PROFILE OF SUCCESSFUL CANADIAN R & D CONSORTIA AND THEIR LINKAGES WITH OTHER COUNTRIES

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PART I: RESEARCH MANAGEMENT PROJECT UNDERTAKEN IN CANADA DURING MAY 11 – JUNE 5, 1992.

RMP: PROFILE OF SUCCESSFUL R&D CONSORTIA AND ITS LINKAGES WITH OTHER COUNTRIES

PROBLEM:

Department of Science and Technology (DST) is exploring solutions to make the national R&D infrastructure more responsive to the need of Indian industries. It intends to embark upon R&D programmes which bring together fund and infrastructure of universities, national R&D labs and private industries for development and production of goods and services.

BROAD OBJECTIVE OF RESEARCH MANAGEMENT PROJECT (RMP):

Identification of new models for organising R&D programmes which would augment production of wealth generating goods and services by Indian industries.

SPECIFIC OBJECTIVE OF RMP:

1) To study selected Canadian R&D institutions and federal programmes/services which over the years

   - have pooled in funds from federal, provincial and industrial sources for carrying out R&D leading to development and production of goods and services.

   - have become well equipped to serve a large number and variety of clients from the industrial sector.

   - have made effective use of international contacts and linkages (formal and informal).

2) To understand linkage mechanisms to transfer technology from labs to industry.
   (Field specificity is not important within the set of high technology sectors such as biotechnology, advanced materials and lasers. The process of transfer of technology from lab to industry to be studied can be interpreted for any high technology sector.)

CANADIAN R&D INSTITUTIONS AND PROGRAMMES TO BE STUDIED:

(A) ~~ORTECH, Ontario~~; Pulp & Paper Research Institute of Canada (PAPRICAN), Quebec.

(B) VISION 2000 of Department of Communications and PRECARN.

Rationale for selecting the above Canadian R&D institutions and federal programmes.

* Providing technical support to local industries, which are significant sources of earnings in the Canadian economy.
* Programmes and enterprises owned and managed in varying proportions by federal, provincial and industrial partners.
* Catering to wide and varied clients.
* Organising clear perceptions of future requirements/needs before taking up R&D projects.

FOCUS OF STUDYING VARIOUS CANADIAN R&D INSTITUTIONS AND PROGRAMMES

~~ORTECH, Ontario~~ / PAPRICAN, Quebec

While studying the organisation and research profile of these R&D institutions, the following information in particular will be sought:

* Changing patterns of funding
* Adjustments in undertaking R&D projects; partners for R&D projects/R&D consortia mobilised.
* Changing patterns of output.
* Change in number and variety of clients.
* Advantages available through international contacts and linkages (formal and informal).
* Mechanism for transfer of technology from research labs to the user (industry).

VISION 2000 / PRECARN, Ottawa

* Nature of services anticipated in the coming 5-10 years.
* Technical features required to deliver the services.
* R&D projects to be undertaken for providing specific technical features.
* Mechanism for feeding in the results of R&D into production enterprises (industry).

CANADA

1. Expenditure on R&D (1991) = $ 9,714 million
   Breakdown:
   - i) Business Entreprises = $ 4,055 million (42%)
   - ii) Federal = $ 2,780 million (29%)
   - iii) Universities = $ 1,059 million (11%)
   - iv) Provincial = $ 712 million (7%)
   - v) Foreign = $ 910 million (9%)
   - vi) Provincial Research Organizations = $ 2 million
   - vii) Private Non-Profit Organizations = $ 196 million (2%)

(Industry is the largest funder & performer of R&D)

2. % of GDP/GERD devoted to R&D = 1.4%

3. Federal S&T expenditure (1991-92)
   Breakdown:

Science Based Departments/Agencies		Approximate Expenditure
i) Environment Canada	=	$ 560 million (huge proportion going into RSA)
ii) National Research Council	=	$ 490 million
iii) Statistics Canada	=	$ 450 million (most on RSA)
iv) Agriculture Canada	=	$ 380 million
v) CIDA	=	$ 370 million
vi) Energy, Mines & Resources	=	$ 370 million
vii) Canadian Space Agency	=	$ 290 million
viii) National Defence	=	$ 290 million
ix) Fisheries & Oceans	=	$ 260 million
x) Industry, Science & Technology Canada	=	$ 240 million
xi) Health & Welfare Canada	=	$ 180 million
xii) Atomic Energy of Canada	=	$ 150 million
xiii) IDRC	=	$ 115 million
UNIVERSITY GRANTING COUNCILS		
i) NSERC	=	$ 490 million
ii) MRC	=	$ 250 million
iii) SSHRC	=	$ 100 million

Performers of R&D (1990), Funders of R&D (1990)
with respect to Canada

PERFORMERS OF F&D		FUNDERS OF R&D	
Business	= $ 5.1 b (56%)	Business	= $ 3.8 b (42%)
Higher Educ.	= $ 2.2 b (24%)	Federal Gov.	= $ 2.7 b (30%)
Federal	= $ 1.4 b (15%)	Foreign	= $ 0.9 b (10%)
Provincial (PRO & NPO)	= $ 0.4 b (4%)	Higher Educ.	= $ 0.8 b (9%)
		Provinc. Gov.	= $ 0.8 b (9%)
	$ 9.1 b		$ 9.0 b

Industry is the largest performer and funder of R&D in Canada

LEADING FEDERAL DEPARTMENTS/AGENCIES FOR EXPENDITURE ON R&D

NRC
NSERC
Agriculture
National Defence
EMR
ISTC
MRC
F&O
AECL
EC
CIDA

LEADING FEDERAL DEPARTMENTS/AGENCIES FOR EXPENDITURE ON RELATED SCIENTIFIC ACTIVITIES (e.g. data collection)

EC
Statistics Canada
CIDA
EMR
NHW
F&O

CANADA (1990-91)

EC	=	$ 540 million
EMR	=	$ 510 million
NRC	=	$ 500 million
NSERC	=	$ 440 million
CIDA	=	$ 375 million
SC/AGR	=	$ 350 million
ISTC	=	$ 275 million

INDIA (1988-89)

DRDO	=	580 crores
DOS	=	415 crores
DAE	=	300 crores
CSIR	=	210 crores
ICAR	=	200 crores
DST	=	160 crores

Justification for Studying Canadian R & D Consortia

Economic constraints are being experienced the world over. Its impact inter-alia has hit the governments': investments on R & D at the national level focus of forms of international S & T relations and expectation from R & D agencies and infrastructure. Government is inclined to support more of R & D initiatives (at national and international levels) leading to production of wealth generating goods and services (such as new materials, biotechnology, high energy physics, human genome, biological diversity, pandemic diseases, and intelligent systems).

