Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

# Rural and Remote Broadband Access Program | Second-Year Report 2003 – 2004

RRBA

Canada

CRC

*"[We foresee] a Canada where the benefits of 21st century economy are being reaped from coast to coast to coast - on our farms, in our fishing, forest and mining industries and in our rural communities where modern communications are helping to surmount the barriers of distance."*

***Speech from the Throne, 2004***

# INTRODUCTION

While Canada holds one of the highest take-up rates for Internet in the world, 20 percent of the country's population, or 6.3 million Canadians living in 3900 rural and suburban communities, still could not receive broadband Internet as of October 2003.

The Communications Research Centre Canada (CRC), an agency of Industry Canada, is dedicated to developing appropriate technologies for connecting Canadians and increasing their capacity to communicate, learn and innovate via broadband technology. As the leading federal laboratory for research and development (R&D) in advanced telecommunications, CRC's researchers are striving to create broadband communications systems that will serve all Canadians, particularly those who are disadvantaged because of lack of communication infrastructure, low population density or remoteness.

In April 2002, CRC launched the Rural and Remote Broadband Access (RRBA) Program, a five-year initiative designed to research and develop cost-effective technologies for bringing broadband access to Canada's rural and remote areas. Milestones of the second year of the RRBA program are detailed in this report.

## PROGRAM MANDATE

The RRBA Program's mandate is to conduct innovative R&D on technologies and systems that will facilitate rural and remote access to interactive broadband multimedia services. Broadband technology can provide all Canadians with equitable access to education, healthcare, global business opportunities and more. Under the RRBA Program, CRC is conducting research and developing and testing innovative, cost-effective broadband technologies. It is also demonstrating system concepts and applications based on these technologies that will help the private sector make the provision of broadband services to Canada's underserved areas financially viable.

*Safeguard, enrich and strengthen the social and economic fabric of Canada and its regions*

*Render reliable and affordable telecommunications services of high quality accessible to Canadians in both urban and rural areas*

Canada's *Telecommunications Act*

## PROGRAM DESCRIPTION

The RRBA Program:

- supports Industry Canada in the development of policies, regulations and standards for making Canada the most connected country in the world;
- creates synergy among CRC's various research groups, capitalizing on their unique expertise in the technologies needed for the deployment of broadband access, such as satellite communications, terrestrial wireless and broadcasting;
- is focused on finding technological solutions that can extend broadband services to rural and remote areas in a timely and cost-effective manner;
- engages public- and private-sector partners to carry out collaborative demonstrations of broadband access technologies and systems for rural and remote areas, leading to potential transfer of technology to industry; and
- includes participation in international standards activities with the aim of reducing the cost of broadband equipment through large-volume manufacturing, and promoting Canadian expertise and technologies to other countries that face similar challenges.

