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Accessing University Research

The Experience of Canadian Industry

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ACCESSING UNIVERSITY RESEARCH

The Experience of Canadian Industry

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PREFACE

It is indeed a pleasure to introduce the first joint publication supported by the International Development Research Centre (IDRC) and the Management of Technology Institute (MTI) at McMaster University, on a subject of mutual concern. MTI is a newly created institute to promote research and teaching in the various aspects of technology management, including management of research. While the interest of MTI in the area of corporate strategies for interacting with Canadian universities is an obvious one, for the IDRC it may appear unusual. Why should the International Development Research Centre - an organization dedicated to the financing of applied research in the developing world - be interested in Canadian corporate behaviour with respect to technology transfer from Canadian Universities? The answer flows from the conjunction of an important set of policy discussions within IDRC on its own corporate behaviour with a realization that there is a potentially important gap in contemporary Canadian science and technology policy research.

The IDRC policy discussions stem from a heightened concern to better understand the processes surrounding the utilization of the outputs of research. IDRC, in its 18 years of existence, has seen as its primary goal the creation of opportunities for applied research to be done in the developing world by scholars and scientists from those countries. The Centre has recently taken a conscious policy choice to increase the emphasis which it places on seeking to influence the course of economic and social development through its sponsorship of research and research-related activities. It is exploring possible courses of action which it could pursue in order to increase the probability that the outputs of the research which it supports will make some positive contribution to the processes of economic and social development.

As part of this policy development process, IDRC has sponsored studies on utilization of research outputs in the developing world[1] and is now organizing a series of workshops, around the world, to discuss a wide variety of university-based institutional innovations designed to capitalize on the universities' own research outputs.

During the preparations for these workshops, a review was undertaken of the work done in Canada under the broad heading of "University-Industry interactions", and especially of the extensive range of studies and enquiries which led up to the Science Council of Canada's Report No. 39 entitled "Winning in a World Economy - University-Industry Interaction and Economic Renewal in Canada", (April 1988). Many of the insights which have

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1 See for example, IDRC Manuscript Report 188e, "Case Studies on Indigenous Industrial R & D Utilization" by N.C.B. Nath and Lokesh Misra, April 1988.

universities and especially to those in countries with a significant, organized corporate sector such as the member countries of ASEAN, or India, or some of the larger countries of Latin America.

It was during the analysis of this literature, which is complemented by similar bodies of work in other industrialized countries and by the work of OECD's Committee on Science and Technology Policy,[2] that it became apparent that the dominant theme of study was on the changes which could be made, or the strategies which could be adopted, by the universities to improve the functioning of the university-industry interface. Little attention seems to have been devoted to the strategies which might be adopted by industrial enterprises as they seek to capitalize on the knowledge generated by research within any university system.

The present volume is the result of a first, preliminary foray into the field of corporate strategies for harnessing the output of Canadian universities. Completed, as it was, in a period of a little over three months in the Spring and early Summer of 1988, the main purpose of the study was to provide an initial sketch of the behaviour and motivations of a small sample of research-intensive enterprises. In the Canadian context, it should serve to highlight some researchable issues and it would be interesting to carry out some comparative evaluations to attempt to gauge the results of some of the strategies revealed. In the developing world context, it may stimulate thinking about the strategies - if they exist - of a variety of institutions which should use the outputs of university research, be they enterprises, parastatals, government ministries or even NGOs.

Not all the approaches used in Canada will be completely transferable to all countries. However, the basic theme of this report - the closer the link between industrial scientists, university researchers, and the better and more profitable the relationship - is likely to be crucial, irrespective of the organization or its environment.

James Mullin
Vice-President, Programme

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2 See, for example, "Industry and University: New forms of Cooperation and Communication" : OECD, Paris, 1984. or "Universities under Scrutiny" : OECD, Paris, 1987.

INTRODUCTION

From the moment science policy has been debated in Canada, voices have been raised urging that university research and expertise be used on behalf of Canadian industry. The Cronyn commission, the first parliamentary enquiry into science and research in Canada, raised this question as early as 1919 (1), and the issue has resurfaced repeatedly since that time.

Behind the call to greater collaboration between universities and business is the expectation that the scientific knowledge and expertise of Canadian universities could be used to improve the performance of Canada's firms.

In the last five years, a number of government initiatives have been announced to encourage such links. For example, both at the federal and provincial levels, governments provide matching funds for university-based research projects initiated and partly funded by industry. Some of these university-industry programs, including the funding of industrial research chairs, are managed by federal government granting councils, such as the Natural Sciences and Engineering Research Council (NSERC) (2). Similar programs are managed by the provinces.

Another noteworthy initiative is Ontario's creation of centres of excellence. These research centres usually involve several universities and are financed by a consortium of companies with matching government funds. As a rule, they focus on strategic areas such as microelectronics and advanced materials. The federal government recently applied this approach on a national scale.