All along, government is keen to organize and coordinate R & D Consortia/Networks where in private industry (manufacturers=user of technology), government research laboratory (producer of technology) and university researchers (education sector=so far trainer of human skills), on an interactive mode for the purpose of innovation (production of more and improved goods and services) agree to the following:

- commit their research staff, facilities and time and money for agreed upon project goals and activities;
- complement skills and abilities of experts from several disciplines;
- avoid duplication of research efforts;
- making use of extra ordinarily expensive equipment and facilities at limited location by diverse researchers community; and,
- generate large volume of research data, which can be selectively interpreted and disseminated to potential users.

This would help in boosting the production of value added goods in the country and the economic prosperity. The national networking could in turn have its coupling connections with simiar networks elsewhere in the world to make the research endeavour and innovation process internationally/globally relevant. This would have greater visibility in results/accomplishments against the geopolitical concentration taking place in North America, Europe, and ASEAN region.

Further development of international R & D networks/consortia (involving ---- industry, government research laboratories and universities) within a framework of programme partially funded by participating governments is receiving acceptance world wide as a useful form of international S & T relations.

* Alliances/Consortia - Definition

- Formal or informal agreement amongst parties cooperatively carrying out a specific activity.

- Parties involved in an alliance share both risks and rewards.

- Parties could be government, industry, and university in a variety of combinations.

- Government involvement in alliances can be of two kinds
  - i) Government - an active performer in science (e.g. joint research partnerships, contracting-in/contracting-out personnel exchange, MDU, etc.) making use of research expertise and facilities.
  - ii) Government - provider of support through resources (e.g. S & T grants, contributions program, provision of information, and brokerage services).

- Contracts in which there is some form of direct sharing of cost between government and the partners.

* Number of federal alliances concluded by 28 Science Based Departments and Agencies (SBDA) during 1990/91 = 7,799. Department/agency wise break up of number of alliances.

Foremost	NRC	1705
	NSERC	1660
	NHW	1050
	ISTC	696
	AGR	597
	EMR	552

These six department/agencies account for almost 80% of the alliance.

* Investment of federal government on these alliances = $750 millions. Investment of partners on these alliances = $647 millions (industry, predominantly which have adequate in-house R & D capability).

* Average expenditures incurred by federal SBDA-alliance project (1990-91) = $190,000 (exception being cooperative arrangements sponsored by AECL = $3.6 million/project, (nuclear program) western diversification = $1.1 million/project).

* Federal SBDA have invested almost equal amounts in two kinds of alliance involvement, i.e., as direct performer of R & D and through indirect financial support through grants and contributions.

* NRC's - IRAP programme also provides funds and technical advice/assistance to about 4500 firms in alliance mode worth $65 millions in 1990-91.

* Out of 7799 federal SBDA alliances, 75% of alliances had industry as its one of the partners; universities were identified as partners by SBDA in almost one third of alliances. Significant numbers of partners were provincial departments and agencies, PRO and NPO.

* (1) Reasons for alliance formation:

  - strengthening level of R & D capability and performance;
  - development of highly qualified personnel;
  - sharing risk, cost and rewards of R & D through networking;
  - establishing a critical mass for R & D;
  - speeding up the process of innovation (product and process development);
  - pooling/complementing/enhancing technical, financial and human resources from government, universities and private sector;
  - greater transfer of R & D results to commercialisation phase.

* Determinants for choosing the partners:
  - capability in providing leadership;
  - availability of technical and highly qualified personnel, R & D facilities and necessary financial resources;
  - scientific merit of the partner to carry out research or produce a product;
  - willingness and capability of partner to take the produce for commercialisation;
  - access to strategic information ability to exploit market opportunities.

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(1) Technologies can't be developed in isolation from industry. Adequate communication between industry and government laboratories has to be established at all stages, beginning with project planning, product design development and up to marketing.

CANADIAN R & D INSTITUTIONS AND FEDERAL PROGRAMMES STUDIED

- PAPRICAN, Québec
- PRECARN, Ottawa
- Vision 2000 (sponsored by Dept. of Communications)

Methodology

Senior Executives Interviewed in PAPRICAN
March 26 and May 20, 1992

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Telex: 05-821541

Project Management:

Mr. Ian T. Pye
Director, Strategic Planning - Technology Development
(also Secretary of Research Program Committees of PAPRICAN)

Dr. Derek H. Page
Director of Research (Physical Sciences)
(also Scientific Editor - Journal of Pulp & Paper Science)

Recycling of Waste Paper:

Dr. Roger C. Howard
Fibres and Paper Physics Section

Effluent Treatment:

Dr. Tibor G. Kovacs
Group Leader
Aquatic Biology Laboratory

Chemical Pulping:

Dr. J. Martin MacLeod
Supervisor, Chemical Pulping Section

Biotechnology:

Dr. Lubo Jurasek
Head, Biological Chemistry Section

Areas of Interest:

- Pulp and paper related biotechnology
- Process improvement in chemical pulping
- Recycling of waste paper
- Characterisation of pulp and paper properties
- Diversification of paper-based products (incorporation of special properties in paper for a variety of applications)
- Effluent treatment of pulp and paper industry

Discussion Topics:

1) What are the sources and amount of funds needed for on-going projects?

2) What is the scope of projects and responsibility of participating partners, i.e., how are these projects identified and concluded for implementation, and what are the anticipated returns of these projects?

3) Who are the principal clients being served through on-going projects? Are there significant shifts in the number and nature of clients served by PAPRICAN?

4) How does the know-how developed at PAPRICAN leave and become useful to the industry?

5) Account of international linkages which are being utilized to keep up with the latest state-of-the-art on pulp and paper R & D by PAPRICAN?

Pulp and Paper Research Institute of Canada (PAPRICAN) — Industrial Consortium/Network with academic involvement.

Canada is the leading exporter of pulp & paper in the world. To continue it leading position, it aims at striving for competitive advantage through R&D in pulp & paper sector. National Statistics on Pulp & Papa & World figures are given at (Annexure —

Company Background: PAPRICAN, established in 1925, is a non-profit research & educational organisation in pulp & paper sector. It employs 375 scientists, engineers & support personnel. It maintains laboratories in Pointe Claire, Quebec and Vancouver, BC. It uses facilities in McGill University (Pulp & Paper Research Centre), Univ. of B.C (Pulp & Paper Centre) and Montreal's Ecole Polytechnique (Canada's largest engineering faculty.

