Communications Research Centre Canada
Centre de recherches sur les communications Canada

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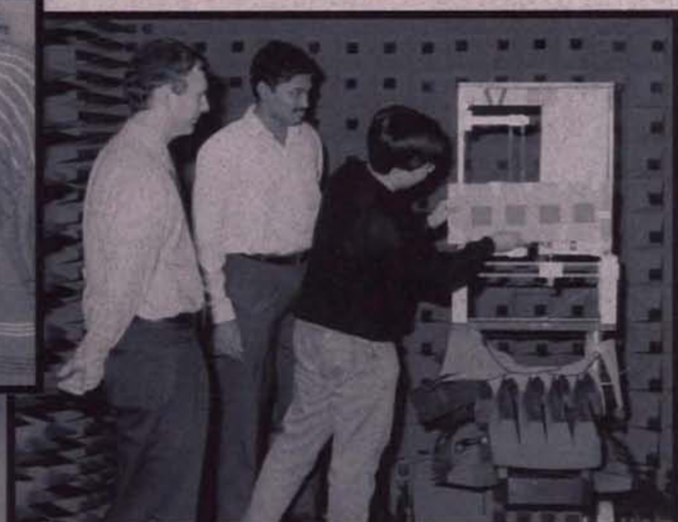
Second Technical Workshop Report

Held under
CIDA sponsored
International R & D Collaboration Program
between CRC (Canada) and C-DOT (India)

Nov 15 - 24, 1999
CRC, Ottawa
Canada



Canada

CRC

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CIDA PROJECT

TECHNICAL WORKSHOP AT CRC

NOV. 15 – 24, 1999

As part of CIDA Project, and as planned during our first CRC / CDOT workshop (May 31 – June 8, 1999), a second technical workshop was held at CRC from Nov. 24 – 24, 1999. In addition to the workshop, a high level CDOT delegation as well as memers of the Project Steering Group (PSG) were also hosted by CRC.

OBJECTIVES

The objectives of this workshop were:

1. Start work on the two collaborative projects defined and finalised during the first technical workshop by placing two C-DOT engineers at CRC. The two projects are – a) development of microstrip patch antennas and b) the development of low noise amplifier and a direct digital modulator or demodulator at 20 Ghz for Ka band satellite transceiver using MMIC technology.

2. Define and finalise six other projects identified and initiated during the first workshop. These are:

   - 155 Mbps satcom Ka band direct receiver
   - Broadband applications connectivity (BADLAB)
   - Broadband wireless access technology (MILTON)
   - Optical components for DWDM and high speed switching
   - DSP ASIC technology development for codec implementation
   - RF Propagation measurement and studies for satcom and terrestrial wireless

3. Finalise and sign a collaborative R and D MOU between CRC and C-DOT.

4. Industrial visits specifically in the areas of selected projects with a view to involve Canadian companies for commercialising the results of collaborative R&D, in partnership with Indian companies through C-DOT.

WORKSHOP PROGRAMME

Appendix 5 gives the agenda for the workshop, and **Appendix 6** gives the list of participants. The overall program consisted of the following activities:

- Individual project discussions
- MOU finalisation and signing
- Lab visits
- Industrial visits
- PSG meeting and their visit of CRC

Project Discussions

To maximise the use of available time, discussions on the 8 projects were carried out simultaneously in parallel among the respective subject experts from CRC and C-DOT. These discussions were facilitated and co-ordinated by the CRC and C-DOT CIDA Project Team Leaders. The projects are described briefly below and are explained more fully in Appendices 1 and 2, which describe project objectives, deliverables, respective roles for CRC and C-DOT, equipment, personnel and other resources required, time frame including start and completion dates, and methodology.

Appendix 1 provides a description of these projects as prepared by CRC. Appendix 2 gives a slightly more detailed version, as prepared by C-DOT engineers in the context of their own R&D programme.

1. Development of low gain L band, S band, and high gain EHF band microstrip patch array antennas.

Although this project was defined during the first workshop, technical specifications were further discussed and revised during this workshop to reflect C-DOT's actual product requirements.

A relatively simple L-band antenna will be designed, fabricated, packaged and tested during the first phase of the project, with C-DOT engineer working at CRC (Nov 1999 – Jan 2000).

At the end of this phase, C-DOT will procure and set up design and testing facilities in India. It is anticipated that the most of the work for the subsequent phases, aimed at the development of more sophisticated antennas, can be carried out at C-DOT with long distance support from CRC through internet.

As of now, the technical progress on this project is quite satisfactory and is on schedule. C-DOT engineer has already simulated, designed, fabricated and successfully tested a single patch.

2. EHF MMIC Development – LNA and Direct Modulator

The objectives are to provide design, fabrication and measurement experience and to develop first a low noise amplifier using small signal linear design and then a direct digital modulator or demodulator using more difficult non-linear design. These products are directly relevant to C-DOT's requirements. There is also a strong possibility of involving a Canadian company in this project, which may eventually find an Indian partner for commercialization purposes.

C-DOT engineer is already working at CRC to do the Low Noise Amplifier design. Due to the late arrival of C-DOT engineer (November instead of Sept as originally planned), and the strict time table for foundry fabrication, the collaborative programme has been slightly modified. Only the first stage of the LNA design will be included in the first foundry run. C-DOT engineer will leave CRC in January and will return in April to do the testing and start the design for the remaining two stages. Full design will be submitted for fabrication during the second foundry run.

It is anticipated that the experience gained during the first phase (LNA design, fabrication and testing) will enable C-DOT to undertake the second design mostly in India, with long distance support from CRC, after the procurement of the appropriate design tools and other R&D equipment,

3. OC – 3 (155 Mbps) Satcom Ka-band Direct Receiver

CRC has developed a patent pending proprietary direct receiver technology. The current lab prototype system works at 90 Mbps at 20 GHz using QPSK . The objective of this project is to extend the data rate to OC–3 (155 Mbps) and bring the concept closer to commercialization beyond the lab prototype by optimizing the design for cost and performance. Since C-DOT has a very good hardware and ASIC design capability, its main contribution will be in the development of the digital hardware.

As is shown in the CRC's project plan, it is expected that C-DOT engineer will work at CRC in 4-6 week spans, 3-4 times over a period of 15-18 months.

Work on this project has already started. CRC has sent its project description and other technical information to C-DOT. Specific project steps and time line are shown in the gnatt chart contained in the CRC's project description document given in Appendix 1.

4. DSP VLSI / ASIC Design

C-DOT has a requirement for an ASIC chip to implement speech coding. Given the use of various coding standards and requirement for multiple channels, it is not clear whether or not developing a customised ASIC starting from scratch is the best solution.

A number of meetings were held to investigate various options including the use of existing DSP's, DSP cores, and the use of advanced DSP ASIC tools to translate DSP algorithms to VHDL (silicon mapping) code.

It was concluded that a 1-2 man months study (carried over 3-4 months) should be conducted to further investigate and analyse various available options and chart out a detailed project plan for the selected path or option. A more detailed description of this study proposal is given in appendices 1 and 2, along with respective roles for CRC and C-DOT.

To carry out this study, it is not necessary for the C-DOT engineer(s) to work at CRC. The study will be carried out over the next 3-4 months.

5. Broadband Applications Connectivity (BADLAB)

C-DOT plans to set up a broadband applications demonstration lab (similar to CRC's BADLAB) using its in-house developed ATM switches. The objective of this project is to asist C-DOT to set up such a lab in India and interconnect the two labs (Ottawa and New Delhi) through a transcontinental high speed link to demonstrate collaborative multimedia applications such as collaborative R&D (between CRC and C-DOT) and virtual school.

During this workshop, a C-DOT engineer spent considerable time with CRC's BADLAB manager and CRC's partners including Ottawa's Heart Institute (fro tele-medecine applications) and Ottawa Carleton Research Institute (OCRI).

C-DOT engineer felt that as a result of these meetings and discussions, he has enough information to start setting up a similar lab in India and no further action is needed in this regard at the moment other than possible consultation through internet.

Once C_DOT has set up its lab, it will contact CRC to inititate the second phase of this project in which BADLAB in Ottawa will be connected to the equivalent lab in India to demonstrate multimedia type applications such as virtual school and collaborative R&D,

6. Broadband Wireless Loop using 5 GHz (Known as MILTON at CRC)

CRC has developed a patent pending low cost proprietary system for implementing broadband wireless access at the local level, as an alternative to the more expensive option of installing optical fiber or using LMDS / LMCS system using much higher frequencies. In fact, this system may be more relevant and useful to India where the existing infrastructure is not nearly as developed as in the developed countries and the other alternate technologies such as LMDS and hybrid cable modem are not as developed yet. For these reasons, C-DOT showed a keen interest in this technology as a wideband access mechanism for its ATM switches.

Since MILTON uses IP, C-DOT plans to develop an ethernet switch by developing a new ethernet switch line card in its ATM Mux.

Once CRC has finalised its system specifications over the next few months, C-DOT could start the development of its ethernet card and other collaborative activities as outlined in the detailed project description.

In the mean time, it may be useful for a C-DOT hardware engineer to participate in the remaining development of the MILTON system to gain first hand experience. A description of duties and required skills has been sent to C-DOT already.

7. Optical Component Development for DWDM and High Speed Switches

C-DOT has already embarked upon the design and development of a DWDM system. CRC has developed a number of innovative technologies and components including grating-based and other components such as add/drop filters, dispersion compensation components, fused fiber couplers, optoelectronic switches, polymer based optical components including wavelength demultiplexers, wavelength demultiplexers integrated with photodetector array, wavelength multiplexers and demultiplexers using glass substrate. CRC's expertise in the optical components can be coupled with C-DOT's expertise in system design to develop a state-of-the-art DWDM system.

C-DOT is quite interested in pursuing a number of these areas. However, before selecting a particular area(s), C-DOT would like to develop a complete commercialisation plan possibly in partnership with some of its Indian industrial partners. CRC and C-DOT will further interact in these areas before specific project(s) can be finalised.

C-DOT will get back to CRC on is action plan for pursuing fiber gratings, dispersion compensation components and fused coupler technology. CRC will send more information on WDM system related technologies and optoelectronic switches to C-DOT.

8. Propagation Studies

Communications equipment supplier and service providers generally rely on existing propagation models which are generally based on measurements done for the developed countries, to derive system specifications for the Indian market. Since climatic conditions in India are quite different, use of such models often results in either over specifications (meaning higher system costs) or service gaps. There is, therefore, a need for carrying out propagation measurements in India and derive the appropriate models, especially in light of expected explosive growth in the wireless services.

While the immediate objective of this project is to provide experience in designing experimental methodologies, apparatus, planning field measurements, data acquisition, software development, data analysis, and interpretation at a selected frequencies, the longer term objective is to enable C-DOT to set up propagation studies program in India to allow the orderly development and installation of wireless technologies and systems.

Discussions were held on two sub projects within this area.

A. Ka band Satellite Link Propagation Studies

C-DOT has developed VSAT communication systems like ISD –16 and ISD – 64 for existing lower frequency satellite systems. India will shortly lauch a new satellite with Ka band beacon which will allow earth-space propagation measurements and studies. These will be required in the design and employment of future Ka band VSAT and other satellite systems.

B. Terrestrial Propagation Studies in L/S bands

These are required for the implementation of C-DOT's TDMA, DECT and CDMA systems.

While it is quite evident that propagation studies are essential for the orderly implementation and growth of wireless services in India, and C-DOT is one of the most competent body to carry out these studies, it is not clear whether such work falls within C-DOT's mandate.

C-DOT will discuss this issue internally and possibly with other organisations including DOT and will get back to CRC for a possible plan of action.

MOU Finalisation and Signing

A formal MOU for R&D collaboration between CRC and C-DOT was discussed, finalised and signed by Gery Turcotte, CRC's President and Dr. K N Gupta, Executive Director of C-DOT, on November 19, 1999 at a brief signing ceremony held at CRC.

Apart from CRC and C-DOT personnel, the event was also attended by representatives from CIDA, IC, and Indian High Commission. Appendix _ gives a copy of this MOU and the press release issued for the occasion.

Lab Visits

In addition to lab visits and discussions by the C-DOT engineers, the following labs and technologies were shown to the C-DOT senior management team.

MMIC / MHMIC Microwave Lab	Dr M Stubbs / Dr V Swarz
VLSI / ASIC Lab	Dr V Szwarc
Microstrip Patch and other Antennas	M Cuhaci
BADLAB (Broadband Applications Demonstration Lab)	M Savoie
Optical Network Technologies	Dr E Berolo
Optoelectronics Materials and Components	Dr. Julian Noad
Optical Communications	Dr Ken Hill
Satcom Ka band direct Receiver	M Caron / D Hindson
Satellite Suitcase Terminal	C Pike
Broadband Wireless Access (MILTON)	J Sydor
Terrestrial Wireless Test Bed	Luc Boucher

The objective here was to give C-DOT's senior management team a first hand exposure of CRC's capabilities and expertise in the areas selected for collaboration, in order to gain their support and acceptance.

External Visits

As per our original CIDA proposal, a small number of external visits were arranged for the C-DOT's senior management team. They visited the following organisations.

Nanowave / Remecs Inc., Toronto

Nanowave has had considerable collaboration with CRC in the past and is currently the leading edge Canadian company in the area of MMIC / MHMIC technologies. It designs, manufactures and sells RF components, subsystems and systems for the wireless market. Both C-DOT and Nanowave showed keen interest in mutual collaboration.

Harris Canada, Montreal

C-DOT is looking to acquire RF technology to meet its immediate needs for the development of mobile base stations required by C-DOT. Harris represents a good candidate for such technology transfer, since Harris is not particularly interested in setting up a manufacturing plant in India and would prefer an Indian partner for exploiting its technology through a suitable collaborative and / or licensing arrangement with C-DOT.

Larcan, Toronto

Larcan was selected to show C-DOT its prototyping and manufacturing facilites which are of similar scale as C-DOT's. Larcan also explained the advanatages of working with a government lab like CRC. C-DOT found this session quite informative and useful.

Mitec, Montreal

Mitec designs, manufactures and sells RF front end subsystems to major cellular and PCN base station vendors. Although no areas could be identified for immediate collaboration, C-DOT may wish to work with this company to enhance its RF capabilities.

NRC, Ottawa

C-DOT visited IIT (Institute of Information Technology) and IMT (Institute of Microstructural Sciences). No immediate mutual interest was identified.

Since these were meant to be only exploratory kind of visits with no direct and clear objectives, the number of visits were kept small. Both CRC and C-DOT have large number of industrial partners. Given C-DOT's initial interest in collaborating with Canaidan companies either itself or along with its Indian industrial partners, CRC will be willing to arrange for expanded industrial interaction if required and requested.

Lunch by C-DOT

Dr. Gupta, Executive Director of C-DOT, hosted a special lunch for CRC and C-DOT research teams which participated in this workshop. Attendance by some 35 CRC researchers is an indication of strong interest and desire in this project.

PSG (Project Steering Group) Meeting - November 16, 1999

Jeet Hothi (CRC) and Jayant Bhatnagar (C-DOT) made a presentation to the CIDA Project Steering Group meeting on the current status of CRC / C-DOT collaborative activities (see Appendix _ for a copy of their presentation). The presentation was well received and PSG members seemed pleased with the progress and the manner in which collaboration has taken place so far.

Visit of CRC by PSG , November 20, 1999

A lively discussion took place after Graham Taylor (CRC) gave an overview of CRC's research labs and its collaborative activities with industry and other national and international organisations. PSG memebers were then given a tour of BADLAB (Broadband Applications Demonstration lab) and DFL (Satellite integration and testing) lab. PSG member reaffirmed their satisfaction with the R&D collaborative part of the overall CIDA project.

Visit of C-DOT by CRC

It was strongly felt that the next project review and discussion meeting should take place at C-DOT. This will allow CRC researchers a direct and first hand appreciation of C-DOT's laboratories, expertise, and technical requirements. The meeting is tentatively planned for Oct. / Nov. , 2000 time frame. An appropriate programme and agenda will be jointly developed before the meeting.

ACKNOLEDGEMENTS

we would like to thank:

C-DOT engineers for their participation, keen interest, long working hours extending late into evenings, and co-operative and pleasant attitude;

George Wieringa of CIDA for his strong support and attending the MOU ceremony;

Claude Dostlar and Aaron Baillie of IC for their on-going support and encouragement for this project;

CRC's President for his moral and general support;

CRC VP's, Research Managers, Director of Marketing, Director of Informatics, Engineering and Scientific staff for their enthusiastic participation and co-operation;

Sylvie Boileau, Lisa McWilliam, Marnie Johnstone (Communications) and John Brebner (Creative Visual Services) of CRC to arrange for the MOU ceremony, photographs and other communications related activities;

Special thanks to Miriam Poole of CRC to take care of CRC's hospitality in such a pleasant manner;

Neelam Mukhija, a technology transfer and industry consultant for his support in organizing and conducting the entire workshop.

Finally, we would like to extend our special thanks to Dr. K N Gupta of C-DOT and his senior managers – Dr P K Bhatnagar and Vijay Madan for taking time from their busy shedule to visit CRC and also for hosting a special lunch for the research teams.

Jeet Hothi
Head, Industrial R&D
CRC

December, 1999

APPENDIX 1

BRIEF PROJECT DESCRIPTIONS AS PREPARED BY CRC

PROJECT TITLE: Microstrip Patch Antenna Development

DESCRIPTION: This project will allow a C-DOT engineer to gain experience in Microstrip Patch Antenna technology through the development of different type microstrip antennas. The project will provide knowledge in the hardware and software tools necessary for the development of microstrip antennas, the design and measurement procedures involved and some of the advantages and limitations of the technology. The project will also provide knowledge on how to setup a basic Microwave Antenna Measurement Laboratory.