While the literature on the subject is extensive, two recent reports are worth noting. In 1985, the Corporate Higher Education Forum (CHEF), a group of approximately sixty chief executive officers from Canada's largest corporations and universities, published a report called "Spending Smarter" (3), dealing with corporate-university cooperation in research and development. The report focused on how to improve collaborative scientific research between the two communities. After suggesting ways of resolving a number of contentious issues, it concluded that collaboration is beneficial for both parties.

The Science Council of Canada, a federal advisory body dealing with science policy, conducted a four-year study of how universities can improve mechanisms for technology transfer and contribute more to industrial competitiveness. In May 1988, the Council published its report "Winning in a World Economy" (4). Its recommendations address a number of managerial and institutional changes, mostly in universities, which would improve the transfer of technology from universities to Canadian industry.

SCOPE OF PRESENT STUDY

The focus of the present report is somewhat narrower. It reviews measures taken by selected Canadian firms to transfer and receive technology from universities. All the firms studied either have a significant in-house research and development capability, or are very dependent on research. They have all benefited from university research.

The premise of this study is that companies need the scientific and technical resources found in universities, to meet their business targets. The study's objective was to discover how each of the selected companies managed the transfer of technology from universities, in order to determine which approaches worked and which did not.

In-depth interviews were carried out with some thirty senior industry executives, all of them users of university research. (See appendix A for summaries of the interviews, and Table 3 for a summary of company data. Table 2 lists the type of links used by the companies in their collaboration with universities.)

The collective managerial experience of these executives was distilled into a set of guidelines or principles (see Table 1). Most of these conform to common sense, but they should help other companies and managers to establish more effective R&D links with universities.

The one overriding conclusion of these observations is that the closer the relationship between a university researcher and an industry scientist, the more profitable it is for all parties.

Each company, of course, approaches a university somewhat differently, depending on the nature of its business and the role that technology plays in its strategy (see Tables 2 and 3). For example, an aggressive research-driven company such as Allelix, with a strategy of acquiring proprietary technology based on genetic engineering and biotechnology, is vigorously pursuing university contacts in relevant areas. A more mature company such as STELCO, one of Canada's largest steel maker, is interested in nurturing a core of internationally recognized steel experts in selected Canadian universities, and will probably pursue entirely different contacts as it diversifies into new businesses.

Some industries approach relations with universities on a sectoral basis. The Mining Industry Technology Council (MITEC), a newly-created body sponsored by all the mining companies in Canada, will serve as an intermediary or facilitator between the industry, government, and mining and metallurgy departments in universities. It hopes to identify major research projects that will improve the competitiveness of the Canadian industry, raise funds for these projects, and select the key performers. A similar role is played by the Institute for Chemical Science and Technology (ICST) described in one of the case studies in Appendix A.

METHODOLOGY

This study is based on interviews with more than thirty senior R&D and Technology executives from fourteen Canadian corporations and institutes. The list of interviewees is presented in Appendix "D", and the questions used as a guide in these interviews are given in Appendix "E". A number of interviews were not included because data was unavailable, time constraints, or because the company did not wish to be the subject of a case study. To preserve confidentiality, unattributed quotes are used in a few cases.

Fourteen cases have been prepared, and are presented in Appendix "A". All financial data, except where indicated, are for 1987, and are in Canadian dollars. From these cases, and other interviews, eight management principles were extracted and summarized in Table 1. The information in the cases is not disguised and has been vetted by company officials.

TABLE 1

EIGHT PRINCIPLES FOR SUCCESSFUL R&D LINKS WITH UNIVERSITIES

1. Define your strategic objectives for R&D links with universities
   . short-term problem solving
   . long-term technological capability

2. Screen and select your university partners: experience and compatibility

3. Familiarise university researcher with your industry and management practices

4. Clearly define the deliverables when preparing research contracts

5. Provide incentives to academic researchers: financial rewards and material support

6. Managing the relationship: monitor links closely

7. Protect your investment: negotiate a fair sharing of intellectual property

8. Develop longer-term strategic links

HOW COMPANIES MANAGE THEIR R&D LINKS WITH UNIVERSITIES

Interviews with thirty R&D executives yielded information about the management practices used by their companies to transfer technology from universities. These practices were then distilled into guidelines or principles presented in Table 1, and discussed below. These principles are not commandments, but rather generalizations, grouped under eight headings, that work for our selected companies.

Principle 1: Define your strategic objectives for R&D links with universities

There are at least a dozen ways the companies interviewed interact with a university (see Tables 2 and 3). Each of these links, be it an R&D contract, an equipment grant, or a company's contribution towards a university chair, represent a resource expenditure. The extent to which these projects are part of an overall plan and a well-defined technology need will determine their effectiveness. All the firms interviewed had a clear understanding of why they maintained relations with the university research community (see Table 3). These objectives fall into two broad categories, short-term problem solving, and long-term strategic capability.

<u>(a) Short-term problem solving</u>

A company will often seek out an expert or access a facility in a university to solve a particular technical problem. This is usually because the company does not wish to invest in that capability. This is generally the case for small companies that cannot afford their own research facilities, for large companies that will only want to use that capability for a short time, or for companies, like GM Canada, where most of their R&D is carried out by their parent company.

