FEASIBILITY STUDY OF A NATIONAL HIGH SPEED COMMUNICATIONS NETWORK FOR RESEARCH, DEVELOPMENT AND EDUCATION

Prepared by:

HICKLING

with

comgate

FEASIBILITY STUDY OF A NATIONAL HIGH SPEED COMMUNICATIONS NETWORK FOR RESEARCH, DEVELOPMENT AND EDUCATION

MAIN REPORT

Submitted to:

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA

Prepared by:

HICKLING

and

COMGATE ENGINEERING ASSOCIATES LTD.

In association with:

THE ALBERTA RESEARCH COUNCIL

THE CGI GROUP

LANG MICHENER LAWRENCE & SHAW

HICKLING REF:3201
March, 1990

NOTE

This is the Main Report of a study prepared by James F. Hickling Management Consultants Ltd. (HICKLING) on behalf of Industry Science and Technology Canada (ISTC), entitled "Feasibility Study of a High Speed Communications Network For Research, Development and Education". There are five volumes in this study:

1. Main Report
2. Volume A: Participant Needs
3. Volume B: Economic Analysis
4. Volume C: Technical Analysis
5. Volume D: Implementation Analysis

PREFACE

This study was commissioned by Industry, Science and Technology Canada to investigate the feasibility of establishing a National High-Speed Communications Network for use by the Canadian research, development and education communities; and by the Canadian information technology industry. The Network would have greater capacity and functionality than existing networks for research, development, and education, and in addition, provide an environment for the development and demonstration of new information technology equipment and services. While the undertaking of this study is not to be construed as a commitment by the federal government to the establishment of a network, the study will provide a solid basis for such an initiative should it be found prudent.

HICKLING is indebted to Dr. Digby Williams, Director, and Joseph Padden and Rafiq Khan, Senior Technologies Advisors, of the Microelectronics Technology Office, Information Technologies Industry Branch, Industry, Science and Technology Canada, for their expert technical and managerial advice in the conduct of this study. The authors would also like to offer thanks to the more than 400 individuals who participated in expert panel sessions, in-person interviews, and surveys; the study would not have been possible without their input. Of course, any errors or omissions are the sole responsibility of HICKLING.

The report was authored by David Arthurs, Phil Kennis, and Daniel Hara of HICKLING under the direction of Dr. Verne Chant; and Roger Choquette and Antony Capel of COMGATE. Significant contributions were made by Dr. Saul Greenberg of the Alberta Research Council; Dr. Frederick Eshragh, Dr. Kalman Toth, and Dr. Samy Mahmoud of CGI; John Lawrence and Andree Wylie of Lang Michener Lawrence & Shaw; Dr. Elmer Hara of the University of Regina; and Dr. Fred Casadei.

EXECUTIVE SUMMARY

Objectives

This study has the primary objective of determining the feasibility of establishing a national high-speed communications network. The secondary objectives are to address the utility of the Network as a means of:

- enhancing collaborative research, and
- achieving a more internationally competitive Information Technologies (IT) sector.

Concept of the Proposed Network

The following are the general characteristics of the proposed Network:

- Provision of user friendly services to organizations involved in research, development and education so that they can communicate, access special equipment, and access information sources. Some of the services may be offered by Value Added Suppliers to the Network.
- Provision of an environment for the development and testing of next generation information technology equipment and services. This includes market needs analyses, product assessments, and technical trials.
- National backbone connecting regional and international networks at an initial capacity of 1.5 Mbs. This capacity will be increased in the future when required to maintain the Network at the forefront of technology.
- Conformance to international (OSI) standards as they evolve. Co-existence with TCP/IP (Transmission Control Protocol/Internet Protocol) and other protocols.
- Use of Canadian technology, equipment and existing transmission facilities to the maximum extent possible.

Anticipated Benefits

The benefits of the proposed Network will accrue to a wide range of organizations in industry, government, and the academic community. These benefits include: improved international competitiveness for industry, improved quality and productivity of research, more efficient use of scarce resources, greater opportunities for small or geographically remote organizations, and improvements in educational techniques.

Study Findings

- The proposed Network is feasible in terms of the economic, technical, and implementation aspects.
- A need for the proposed Network has been expressed by industry, government, and the academic community.
- The expected incremental net present value of the proposed Network is $1.5 billion over 20 years, with an 80% confidence interval from $1.1 billion to $1.9 billion.
- It is recommended that the proposed Network be implemented quickly in order to capture the maximum benefit for users in the research, development, and education communities, and to capture the "window of opportunity" for the information technology industry.

Implementation

The mission of the proposed Network has been defined as: Enhancing Canada's global competitiveness and improving Canadian society by providing the means for organizations engaged in the strategic areas of Research and Development, Information Technologies, and Education to connect with each other, and with information sources, special equipment and international resources.

In support of that mission it is recommended that uses of the Network be as wide as possible, with the restriction that it not be used for commercial purposes. Similarly, access to the proposed Network should be as general as possible.

The proposed Network can be implemented in such a way that it meets the needs, concerns, and interests of most potential participants. This is important since the proposed Network can only be successfully implemented by the cooperative effort of government, industry, and the academic community. Government efforts must be seen to be in harmony with the concept of a single, national R&D Network. Because of the industrial development aspects of the Network, it is proposed that ISTC should continue to be its lead sponsoring agency.

An important function of the proposed Network will be to promote the development of new services and applications to run on this and other networks. This will benefit both researchers who will use the services, and the information technology industry who will develop them for domestic and foreign markets.

All participants should have equity in the proposed Network. A suggested breakdown for funding is: federal government 60%, provincial governments 5%, regional networks 5%, carriers 25%, and industry 5%. Some of these contributions will be in the form of discounts and services.

A number of options have been identified which could be pursued with the carriers and the CRTC to obtain permission for the discounts on transmission costs which would be the carriers contribution.

The proposed Network should be managed by a dedicated, full-time organization. All participants should have representation. All Canadian companies should have the opportunity to participate in Network operations. All networks should ultimately be part of a unified management structure.

The proposed Network should build on the experience and expertise of existing network management structures such as CAnet and the regional networks. There should be only one national network initiative.

Study Approach

The study was conducted in four parts:

Participant Needs Analysis - examined international experience in research, development, and education networks; current and future applications for such a network; and the needs, concerns, and interests of potential participants.

Economic Analysis - examined the incremental costs and benefits of the proposed Network, and rationale for government sponsorship.

Technical Analysis - examined options for the logical and physical design of the proposed Network.

Implementation Analysis - examined the concerns of potential participants with respect to the different aspects of implementation to find a common basis for cooperation.

International Experience

The Canadian situation in networking was compared to the situations in the United States, Europe, and Japan. Most of the countries surveyed have networks for research and development of much higher capacity and capability than those which currently exist in Canada. These networks are seen by the governments as infrastructure vital to their national interests and so are substantially funded by the public sector.

Most of these networks were developed for increased connectivity among academic communities. Industrial use of national networks is restricted. This is changing, however, and it is anticipated that industry will become active users of the networks in the near future, particularly as governments mandate network objectives towards industrial development.

The trend is towards Open Systems Interconnection (OSI) standards. This is happening more quickly in Europe than in the United States, but the US government has specified conformance with OSI for all its purchases.

The benefits of research networks are being realized around the world. Network use, capability, and capacity are increasing at an astonishing rate.

Participant Needs

Participants were segmented as users, (for research, development and education; or for information technology development), suppliers (for information technology equipment and services; transmission services; or regional network services), and sponsors (federal or provincial governments). Over 400 individuals took part in the information gathering through expert panel sessions, in-person interviews, telephone interviews, and a questionnaire distributed over existing networks.

While each group of potential participants had their own needs, concerns, and interests, the reception for the concept of the Network was enthusiastic.

The academic community was very vocal about the necessity of such a Network to the success of their research and their continued participation in the international community of scholars. They also pointed out the substantial benefits to Canadian education.

The information technology industry was also supportive of the concept. Most Canadian companies are not able to afford their own test networks. They see the proposed Network as an excellent vehicle to determine market demand for new products, try out new technologies, and demonstrate to world markets the success and value of their products. Many companies are eager to catch the "window of opportunity" for entry into the world market for OSI conformance products. The carriers were also supportive.

The enthusiasm of companies in research areas other than information technologies was dependent on their previous exposure to network use. This is not surprising as the experience around the world has been that the benefits of networks become obvious with use and that demand grows quickly. Many companies will need to be provided with a low cost introduction to networks.

Most provincial governments realize the potential benefits of the proposed Network to their regional economies. They have indicated their support of the concept and many are already providing funding to their regional networks.

Economics

The incremental benefits of the proposed Network were compared to the incremental costs. The expected present value of network costs is $157M. Incrementality was measured against a reference case representing the evolution of Canadian networks without the proposed initiative.

As noted above, the incremental net present value, over 20 years, of the proposed Network was estimated to be between $1.1 billion and $1.9 billion (80% confidence interval).

The internal rate of return is expected to be 53%, with an 80% confidence interval from 45% to 62%. The likelihood of failing the Treasury Board guideline of a 10% rate of return is negligible.

Rationale for Government Sponsorship

There are many parallels between the historic role of the transportation infrastructure in economic development and the role of a data communications network. The introduction of a high-speed network will have the same type and size of impact on R&D productivity as improved transportation has had on productivity in manufactured goods.

However, the development of a high-speed network is unlikely without government sponsorship because of the inability of the first firm to recover the costs of "market making" - educating consumers and developing technology.

Other rationales for government sponsorship include promoting and supporting research, development, and education; encouraging rapid adoption of productivity enhancing technologies; compensating for market imperfections; and creating a market place for new products and a national showcase for Canadian technology, products and services.

Technical Analysis

The basic feasibility of establishing a coast-to-coast data network at 1.5 Mbs is not in doubt since such networks are operating in the United States today. They do not, however, meet all of the proposed Network's goals and do not fully implement international (OSI) standards.

Availability of Canadian network products which support OSI standards is a concern. At least two firms, however, will have the necessary products ready in the near future.

It is felt that the use of the proposed Network for the development of information technology equipment and services can coexist with the use of the Network to support research, development, and education without conflict if a Network Emulation Facility is provided for initial testing of products impacting the basic transmission of data.

Co-existence of the current TCP/IP networks with the proposed OSI standards will not be a problem. Communication between these, and other, standards will be possible. Users can migrate to the new standards when they see fit. The technology base for the Network, allowing connectivity between OSI and TCP domains, would reflect the predicted market demand for the next five years, and in this sense would be in advance of the current national R&D networks.

Access will be provided to users across Canada. Proposed physical architectures provide up to 32 nodes, with 1.5 Mbs rates for connections to major centres and regional networks, lower rates for links providing enhanced universal access.

Three options have been presented, with estimated costs of 50.5, 54.5 and 57.9 million dollars over a five-year period. Considering the additional cost of the third option compared with the significant increase in access provided, the third option is highly recommended.

Conclusion

The proposed Network is feasible in terms of the economic, technical, and implementation aspects. A need for the proposed Network has been expressed by industry, government, and the academic community. It is recommended that the proposed Network be implemented quickly in order to capture the maximum benefit for users in the research, development, and education communities, and to capture the "window of opportunity" for the information technology industry.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

It is becoming increasingly apparent that commerce in ideas is achieving an importance to national economies that is as significant as commerce in material goods. Because of this, access to information is taking on new value. The value, however, is constrained by the speed, accuracy, and cost at which the information can be shared.

Research, development, and education activities are dependent on the exchange of information. Universities, industry, and government are increasingly being asked to cooperate on research projects, often from locations remote from each other, in order to maximize the results from each research dollar. Industrial competitiveness is linked to the speed with which information flows because of the necessity to minimize product development and commercialization time. The information technology industry in particular requires satisfactory communications infrastructure and an environment which supports the development and testing of products.

For these reasons, a national communications network for research, development, and education is considered by many to be strategically important to our country's economic future. There are two goals: 1) to electronically connect every researcher to information databases, special equipment, computing resources, and other researchers, both nationally and internationally; and 2) to provide an environment for the development of state-of-the-art communications equipment and services. The benefits of such a network would include the following:

- Improved international competitiveness in technology based industries because of better access to information,
- Stronger information technology industry because of new opportunities to develop and test products,
- Improved quality and productivity of research by promoting communication and collaboration among researchers,
- Shortened time for dissemination of information between research organizations and industry, and therefore the time to introduction of products into the economy,
- More efficient use of scarce resources by sharing them among geographically dispersed organizations,
- Improved opportunities for organizations which are small or geographically remote to participate in research and development, and
- A more highly skilled population due to an improved educational system.

Today, networking in Canada supports the basic ability to communicate with sites around the world, but lacks the higher level capabilities that are needed to satisfy the needs of the research, development and education communities, and the information technology industry. Existing networks not only lag well behind the growing needs of the research community for access and capacity, they are too fragmented to develop unaided into a single, coherent system. They also do not provide a capability for companies to test network equipment and services under real operating conditions.

1.2 STUDY OBJECTIVES

HICKLING was asked by Industry, Science and Technology Canada (ISTC) to investigate the feasibility of establishing a National High-Speed Communications Network for the Canadian research, development, and education community (referred to in this report as "the Network"). The Network would have greater capacity and functionality than existing networks for research, development, and education, and in addition, provide an environment for the development and demonstration of new information technology equipment and services using the new international standards (OSI). Secondary objectives of the study were to examine the utility of the Network as a means of enhancing collaborative research and as a means of promoting a more internationally competitive information technology sector.

Determining the feasibility of such a network implies the evaluation of three aspects:

Technical Feasibility Can the needs of the users be met with the technology and infrastructure which exists, or can reasonably expected to be developed?

Economic Feasibility Will the benefits (tangible and intangible) to each of the participants in the network (users, suppliers, and sponsors) exceed their costs?

Implementation Feasibility Can the funding, management, construction, and operation of the network be successfully arranged among participants?

1.3 APPROACH

The study was conducted in the following four parts:

Participant Needs Analysis

First, the experience of Canada, the United States, Europe and Japan in creating and operating research, development, and education networks were reviewed. Then, current and future applications of high speed networks were examined. Finally, organizations which are potential participants in the network as users, suppliers, or sponsors were consulted regarding their needs, concerns, and interests.

Economic Analysis

The cost of the Network was compared to the benefits to be obtained from the Network due to increased productivity resulting from improvements in collaborative R&D and the opportunity to develop advanced Information Technologies. Costs and benefits were incremental to the base case of a lower speed network. Finally, the economic rationales for government sponsorship were examined.

Technical Analysis

The evolution of required network capabilities was examined based on current and future network applications and participant needs and concerns. Based on these required capabilities, a number of options for the logical and physical design of the network were developed.

Implementation Analysis

Factors influencing implementation were examined in light of the needs of potential participants. They include mission, objectives, access, use, services, management structure, and evolution from existing networks. Telecommunication regulations, which influence the design, implementation and cost of the network, were also considered.

2. PARTICIPANT NEEDS ANALYSIS

2.1 OBJECTIVES

The Network must be designed, operated, and managed to satisfy, to the greatest extent possible, the needs of the Network participants. In order to assess those needs, three steps were taken. First, a review was made of network experience in Canada, the United States, Europe, and Japan. Second, current and future network applications were examined and classified. Third, potential network participants were asked about their needs, concerns, and interests regarding the network. Details of the Participants Needs Analysis can be found in Volume A of this study.