SPECIFIC OBJECTIVES:

The objectives are planned to provide design, fabrication, packaging and testing experience for microstrip antennas in a progressive manner. The following Microstrip Antennas for Communication System at different frequencies will be designed during this project:

1) A low gain microstrip Linearly Polarized (LP) antenna around 2GHz,
2) A low gain microstrip Circularly Polarized (CP) antenna around 2GHz,
3) A medium gain X or Ku-band microstrip antenna for LP operation,
4) A Ka-band microstrip antenna for LP operation.

KEY PERSON AT CRC:

Michel Cuhaci

KEY PERSON AT CDOT:

TBD

TIME FRAME/DURATION:

This activity will extend over two years, in three 6 months periods.

RESOURCES:

CRC – VPRS/RAAT

Pentium workstations with Ensemble and/or IE3D software.
Antenna prototype fabrication, including material, layout, mask, etching and assembly.
Antenna measurement facility
18 man/month

CDOT – 1 microwave design engineer

Pentium workstations with TBD antenna design software

DELIVERABLES/OUTPUTS:

Reports – reports on simulated and measured microstrip antenna characteristics.
Publications – possible
Prototypes – prototype microstrip antennas
Training – microstrip antenna design/measurement procedures
Technology transfers – microstrip antenna design concept

PROJECT TITLE: EHF MMIC Development

DESCRIPTION: This project will allow C-DOT engineers to gain experience in GaAs MMIC technology through the development of MMIC chips. The project will provide knowledge in the hardware and software tools necessary for the development of MMICs, the design and measurement procedures involved and some of the advantages and limitations of the technology.

SPECIFIC OBJECTIVES:

The design and measurement of two EHF MMIC components for transmitter and receiver communications systems will be accomplished. The first, a low noise amplifier, will provide small signal, linear design experience and the second, a direct digital modulator (or demodulator), will provide non-linear design experience.

KEY PERSON AT CRC: Valek Szwarc

KEY PERSON AT CDOT: Vinay Madhav

TIME FRAME/DURATION:

The relatively long design and fabrication times, and the constraints of fiscal year expenditures, dictate that this activity will extend over two years.

One possible timeframe is as follows:

LNA design (1 st stage)	15/11/1999 –	10/1/2000
MMIC fabrication	20/12/1999 –	31/3/2000
Measurements	1/4/2000 –	31/4/2000
LNA design/revision/review	1/5/2000 –	1/6/2000
MMIC fabrication	1/6/2000 –	1/9/2000
Measurements	5/9/2000 –	15/9/2000
Modulator Design	1/6/2000-	1/12/2000
MMIC fabrication	1/12/2000-	31/3/2001
Measurements	1/4/2001-	14/4/2001

Development of the LNA and modulator will be carried out by C-DOT engineer in consultation with CRC staff. The work will be carried out at C-DOT and/or CRC depending on circumstances and the ease or difficulty experienced in carrying out consultations electronically.

RESOURCES:

CRC – Sun workstations with Libra
MMIC fabrication

CDOT – 1 or 2 microwave design engineers
Workstations with Libra

DELIVERABLES/OUTPUTS:

Reports – reports on simulated and measured MMIC characteristics
Publications – possible publications on modulator
Prototypes – three MMIC devices
Training - MMIC design/measurement procedures
Technology transfers – MMIC modulator concept

CRC RESOURCES

FY 99/00

1 Libra Workstation
Foundry fabrication
3 weeks Res.- 04
1 month ENG-03 support
3 weeks EL-05 support
Libra maintenance, wafer prober & test equipment usage
Microwave probes

FY00/01

Foundry fab (LNA)
Foundry fab (Modulator)
3 weeks Res.-04
2 month ENG-04 support
3 weeks EL-05 support
Libra maintenance, wafer prober & test equipment usage

PROJECT TITLE: DSP VLSI Design

BACKGROUND: The implementation of communications systems, speech vocoders, error correction devices etc. frequently originates with the development and refinement of sophisticated algorithms in such languages as C or C++. Furthermore, the initial proof of concept or actual production implementation is frequently carried out on suitable general purpose processors or DSP processors that can effectively execute the compiled software. To achieve optimal performance the actual implementation may require a re-coding of the algorithms in assembler language. In instances where performance and/or cost dictate it an ASIC implementation may be necessary. In considering the economics of an ASIC implementation it is imperative to consider the cost and time associated with the execution of the design. Ideally, for designs that have been developed in C or C++ and functionally tested one would like to be able to go directly from the programming language to a VHDL implementation. Some steps in this direction have been taken by Frontier Design Inc. with their DSP Station. The company has for example claimed to have implemented the G.726 ADPCM Speech Codec with this tool. The implementation in question requires 5k gates (plus memory) and is capable of operating in full duplex mode.

BRIEF DESCRIPTION: C- DOT has identified a number of applications whose implementation is contingent on the implementation of a vocoder that meets the G. 729 standard for 8 kbps voice compression. Furthermore in the applications of interest the vocoder module/ASIC would have to handle up to 24 voice channels. To implement such a module the following options have been identified for Phase 1:

i) Design of ASIC around commercial macrocells (G. 729 macrocell, DSP macrocell, processor macrocell).
ii) Direct implementation of vocoder algorithms in VHDL
iii) Implementation of vocoder algorithms by means of newly available CAD tools capable of mapping algorithms in C or C++ into synthesizable VHDL code.

The proposed work at CRC is intended to investigate viability of options (i) and (iii) by:

- Identification of DSP ASIC tools: through an evaluation of a commercially available DSP/ASIC CAD tool of choice (e.g. DSP station from Frontier Design) in terms of its suitability for rapid prototyping through mapping of C and/or C++ code into synthesizable VHDL
- Identification of DSP core vendors: determination of commercial availability and suitability of vocoder, DSP and processor macrocells
- Analysis and Conclusions

On the side of C-DOT the work will involve the following tasks:

- Estimation of CODEC complexity
- Identification of DSP ASIC tools

- Identification of DSP core vendors
- Identification of complete solution providers
- Analysis and Conclusions

To assure close collaboration and effective exchange of information both C-DOT and CRC will jointly address two of the above areas as specified and collaborate on drawing up the Analysis and Conclusion.

Should the initial investigation point to the viability of using advanced CAD tools for the mapping of algorithms from C /C++ into VHDL then CRC and C-DOT may consider a joint Phase 2 R&D activity to investigate further the design methodology and relevant tools for the mapping of vocoder algorithms from C /C++ into VHDL with view to evaluating their potential and limitations. At this point we can only estimate that a Phase 2 activity would require the participation of two to three engineers. One ASIC designer from CRC and one or two DSP/ASIC engineers with vocoder experience from C-DOT.

SPECIFIC OBJECTIVES: Near term activity (Phase 1): identify R&D options and objectives in the context of C-DOTs and CRC's respective goals and missions.
KEY PERSON AT CRC: V. Szwarc
KEY PERSON CDOT: Chandrashekar B. U.
TIME FRAME DURATION: Four months. (Phase 1). Project can be initiated as early as Dec. 1999.
RESOURCES:
CRC: One VLSI Engineer
Workstation, CAD tools: Mentor Graphics, Xilinx FPGA tools
CDOT: DELIVERABLES / OUTPUTS: Report on work done.
PUBLICATIONS: possible publication – will depend on depth of analysis and choice of representative circuits.
TRAINING: N/A
TECHNOLOGY TRANSFER: Knowledge obtained in course of study.
CRC Resources
Four weeks Eng. 04 effort
One week Eng. 06 effort

Software –lease (if required)*

* The current plan calls for using evaluation software from Frontier Design to carry out this study. If evaluation software is not available for the necessary period it may be necessary to lease it for several weeks.

STATEMENT OF WORK FOR PROJECT:

155 Mbps SATCOM K-BAND DIRECT RECEIVER

1. BACKGROUND

CRC/RSS has entered into an agreement with C-DOT to develop a prototype direct receiver in the 20 GHz band based on a 5-port junction front end and the novel I&Q regeneration technique developed by RSS. The I&Q regeneration technique compensates for the phase and gain imbalance introduced in the receiver front end as well as most of the phase imbalance introduced at the transmitter and generates the baseband I&Q signals. The receiver is to be capable of receiving 155 Mbps QPSK modulated signals and the project covers the electronics from the front end down to and including the generation of the baseband I&Q signals. CRC/RSS will train C–DOT personnel in order for them to be able to re-create and re-design the electronics as required in future projects.

This document provides detail on the tasks to be executed and identifies the contribution and deliverables of each party. A schedule is proposed as a guideline. Any deviation from this schedule due to any constraints will have to be discussed by both parties and agreed before to be put in force.

2. OBJECTIVES OF THE PROJECT

The project aims to develop a lab bench prototype direct receiver and required testing hardware adapted to the C-DOT product requirement for their ATM backbone satcom terminals. A second aim is to train C-DOT personnel such that further design and/or re-design activities can be undertaken by them as required in future projects.

Figure 1 shows a block diagram of the hardware addressed in this project. There are three main functional blocks in the receiver chain. First the front end made of a 5–port junction, single ended mixers and a section of video amplification. This block is referred to as the "front-end" or FE block. The second block consists of the AGC circuit and the anti-aliasing filters. It is referred to as the "baseband processing" or BBP block. Finally the I&Q regeneration block referred to as the I&Q block constitutes the third element of this project.

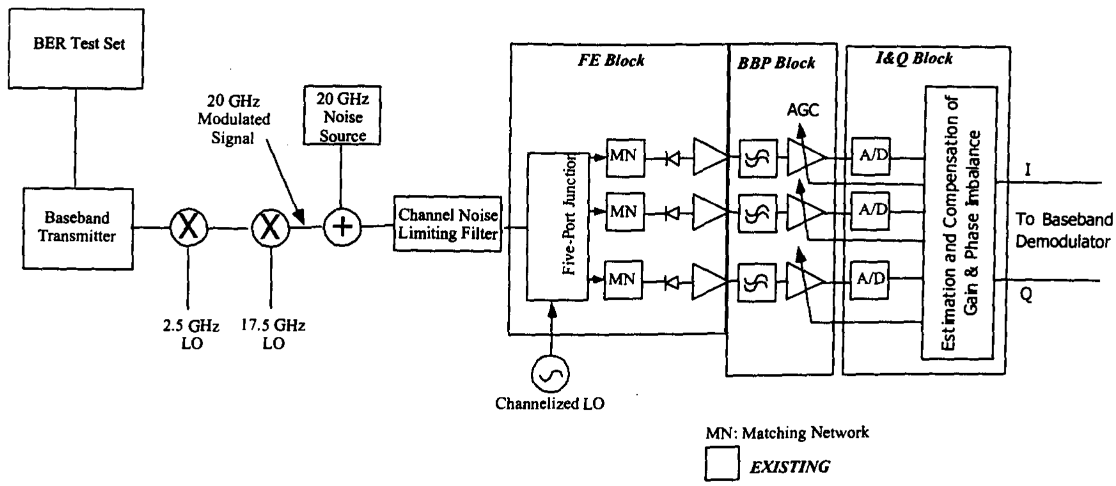

Figure 1: Subsystem to be addressed in this project.

In order to be able to test the receiver, a number of other elements are required. The baseband transmitter is to be developed under a development contract to industry and managed by CRC/RSS. CRC's existing up-converter chain shaded in Figure 1 is to be used to generate the 20 GHz modulated signal from the baseband transmitter output. CRC's existing wideband channel noise generator also shaded in Figure 1 is to be used in this project. C-DOT I&Q demodulator is to be used in the final integration and testing of the receiver. Various test instruments are to be used in the project. In particular there is a need for a BER test set operating at up to 155 Mbps, signal sources at 2.5 GHz and 17.5 GHz, spectrum analyzer, oscilloscope and logic analyzer.

3. TASKS

In this section the various tasks of this project are described and the contribution and deliverables are identified.

3.1 TASK 1: RECEIVER SYSTEM DESIGN DOCUMENT

This task is to be conducted by C-DOT. This document identifies the functional requirements of the end product sought for by C-DOT in their ATM backbone satcom terminal. The document provides detailed specifications of the form, fit and functions of the receiver as well as critical interfaces. It will be the main input to Task 2.

3.2 TASK 2: TEST BASEBAND TRANSMITTER AND DIRECT RECEIVER SYSTEM DESIGN DOCUMENT

This task consists in developing the system design document of the test baseband transmitter and the direct receiver lab bench prototype to be developed in this project. It provides detailed specifications of the form, fit and functions of the baseband transmitter, the direct receiver and its subsystems. It takes as input the receiver system design document of Task 1 and generates a document defining the desired system from this project. This task is jointly conducted by CRC/RSS and C-DOT.

3.3 TASK 3: TEST PLAN DOCUMENT

This task jointly conducted by CRC/RSS and C-DOT defines the tests to be performed on each of the receiver functional blocks identified above as well as on the baseband transmitter and the integrated system to ascertain that the project objectives are met. The document includes as a minimum a section defining the test requirements. It is not intended in this task to develop a test plan as elaborate as in a final product test plan that is to say that the procedure used to test the specifications will not be described unless critical to the testing. For standard tests, good engineering practice will be used and testing techniques will be reported in the test reports.

3.4 TASK 4: I&Q REGENERATION ALGORITHM FINAL DESIGN

Task 4 is to finalize the design of the algorithm using Matlab and/or SPW computer tools to meet the requirements identified in the system document resulting from Task 2. The task will be conducted jointly by CRC/RSS and C-DOT with RSS having the lead. Consideration of ASIC requirements will be identified by C-DOT while CRC/RSS role will be to design the algorithm to meet the functional specifications of the I&Q block. The output of this task is an I&Q block implementation report with sufficient details to enable the fabrication of the ASIC by C-DOT. The SPW model of the final design will be delivered to C-DOT which will undertake the development and fabrication of the ASIC in Task 5.

3.5 TASK 5: I&Q REGENERATION BLOCK ASIC DESIGN AND FABRICATION

This tasks takes the SPW model of the final design of the algorithm and the implementation report of Task 4 and the design and fabrication of the ASIC is carried out by C-DOT. C-DOT will provide to CRC the final VHDL code of the ASIC fabricated. C-DOT will conduct the basic testing of the ASIC and will provide CRC/RSS with 10 samples once good operation is confirmed. One of these samples will be used in the final integration and testing of the receiver chain. Associated specifications and documentation will also be provided to CRC/RSS by C-DOT.

3.6 TASK 6: FRONT END DESIGN AND FABRICATION

Task 6 consists in designing the 5-port junction together with the single ended mixers and the video amplifiers. This task is to be conducted jointly by CRC/RSS and C-DOT. Due to cost sensitivity of the final product, C-DOT will specify the substrate to be used in developing the junction and will design the single ended mixer circuit to be used. CRC/RSS will design the junction based on that substrate and according to the specifications identified in the system document (Task 2). Fabrication cost is estimated at $5K. Once C-DOT has finalized the design of the single ended mixer circuit and CRC/RSS, the design of the junction, C-DOT will provide their circuit design to CRC/RSS (e.g., Gerber file or equivalent) and a final integration and fabrication will be made at CRC/RSS. The video amplification circuit design and implementation will be carried out jointly by both parties. The output of this task is a FE block fully functional with a test report according to the test plan (Task 3).

3.7 TASK 7: AGC AND ANTI-ALIASING FILTER DESIGN AND IMPLEMENTATION

This task is to design the AGC circuit to meet the system document specifications (Task 2) and the corresponding anti-aliasing filters. C-DOT is to take the lead on the design of the AGC circuit. Once finalized, CRC/RSS will implement and test the AGC circuit according to the test plan to ascertain its good operation. CRC/RSS will design and implement the anti-aliasing filters and will provide a test report as defined by the test plan.

3.8 TASK 8: I&Q BLOCK AND DEMODULATOR INTEGRATION AND TESTING

This task consists in designing and developing a PCB to include the I&Q ASIC and glue logic required to interface to the AGC and I&Q demodulator to be provided by C–DOT. The schematic diagram is to be provided by C–DOT to CRC/RSS that will fabricate the PCB. Both parties will perform jointly the assembly and testing of the PCB and generate a test report as required.

3.9 TASK 9: BASEBAND TEST TRANSMITTER DESIGN AND DEVELOPMENT

This task is to be conducted by CRC/RSS. A statement of work will be created to specify the functional and interface specifications of the baseband transmitter. Then a request for proposal will be issued and a contract awarded to a suitable private company to undertake the development of this baseband transmitter. The contract will be managed by CRC/RSS and is estimated at $60K. Two fully populated boards and two unpopulated boards will be delivered to CRC/RSS of which one of each will be sent to C-DOT. A copy of the final report of the contract will be sent to C-DOT. If there is a need to perform adjacent channel interference tests (TBD), more units may need to be integrated.

3.10 TASK 10: CHANNEL NOISE GENERATION AND FILTER DESIGN AND IMPLEMENTATION.

CRC/RSS has designed and implemented a channel noise generator and noise limiting filter for their previous prototype work. This task consists in CRC/RSS providing C-DOT with the design details/specifications of the channel noise generator and a noise limiting filter to C-DOT with associated documentation and test reports.

3.11 TASK 11: RECEIVER FINAL INTEGRATION AND TESTING

This task consists in integrating the three functional blocks together and to conduct receiver tests. This task will be conducted jointly by C-DOT and CRC/RSS. A test report according to the test plan will be generated in this task. Acceptance of the test report will conclude this project.