Asked why GM Canada would use university researchers, Carl Wintermeyer, its Manager of R&D, replied: "University-based projects are relatively easy to start, and despite the overhead of 65% that the universities usually charge, are usually cheaper than doing it in-house. There's a number of federal and provincial government programs that will contribute up to 50% of the costs of university-industry research. Then there is also the synergy that is set up between the university researcher and the GM engineer." For GM, these projects generally last a year.

Jeff Edington, Alcan's Vice President responsible for its three research centres, justifies links with universities as follows: "It gives us access to very bright people and highly specialised equipment which would be uneconomic for us to employ or own, particularly if we require them only for a relatively short period of time, such as three years. It also allows us to hire very good people into our research centres."

(b) Long-term technological capability

Problem solving is not the only need, however. The companies interviewed spend considerable effort on maintaining longer-term links with particular universities to meet a number of strategic needs: developing a basic research capability to support their own R&D, accessing a world-wide network of university scholars, and training and hiring skilled graduates.

One executive from a large R&D company describes his company's links with universities as a strategic partnership: "We view universities very much like a major supplier, and we want to build the best possible link to access the knowledge, recruit the top graduates, and help develop our managers in the field. We want to make that supply as reliable as possible." That company's strategy for building university links arises out of its very ambitious growth targets.

i. Developing a supporting R&D capability in basic research

A key strategic reason behind developing a long term relationship with the university community is to enhance a company's capability in basic research to complement its own, more development-oriented work. For example, Connaught Laboratories, Canada's largest producer of vaccines, recognizes this clearly. "We don't have the resources for basic research," says Keith Dorrington, Connaught's Vice President for Research and Development. "Our in-house efforts are more applied and product-oriented, so we need to identify basic research capabilities, or the more basic side of the R in the R&D, within universities. We use our university links primarily as a mechanism for gathering technology."

ii. Accessing a world-wide network of university scholars

Closer ties with a university researcher may not only result in a research contract. They can also open channels to much softer information transfer, based on that researcher's contacts with his peers around the world. These network-based contacts can be especially valuable if the researcher has an international reputation. Fast growing high-technology firms like Connaught, BNR, and Allelix are very much aware of these links.

Ted Rhodes, Vice President of Technology for Polysar, one of the world's largest producers of synthetic rubber, also recognizes the usefulness of university networks: "A major source of information on polymers is in universities. So you scan the universe, and find oases or islands of expertise, and develop whatever link is necessary to get that information."

iii. Training and hiring skilled graduates

Universities can be considered as the source of trained graduates and future employees. This is particularly vital for some high technology companies which have set ambitious growth targets. They need a steady supply of new employees, and look upon their access to a pool of highly qualified graduates as a "strategic weapon". In fact, Bell Northern Research uses the number of graduates hired from a particular university as an evaluation criteria in assessing its links with that university.

The Pulp and Paper Research Institute (PAPRICAN), a research centre supported by all major pulp and paper producers, adopted a somewhat different approach. Ten years ago, PAPRICAN and its industrial advisory board recognized the industry's need for engineers trained in pulp and paper-making technology. Normal engineering degrees do not cover these areas in sufficient detail. In cooperation with two major universities, PAPRICAN developed a one year course-oriented Masters of Engineering degree that meets the industry's requirements.

Recruiting needs are common to all the companies interviewed and are generally a significant component in their university relations.

Principle 2: Screen and select your university partners: experience and compatibility

Once a company understands why it needs the research resources found in universities, the next step is to chose the best possible partner. The selection criteria should include both the expertise that matches the need, and compatibility.

The matter of expertise is not trivial, since some of the executives interviewed had encountered instances of misrepresentation. These included cases where an academic promised more than he could deliver, or claimed to have skills and knowledge which did not exist. These issues as a rule can be clarified early in a relationship.

The question of compatibility is more subtle. Jock McKay, director of R&D for STELCO, Canada's largest steel maker, admits that not all professors are suitable for work with industry. The choice is usually based on personal compatibility and genuine interest in the industry's problems. There is usually a middle ground between purely theoretical work and the applied problems of industry. "You don't want clones of industry," warns Jock McKay, "you want them to keep their fundamental outlook, and to stay with a problem as long as they feel it is necessary." Stelco has close ties with about ten of Canada's leading universities. Jock McKay was able to refer to some twenty university professors that he dealt with by their first names. "You have to be selective in choosing who you're going to work with," he says. "The ones we deal with are of the highest repute, and many have won international awards for excellence in science."

In the case of Connaught, "our experience in these contacts has been very good," observes Keith Dorrington. "In almost all cases we knew the individual very well before we started collaborating. We chose university researchers who are not only interested in research, but with whom we felt comfortable. It is necessary to evaluate the university partner's role in a project, and assess to what degree he is interested in working with the company for a common goal, rather than just for the money. That's the key to good collaboration."