2.2 APPROACH

2.2.1 Participant Segmentation

The Study team interpreted the term "participant" in its broadest sense, classifying potential participants as either network users, suppliers, or sponsors. An organization may belong to more than one group. This classification scheme is described below.

Network Users

1. **Research, Development and Education Users (R&D Users).** R&D Users are defined as organizations doing research and development or education in areas other than IT, such as medicine, chemistry, physics, etc. These users may be located at universities, provincial or federal research organizations or in private industry. They may be doing individual research or be affiliated with a research consortium. Small users are also included in this subgroup, and include organizations who traditionally have not been able to afford access to the regional R&D networks.

2. **Information Technology Users (IT Users).** IT Users are defined as researchers in areas related to information technology. These users could be located at universities, publicly funded telecommunication research centres, or may be private-sector companies engaged in IT research. This subgroup also explicitly accounts for small IT companies who traditionally have not been able to afford their own test networks or access to the regional networks.

Network Suppliers

3. **Information Technology Suppliers (IT Suppliers).** IT suppliers include organizations that provide IT based equipment (routers, user interfaces) or services (access to specialized databases, or journals etc.) to the Network, excluding the Carriers. Often, an organization will be both an IT user and an IT supplier.

4. **Common Carriers (Carriers).** Carriers are defined as regulated common carriers capable of providing communications service or facilities (link channel capacity) to the Network on a national scale. Carriers include the Telecom Canada member companies and CN/CP. Value added resellers are not included in this category but are identified in the IT supplier group above.

5. **Existing R&D Networks (R&D Networks).** Existing R&D networks include the academic networks currently operating in Canada. These networks have organizational structures for purposes of policy, management and operation. They have their own objectives and needs which must be addressed and which in some cases are over and above the needs of their users.

Network Sponsors

6. **Provincial Governments.** Every Province and Territory in Canada would be invited and encouraged to access this network. For the moment, regional networks are defined geographically by provincial boundaries, and thus the needs of the Province are closely aligned with the needs of the regional networks. Many provinces have not yet established a regional network.

7. **Federal Government.** The benefits of the network contribute to the objectives of a number of federal government departments. Areas of benefit include industrial competitiveness, education, research, regional development, and national unity.

In addition to the classification described above, there are additional dimensions by sector (government, industry, academic) and by region (each province and territory). Figure 1 provides a summary of all the different dimensions of the participants in this network.

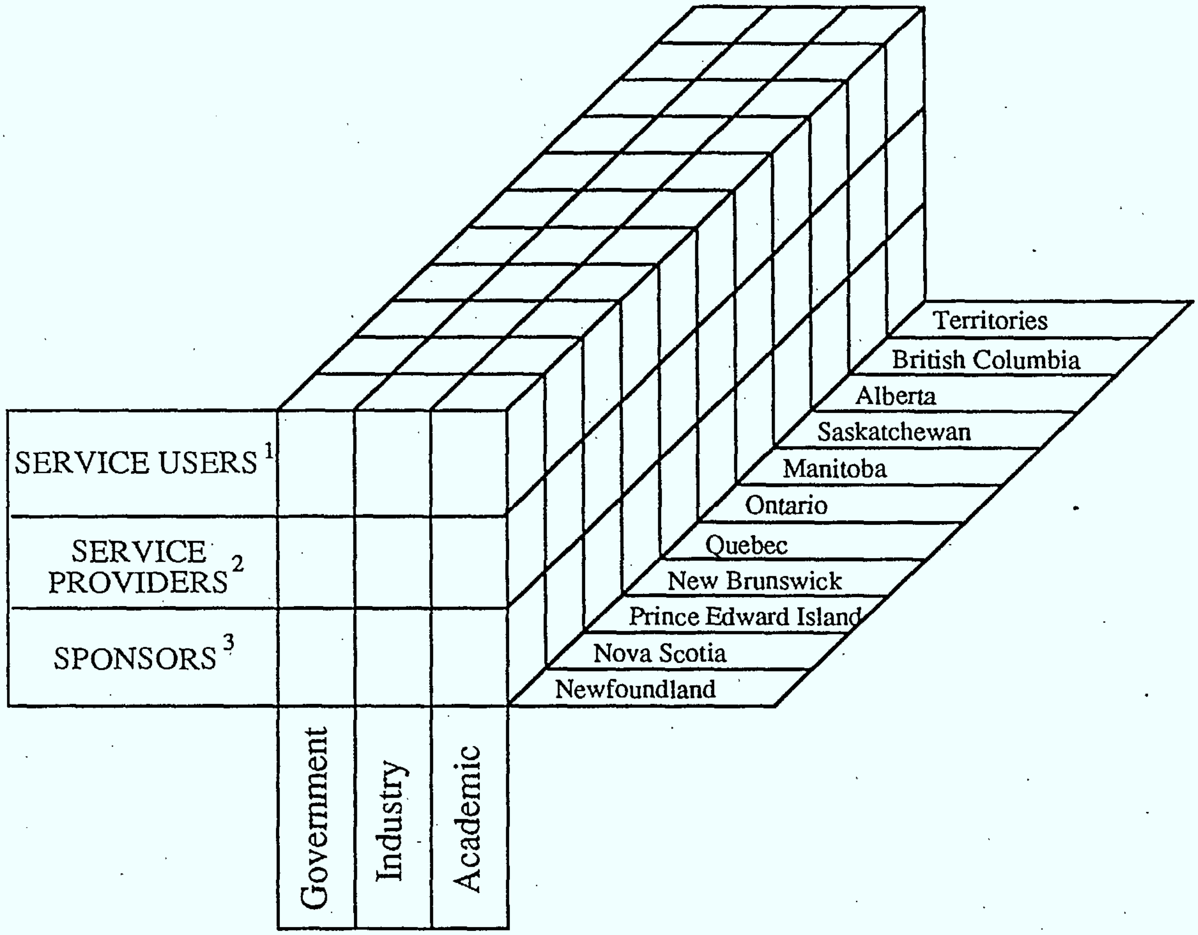
2.2.2 Information Gathering Instruments

Four main instruments were used by the study team to identify potential participants and obtain information on their needs and objectives:

- Expert Panel Sessions;
- In-person interviews;
- A network questionnaire distributed via Netnorth and CDNnet; and
- Telephone Interviews.

Every effort was made to contact as many potential participants as possible. In fact, the project team received direct input from more than 400 individuals who took part in one of the four survey instruments. The project team has discussed this network initiative with government officials in every province and territory in Canada, and also with federal government representatives.

Figure 1 Network Participants Segmentation



Notes:

[1] Service Users include R&D Users and IT Users
[2] Service Providers include IT Suppliers, Carriers and Regional Networks
[3] Sponsors include Federal and Provincial Governments

A brief description of each instrument is provided below:

Expert Panel Sessions

The expert panel sessions were organized as informal round-table discussions, designed to collect information from the large base of potential participants in the Network. Each of the four sessions, two in Ottawa and one in both Montreal and Vancouver, had its own regional flavour and was very useful in developing a clearer understanding of the wide ranging needs, interests and concerns of potential participants.

At each session, representatives from the regional network, local universities, local research centres, local information technology companies and the CAnet advisory board were in attendance, and participated actively in the discussion period. In addition, at some of the sessions representatives from NSERC, Centres of Excellence and the Science Council were in attendance as observers.

These sessions provided excellent background information for subsequent in-person interviews and the information gained through exchanges among panelists was helpful in classifying the issues to be addressed by the study team.

In-Person Interviews

More detailed information was collected through in-person interviews with provincial governments, Information Technology companies, carriers, research organizations, designated Centres of Excellence, and universities. These visits provided an excellent opportunity to acquire a more thorough understanding of the needs of each of the players, and provided insight into their willingness to contribute to this venture.

Officials within all ten provinces, and both territories were contacted. Also, 28 companies were interviewed on-site, across Canada. Over 50% of these interviews were carried out in Ontario, as the majority of IT companies and major carriers are located in the Toronto and Ottawa areas. Approximately 20% were carried out in Quebec, and 10% in British Columbia. The remainder of the interviews took place in Alberta, Saskatchewan, Manitoba and Nova Scotia.

Network Questionnaire

A questionnaire was distributed through Netnorth and CDNnet to receive feedback from Canadian researchers who currently use the research networks available in Canada. Survey respondents provided an indication of the applications which they require (which they may or may not have access to at the present time), their requirement for a more capable network, and the general benefits of a high-speed communications network.

Over 200 respondents completed the questionnaire. The profile of these respondents includes 60% from university professors, 18% from publicly funded research laboratories (primarily NRC), 13% from graduate students, 8% from network managers at universities, and 1% from private sector companies engaged in R&D. These numbers indicate the current participation by the different user groups on Canadian networks.

Telephone Interviews

As small IT companies were not polled by the expert panel sessions, the in-person interviews, or the network survey, it was judged that additional phone interviews were required to adequately cover this user group.

Over 70 organizations, with representation from every province, were asked to answer a short questionnaire regarding this study. Approximately 32 organizations participated, a response rate of about 45%.

2.3. NETWORK APPLICATIONS

Current applications available on networks, and the extent with which they fulfil needs, determine the amount of participation by network users. Also, future applications for the Network must be anticipated so that the evolution of the network can be properly planned. In fact, it is anticipated that the network will serve as a vehicle for the development and testing of future information technology products and services.

The following sections describe some generic network applications categorized according to the needs which they fulfil:

Supporting Communications Between Researchers

Asynchronous messaging covers the familiar electronic mail systems now commonly used. The domain also includes more sophisticated versions of electronic mail, including multi-media, semi-structured, and semi-formal mail systems.

Bulletin boards and asynchronous conferencing are systems that allow people to interact with a large community by posting and viewing messages, and joining and actively participating in on-going discussions of some topic of interest.

Real-time remote conferencing permits formal or semi-formal meetings among geographically distributed people. Techniques for transmitting a sense of participatory presence and for sharing data over distances are necessary for remote conferencing to be successful.

Casual real-time interaction is a crucial, yet often overlooked component of scientific collaboration. While formal meetings take care of key events in the scientific process, casual interaction at the interpersonal level is the glue that keeps collaboration working. Several innovative systems are being experimented with that bring people together electronically in frequent, informal, unplanned, high quality interactions.

Accessing Remote Equipment

The access, monitoring and operation of remote equipment has two aspects: access to remote computational power (such as super computers), and real-time systems for remote operation (such as tele-robotics).

Storing and Retrieving Information

The concept of the digital library includes conventional approaches such as the electronic repository and bibliographic databases, as well as sophisticated uses of hyper-text. All information sources are covered, not just those found in traditional libraries. The digital library is the backbone behind the communal knowledge base.

Development of Information Technology Products

Development is used here in its broadest sense. It includes the evaluation of market requirements and the assessment of market acceptance, as well as the operational test of hardware and software.

2.4 INTERNATIONAL SITUATION

This section draws some general conclusions regarding how Canadian research networks compare to research networks in other countries. These networks are compared in terms of protocol development, performance, network applications, access and use, and funding.

Protocol Development

Canadian networks are generally based on American equipment and thus use communications protocols developed for use on these computers, such as DECNET, NJE, and TCP/IP. However, Canada, through UBC and CDNnet, has been in the forefront of software development such as the EAN implementation of X.400 mail specification (ISO/OSI standard), which is also used in the European EAN network. Major efforts are underway in Europe, mostly with government support, to complete and test a full set of ISO/OSI specification software covering all network services (mail, news, directory, remote job entry, remote login, etc.) in preparation for an international migration of network protocol to the OSI standard. Although the U.S. has formally recognized its commitment to moving towards the OSI standard, the TCP/IP standard is so deeply entrenched that it is generally accepted that the U.S. will migrate to OSI at a slower rate than the rest of the world.

Network Performance

The existing national networks in Canada (Netnorth and CDNnet) are considerably slower than existing networks in the U.S. (NSFNET), U.K (JANET), Germany (DFN) and Japan (NACSIS). In all of these countries, with the exception of Canada, T1 backbone links exist or are being implemented. The U.S. is also considering an upgrade of the existing NSFNET backbone to T3 speeds.

Network Applications

Use of network services does not differ greatly in North America and Europe. The most popular services are mail and news, followed by file transfer, remote login, and remote job entry where these services are offered.

Japan's R&D networks are more oriented towards public access to information databases and news than networks in other countries. The major purpose of the NACSIS system is fast, local access to one of the largest databases of scientific and technical information in the world; electronic mail and other networking services are provided but assume less importance in the system design. In order to offer an online information retrieval service and catalog information service to researchers at universities, a high performance computer system is installed to meet the needs of large-scale database services.

Test Beds

The major purpose of ARISTOTE, a French national R&D network is to act as a testbed for French research institutions to develop networking technology.

The Sigma Network in Japan is a research and development testbed network designed for use in the Sigma Project, which is intended to promote increases in software productivity by producing a standard work station environment for use in Japan.

An important component of NSFNET (and ARPANET to a certain extent) is research into network design and performance. An independent research network is being used to develop and test new technology for the backbone, to provide a facility for the anticipated migration of OSI protocols in the coming years, and for the development of gigabit technology. The testing of products and services does not in any way affect the performance or reliability of the operational network -- the two are kept separate.

The JUNET system is intended as a testbed for networking development rather than an R&D production network.

Access and Use

The participation of industrial companies in R&D networks in all countries appears to be minimal. Many networks specifically exclude corporate or profit-oriented organizations from membership or connection. In the U.S., commercial, for-profit use of research networks is currently not acceptable, although this is expected to change. In Canada, use of research networks by commercial for-profit enterprises is not generally forbidden, but they are usually assessed a higher membership fee (which acts as a barrier for small companies), and the participation rate by industry in Canadian networks is also quite low. Some European networks have commercial enterprises as members; especially those that are funded by membership fees. In Japan, the NACSIS/N1net network currently does not have direct connections to commercial organizations. However, there are 176 companies participating in HEPnet.

Funding

The importance placed on networking by governments in each country is reflected by the way national networks are funded. Here, Canada is an exception: for the most part, Canadian networks have been funded by member organizations. While most of these member organizations are universities and therefore government-funded, the money they spend on network membership usually comes from general research or computer centre budgets. In the U.S., the government has funded capital expenditures for most national networks, and provides initial capital and partial funding to mid-level networks (equivalent to Canadian provincial networks). The majority of national networks in Europe are directly funded by the national government concerned, and continental network research is funded by the European Community. The Japanese government has completely financed the NACSIS network and database development. These governments view networks as a necessary infrastructure.

Future Plans

In virtually all the countries reviewed, there are active plans for enhancing, expanding, and/or unifying their R&D networks and hence the efforts towards establishing international standards. Governments are becoming the driving force behind network development. The political organization of networks along national lines will become more pronounced, as national governments take on more of the funding, operating, and policy responsibility.

Canada: In Canada, the National Research Council is supporting the implementation of the CAnet national backbone system. As part of this implementation, plans have been made to develop or enhance regional networks in all provinces of Canada. every province will have the capability to connect a regional network to CAnet according to the schedule in the CAnet business plan. Except for some links within BCnet, none of the regional networks currently operate at T1 speeds.

Funding to operate CAnet has been identified by the regional networks and NRC, with additional resources to be supplied by the University of Toronto (the CAnet operator) and IBM (supplier of routers for NSFnet and CAnet). Network implementation is scheduled for the summer of 1990, with self-sufficiency occurring after three years.