Source of funds: PAPRICAN's annual budget of $31 million during 1991 was contributed as per following breakdown

- *53 Maintaining Member Companies = $25M (~81%)
- ISTC = $2.5M (~8%)
- Grants-In-aid (allied industry) = $1.7M (~5.5%)

(* Most of them are Canadian pulp and paper manufacturing industries. The annual membership fee by Pvt Company is worked at a formula of $1.20/tonne of pulp and paper produced annually. If any private industry is having more than 100 personnel engaged in R&D, 25% reduction in membership fee is offered)

While Govt of Canada has provided the support for capital cost & building of PAPRICAN, operating cost for its 80 on-going research projects is mostly met by PAPRICAN's 53 maintaining member companies (Annexure —). Specific research projects have received funds from any of 85 allied industries and 9 Federal & Provincial Govt's (ISTC, EMR, NRC, Env Canada, Forestry Canada, NSERC, Science Council of BC, Quebec's Min of Commerce).

Research Focus: Research focus of PAPRICAN has been on precompetitive research & development in pulp & paper sector. It dabbles on such problems which cuts across the requirement of practically all pulp & paper producing companies. PAPRICAN does not focus on product development tasks, since the participating companies as potential competitors are difficult to be convinced for cooperative research. 45-55% of its research investments are on basic research, having immediate

application in pulp & paper mills. Its emphasis has been greatly on process R&D, generic aspects like cellulose & wood chemistry, mechanical & chemical pulping, paper making & product quality (strength, whiteness), recycling of waste paper, effluent treatment (organochlorides). Major Research Program & Areas are at (Annex

Education focus: PAPRICAN in cooperation with McGill & UBC offers Master Degree in pulp and paper engineering (since 1984; 1½ yr course, for scientists & engineers to orient towards engineering practices & mill operations; 95 degrees have been awarded so far). PAPRICAN developed the curriculum for this course, as well as the course material. The course is totally administered by McGill Univ. Largely out of its practical

PAPRICAN offers PAPRICOURSE (since 1981, 2 week course; for operating engineers & technical staff of pulp and paper companies; on scientific & engineering fundamentals of pulping & paper making. PAPRICAN offers PAPRIPRINT (since 199 3 days course, to educate paper makers on the needs of printers & printing process. An effort on understanding manufacturing variables & customer's requirement or problems) PAPRICAN has been offering 10 scholarships to students pursuing Masters Course in pulp & paper engineering. PAPRICAN has produced 13 video films on topics such as printing process, calendering, coating of paper, Kraft pulping, liquid-paper interaction

PAPRICAN - University Links

- Six of PAPRICAN's scientists – cross appointed to Deptt of Chemistry & Chemical Engg, McGill U (since ...)
  – enjoy academic priviledges, including supervising PhD in pulp & paper area; teaching graduate / undergraduate levels.
- Two of PAPRICAN's scientists – cross appointed to Deptt of Mechanical & Electrical Engg, UBC (since ...)
  – 8 Professors of UBC as well are supervising graduates on industry relevant problems.
- PAPRICAN along with 20 Companies – granted establishment of electron microscopy lab in Ecole Polytechnique
- PAPRICAN offers 10 scholarships for Students doing Masters Course in Pulp & Paper Engineer...
- PAPRICAN with the help of NSERC — is funding 2 University chairs at UBC
- PAPRICAN is leading the — NCE on Mechanical & Chemimechanical Wood Pulps. This activity aims at enhancing quality & expanding internat... market of Canadian pulp & paper, through application. This network began in Aug 1990 involves funding of $14 ... over 4 years from NSERC. Participants involved a 34 scientists, 34 graduates, 8 PDF, 3 Professors & 8 Techn... Details in Annexure.

Practical tips behind PAPRICAN's R&D & Educational Success

(i) Maintains close & continuous interaction between PAPRICAN Staff & those of Pulp & Paper M...
(Each of 15 Senior researchers of PAPRICAN are assigned 1 Pulp & Paper mill and the visits are made freque... Industry Executive Seminars = Mill management seminars are held biennially)

(ii) Careful selection of PAPRICAN scientists for cross appointment in Universities (technical proficiency & acceptability of scientists by University community)

(iii) Successful working relationship and university cooperation gets developed gradually over the years and predominantly through informal goodwill
(about 10 yrs was the time suggested by PAPRICAN for meaningful interaction with University)

(iv) Active consultation with industry to draw the strategic plans for organisi... R&D programs & its reviewing
(The Research Program Committee having 33 members drawn from industry –
Federal Govt – 2 Professors ... PAPRICAN Staff – ...)

Network of Centre of Excellence - Mechanical & Chemimechanical Wood Pulps Network

Papricans role

The idea for this Network orginated and approval for the objectives and funds involved was received by ISTC. ISTC requested PAPRICAN to lead this federal government approved initiative, i.e., Network on Mechanical and Chemimechanical Pulps. This Network attempts at making high yield pulps with enhanced strength, stable an high brightness and reliable uniform quality.

Management of Research:

A board of directors has been appointed to oversee the management of this Network. It comprises of:

Chairman - President of PAPRICAN
Members from universities = 3
Pulp and paper industry and allied industries = 5
Federal government (ISTC, forestry) = 2
Secretary = Director of PAPRICAN
Associate members - industry (Dupont Canada) putting in money for scholarships for postgraduate students working within the Network.

Funding of Research:

Most of the funds for pursuing research under this Network comes from Canadian federal source. One industry, i.e. Dupont Canada Inc. (MNC - Branch Unit) has recently put in funds to extend scholarships for postgraduate students working within this Network. Participation of industry in cash or kind is being encouraged, as a principle.

Players in Research:

This concept has pooled in most related nine universities and research scientists across Canada on an interactive mode and for an industrially relevant end use, reviewing direction of research plans has been put under the charge of a not for profit private research institute, i.e. PAPRICAN (which enjoys support of as many as 49 Canadian pulp and paper and allied industries). It also has participation of two federal research laboratories under NRC, besides PAPRICAN.

Ultimate Advantage:

The ultimate output is to improve the process in making superior Canadian wood pulp which would be preferred by buyers (overseas countries) in international markets.

Universities in Canada have been put under the NCE concept to pursue research in topics of ultimate interest to pulp, paper and allied industries.