4. SCHEDULE AND RESOURCES

Figure 2 shows the schedule for this project. The schedule identifies CRC/RSS human resource requirement for each task as well as the time span of each activity. It also indicates when C-DOT personnel is expected to be available at CRC|RSS.

155 Mbps SATCOM K-BAND DIRECT RECEIVER

Task	Effort from CRC/RSS	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01
#1: Receiver system design document from C-DOT		▲														
#2: Prototype receiver and baseband test transmitter	0.5 p-m		▲													
system design document																
#3: Development of test plan	0.5 p-m															
#4: I&Q regeneration algo final design	3 p-m															
#5: ASIC design and fabrication																
#6: 5-port junction design&fabrication	2 p-m															
Mixer circuit design																
Integration and video amplifiers	1 p-m															
#7: AGC circuit design																
AGC implementation and test	0.75 p-m															
AAF design, implement and test	0.25 p-m															
#8 : I&Q and demod integration	1 p-m															
#9: Test transmitter dev. Contract	1 p-m															
#10: Prototype receiver integration & test	3 p-m															
Management	1 p-m															
Total effort	14 p-m															
RSS November 29, 1999																

Note: C-DOT personnel at CRC

Figure 2 : Schedule for the project

DRAFT/DRAFT /DRAFT

Project Definition/Ka-Band Propagation Concept Definition

Project Title: Concept Definition/Ka-Band Propagation Studies

Brief Description:

Ka-band earth-space propagation measurements in India will be feasible in the near future with the launch of a satellite carrying Ka-band beacons. Scientific merits and potential applications from C-DOT's point of view, along with technical requirements for implementation and conduct of such measurements, should be evaluated prior to initiation of a measurement program.

Specific Objectives:

Objectives of the concept-definition phase include:

- Gather technical information needed for design of measurements, such as location of satellite, stationkeeping parameters, and relevant beacon specifications, along with site-specific (e.g., climatic) aspects and benefits of the measurements (C-DOT);
- Survey existing propagation facilities/institutes, and relevant propagation measurement results for India, and determine if collaborative alliances with other Indian organizations are beneficial for this project (C-DOT);
- Specify measurement goals, evaluate general measurement approaches, identify potential sources for requisite equipment, and estimate corresponding costs (C-DOT/CRC);
- Summarize software requirements for equipment control, data collection and analysis (CRC/C-DOT); and
- Conceptually design a Ka-band propagation measurement facility to achieve objectives of the project (CRC/C-DOT). [Responsibilities could be reversed here if C-DOT prefers.]

Key Person at CRC: D.V. Rogers

Key Person at C-DOT: ?

Time Frame/Duration: 6 calendar months

Resources: TBD

Deliverables: Report on Concept Phase (C-DOT/CRC)

PROJECT TITLE: Development of Facilities for Propagation Research

DESCRIPTION: This project will allow a C-DOT engineer to gain experience in the field of radio propagation. This project is meant to acquaint the C-DOT engineer with the various phases of propagation of propagation research.

SPECIFIC OBJECTIVES:

1 The determination of the information needed by a project and to be obtained by measurements, 2- The determination of the experimental methods needed to obtain the required information, 3- The determination of the experimental apparatus needed to perform the experiments, 4- The design of the experimental apparatus, 5- The fabrication and testing of the experimental apparatus, 6- The planning of field measurements, 7- The taking of field measurements, 8- Data acquisition and data storage, 9-Software development for the purpose of data processing., 10-Data processing, 11- Interpretation of results, 12- Preparation of results for use in applications.

KEY PERSON AT CRC:

Dr. Jules LeBel

KEY PERSON AT CDOT:

TBD

TIME FRAME/DURATION:

This activity will extend over a period of two years, in three 6 month periods.

RESOURCES:

CRC-VPRS
Access to propagation laboratories and access to advice from propagation specialists. UNIX workstations and Pentium workstations.

C-DOT- 1 propagation engineer. Pentium and/or UNIX workstations.

DELIVERABLES/OUTPUTS:

Report on stay at CRC.
Report(s) on field measurements.
Publications – possible
Training - propagation measurement techniques
Training – propagation data interpretation

Protected: For Distribution to Government and NDA Companies

MILTON
(Microwave-Light Organized Network)

A Project of the Research Broad Band Wireless (RBBW) Group

The Broad Band Terrestrial Wireless Group at the Communications Research Centre undertakes the investigation, research, and development of wireless techniques used to support high capacity digital communications links.

Objective:

The objective of the MILTON project is to develop new wireless techniques and technologies capable of providing data delivery densities of 100 to 1000 Megabits per second per square kilometer of urban area. This technology will be highly bi-directional supporting high speed data exchanges between subscribers and providing multi-media interactivity between users. As designed, system will distribute high quality video and audio information as well as standard internet-type data.

Because MILTON technology is wireless, there is no dependence on wire-line connections to make it fully functional. It is felt this technology can be quickly implemented in regions not having a coaxial (TV) cable and/or telephone line infrastructure. One of the objectives of this work is to develop technology for the export market. Realizing the sensitivities of such markets to cost, most of the technical objectives of the MILTON project can be achieved using existing technology taken from the satellite TV, personal computer, and the cellular/1900 MHz PCS telephony components industry.

Applications:

Applications for this technology include wireless telephony using TCP/IP, broad band Internet access, video-on-demand, tele-presence, live music and theatre distribution, etc. In fact, any cultural, social, or educational event that can be produced, stored or recorded as electronic data and packaged as web-site information will be easily distributed by MILTON.

What differentiates MILTON from other (principally cable TV and telephone internet modem) technologies is its distributed network architecture. High bandwidth producers of information will no longer have to access central switching offices via dedicated broad band links so that their information becomes available to the network at large. It will be possible for subscribers to set up the equivalent of radio stations, television stations, video rental shops, and other audio/visual/multimedia resource centres from their homes and small offices. As a consequence, the high infrastructure costs associated with such information distribution endeavors (largely due to requirement for dedicated high band width links and associated network access costs) are mitigated.

MILTON is embodied within two physical subsystems that need to be described in order to appreciate the intended applications of the overall system.

First of all, MILTON is a microwave radio system that uses very low power signals to relay data between a hub antenna and urban users located within a 1-2 kilometers radius of the antenna (for rural the distance can be up to 5-10 km radius). Different deployment techniques are used for urban and rural environments. In an urban environment, there is the expectation of obstruction by foliage and buildings, hence the operational radius is smaller. In a rural environment, less obstruction is expected, thus resulting in longer communications distances. For rural applications it is envisaged that a single hub will provide the data requirements of a sparse, widely distributed population (within ~10 km of the hub). In an urban environment, numerous hubs would be required to meet the requirements of a higher population density.

The hub consists of an integrated antenna array, digital radio, and digital switch mounted on a power pole, lamp standard, or medium height (~5 story) building. The coverage pattern of the hub antenna is best visualized as rosette of antenna beams, each beam being an oblong radio micro-cell. Typically a rosette contains 32-48 micro-cells. This configuration of cells allows a very high data carrying capacity. Each fully loaded MILTON rosette is capable of receiving, transmitting, and switching in the order of 1000-1500 Megabits of information per second. This is equivalent to about 800-1000 simultaneous high quality video conferencing sessions; about 300-500 simultaneous video-on-demand sessions; or 1500-15000 unblocked Internet sessions running at modem speeds in excess of 100 kilobits per second (a conventional phone modem supporting Internet runs at about 20 to 60 Kilobits per second). MILTON rosettes can work individually, supporting the above capacities within their coverage areas, or they can be interconnected by optical fiber (light) to form a large metropolitan high speed data network. CRC is in the process of applying for a US patent covering this concept.

The second component of the system is the subscriber terminal. This unit is called an 'Internet Antenna'. The device mounts on the roof of the subscribers' buildings (wall or roof) and is oriented toward the rosette hub....perfect visibility of the hub is not necessary and clutter by trees and even partial obstructions by one or two adjacent buildings can be tolerated. CRC has conducted extensive propagation measurements using proposed MILTON frequencies, and is developing urban installation models which will ensure high availability of the system to users.

A personal computer is connected to the internet antenna via a standard, off-the-shelf Ethernet card. Software loaded into the PC and embedded within the Internet Antenna automatically sets up a high speed data link between the digital switch located at the hub and the PC. All protocols used in this operation are TCP/IP: ie, to the user the connectivity appears as an Internet connection.

For Wireless Local Loop applications requiring services such a telephone, an interface which provides dial tone on one side and a 10 Base T Ethernet TCP/IP port on the other is being developed. This device will allow Voice-over-Internet (VOIP) type telephone service. Because of the high speed and high QOS of the switching system present at the hub, latency and delay will not be a problem here as it is with conventional VOIP systems. Such telephony-only type services will not require the use of a personal computer to access the network.

Unlike conventional wireline Internet, this system will allow the rapid, almost real-time transfer of video files, digitized film, CD audio, digitized voice, and other high content electronic information that cannot be transferred because of "bandwidth bottlenecks". Individual users of the system can demand as little or as much bandwidth (~ 10 megabits/sec) as they need to support their requirements. One significant attribute of the system is its bi-directional capability. In theory, users will be able to download and upload data at megabit-per-second speeds. Information distribution centres that have files (such as digitized film and audio) will be able to use MILTON without the requirement for dedicated high bandwidth links to centralized data distribution points, which is typical of conventional wire-line high speed data systems. As a result, many new multimedia applications will be supported at low cost. A distributor of high content electronic data will only need a high capacity computer (a server) and a MILTON Internet Antenna connection to operate as a wireless multimedia resource centre.

Some means of billing for bandwidth used and collecting payments will have be devised for this system, especially since it will carry and distribute high value cultural content materials such a film and music, which are usually copyrighted. However, this issue is being considered with the Internet in general, and decisions and techniques formulated there will conceivably migrate to MILTON.

Some applications are:

1) Video-on-Demand file Server: A neighbourhood video store with a MILTON link could have a library of digitized films. These films would be stored as files on high capacity video server system computers. Users in the MILTON coverage area would access these files (just as a web site is accessed) and download them in real time for viewing. The video data is sent as high quality MPEG2 video streams which has significantly higher resolution than conventional VHS taped video. Unlike typical video tape distribution (rental) stores which only have thousands of the most popular video selections available; in MILTON the selection is limited only by the memory size of the aggregate digital video server population. This would allow the storage of more esoteric, less popular content that normally does not see commercial distribution (like National Film Board films, old CBC news clips, foreign language films, international television broadcasts, etc..).

2) Real-time Video Broadcast: Plays, theater, music performances, and other forms of live entertainment taking place at some locale within the MILTON coverage area could be broadcast through the MILTON system. Using real time digital video cameras (MPEG1) and sound encoding technology, such programs would be presented and addressed as Internet web-sites and accessed accordingly. Subscribers would view the programs on their computers or on home entertainment systems connected to computers. The advent of Digital Video Disk recording technology and low cost MPEG equipment and the use of MILTON as a distribution system, would allow the production and distribution costs of live entertainment to be significantly reduced.

3) CD Audio-on-Demand: As with video-on-demand, music could be stored on file server technology and called up remotely as a web site. Music would be downloaded to the subscriber computer and played on a home entertainment system. A typical MILTON channel would support about 60 simultaneous CD Audio-On-Demand sessions. Compressed audio files (such as the popular MP3 format) would be delivered at much faster rates. Musicians and other artists would not be faced with the large overhead costs typical of the current commercial music distribution industry. Using the inherent

billing system based on credit card numbering of MILTON, revenue return to artists could almost be immediate and highly scaleable allowing extensive niche market penetration.

4) Interactive Distance Education: Course material could be presented to a distributed audience of pupils; real time interactivity would be facilitated by this system. Additionally, course notes could be stored as video files (containing problem solving examples, demonstrations of techniques, etc.) that would be electronically available through MILTON. Remote teacher-pupil interactivity on an individual basis would be supported. There are several rural pilot projects (Manitoba, Alberta) which already demonstrate the efficacy of such learning and teaching concepts. MILTON would allow the extension of these concepts to the urban core of cities.

5) High Speed Internet Access: Users to the system log onto downlink channels capable of data delivery speeds of up to 22.5 Megabits/Sec. Such channels are shared amongst users in a rosette petal. Users having large file transfers are automatically assigned dedicated channel slots which may be held for long periods of time. Uplink channels giving users return data rates in the order of 128 Kilobits/Sec to 6 Megabits/Sec are provided. The system automatically assigns bandwidth-on-demand. Competing Internet Service Providers (ISPs) can be accommodated on the same rosette and service providers do not have to have access to the hub to set up their service.

6) Rural Telephony: Using Dial Tone/TCP/IP interface devices this system will be able to route digitized telephony voice (from fixed telephones). A telephone switching network is created within a rosette and all telephones within the rosette can easily communicate with each other. To route calls outside the rosette, a TCP/IP to PBX bridge is used at the hub to connect the WLL telephones of the rosette to the world at large. This system has application in many rural parts of Canada not adequately serviced by conventional telephone because of distance, low user take up rates, or lack of wireline infrastructure.

7) Tele-medicine: The high data rate capability of MILTON allows high definition, information rich data files such as X-Rays; electrocardiograms; and electroencephalograms to be sent between doctor's offices and laboratories. These rates will also allow high quality (CD quality) sound to be transferred allowing cardiologists to listen to the heart sounds of distant patients. Such files and signals would normally require fiber optic cable to be installed on the doctors' premises, with MILTON, only Ethernet cabling would be require to a roof mounted antenna. Privacy is ensure by a number of TCP/IP based encryption standards which could be implemented; privacy is further enhanced by the containment of the RF signal to a highly localized locale.

Conclusion

The MILTON project is an ambitious attempt to address the issues of bandwidth, capacity, and bi-directionality which underpin the development and evolution of the information highway. By using novel wireless network concepts and current technologies, researchers in the Broad Band Wireless Networks Group at CRC (VPTWS) are addressing these issues and outlining the technologies necessary to realize solutions. Work is currently being undertaken to study the information carrying capacity of the MILTON rosette system. Frequencies for the system are being chosen, and an investigation into the electromagnetic attributes of the system (antennas, signal transmission, etc) are being undertaken. CRC is working toward the development of a prototype system that would be installed in an urban neighbourhood for testing and evaluation. Collaborative links are also being formed with selected Canadian companies to help foster and exploit the technologies that are being developed within the project.

APPENDIX 2

BRIEF PROJECT DESCRIPTIONS AS DETAILED BY C-DOT

LIST OF COLLABORATIVE PROJECTS

- MICROSTRIP PATACH ANTENNAS
- MMIC DEVELOPMENT
- SATCOM KA-BAND DIRECT RECEIVER AT 155 MBPS
- DSP VLSI / ASIC TECHNOLOGY
- BROADBAND APPLICATIONS CONNECTIVITY (BADLAB)
- BROADBAND WIRELESS LOCAL LOOP (BADLAB)
- OPTICAL TECHNOLOGIES
- PROPAGATION STUDIES

Project Proposal for Development of Patch Antennas

Project Title : Low Gain L band ,S band and High Gain EHF band Microstrip Patch Antenna

Background :

The proposed EHF band point to point Digital Radio System for ATM connectivity will be a very compact suitcase terminal type of equipment suitable for outdoor deployment . Conventional high frequency radio systems had been using dish paraboloid kind of high gain antenna . These kind of antennas need separate mounting arrangement and they interface with the rest of the RF system using an external wave guide. With the emergence of Microstrip Patch Antennas and Patch Arrays , the trend is changing towards using more and more of these type of antennas . These antennas are relatively easy to manufacture and are quite low cost. These are two dimensional structures (flat), considered to be the state of the art and they blend conveniently with the rest of the electronics of the system.. They can even be mounted on the back of the front cover in a suitcase terminal type of equipment. CRC has very strong background in the field of antenna development , more specially the Microstrip Patch. Some of the best people of this field are working at CRC. It is proposed to develop a low gain L band and subsequently S band and EHF band Microstrip Patch Array Antenna in collaboration with CRC. The lower gain S band antenna will be used for VSAT. The L band antenna will be used in TDMA-PMP,CDMA-WLL wall mount unit and / or DECT-WLL wall mount unit . The high gain EHF band antenna will be used in the proposed EHF band Point to Point Digital Radio.

This project will give C-DOT engineers hands on experience on Antenna Technology and Measurements and will specially help them in gaining expertise in the design and development of Microstrip Patch Antennas which is an evolving technology . The project will also provide knowledge in the software tools and simulation techniques necessary for the development of Microstrip Patch Antennas. The C-DOT engineers will have the opportunity to go through the full design cycle of it while designing different types of Microstrip Patches . The advantages and limitations of the technology will also be made clear .

Details of Project :

The objective of the project is to design , fabricate , package and test a low gain L band antenna using two or three microstrip patches and a high gain EHF band antenna using microstrip patch arrays and suitable feed network . First a linearly polarized L band antenna will be developed which is relatively easier and as the experience is gained in the design process , a linearly polarized S band antenna will be taken up for design. After this the high gain pencil beam EHF band antenna with linear polarization will be developed. Near field and far field testing will be performrd for all the antennas and radiation patterns will be plotted. The fabrication of the antennas will take place at CRC or locally available fabrication facility. Assembly and testing of these antennas will be done at CRC labs. At the end of the project two microstrip patch antennas will be delivered to C-DOT and the engineer from C-DOT would have gained enough expertise to take up new designs on his own to cater to the future needs of C-DOT . A suitable software simulation tool will also be identified which could be bought and installed at C-DOT so that the designs could be taken up locally.

Manpower Resources : One engineer from C-DOT to work at CRC , preferably in spans of time with specific mission .

Equipment Resources

From C-DOT Side : ENSEMBLE software tool for EM simulation of microwave structures , Testing instruments like VNA , Spectrum Analysers , Synthesized sweeper etc.