The CAnet routers will be initially capable of operating at T1 speeds, and further upgraded to a new version which will support T3 speeds next year. However, the regional networks, which will pay full CAnet costs in three years, have insufficient resources to pay for upgrading the communication links to T1 speeds. While there is significant support for T1 speeds at the outset, the cost of the Canadian T1 service is currently about 8 times that of comparable service in the U.S. Recent tariff filings, if approved, will reduce Canadian rates to about half of the current rates.

United States: There is general consensus in the U.S for the establishment of a National Research and Educational Network (NREN), with NSF as its lead agency. This stems from the existing U.S. Internet being far from uniform in the type and quality of service. It also does not yet reach the entire research community. Agencies like DoD, DoE, NASA and NSF have created their own networks (or in some cases several networks) to support individual missions, the results being some interconnectability problems. Users may have five or six identification numbers which creates addressing problems for electronic mail. The traffic on NSFNET and other research networks in the Internet is primarily electronic mail. Real time connections to advanced computers are frustrating because of delays and unexpected disconnects. Breakthroughs in enhancing service requirements depend on cross-disciplinary research and, therefore, the need for one cohesive national network.

A three phase plan exists to build the NREN:

Phase 1: Is complete and involved the NSFNET backbone being upgraded to T1.

Phase 2: Is currently underway and involves upgrading the service provided to about 200 research institutions using a shared backbone with T3 (45 Mbs) capacity.

Phase 3: Will provide one to three gigabit per second networking services to selected research facilities and 45 Mbs networking to 1000 sites. Deployment is not expected until middle to late 1990's. Research in gigabit technology is currently underway. Several key development areas include (1) switching systems for ultra-high speed communications links; (2) network to computer interfaces making it possible to exchange data in multiple formats and media at high speeds; (3) software programs to manage the network; (4) telecommunication links to support the network.

As NREN evolves from NSFNET, a three level hierarchy will be maintained:

- Level 1: Campus or research organization;
- Level 2: Mid-level network or regional network (defined on a regional basis or discipline basis) linking individual sites; and
- Level 3: The backbone itself which would physically link the different regional networks.

There is a general commitment in the U.S. to move to ISO-OSI as soon as possible. DEC and IBM have announced to their international clients and the U.S. government that they fully intend to implement OSI by this fall. A transport layer of OSI running with TCP/IP already exists. Most of the experts in this field have indicated that interoperability between TCP/IP and OSI is not an area of concern .

Universality of access is also a feature of NREN. It is anticipated that the NREN will give researchers, students and colleges of all sizes, as well as large and small companies in every state, access to the same high performance computing tools, data banks, supercomputers, libraries, specialized research facilities and educational technologies.

Europe: A report submitted in Spring 1989 to the European Economic Commission by RARE, the European body for coordinating national academic networks, has proposed a European High-Speed Networking Initiative, to consist of a central backbone called VENUS, regional networks, and supporting networks for specific disciplines. Plans call for 20 to 40 nodes across Europe, serving from 200 to 500 sites. A phased improvement in network speeds is considered, with 2 Mbs immediately, 100 Mbs in a few years time, and gigabit speeds by the end of the century. Initial costs were stated as $6 Million annually in the near future, rising to $24 - $30 Million later.

In West Germany, a national fibre optic network is being installed by the Deutsche Bundespost. This "Forerunner" network, with capacities up to 140 Mbs, is intended for video teleconferencing and other high-bandwidth requirements, and will be available for scientific networking including graphics transmission and access to supercomputers. At the Regional Computing Centre of Stuttgart University, applications are being developed and installed to make use of this capacity. Two projects are in progress to connect research centres located 1000 km and 150 km from Stuttgart with the Cray 2 supercomputer there at speeds of 100 Mbs. Several years will be required to reach this speed, and costs of the high-speed link must still be negotiated with the PTT, which is in the midst of deregulation.

The campus of Cambridge University is spread over relatively long distances within the city of Cambridge, U.K. A new network using about 200 kilometres of optical cable has recently been completed to connect existing local networks. Both the local networks and the connecting network use a design called the Cambridge Fast Ring, which permits relatively cheap hardware and low complexity. The new network, built with support from Olivetti Corp., has potential speeds in the Gigabit range and has been tested at 600 Mbs.

An organization has been set up by the Italian Ministry of Scientific Research and Technology to develop a high-speed national backbone connecting all research institutes and universities in Italy. This organization is called "Gruppo Armonizziazione delle Reti per la Ricercha (GARR)". The system will use 2 Mbs leased lines and offer four protocols: X.25, TCP/IP, DECNET, and SNA. Migration to full ISO/OSI protocols will be undertaken as soon as feasible. The backbone will also have a high-speed link to CERN, the European high-energy physics centre located near Geneva.

The network will be financed by the Ministry of Scientific Research and Technology at a estimated rate of 9.7 Million ECU/year (about $14 Million), with half to pay for leased lines and the remainder for control units and software.

Japan: The Science Information Network (also referred to as NACSIS) appears to be the unifying force to realize a single network that serves the R&D interests of Japan.

2.5 SUMMARY OF PARTICIPANT NEEDS

This section presents a summary of the current needs of all the Network participants, and represents an amalgamation of all the information collected by the four different collection methodologies identified above.

The current needs of each user group has an impact on the technical design and/or implementation of the Network. As a result, user needs are categorized under these two broad headings (see below). The reader should be aware that **this section is a summary of the opinions of each network participant, and these opinions may or may not coincide with the recommendations of the project team.**

Table 1 provides a summary of the needs and concerns of each of the different participants.

2.5.1 Participant Technical Design Comments

- The Network should **connect** all researchers and students across Canada independent of affiliation, location, size and research discipline. International connectivity to the U.S. Internet, as well as to networks in Europe and Asia are extremely important and must continue to exist. Users of existing or planned networks must be able to migrate to this network **without any loss of service**. For the moment, connectivity in Canada and the U.S., can be attained by being able to interoperate with users using **TCP/IP protocols**;

- The Network should be **highly reliable** in terms of network availability and in the services it provides. Consideration should be given to **gradually introducing upgrades** to ensure network reliability;

- The Network should provide **basic services** consisting of directory and routing service, electronic mail, bulletin boards, file transfer, remote login, basic security, user support and network news. The Network should also be capable of providing **enhanced value-added services,** including library services for bibliographic searches, document retrieval, and enhanced security service for those who need further assurances of the integrity of their data.

- The Network should be a state-of-the-art **high capacity** environment (T1) which supports a wide range of users and network services. For IT users, the network must always be at least one step ahead of commercial offerings to support the development of **future services**;

- The network should support a **multi-media environment** of **voice, data, text and image** (including video). Requirements associated with real time applications such as video and voice were mainly mentioned by users with a related IT research interest. Full motion video applications were not seen as a short term requirement, although most R&D Users saw a migration to video applications, such as video conferencing and education, in the near future;

- The Network should provide **standardized, transparent and easy to use network to computer interfaces** which eliminate all unnecessary and intimidating procedural steps;

- The Network should accommodate smaller users by providing **low cost access options** such as dial-up access;

Table 1 The Needs of Network Participants

CONCERNS	SERVICE USERS		SERVICE PROVIDERS			SPONSORS	
	R&D USERS	IT USERS	IT SUPPLIERS	REGIONALS	CARRIERS	PROVINCIAL GOV'T	FEDERAL GOV'T (ISTC)
TECHNICAL	1. Connectivity to Regional, National and International Networks 2. Reliability 3. Access to basic services 4. Access to advanced services 5. High capacity 6. Capable of multi-media 7. User Friendly 8. Low cost access alternatives must be made available	1. Access to different levels of the network 2. High capacity (T1 as a minimum) 3. Access to real world Beta test 4. Access to all transmission media 5. Network intelligence contained on the edges of network 6. Migration to ISO 7. Smooth technology migration to T3 and higher speeds 8. Multi mode/media 9. Connectivity 10. Security 11. Low cost access	1. Open to multiple vendors 2. Beta Test site 3. State of the art equipment & services 4. Open to third party Value-Added vendors (database)	1. Inter-operability with other regional, national and international networks 2. Coexistence of TCP/IP & OSI 3. Only one sub-network for a region	1. Use existing transmission services 2. Network must consist of all types of transmission media 3. Network must interface with carrier offerings (eg. ISDN)	1. Regional Networks must continue to exist.	1. Support ISO/OSI standards 2. Trans-Canada end-to-end digital connectivity 3. Minimum technical capacity of 1.5 Mbs 4. State of the art protection and network management features 5. Offer test facilities
IMPLEMENTATION	1. Elimination of Duplication /Single initiative /Single management structure 2. T1 Tariff Rates must be reduced 3. Distance independent fees Fixed - academic Variable - industry 4. Basic services included in user fees 5. Advanced services paid in addition to basic fee 7. Representation on board 8. Access to network permitted for non-commercial purposes based on honor system 9. Consistency with international use policies	1. Clearly defined mission statement 2. Elimination of Duplication /Single initiative /Single management structure 3. Must be implemented quickly 4. OSI conformance testing through accredited organizations (eg. CIGOS) 5. Preference for usage based fees 6. Willingness to pay preference for contributions in kind 7. Full-time business-like management required 8. Propriatory interests must be minimized 9. Access to network permitted for non-commercial purposes	1. Market development is the objective 2. Discounts on Services & Equipment for Marketing purposes 3. Interested in network management 4. Tax credits for contributions/R&D	1. Must be joint participants in management of backbone network 2. Must recognize and take advantage of experience and expertise of existing regionals 3. Predatory networks must be addressed 4. Back door connections must be minimized 5. Must meet needs of current client base. 6. Formal marketing and management structures must exist 7. Direct connectionsto backbone must be minimized 8. User fees fixed for a level of service	1. Market development is the objective for participation 2. Would give consideration for reduced tariff rates 3. Re-selling is a concern 4. No commercial bypass (policed by honor system) 5. Voice may cause regulatory problems 6. Interested in network management 7. Desire formal recognition of contribution (reflected in rate structure)	1. Elimination of Duplication /Single initiative /Single management structure 2. Build on CAnet, etc. 3. Accomodate the different states and needs of provinces 4. Regional Development 5. Want representation 6. Health & Education Sectors represent large beneficiaries.	1. Maximized use of Canadian Technology 2. Use of existing transmission facilities 3. Connectivity to Regional, National, International networks 4. Self supporting after 5 years 5. Work jointly with Regional Networks 6. Network will not be free (equity required from all participants)

- The Network should provide access to the various levels of the Network itself **facilitating** the development and testing of new products (OSI conformance, high speed protocol development, error correction and avoidance protocols) and new services (value-added database service, OSI conformance centre);

- The Network should be allowed to be used as a **beta test site**, which goes beyond the testing that can be done in a laboratory experiment;

- The Network should use **all transmission media** (fibre-optic, microwave and satellite facilities); the media should coexist and interoperate with no implied hierarchy;

- The **network intelligence** should reside on the periphery of the network (ie. end systems), not be imbedded in the switches and routers on the network. However the Network must be intelligent enough to manage itself;

- The Network should provide a **migration path** to ISO/OSI;

- The Network should make available state-of-the-art **security and access control**;

- The network architecture should be **open** to multiple vendors;

- The Network should lease **existing transmission facilities**, to the extent possible;

- The Network should be **capable of interfacing** with public carrier offerings, both current and future, such as the **evolving ISDN service** offerings. The network should be in line with the strategic direction of the carriers;

- There should be only **one subnetwork** for each geographic region. A "region" may be defined as either a province, an area within a province, or a group of provinces. The concern here is that **"predatory networks"**, may emerge in the more highly populated areas, and undercut the existing regional networks and attract traffic away from the existing networks.

2.5.2 Participant Implementation Comments

- The national networking initiatives must **eliminate duplication** of effort and funding. Only one national research network should physically exist, sponsored by one leading agency. The ISTC network must build on and extend the CAnet, CDNnet and Netnorth initiatives to ensure that a network is put into place that provides the highest level of service to the highest number of users, at reasonable cost. Users want to pay **one connection fee**, and have access to a wide assortment of services;

- User fees should be **distance independent**. Users are willing to pay more for higher connection speeds but are not willing to pay more to send data further. It was also felt that user fees should be **fixed** for a given level of service (scaled fee based on speed of connection). For example the fee for dial-up service would be less than high speed access. In addition the fixed fee is attractive from a budgeting perspective. The rate structure should also **not increase dramatically** from year to year.

- The existing tariff rates for T1 service pose a barrier for organizations to connect to the Network. Unless rates come down significantly, ongoing **government assistance** will be required in order to provide affordable access to all participants;

- The costs to provide **basic services** should be included in the user fees. Special **value-added services** should not be embedded in fees, but made available at additional cost;

- Users want **representation** on the Network board of directors. This elected representative would protect the interests of his constituency and also keep the users informed of future directions and services provided by the Network;

- Traffic on the Network should be **non-commercial**, and the definition of acceptable usage has to be clearly conveyed. Access and use of the Network should be based on the honour system, due to the difficulty in policing the transmission of packets. This network must interoperate with other international networks (Internet in the U.S.), therefore some consideration must be given **to ensure consistency** in the acceptable use definitions, between these networks.

- The Network must be **implemented quickly** (by early 1991). There is a window of opportunity to sell OSI-based products to the U.S. and Europe. If the implementation of this Networks drags on, this window may be lost;

- The creation of a **certified OSI conformance test centre** (possibly spearheaded by CIGOS) on the Network may provide the incentive and the knowledge base required for companies to develop OSI compatible hardware and software;

- The Network must be **managed** by a full-time, professional organization or association. The technical centre must be open 24 hours a day, seven days a week. The network manager must be selected so as to **minimize proprietary interests** which might conflict with, or bias participation by the fullest spectrum of Canada's information technology industry;

- The formation of **a broad-based user community** must happen quickly in order to attract developers of value-added services.

- Although the acceleration of this network is outside the **timing** of the plans of carriers to provide these services, they view the concept positively as it may bring them differentiation with respect to commercial offerings (video conferencing) and an opportunity to **develop new markets**;

- The Network should not carry **commercial bypass** traffic. The carriers are comfortable with the honour system being used to limit the commercial traffic on this network;

- **Formal recognition,** from the CRTC, of any carrier contribution (contributions must be reflected in tariffs);

- The needs of the **current client base,** predominately R&D users in the academic sector, must be met;

- The regional networks should be **joint participants** in the management of the national network;

- The current body of technical and management experience attained by regional network managers should be **incorporated** into an implementation plan for this network.

- **Full-time** network manager(s), and **formalized marketing and management structures** must be put into place at the regional and at the backbone network levels. Some regional networks already have these formal structures in place, whereas other networks are more informal in their management approach.

- Users should be dissuaded from **directly connecting to the backbone**, instead of connecting to the backbone via the regional network. Direct connections to the backbone would deny regional networks from collecting revenue from large users, which could jeopardize their operation.

- **Back-door connections** should be minimized, and access to the Network must be handled formally.

3. ECONOMIC ANALYSIS

3.1 OBJECTIVES

To assess the economic worth of a Canadian high-speed communications network for research and development, two questions must be answered:

1. **Are the incremental benefits of the Network greater than the incremental costs?**

   The incremental benefits and costs must be identified and given a dollar value. Incremental benefits should exceed incremental costs if the proposal is to be accepted. Incrementality is measured against a reference case representing the future if the Network is not created.