Network of Centres of Excellence - Mechanical and Chemimechanical Wood Pulps Network

Salient Features:

1. Goal: To enhance quality and expand international markets of Canadian wood pulp, through the application of technology.

2. Specific scientific and technical objectives:

   - determine chemical composition and formation of organic material, imparting yellow colours to wood pulp, when exposed to heat and light;

   - develop chemistry to remove chromatophores in pulp so that the product made with it is whiter;

   - modify/develop new energy saving process to make pulp, which is stronger and possesses higher opacity;

   - outline engineering fundamentals of new processing technology; and,

   - develop computer controlled technology for making pulp, which would help in getting highly uniform products.

3. Duration of the project: 4 years (beginning August 1990).

4. Collaborating institutions (principal collaborators): 12 (34)
   Break up: UBC (7); McGill University (5); Lakehead and QUTR (4 each); PAPRICAN and McMaster University (3 each); NRC (2); University of Ottawa, Mount Allison, University of Western Ontario and Queen's University (1 each).

   9 universities, 2 federal research laboratories, 1 not for profit private research institution. [1]

5. Federal government contribution: $14 million from ISTC

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[1] Numbers of participants in the Network: 34 scientists, 34 graduate students, 9 postdoctoral fellows, 3 professionals and 8 technicians.

International Interaction of PAPRICAN:

- PAPRICAN maintains informal linkages with its counterparts, namely:

  - Institute of Paper Science and Technology, Georgia Institute of Technology (US);
  - Swedish Pulp and Paper Research Institute;
  - French CPT, Grenoble; and,
  - Domstead University (Germany), a leading authority on recycling of waste paper.

- PAPRICAN supports participation of its research staff in three to four professional meetings abroad and regular exchange of information.

- PAPRICAN allows its research staff to spend varying lengths of time (3 months-6 months-1 year) for training R & D work and to learn about the operation and maintenance of new machines.

- PAPRICAN interacts with three major suppliers of chemical pulping equipment (Kamyr-Sweden, US; Sunds Defibrator-Anland, Sweden; Beloit-US) on issues related to chemical pulping digesters.

- PAPRICAN has been able to secure assistance of subsidiaries of MNC besides Canadian Industry and Federal Government (ISTC - Regional Industrial Expansion Program) to establish Pilot Bleaching Plant.

- PAPRICAN's program on Pulp and Paper Biotechnology has close interaction with select research groups in US and Finland related to:

  - biological bleaching of wood pulp, using zylanase enzyme derived from a fungi I. veredei. This being successfully used by two mills in Canada.

  - biological degradation of lignin in association with researchers at Oregon Graduate Centre, Portland; University of Georgia, Atlanta; and USDA, Madison, Wis.

Relevance of PAPRICAN Model of R & D to India:

There has to be a unanimity of research needs and priorities amongst professional community industry, government research laboratories, teaching universities and engineering institutions. This concern is the precursor of bringing together of interests and pulling out the most relevant R & D support channels offered by federal and provincial governments, for furtherance of R & D tasks.

Each goal should be explicitly stated and should find support/confirmation of industry operating personnel. Wisdom of researchers has to be close to production requirements.

Very often informal interaction between universities and research laboratories, coupled with support of professional associations of industry in a given sector makes the task clearer for federal and provincial governments for their judicious, critical and marginal investments on R & D initiatives.

Bringing in strategic alliances on tasks related to 'product development' is not viable because of the competitive interests, nuances and returns anticipated.

Greater mobility is required between university faculties, research laboratory faculties and operating professionals in related industry. This ensures a total appreciation of basic science and engineering fundamentals - up to the operating elements of production systems.

DST is charged with promoting R & D in emerging areas of S & T, which cuts across a number of disciplines and institutions. In its endeavour for launching R & D initiatives in areas such as biotechnology, advanced materials, robotics and those related to upgradation of technology in manufacturing industries (transport equipment, telecommunications, textiles, power generators and transmissions, chemicals - drugs and pharmaceuticals, and steel) the above elements would be pertinent in chalking out its strategies.

Adequate exposure and greater linkages of researcher in laboratories to actual mill operations has to be the basis of identifying research problems and carrying out research projects.

Pulp and Paper at a Glance - National Significance

Pulp and Paper Production and GNP

GNP (1990)	Gross Production of Industry (1990)	Pulp & Paper Share %
$653,677 mill.	$22,750 mill.	3.48%

Pulp and Paper Exports and Canadian Foreign Trade

Total Canadian Exports (1990)	Pulp & Paper Exports (1990)	Pulp & Paper to Total Exports % (1990)
$140,989,297,000	$15,171,820,000	10.76% (second leading export item of Canada)
Breakdown: • newprint	$5,884,114,000	4.2
• wood pulp	$6,105,603,000	4.3 (predominantly bleached & semi-bleached softwood pulp)
• other paper and board	$3,182,103,000	2.3 (predominantly for printing & writing, container board

Growth of Pulp & Paper Industry

Total Forest Land (1986)	Total Area
4,533,000 sq.km.	9,971,000 sq.km.

Total Forest Volume (1986)	Forest Volume by Species
23,154 million cu.metres	Coniferous (spruce, pine, fir etc) 17,834 mill.cu.metres
	Decidious (poplar, birch, maple, etc.) 5,320 mill.cu.metres

WORLD FIGURES			
World Production of Wood Pulp			
Region	**Production (1988) (in tonnes)**	**Leading Countries & Their Production (in tonnes)**	**Apparent Consumption of Wood Pulp (in tonnes)**
North America	79,348,000	US = 55,530,000 Canada = 23,818,000	54,903,000 15,622,000
West Europe	32,094,000	Sweden = 10,074,000 Finland = 9,001,000	7,058,000 7,452,000
Asia, Africa, Oceania	16,889,000	Japan = 10,407,000 S.Africa = 1,284,000 India = 1,000,000	13,453,000 1,067,000
Latin America	6,757,000	Brazil = 4,375,000	
Others	16,783,000	USSR = 10,374,000	

World Exports of Wood Pulp by Countries

Region	Leading Country	Quantity Exported (tonnes) (1988)
North America	Canada	8,407,000
West Europe	Sweden	3,156,000
Latin America	Brazil	1,061,000
Africa,Asia,Oceania	New Zealand	483,000
Others	USSR	1,088,000

World Production, Export & Demand for Newsprint (selected countries, 1989)