From CRC Side : ENSEMBLE ,ARPS and IE3D software tool for EM simulation of microwave structures , Antenna prototype fabrication , including layout , mask , etching and assembly. Anechoic chambers for testing of antennas .Testing instruments like VNA , Spectrum Analysers , Synthesized sweeper etc.

Deliverable Outputs

L band low gain antenna ,S band and EHF band high gain LP antenna. Expertise in Microstrip Patch Antenna design. Setting up antenna facility in CDOT. Expertise in near field and far field antenna measurement techniques , Reports, Technical Papers etc

Work plan

Start date 22/11/99

SN	Activity	Responsibility	Place of Activity	M Ms C-DOT	CRC
	Low Gain L band Patch Antenna				
A	Reading manuals. Simulate patch on GML substrate to check for the bandwidth. Order material. Review design.	CRC & C-DOT	C-DOT	0.25	
B	If bandwidth can't be met, Design with air dielectric. Check the parameters. Make single patch layout. Fabricate and test the patch.	CRC & C-DOT	CRC	0.25	
C	Learn ARPS. Layout with ideal feeds. Design feed and test. Combine patch and feed. Review array design.	CRC & C-DOT	CRC	0.25	
D	Layout of array. Creating mask. Fabrication and testing of array	CRC & C-DOT	CRC	0.25	
E	Radome analysis. Learning ensemble 6.Making field model	CRC & C-DOT	CRC	0.25	
F	Making measurements in anechoic chamber	CRC & C-DOT	CRC	0.25	

G	Make report. Get details of substrate selection, Radome selection. Get the details of system requirements.	CRC & C-DOT	CRC	0.25	
H					

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After designing the L band antenna,the Sband antenna design will be taken up in CDOT with the soft ware tools available in CDOT. The low gain S band antenna design activity will extend over three to four months including fabrication and testing . The high gain EHF band antenna will take about four to six months for design , fabrication and testing . Radom effect analysis and rework could take another two to three months . Hence the total activity will extend over an year.

Project Proposal for Development of MMICs

Project Title : Low Noise Amplifier & Direct Modulator MMICs

Background :

C-DOT has been working on transmission technologies and has developed good expertise in point to point digital radios , TDMA Point to Multipoint Radio System, Wireless Local Loop System and Satellite Communication systems. We have a strong RF team which has expertise in the design of various RF sub-systems like Amplifiers , LNAs , mixers, synthesizers etc. using hybrid MIC technology. These technologies are relevant at lower frequency bands like L , S , and C bands but start showing their limitations at higher frequencies like EHF band. CRC's key RF people are currently working in the 20-30 GHz range and have developed good expertise in design of MMICs and MHMICs at these frequencies. They also have a state of the art testing and wafer probing facility for MMICs . It is proposed to develop a low noise amplifier and a direct modulator MMICs in the EHF band in collaboration with CRC which will eventually be used in the Extra High Frequency Point to Point Digital Radio System .

Details of Project :

The design and characterisation of a EHF band Low Noise Amplifier and a Direct Modulator/Demodulator for use in the receiver and transmitter sections of the proposed Digital Radio System will be accomplished. The first , a medium gain low noise amplifier design will use small signal analysis and linear simulation techniques. The second , a direct I-Q Modulator/Demodulator will use Linear simulations as well as non linear harmonic balance analysis. CRC has good understanding with some of the GaAs foundries and these MMICs will be fabricated at Phillips Foundry at Paris. Wafer probing and testing of these MMICs will be performed at CRC labs. At the end of the project C-DOT will have two EHF band MMICs which will be used in the proposed EHF band point to point digital radio system.

The LNA being designed is a three stage device. CRC is sending some of its MMIC designs to the foundry for MMIC fabrication by 20/12/99. As it is not possible to complete the whole LNA MMIC design in the remaining four weeks and CRC goes to the foundry only twice or thrice a year, it is proposed that a single stage LNA MMIC be designed and fabricated in this foundry run. This would not only give C-DOT a good exposure to the complete MMIC development cycle in a short period, but would also aid in verifying the behavioural models of the Coplanar Wave transmission lines which are proposed to be used in the LNA as well as the Direct Modulator Designs. The wafer is expected to be back at CRC after fabrication by last week of March.

SN	Activity	Responsibility	Place of Activity	Duration (Weeks) C-DOT	Duration (Weeks) CRC
	Low Noise Amplifier MMIC (Start of Activity: 15/11/1999)				
A	Defining the specifications	C-DOT	C-DOT	completed	completed
B	Investigate Properties of PHEMT & Foundry Process	CRC & C-DOT	CRC	1	
C	Stabilize the PHEMT and Perform Noise Figure and Gain Trade-off of First Stage of the 3 Stage LNA	CRC & C-DOT	CRC	1	
D	Developing Ideal Matching Circuits for the first stage	CRC & C-DOT	CRC	1	
E	Changing ideal elements to MMIC elements of first stage	CRC & C-DOT	CRC	1	
F	Layout and Preliminary ElectroMagnetic(EM) analysis of first stage – Ready for MMIC fabrication	CRC & C-DOT	CRC	1	
G	Developing ideal Matching circuits for second and third stages	CRC & C-DOT	CRC & C-DOT	1 –CRC 2-C_DOT	
H	Layout and detailed EM analysis of the complete 3 stage LNA	CRC & C-DOT	CRC & C-DOT	1 – CRC 3– CDOT	
I	Testing of the single stage MMIC in the 2nd Week of April	CRC & C-DOT	CRC	1.5	
J	Changes (if required) to be made on the 3 stage LNA design based on the single stage LNA test results. Integration with CRC foundry process. MMIC design ready for the May foundry run.	CRC & C-DOT	CRC	1 to 3	
J	Testing of the 3 stage LNA in the month of August(tentative)	CRC & C-DOT	CRC	1.5	

SN	Activity	Responsibility	Place of Activity	Duration (Weeks) C-DOT	Duration (Weeks) CRC
	Direct Modulator MMIC				
A	Defining the specifications	C-DOT	C-DOT		
B	Device conceptualisation and process selection	CRC & C-DOT	CRC	1	1
C	Design & simulation on ADS using ideal elements of the following blocks of the direct modulator: i) Quadrature Power Divider ii) In-Phase Combiner iii) Balanced Mixer	CRC & C-DOT	CRC & C-DOT C-DOT C-DOT CRC	 1.5 1.5 2	
D	Simulation of the Baseband signals and the Demodulator for system performace testing.	CRC &C-DOT	CRC&C-DOT	2-C-DOT 2-CRC	
E	Integration of all the blocks of the direct modulator. Simulation and EM analysis.	CRC & C-DOT	CRC	1	
F	Changing the ideal elements to MMIC elements, Layout and Electromagnetic Analysis(EM)	CRC-CDOT	CRC&C-DOT	1–C-DOT 2-CRC	
G	Critical Design Review and Integration with the CRC foundry process. MMIC design ready for planned October 2000 foundry run The design takes about 14 weeks for fabrication .	CRC & C-DOT	CRC	1	
H	Prototype testing .	CRC & C-DOT	CRC	2	

Summary of Specific objective : The usage of discrete components at EHF microwave frequencies is not suitable for large volume production environment as at these frequencies the device parasitics and other electrical problems would necessitate extensive post assembly tuning. The project will help C-DOT to gear up for a system in the increasingly popular Ka-Band and give exposure to the hardware and software tools necessary for the development of MMICs. In future C-DOT should independently be able to go to MMIC foundry with various designs.

Time Frame : The relatively long design and fabrication times dictate that the total activity would extend over two years even though the physical presence of a C-DOT engineer at CRC may not be required for this long time.

Manpower Resources : For LNA MMIC - One engineer from C-DOT
For Direct .I/Q Modulator MMIC – Two Engineers from C-DOT

Prerequisite : The engineers from C-DOT needs to be skilled in the following areas

1. Advanced Design system/ LIRRA software tool for Microwave simulation
2. MIC layouting and design skills
3. Good knowledge of Modulation and DemodulationTechniques, RF test instruments like VNA , Spectrum Analyzer , Noise Sources etc. and experience in testing of microwave circuits.
4. Very sound RF/Microwave background

Equipment Resources

From C-DOT Side : Advanced Design System simulation software for microwave circuits , HP Eesof 's LIBRA software package, Momentum EM analysis tools, Testing instruments like VNA , Spectrum Analysers , Network Analyzers, Synthesized sweeper etc.

From CRC Side : Advanced Design System simulation software for microwave circuits , HP Eesof 's LIBRA software package, Momentum EM analysis tools, Testing instruments like VNA , SpectrumAnalysers , Network Analyzers, Synthesized sweeper etc Wafer probing tool. MMIC Fabrication facility .

Deliverables / Outputs : Measured results of EHF band LNA MMIC and EHF band Direct Modulator MMIC, Simulation reports of MMICs Technical Papers / Reports etc.

Glossary:

ADS	Advanced Design System
C-DOT	Centre for Development of Telematics
CRC	Communication Research Centre
EHF	Extra High Frequency
GaAs	Gallium Arsenide
LNA	Low Noise Amplifier
MMIC	Monolithic Microwave Integrated Circuit
MIC	Microwave Integrated Circuit
MHMIC	Monolithic Hybrid Microwave Circuit
TDMA	Time Division Multiple Access
VNA	Vector Network Analyser

Project Proposal for Development of ATM over satellite

Project Title : 155Mbps satcom Ka-band direct receiver

Background :

C-DOT is in the process of providing solutions in broadband technologies. It is in the process of developing family of ATM and SDH broadband communication systems. By using these systems together, C-DOT would create solutions for high speed terrestrial backbone optical networks. However, optical networks lack connectivity of remote inaccessible areas that cannot be economically connected over fibre. A proposed solution to connecting such areas is a high frequency satellite based system. Various ATM switches could be interconnected via satellite using STM-1 link.

As the existing S and C bands are fairly crowded with introduction of commercial wireless systems like PCS, PCN and other satellite systems, C-DOT proposes to develop a satellite based point-to-point digital radio system in the EHF band for inter-exchange broad band connectivity. This satellite link would carry ATM, SDH or ATM over SDH payloads.

C-DOT has experience in some areas of satellite communications. CRC already has research expertise in high speed RF enabling technologies. C-DOT's experience and CRC's expertise in the high frequency area can be combined to develop modules for designing a complete satellite based ATM system.

Details of Project :

The objective of the project is to design, fabricate and test a 155Mbps satcom ka band direct receiver. The receiver consists of the following modules:

- 5 – port device
- I&Q regeneration
- QPSK demodulator and decoder.
- AGC
- AAF and video amplifiers.

The technology for this new concept of direct receiver is with CRC and has been proved for 90Mbps. This project aims at extending this concept to 155Mbps so that this can be used for broadband satellite networks.

Work Plan **Start Date :29/11/1999**

SN	Activity	Responsibility	Place of Activity	M Ms C-DOT	CRC
	155Mbps satcom ka band direct receiver				
A	Defining the specifications	C-DOT	C-DOT	1	-
B	I&Q algorithm final design including feedback to control AGC.	CRC & C-DOT	CRC	1.5	1.5
C	AGC Circuit design, implementation and testing	CRC & C-DOT	CRC	0.5	0.5
D	AAF design, implementation and testing	CRC & C-DOT	CRC	0.5	0.5
E	Baseband test transmitter specification and testing	CRC & C-DOT	CRC	0.5	0.5
F	Design of QPSK demodulator and decoder	C-DOT	C-DOT	3.0	3.0
G	Review existing transmitter up-converter chain to bring the	CRC & C-DOT	CRC	0.5	0.5

	signal to 20GHz and define requirements for modifications				
H	5-port junction with mixer diodes and video amplifiers design, implementation and testing	CRC & C-DOT	CRC	1.5	1.5
I	Definition and execution of test plan	CRC & CDOT	CRC	2	2

Time Frame : The 155Mbps ka-band direct receiver takes about 15 months including fabrication and testing .

Manpower Resources : Three engineers from C-DOT to work at CRC , preferably in spans of time with specific mission . (1 engineer with expertise in Microwave hybrids, 1 engineer with expertise in Demodulators and 1 engineer with expertise in filters and AGC.)

Prerequisite : The following skill set is expected for the team of engineers from C-DOT

1. Knowledge of QPSK demodulators.
2. Knowledge of Micro wave hybrids.
3. Knowledge of AGCs and AAF.
4. Good knowledge of RF test instruments like VNA , Spectrum Analyzer etc. and experience in testing of microwave circuits.
5. Very sound RF/Microwave background

Equipment Resources

From C-DOT Side :

Instruments: Logic analyzer, digital oscilloscope, spectrum analyzer (all this instruments are available at C-DOT)

BER Test set(has to be checked for 155Mbps).

Software: SPW from Cadence (coexistence with HP-ADS has to be verified).

Financial Resources:

Cost of Cadence Tools: TBD

Cost of ASIC fabrication: TBD
Cost of DTA : TBD

From CRC Side :
Instruments: Logic analyser, digital oscilloscope, spectrum analyser, BER Test set.
Software: SPW from Cadence (coexistence with HP-ADS has to be verified).
Financial Resources: TBD

Deliverable Outputs

155Mbps ka-band direct receiver, ASIC for I & Q regeneration and ASIC for QPSK demodulator, Expertise in design of 5-port networks and I & Q regeneration, Reports, Technical Papers etc

Other Details and Remarks :
The project can be initiated once the system level specifications and the submodule level specifications are finalised.

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Project Proposal for DSP ASIC technology

Project Title: DSP ASIC Design

Background

C-DOT has a state of the art ASIC design centre that supports both front-end design for ASICs and fast prototyping environment for complex telecom designs. CRC also has design laboratory for digital ICs with expertise in DSP research. One of the key areas of common interest could be DSP ASIC design. This in turn calls for survey & research of existing algorithms for the implementations on to silicon.

In this regard, it is proposed to develop the DSP ASIC in a joint venture with CRC for the purpose of using it in different C-DOT products, particularly TRAU and IP, which require speech processing. More specifically, the ASIC will be used for customized applications like speech CODEC, speech recognition, voice mail, etc.

Details of the Project

C-DOT and CRC personnel held joint discussions during 15th to 23rd Nov. 1999 on this subject at CRC-Canada. To start with, the ASIC approach was weighted against the more conventional general purpose DSP based solution currently used by both C-DOT & CRC. It was concluded that the ASIC approach becomes attractive only if the numbers were large enough for such a solution. The individual blocks of the ASIC were discussed in detail. It was felt that it was feasible to implement the ASIC in a large EPLD/FPGA to begin with. However, the complexity of building an integrated speech CODEC handling different international standards or even a single standard for multiple channels (of the order of 15 to 30) will be difficult. Examples of one such CODEC implemented for MELP, a speech CODEC at 2.4kbps, was quoted and its complexity for a single channel ASIC implementation is equivalent to a DSP processor like TMS320C4X, which is quite huge. On the other hand, simpler CODECs at 16, 24, 32 and 40kbps, based on G.726 ADPCM are available as macro cells with a complexity of 7000 gates, 256x16 RAM and 512x22 ROM for four channel implementation. This commercially available macro cell from Mentor Graphics is a fully synthesizable VHDL-RTL source code and it is an Intellectual Property of Mentor Graphics. Such macro cells can be directly utilised, for example, in CORDECT base stations. Thus, the estimation of complexity of a speech CODEC is not simple and requires roughly about 150 man hours, for each speech CODEC, by a person who has an understanding of the CODEC as well as the ASIC design intricacies. In any case, for applications like TRAU and VOIP, multiple CODEC standards need to be accommodated. Implementation of such a flexible CODEC is indeed a Herculean task.

So the customised speech CODEC ASIC implemented could be used only in applications like voice mail or compressed announcement playback. Speech recognition has no standards involved and therefore could be implemented as an ASIC.

It is also important to be aware of the availability and cost of tools for modelling and simulation for customised DSP ASIC development. Some tools from Texas Instruments, Thomson-CSF, DSP Group and Newbridge (Castleton) can be looked into which contain DSP building blocks like MAC, filters as VHDL libraries. Tools converting DSP algorithms written in high level languages like C to VHDL code are also available. The efficiency of such tools needs to be determined. This helps in estimating the development cost more precisely, since one of these tools is required for ASIC development.

Further, another promising approach to build complete solutions for end applications is based on using general purpose DSP processor cores as macro cells in a custom IC containing several such cores.

Some of these cores like DSP56000 family from Motorola are available commercially. It is more flexible to use them so that any application can be developed on a general purpose ASIC built on these macro cells. The cost of development of custom ASICs for specific needs has to be weighted against the above option as well as buying out commercially available complete solutions (similar to G.726 CODEC) as macro cells.

Based on these considerations, the future path of the DSP ASIC program will be determined. A time frame of 4 to 8 weeks may be required for the activity of exploring various approaches before determining the final path.