2. **Is there a rationale for government sponsorship?**

   If net benefits are positive, are there reasons why the private sector would not undertake timely provision of the network without government sponsorship?

3.2 APPROACH

Hickling's review of high speed networks in other countries revealed that no other country has attempted to establish the potential net benefits of a high speed research network. Those networks which have been implemented in the United States, Japan, and Europe, have gone ahead on a strategic basis without a quantitative assessment of benefits and costs.

The measurements of benefits and costs within this study follow the standard methodologies of benefit/cost studies. The methodologies employed conform to the standards of the Government of Canada's Benefit-Cost Analysis Guide, published by the planning branch of Treasury Board.

Details of the Economic Analysis can be found in Volume B of this study.

3.2.1 Classifying Benefits

Two types of benefits are expected from the Network; the significant enhancement of productivity by R&D workers, and the creation of industrial opportunities for the Canadian Information Technology (IT) industry.

The network will increase the productivity of R&D workers by:

- Enabling R&D workers to access specialized research facilities, such as super-computers, from remote locations.
- Permitting greater and more efficient collaboration between R&D workers.
- Providing access to and stimulating the creation of a variety of data-base, research, and other services.

Industrial opportunities will be created for the Canadian IT industry by:

- Facilitating the development of next-generation information products based on international standards for global markets.
- Providing a test-bed for equipment used to support the network.
- Providing an environment for developing and test-marketing services designed to support R&D.
- Providing an opportunity to familiarize a broad international user-base with Canadian IT products.

3.2.2 Reference Case

The benefits and the costs of the ISTC Network were measured against a reference case to assess incrementality. The reference case was modeled after CAnet, a network currently being considered for funding by the National Research Council. The ISTC Network has higher speed, a broader mandate, and higher cost than CAnet.

It should be noted that the relative evaluation of the reference case is based on the study team's own assessment of the benefits of a hypothetical lower speed network, and does not necessarily reflect the opinions, plans or intentions of CAnet sponsors.

To assess whether the additional benefits of the ISTC Network are worth the additional costs, the same benefit/cost estimation model was applied to the two network concepts, with the following differences in input values:

- **No IT benefits.** The reference case is assumed to have no IT development benefits. As currently proposed, the reference case does not include a mandate for this objective. In addition, it reflects neither the speed nor the standards required to develop emerging technologies.
- **Later start date for some R&D User applications.** The start date when some network services (e.g. video conferencing) for R&D Users are available through the reference case is assumed to be later than through the ISTC Network. Depending on the application, this may be due to the reference

case achieving the required network speed at a later date, or to less staff time available to promote the introduction of new applications.

- **Later maturity date for some R&D User applications.** The date when applications can be expected to achieve their mature form (and consequent mature productivity impact) is later for the same reason as the later start dates.

- **Lower participation.** The proportion of R&D expenditure represented by subscribers is expected to be lower under the reference case. Private sector participation is expected to be substantially lower because of the lower speed, academic focus, and likely pricing structures of the reference case. Government and institutional participation is expected to be somewhat lower with the lower speed and the loss of interaction with the private sector.

- **Lower costs.** The costs of the reference case are expected to be significantly lower than the ISTC Network. Higher network speeds plus staff time for ensuring an accessible system with a good menu of applications are the principle reasons for the ISTC Network being more expensive.

It is expected that the reference case will ultimately offer the same applications with the same productivity impacts at maturity to R&D Users. The increased benefit from ISTC Network is to have these applications:

- introduced sooner
- reach maturity sooner
- apply to a wider user-base, particularly in the private sector

These benefits are combined with the IT development benefits available only to the ISTC Network to establish total incremental benefits of the ISTC Network. These benefits are then compared to the additional cost.

The impacts of many benefits of the ISTC network could not be captured accurately in the cost/benefit model and have been omitted. For example, the definition of R&D expenditures used in the model excluded areas such as education, the social sciences, and the humanities, as well as some minor technical applications. Therefore, the net benefit estimates by the model are conservative.

If incremental benefits exceed incremental costs, then the additional expenditure required by the ISTC Network over a lower speed network alternative is considered worthwhile.

3.2.3 Assessment of Uncertainty

A significant drawback with many benefit/cost studies is that they do not provide a quantitative assessment of the degree of uncertainty associated with their estimates. At best, high and low estimates are provided. Unfortunately, high and low estimates are dependant on the joint assumption that every key factor turns out either poorly, or favourably. Either case is extremely unlikely.

HICKLING has applied a method of quantifying uncertainty called RAP (Risk Analysis Process) in the economic analysis of the Network. It produces expected values and surrounding confidence intervals for economic estimates. The information that it incorporates includes both available statistical data, and the knowledge and experience of those most familiar with the problem at hand.

Each variable of importance to the analysis of a given problem is assigned a probability distribution, reflecting the underlying uncertainty. These estimates are then combined to provide an estimate of the probability that the output variables of interest vary from their expected value.

3.2.4 Analysis

The economic analysis involved three steps:

1. **Development of the structure and logic models.** This step establishes the methodologies and ascertains which variables and assumptions must be considered in the decision problem.

2. **Development of initial parameter values and ranges.** In this step, estimates and ranges are developed for each variable and assumption identified in Step 1. These estimates are based on the consulting team's statistical analysis of actual data and expert judgement drawn from experience in the field. The experts are best qualified to provide quantitative and qualitative information necessary to complete the analysis. Their experience, training, "street-wise" judgement and knowledge of relevant facts and issues provide a database and analytical process which would be impossible to model.

3. **Simulation.** Once the experts have completed their work, the ranges for each assumption are transformed into input probability distributions. And once final distributions are generated for all assumptions and variables, they are combined using probability theory to yield a probability distribution for each output variable of interest. This step involves a statistical technique called Monte Carlo Simulation.

3.3 RESULTS

3.3.1 Incremental Benefit

Figure 2 shows the incremental Net Present Value obtained by subtracting the benefits and costs of the low speed network represented by the reference case. The expected NPV is $1.5 billion, with an 80% confidence interval from $1.1 billion to $1.9 billion.

Figure 3 shows that the Internal Rate of Return on the additional investment in the ISTC Network is expected to be 53%. The 80% confidence interval is a rate of return of between 45% and 62%. (Note that the scale in the figure is percentage/10.)

Figure 2 Incremental Net Present Value

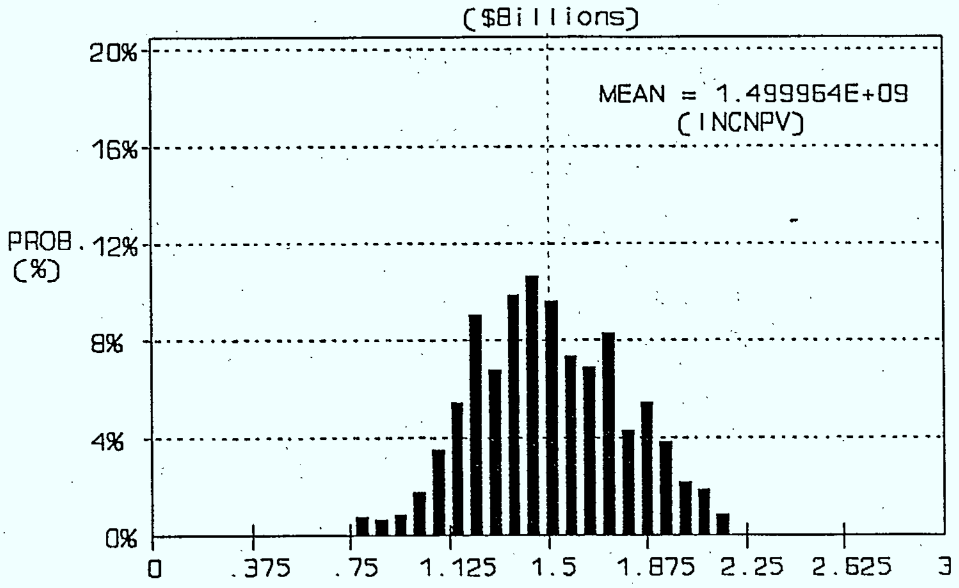
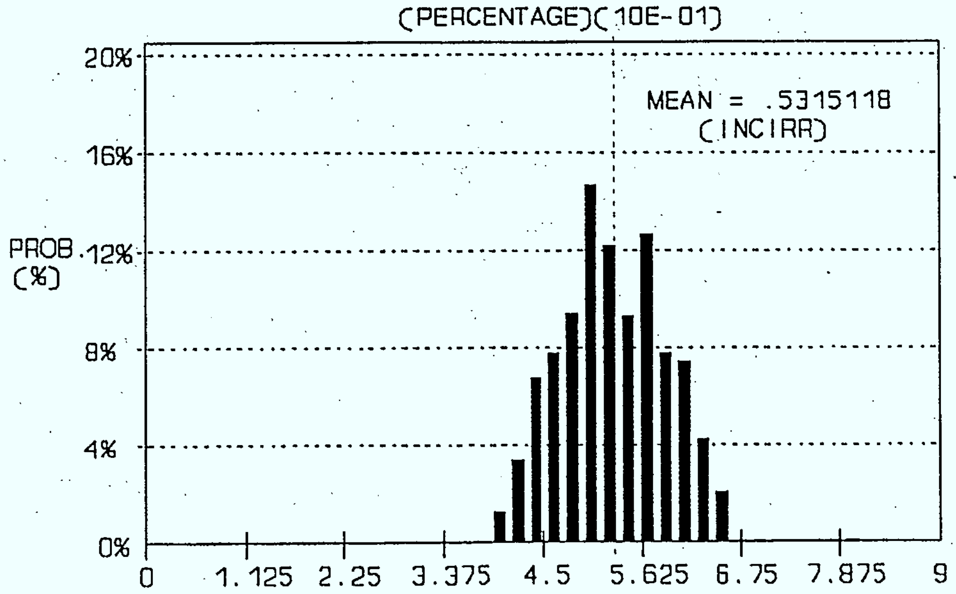


Figure 3 Internal Rate of Return



These results indicate that the likelihood of failing the Treasury Board guideline of a 10% rate of return is negligible.

3.3.2 The Rationale for Government Sponsorship

If net benefits are positive, are there reasons why the private sector would not undertake timely provision of the network without government sponsorship?

Comparison with the Transportation Infrastructure

Data communications networks and transportation networks (roads, rail, etc.) are very similar. As networks, they both move things. Physical goods and people are moved by transport. Data and, more important, services, are moved by a data-communications network.

The significance of a high speed network for Canadian economic development can be explained through a comparison with the historical role of transportation.

Transportation is well known for its key strategic role in economic development. Transportation shortens the **economic distance** between firms. Although physical distance does not change, cheaper and more efficient transportation makes the transport of goods between two points cheaper, and therefore closer in the economic sense.

By shortening the economic distance, cooperation and specialization become easier. Firms with complementary skills can contract to purchase from one another instead of each providing for themselves. This permits specialization, which in turn increases productivity. Specialized firms are more able to understand and deal with their end of production.

Investment in improved transportation has historically had two effects on economic development:

- It has permitted specialized firms and institutions to cooperate profitably by shortening the economic distance between them.

- It has permitted greater specialization by firms and institutions, leading to increases in productivity of each firm.

The introduction of a high-speed network will have the same type and size of impact on R&D productivity as improved transportation has had on productivity in manufactured goods.

The Free Rider Effect

From a private sector perspective, investments are not usually required to cover their operating costs immediately. Losses in initial years of operation are expected to be recovered in later years as a business grows.

An exception occurs when a private firm must pay costs not just for itself, but for all firms. If the first firm in a market must pay to educate consumers and develop technology, then subsequent firms in the market receive the free benefit of the first firm's "market making" efforts. This is the "free rider" effect.

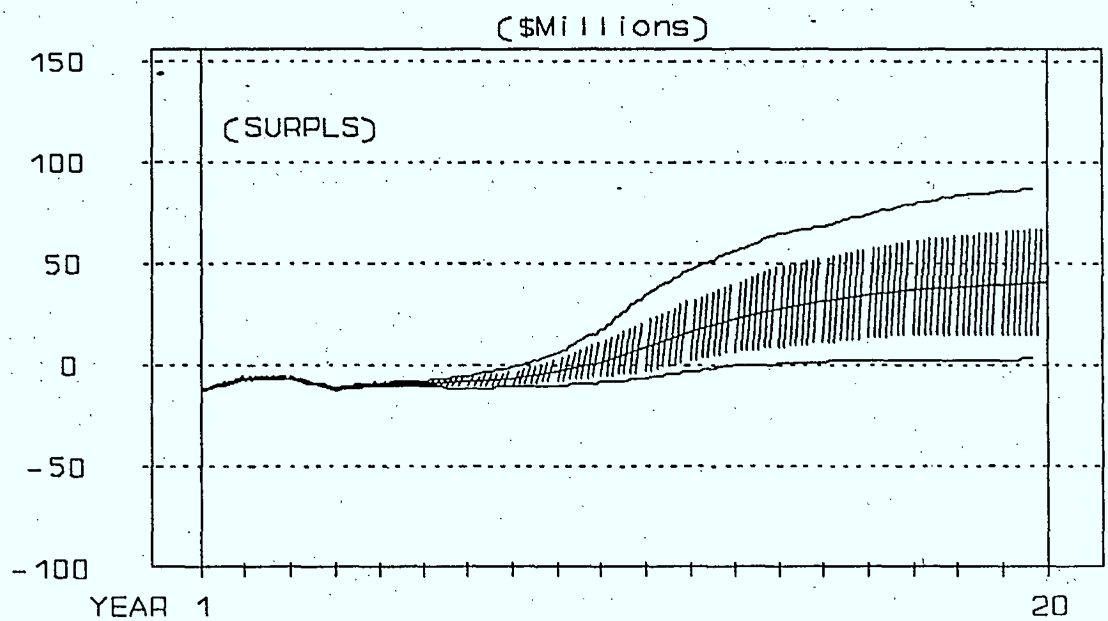
If the free-rider effect is significant, it can delay or prevent the introduction of a new service. A private firm who offers a high-speed network too early will be burdened by the costs of developing applications and building user familiarity. Later entrants to the market will be able to under-price the first firm because they will not be burdened by the accumulated debt of these "market making" efforts.

Therefore, if the break-even year of a privately offered network is too far in the future, private sector firms will not undertake the project even if total benefits exceed total costs. If they do so, they will be paying a substantial part of the costs, but other firms will be reaping the benefits. ISTC sponsorship will be required to ensure a timely introduction of the Network which maximizes the benefits to the Canadian economy.

Figure 4 shows the excess of willingness to pay by network users over costs. The central line represents the expected value. The shaded area represents the range of uncertainty covered by one "standard deviation". The two outside lines represent a 90% confidence interval. That is, there is a 90% certainty that the true value lies between the two lines.

Revenues were estimated as a proportion of user benefits, allowing for market imperfections. IT willingness to pay is a low proportion of total benefits because of the difficulties in financing Research & Development, and because a greater proportion of the benefits go to consumers and are not extractable through producers.

Figure 4 Willingness to Pay



The mean expected break-even year, represented by the central line is year 10 of operation. The 90% confidence interval lies between year 9 and year 13.

Year 9 is too far in the future for immediate private sector feasibility. Normal desirable break-even periods for the private sector fall within 5 years or less in North America. Given the special considerations of the free-rider problem, the break-even horizon required by the private sector for this project would be shorter than 5 years. This assumes that the objective to maintain the network at the leading-edge of technology is fulfilled. The network could become self sufficient sooner if the network speed were not increased.