Several companies actually go through a process of screening universities with which they want to work. BNR's screening process begins with qualifying a university, based on its interest in technologies of importance to the company, the quality of its existing research, and the suitability of its students as potential recruits. The next phase is to develop a "one-on-one" relationship with a university professor. A first contact can be established in a number of ways, through a campus visit by someone from the company, or a meeting at a conference, or even through a referral from someone else in the company's network. After two or three meetings, a link is established with the appropriate technical manager in the company. This personal one-on-one link between a manager and a university professor is crucial to the program, and sometimes takes four to five years to mature.

Principle 3: Familiarize university researchers with your industry and management practices

Most executives recognize the need to bring the university researcher closer to the industrial environment. This is essential if the researcher is to make a useful contribution. According to Alcan's Jeff Edington, there is a need to educate university researchers both in the conditions and processes of operating plants, as well as in project management techniques. A university researcher has to be acquainted with the discipline of milestones and deliverables, if he is to interface professionally with industry researchers and engineers. This process can take from three to five years. Moreover, a university researcher has to be thoroughly familiar with working conditions in the plant. Otherwise, says Edington, his research solutions will be totally impractical.

Ted Rhodes, Polysar's Vice President of Technology feels that collaboration with university researchers should continue throughout the entire development process. It should not end with a bench-scale laboratory demonstration of a process. When the company develops the pilot plant for the process, and scales it up to do some preliminary market testing, the professor should also be involved, either in the pilot plant, or as a consultant. It is this close interaction that can often be tremendously beneficial to both parties, says Rhodes.

Principle 4: Clearly define the deliverables when preparing research contracts.

Valuable exchanges can occur between university and industry scientists, through consultations, seminars and discussions. On signing a contract, however, it is important that the deliverables be defined clearly and understood by both parties. A deliverable is the output of a research between a company and a university, see Appendix B. The contract covers not only payment modalities, but deliverables, and intellectual property.

Alcan's Jeff Edington admits that his company could do a better job of spelling out deliverables and defining projects more clearly before handing them over to universities for contract work. "We need to define our problems clearly enough so the research results can be useful to us", he says.

Peter Tarassoff, Director of Noranda's Research Centre in Montreal, agrees: "You have to specify all the deliverables, and don't leave any loose ends. It's important to have both parties understand what is expected from the agreement."

For Don Mills, Director of R&D at Ontario Hydro, there are two requirements for a successful university-based project: the deliverables are well defined, and there are no tight time constraints. A good example is the metallurgical problem of characterising the behaviour of hydrogen in zirconium, a metal used in pressure tubes for the CANDU nuclear reactor. This problem was given to a professor of metallurgy, who worked on it for several years, and in the process generated valuable data, not to mention good thesis material. Generally, "real-time" problems in an operating plant are not referred to a university. "The research results would not be useful to an operator," says Mills.

Finally, there is the risk of defining deliverables too tightly, so that an academic will feel overly constrained. Les McLean, STELCO's Vice President of Technology, believes that "if you bring a professor to work in the STELCO R&D lab, and have him work on rigidly defined projects with strict timetables and milestones, then it's not likely to work. You can't tame a professor and tell him what to do."

Principle 5: Provide incentives to academic researchers: financial rewards and material support

There are a variety of ways in which a company can provide incentives to a university researcher, in addition to covering his or her direct costs.

"Good university professors cost money," says Alcan's Jeff Edington. As part of the incentive package to gain the best possible cooperation from a professor, Alcan will often supplement the costs of a contract with a consulting fee.

Stelco grants fellowships to graduate students with outstanding records. The fellowships are in the form of a substantial cash award to the student, to supplement scholarships from a government granting council. Stelco will also assist the winning students' professors with a donation of experimental equipment.

A good example is offered by a project on modelling the flow of molten steel to study wear patterns in a vacuum degassing unit, a key step in steel manufacturing. Stelco gave a fellowship to a McGill student. The company's

A good example is offered by a project on modelling the flow of molten steel to study wear patterns in a vacuum degassing unit, a key step in steel manufacturing. Stelco gave a fellowship to a McGill student. The company's research lab also designed and manufactured a high-precision plexiglass model of the vacuum degassing unit for his professor as part of the fellowship. Water, which in scaled-down models behaves almost identically to molten steel, was used to simulate the flow patterns. This equipment allowed the university professor and his student to model and perform calculations predicting the flow of molten steel and the wear patterns as they would occur in the full-scale unit. The plastic model, costing several thousand dollars, would have been very difficult to build in the university machine shop.

For Allelix, a Toronto biotechnology company, successful collaboration must occur on both an intellectual and a material level. It may include providing supplies, chemicals, consulting fees, and even sending a graduate student to a conference to seek out information.

Principle 6: Managing the relationship: monitor links closely

The single strongest theme emerging from the interviews is the need for close links between a company and a university researcher. These projects must be closely monitored.

Polysar's Ted Rhodes, formerly a professor of chemical engineering, says that most failures can be tracked down to inadequate monitoring by the industry scientist. "A good researcher must be at the university at least once every six weeks, and the university researcher should be visiting the company just as often. The best collaboration happens when the two scientists work closely together." The worst form of collaboration happens when money is awarded, with no real interest on the part of the company, other than a vague hope that something useful will happen.