Work plan ***Start date: 6th December 1999***

SN	Activity	Responsibility	Place of Activity	Man-months C-DOT	CRC
1	**Estimation of CODEC complexity**	**C-DOT**	**India**	**2**	
1.1	Selection of a suitable CODEC				
1.2	Detailed study of the algorithm				
1.3	Division into functional blocks				
1.4	Determination of gate count, RAM/ROM requirements for each block (Input from activity 4 may be used)				
1.5	Complete estimate of complexity of the algorithm				
1.6	Review/Verification				
2	**Identification of DSP ASIC tools**	**CRC**	**Canada**		**1**
2.1	Explore tools containing VHDL libraries for MAC, FIR, etc.				
2.2	Explore tools for algorithm to silicon mapping.(C/C++ to VHDL)				
2.3	Compare and evaluate the tools qualitatively				
3	**Identification of DSP core vendors**	**CRC& C-DOT**			**1**
3.1	Analysis of commercially available DSP cores	CRC	Canada		
3.2	Selection of a suitable DSP core for the application considered	CRC & C-DOT			
4	**Identification of complete solution providers**	**C-DOT**	**India**	**1**	
4.1	Explore and evaluate the availability of algorithms as VHDL macro cells				
4.2	Give inputs to activity 1				
5	**Analysis and conclusion**	**CRC& C-DOT**		**1**	
5.1	Compare the options of ASIC implementation based on activities **2**, **3** and **4**				
5.2	Check the suitability of CODEC prototyping in FPGA/EPLD based on input from activity **1**.				
5.3	Consider the viability of the project				
5.4	Chart out a detailed project plan for ASIC development with development/equipment cost, shared responsibilities and time frame				

Summary of Specific Objectives

1. Estimation of CODEC complexity

Determine the complexity of a speech CODEC (possibly G.729 and/or ETSI 06.60 or any other suitable CODEC) implementation in hardware in terms of logic gates, RAM and ROM requirements.

2. Identification of DSP ASIC tools

Study the tools available for DSP ASIC development. Features for implementing various blocks of DSP easily (providing DSP libraries or signal analysis/C code to VHDL converters) should be looked into. A summary of various vendors, cost and features to be provided.

3. Identification of DSP core vendors

DSP core vendors to be identified. The architectures of available DSP cores to be studied to choose a proper core customised for speech processing applications. A matrix containing various cores, cost, features, logic gates is to be generated. The cost of RAM/ROM has to be separately addressed.

4. Identification of complete solution providers

Complete commercial solutions available for CODECs, voice activity detection in silicon have to be investigated. The cost and logic gate complexity of such macro cells is to be compiled. This in turn can be used to estimate Item No. 1.

5. Analysis and Conclusion

One of the following paths to be taken for pursuing the activity further, based on the suitability of these options

- Develop customised ASICs for each application.
- Use commercially available solutions as macro cells for each application.
- Use commercially available general purpose DSP cores as an array in a customised DSP ASIC useful for multiple applications.

For the selected option, an R & D project plan should be proposed including the roles for CRC & C-DOT.

Time Frame : 2 Months- 4 Months

Manpower Resources : 1 or 2 Engineers from C-DOT to work in India.
1 or 2 Engineers from CRC to work in Canada.

Prerequisite : The Engineer from C-DOT needs to be skilled in the following areas

1. CAD VLSI tools and knowledge of VHDL/HDL Synthesis
2. Design experience in DSP Blocks and Knowledge of VLSI Design
3. Experience in algorithm implementations in high level/assembly language.

The Engineer from CRC needs to be skilled in the following areas

1. CAD VLSI tools and knowledge of VHDL/HDL Synthesis
2. Knowledge of VLSI Design

The project requires skilled engineers.

Equipment Resources

From C-DOT Side : Workstation with high level/DSP assembly compiler and full time Internet connectivity.
From CRC Side : Workstation with full time Internet connectivity where various tools can be evaluated.

Project Co-ordination

A good project co-ordination team is desired at two levels. This will essentially constitute a review at local level at CRC & C-DOT and at project co-ordination level.

Deliverable Outputs

A proposed R & D project plan including the roles for CRC and C-DOT for the ASIC, based on the feasibility of the options.

Other Details and Remarks

The project plan should include the resources required for prototyping and testing of the ASIC. Serious importance should be given for project co-ordination and selection of engineers for the proposed project. Enough support should be provided to the engineers for project execution and co-ordination. The exchange of information between C-DOT and CRC engineers will be done through email with a review periodicity of one week.

Contact persons

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Glossary

ADPCM	Adaptive Differential Pulse Code Modulation
ASIC	Application Specific Integrated Circuit
C-DOT	Centre for Development of Telematics
CODEC	COder – DECoder (for speech)
CRC	Communication Research Centre
DSP	Digital Signal Processing
EPLD	Erasable Programmable Logic Device
FPGA	Field Programmable Gate Arrays
IP	Intelligent Peripheral (a network entity of Advanced Intelligent Network)
MELP	Multipulse Excited Linear Prediction
RAM	Random Access Memory
ROM	Read only Memory
TRAU	Transcoder and Rate Adaptation Unit (a network entity in GSM)
VHDL	VHSIC Hardware Description Language
VLSI	Very Large Scale Integration
VOIP	Voice Over Internet Protocol

Documented on November 23, 1999

Broadband Applications Connectivity project – Phase 1 Report

Project Title : Broadband Applications Connectivity

15th Nov 1999

Discussions with Mr. Jeet Hothi & Mr. Neelam Makhija on all the projects. Mr. Hothi & Mr. Neelam were explained about the objectives of C-DOT on all projects. Jayant and myself explained about the need to setup CRC's equivalent of BADLAB at C-DOT. Issues relating to CPE's, connectivity and multimedia applications to be marketed in India were also explained to them. C-DOT is setting up a Broadband Network in India and ATM being a new technology, we need to setup CRC's equivalent of BADLAB for demonstration of various multimedia applications over ATM to prospective customers/DOT, India.

Meeting with Mr. Eric Tsang, Associate Director, Business Development along with Mr. Hothi and Mr. Jayant. Objectives of C-DOT in setting up CRC's equivalent of BADLAB were explained to him.

16th Nov 1999

Meeting with Mr. Eric Tsang, Mr. Michel Savoie, Manager BADLAB and Ms. Debbie Kemp, Marketing Officer, Marketing Division, CRC.

Mr. Michel was explained the objectives of C-DOT by myself and Mr. Eric. The need to study the details of their CPE's, national network, internal network, BADLAB network and the international network were explained to Mr. Michel.

Meeting with Mr. Roy Marsh, Project Manager, Tele-health, at Ottawa Heart Institute (OHI) for discussions on Tele-health employed over ATM Networks.

At OHI, they are using two types of links for Tele-medicine. One is a 512 Kbps ISDN link (4 x 128 Kbps) and the other is a ATM link. OHI has connectivity to 4-5 places in Canada in addition to one link to CRC.

The ISDN link is connected to a Tele-medicine station from Computing Devices, Canada and the ATM link is connected to TANDBERG health care system. The TANDBERG health care system is connected to MPEG2 Codec and the transmission is at 4 Mbps (MPEG2 over ATM). The details of TANDBERG system can be had from

http://www.tandbergusa.com

Various medical equipments/accessories can be connected to the TANDBERG system, viz. Electronic Stethoscope, Dermascope, X-ray Scanner, close up Camera for ECG, etc. Presently only the Electronic stethoscope (Stethos make, Montreal) and the Close up Camera are connected to the TANDBERG system, since it is Heart Institute. For X-ray and Radiology, one needs a special digital scanner which can be connected to the TANDBERG system. One needs a very good Monitor/Display for viewing the X-rays/Tele-medicine. Presently OHI has a 2000 x 2000 resolution monitor supplied as a part of integrated medical system by TANDBERG. For exceptionally good resolution one should go for about 4000 x 4000 resolution monitor.

For tele-medicine applications, the audio/video over the ATM has to be at CBR and NOT UBR/VBR. One needs very good encoders/decoders for proper synchronisation between the local and remote end (since tele-medicine has to be in real time).

ATM is NOT being sent over Satellite, as the Satellite link at 6 Mbps is very costly. Only the ISDN is being sent over Satellite at 768 Kbps.

The setting up of the Tele-medicine/TV Studio should be done by an Audio/Video professional who has experience in Audio/Video Lab setup. The Color of the walls should be Grey. The Tele doctors/Tele nurses should not wear white coats/white dresses. Another very important aspect is the furnishings and lightning in the Tele-medicine/TV studio. Lightning should be of the order of 1000 W/sq. ft (?).

The ATM switch is from NORTEL and the interface is at 45 Mbps. The MPEG2 Codec is also from NORTEL.

17th Nov 1999

Meeting with Mr. Michel Savvoe, Manager, BADLAB, CRC, Canada.

He explained the basic CRC BADLAB Network configuration. The basic configuration is as shown in figure 1. The details of various switches, routers, multimedia workstations is also enclosed.

The hardware for multimedia workstations –

- Sun Solaris
- SPARC workstation

Network Interface Cards:-

- FORE PCA-200EPC
- FORE LE

Software for multimedia workstations –

- ISABEL

The NIC's from New Bridge, Bay Networks are not as good as FORE's NIC. The FORE's NIC does traffic shaping, whereas the others don't do traffic shaping.

The CODEC's used are PARALLAX's mJPEG card. This manufacturing of this card has been stopped now.

BADLAB has both mJPEG and MPEG2 for Video-conferencing.

All the NIC's in BADLAB are supporting MMF which can cover a distance of about 2 kms as used in CRC, upto the SATCOM test bed.

Presently the satellite at SATCOM test bed in CRC supports T1/E1 and DS3 over Ku band.

The Video-conferencing software used at BADLAB is from ISABEL. BADLAB has two releases of this software, release 3R3 and 3R4. 3R3 runs on SUN Solaris, SGI Ericsson on O2 and Linux (3R3 gives only black & white video over Linux). This has been installed in PC's (Pentium PIII). Release 3R4 is not backward compatible with 3R3. Details on ISABEL software can be had from

http://isabel.dit.upm.es

MMF to SMF converters can be had from NBASE. Details on MMF to SMF converters can be had from

http://www.nbase-xyplex.com

BADLAB has carried out trials for HDTV at 26 Mbps using MPEH2 with Japan.

The Cameras models in BADLAB are :-

- CANON VC-C3 Communication Camera (Analog with remote)
- CANON VC-C1 MK II (Analog with remote)
- JVC Color Video Camera TK-1280U with VICON PAN & TILT Unit (PTU)
- SONY Camcorders (Digital without remote)

The Document Camera in BADLAB is :-

- ELMO Visual Presenter EV-500AF

The Projector in BADLAB is :-

- BARCO Multimedia LCD Projector – BARCODATA 2100
- http://www.barco.com

The Video Capture Card used with the PC's is :-

- ATI ALL-IN-WONDER PRO Card. This accepts analog video input, s-video input and camcorders digital input.
- http://www.ati.com

19th Nov 1999

Meeting with Mr. Jim Yuan, Director of Technology and Advanced Applications and Ms. Carol Sage, Director, Network Applications & Digital Media at Ottawa Centre for Research and Innovation (OCRI).

- OCRI is into Webcasting business.
- http://www.ocri.ca and http://www.thebusinessedge.com

22nd Nov 1999

Meeting with Mr. John Speance

He explained the concept of Virtual Classroom and Distance Education.

Project Proposal for Development of BB WILL

Project Title : Broad Band Wireless In the Local Loop

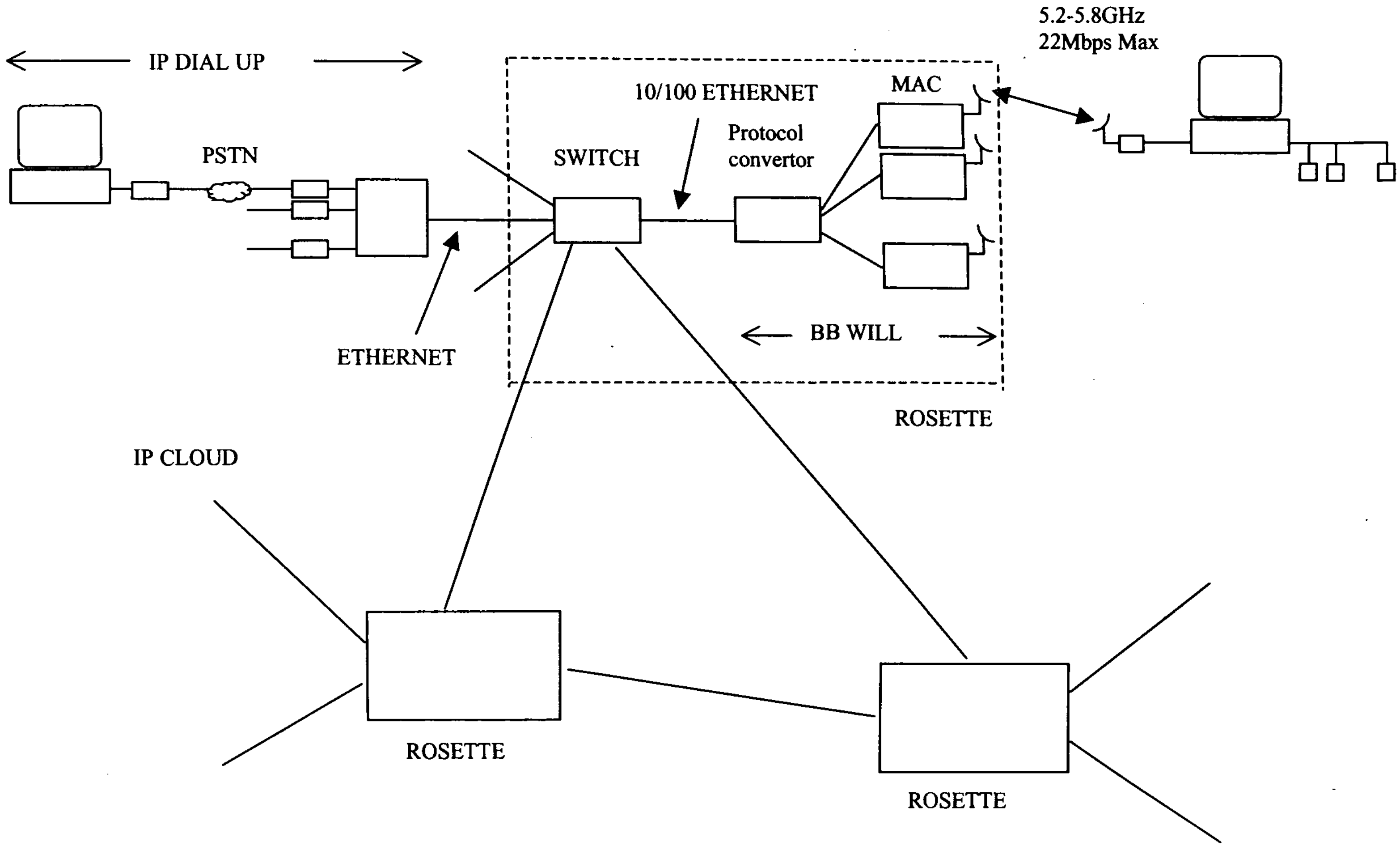
Background

The addition of the Broad Band Wireless In the Local Loop capability to the CDOT ATM product family was envisaged as the means to provide a scalable, flexible, cost effective and easy / quick time to install access technique. There are two options to be pursued in this regard. 1) Implement ATM over wireless and 2) Implement IP over wireless. The first option offers all the advantages of ATM to the subscribers, but has the disadvantage that ATM is yet not widespread at the desktop. Customer premises equipment may not be available and will be costly. The second option would yield a broadband wireless access solution for IP, which is in high demand and is widely accepted at the desktop; though this will not offer the advantages of ATM (CBR is not possible), but the IP world is growing fast and this disadvantage can be soon expected to be overcome.

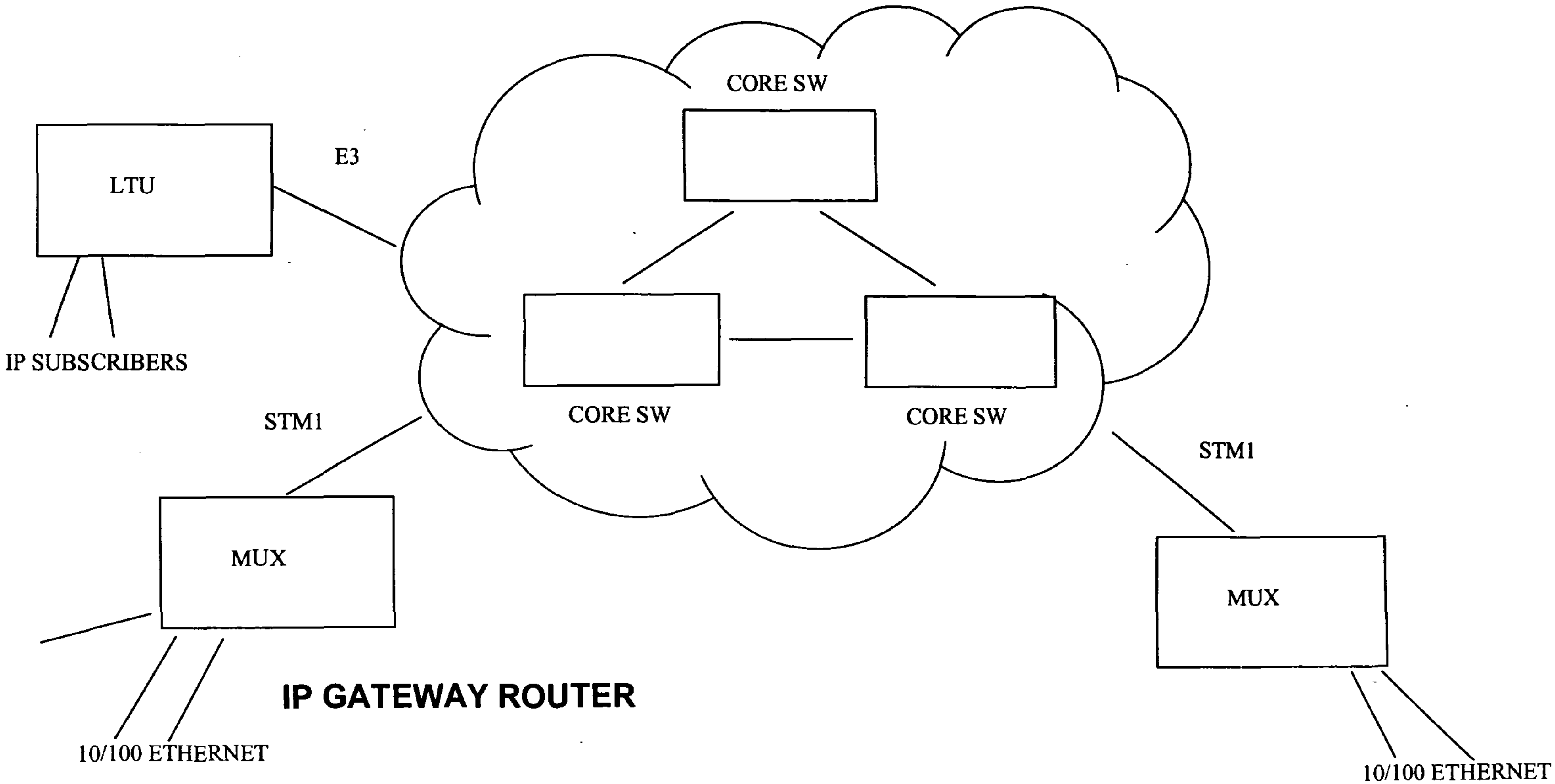
With IP networks fast emerging as a competitor to ATM, CDOT would have to add IP capability to its ATM product family. To cater to immediate IP needs, CDOT would have to carry IP over its existing ATM product family at the moment. This would need development of IP line cards in the core switch for the IP backbone (Packet over SONET), in the ATM MUX / LTU for IP access.