Therefore, although the long run benefits to the Canadian economy significantly outweigh the costs, the provision of a high speed network is unlikely without government sponsorship such as ISTC can provide.

Further Rationales for Government Sponsorship

When network technology prices fall enough, the free-rider effect will be overcome. However, there are reasons to believe that waiting to this point in time will not be desirable for the Canadian economy and that the ultimate levels of service offered will be less than is best for the Canadian economy as a whole. Early introduction and high network speeds enabled by government sponsorship will have these advantages:

- **Early Adoption of Productivity Enhancing Technology.** Private firms do not adopt new technology soon enough. Firms considering the adoption of new technology do not account for the benefit their example has in testing the worth of the technology for others. Government sponsorship of the network will allow the network to be established earlier and grow faster than it would be under private auspices. The benefits of early introduction expand exponentially over time.

- **Overcoming pricing constraints.** The network has significant fixed costs. Constraints on how users may be charged can mean that the network will be unable to fund itself in its early stages, even though the benefits to users exceed the costs of operation.

- **Promotion of Research & Development.** R&D tends to be under provided in all countries due to imperfect intellectual property laws and difficulties raising financing. The problem in accentuated in Canada by our branch plant economic structure. The R&D community in Canada is relatively small for a developed country. ISTC sponsorship of a high speed development network promotes and supports R&D without requiring project screening, and puts the R&D community in closer touch with other communities around the world.

- **Overcoming training cost barriers.** Initial adopters of new technologies, such as the use of high speed networks, overestimate training costs because they do not account for the benefits their own staff training has on enriching the labour pool for others. High perceived costs for training and maintaining staff expertise, can stunt or prevent network growth. ISTC sponsorship in the short term can overcome this problem by permitting aggressive pricing of network services in the initial years.

- **Overcoming network externalities.** A common problem to all networks is the need to start with healthy initial subscriber base. This tends not to happen naturally because each firm will postpone joining until enough other firms join to make it worthwhile. ISTC sponsorship can allow aggressive pricing and a broad initial user base.

- **Market Making.** Governments have always had a valid role in providing market places where individual firms can compete and where customers may shop and compare. There is a growing need for a market place in electronic services, particularly for the growing industry in data base services. The high speed research network can provide a market place in the form of a single point of access for all these services.

- **Industrial Benefits.** IT product development requires assistance and support for the same reasons as Canadian R&D as a whole. The provision of an independent government sponsored development environment by the network is an effective means of supporting a key Canadian industry. An open access publicly sponsored test facility provides confidence to third parties in product performance and preserves domestic competition in the IT industry.

- **Education.** The Network could have substantial benefits to education and training, both generally and specifically in Information Technologies. The provision of education has traditionally been a government responsibility.

These are considerations that cannot be captured by the private sector through revenues.

3.4 CONCLUSION

The economic feasibility of the proposed high speed research network was assessed in a manner which explicitly considered the significant uncertainties concerning many key benefit determining factors.

Despite the uncertainty with individual values, the network shows a very robust positive return. This indicates that, under any combination of likely circumstances, a high speed research communications network is an excellent investment for Canada.

With regard to the two question posed at the beginning of the chapter:

1. **The incremental benefits of the high speed network proposed by ISTC may be expected to significantly exceed incremental costs.**

   A lower speed network sacrifices most of the benefits of a development environment for the Canadian Information Technology industry, and it significantly postpones productivity gains for the R&D sector.

The gain sacrificed by losing the IT development environment function is 90% certain to exceed a present value of $400 million, and is expected to be $695 million.

The postponement of productivity gains also represents a significant loss to the economy. A lower-speed network restricts the applications that can be offered and provides poorer service for those seeking to seriously collaborate or share facilities. While the cost of higher speeds will eventually become affordable, the postponement will slow the adoption of new technologies, prevent the introduction of new services, and lose the potential productivity gains during the intervening time. The productivity gains from early adoption of higher speeds is 90% certain to exceed a present value of $550 million, and is expected to be $810 million.

In total the net additional benefit from choosing the high speed network proposed by ISTC is 90% certain to exceed additional costs by a present value of $1.1 billion, with an expected value of $1.5 billion.

The real rate of return on the additional investment is 90% certain to exceed 44.8%, and is expected to be 53.2%. The likelihood of failing the Treasury Board guideline rate of return of 10% is negligible.

2. **There is a good rationale for government sponsorship.**

The alternative to government sponsorship is private sector provision. The early introduction of a high speed network is not feasible on a private sector basis. The year break-even year (revenues meeting operating costs) is 90% certain to exceed year 9 of operation, and is expected to be year 10. Because of the length of time until break-even, and because the first market entrant is disadvantaged by the costs of market-making, private sector firms are very unlikely to offer a high-speed network.

In addition, sponsorship of the network furthers these public goals:

- Promotes and supports R&D without having to screen projects.
- Demonstrates the productivity impact of new technologies, encouraging rapid adoption.
- Compensates for market imperfections including the over estimation of training costs and the under estimation of joint benefits of wide participation in a network.
- Creates a market place for the competitive provision and development of information related services.

Each of the above considerations is a rationale for ISTC sponsorship because they promote industrial productivity and development, and because their benefits cannot be captured by a private sector network provider.

Therefore, the high speed communications network for Canadian research & development proposed by ISTC is a project with significant positive returns and a good candidate for government sponsorship.

4. TECHNICAL ANALYSIS

4.1 INTRODUCTION

The technical feasibility of the Network was examined in sufficient detail to permit the expected capabilities of the Network to be estimated and to allow preliminary cost estimates to be made. Details of the Technical Analysis can be found in Volume C of this study.

An example Network design has been proposed since specific physical details will only be available when the Network participants have been identified and after other Implementation and Policy issues have been resolved. Information generated as a result of the Technical Analysis was used to brief potential Network participants during the study. These presentations highlighted the need to satisfy industrial as well as academic clients, and promoted the support of international standards with a coexistence and migration plan for existing methods.

The basic feasibility of establishing a coast-to-coast data network at T1 data rates was not in doubt since such networks are operating in the United States today: However, these existing networks do not meet all of the Network's goals, and do not fully implement the international standards.

4.2 SUMMARY OF PROJECT TECHNICAL OBJECTIVES

The following section summarizes the technical objectives of the Network and indicates how these objectives will be met by the proposed Network.

4.2.1 Service to Users

The Network must meet both the needs of Canadian Research and Development users and the needs of Information Technology product and service developers. Users will require 'user-friendly' access to the services provided over the network and do not wish to be concerned about the underlying communications details. On the other hand, developers of products and services will require full access, since they will be developing these communications details.

Research, Development and Eduction Users (R&D Users)

The proposed architecture supports domains of users using traditional protocols (such as TCP/IP) and new users employing the emerging new international standards (i.e. ISO standards). Interoperation between domains may be accommodated in either of two ways: a user may install multiple protocols in his end system to permit operation into multiple domains, or a user may use a gateway function within the Network to translate between the domains.

1. Access using ISO based protocols will be the preferred approach. Maximum support for ISO based applications will promote the migration to these protocols.
2. Access using TCP/IP based protocols will be supported as an interim measure. Support for TCP/IP based applications will draw from existing implementations and the existing academic community. Certain foreign and regional subnetworks will only be accessible using TCP/IP.
3. Access to other protocols, and other instances of ISO and TCP/IP protocols, above the Network Layer will be supported only to the extent that they may co-exist on the Network. For example, this will permit the offering of protocol testing services over the Network. This sub-group will be expected to completely support themselves, and other users on the network will be protected from them by features within the Network routing equipment.

Information Technology Users (IT Users)

Traditional networks generally address the needs of R&D Users but do not emphasize the support of Information Technology product and service developers. The proposed Network design permits multiple domains to co-exist, for example for experimental purposes.

1. For IT Development work above the Network Layer of the OSI model, the users must conform to the Network Layer service specification and must operate within a closed group of Network Addresses. Protective features should be included in routing equipment.

2. Work within the Network Layer will be difficult to accommodate in the on-line Network, although the existence of the Network will promote the development of these components. An off-line Network Emulation facility is budgeted to support this work. This facility includes multiple Routers interconnected with simulations of long distance communications lines.

3. Work in the lower part of the Network Layer and below will be unique to each communications technology. Early development of such technologies is normally done by single vendors, since the use of standardized protocols at these layers is less common for wide area networks. Certain satellite and mobile host applications (e.g. cellular radio subnets) may be exceptions. In general, the development of these technologies will initially be carried out using facilities purpose-built by the vendor. Once the basic operation of the new technology has been verified it may be integrated into the Network for operational trials by attachment to the router devices.

4.2.2 Use of Internationally Approved Standards

The development and use of internationally approved standards will promote international trade and permit the global interchange of information and provision of information services. This international trade will be both in the products which implement the standards and the information that can be transmitted via the compatible international communications systems. Indeed in Europe, extensive effort is being applied to generate the European standards necessary for the free trade in products and information services.

For data, these standards are generally following those issued by the International Organization for Standardization (ISO), and the Canadian and United States governments have also endorsed these for government use. Thus an essential objective of the Network is to accelerate the development of Canadian products to these standards and to provide a test-bed for these international standards. This will make Canada more competitive in these international markets.

The Network is expected to support the transfer of voice, video and other forms of electronic communications in addition to data. These communications will take place using an integrated communications network. While the current Network proposal addresses standards from the viewpoint of data standards, it is expected that standards applied to the transfer of voice, video and other communications information, when they become available, will follow these data standards.

Traditional Protocols

In the shorter term, many existing defacto communication standards are in use. Many of these are manufacturer or application specific. Both IBM and DEC have announced migration paths between their own communications standards and those of ISO. Application specific standards such as that developed in the US for the military are still also in common use, especially in the academic community. Traditional networks have generally followed the TCP/IP military standards developed in the United States, although most of these existing networks have announced migration plans to the new ISO standards.

The proposed Network provides interim support for the traditional TCP/IP (and associated methods) and encourages the future migration to ISO standards.

4.2.3 Access Provided to Users Across Canada

Canada has many centres of technical excellence from coast to coast. These centres include large organizations with relatively complete research support facilities; medium sized organizations with limited resources; small, possibly start-up, organizations with little support; and individuals with no resources at all. Communities of interest may not correspond to their physical locations, and today many of these diverse groups can more easily collaborate internationally (especially with the United States) than Nationally. Today more than ever, prosperity depends upon the flow of information and collaboration. The Network must provide easy access for users across Canada; must provide universal access to the full range of users, big or small; and must support all of the disciplines considered essential to Canada's future.

It is proposed that the primary method of access to the Network will be via Regional networks. Where Regional networks do not exist, or are unavailable to the particular user, low cost access methods are provided. Dial-in circuit switched methods and packet switched services (such as Datapac) using the public telephone network will provide economical access to small, low volume users. High volume users will be capable of accessing the network using their own Router devices or by special arrangement. Preferred access will be via the Regional networks since these will be best able to provide direct and attentive support to the user.

Specifically included in the proposed Network plan are interconnections to remote parts of Canada to ensure that all regions participate in an equitable manner.

It will be important for access policies set for the national Network to also be implemented by the Regional networks. So that the Network will be able to influence the development of consistent policies, the proposed management structure will formulate strategies and offer access and pricing structures to users which promote the desired policies. In addition, this structure will support the users and promote the use of the Network for all types of research.

4.3 SUMMARY OF PROJECT CRITICAL TECHNOLOGIES

Certain key technologies are considered essential to the High Speed National Network, either because they will represent growth opportunities for Canadian Information Technology industries, or because the successful fielding of the Network will require that these technologies be in place.

4.3.1 Services Offered by the Network

Many opportunities exist for the development of information related services using the new ISO standards. A budget to accelerate the development and introduction of new services is included in the Network plan. Certain services must operate with interim mechanisms to permit the Network to be fielded, while others are not essential to the basic operation of the Network.

Directory and Network Management Services

Directory and Network Management services are considered essential to the Network. (Network management in the context of this section refers to the monitoring and control of the Network and the Network's interfaces, it does not refer to the general network management issues discussed in the Implementation section of this report.) During study discussions, several Canadian vendors indicated plans to introduce products in these areas. Both services may be provided by interim mechanisms should specific products not be available for initial deployment of the Network.

It is proposed that Directory services will be provided by local users until ISO compliant products are available.

Electronic Mail Service

Electronic Mail is also a service which is planned to be offered over the Network, and many vendors have developed and are developing ISO compliant electronic mail implementations based on the CCITT X.400 standards. Unfortunately many existing implementations use differing standards. It is proposed that these implementations utilize available gateway style conversions so that X.400 will become the basis for future electronic mail functions. The coexistence of the TCP/IP domain will permit current electronic mail implementations within this domain to be supported by the Network.

Service Development

Universal access to the Network by a large range of users will facilitate the trial introduction of new, and sometimes custom, services. This will encourage the creation and early trial of many innovative service products. The Network plan includes funding to accelerate the development and trial of new services.

4.3.2 Integrated Services Digital Network (ISDN)

The offer of communications services using an Integrated Services Digital Network has been the plan of most carriers throughout the world for a number of years. Some trials are taking place, but widespread introduction of these services has yet to begin. This represents an opportunity for Canadian vendors, and many are producing preliminary products according to ISDN standards. Although this technology is not essential for the Network's introduction, it represents a key growth opportunity that shall be supported by the Network.

4.3.3 Development and Trial of New Networking Ideas

Major developments are occurring in networking technologies using innovative media, or using innovative techniques on existing media. Opportunities exist for the development of new cellular radio systems, satellite communications methods, fibre optic media, and so on. Each of these are very often only part of the solution, generally omitting certain components of an end-to-end communications capability (for example, omitting a local access capability to the final end users). The Network will provide a method for the trial use introduction of new wide area networking technologies such that they may be used in conjunction with existing mechanisms. This will permit the new methods to be evaluated in the context of a full end-to-end service. Although no new networking technologies are required to field the initial Network, the Network will permit the trial and evaluation of new networking ideas.

4.3.4 Use of Very High Speed Data Speeds

Recent major reductions in long distance data transmission charges will be key enabling factor for the Network. Recent reductions in long distance data communication charges of approximately 50% have occurred. The estimated cost for T3 (44 Mbps) service in the fourth year were estimated to be twice the current T1 rates. The introduction of T3 speeds will ensure that the Network continues to offer state of the art facilities to its users.

4.3.5 Security and Access Control

Security is a growing concern to all users. Since the Network will be used by a wide range of users, some of them students, high levels of information security will not be possible. Each Network user, whether a service supplier or consumer, will be responsible for protecting his information assets. Suitable facilities under control of Network Management will be included to monitor security aspects, and control access and use of the Network.

4.3.6 Use of ISO Routers

The current proposed Network plan recommends the use of ISO Routers. An alternate plan might use TCP/IP routers with a migration plan to ISO devices. The decision to proceed directly to the ISO devices is tentative, but strongly recommended based on the expected availability of the new devices. It is believed to be more straightforward to coexist TCP/IP on the ISO Router base than to coexist the ISO procedures on the TCP/IP base. The use of ISO Routers represents both an opportunity for Canadian vendors and a key need of the Network. During study discussions, at lease two Canadian vendors indicated their plans to introduce such devices in the near future. The use of either type of Router will not significantly affect the cost of the Network.

