UHF antennas where Wi-Fi connectivity was established at 5 Mbit/s over a range of 5 km in a non line-of-sight point-to-point setup at 700 MHz. It was observed that the range of 802.11b/g WLAN operating at 700 MHz can double in non line-of-sight conditions and quadruple in line-of-sight, as compared to 2.4.GHz.



Antennas used for the Wi-Fi experiment at 700 MHz

The MILTON system

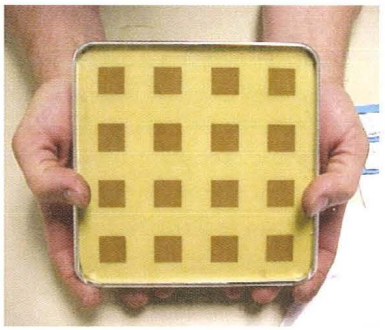
CRC also completed the development of its 5 GHz multimedia wireless access system called MILTON (microwave-light organized network). As a last-mile solution that can interface with optical fibre and Gigabit Ethernet networks, this technology is well suited to cover dense portions of rural communities where the bulk



24-petal MILTON Hub antenna

of the population is within a 1.8-km radius (10 km^2 area). The system can reuse frequency up to six times by means of a 24-petal hub antenna.

Currently, the system provides up to 22 Mbit/s forward and 3.4 Mbit/s return capacity per subscriber and can serve up to about 700 homes. It includes low-cost subscriber terminals using double dielectric-layer patch antenna technology (20x20cm, 17 dBi gain) and a 24-petal rosette hub antenna. Cognitive radio functions that make cells highly adaptive



MILTON subscriber terminal

in the presence of interference were added to the hub and user terminals.

The MILTON system has been deployed for field trials in a suburb of Ottawa. One hub and six terminals have been in operation since September 2004. In December 2004, the Government of India made the MILTON technology a prime area of investigation for its Centre of Development of Telematics (C-DOT), and acquired the technology for field tests in Bangalore.

Broadband access through digital television broadcasting

Because of their wider coverage capabilities, broadcast transmission technologies can be effective in bringing broadband access to rural areas. For example, digital television (DTV) can carry about 20 Mbit/s of broadband capacity in a 6 MHz television

channel over a coverage area of up to 70 km radius. CRC reviewed the three current DTV technology standards used across the world, and found them to be well suited for carrying broadband applications in the forward direction. CRC verified the extent of coverage in the field and confirmed that it can be improved and shaped using on-channel repeaters.

The concept of using DTV-ATSC in the forward direction and DVB-RCT for the return link was studied to provide two-way, high-speed data services for broadband access. DTV-ATSC is the digital television standard developed by the Advanced Television System Committee in the United States. The Digital Video Broadcasting Project in Europe has adopted the DVB-RCT (return channel terrestrial) standard.

An experimental DTV transmitter station is being upgraded in the Ottawa area to allow a full-scale demonstration of this bi-directional service. Researchers have demonstrated the feasibility of encapsulating IP data over the DTV transport stream, using a high-capacity data server that integrates multimedia applications and a prototype of a low-cost IP receiver. A bridge from the DTV IP receiver to Wi-Fi is also being developed.

In Canada as elsewhere, the transition from conventional analogue television to DTV offers the opportunity to use television bands more efficiently and free spectrum for other applications, such as broadband access. Distributed transmission networks using synchronized transmitters operating on a single channel could be implemented to carry the same television programming over large areas. Network planning studies were conducted, based on the TV Ontario network, to test the applicability of the distributed transmission concept on a large scale. TV Ontario uses different channels to broadcast the same programme across the province and consists of high and medium power transmitters and a large number of low-power frequency-translators distributed over the territory. It was found that common channels could be used in moderately congested areas by employing groups of low-power translators in a single-frequency network mode.

Alma's Harbor, New Brunswick, Canada

Using these technologies around the world

The use of the 20/30 GHz bands for satellite broadband access allows for small and potentially low-cost terminals that should make it easier to deliver services to any remote location where there is satellite coverage. The use of such high frequency bands will, however, limit the applicability of the technology to areas of the world with little precipitation because the signal tends to be heavily attenuated by rain. The MILTON system has potential in populated areas where no wired infrastructure exists.

With respect to the use of the low UHF range for wireless broadband access, this should have a global appeal – especially in developing countries where the UHF spectrum is not heavily used. In the transition from analogue to digital television broadcasting, broadcasters could take advantage of the data transmission capability of the new DTV systems to provide data services such as broadband access, as long as means are found to provide for the return channel.

With the development of new standards, such as the IEEE 802.22 wireless regional area network (WRAN) standard, low cost broadband access technology could become available and usable in television bands worldwide. The technology will include cognitive radio features that will allow sensing the presence of television broadcast signals in the area and avoid potential interference by automatically selecting an unused television channel for its operation. This could have a huge impact on efforts to create broadband access in large developing countries. Although best suited for sparsely populated rural areas, it could also be a cost-effective solution in more populated areas where some television spectrum remains unused. ■