CRC currently is in the process of development of a BB WILL system which carries IP over wireless. This technique would be able to carry IP at high bandwidths of the order of 22Mbps towards the subscriber / 8Mbps towards the network (maximums) and could be used to provide high speed data exchange / multimedia interaction. The system offers higher bandwidths compared to ADSL, and other advantages of a WILL over conventional BB access techniques like fibre. A typical network scenario would look like:

CRC BB WILL System



The CRC BB WILL can be interfaced with the ATM switch by implementing an ETHERNET switch in the ATM product family. The ETHERNET switch can be implemented by designing a new ETHERNET line card in the ATM MUX. The typical network scenario may look like:



Therefore the design of an ETHERNET line card in the ATM MUX is proposed.

Details of Project

The aim is to develop an ETHERNET card in the ATM MUX. This would not only help in supporting BB WILL access, it could also be used for providing IP access over ETHERNET.

The ATM MUX line cards support two nibble buses towards the CSC card, i.e. an aggregate bandwidth of 400Mbps. Therefore, the proposed ETHERNET line card can support four 100Mbps ETHERNET ports. AAL5 SAR functionality would have to be supported. A high end processor would be required in the card to support the function of local IP routing. AMC, via control bus, would participate in centralised routing.

Specifications

SYSTEM

- THE ATM MUX CAN BE POPULATED BY ETHERNET LINE CARDS & ATM STM1 LINE CARDS
- THE NUMBER OF EACH TYPE OF LINE CARD IN THE SYSTEM WILL DEPEND ON THE REQUIREMENT OF LOCAL SWITCHING / TRAFFIC TOWARDS THE BACKBONE

CARD

- INTERFACE
  - FOUR 10/100 Mbps ETHERNET PORTS
  - TWO NIBBLE BUS PORTS TOWARDS CSC CARD
  - CONTROL BUS FOR CONTROL FROM AMC
- PROCESSING

- AAL5 PROCESSING
- HIGH END NETWORK PROCESSORS REQUIRED FOR HANDLING 10/100 Mbps ETHERNET SAR FUNCTIONALITY AND LOCAL IP ROUTING
- IP ROUTING HANDLED LOCALLY / BY AMC VIA CONTROL BUS

Work Plan

SN	Activity	Responsibility	Place of Activity	C-DOT	CRC
	Broadband wireless local loop			**Months x people**	**Months x people**
A.	Ethernet line card design / testing	CDOT	C-DOT	9 x 1	
B.	Software for the Ethernet line card, for IP routing, …	CDOT	CDOT	6 x 1	
C.	Integration / testing of ETHERNET switch	CDOT	CDOT	1 x 2	
D.	Defining BB WILL System Specs	CRC	CRC		2 x ?
E.	BB WILL System testing / field trial	CRC	CRC		9 x ?
F.	Propagation study for Indian conditions	CDOT	CDOT	15 x 1	
G.	Development of prototype BB WILL for CDOT	CRC	CRC		? x ?
H.	Movement of prototype to CDOT				
I.	Integration with BB WILL system	CDOT & CRC	CDOT	? x 2	? x 1
J.	Field trial of BB WILL system	CDOT & CRC	CDOT	? x 2	? x 1
K.	Technology transfer of the BB WILL system	CDOT & CRC	CRC	? x 3	? x ?
L.	Manufacture of BB WILL in CDOT	CDOT	CDOT	? x ?	
M.					

Note : The Technology Transfer step could be shuffled to anywhere after CRC finishes BB WILL system testing / field trial

Time Frame

The key deliverable – the CDOT+CRC BB WILL system can be delivered in 15 months.

Start Date : To be decided

Manpower Resources

- One engineer from CDOT ATM group for designing the Ethernet line card / testing of ETHERNET switch
- One engineer from CDOT ATM group for integration of BB WILL/ field trial / technology transfer
- One engineer from CDOT RF group for integration of BB WILL / field trial of BB WILL / technology transfer
- One engineer from CDOT ATM S/W group for writing card specific software for the ETHERNET line card
- One engineer from CDOT for doing propagation studies in Indian conditions
- Manpower required from CRC for development of prototype for CDOT
- Manpower required from CRC for Integration / field trial
- Manpower required from CRC for technology transfer
- One engineer / technical assistant from CDOT during technology transfer for manufacturing

Note: In addition to this the ATM software team would have to implement IP routing and other IP related software design.

Prerequisite The following skill set is expected of the engineer from C-DOT (for design)

1. Experience in high speed / high complexity digital card design
2. Knowledge of CDOT ATM product family

3. Knowledge of EPLD design
4. Knowledge of 10/100Mbps ETHERNET
5. Understanding of RF

Equipment Resources

From C-DOT Side : (New purchases)

Instruments : Emulator / LA pods for any new processor, ETHERNET test equipment, RF test equipment (to be identified)
Software : ETHERNET analysis / diagnosis tools

Note: Equipment will also be required for propagation studies

From CRC Side :

Instruments :
Software :

Project Co-ordination

- A good co-ordination is required between the teams in CDOT & CRC at a high management level.

- A reviewer is required at CDOT to review the card design activity.
- A two level project co-ordination team is required in CRC & CDOT during integration / field trial. One at review level and another at project co-ordination level.

Deliverable Outputs

Ethernet line card, Ethernet switch, Integrated CDOT+CRC BB WILL system, CRC BB WILL specifications, Propagation study reports, Ethernet card documents, TOT documents

Other Details and Remarks

1. The project can be initiated immediately, pending receiving specifications from CRC regarding the BB WILL system / testing of BB WILL system by CRC, because the ETHERNET card will in any case be useful in the CDOT ATM product family as an IP over ETHERNET access mechanism.
2. CDOT could, in parallel to this project, start design of ATM over wireless system OR explore, with CRC, the possibility of modifying the CRC BB WILL system for ATM.

Contacts

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Project Proposal for optical modules

Project Title : Optical Component Development for DWDM & High Speed Switching

Background

Optical Communication is considered a key technology for implementing broadband switching and transmission systems. DWDM Equipment is considered as an excellent choice to have fiber based transmission equipment with the ease of cheap, efficient and fast optical networks . C-DOT already started study and paper design work on DWDM. CRC has a range of expertise and they have evolved and designed WDM systems, opto-electronic (3X3, 4X4) Switches, Glass/Semiconductor EDFA, Grating based optical components etc. CRC's expertise in the optical components areas can be coupled with C-DOT expertise in systems design to develop contemporary and futuristic components of an optical network

SN	Activity	Responsibility	Place of Activity	Man-months	
				C-DOT	CRC
1	**Major activities to be defined**				
1.1	Sub-activities to be defined				

Details of Project :

CRC's work in the area of Photonics involves development of various components/subassemblies and sub-modules for use in different optical systems. Some of these component technologies are available for commercial use and some technologies are currently under development for various futuristic applications. The following is the list of various components developed/under development at CRC:

1. Fiber Bragg Grating : Fiber Bragg grating finds use in WDM system for dispersion compensation, EDFA gain flattening, add/drop of selected wavelengths, filters etc.

2. Fused Fiber Couplers : These are used for signal tapping, signal splitting and wavelength multiplexing/demultiplexing applications in optical systems.

3. Polymer based optical components : Currently research is going on for components based on this technology as they are expected to be cheap and have easily manufacturability. Wavelength demultiplexer is one such component which can be made using this technology.

4. Optical Switches : These are also under development at CRC.

5. Various Optical submodules/subassemblies are also being developed at CRC e.g. wavelength demultiplexer integrated with photodetector array.

6. Wavelength multiplexers/demultiplexers using glass substrate are also currently under development at CRC.

7. Various optoelectronic components e.g. interfaces at OC-48/OC-192 are also under development at CRC.

For the planned WDM project, the following optical components will be required by C-DOT:

1. Couplers (Tap, for mixing pump and signal for amplification)
2. Fiber bragg gratings
3. Optical Isolators
4. Optical circulators

5. Erbium doped fiber
6. Variable optical attenuators
7. Wavelength division multiplexers/demultiplexers (for 8/16/32 channels)
8. Pump lasers at 980 nm
9. Optical tx.(with specific wavelengths) & rx. At STM-4/16
10. Dispersion compensating fiber
11. Photodetectors
12. Various types of filters

Therefore fiber bragg gratings and fused fiber couplers appears to be the common area where C-DOT can be benefited with CRC's expertise. It is feasible to make these components in India for commercial use. In this regard, two possibilities arise:

1. C-DOT takes the task of developing and manufacturing these components.
2. The technology for the development and manufacturing of these components is taken in India by some other institution other than C-DOT.

The project is being viewed at the following three levels :

1. Bragg Gratings
2. Optoelectronics
3. Photonics

In the area of Bragg Gratings C-DOT will work out the possibility of posting one skilled engineer in CRC labs for acquiring the technology and learning to make bragg gratings.

The area of optoelectronics is interesting to C-DOT for creating high bandwidth switching systems (already underway at C-DOT). CRC will provide more details of the optoelectronic technologies available for C-DOT. A detailed study will determine the areas in which CRC and C-dOT will collaborate for systems development.

The area of photonics at CRC includes work on WDM and glass based passive optical components. C-DOT will await details of CRC effort in the WDM area. C-DOT will study the possibility of aligning its upcoming DWDM project with that of CRC so that a WDM system can be made jointly by CRC and C-DOT.

Time Frame	:	24 Months (in multiples of 3 or 4 month stretches)
Manpower Resources	:	at least 3 Engineers from C-DOT to work at CRC in each of the three areas..
Prerequisite	:	

The Engineer from C-DOT needs to be skilled in the following areas :

1. Knowledge of new research areas in optical communications.
2. Knowledge of optical device physics.
3. Working experience of designing optical systems.
4. Skills in digital electronics design.

Equipment Resources

From C-DOT Side	:	To be determined.
From CRC Side	:	To be determined.

Project Co-ordination

A good project co-ordination team is desired at two level. This will essentially constitute a review at local level at CRC & C-DOT and project co-ordination level.

Deliverable Outputs

To be determined individually for each of the three areas.

Other Details and Remarks :

A definition of optical network systems can be provided by C-DOT. The identification and definition of each optical module can be done through a detailed series of interaction between CRC and C-DOT.

Glossary:

C-DOT	Centre for Development of Telematics
CRC	Communication Research Centre
OXC	Optical Cross connects
DWDM	Dense Wavelength Division Muliplexer
EDFA	Erbium Doped Fiber Amplifier
OADM	Optical Add Drop Multiplexer
ATM	Asynchronous Transfer Mode

Study of Radio Wave Propagation Project

Project Title : Study of Radio Wave Propagation for a satellite link in **ka** band

Background :

C-DOT has developed VSAT communication systems like ISD-16 and ISD-64. We have good expertise in developing the hardware for these systems, but not much attention has been paid towards studying the propagation of radio waves in the atmosphere. All the wireless transmission systems communicate using EM waves, which propagate in the atmosphere. At lower frequencies, the majority of the loss these EM waves suffer while propagating through the atmosphere, is contributed by the free space loss. As the frequency of operation goes higher and higher the other losses like precipitation, melting layer, multipath fading loss, diffraction loss, scattering loss etc., start adding to the free space loss and contribute significantly to the over all loss. A careful study has to be performed as to how these losses affect the system performance. Some times all these losses may add up to cause a severe fading and total loss of link. CRC has performed studies in this area and developed good expertise in the field of radio wave propagation and estimation of various atmospheric losses including rain attenuation. C-DOT will work together with CRC for studying radio wave propagation to determine the coverage area and reliability of C-DOT ISD systems.

Details of the Project :

Ka-band earth-space propagation measurements in India will be feasible in the near future with the launch of a satellite carrying Ka-band beacons. Scientific merits and potential applications from C-DOT's point of view, along with technical requirements for implementation and conduct of such measurements, should be evaluated prior to initiation of a measurement program.

Workplan : **Start Date :**

SN	Activity	Responsibility	Place of Activity	C-DOT Man Months	CRC Man Months
1.	Study of information needed by a propagation project	C-DOT & CRC	C-DOT & CRC	**6.0**	
1.1.	Propagation subject study	C-DOT	C-DOT & CRC	1.0	
1.2.	Concept definition study	C-DOT & CRC	CRC	5.0	
1.3.	Specifications of system to be studied	C-DOT & CRC	CRC		
1.4.	Terrain and Weather Studies	C-DOT	CRC		
1.5.	Study of methods for information acquisition	CRC & C-DOT	CRC		
1.6.	Cost studies	CRC & C-DOT	C-DOT		
1.7.	Identification of the known parameters	CRC & C-DOT	CRC		
2.	Identification of parameters to be studied	CRC & C-DOT	CRC		
3.	Planning for propagation studies	CRC & C-DOT	CRC & C-DOT		
3.1.	Planning for field measurements	CRC & C-DOT	CRC		
3.2.	Data acquisition and storage planning	CRC & C-DOT	CRC		
3.3.	Identification of experimental apparatus required	CRC & C-DOT	CRC		
3.4.	Identification of custom experimental apparatus	CRC & C-DOT	CRC		
3.5.	Procurement of off-the-shelf experimental equipment	C-DOT	C-DOT		
3.6.	Identification of data analysis software	CRC & C-DOT	CRC		
3.7.	Procurement of off-the-shelf Data Analysis software	C-DOT	C-DOT		
4.	Preparation of custom measurement equipment	CRC & C-DOT	CRC & C-DOT		
4.1.	Design of custom equipment	CRC & C-DOT	CRC		
4.2.	Procurement time	CRC & C-DOT	CRC		
4.3.	Assembly of custom equipment	CRC & C-DOT	CRC		
4.4.	Testing of custom equipment	CRC & C-DOT	CRC		
4.5.	Deployment of custom equipment	C-DOT	C-DOT		
5.	Development of Data acquisition software	CRC & C-DOT	CRC & C-DOT		
5.1.	Specification	CRC & C-DOT	CRC		

5.2.	Design	C-DOT	C-DOT		
5.3.	Coding	C-DOT	C-DOT		
5.4.	Testing	C-DOT	C-DOT		
6.	Field measurements, Data acquisition and storage	C-DOT	C-DOT		
7.	Processing of measured data	CRC & C-DOT	CRC & C-DOT		
7.1.	Development of data analysis software	CRC & C-DOT	CRC & C-DOT		
7.2.	Analysis of measured data	CRC & C-DOT	CRC & C-DOT		
7.3.	Interpretation of results	CRC & C-DOT	CRC		
7.4.	Preparation of results for use in applications	CRC & C-DOT	C-DOT		

Summary of Specific Objectives:

This project will allow C-DOT engineers to gain expertise in the area of Radio Wave propagation at various bands like S/C band and EHF band. It would also help them in estimating various losses and coverage area of various wireless systems. This will help in formulating system specifications for radio products in the S/C Band.

Objectives of the concept definition phase are :

1. Gather technical information needed for design of measurements, such as location of satellite, station keeping parameters and relevant beacon specifications, along with site-specific (e.g. climatic) aspects and benefits of the measurements to C-DOT.

2. Survey existing propagation facilities/institutes, and relevant propagation measurement results for India, and determine if collaborative alliances with other organisations are beneficial for this project (C-DOT).

3. Specify measurement goals, evaluate general measurement approaches, identify potential sources for requisite equipment, and estimate corresponding costs (C-DOT/CRC).

4. Summarize software requirements for equipment control, data collection and analysis (C-DOT/CRC) and

5. Conceptually design a Ka-band propagation measurement facility to achieve objectives of the project (CRC/C-DOT).

Time Frame :

This activity will extend over six months.

Prerequisite :

The engineer(s) from C-DOT needs to be skilled in the following areas :

1. Radio engineering.
2. Statistics and Probability.
3. Computerised data analysis.
4. Instrumentation.

Equipment Resources

From C-DOT Side :

1. Relevant literature.
2. RF antenna, measuring equipment and components.
3. Weather sensor kit.
4. Data analysis software application (Eg. MATLAB).

From CRC Side :

1. Relevant literature.

Financial Resources :

An amount of approximately USD ______ is envisaged.