4.3.7 Conformance & Protocol Testing

Conformance and testing are important for two reasons: the Network must ensure that new equipment which is added does not impair ongoing operation, and secondly, that the Network provide facilities to support the provision of testing services to its clients. Both of these viewpoints stem from the Network's objective to facilitate the development of information technology products and services for domestic and international markets. To meet the needs of the international market, the Network must follow the conformance and certification procedures which are being developed internationally.

Testing of Network Equipment

New equipment to be attached to the network must not disturb the ongoing "operational" role of the network. Some of this new equipment may be experimental equipment and highly suspect. Several categories of new equipment might be considered, from fully certified commercial equipment to highly experimental equipment. While Network Management will control the attachment of such equipment, it will be necessary to provide a mechanism for conformance testing.

The proposed Network will facilitate the following approach to conformance and protocol testing:

1. For transmission and subnetwork equipment related to the lower three layers of the OSI model, testing must be carried out by the administration of the subnetwork concerned, to ensure that the new equipment does not affect the ongoing operation of the subnetwork. Thus, for example, the introduction of a new T1 line must follow testing to the constraints imposed by the wide area network equipment.

2. Only restricted testing of selected components of the Network Layer will be feasible in the on-line portion of the Network. Other components will need to be tested off-line. The Network Emulation Facility is provided to support such testing.

3. For protocol implementations above the Network Layer, these must be tested to the requirements of the respective end system protocol stack, and this will be facilitated by the ISO testing service to be discussed in the next section. A closed user group address on the Network will permit such testing to be carried out without affecting an operational implementation of the same protocol stack. For example, the testing of an X.400 Electronic Mail implementation would be carried out using a unique remote Network Address which has been allocated to the X.400 test function.

Testing Services

The international sale of products meeting the ISO standards will require that equipment be tested and certified as being compliant to the appropriate standards. Initiatives in Europe, Japan, the United States and Canada have begun to establish such facilities. Groups wishing to offer ISO conformance test services for certain ISO standards may do so over the Network. The Network would also support the preparatory, documentation and general communication components of a test and certification program. In addition, ad-hoc interoperability testing, which is considered to be an essential adjunct to formalized testing, may be carried out over the Network. The Network may also support access to foreign testing services and may offer Canadian testing services to foreign users. Successful operation of equipment on the national Network will provide important marketing visibility and credibility to a vendor's new offering.

It is proposed that the testing service would be developed and supported by the Network's staff in the same manner as other third party services to be offered over the Network. To facilitate access to international markets, product testing should follow international initiatives for conformance and certified testing.

4.4 SUMMARY OF EXAMPLE PHYSICAL NETWORK ARCHITECTURE

The Canadian Network will consist of a number of interconnected subnetworks. Some of these subnetworks exist today and some will be developed in the future. These subnetworks must be connected together using a high speed backbone, and the feasibility of this backbone is the subject of this study. This backbone will also influence the operation of the subnetworks, encouraging the establishment of a universal national access policy for all users.

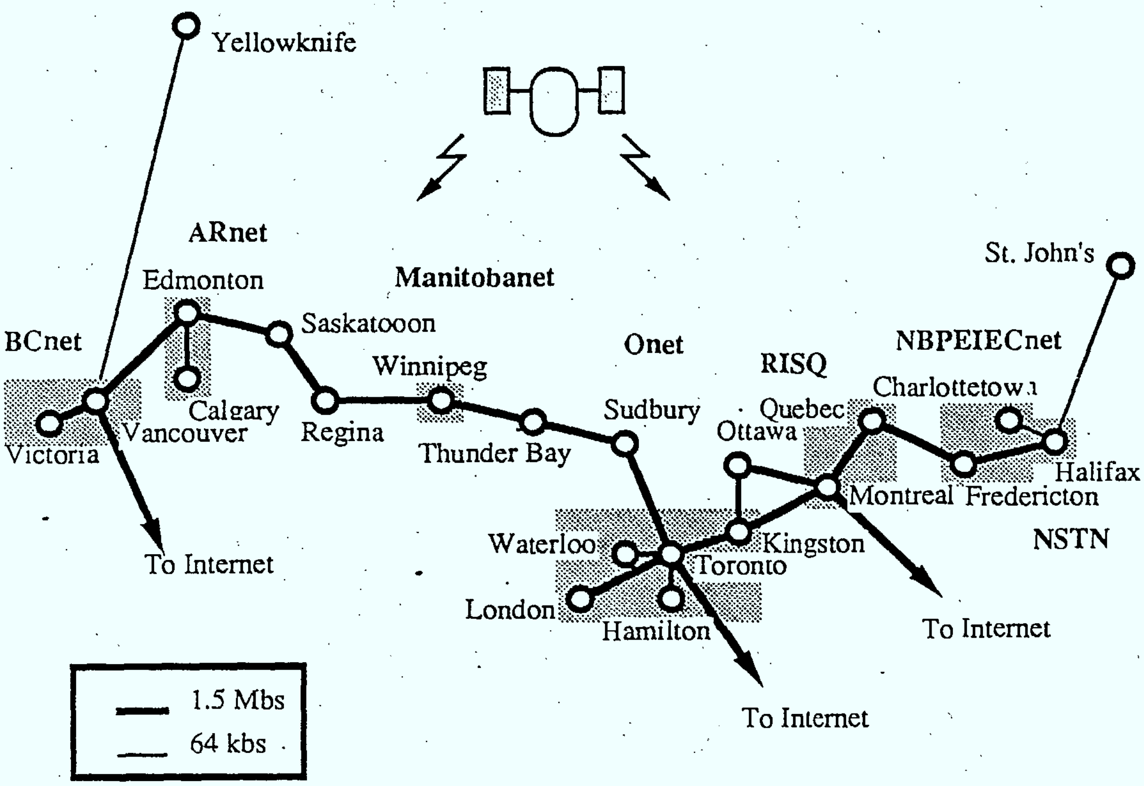
A logical architecture for the Network has been proposed which will ensure maximum flexibility, able to respond to the growth in user requirements and changing underlying technologies. This architecture is consistent with the ISO based international standards and will permit the Network's connection to foreign networks.

A conceptual topology has been assumed, composed of basic terrestrial coast-to-coast 1.5 Mbs links between Halifax and Victoria with lower speed 64 kbs links to Yellowknife, Charlottetown and St. John's. It also plans speed upgrades on all links in the fourth year; 1.5 Mbs to 44 Mbs and 64 kbs to 1.5 Mbs. The enhanced multi-media option would add a parallel satellite link between two of the nodes with an upgrade to four nodes in the fourth year. To provide enhanced universal access to areas not served by existing regional networks, a third option adds 10 nodes to the basic 22 nodes, these extra nodes are sited outside the major urban areas and linked using 64 kbs channels, upgraded to 128 kbs in the fourth year.

The three options are presented with estimated costs of 50.5, 54.5 and 57.9 millions of dollars over a five year period. Considering the additional cost of the third option compared with the significant increase in access provided, the third option is highly recommended. This option is shown in Figure 5.

Cost estimates include **personnel costs**, including salaries and benefits, overheads and staff training; **capital and installation costs**, including all nodes, installation of links, and equipment for Network Management and Technical Centres; and **annual operating** costs, including link rental, international network connection charges, equipment maintenance, Network service development, marketing costs and other operating costs.

Figure 5 Network Physical Design Layout



PLUS: ten more links at 64 kbs, not serviced by regionals

5. IMPLEMENTATION ANALYSIS

5.1 OBJECTIVE

There is a growing consensus around the world that the networks of the future can only be successfully implemented by the cooperative effort of government, industry, and the academic communities. No group, by themselves, can obtain the full benefits possible from the synergy created when all groups work together. Each group brings important resources to the venture, such as finances, technical expertise, and manpower.

While networks require collaboration, the politics involved can provide some difficult implementation problems. Each group has their own concerns, objectives and priorities. Often, the interests of each group are perceived to be in conflict with those of other groups. If this attitude were to predominate, it would prove to be a destructive force in the implementation and operation of the network.

Therefore, it is essential that the interests of all potential participants be considered and that a common ground be found for cooperation. The Participant Needs Analysis of this study concentrated on discovering the interests and concerns of each of the major groups of potential network participants.

Each of the following sections relate the interests of potential participants to the different aspects of implementation. The approaches suggested here should be acceptable to most participants. Implementation details will have to be discussed and agreed upon jointly by participants during future stages of network implementation. Details of the Implementation Analysis can be found in Volume D of this study.

5.2 MISSION AND OBJECTIVES

To enhance Canada's global competitiveness and improve Canadian society by providing the means for organizations engaged in the strategic areas of:

- Research and Development,
- Information Technologies, and
- Education

to connect with:

- Each other,
- Information sources,
- Special equipment, and
- International resources.

The mission can be broken into the following specific objectives:

- To catalyse and accelerate the development and use of advanced Canadian network technologies and information services.
- To increase the sharing of information and the forging of alliances among government, industry, and education, within Canada and abroad.
- To enable all organizations, regardless of size or location, to make valuable contributions to Canada's knowledge base.
- To stimulate and support private and government initiatives for research, development and education in all fields and sectors of the economy.
- To provide organizations with cost effective access to special equipment and information resources which will enhance the productivity and quality of their work.
- To stimulate and support private and government initiatives in the conduct and commercialization of research.
- To provide a research environment where the full benefits of modern communication systems are understood and obtained.

5.3 USE

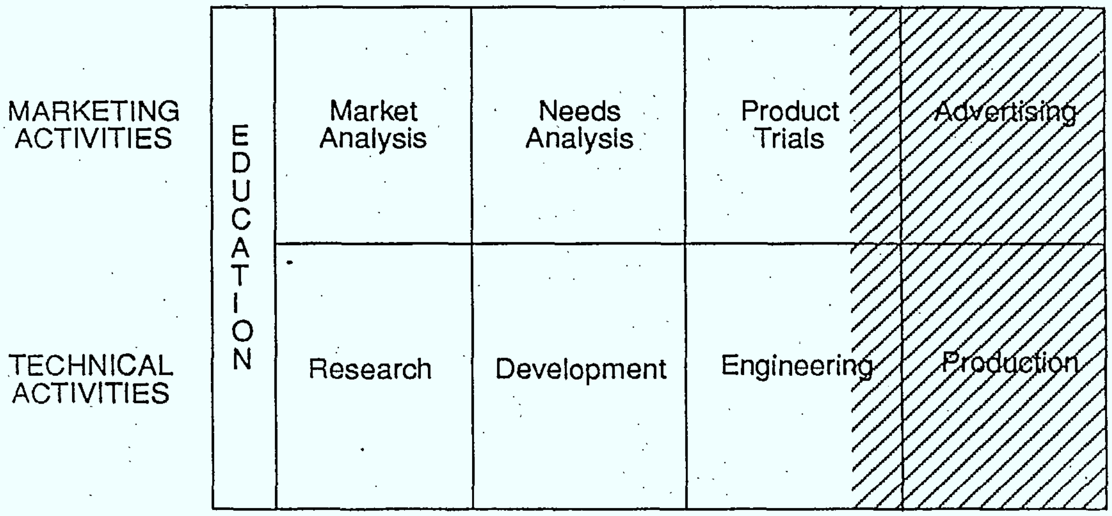
The maximum benefit of the network will only be derived if the maximum use is made of its capabilities. However, because the network will be partially publicly funded, at least initially, there must be some restrictions on use to protect private interests.

There are three general principles which should be applied when deciding what uses of the Network are appropriate:

- The Network is to be used to support research, development and education,
- The Network shall not be used for commercial activities, and
- The Network shall not compete with commercial offerings.

Research, Development and Education are used here in their broadest sense. The terms include activities in the technology development process (see Figure 6) such as Market Analysis, Research, Needs Analysis, Development, Engineering, and Product Trials. Advertising and Production would generally not be considered appropriate uses. It is acknowledged that there is a grey area between appropriate and inappropriate use of the Network where discretion will be required.

Figure 6 Technology Development Process



It is essentially impossible to directly *police* the content of traffic which flows over a network. For this reason, use of the Network will have to be controlled primarily by the honour system.

The *field of application* in which research, development and education are performed is not important. For example the physical sciences, the biological sciences, the social sciences, and the humanities would all be included. The development of information technologies equipment and services is a specific part of the physical sciences which should be given explicit and special consideration in all aspects of the Network implementation. Specific technical implementation issues associated with the support of this policy are discussed in the technical implementation section.

The provision of *commercial services* is an important exception to the restrictions on commercial use of the network. Value Added Suppliers (VAS) should be allowed to provide research, development and education participants with services for a fee. These value added services would supplement the basic suite of Network services. Such an arrangement between the Network and the VAS will provide Network users with applications which the Network by itself could not afford to develop or maintain.

As a matter of policy, the Network should not compete with public service offerings available from the carriers. By the very nature of telecommunication services, the Network will in fact be providing, in some cases, equivalents to those services available on the public networks. However, the purpose of the Network is to make networking capabilities available and affordable to the research, development, and education community, not to provide a by-pass to public offerings. It is also within the Network's mandate to provide innovative services in advance of when such services are available commercially with a view to promoting the development and eventual use on the public networks. To achieve this goal, the carriers must be encouraged to participate in the Network's implementation and the Network must maintain a position of capacity and functionality which is a step ahead of what is implemented in the commercial environment.

The principles outlined above conform to the informal guidelines for acceptable network use which have evolved internationally. Such conformance is important since it is vital that Canadian networks be granted permission to connect to the world Internet.

5.4 ACCESS

Open access is essential to achieving the ubiquitous connectivity necessary to achieve the maximum benefit from the network. Access to the network should be made available to anyone performing research, development, or eduction, and to anyone providing a service which supports research, development, and education. This includes scholars, industry and government. As will be discussed later in the Regulatory section, non-discriminatory access also opens up opportunities associated with the provision of carrier services in support of the Network at lower than tariff rates.

There are two general principles which should be applied when deciding who should have access to the network:

- Anyone with a legitimate use for the network (see Section 5.3) should be able to obtain access.

- There should be no impediments to access caused by an organizations size, location, or class.

To meet the access needs of the many different participants, a variety of access methods will be required which differ in technology, capability, and cost. These will include dedicated accesses to a regional network or the backbone, and temporary accesses through the PSTN (e.g. dial up) or PDN's (e.g. Datapac). The proposed Network architecture accommodates these access alternatives.

The implementation of these access mechanisms should be tailored to meet the needs of a wide range of potential users, with special consideration given to the needs of the small user. With this in mind, Option III, the multi-media, multi-access option has been recommended for implementation.

The privilege of open access must be accompanied by both a high ethical standard of conduct by network users, and an appropriate level of security on the part of the network to make it resistant to intentional or unintentional attack. The primary obligations of the network are to ensure data integrity and to prevent misuse of the network. The confidentiality of information transmitted over the network should be the responsibility of the sending organization, although the Network may provide a security service as user needs develop.

The Network will provide connections to international networks through the Internet. Three international links have been proposed for implementation at T1 rates. In addition, the Network should negotiate reciprocal agreements for access to international sources of information and special equipment. Such agreements will be important given the international flavour of research, development, and education activities.

In Canada, networks are used almost exclusively by the large universities. In the short term, the academic involvement should be extended to the smaller universities and the community colleges. Eventually, the network should be accessible to high schools and public schools.