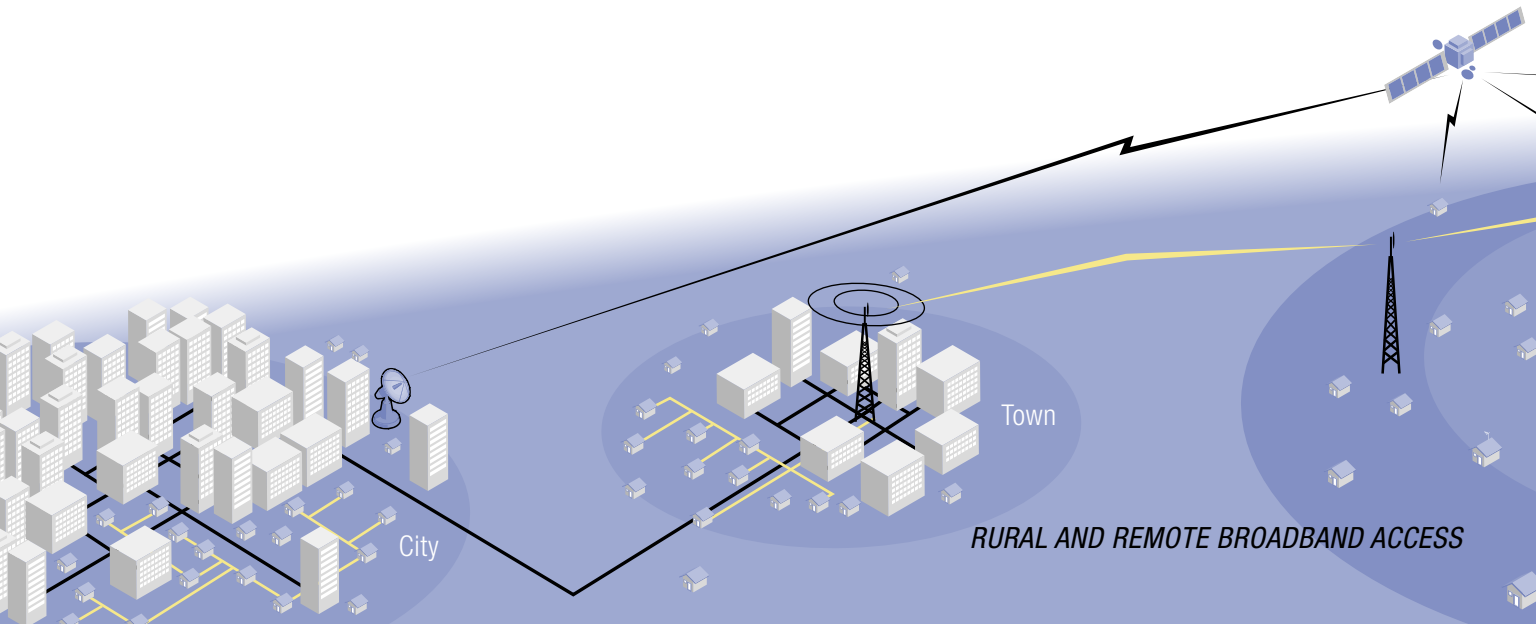
| RRBA Program Budget<br>Fiscal Year 2003-2004 | |
|---|---|
| $0.83M seed funding | $2.43M salary, operating and maintenance funds from CRC's research branches |

## PROGRAM GOVERNANCE

The RRBA Steering Committee is comprised of representatives from Industry Canada, universities, private industry and CRC research managers. Chaired by RRBA Program Manager Gérald Chouinard, the committee brings its recommendations to the CRC R&D Committee (CRC's President and Vice-Presidents) where the funding of the program is decided.

After evaluating the R&D projects conducted during the first year of the program and commenting on the quality and relevance of the results, the Steering Committee provided guidance for the projects worth pursuing as part of the program and suggested new R&D topics to be undertaken. These comments were considered by the research managers in the preparation of their proposals for the second year of the program.

A total of 16 project proposals were submitted to the Steering Committee at the start of fiscal year 2003-2004. Comments and guidance on these proposals were produced and a priority list was established. The CRC R&D Committee selected 11 of these projects for seed funding. Nine projects were the continuation of first year projects. One project dealing with Internet Protocol (IP)-based communications in the radio frequency (RF) range below 1 Gigahertz (GHz) was an amalgamation of two first year projects, and a new project on Digital Television (DTV) Return Channel was approved.