Deliverable Outputs :

1. Stage-wise activity reports.
2. Comprehensive report containing information on instrumentation, description of data acquisition software, data analysis software and inferences from acquired data. Any constraints, which may be faced by the proposed system specs, will be mentioned.

Contacts :

C-DOT	**CRC**
Jayant@cdortd.ernet.in	dave.rogers@crc.ca
prajwal@cdotb.ernet.in	cesar.amaya@crc.ca

Glossary :

CDMA	Code Division Multiple Access
C-DOT	Centre for Development of Telematics
CRC	Communication Research Centre
V-SAT	Very Small Aperture

Study of Radio Wave Propagation Project

Project Title : Study of Radio Wave Propagation for a Terrestrial Point to Point Link in L / S band

Background :

C-DOT has developed terrestrial communication systems like TDMA-PMP system , Point to Point Digital Radio system , Wireless Local Loop system etc. We have good expertise in developing the hardware for these systems, but not much attention has been paid towards studying the propagation of radio waves in the atmosphere. All the wireless transmission systems communicate using EM waves, which propagate in the atmosphere. At lower frequencies, in a LOS communication system, the majority of the loss these EM waves suffer while propagating through the atmosphere, is contributed by the free space loss. As the frequency of operation goes higher and higher the other losses like multipath fading loss, diffraction loss, scattering loss etc., start adding to the free space loss and contribute significantly to the over all loss. In a non-LOS link effect of these losses are even more predominant. A careful study has to be performed as to how these losses affect the system performance. Some times all these losses may add up to cause a severe fading and total loss of link. CRC has performed studies in this area and developed good expertise in the field of radio wave propagation and estimation of various atmospheric losses including rain attenuation. C-DOT will work together with CRC for studying radio wave propagation to determine the coverage area and reliability of C-DOT TDMA, DECT and CDMA systems..

Details of the Project :

Study of Radio Wave propagation and atmospheric loss estimation including rain attenuation, at different frequency band like S, C and EHF band. The links studied would be Point to Point LOS / Non LOS link and Point to MultiPoint Links.

Workplan : **Start Date : TBD**

SN	Activity	Responsibility	Place of Activity	C-DOT ManMonths	CRC ManMonths
1.	Study of information needed by a propagation project	C-DOT & CRC	C-DOT & CRC	**4.0**	
1.1.	Propagation subject study	C-DOT	C-DOT & CRC	1.0	
1.2.	Specifications of system to be studied	C-DOT & CRC	CRC	0.5	
1.3.	Terrain and Weather Studies	C-DOT	CRC	1.0	
1.4.	Study of methods for information acquisition	CRC & C-DOT	CRC	0.5	
1.5.	Cost studies	CRC & C-DOT	C-DOT	0.5	
1.6.	Identification of the known parameters	CRC & C-DOT	CRC	0.5	
2.	Identification of parameters to be studied	CRC & C-DOT	CRC	**0.25**	
3.	Planning for propagation studies	CRC & C-DOT	CRC & C-DOT	**2.0**	
3.1.	Planning for field measurements	CRC & C-DOT	CRC	0.5	
3.2.	Data acquisition and storage planning	CRC & C-DOT	CRC	0.25	
3.3.	Identification of experimental apparatus required	CRC & C-DOT	CRC	0.25	
3.4.	Identification of custom experimental apparatus	CRC & C-DOT	CRC	0.25	
3.5.	Procurement of off-the-shelf experimental equipment	C-DOT	C-DOT	0.25	
3.6.	Identification of data analysis software	CRC & C-DOT	CRC	0.25	
3.7.	Procurement of off-the-shelf Data Analysis software	C-DOT	C-DOT	0.25	
4.	Preparation of custom measurement equipment	CRC & C-DOT	CRC & C-DOT	**3.5**	
4.1.	Design of custom equipment	CRC & C-DOT	CRC	1.0	
4.2.	Procurement time	CRC & C-DOT	CRC	?	
4.3.	Assembly of custom equipment	CRC & C-DOT	CRC	1.0	
4.4.	Testing of custom equipment	CRC & C-DOT	CRC	1.0	
4.5.	Deployment of custom equipment	C-DOT	C-DOT	0.5	
5.	Development of Data acquisition software	CRC & C-DOT	CRC & C-DOT	**1.0**	
5.1.	Specification	CRC & C-DOT	CRC	0.25	
5.2.	Design	C-DOT	C-DOT	0.25	

5.3.	Coding	C-DOT	C-DOT	0.25	
5.4.	Testing	C-DOT	C-DOT	0.25	
6.	Field measurements, Data acquisition and storage	C-DOT	C-DOT	**12.0**	
7.	Development of Data Analysis software	CRC & C-DOT	CRC & C-DOT	**6.0**	
7.1.	Specification	CRC & C-DOT	CRC	1.0	
7.2.	Design	C-DOT	C-DOT	2.0	
7.3.	Coding	C-DOT	C-DOT	2.0	
7.4.	Testing	C-DOT	C-DOT	1.0	
8.	Processing of measured data	CRC & C-DOT	CRC & C-DOT	**4.0**	
8.1.	Analysis of measured data	CRC & C-DOT	CRC & C-DOT	1.0	
8.2.	Interpretation of results	CRC & C-DOT	CRC	1.0	
8.3.	Preparation of results for use in applications	CRC & C-DOT	C-DOT	2.0	

Summary of Specific Objectives:

This project will allow C-DOT engineers to gain expertise in the area of Radio Wave propagation at various bands like S/C band and EHF band. It would also help them in estimating various losses and coverage area of various wireless systems. This will help in formulating system specifications for radio products in the S/C Band.

Time Frame :

This activity will extend over eighteen to twenty-four months.

Prerequisite :

The engineer(s) from C-DOT needs to be skilled in the following areas :

1. Radio engineering.
2. Statistics and Probability.

3. Computerised data analysis.
4. Instrumentation.

Equipment Resources

From C-DOT Side :

1. Relevant literature.
2. RF antenna, measuring equipment and components.
3. Weather sensor kit.
4. Data analysis software application (Eg. MATLAB).

From CRC Side :

1. Relevant literature.

Financial Resources :

An amount of approximately USD 50,000.00 is envisaged.

Deliverable Outputs :

1. Stage-wise activity reports.
2. Comprehensive report containing information on instrumentation, description of data acquisition software, data reduction software and inferences from acquired data. Any constraints, which may be faced by the proposed system specs, will be mentioned.

Contact Persons :

C-DOT	CRC
jayant@cdotd.ernet.in	
prajwal@cdotb.ernet.in	jules.lebel@crc.ca

Glossary :

CDMA	Code Division Multiple Access
C-DOT	Centre for Development of Telematics
CRC	Communication Research Centre

APPENDIX 3

MEMORANDUM OF UNDERSTANDING

BETWEEN CRC AND C-DOT


Corporate Services
New Alliances
Nouvelles alliances
Technology Transfer
Radio Science &

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding (hereinafter "MOU") made and effective as of this 19 th day of November, 1999.

BETWEEN:

HER MAJESTY THE QUEEN IN RIGHT OF CANADA, as represented by the Minister of Industry through the Communications Research Centre Canada (hereinafter "CRC")

AND:

CENTRE FOR DEVELOPMENT OF TELEMATICS, a telecommunications technology centre of the Government of India (hereinafter "C-DOT")

WHEREAS,

CRC has demonstrated unique technical expertise and capabilities relating to various aspects of communications, including satellite communications, communications systems networks and protocols, signal processing, data compression, information processing, radio propagation, antenna design, terrestrial wireless communications, high speed digital circuits, monolithic microwave integrated circuits, and broadband networks;

C-DOT is carrying out advanced research and developmental activities in narrowband and broadband public switching and transmission networks, terrestrial radio systems, satellite systems, optical communication equipment, network protocols and network management systems;

The parties recognize the importance of telecommunications technologies for the political, economic, social and cultural development of both countries;

The mandate of CRC includes conducting collaborative research and development projects with universities, industry, governmental organizations, and other research institutes;

Combining the expertise of these organizations through specific research projects can advance the state of technology and the demonstration of applications;

CRC and C-DOT have, in the conduct of their undertakings, identified specific opportunities for collaboration relating, in particular, to domestic and international initiatives in broadband systems, wireless techniques, optical communications equipment, DSP / VLSI design and satellite communications;

C-DOT and CRC desire to establish the framework for a Co-Operative Program designed to meet their respective missions and requirements by advancing the development of telecommunications technologies and applications, through such activities as collaborative research undertakings and the exchange of personnel;

NOW THEREFORE, the parties have reached the following understanding:

1. DEFINITIONS

1.1 **"Background Technology"** means Intellectual Property other than that developed under the Work in Project Agreements, which is proprietary to one or the other party and is necessary for the development and usage of the Work of any Project Agreement.

1.2 **"Co-operative Program"** means the arrangement of projects carried out by the parties pursuant to this MOU, each of which projects is specified and agreed to by both parties and set out in a Project Agreement.

1.3 "**Confidential Information**" means any information, including drawings, samples, devices, demonstrations, Know-how, software, reports and other materials of whatever description, whether subject to or protected by copyright, patent, trade secret, industrial design or any other form of intellectual property protection, howsoever disclosed or communicated before or after the effective date of this document by one party to the other party, which if in written form is labelled as "Confidential", and if disclosed orally and identified as confidential at the time of oral disclosure is furnished to the receiving party within thirty (30) days after such disclosure in a written summary labelled as "Confidential", but does not include information which:

a) is now, or hereafter, through no act or failure to act on the part of the receiving party, becomes generally known or available to the public without breach of this document or any subsequent agreement made pursuant thereto;

b) is known to the receiving party at the time of disclosure of such information or is developed by the receiving party independently of such disclosure;

c) is hereafter furnished to the receiving party by a third party without that third party being in breach directly or indirectly of an obligation to the disclosing party to keep the information confidential; or

d) is disclosed as required by statute or judicial decree.

1.4 **"Foreground Technology"** means any Intellectual Property which results from or is otherwise created pursuant to or for the purpose of the performance of the Work of any Project Agreement.

1.5 **"Intellectual Property"** means any invention, patent, utility model, copyright, trade-mark, industrial design or integrated circuit topography right, or any right of whatsoever nature in computer software and data, trade secrets or Know-how, or any intangible right or privilege of a nature similar to any of the foregoing, in every case in any part of the world and whether or not registered, and includes all granted registrations in respect of any such right.

1.6 **"Invention"** means any new and useful art, process, machine, manufacture or composition of matter, or any new and useful improvement thereof.

1.7 **"Know-how"** means the proprietary information, processes, techniques, or methodologies of either party.

1.8 **"Project Agreement"** means a specific binding agreement which is entered into by the parties in furtherance of the objectives of this MOU, as more particularly described in Section 3.

1.9 **"Work"** means all the tasks, deliverables and other obligations specified in the Project Agreements.

2. SCOPE AND PURPOSE

2.1 The purpose of this MOU is to establish a framework for the cooperation of the parties in research and developmental activities relating to the fields of telecommunications. This document describes the framework under which further Project Agreements may be entered into between the parties, and together with these Project Agreements, specifies how the Work will be conducted, the mutual objectives of the parties advanced, the responsibilities of the parties discharged, and this MOU and any further Project Agreements managed.

2.2 Nothing in this MOU will be construed as creating legal relations between the parties, or creating any legal entity or the relationship of principal and agent, legal partnership, or joint venture between the parties, or any material responsibility on the part of one party for the debts or liabilities of the other party, and no party will represent otherwise to any other person. Neither party has the authority to bind the other party, contract in the other party's name, or create any liability against the other party, nor will it hold out that it has any such authority. No party will be obliged to initiate, negotiate, approve or execute any, or any particular, Project Agreement, or any other agreement, as a result of this MOU.

3. COOPERATIVE PROGRAM AND PROJECT AGREEMENTS

3.1 During the term of this MOU, the parties agree to endeavour to define and negotiate technical projects and support activities and to enter into Project Agreements for each of these. Some of the projects may comprise the provision of technical services by one party to the other party, while others may be collaborative or jointly supported projects and may include, with the consent of both CRC and C-DOT, the participation of third parties.

3.2 The nature of Work under the Cooperative Program may include the following:

(a) the provision of technical services;
(b) the transfer of and the grant of permission to use Intellectual Property;
(c) the exchange of scientific and technical personnel, pursuant to the terms and conditions of Interchange Canada or a similar program; and
(d) the sharing of facilities.

3.3 Each Project Agreement will, subject to the approval of the parties:

(a) define and identify the objective, scope, Work, schedules, milestones, involved personnel, expected results, and expected resource commitments required of each party;
(b) identify the possible participation of any third parties, and set out the roles and responsibilities thereof;
(c) define the nature and scope of the Background Technology to be exchanged, the terms and considerations for such exchange, and the permitted use of such Background Technology; and
(d) describe the requirements for or restrictions on the publication, protection, use and commercial exploitation of any Foreground Technology.

4. CO-ORDINATION OF THE MOU

4.1 This MOU will be coordinated by Jeet Hothi, Head, Industrial R&D Projects and Dr. Gerry Chan, Vice President, Terrestrial Wireless Systems as the representatives for CRC, and by Jayant Bhatnagar, Senior Program Manager, ATM and P.K. Bhatnagar, Director, Switching as the representatives for C-DOT. Either party may change its representatives by providing written notice thereof to the other party at least fifteen (15) days before such change.

4.2 The above representatives, or their delegates, may meet or otherwise communicate as required in order to:

(a) propose and negotiate the subject matter and terms of a Project Agreement;

(b) review the progress and results of Work performed under any Project Agreement;

(c) propose, as necessary, any modifications to the Work or the terms of reference of a Project Agreement;

(d) discuss, as necessary, the terms of reference of this MOU, and propose modifications as appropriate; and

(e) discuss and endeavour to resolve any difficulties arising from the joint activities carried out under this MOU.

5. NOTICES

Where in this MOU any notice, request, direction or other communication is required to be given or made by any of the parties, it will be in writing and will be effective if sent by registered mail, by facsimile or delivered in person, postage prepaid or charge prepaid, as the case may be, addressed in the case of CRC to:

Jeet Hothi
Building 74, Room 208
Communications Research Centre
3701 Carling Avenue
Box 11490, Station H
Ottawa, Ontario
K2H 8S2

Telephone: (613) 998-2168
Facsimile: (613) 998-5355

and in the case of C-DOT to:

Jayant Bhatnagar
Centre for Development of Telematics
6th Floor, Samrat Hotel, Chanakyapuri
New Delhi – 110 021
India

Telephone: 91-11-4104815, 4107297
Facsimile: 91-11-4104815

or to such other addressee as a party may designate by giving thirty (30) days prior written notice.

6. PARTICIPATION OF THIRD PARTIES

The collaborative research and development projects may include the participation of third parties, under terms and conditions which will be negotiated and set out by the parties in the relevant Project Agreement prior to the execution of any agreement with such third parties.

7. INTELLECTUAL PROPERTY RIGHTS

7.1 Each Project Agreement will define the nature and scope of the Background Technology to be exchanged, the terms of and consideration for this exchange, and the respective rights of the parties in the Foreground Technology.

7.2 Except as may be otherwise specifically provided for in a Project Agreement, each party intends to retain all right, title and interest, in, to and under its respective Background Technology, and each party will freely use, enjoy, license, dispose of, or otherwise exploit any of its respective rights, titles and interests in, to and under its Background Technology in its sole discretion.

7.3 Except as may be otherwise specifically provided for in a Project Agreement, and subject to any third party obligations to which a party may have agreed prior to the term of the relevant Project Agreement, each party intends to grant to the other party a non-exclusive, non-transferrable, royalty-free, world-wide licence to use such of its Background Technology as it may disclose but only as may be necessary for the other party to perform its obligations under that Project Agreement, such licence automatically terminating upon the termination of that Project Agreement.

7.4 Except as may be otherwise specifically provided for in a Project Agreement, each party intends to retain all right, title and interest to Foreground Intellectual Property which is developed solely by its respective employees.

7.5 Except as may be otherwise specifically provided for in a Project Agreement, each party intends that the Foreground Intellectual Property developed by employees of both parties will be jointly owned by those parties, and each of those parties will have the right to independently use, modify and license such Foreground Intellectual Property without accounting or consent from the other party.

8. CONFIDENTIAL INFORMATION

8.1 Each party intends to protect the Confidential Information disclosed or communicated to it by the other party with a reasonable degree of care and one that is at least equal to the degree of care used to protect its own Confidential Information, and to use the Confidential Information disclosed or communicated to it by the other party only for the purposes required or contemplated by this MOU or the relevant Project Agreement. The parties will negotiate, for each Project Agreement, the terms and conditions for the exchange of Confidential Information relating to the Work to be performed under that Project Agreement.

8.2 Both the parties acknowledge that each party is subject to their respective national laws and Acts related to Access to Information.

9. PUBLICATIONS AND ENDORSEMENTS

9.1 The parties recognize that it is part of each of their roles to disseminate information through publication, but further recognize that the publication of certain information may compromise the Intellectual Property rights of the parties. The parties will therefore negotiate appropriate terms and conditions in each Project Agreement relating to the approval process for publication of any thesis, article, seminar presentation, paper or other similar disclosing material prepared in respect of any Work done under the Co-operative Program.

9.2 Neither party will use the name of the other party in any form of advertising or promotion, nor imply that the other party endorses any product, process or standard, but the parties may acknowledge support for, and the nature of, this MOU, accurately and appropriately describing in any such statement the relationship of the parties.