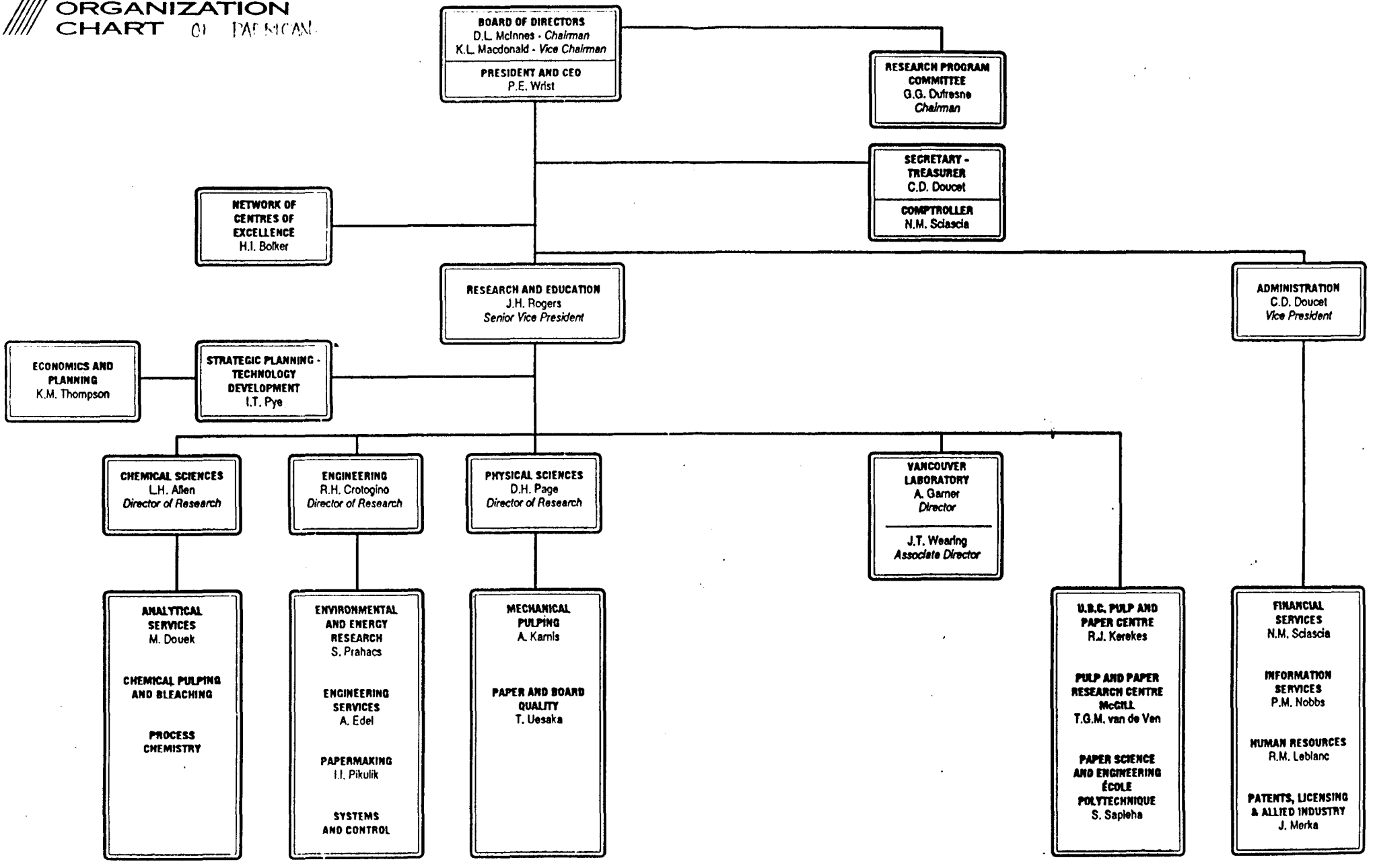
Country	Production of Newsprint (tonnes)
Canada	9,640,000
Japan	3,217,000
Sweden	2,173,000
USSR	1,800,000
Finland	1,182,000
India	300,000

Country	Export of Newsprint (tonnes)
Canada	8,466,000
Sweden	1,745,000
Finland	948,000
Norway	733,000
USSR	360,000

Country	Demand for Newsprint (tonnes)
US	11,982,000
Japan	3,554,000
UK	1,920,000
Germany	1,596,000
USSR	1,451,000
India	480,000

India's demand for newsprint and wood pulp is marginally more than its production.

ORGANIZATION CHART OF PAPRICAN



References

1) Reference Tables 1990, Canadian Pulp & Paper Association, 44th ed., Dec. 1990.

2) PAPRICAN Annual Report, 1991.

3) Report to Industry - Mechanical and Chemimechanical Wood Pulps Network Report, No. 2, Sept. 1991.

4) Accessing University Research - the Experience of Canadian Industry, J. Andre Polf, Management of Technology and Innovation Institute, March 1989.

5) Consultants report on UNDP project in India on 'Refining of Non-Wood Fibre Pulps', Nov. 1991.

6) Industry - Executives Seminar Proceedings, Dec. 1991.

7) Biotechnology in the Pulp and Paper Industry, M.G. Paice, L. Jurasek, R. Boubonnais, July 1991.

8) Canadian Pulp and Paper Industry Annual Report, 1990.

PRECARN (Industry driven initiative for precompetitive R&D)

- Canadian Institute for Advanced Research (CIAR) has been instrumental in establishing Precarn
- Striking features of Precarn (incorporated as not for profit organisation since May 1987)
    - Provides multi industry bridge to leading researchers in university & government lab
    - (The services and resource industry e.g. electrical utilities, petroleum, communications, mining industries have evinced greater involvement in Precarn as compared to manufacturing industry in Canada)
    - An industrial network with academic involvement
      (Bulk of Precarn members are broad cross section of users of technology. These industries are willingly drawn to the need for cooperation on longer term precompetitive high risk research in the field of Artificial Intelligence & Robotics)
    - An example before Government that long term research needs can be invested via industry
      (Unlike conventional way of directing it via university system)
    - The members and participants in projects under Precarn aegis and Government (Federal & Provincial) foresee advantages in 'collective approach' to - sharing of effort, experience, highly qualified research talent & avoidance of wasteful duplication of research effort as compared to 'individual strength'
- Precarn Membership
    - 33 industries are its members (These represent companies in a broad spectrum e.g. steel, petroleum, communications, aerospace, automobiles, electrical utilities, mining, brewing, pulp & paper). It includes 5 foreign MNC and 3 Canadian MNC)
    - 3 are its associate members (Federal Govt & Universities are included in this category. Federal Govt representatives being National Defence, Communications & NRC)
- Expected role of Precarn members
    - make annual investment to Precarn (Membership fee being $25,000/year)
    - sponsor research projects under the aegis of Precarn (designing of project, testing results)
    - participate in management of project
    - contribute to the research project (by way of committing its people, time & facilities for research)
- Privileges of Precarn members
    - regular briefing on all research programs
    - royalty free access to intellectual property developed in projects
    - advanced briefing on IRIS (a National Centres of Excellence - Institute of Robotics & Intelligent Systems)
- Role of Government
    - Source of funding [Present Pattern: Federal ([illegible]) = 46%; Provincial (Quebec, Ontario [illegible]) = [illegible]; Industry 34%]