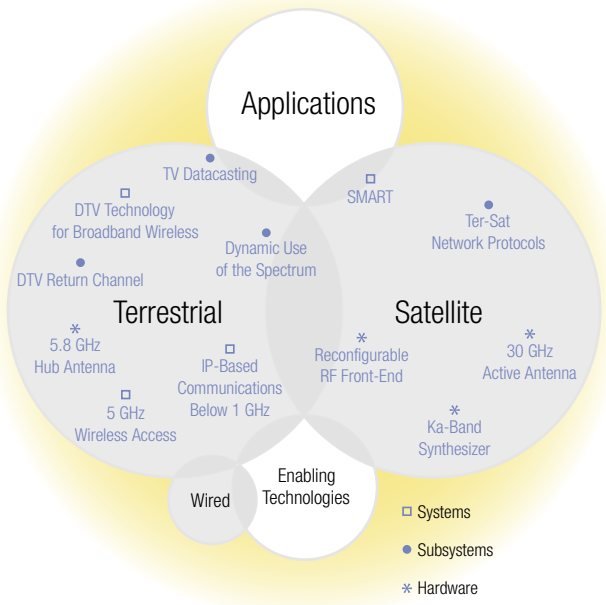


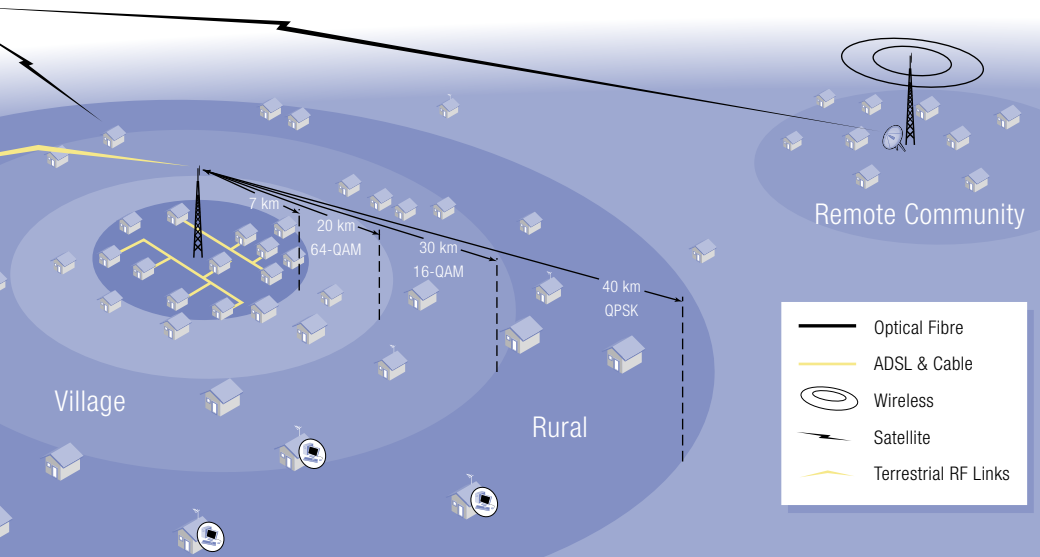
## RRBA PROGRAM ACTIVITIES IN 2003–2004

Over the past year, broadband has evolved in the marketplace and the Government of Canada has increased its support for broadband access to remote communities, as illustrated by the two Industry Canada programs on broadband, Broadband for Rural and Northern Development and the National Satellite Initiative (see side boxes). This has helped identify some major trends in the technologies required to reach Canadians with broadband services.

The second year of the RRBA Program saw the continuation of work from the most promising areas. The results of the 11 R&D projects undertaken during the year are summarized below. In addition, CRC provided support for BRAND and NSI; moved closer to the demonstration and field trials of a CRC-developed technology (MILTON); and continued demonstrating satellite broadband applications.

### R&D PROJECTS IN 2003-2004




*Spectrum, Information Technologies and Telecommunications (SITT) of Industry Canada initiated the Broadband for Rural and Northern Development (BRAND) pilot program in September 2002. A $45 million contribution was announced in October 2003 for 33 selected community-driven projects and $35 million was announced in April 2004 for 25 more projects. This is part of the Government of Canada's commitment to ensure that all Canadian communities have broadband Internet access by 2005. CRC provided technical support for the program.*

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*SITT has implemented the National Satellite Initiative (NSI) to help reach some 400 remote and First Nations communities with broadband service by providing the satellite transmission capacity. Two public-benefit transponders are being used at C-band on Anik E2, worth $20 million. Using the northern beams of Anik F2, $50 million of transponder capacity will be provided at Ka-band. Furthermore, $85 million worth of satellite capacity will be contributed over the next 10 years from Infrastructure Canada, to bring broadband to these remote communities.*

# A - R&D PROJECTS

### Terrestrial Wireless Technologies

- Work proceeded with the development of frequency converter prototypes to bring Wi-Fi® communications to the low Ultra High Frequency (UHF) range to take advantage of better propagation characteristics. Preliminary field testing indicated that a down-conversion of Wi-Fi® from 2.4 GHz to 700 Megahertz (MHz) extends the transmission range by a factor of four in line-of-sight (LOS) conditions and by a factor of two in non-LOS. Better integrated prototype converters will be developed for more extensive field trials.