10. CONTRIBUTIONS

Each party will specify in the relevant Project Agreement its respective contributions of financial and in-kind resources (including all costs or estimated costs) for the Work being performed under that Project Agreement. Except as may be otherwise specifically provided for in a Project Agreement, the contributions of C-DOT and CRC will each consist of the provision of scientific and technical management and expertise, and each party will bear the costs of its participation in this MOU and in any subsequent Project Agreement. No costs incurred by one party will be assumed by the other party unless that other party otherwise accepts in writing the assumption of such costs prior to the incurrence thereof.

11. TERM AND TERMINATION

11.1 The term of this MOU will commence on its effective date and remain in effect for a period thereafter of three (3) years, unless the MOU is earlier terminated in accordance with the provision below. This MOU may be extended prior to its expiration by the mutual written agreement of the Parties.

11.2 Either party may terminate this MOU by giving a written notice to the other party to take effect three (3) months after receipt thereof.

11.3 Notwithstanding the expiration or termination of this MOU, any and all Project Agreements then in effect, and not in default, will continue in accordance with the terms and conditions thereof.

12. GENERAL PROVISIONS

12.1 This MOU may be amended in writing at any time by mutual agreement of the parties.

12.2 This MOU constitutes the entire understanding of the parties, and is intended as a final expression thereof.

****

IN WITNESS WHEREOF the parties have executed this MOU as attested by the signatures of their officers duly authorized for such purposes.

For Her Majesty the Queen in Right of Canada as represented by the Minister of Industry:

____

Dr. Gerry Turcotte
President, Communications Research Centre

____

WITNESS

For Centre for Development of Telematics

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Dr. K. N. Gupta
Executive Director, Center for Development of Telematics

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WITNESS

APPENDIX 4

AGENDA FOR THE SECOND C-DOT VISIT TO CRC

Nov 15 – Nov 24, 1999

AGENDA FOR THE SECOND C-DOT VISIT TO CRC

Nov 15 – Nov 24, 1999

DAY 1

INTRODUCTION / WELCOME

INTRODUCTION AND ASSIGNMENT OF C-DOT ENGINEERS TO THE RELEVANT PROJECTS AND LABS

REVIEW STATUS OF OUTSTANDING OR ROUND 2 PROJECTS (NOT FIRMED UP DURING THE FIRST VISIT) AND START FURTHER DISCUSSION ON THESE.

DAY 2

- CONTINUATION OF PROJECT DISCUSSIONS FOR THE ROUND PROJECTS AND LAB VISITS
    - OPTICAL
    - BROADBAND WIRELESS LOOP AT 5 GHZ. (MILTON)
    - PROPAGATION
    - BADLAB
    - DIRECT DIGITAL RECEIVER AT OC-3 FOR SATCOM
    - DSP VLSI / ASIC
    - ETC
- PRESENATATION TO PSG MEETING ON THE STATUS OF CRC / C-DOT COLLABORATIVE ACTIVITIES
- VISIT OF OTTAWA HEART INSTITUTE FOR TELEHEALTH APPLICATIONS

DAY 3

- ARRIVAL AND RECEPTION OF CDOT EXECUTIVE TEAM
- CONTINUATION OF PROJECT DISCUSSIONS AND LAB VISITS
- HOSTING OF PSG MEMBERS AT CRC

CRC OVERVIEW TO PSG
CRC LAB VISITS FOR BY THE PSG MEMBERS

DAY 4

PROJECT DISCUSSIONS AND LAB VISITS CONTINUED

VISIT OF OCRI TO STUDY BROADBAND APPLICATIONS

DISCUSSION AND FINALISATION OF MOU

DAY 5

C-DOT SENIOR MANAGEMENT TEAM -

INTRODUCTION AND WELCOME BY CRC'S PRESIDENT

CRC OVERVIEW

LAB VISITS - BADLAB

DFL

MOU SIGNING CEREMONY

SATURDAY AND SUNDAY

DAY 6

- C-DOT SENIOR MANAGEMENT TEAM –

  INDUSTRIAL VISITS IN THE AREA OF IDENTIFIED PROJECTS

  NANOWAVE / REMECS, TORONTO
  LARCAN TECHNOLOGIES INC., TORONTO

- C-DOT ENGINEERING TEAM –

PROJECT DISCUSSIONS AND LAB VISITS CONTINUED

DAY 7

- C-DOT SENIOR MANAGEMENT TEAM –

  VISIT OF CRC LABS IN THE AREAS OF IDENTIFIED PROJECTS

  MMIC / MHMIC Microwave Lab
  VLSI / ASIC Lab
  Microstrip Patch and other Antennas
  BADLAB (Broadband Applications Demonstration Lab)
  Optical Network Technologies
  Optoelectronics Materials and Components
  Optical Communications I
  Satcom Ka band direct Receiver
  Satellite Suitcase Terminal
  Broadband Wireless Access (MILTON)
  Terrestrial Wireless Test Bed

  LUNCH HOSTED BY C-DOT FOR THE RESEARCH TEAMS

  VISIT OF NRC – Institute of Information Technology and
  Institute of Microstructural Sciences

- C-DOT ENGINEERING TEAM –

  PROJECT DISCUSSIONS AND LAB VISITS CONTINUED

DAY 8

- C-DOT SENIOR MANAGEMENT TEAM –

  INDUSTRIAL VISITS IN THE AREA OF IDENTIFIED PROJECTS

  HARRIS CANADA, MONTREAL
  MITEC INC., MONTREAL
  DEPARTURE FROM MONTREAL

- C-DOT ENGINEERING TEAM –

  PROJECT DEFINITIONS AND FINALISATION

  NEXT STEPS

  DEPARTURE FROM OTTAWA

APPENDIX 5

CIDA PROJECT STATUS

R AND D COLLABORATION BETWEEN CRC AND C-DOT

PRESENTATION TO TELECOMMUNICATIONS FRAMEWORK PROJECT STEERING GROUP

NOVEMBER 16, 1999, OTTAWA

CRC PROPOSAL (AUG / SEPT., 1998)

A DEFINITION PHASE

- VISIT OF C-DOT (FEB., 1999; SEE TRIP REPORT)

  - IDENTIFICATION OF INITIAL AREAS OF INTEREST
  - STUDY OF IT TRAINING REQUIREMENTS
  - R&D STIMULATION PROGRAM STUDY REQUIREMENTS

- TECHNICAL WORKSHOP AT CRC (MAY /JUNE 1999)

  TO IDENTIFY, SELECT AND DEFINE PROJECTS OF MUTUAL INTEREST

B PROJECT IMPLEMENTATION PHASE (SEPT, 99)

C HIGH LEVEL VISIT

A FACT FINDING MISSION BY C-DOT TO STUDY CANADIAN R&D INDUSTRY ASSISTANCE PROGRAMS SUCH AS IRAP, TPC, AND NSERC

CRC PROPOSAL (AUG / SEPT., 1998)

A DEFINITION PHASE

- VISIT OF C-DOT (FEB., 1999; SEE TRIP REPORT)

  - IDENTIFICATION OF INITIAL AREAS OF INTEREST
  - STUDY OF IT TRAINING REQUIREMENTS
  - R&D STIMULATION PROGRAM STUDY REQUIREMENTS

- TECHNICAL WORKSHOP AT CRC (MAY /JUNE 1999)

  TO IDENTIFY, SELECT AND DEFINE PROJECTS OF MUTUAL INTEREST

B PROJECT IMPLEMENTATION PHASE (SEPT, 99)

C HIGH LEVEL VISIT

A FACT FINDING MISSION BY C-DOT TO STUDY CANADIAN R&D INFRASTRUCTURE AND VISIT SELECTED COMPANIES

CRC PROPOSAL – SALIENT FEATURES

A THOROUGH AND CAREFUL REVIEW OF INDIAN CAPABILITIES AND REQUIREMENTS

DEVELOPMENT OF ACTUAL TECHNOLOGIES OF INTEREST TO BOTH CRC AND C-DOT

A SET OF CLEARLY DEFINED PROJECTS IN TERMS OF SPECIFIC OBJECTIVES, DELIVERABLES, AND OTHER DETAILS

MINIMUM EXPENDITURES ON TRAVEL AND MANAGEMENT FUNCTIONS

MAXIMUM ALLOCATION TO R&D AND OTHER TECHNICAL ACTIVITIES

PROFESSIONAL BUSINESS LIKE APPROACH FOR PROJECT MONITORING AND REPORTING

AN UP-FRONT AGREEMENT ON SHARING AND COMMERCIALIZING RESULTING IP

PROPOSAL PRESENTED TO CIDA / IC: SEPT, 99
APPROVED AT CIDA STEERING COMMITTEE MEETING IN INDIA .... NOV 1998

CRC PROPOSAL – SALIENT FEATURES ....

ADVANTAGES TO C-DOT

- LEARNING EXPERIENCE – EXTENSIION OF THEIR EXISTENCE KNOWLEDGE
- DEVELOPMENT OF PRACTICAL PRODUCTS
- LONG TERM R&D
- LONGER TERM MUTUALLY BENEFICAIL RELATIONSHIP BEYOND CIDA

ADVANTAGES TO CRC

- DEVELOPMENT OF IP
- ADVANCED R&D
- RESOURCE LEVERAGE
- LONGER TERM MUTUALLY BENEFICAIL RELATIONSHIP BEYOND CIDA

- **INDIAN TRIP (FEB 1999; SEE TRIP REPORT)**

A. **C – DOT IN BRIEF**

- ESTABLISHED IN 1984
- BUDGET OF $60 MILLION
- STAFF OF 1000
- PREMIER R&D ORGANIZATION IN INDIA
- TWO MAJOR DIVISIONS – SWITCHING (40%)
- TRANSMISSION
  - TERRESTRIAL WIRELESS
  - SATELLITE
  - OPTICAL FIBRE / NETWORKING

(NO PROPAGATION AND BROADCASTING)

- MORE THAN 72 MANUFACTURERS
- PILOT PRODUCTION FACILITIES
- TYPICAL ROYALTIES OF 3.5%
- PREMIER R&D ORGANIZATION IN INDIA

TECHNICAL WORKSHOP
MAY 31 – JUNE 8, 1999

OBJECTIVE:

TO IDENTIFY, SELECT AND DEFINE R&D COLLABORATIVE PROJECTS

PROGRAM

PRESENTATIONS

- 5 RESEARCH BRANCHES
- C-DOT
- DISCUSSION

LAB VISITS

- TERRESTRIAL WIRELESS TEST BED
- MMIC / MHMIC
- VLSI / ASIC
- MICROSTRIP PATCH AND OTHER ANTENNAS
- PROPAGATION
- EM COMPATIBILITY
- BADLAB AND VIRTUAL SCHOOL
- OPTICAL NETWORK TECHNOLOGIES
- OPTOELECTRONICS MATERIALS AND COMPONENTS
- OPTICAL COMMUNICATIONS
- DIRECT DIGITAL RECEIVER
- SATELLITE SUITECASE TERMINAL
- DIGITAL VIDEO
- CRV -COV

TECHNICAL WORKSHOP

DETAILED DISCUSSIONS

- VLSI / ASIC
- MMIC / MHMIC
- MICROSTRIP PATCH ANTENNAS
- BADLAB CONNECTIVITY
- DIRECT DIGITAL RECEIVER
- PROPAGATION STUDIES
- BROADBAND WIRELESS LOCAL LOOP (MILTON)
- "OPTICAL TECHNOLOGIES "

PROJECT SELECTION AND DEFINITION

- MICROSTRIP PATCH ANTENNAS
  - A LOW GAIN MICROSTRIP LINEARLY POLARISED (LP) ANTENNA AT 2 GHZ
  - A LOW GAIN MICROSTRIP CIRCULARLY POLARISED (CP) ANTENNA AT 2 GHZ
  - A MEDIUM GAIN X OR KU BAND LP MICROSTRIP ANTENNA
  - A KA BAND LP MICROSTRIP ANTENNA
- MMIC DEVELOPMENT
- DSP VLSI DESIGN

- PROPAGATION STUDIES
- OC – 3 SATCOM KA-BAND DIRECT RECEIVER
- BROADBAND APPLICATIONS CONNECTIVITY
- BROADBAND WIRELESS LOOP AT 3-7 GHZ (MILTON)
- OPTICAL COMPONENT DEVELOPMENT FOR DWDM
- MOU

INDIAN TRIP
INITIAL AREAS OF MUTUAL INTEREST

- MMIC, MHMIC FOR RF COMPONENTS
- ASIC TECHNOLOGY
- MICROSTRIP PATCH ANTENNAS
- CODING AND ACCESS TECHNIQUES
- DIRECT DIGITAL RECEIVER
- OPTICAL FIBER TECHNOLOGIES
- WIRELESS SYSTEMS AND TEST BEDS
- DIGITAL VIDEO COMPRESSION
- VOICE COMPRESSION
- BROADBAND APPLICATIONS

PROJECT DESCRIPTION GUIDELINES

- PROJECT TITLE
- BRIEF DESCRIPTION
- SPECIFIC OBJECTIVES
- KEY PERSON AT CRC
- KEY PERSON AT C-DOT
- TIME FRAME / DURATION
- RESOURCES: PERSONS, EQUIPMENT, MATERIAL, FABRICATION, TESTING ETC
- DELIVERABLES / OUTPUTS – REPORTS, IP, PATENTS, PUBLICATIONS, PROTOTYPES, TRAINING, TECHNOLOGY TRANSFER ETC
- OTHER DETAILS AND / OR COMMENTS IF NECESSARY

NEXT MEETING

TENTATIVE DATE: SEPT 20 – 24, 1999 AT CRC

OBJECTIVES

- START FIRST 3 PROJECTS
- SIGN MOU BETWEEN CRC AND C-DOT
- FINALIZE REMAINING PROJECTS
- INDUSTRIAL VISITS IN THE AREA OF SELECTED PROJECTS

SPECIFIC ACTION ITEMS

C-DOT

- APPROVAL OF SELECTED PROJECTS BY SENIOR MANAGEMENT
- SELECTION OF ENGINEERS TO START WORK AT CRC
- SELECTION OF C-DOT DELEGATION FOR SEPT MEETING
- COMMENTS ON DRAFT MOU

SPECIFIC ACTION ITEMS ...

CRC

- ORGANIZATION OF SEPT MEETING
- ARRANGING LAB OR OTHER OFFICE SPACE AND WORKING TOOLS FOR C-DOT ENGINEERS
- FINALIZATION OF SEPT MEETING
- ARRANGING INDUSTRIAL VISITS

CIDA / IC - ARRANGING

- TRAVEL FOR THE C-DOT DELEGATION
- WORK VISAS
- HOUSING FOR C-DOT ENGINEERS

FEEDBACK

CIDA / IC

“THANK YOU FOR YOUR EXCELLENT JOB IMPLEMENTING THE FIRST C-DOT MISSION.”

“THE OBJECTIVES OF THE MISSION WRE EXCEEDED IN MOST AREAS.”

C-DOT

“WE ALL THANK YOU FOR YOUR WARM WELCOME AND HOSPITALITY AND WONDERFUL CRC / C-DOT TECHNICAL WORKSHOP CO-ORDINATION.”

“WITH APPRECIABLE SUPPORT FROM CRC, SPECIFIC PROJECTS HAVE BEEN SUCCESSFULLY DEFINED”

APPENDIX 6

LIST OF PARTICIPANTS

C-DOT ENGINEERING TEAM

Jayant Bhatnagar, Team Leader
B U Chandrashekar, DSP VLSI / ASIC
P G Neelangandan, DSP VLSI /ASIC
Atul Gupta, Optical Technologies

Krishan Kumar P S , Broadband wireless local loop project
Naresh Bhambhani, BADLAB
Prajwal S, Propagation studies
R Murli Mohan, Satcom Ka band Direct Receiver

V Sreekrishnan, Microstrip patch antenna project
G Vinay Kumar MMIC Technology

C-DOT SENIOR MANAGEMENT TEAM

Dr K N Gupta, Executive Director
Dr P K Bhatnagar, Director, Switching systems
Mr Vijay Madan, Director, Transmission Systems

CRC

Gerry Turcotte, President
Graham Taylor, Director, Marketing
Dr. Gerry Chan, VP, Terrestrial Wireless
Jack Rigley, VP , Satellite Communications

M Cuhaci, Manager, Advanced Antenna Research
Luc Boucher, Manager, Terrestrial Wireless Test Bed
Dr. Jules LeBell, Senior Scientist, Radio Propagation
Dr Malcolm Stubb, Senior Scientist, MMIC / MHMIC Technologies

Dr. Ken Hill, Principal Scientist, Optical Communications
Dr. Ezio Berolo, Research Manager, Optical Network Technologies
Dr. Julian Noad, Research Manager, Optoelectronics Materials and Components

Mario Caron, Research Manager, Satellite Systems
Dan Hindson, Senior Engineer, Satellite Systems
Corey Pike, Senior Engineer, Satellite Earth Terminals
Dr. Valek Zzwarc, Research Manager, Microelectronics Division

John Sydor, Manager, Broadband Terrestrial Wireless Technologies
M Savoie, Manager. BADLAB
John Spencer, Manager, Virtual School Project
Jeet Hothi, Head, Industrial R&D

Dr. Dave Rogers, Senior Scientist, VHF – EHF Propagation Division
Eric Tsang, BADLAB
Karen Bryden, Voice processing and compression technologies
Luc Desormeaux, DSP VLSI / ASIC

PSG MEMBERS WHO VISITED CRC

N K Sinha
R N Bhardwaj
M Ravindra
R Kapur
M P Tangirala
M Uppal

CIDA

George Wieringa

INDUSTRY CANADA

Keith Parsonage
Claude Dostaler
Aaron Baillie

CONSULTANTS

Neelam Mukhija