5.5 SERVICE DEVELOPMENT

Existing research and academic networks provide three principle types of network services: electronic mail and messaging, file transfer, and connection to remote host computer systems. To meet current and future Canadian needs, 1) these services must be improved in capacity, connectivity, functionality, and usability; and 2) the development of OSI based offerings of these services must be encouraged. Plans for the implementation of Network services must be consistent with these two objectives.

The services available to Network users will be of two types: those available as a basic service on the network, and those available as an enhanced service provided by a third party (Value Added Supplier or VAS). The basic Network service should be included in the Network connection fee. The Enhanced Network Service offered by VAS may be charged for at the discretion of the VAS service provider or provided free of charge for development and promotional reasons.

Basic Network services which are recommended for initial implementation are described in the Technical Implementation section of this report.

The development of OSI based services as well as the development of targeted Enhanced service offerings should be encouraged through the appropriate use of Network funds and resources. The implementation plan must recognise the requirement for the funding of third party service development as well as the development of a service development program to which permanent staff have been dedicated. The proposed Network budget has recognised the importance of service development in the Network's implementation. Approximately 10% of the Network recommended staffing requirement over the five year implementation period is dedicated to service development. In addition, service development funding represents roughly 10% of the Network's annual operating cost budget.

5.6 INFORMATION TECHNOLOGIES DEVELOPMENT

The Network implementation plan should recognise the Network's mandate to foster the development of information technologies products and services.

Specific Network features associated with its architecture and policies include:

- Access to all network stack levels,
- Access to real traffic loads,
- The ability to interface and test hardware on the network,
- The ability to access varying subnetwork technologies including fibre, satellite, and microwave,
- Provision of conformance testing facilities,
- Network performance information,
- Access to a trial community of users, and
- Opportunity to participate in network operations and management.

The potential conflict between providing a highly reliable network and providing the capability to test new information technologies is an important implementation issue. Procedures and facilities should be established which allow both of these objectives to be met. The proposed Network architecture explicitly provides for the co-existence of a service and IT development mandates. As discussed in the technical implementation section, IT user access to the Network's communications mechanisms should be restricted in order to minimise interference with the ongoing operation of the network. A Network Emulation Facility should be provided to permit off-line testing of initial products and services to address the needs of IT users wishing to experiment with products which could interfere with the network.

On-line operational testing and evaluations may be carried out on the network itself after obtaining the approval of the network that the proper safeguards are being taken.

The Network Emulation Facility should be a purpose built facility, separate from the network. The Facility will simulate the operation and traffic of the real network, providing a test bed for experimentation. When new products have been adequately demonstrated in the Facility, permission may be obtained to prove the products on to the network.

5.7 FINANCING

5.7.1 Funding Sources

All participants should have equity in the network. There are five groups of participants who can be expected to provide some degree of funding. These are: the federal government, the provincial governments, the regional networks, the carriers, and the suppliers of network products.

Determining the amount of funding each group will contribute will require further negotiations among the groups. The following paragraphs examine some of the rationales for funding levels which can act as a starting point for negotiations. The intent is to provide a relative measure of funding, but in order to provide a sense of magnitude, the contribution from each group has been calculated assuming Option III costs of $58M over five years. The total cost the network over 20 years is expected to have a present value of $157M.

Federal Government

National backbone networks throughout the world are heavily subsidized, if not entirely funded, by government. Networks are seen as vital to national interests and, for a number of reasons, worthy of public support.

The lead Canadian federal department with significant interest in the implementation of this network is Industry, Science and Technology Canada (ISTC), however it should be considered a government initiative in which other interested departments, particularly the Department of Communications and Treasury Board, are significant players.

The Network will contribute significantly to the achievement of many ISTC objectives. In particular, the benefit to the academic community should be of interest to NSERC, SSHRC, and MRC, the benefit to the research community should be of interest to the National Research Council, and the benefit to Canadian industrial performers should be of interest to ISTC as a whole.

It is proposed that the federal government contribute 60% of the cost of the network in the first five years. This represents approximately $35M, or $7M per year.

Provincial Governments

The network will have significant regional benefit by helping to remove the barriers of size and distance. The primary role of the provinces should be support of their regional networks. This support is active in most cases where regional networks already exist. Provinces which do not already have a network should work quickly to implement one.

It is proposed that the provincial governments pay for half of the capital cost of the physical connections (routers, processors etc.) in their province. This will vary by province according to the number of nodes. Larger provinces will require more nodes and will pay a higher proportion of the total cost. In total, the provinces will pay approximately $2.5M over five years, or $0.5M per year.

Regional Networks

The national network will make the regional networks much more valuable to their users by providing higher speed connectivity to other regional and international networks. Also, the national network will support the regionals in operating their network and developing new applications.

It is proposed that the regional networks contribute the amounts currently budgeted for backbone service which is approximately $100K per year per regional network. Assuming that there will be ten regional networks in the near future, the total regional contribution will approach $4M over five years.

Carriers

Communications costs are the largest cost for the network, representing approximately 50% of total expenditures. The carriers will benefit from the creation of market demand for new services which the network will cause.

It is proposed that the carriers lease lines at cost to the network. This approach has been broached with the carriers and is considered feasible. Assuming that cost is about half of the tariff rate, this would represent a contribution of approximately $15M over five years, or $3M per year. Appropriate approaches to deal with the regulatory implications of such a strategy are discussed in Section 5.7.

Industry

The Network will provide significant experience and marketing benefits to companies which supply equipment and services for the construction and operation of the network.

It is proposed that industry contribute equipment to the network at a 50% discount of list price. This represents a contribution of approximatcly $2.5M ovcr five years, or $0.5M per year.

5.7.2 User Fee Structure

Ideally, most users will connect to the national network through a regional network. In such cases, user fees would be paid to the regionals, who would in turn pay a portion to the national network. However, there are two reasons why the national network must address user fees. First, some users will want or need direct access to the backbone. Second, the structure of user fees is important to some of the objectives of the national network.

There are four general principles which should be applied when deciding the user fee structure:

- Users should, in the short term, not pay more for the network at T1 speeds than they are currently paying for 56 kbs speeds.
- The user fees for dedicated access basic service should be fixed for a given speed of service.
- The user fees for non-dedicated dial-in or PDN access users should be determined by the carriers.
- The amount users pay should be independent of distance.

Fee Levels

The academic community is a large and important user group for the network. Due to funding constraints, they will be unable to pay more, in the short term, for a higher speed network, in spite of the additional benefits. Small users will most likely access the Network through non-dedicated connections provided by the carriers. The fee structure for these connections will be determined by the carriers.

Fixed Fees

It was primarily the academic community who demanded fixed fees. They have a number of concerns:

- For budgeting purposes, they need to know what their networking costs are ahead of time. Usage based fees would not allow this.
- They feel that usage based fees will inhibit use, when use should be encouraged.

Industry, especially small users, expressed a preference for usage based fees. Their concerns are:

- They wish to optimize cash flow. Paying a usage based fee overtime is often preferable to paying a fixed fee ahead of time, even when there are net savings.

- They hesitate to commit themselves to an expense when they are unsure of the benefits.

The fixed user fee has been recommended over the usage based fee, in the short term, for the following reasons:

- The academic community will initially be the largest user group.
- Industry, including small users, will accept a fixed fee as long as there are low cost options.
- Use should be encouraged as much as possible.

In the long term there may be justification to move towards a usage based fee, at least in part. There is some concern that under a fixed fee, the network will be perceived as a free good and that usage growth will be uncontrolled. This is not totally accurate as there are many significant costs associated with using a network which the user must bear, other than the connection and transmission costs. Therefore if usage increases dramatically, it suggests that users are obtaining significant benefits which will accrue to the nation as well as themselves.

In any case, in the short term usage growth is desired and should be promoted. If there comes a time when network use grossly exceeds the networks ability to grow, it may become necessary to implement pricing mechanisms to control use.

Distance Independence

One of the primary objectives of the Network is to encourage people to collaborate with others, and use special equipment, which are remote. This can only be accomplished if there are no penalties for the distance of communications. As a result, even if a usage fee is developed in the future, it is not recommended that any distance component be built into it.

5.8 MANAGEMENT STRUCTURE

The following general principles should be applied when determining the Network management structure:

- The Network must implement the policies of its Owners,
- All participants should have a voice in the Network,
- Network operations experience should be open to all interested organizations,
- The operational management structure should build on existing capabilities,
- Network management and operations should be performed by a dedicated full-time organization, and

- All networks should ultimately be part of a unified management structure.

5.8.1 Management Hierarchy

The recommended management hierarchy builds on the hierarchy of existing networks.

At the bottom are individual users within an organization. They may use isolated workstations, but are more likely to be connected to their organization's internal network. The organization's network may be local or wide area, within an office, through a building, across a campus, or across the nation.

The first level of management is provided by the users' organization to operate its network. The users interact with this first level of management.

The second level of management operates the regional network. Users and users' organizations' networks interact with this second level of management.

The third level of management operates the national backbone. The regional networks interact with this third level.

This third level of management reports to the national network board of directors.

5.8.2 Network Operating Company and Board of Directors

It is recommended that the Network operating entity be incorporated as a company. This would provide a well-defined structure in concept and in law within which to operate.

The Network "Company" would operate the Network. It would also own any Network assets that are not owned by other entities (primarily regional networks). Fair and equitable sharing of teh assets of teh Network Company would then be accomplished through the normal company shareholding structure. It is possible that there may be only one shareholder.

It is proposed above that several organizations share in the costs of establishing the Network. It is suggested that these organizations who will have significant financial (and perhaps non-financial) interest in the Network should negotiate a Memorandum of Understanding (MOU) outlining the roles, responsibilities and funding arrangements amomng themselves. Such an MOU should also specify the shareholding arrangement and the composition of teh Board of Directors. For example, it may be agreed that represnetation from the user group (large or small) is appropriate even though such representatives may not have any Company ownership. It may also specify a procedure for election of the Board of Directors if such a procedure is different from the normal shareholder voting procedure. All parties with significant interest in the Network should be parties to the MOU, and all shareholders must agree and sign the MOU. With this vehicle, all parties will have assurance as to the particiaption, roles and responsibiities of other parties, and can act accordingly.

The Board of Directors would perform the normal functions for an incorporated company, i.e. set policy, approve budgets, and hire and direct company management (President or Executive Director).

5.8.3 Network Staff

Executive Director

The Executive Director (Director) and his staff should be responsible for implementing the policies approved by the Board of Directors on a day-by-day basis. The Executive Director should also be responsible for influencing external organizations in the implementation of policies consistent with the Network's policies.

Planning and Acquisition Staff

The Planning and Acquisitions Staff, under their manager, are responsible for Near and Long term Network planning, and the acquisition and installation of new Network equipment. The staff for this function should be assembled at the earliest time.

Network planning will involve the development of strategic plans to manage the development of the Network over both the near and long term. Near term planning would generally deal within a time horizon of one to three years, and would deal with proposals to implement specific Network expansion by the purchase or lease of equipment and services. Long term planning would generally deal beyond the two year horizon, and would deal with more general strategic plans based on a judgement of evolving technologies. Planning must include the development of the communications components of the Network and the Services offered over the Network.

The acquisition of new equipment or services will require technical input to ensure that the products meet the approved requirements. This will include the issue of specific requests for proposal, the evaluation of bids, the technical recommendation for purchase, any technical writing required, the incoming inspection and acceptance of equipment or services, and the arrangements necessary for the installation and commissioning of the equipment or services. It is expected that some acquisitions may follow a standing plan for the purchase of ongoing products or services which are general 'consumable' items. This function will operate in conjunction with the business' purchasing agent.

This function would operate closely with the maintenance function (to be discussed below), and the actual installation and commissioning of equipment would be carried out by personnel from the vendor, a third party contractor, or by Maintenance staff.

Maintenance and Operations Staff

The Maintenance and Operations Staff, under their manager, are responsible for the day-to-day operation of the Network. The equipment owned or leased by the Network must be monitored, controlled and maintained. Where third party contracts are being issued, or where equipment or services are being leased, this function must monitor the performance of these other parties and take any actions necessary to resolve any difficulties.

Maintenance services may be contracted to third parties. This is a particularly good idea considering the national scope of the proposed Network. Many communications and computer companies will supply maintenance services for third party equipment. A difficulty may arise if the equipment in service is considered by its supplier as being leading edge or in other ways proprietary. It will be important to coordinate the selection of the maintenance service supplier so that this does not become an impediment to the introduction of leading edge equipment or services.

Maintenance and operations will not only involve the monitoring and control of owned and leased equipment but will also entail the monitoring and potential control of the services provided by the long haul carrier. Thus many types of equipment and service must be monitored and controlled, and the need for a centralized facility with a uniform interface is required.

This function shall also include the management of foreign interfaces, the Network sensitive components of client interfaces, operational services offered by the Network itself, and any required Billing functions.

Marketing and Service Development Staff

The Marketing and Service Development Staff, under their manager, is responsible for the development of services offered by the Network as discussed in the Service Development section of this report. This will include the development of Directory and electronic mail services. The Network Marketing and Service Development Staff will work closely with the Client Services Staff and the Technical Centre.

Client Services Staff

The Client Services Staff, under their manager, will operate the Technical Centre. The first line of contact for clients is preferred to be a Regional network. This would reduce the manpower requirements of the Client Services Staff. However, the Regional networks themselves will need support, and some users may not have access to Regional networks, thus a basic Client Support staff shall be required for the Network.

The Technical Centre is responsible for the distribution of technical information to clients, the promotion of the Network, and the establishment of a strong user community. It is suggested that this function be separated from the Maintenance functions since the Technical Centre will have some conflicting objectives compared to the Maintenance functions.

Client Services Staff will distribute information to the Network's clients, and will generally promote the development of products and services, both to R & D Users and Information Technology developers. It would reproduce or create documents to describe Network use, would arrange for seminars or conferences to promote areas of mutual interest, etc.

The Technical Centre should also have a strong input to the long term planning process, and may also provide advice regarding near term planning.

The Technical Centre may also operate the Network Emulation Facility, although cooperation with the Maintenance and Operations Staff would be essential in this area.

Finance and Administration Staff

The Finance and Administration Staff, under its comptroller, would provide administrative support to the Network's staff.

5.9 REGULATORY ISSUES

Implementation of the Network will require the leasing of channels (T1 and T3) from a common carrier as detailed in the Technical Analysis section of this report. Such services and facilities will be leased from the members of Telecom Canada , CP Telecommunications ("CNCP") or Telesat Canada. As previously noted in the Technical Analysis section, the cost of these services and facilities will represent a significant proportion of the expenses of operating the Network[1]. Important savings could thus be achieved by the Network if the required services were made available by the carriers at special or reduced rates, or at cost, in recognition of the Network's special research, development and education role and function.

Since the services and facilities offered by the regulated carriers are required by law to be offered at tariffed rates, any departure from the tariffs approved for them raises regulatory issues.

The Canadian Radio-television and Telecommunications Commission ("CRTC", the "Commission") regulates Telesat Canada, CNCP and all the terrestrial carriers who are members of Telecom Canada, except those who provide service in the three Prairie provinces pursuant to the Railway Act (the "Act")[2]. The CRTC, in approving rates for competitive and optional services and facilities, requires that all rates not only be compensatory, but also make a profit (termed "contribution" in the industry) and that they be charged to all persons equally for the same services and facilities supplied in similar circumstances. This approach has not foreclosed certain variations in the tariffs, such as those based on volume discounts. The test of the acceptability of such variations has been largely whether they are made available to any party who meets the eligibility norms established for them in the relevant tariff.