- CRC continued to develop its 5 GHz multimedia wireless access system called Microwave Light Organized Network (MILTON). The current implementation provides 32 Mbit/s[1] (22 Mbit/s net) forward and 11 Mbit/s (3.4 Mbit/s net) return capacity. Refinements to the hub antenna and subscriber terminals were made. Two user terminal phased-array antennas covering the complete 5 GHz license-exempt range (4.9-5.9 GHz) were developed using double dielectric-layer technology: 4x4 patches (20x20cm, 17 dBi gain) and 16x16 patches (80x80cm, 23 dBi). Investigation started on a narrower band self-diplexing antenna with a 45 dB isolation requirement for full-duplex operation but more work is needed to bring it to reality. The development of algorithms for the pilot tone polling subsystem and remote configuration and control of the user terminals were completed. Cognitive radio functions to help avoid interference at 5 GHz were added to the hub and user terminals. Field trials are scheduled to start in June 2004 and negotiations have started with industry for the transfer of the technology.

- Researchers undertook the development of a flexible Orthogonal Frequency Diffusion Multiplex (OFDM) modem emulator based on the built-in Fast Fourier Transform (FFT) to provide adaptive modulation, frequency agility (by turning on and off certain carriers) and spectrum monitoring capability. The emulator, developed on a fast personal computer (PC) with high-end audio cards, is intended for the investigation of adaptive approaches to optimize the opportunistic use of free or under-used spectrum.

### Broadcast Transmission Technologies

- Digital television (DTV) can typically carry about 20 Mbit/s of unidirectional broadband capacity per 6 MHz TV channel over a coverage area of up to about 70 km radius. Test results confirmed that coverage can be improved and shaped using on-channel repeaters. The concept of using DTV-ATSC[2] in the forward direction and DVB-RCT[3] for the return link from the user terminals was studied to provide two-way, high-speed data services for RRBA applications. DVB-RCT equipment is being acquired for testing and integration into a bidirectional demonstration system. Software is being developed to help find available TV channels that can be used to implement RRBA with DTV and DVB-RCT in a given region.

- Researchers demonstrated the feasibility of encapsulating IP data over the DTV-ATSC transport stream by multi-protocol encapsulation. Sensitivity of IP traffic to packets lost over transmission will be analyzed.

- A high-capacity data server supporting a number of multimedia services and providing connectivity to the Internet was developed. A data caching software tool was implemented on the server to reduce the number of requests to the Internet. A data carousel system (multicast but not IP) was also implemented for the cyclic broadcast of data objects to achieve functions such as weather, news and file download services.

- A prototype of a low-cost IP receiver based on a commercial computer card was developed to capture unicasting and multicasting IP streams from specific DTV sub-channels and transfer it to the proper application on the host PC.

- Steps have been taken to progressively equip the Manotick UHF DTV experimental station with Internet access and with the equipment for a complete broadband access base station. The receiver antenna for the return link was acquired and installed on the tower. A complete demonstration system using this base station will be developed in the third year of the program.

### Satellite Broadband Access Technologies

- Satellite broadband access work concentrated on technologies capable of reducing the manufacturing and installation costs of Ka-band terminals that, because of the use of higher frequencies, should become smaller and lighter and provide an attractive solution for broadband access to communities and individual households.

- Researchers advanced their investigation on reflect-array technology and preference was given to offset-fed arrays with different focal points at 20 GHz and 30 GHz to minimize feed blockage and the need for a complex waveguide orthomode transducer. The concept of adjoining reflect-arrays to function as a larger array was successfully proven. Work advanced on spatial power-combining techniques to produce sufficient RF power from a Ka-band antenna through a distributed power phased-array feed system using low-cost active elements. The prototype of a 37-element passive array was produced and gave results as expected.

- Direct modulator and demodulator compensation techniques were developed and tested successfully and the technology is being transferred to industry. Solid-State Power Amplifier (SSPA) linearization was developed and further refinements were made for transfer of the technology to industry. The frequency synthesizer was delivered by the contractor and was shown to meet the stringent requirements needed for operation in the DVB-RCS[4] environment in the Ka-band.