"These links do not work well if you just give a project to a researcher, and hope that he will come back with the results when he's finished," says Murdoch McKinnon, CAE Electronic's Director of R&D. "You need to give him direction and manage him throughout the project."

For BNR, each university relationship is carefully managed and monitored regularly in terms of its usefulness to the company. Evaluation criteria include the strategic importance of the technology to the firm, the company manager's enthusiasm for working with a particular professor, and the usefulness of the university in supplying students for hire.

In commenting about university contacts within Alcan, Jeff Edington says: "These contacts have to be done professionally, they require a lot of time -- up to 10% of a project leader's time -- and they are not cheap."

Edington stresses that the contact person for Alcan must be the person who will use the university research results, and that the selected university researcher must be of the highest quality. "The three ingredients for a successful university collaboration are financial incentives, intellectual excellence, and closeness between the two parties at all times," concludes Edington.

Not all university-industry links are successful. Every year, companies will abandon a few of these joint projects. "We are not a charitable organization", emphasizes one senior executive.

Principle 7: Protect your investment: negotiate a fair sharing of intellectual property

Intellectual property, patents and licensing are some of the most sensitive and contentious issues in all university-industry collaboration. Simply put, both parties have fundamentally opposite motivations for doing research. On the one hand, the university researcher is interested in publishing and disseminating the fruit of his labours for recognition and promotion. On the other hand, the firm is interested in protecting its discoveries through secrecy agreements, patents, or exclusive licenses, in order to maintain a strategic advantage over its competitors. As a rule, companies are not interested in investing heavily in ideas that are already in the public domain, since they are unlikely to yield any competitive advantage.

Nonetheless, as university-industry collaboration becomes more prevalent, both communities have been moving towards an understanding. Universities are becoming more sophisticated in appreciating the commercial value of research results, and corporations have learned some of the imperatives of the academic world. A number of working arrangements have been devised, and include for example:

(a) provisions for a university professor to publish any results from an industry contract, provided the information is first cleared by the company, and adequate protective measures such as patent applications, have been taken;

(b) allowing the ownership of a patent remain with the professor or the university, but giving the company an exclusive right to use the technology, in return for a licensing fee;

(c) keeping patent rights with the company, but giving the university or researcher a royalty fee.

There can be several variations on these arrangements, depending on the university's approach to intellectual property, or a company's policies.

An increasing number of university researchers are also agreeing to sign confidentiality or non-disclosure agreements, in order to have access to a company's proprietary scientific information. These agreements seek to protect a company from having its carefully acquired technology "leak" through university channels to their competitors.

Corporate-university research collaboration is changing some of the traditional norms of scientific behaviour. The environment is shifting from one of unrestricted flow of information, to a new norm of "limited secrecy".

Principle 8: Develop long-term links

The benefits of longer-term strategic links between a company or industry and the university research community should be obvious from the preceding principles. Through such links, companies can develop a capability in basic research, which will complement their own developmental efforts; through their university links, they can access a world-wide network of university scholars; and they use these links to recruit some of the best graduates. To enjoy these benefits, however, requires careful nurturing and long-term commitment. For example, PAPRICAN's links with McGill University in Montreal go back to 1925 and last year the two organizations signed a new administrative agreement outlining their ongoing educational and research collaboration (see Appendix "C").

SUMMARY

Table 2 lists a selection of long-term measures adopted by the companies interviewed in this report. These measures are not comprehensive, nor are they mutually exclusive. Some measures will fit the needs of a corporation better than others. Examples of how these measures are used in practice are given in the case studies contained in Appendix A. Table 3 shows the mix of university links adopted by each of the companies interviewed, as well as the rationale or objectives for these links, as stated by company officials.

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(1) "A Science Policy for Canada", Report of the Senate Special Committee on Science Policy, Chairman: Hon. Maurice Lamontagne, Vol.1, 1970.

(2) "Awards Guide", Natural Sciences and Engineering Research Council of Canada, September 1987.

(3) "Spending Smarter", Corporate Higher Education Forum, 1985.

(4) "Winning in a world economy", Science Council of Canada Report no. 39, April 1988.

TABLE 2

FOURTEEEN STRATEGIC LINKS FOR UNIVERSITY-INDUSTRY R&D COLLABORATION

Based on data from case studies

1. Develop a program for contracting research to universities or supporting research through grants.

2. Sponsor a university chair alone, jointly with other companies or with the support of government, in a relevant industrial discipline.