Four options have been identified which could be pursued with those carriers that are regulated by the CRTC.

---

1 Approximately 45% of the total operating costs over the first five years.

2 See Volume A of this study for a discussion of the Canadian regulatory environment.

1. Special Facilities Tariffs

The requirements of the Act have not precluded the approval of rates for services and facilities which are customer-specific or designed for unique needs. The resulting tariffs are referred to as Special Assembly or Special Facilities Tariffs ("SFT"). They are approved using much the same criteria as those used to approve general tariffs although, by definition, the rates established are customer-specific.

The threshold question whether a party can rely on a SFT is the extent to which his requirements cannot be accommodated by generally applicable tariffed services and facilities. In some cases, questions are raised by the Commission whether the configuration of the facilities and services characterized as special assembly, if broken into its constituent components, could not be in fact tariffed in the normal course.

The level of the rates involved in SFT are determined on the basis of costing information. The tests employed for competitive and optional services and facilities as to whether the rates are compensatory and make a contribution are used.

It may be possible to argue with success that what is proposed by the Network is the use of underlying facilities and services in a unique technical configuration and for a unique purpose. It may be difficult however to make a convincing case. The Network itself may be unique but it may not be easy to demonstrate to the Commission that the services and facilities of the carriers necessary to link its components or interconnect it with the public switched network are unique, especially if such services and facilities are already included in the carriers' general tariffs. Secondly, the level of SFT rates are determined, like tariffs for competitive and optional services and facilities, by reference to whether they are compensatory and make a contribution. The Commission will not easily depart from applying those tests in setting SFT rates.

2. Trials

The Commission has authorized the carriers to carry on technology or market trials of new applications of technology or of proposed new services or facilities, without establishing tariffed rates for them in the normal course. Usually, tracking information with respect to the revenues and costs associated with the trial must be filed while it is conducted, in order to allow the Commission to monitor whether the related losses, if any, may have an impact on the revenue requirement of the carrier, with a consequent effect on the rates charged by the carrier for other services.

Technology or market trials, by definition, are authorized for a limited period. They generally last one or two years. At the end of the authorized period, the proposed innovation or the proposed new service is abandoned by the carrier or is tariffed as a permanent service offering. Alternatively, an extension of the trial period may be granted.

It may be possible to argue that the Network's proposal constitutes a technology trial in that it represents a new configuration of telecommunications resources for a new and unique function never served before. On that basis, the carrier and the Network could request that the necessary underlying facilities be made available at cost or at a discount.

There are two important regulatory problems with this approach. First, market or technology trials have been 'in-house' trials. They are considered necessary by the regulator to foster innovation, encourage the development of new technology and avoid the full-scale introduction of services without testing them adequately first. They are arguably carried on for the indirect benefit of the general body of subscribers and, as such, to be encouraged. These considerations are not valid in the case of the Network, despite the broad social implications inherent in its stated goal. The Commission might, however, be able to be convinced that a novel approach to non-commercial trials is warranted in the circumstances of this case and that it is authorized by the Act. It may be easier to make a convincing case if the carrier itself plans to use the Network to test new technologies and standards.

A second problem is the fact that a trial implies a term at the end of which either the trial terminates or the offering becomes an item in the carrier's general tariff. This problem may be insurmountable.

3. Treatment of the Network as a Charity

It may be possible to constitute the Network as a non-profit organization and to have it claim charitable status with Revenue Canada as a non-commercial organization devoted to educational and research goals. The carriers may then be convinced to make donations to the Network for which they would be eligible for a tax credit, while tariffed rates are charged for the services and facilities leased from them by the Network. This approach would not require Commission approval. The Commission does not scrutinize the corporate donation policies of the carriers under its jurisdiction.

4. Experimental or Special Use Tariffs

The requirements of the Act with regard to the setting of rates on an equitable basis to all persons are not absolute. The Commission has some discretion in assessing whether a discount from tariffed rates for certain purposes is justifiable under the Act.

A fairly recent example of discounts authorized for certain purposes are the discount rates authorized by the Commission in 1985 for RF Channels leased from Telesat Canada.

In the early 1980's, pursuant to its broadcasting jurisdiction, the Commission licensed a number of satellite-to-cable programming services. Telesat Canada had available channels on its 6/4 GHz and 14/12 GHz satellites but most of the fledgling programming services could ill afford the rates charged for them in their early years of operation. The Commission approved an application from Telesat Canada for a revision of its tariffs so as to permit, for a period of two years, the leasing of partial RF channels or whole unprotected preemptible RF channels, at discount rates, for experimental purposes. Telesat stated as its objective the encouragement of the development of new satellite telecommunications services, thereby increasing space segment utilization. The program was referred to as an experimental services program. It was renewed for a further similar period at its expiry.

The experimental program authorized by the Commission had the stated aim of benefiting the carrier rather than according preferential treatment to particular users. However, in practice, the benefits of the discount would obviously accrue only to a certain narrow class of users, if not to predetermined parties. Nevertheless, the discount was theoretically applicable to any party who could satisfy certain criteria. Those criteria were set out in the tariff and were based largely on the requirement that the user's service be 'new'.

Another example of a special use tariff was a special discount rate negotiated between TV Ontario ("TVO"), the educational television authority in Ontario, and Telesat Canada in the early days of TVO's development. This approach may have interesting potential for the Network. The Commission may be prepared to authorize discounted rates for research, development, and education purposes, on an experimental basis, although this could well be possible only for a limited period.

The Commission may also be open to discuss special discounts on a continuing basis for facilities and services used for research, development, and education as defined in a tariff. Eligibility for the discount could be spelled out in the tariff. Although, in practice, no other party but the Network may be in a position to satisfy the criteria established, the exception would remain, in theory, generally available. There are of course many arguments to be advanced to support the contention that discounts to foster research, development, and education do not constitute unjust discrimination or undue or unreasonable preference or advantage within the meaning of the Act. They range from promotion of the development and introduction of new telecommunications technologies and standards to improvement of research, development, and education at large.

5.10 VIABILITY AS A NATIONAL PROJECT

A wide variety of organizations from across Canada have expressed strong interest in participating in The Network. The form of this participation varies among organizations, for example:

Organization	Potential Role
Federal Government	Funding, Policy, Services
Provincial Governments	Funding, Education, Regional Development
Universities and Public Research Organizations	Management, Operation, Use
Information Technology Companies	Operation, Supply, Use
Regional Networks	Operation, Management, Policy
Carriers	Operation, Supply

Many organizations in a position to supply equipment, services, or expertise to the Network, are willing to do so at a substantial discount. Users of the network are willing to pay for services, but in the case of academic, institutions the ability to pay is constrained, and in the case of private companies a trial period is necessary to prove the value.

If funding for the Network is approved by the federal government, extensive discussions will be required among potential participants to further define their roles and degree of commitment. However, there is little doubt that **the Network is a viable national project** with sufficient support expressed by government, industry, and the academic community.

5.11 RELATIONSHIP TO OTHER GOVERNMENT INITIATIVES

There are a number of other initiatives currently underway which also address aspects of the Canadian communications infrastructure and industry:

Government Telecommunications Network - GTN is a federal agency which provides communications services (primarily voice) to federal government departments. GTN will be able to connect with the Network in much the same way that carrier commercial offerings will be able to. Anticipated changes in the mandate of GTN may allow it to participate actively in the management and operation of the Network, however its involvement must be limited within its current mandate.

Vision 2000 - Vision 2000 is an initiative promoting the joint efforts of the Canadian communications industry to develop future oriented products "for the year 2000". The project was started by the Department of Communications, but is now being actively pursued by the cooperative efforts of a large number of Canadian firms. The concept is to enable communications anywhere, anytime, any place and will realize the dream of ubiquitous connectivity among all communications equipment.

The goals of the Network can be considered as a subset of the goals of Vision 2000, though Vision 2000 is oriented more towards personal communications. There is no planned intention to join the two initiatives, but both are being kept actively aware of the other's progress to avoid duplication and ensure cooperation.

CAnet - CAnet is an initiative to create a national backbone network to connect existing regional networks. It has been promoted by the academic community with the support of the National Research Council. An operating company composed of The University of Toronto, IBM, and INSINC has been formed and is awaiting Treasury Board approval for implementation. CAnet will operate with a linked dual-ring topology at 56 kbs and use the TCP/IP protocol intially. The provision for supporting development of information technology products is not one of its goals. The objective of CAnet is to achieve connectivity and speed improvement over existing networks at a low cost.

The network examined in this study differs from CAnet in some significant respects, including:

- The use of 1.5 Mbs links,

- OSI standards conformance,
- Support for the development of information technology equipment and services,
- Participation by all interested Canadian information technology companies for supplying and operation, and
- More intensive marketing to industry.

However, the network examined in this study meets all of the objectives of CAnet. The Network increases the **scope** of CAnet providing **enhanced** capability and should be considered as a natural **evolution** from CAnet.

5.12 LONG TERM FINANCIAL VIABILITY

The economic analysis conducted for this study showed that the Network would become self supporting in approximately nine years. This analysis assumed that 1) the Network will be maintained at the highest practical speeds and technology, and 2) the fee structure will be set aggressively to promote use. These assumptions were dictated by the objectives of the Network. If these objectives were relaxed, financial viability could be reached more quickly.

It should not be surprising, however, if the Network were to continue to meet all of the objectives described in this study, that ongoing government assistance would be required. Justification for such assistance has been outlined in this study.

6. CONCLUSION

6.1 SIGNIFICANCE FOR CANADA

Due to the geography of Canada and the distribution of its people, communications has always played a very important role in Canada's history. From the canals and railways of the nineteenth century to the highways and broadcasting networks of the twentieth century, the Canadian society and culture has grown dependent on excellent communication systems.

This role of communications in Canada has helped make the communications industry Canada's leading area of high technology achievement. According to industrial research and development statistics (1987) about 25% of all industrial R&D is in the area of telecommunications.

Like all industrialized countries Canada is in the midst of a profound shift in its reliance on the creation, communication and consumption of information to create jobs, wealth and economic progress -- ie. an information based society.[1] Underlying this shift is the necessity for a communications infrastructure, which is as important to the information age as the rivers, railways and highways were to earlier eras. In fact the Science Council has referred to this computer based communications structure as a "transformative technology", and the one that will have the greatest impact of all technologies on societal change.

In the past decade, all major industrialized countries without exception have adopted broadly-based strategies aimed at developing communications infrastructure for this new information age. These strategies may include large-scale research projects, government funding aimed at improving technology diffusion, and reform of laws and regulations to foster a more innovative environment. Canada has not responded to these changes with the same vigour as other advanced nations, and with the same spirit that was evident in our past achievements in communications.

There are two general schools of thought on the positive correlation between R&D expenditure and economic growth. The concept of demand pull postulates that the innovation process is driven by the market demand for the products of the process. The notion that changes in consumer trends "call forth" inventions as required does have some intuitive appeal; the knowledge that a market exists for a product certainly provides a motive to develop the product. Equally as appealing, however is the technology push view; that it is the availability of new S&T knowledge that induces the development of new products.

The proposed Network can be defended on both a market pull and a technology push basis. For example the university researcher working in fluid dynamics or remote sensing requires a high bandwidth network to accommodate high computational experiments, and thus

[1] Some experts have likened this shift to the transition from an agricultural to an industrial society.

represents an existing market for such a Network. In the same vein, researchers participating in the Centres of Excellence Program, require such a network in order to collaborate with a colleague who may be thousands of miles away. Existing networks are unable to provide the level of service (eg. video conferencing) required by these researchers. However for other firms and institutions the availability of this Network, on its own, will accelerate the development of new products and services, and in some cases create new markets which would not otherwise have occurred. It is hoped that Federal support for a high-performance research network would drive technology forward and develop a market for more advanced networking services, which would create more jobs, and ensure Canada's place as one of the leaders in the information age.

Bearing in mind the two different phenomena described above there are a number of reasons why the Federal government should invest in this Network.

- Improvement in the Existing R&D Infrastructure;
- Improvement in International Competitiveness;
- A means to attain the objectives set out by the National Science and Technology Policy; and
- High-speed R&D networks are in place or are being implemented in other industrialized countries.

6.2 RECOMMENDATIONS

1. The ISTCnet concept should be implemented quickly.

2. There should be only one national R&D data communications initiative.

3. The fee to the users should be no higher than present initiatives. Fees should be independent of geographic location and distance. Fees should be independent of data volume (fixed). Fees should be structured such that there are low cost methods of access; cost should not be a barrier to entry.

4. The network should move as quickly as practical to ISO standards.

5. The network should use a wide variety of Canadian products to the extent possible.

6. The network should promote the widest possible participation by industry, government, and the academic community.

7. The network should promote the development of next generation network technologies and services.

8. The network should use commercially available carrier offerings to the extent possible. The network should promote the development of commercial communication services by the carriers as public offerings where they have been shown to be commercially viable on the Network.

9. The network should constantly evolve to higher capacity and higher functionality, while maintaining conformance to international standards, so that it maintains a position at the leading edge of similar international networks.

GLOSSARY

CCITT	Comite Consultatif International Télégraphique et Téléphonique.
CANET	Canadian network initiated and organized by NRC, formerly called NRCNET.
CDNnet	Canadian network based at University of British Columbia - started as NSERC - supported research project to implement EAN software.
CERN	Centre European des Recherches Nucleaires.
CRTC	The Canadian Radio-television and Telecommuni-cations Commission. The agency responsible for regulation of the broadcast industries in Canada and the federally incorporated telecommunications common carriers.
DEC	Digital Equipment Corporation
DECnet	A proprietary network for Digital Equipment Computers.
EAN	Software package implementing ISO X400 service; in Europe a netowrk which uses this software.
GARR	Gruppo Armonizziazione delle Reti per la Richercha.
IBM	International Business Machines.
ISDN	Integrated Services Digital Network. A fundamental feature of ISDN is the use of "out-of-band" signalling, signalling that is transmitted independently and simultaneously with communications traffic.
ISO	International Organization for Standardization; responsible for publishing the Open Systems Interconnection Reference Model.
kb	Kilobyte: 1 kb = 1024 bytes (accurately), a thousand bytes (colloquially). Also used as an abbreviation for kilo-baud.
Mb	Megabyte: 1 Mb = 1,045,576 bytes (accurately, 1024 x 1024), one million bytes (colloquially, and more usually).

NACSIS	National Centre for Science Information Systems (JAPAN).
NJE	IBM communications protocol "Network Job Entry".
NREN	National Research Education Network.
OSI	Open Systems Interconnection. A model of communicating processes established for use in the definition of inter-machine protocols.
PDN	Packet Data Network.
PSTN	Public Switched Telephone Network
RARE	Réseaux Associés pour la recherche Européenne
SNA	Synchronous Network Architecture
TCP/IP	Transmission Control Protocol/Internet Protocol
T1 Carrier	A designation of a transmission circuit, referring to its capacity. T1 Carrier has a bandwidth of 1.544 Mbps and T3 Carriers operate at 45 Mbps.
UBC	University of British Columbia.
VENUS	European High-Speed Networking Initiative.
X.25	A commercial packet network access protocol that specifies three levels of connections. The X.25 physical level, link level, and packet level correspond to the first three layers of the ISO/OSI model.
X.400	CCITT standard message handling service