- Work continued on the investigation and development of design techniques and basic prototype Ka-band electronic components such as vector modulator, RF filters and stripline power splitters using MMIC[5], LTCC[6] and MEMS[7] technologies for possible use in highly integrated, reconfigurable RF front ends for low-cost, frequency agile, and highly-reliable modems for satellite earth terminals.

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[1] Mbit/s: Million binary information units (bit) per second, [2] DTV-ATSC: Digital Television Standard developed by the Advanced Television Systems Committee in the US, [3] DVB-RCT: Standard adopted by the Digital Video Broadcasting Project in Europe for the Terrestrial Return Channel, ETSI (EN 301 958), [4] DVB-RCS: Digital Video Broadcasting – Return Channel Satellite (ETSI EN 301 790), [5] MMIC: Microwave Miniature Integrated Circuit, [6] LTCC: Low Temperature Co-fired Ceramic, [7] MEMS: Micro-Electromechanical Microwave Systems

- CRC advanced its study on innovative transport, network and link protocols for the transmission of IP-based broadband services over satellite circuits. The satellite transmission capacity is maximized through the concerted use of dynamic satellite bandwidth allocation and a link performance enhancer replacing the usual Transmission Control Protocol (TCP) to reduce the link latency while meeting specified levels of Quality-of-Service (QoS). A more optimum Flow Control was developed to support QoS, especially in congested and bursty networks. These algorithms have been integrated into a Satellite Capacity Optimization and Performance Enhancement (SCOPE) Linux box. It was found that the SCOPE box could reduce the service latency by more than 70 percent and increase the end-user traffic throughput by a factor of five. These functionalities can be added through either a compatible upgrade to current open-standard DVB-RCS terminals or through a more optimized upgrade to future DVB-RCS terminals. This technology is expected to be transferred to industry soon.

## B - FIELD TRIALS

Field testing for the MILTON system is scheduled to take place in a semi-rural suburb of Ottawa during summer 2004. These field trials will show the system's capability for wireless broadband access, frequency reuse and cognitive radio operation, and they will demonstrate the proof-of-concept to industry. Necessary equipment has been developed, including the production of 25 low-gain subscriber terminals and 10 higher-gain terminals for extended coverage up to 4 km. An optical fibre connection has been brought to the expected location of the hub station where the 24-petal rosette hub antenna will be mounted.

Field trials of Wi-Fi® technologies at 700 MHz are planned for December 2004 using 802.11b/g units, the developed frequency converter prototypes and simple UHF antennas. Field trials of enhanced Ka-band earth terminals will take place when Anik F2 is available for tests.

## C - RRBA PROGRAM REPRESENTATION

The RRBA Program provided technical expertise to the BRAND and NSI programs (see side bar on page 3) and was described to various groups within Industry Canada. Visitors to CRC from many parts of the world, including Europe, South America and Australia, were introduced to the program. The RRBA Program was also presented in a seminar organized by CITEL[8] in El Salvador. Material from this presentation was used by the International Telecommunication Union (ITU) development sector in a manual on Broadband in Developing Countries. The RRBA Program was also described in two presentations given at the WIC2003[9] conference in Ottawa.

CRC is participating in the work of the IEEE in the context of using license-exempt devices in the VHF/UHF TV-bands, as proposed by the Federal Communications Commission (FCC). The role of the RRBA Program in this forum is to contribute in the development of a transmission standard with special considerations towards providing broadband access in rural and remote areas in this range of frequencies due to inherent superior propagation characteristics. This effort should lead to the development of a suitable open standard similar to 802.11 for ultimate high volume production of low-cost user terminals.

## D - RELATED BROADBAND APPLICATIONS DEMONSTRATIONS

Together with partners such as the National Research Council, Telesat, and CANARIE Inc., CRC has been carrying out demonstrations of broadband applications in Canada's northern communities. These demonstrations complement the RRBA Program. The applications demonstrated require broadband capacity on satellite links and little additional infrastructure.