[illegible]

* Role of Universities
  - Source in 130 most competent academic researchers located in select universities (including Univ of Toronto, McGill, UBC, Queens, Simon Fraser) for 22 research projects
  - participate as an academic network with industrial involvement under the National Centre of Excellence. Institute of Robotics & Intelligent Systems (IRIS)
  - provide leadership for projects under IRIS.

* On-going projects under the aegis/management of Precarn
  - 4 projects costing approximately $40M
    - Advanced Process Analysis and Control Systems: Begun in July 1990; For use in operation & control of pulp & paper mill Funds $9.3M over 5 years Lead Agency - Ontario Hydro Participants - 5 Precarn Members & Univ of Toronto
    - Intelligent Graphic Interface: Begun in Feb, 1991; To facilitate human interaction with complex real time monitoring & control systems in telecommunication pulp & paper mills & power distribution Funds $6.9M over 5 years Lead Agency - Participants - 9 Precarn members & Simon Fraser Univ
    - Autonomous Robot for a known environment: Begun in Sept, 1991 To develop mobile robot that can navig in known environment using maps & computer vision system Funds $7.1M over 4 years Lead Agency - Ontario Hydro Participants - 3 Precarn Members, Univ of Toronto & York Univ.
    - Telerobotics Development System: Begun in Jan 1992. To develop advanced telerobotic development test bed system Funds $11.5M over 5 years Lead Agency - MPB Technologies Inc (engaged in laser/fiber optics guidance sys Participants - 3 Precarn members, McGill Univ.

* The above projects satisfy following criteria
  - all are in the field of AI/Robotics
  - are longer term research investments
  - have at least 3 Precarn members as its sponsors
  - have built an effective & lasting university - industry linkages
  - are expected to contribute to Canada's industry understanding & applic of Technology

Ongoing projects under the aegis/management of Precarn (cont'd)

- Management of Institute of Robotics & Intelligent Systems (IRIS), one of the 15 NCE established in Nov 1989. Salient features of NCE are as under
  - Financed by NSERC worth $24M over 4 years
  - Puts 38 companies in close contact with 120 academic researchers from 20 Canadian Universities
  - Comprises of 22 University based research projects (in three areas: Intelligent robotic systems, computational perception & knowledge based systems)
  - 15 fellows of Canadian Institute for Advanced Research (CIAR) are providing leadership for 22 projects
  - Overall thrust of 22 projects has been basic research holding potential for industrial applications.
  - Closest equivalent to IRIS = Advanced Robotics Research Ltd, housed at University of Salford, UK. This organisation has 10 leading UK companies as an industrial consortium & receives federal input of £ 5M/year.

- Precarn Research Program Budget $60M (1991)

* Ownership of research results (Intellectual Property)
  - Could rest with Provincial Government / Lead Agency
  - Precarn only wishes to have royalty free access of research results.

* International contacts

  Precarn interests at present is to keep apprised of the state-of-the-art and ~~R&D~~ programs on intelligent manufacturing systems in UK, France, Japan, European Community (especially under the aegis of ESPRIT & EUREKA). Recently Canada & France exchanged latest endeavours in the field of AI / Robotics during a three days workshop at Ottawa May 17-21, 1992)

* Technology in Government versus industry's approach to innovation in high tech areas

Government	Private industry
• Decision making diffused	• Very focussed and clearly demarcated decision taking tasks.
• Wishes to plan safe & seeks assured winning options	• Willing to take risk, does not mind making mistakes.
• Prefers to stage decisions & often rues on strategic issues	• Since technology is changing fast, private industry seeks quick decisions from Govt (besides its own investments)
• Govt always wishes to mount [illegible] projects against a	

VISION 2000 Inc : Federal Initiative of Department of Communications

* Canadian strengths in Telecommunications
  - Canada has been amongst the world leaders in telecommunications includ personal communication technology. Canada's expenditure on telecommu R&D is 0.16% of GDP (1988) as compared to 0.3% of GDP by US, Japa & Germany.
  - World demand for telecommunication equipment = $100B
    World demand for telecommunication services = $400B
  - Canada has 4% share of world telecom market (1988) as per breakdown given
    Telecom equipment sale = $4B
    Telecom service sale = $16B
  - Canadian Communication & Information Technology Industry spends more em as compared to other industries in Canada.
  - Investment on telecommunication R&D by competing partners of Canada
    1987 US = $13B
    Japan = $4.7B
    Germany = $2.5B
    Canada = $850M

* Vision 2000 Inc :
  - A non profit organisation set up in 1989. 38 key Canadian Communicat & Information Technology Companies, research organisations, academia and select Govt depts are its members.
    (Private industry largely producers of technology are its members; includes 4 foreign MNC, 3 leading Canadian MNC & 4 Consulting Companies)
  - It aims at enhancing competitiveness of Canadian Communication indust (equipment & services) in global markets.
  - Specific objectives being to
    - facilitate and accelerate development and introduction of advanced personal communication technologies, services & networks (through building cogent consensus in private & public sectors)
    - develop better links amongst technology: markets, regulatory bodies & standards.

* Advanced Personal Communication (APC) includes
  - Convergence of telecommunication, broadcasting, Cable & information technology
  - Integration of data, text, image & vision
  - Easy to use portable multimedia terminals
  - Direct seamless connection of people & information
* Advantages of advanced personal communication technologies, networks & services
  - Enhanced productivity at work place
  - Improved efficiency of social services
  - Help people in sharing ideas, experiences & values
  - Increased enjoyment of leisure time

* Mode of accomplishing mission by Vision 2000 Inc

  Collaborating ventures among ~~university~~ industry, government & research community in University. 7 theme areas and 15 projects (R&D Consortia worth $ 30M have been identified in May 1991. The text of Memorandum of Understanding for these projects ~~to~~ are under finalisation. Deptt of Communications in participating in 11 of the 15 projects and are to share $ 7.7M in partnership cost. 2 labs namely Communication Research Centre, Ottawa and Canadian Workplace Automation Research Centre would be participating in the projects.