3. Support graduate students to do industry-related research.

4. Hire summer or co-op students to work in the company.

5. Provide support for Post-Doctoral fellows to do research on company premises.

6. Provide facilities and support for university professors to do research on company premises.

7. Allow company scientists to hold part-time university appointments.

8. Set up a management structure in the company with explicit responsibility for university links.

9. Give responsibility to a senior executive for specific university links.

10. Participate in university-based centres of excellence.

11. Have a major input into a degree-granting program.

12. Contribute research equipment to a university.

13. Allow company employees to pursue advanced research degrees.

14. Have a scientific advisory board composed of distinguished university professors

TABLE 3: SUMMARY OF CASE STUDIES: COMPANY DATA

Company	Total Sales ($)	Total R&D ($)	No. of Employees	No. of R&D Employees	Level of Univ. Effort ($)	Types of University Links	Strategic Objectives for University Links in R&D (Why company is pursuing links)
Bell Northern Research	-	660 million	6,000	6,000	2-10 million	1,2,3,4,6, 8,10	- access to technology - strategic supply of graduates
Alcan Aluminium	6.8 billion	115 million	63,000	700	1 million (est.)	1,2,3,4,5, 10	- complement expertise in research centers - hiring of good scientists for laboratories
Pulp and Paper Research Inst.	not for profit	24 million	360	360	3 million	1,2,3,4,5, 6,7,8,9, 11,12,13	- selective long-term collaboration with three universities, to complement own effort - training of qualified operators/managers for plants - training of scientists - basic research in relevant areas
SEMEX Canada	21 million	400,000	40	0	400,000	1,2,3,7,9, 10	- very cost effective - only research capacity for industry is in universities - company has no laboratories
CAE Electronics	250 million	55 million	2,700	500 (est.)	1-2 million	1,3,4,5,6, 7,9,10,11, 12,13	- contribution to product development, more speculative basic research - supply of graduates
Atomic Energy of Canada	290 million	260 million	4,900	3,100	2 million	1,2,3,4,5, 6,7,10, 12,14	- extension of R&D expertise - increased sharing and management for universities of AECL facilities
Ontario Hydro	5.2 billion	56 million	33,000	660	300,000	1,3,4,5,7, 10,11,13	- extension of R&D expertise, particularly in new areas, and in provision of basic data
General Motors of Canada	17 billion	45 million	44,700	1	3-4 million	1,2,4,9, 10,12	- cost effective - project-oriented research solutions

Note: all financial data is in Canadian dollars

TABLE 3 (CONT'D.): SUMMARY OF CASE STUDIES: COMPANY DATA

Company	Total Sales ($)	Total R&D ($)	No. of Employees	No. of R&D Employees	Level of Univ. Effort ($)	Types of University Links	Strategic Objectives for University Links in R&D (Why company is pursuing links)
Institute for Chemical Science and Technology	not for profit	1 million	1	1	1 million	1,3	- pre- and non-competitive research projects, funded through grants, contracts
STELCO Inc.	2.5 billion	11 million	17,000	130	450,000	1,2,3,7,9, 10,12	- extension of R&D resources to maintain competitiveness - strategic investment in basic research
Allelix Inc.	4.5 million (a)	17 million	240	180	750,000	1,2,3,4,5, 6,7,10,14	- extension of R&D resources, to keep up with developments, and provide key proprietary technology
Polysar Ltd.	2.5 billion	73 million	6,500	550	1-2 million	1,2,3,4,7, 10,13,14	- used to attract promising graduates to work for company - participation in basic-type research in product and process development - cost effective - contact with network of world experts
Connaught Lab.	195 million	24 million	1,100	160	700,000	1,3,4,5,7, 8,14	- provision of key technologies - source of scientists for own labs - contact with network of world experts
Noranda Inc., Technology Centre	7.3 billion	14.5 million	44,000	150	700,000	1,2,3,4,7, 8,9,10, 12	- extension of own R&D capabilities - source of future employees

Notes: (a) including research contacts

Type of University Links

1) contracts, grants for research
2) sponsorship of university chairs
3) support of graduates students
4) hiring of summer and co-op students
5) post-doctoral fellows doing research in company
6) university professors doing research in company
7) company scientists hold university cross-appointments
8) management structure in company to deal with university links
9) senior executive actively involved with university links
10) participation in university-based centres of excellence
11) major input into degree-granting programs
12) contribution of research equipment
13) company employees pursuing advanced research degrees
14) scientific advisory board composed of university professors.

APPENDIX "A"

FOURTEEN INDUSTRIAL CASE STUDIES

BELL NORTHERN RESEARCH LTD.

Company Background

Established in 1971, Bell Northern Research (BNR) is Canada's largest private industrial R&D company. Considered to be the innovation leader in telecommunications systems and component design, BNR pioneered the development of fully digital telecommunications.

The company's expertise is in core technology areas such as semiconductors, software, and fiber optics. This is reflected in the BNR-designed products manufactured by Northern Telecom -- including switching and transmission systems, terminals, and telephone equipment -- used by telephone companies, global corporations, small businesses, government and military agencies, and education, health, and financial institutions in more than 90 countries.

BNR has a close working relationship with its corporate parents. Northern Telecom, the world's leading manufacturer of fully digital telecommunications systems with 1987 sales of US$ 4.9 billion, owns 70 percent of BNR. Bell Canada, one of North America's largest telephone companies, owns 30 percent.