### SMART

The Satellite Multimedia Applications Research and Trials (SMART) Program demonstrates broadband satellite communications services and applications, and provides technical support to other government entities. In fiscal year 2003-2004, all SMART Labrador satellite-served sites were visited to perform final maintenance prior to commercialization and technical support was provided to Canadian pavilions at ITU World and at the World Summit on Information Society.

### MUSICGRID

MusicGrid's primary objectives were to enable, expand and enrich Canadian music education programs in urban, rural and remote communities, and to demonstrate key principles for the future of large-scale broadband e-learning. It extended broadband's reach by linking fibre optic, satellite and international broadband networks by interoperation of heterogeneous videoconference platforms and by the development of new asynchronous broadband visual communication tools. Over 150 scheduled broadband videoconference learning sessions had been carried out by the end of the project in March 2004.

[8] CITEL: Comisión Interamericana de Telecomunicaciones, Inter-American Telecommunication Commission, [9] WIC2003: Wireless Industry Congress 2003, Ottawa, September 21-23

## A LOOK FORWARD

In an effort to focus the program's R&D on technologies and system concepts that can be developed and demonstrated within the time frame of the five-year program, four main areas have been identified for the continuation of the program.

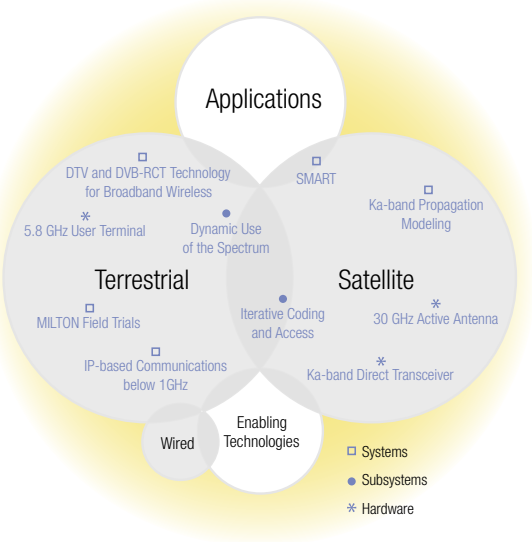
For the third year of the RRBA Program, R&D will concentrate on:

- demonstrating the MILTON 5 GHz license-exempt technology in field tests, completing its development to a point where it can be transferred to industry, and experimenting with the system in lower frequency bands to extend its reach;
- experimenting with low-cost broadband access technologies such as Wi-Fi®, using frequencies below 1 GHz and various network topologies in order to extend their reach for rural applications;
- amalgamating and pursuing R&D projects related to the use of DTV to deliver broadband access and the use of DVB-RCT technology to provide the wireless return link in view of developing a complete system prototype for demonstrations and field trials; and
- continuing the development of Ka-band technology to reduce the equipment and installation cost of broadband access earth terminals.

In addition, CRC will undertake further systems studies and will continue to provide technical support to Industry Canada's BRAND and NSI Programs. CRC will take part in relevant spectrum-related activities (policy, regulatory) initiated by IC to investigate the possibility of using the lower UHF range for rural and remote broadband access, and will also participate in standards-related activities (IEEE, ITU-R) to spur the development of worldwide transmission standards for this type of broadband access. It will also transfer relevant technologies to Canadian companies so that they can deploy affordable broadband access systems in rural and remote areas in a timely fashion.

While, for most communities, the more densely populated area can be covered by current technologies, reaching all citizens of the community, including those living in surrounding scarcely-populated areas, is still a challenge. Hence, special attention will be given to the use of wireless access technologies that would take advantage of the more favourable propagation characteristics of the lower UHF range. This will allow wireless systems installed in low population density areas to have a better reach in the rural context.

## EXPECTED R&D PROJECTS 2004-2005




The development of these low UHF wireless solutions, be it Wi-Fi®, Wi-Max® or DTV-based, will provide the bridge between making broadband widely available to ***communities*** and making it widely available to all ***Canadians*** in these communities. The RRBA Program continues to strive to develop and demonstrate technologies that can be universally standardized with a view to reduce the cost of equipment through volume production by competing manufacturers so that industry can develop viable business cases in trying to reach all Canadians.

**More Information:**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Cat. No. Iu105-1/1-2004
ISBN 0-662-68337-4
54177B