* Punch of R&D Consortia
  - Heavily ~~of~~ on diffusion of R&D i.e successful product commercialisation in global markets considering that enough has been invested on R&D focus by Canada on Communication & information technology
  - Lays emphasis on need for collective and coordinated response of Canada to the changing market structure offered by highly adaptive and aggressive competitors in the global markets.
  - Pooling effort is becoming imperative because the life span of product is becoming shorter as compared to huge investments & costs for technology development.

* Inherent weakness in R&D Consortia needed
  - The ~~users of~~ producers of technology as partners in R&D Consortia projects are finding difficulty in forseeing long term advantage & actions to Canada in the field of communication & information technology

SALIENT FEATURES OF CANADIAN R & D INSTITUTIONS AND FEDERAL PROGRAMMES STUDIED			
VARIABLE	**PAPRICAN**	**PRECARN**	**VISION 2000**
Position in research spectrum	•conduct research on common problems faced by pulp & paper mills •knowledge resulting from research has immediate application for industry	Conducts precompetitive research where knowledge generated on 'Intelligent Systems' is less immediately applicable.	Attempting at diffusion of R&D already done, to improve commercialization/better services to customer.
Range of industrial participation	Member companies=53 (all coming from single sector= pulp & paper mills) Commonality of uniform pulp mills	Member companies=38 (2/3 of its members are wide variety of users of technology representing several sectors)	Member companies=39 (all coming from single sector = telecommunications)
System devised for membership fee for industrial members to the organization/federal program	On pro rata basis $1.20/tonne of pulp & paper produced annually (25% reduction to this rate applicable if a company has 100 or more personnel doing R & D	$25,000/year (uniform membership fee regardless of size of the company)	On pro rata basis (private companies=$100,000/yr; univ., gov't. depts. & small companies=$1,000/yr.)
Role of government (w.r.t operational research fnopr. cost	Government is a minor source of funds (approx. 8% of the operation cost) Reason: created by industrial initiative	Government an important source of funds (approx. 20-30%) (Even though largely created by industrial initiative)	Initiative of Federal Gov't (degree of competition amongst member companies as participants is still much higher to prevent appreciation of value of cooperative research)
Role of university	Universities are involved - McGill, UBC, Ecole Polytechnique (smaller numbers of universities but having long term continuous interaction)	Interaction with large number of universities (at least 1 per project)	Does not involve universities at large
International contacts	Extensive	Limited	-
Number of on-group projects	80 + NCE (Mechanical & Chemi-mechanical wood pulps)	5 + NCE (Artificial intelligence & robotics)	None (10 broad project titles identified, collaborating partners being negotiated)

(8)

PART II RELEVANCE OF THE RMP IN INDIAN CONTEXT

COMPARISON OF SOCIO-ECONOMIC INDICATORS

		INDIA	CANADA
1.	GEOGRAPHIC SIZE (sq. miles)	1,266,595	3,849,000
2.	POPULATION - 1990 (Millions)	849.5	26.5
	% annual growth rate (1983-88)	2.0	0.9
3.	GROSS NATIONAL PRODUCT - 1989 (US$ Billions)	287	500
4.	GROSS NATIONAL PRODUCT PER CAPITA - 1989 (US$)	350	19,020
5.	AVERAGE ANNUAL RATE OF INFLATION (1988-90)	7.9	7.1
6.	LIFE EXPECTANCY AT BIRTH (Years)-1990	59	77

7.	AGRICULTURAL COMMODITIES	Rice, Sugar, Tobacco, Coffee, Tea, Wheat, Coarse Grains, Cotton, Oilseeds, Vegetables, Fruits, Spices, Jute, Fish	Wheat, Barley, Maize, Canola, Oats, Fish, Livestock (cattle) & Products, Timber, Newsprint, Pulp & Paper Boards
8.	MINERAL RESOURCES	Iron Ore, Coal, Mica, Bauxite, Gypsum, Manganese	Nickel, Zinc, Sulphur, Asbestos, Potash, Copper, Lead, Iron Ore, Coal, (Bituminous variety) Uranium
9.	MAJOR INDUSTRIES (Output US $Millions)	Machinery & Transportation Equipment (18,899) Textiles & Clothing (11,630) Chemicals (10,452) Food & Agriculture (7,996) Gems & Jewellery	Machinery, Transportation Equipment (42,765) Newsprint & pulp Food & Agriculture (25,659) Chemicals (15,395)
10.	EXPORTS - 1990 (US$ Millions)	17,967 (Partners: US, USSR, Japan, UK)	125,056 (Partners: US, EC, Japan)
11.	IMPORTS - 1990 (US$ Millions)	23,692 (Partners: Japan, US, Germany, UK)	115,882 (Partners: US, EC, Japan)
12.	TRADE BALANCE - 1987-88 (US$ Millions)	- 5,777	8,881

SCIENCE & TECHNOLOGY INDICATORS

INDIA

R&D FUNDING

1.	NATIONAL INVESTMENT ON R&D (1988-89)	Rs 3471.81 crores (approx. US$ 1926 M)
-	Break down:	
	·Central Government	Rs 2513.79 crores (72.4%) (approx. US$ 1396 M)
	·Industry (895 private industrial units & 121 public sector units)	Rs 725.11 crores (20.9%) (approx. US$ 401 M)
	·State Government	Rs 232.91 crores (6.7%) (approx. US$ 129 m)
2.	% OF GNP DEVOTED TO R&D (1988-89)	1%

3. MAJOR SCIENTIFIC DEPARTMENTS & AGENCIES = 14

Defence of Research and Development Organization (DRDO)
= Rs 580 Cr (approx. 26.7%)

Department of Space (DOS)
= Rs 415 Cr (approx. 20.0%)

Department of Atomic Energy (DAE)
= Rs 300 Cr (approx. 14.0%)

Council of Scientific and Industrial Research (CSIR)
= Rs 210 Cr (approx. 9.8%)

Indian Council of Agricultural Research (ICAR)
= Rs 200 Cr (approx. 9.3%)

Department of Science and Technology (DST)
= Rs 160 Cr (approx. 7.2%)

Department of Environment (DOEn)
= (approx. 6.8%)