Northern Telecom, BNR's principal owner, has established the goal of becoming the world leader in the manufacture of telecommunications equipment by the end of the century. BNR's commitment to Northern Telecom's strategy, is reflected in a projected growth rate that is generating an unprecedented demand for top-quality university graduates.

BNR's key human resource policy principle is "to find the best people available, and to help them get even better". BNR's R&D activity (the company's 1988 operating budget is estimated at US$ 560 million) supports more than 6,500 full-time staff in nine locations in the United States, Canada, and the United Kingdom. More than 65 percent of these employees have university degrees, with nearly one in every four holding a Master's or Doctorate (including some 140 PhDs in electrical engineering and computer science).

University links

BNR's strategy for building university links is based on its need for large numbers of highly qualified graduates, as well as new technology. These links are coordinated by BNR's University-Industry Program, which strives to provide a mutually beneficial arrangement for the university and for the company. BNR officials stress the importance of enhancing the capability both of the company and its supplier -- the academic institution involved and the individual graduate.

BNR began to formalize its efforts to foster university talent in the early 1970s when Dr.Robin R.(Bonnie) Jackson, then BNR's director of personnel, undertook a project fueled by his strong interest in both technology and development of top-quality people. Convinced that BNR's technology success depended on its commitment to developing the leadership potential of young people, Dr. Jackson set about to stimulate BNR-university interaction by encouraging networking between BNR staff and professors, and sabbaticals for academics at BNR facilities.

Even with Dr. Jackson's efforts, by the early 1980s the company's accelerated demand for graduates in all areas of information technology far exceeded the university supply. Studies at the time indicated that Canada's output of qualified computer scientists and electrical engineers, for example, would have to double to maintain BNR's demand for high quality graduates.

A major component of BNR's University Interaction Program (UIP) is research "windows" -- research contracts with talented faculty members and their graduate students in departments relevant to BNR needs and objectives. This program typically begins by qualifying a university on the basis of its interest in technologies of importance to BNR and Northern Telecom, the quality of its existing research, and the suitability of its students as potential recruits. First contact can be established in a number of ways -- through a campus visit by someone from BNR's UIP group, through a meeting or conference, or through a referral from someone in the BNR network. Following two or three meetings, a link is established with the appropriate technical manager at BNR. The ensuing one-to-one link between the BNR manager and the university professor is crucial to the program and can sometimes take four to five years to mature.

There are currently some 64 university windows with contracts ranging between $10,000 and $60,000. Each window is carefully managed and evaluated regularly to ensure its continued relevance to BNR's customer-driven R&D. Evaluation criteria include the strategic importance of the technology to the company, the BNR manager's enthusiasm for working with a particular professor, and the performance of the university in developing students.

Despite the best of intentions, not all windows are successful, and a few are closed every year. Failure is frequently due to an inability to develop a strong working relation between a university professor and a company researcher. Interests may shift, areas of expertise may no longer be relevant, or there may be an incompatibility between two individuals.

The way windows evolve varies from case to case. In one instance, a professor who received some funds under a window program was able to shift the direction of his research to align it more closely to BNR's interests. He also succeeded in having several of his graduate students employed by the company. In another example, it was a graduate student hired by BNR who created the window link with his former professor. In other cases, academics will spend their sabbaticals at BNR: at present, there are six such positions.

The company regularly sends liaison teams to universities to identify opportunity areas and exceptional graduate students before they receive their degrees. These teams meet with graduate students and their professors and make new contacts that supplement the regular campus recruiting that goes on year-round.

BNR also provides cooperative work programs for targeted undergraduate students identified as having very high potential. In 1987, this program enabled some 1,000 university students to work in BNR labs alongside the company's more than 4,000 professional staff.

BNR also contributes to the funding of new faculty positions, in some cases working in concert with programs funded by the federal government through the Natural Sciences and Engineering Research Council (NSERC). By the end of 1989, BNR plans to help establish 20 new faculty positions in Canadian universities.

BNR also funds industry-university institutes of excellence. By the end of 1987, the company supported eight such centers in North America including Quebec's Institut national de la recherche scientifique, the Alberta Telecommunications Research Centre, the Telecommunications Research Institute of Ontario, the Information Technology Research Centre, the Ottawa-Carleton Research Institute, and the Ontario Centre for Materials Research.

BNR would like to increase its links with universities, and triple the proportion of its technical managers involved with the window program from 10 percent to 30 percent. BNR encourages its managers to seek these contacts by covering travel expenses to any of the 25 universities involved in the UIP, and by recognizing successful work with universities at the time of a manager's annual performance appraisal.

ALCAN ALUMINIUM LTD

Company Background

Alcan is one of the largest primary aluminum producers in the world, generating 13% of the free world total in 1987. Through subsidiaries and related companies around the world, Alcan is vertically integrated throughout all stages of the industry, including bauxite mining, alumina refining, aluminum smelting, fabricating semi-finished and finished products, and sales. In 1987, the Alcan Group of companies comprised 63,000 employees, and accounted for US$ 6.8 billion in revenues.