Others (ICMR, DNES, UGC, DOD, DBT, DOE, DOEdu)

4. INDUSTRIAL R&D EXPENDITURE (PUBLIC & PRIVATE): 1988-89 = Rs 697 Crores

Breakdown (Industry Group Wise): 1988-89

* Defense Industries	= Rs 129.70 Crores
* Electrical & Electronics	= Rs 118.03 Crores
* Metallurgical Industries	= Rs 74.93 Crores
* Chemicals (other than fertilizers)	= Rs 66.65 Crores
* Drugs & Pharmaceuticals	= Rs 56.00 Crores
* Industrial Machinery	= Rs 29.66 Crores

(1 Crore = 10 Million)

5. STOCK OF S&T PERSONNEL (1990) = 3,809,000

* SCIENCE	= 2,620,000
* ENGINEERING	= 1,189,000

(Science - includes Bachelors Degree & above
Engineering - includes Diplomas and Degree holders)

MANDATE OF DEPARTMENT OF SCIENCE & TECHNOLOGY (One of the three constituent Departments of Ministry of Science & Technology)

Includes:

* Formulation of policy statements & guidelines on S & T and their implementation

* Promotion of new ares of S & T (e.g. materials science, biotechnology)

* Coordination of areas of S & T in which a number of Indian Institutions/Departments have interest & capabilities

* Coordination of activities related to international S & T collaborations (other than atomic energy & space)

* Grants to national research institutions, scientific associations and bodies

* Coordination of multi-institutional, inter-disciplinary activities in S & T

MAJOR CHALLENGES IN MANAGEMENT OF S&T IN INDIA

- Commercialisation of S&T (Transfer of technology from lab to industry);

- Securing greater investments and efforts on R&D by the private sector;

- Establishment of economically gainful joint R&D ventures;

- Evaluation and impact assessment of research support and management of national programs;

- Strengthening of infrastructure in emerging areas such as biotechnology, advanced materials, lasers, artificial intelligence;

- Alliances amongst universities, government research labs and private industry for production of value added goods & services;

- Earning of revenue by Government Research Labs from industry (research contracts)

DESIRABLE STEPS IN ORGANIZING FUTURE R & D PROGRAMMES IN INDIAN CONTEXT (based on preliminary visits under the RMP)

* Technology needs to be developed in greater consultation with requirement of industry / customer.

* Adequate communication between industry & researcher in government/university has to be established from project planning stage to marketing.

* Working relationship between industry & university is gradual process often requiring 5-10 years of continuous interaction.

* Industry led postgraduate courses provide better direction to university education.

* Having people, time & facilities of private sector committed for alliance mode of product development tasks is of utmost significance.

* Greater movement of researcher across university, laboratories & industry must.

Insights would be useful for DST in reviewing the Technology Policy Statement (TPS) and developing programs under the Advanced Material Research Board – an autonomous structure for R&D in the area of new materials

PROSPECTS OF INTERACTION BETWEEN INDIA & CANADA (Tentative Views)

AREAS

1. Technologies important because of geographic size

   - Telecommunications
   - Remote sensing

2. Technologies important because of abundance of natural resources

   - Agriculture (Oilseeds, Pulp & Paper, Livestock & products)
   - Hydro power generation
   - Metal & mineral processing

3. New and emerging technologies

   - Biotechnology (Oilseeds, Livestock, Chemical & Pharmaceuticals)
   - New materials (Biomaterials, Engineering materials)
   - Intelligent systems (Robotics, AI, Neural Networks)

NATURE OF ACTIVITIES

* Establishing capacity in long distance communication
* Joint ventures, cooperative R&D projects
* Participation in R&D consortia/networks of Centres of Excellence
* Training of S&T manpower

INDIAN AGENCIES

DST, DBT, ICAR, ICMR, CSIR, DOE, DOEn, Ministry of Energy, Mines & Communications, Department of Economic Affairs

CANADIAN AGENCIES

CIDA (CPB, NGO); IDRC (Cooperative Projects Research groups); NSERC (Fellowship programs & NCE); ISTC (Technology innovation & research networks, Scholarships & Special project groups); NRC; Ministry of Communication (Research & Spectrum Group); PRO, Ontario Technology Fund; PAPRICAN, PRECARN, CEA; ONTARIO-HYDRO; CANMET; CCRS; AUCC

IDRC - CIDA - INDIA INTERACTION

IDRC & CIDA - LEAD AGENCIES RESPONSIBLE FOR DELIVERING CANADA'S ODA

- TO DATE, CIDA HAS CONTRIBUTED TO ENERGY & ENVIRONMENT SECTOR IN INDIA BESIDES COMMODITY ASSISTANCE PROGRAM (INCLUDING WHEAT, POTASH, AND SULPHUR).

- IDRC HAS CONTRIBUTED TO AGRICULTURE, HEALTH & INFORMATION SCIENCES SECTOR IN INDIA. * PRESENT TRENDS SUGGEST GREATER FOCUS/REORIENTATION OF INVESTMENTS ON PARTNERSHIP PROGRAMMES INVOLVING MUTUALITY OF INTEREST AND SUSTAINABILITY BEYOND THE TERMS OF PARTNERSHIP PROJECTS BY IDRC AND CIDA.

*(In view of this in-depth case, studies would be required as a follow-up to arrive at commonality of interest as equal partners.)

SALIENT FEATURES OF INDIA'S EIGHTH FIVE YEAR PLAN 1(1992-1997)

LAUNCHED ON APRIL 1, 1992

DESIGNED TO:

- STRENGTHEN ITS INFRASTRUCTURE
- TACKLE UNEMPLOYMENT, ILLITERACY, & POPULATION
- OTHER MAJOR THRUST AREAS AGAINST BACKGROUND OF ECONOMIC REFORMS INCLUDE

  * Energy
  * Transport
  * Communication
  * Irrigation

CANADIAN AGENCIES – for future contact.

- IDRC (research program group)
- CIDA (Canadian Partnership Program, Non-Governmental Organization)
- NSERC (Fellowship programs; Network of Centre of Excellence)
- ISTC (Technological innovation & Research Networks, Scholarships & Special project groups)
- Ministry of Communication (Research & Spectrum Group)
- Provincial Research Organization (APRO, Ortech International)
- Provincial Government (Ontario Technology Fund)
- Provincial Research Organization (Ortech International, Ontario Technology Fund)
- PAPRICAN
- Precarn
- CEA & Ontario Hydro, CANMET, CCRS
- AUCC