Alcan's principal technology group is contained in Alcan International Limited. It has two divisions -- technology and research and development. The technology division is concerned with improving technologies used by Alcan's traditional aluminum operations world-wide.

The R&D division concentrates on fundamental research, on product and process improvement, on new product development for the mainline business, and on technology development for new business opportunities. While Alcan's historical research focus was on process improvement, in 1987 about 40% of its R&D effort was directed to new business development. This is the result of a major corporate diversification effort undertaken in the early 1980's, in response to stable and even declining demand for aluminum. This change was captured in Alcan's new 1986 mission statement to lower costs and become "the most innovative, diversified aluminum company in the world."

Exploratory and new product development work includes transportation, aerospace and defence, energy-intensive businesses, ceramics, metal matrix composites, and special chemicals

The R&D division consists of 700 employees located mainly in Canada (Kingston, Ontario and Jonquière, Québec) and Britain (Banbury, Oxfordshire). The three laboratories have now been in existence for several decades. Total R&D expenditures for the company, including work done in the three laboratories as well as process engineering done in the plants, is about US$ 95 million.

There are over two hundred Alcan plants around the world. In some plants, significant development work can occur. In one specific instance, over eighty percent of the development work for a new casting mold, considered to be a major breakthrough for the company, took place in one of its Canadian plants, with the remainder occurring in one of the research centers.

While the operating costs of the research labs can be determined very precisely, costs of engineering development projects which occur on plant sites are much more difficult to track. Recent R&D tax incentives by the Canadian government have encouraged large companies like Alcan to improve their monitoring of R&D activities.

University links

There is no overall corporate policy on university interaction. Initiatives are left to individual senior executives, who may chose to work with selected universities. Contacts can be initiated by project managers faced with specific needs, or to respond to specific community needs.

In the R&D division, the responsibility for managing university links lies with the directors of each of the three research centers.

Jeff Edington, the Vice President responsible for the three research centers, justifies links with universities as follows: "It gives us access to very bright people and highly specialized equipment which would be uneconomic for us to employ or own, particularly if we require them only for a relatively short period of time, such as three years. It also allows us to hire very good people for our research centers."

There are a number of ways Alcan interacts with universities. The most simple channel is that of grants and contracts. In Canada, current grants and contracts with universities amount to approximately $640,000. Grants are usually given in cases of significant educational effort such as a Ph.D. or M.Sc. thesis. Contracts are tied to specific deliverables.

The two Canadian research centers hire about twenty-five summer and co-op students every year, for periods of six to twelve weeks. They also host about six post doctoral fellows who use the laboratory facilities. Occasionally an Alcan scientist will spend six month to a year in a university laboratory, and some will even teach a university level course. There are no cross-faculty appointments of Alcan scientists, but the company has sponsored three university chairs.

In general, university interaction is easier at the research laboratory level, where scientists work with scientists. It is much more difficult to stimulate this interaction in the engineering development of processes or products, which generally happens in operating plants. "Canadian engineering faculties have no real understanding of engineering development at the plant level," says John Wilson, Vice President of fabrication technology.

There is a need to educate university researchers in the conditions and processes of operating plants, as well as in project management techniques. A university researcher has to be acquainted with the discipline of milestones and deliverables, if he is to interface professionally with industry researchers and engineers. This is a process which takes from three to five years.

Jeff Edington, who oversees research and development activities, is not totally satisfied with the results of university links to date. Sometimes Alcan itself does not define projects clearly enough before handing them over to universities for contract work. "We need to define our problems clearly enough so the research results can be useful to us", he says. A university researcher has to be thoroughly familiar with the working conditions in the plant. Otherwise, his research solutions may turn out to be impractical.

Having university professors spend time at the plant site is not always feasible. There is considerable resistance to their presence in a plant because it takes up too much of the time of management and technical people, already stretched to the limit.

The Alcan experience in Britain is somewhat different from that in Canada. First, a policy decision in the early 1980's to hold the number of employees constant at two hundred, but imposing no budgetary limit, created an incentive for project managers to contract out as much as possible. The push to diversify into new businesses and products also created a need to increase outside contacts with appropriate universities. These contacts have since grown by a factor of four to five.

Contact between a university and the U.K. lab is generated by the project leader, who usually has four to five technical people reporting to him. "These contacts have to be done professionally, they require a lot of time -- up to 10% of a project leader's time -- and they are not cheap. Good university professors cost money," says Jeff Edington. As part of the incentive package to gain the best possible cooperation from a professor, Alcan will often supplement the costs of a contract with a consulting fee.

Edington stresses that the contact person for Alcan must be the person who will use the university research results, and that the selected university researcher must be of the highest quality. "The three ingredients for a successful university collaboration are financial incentives, intellectual excellence, and closeness between the two parties at all times," summarizes Edington.

Alcan is not facing the same degree of dramatic growth as BNR, and consequently it does not see the need to develop university faculty to the same extent. It does plan to diversify into new technologies, some outside its traditional lines of business, and sees the need to tap more systematically into the pool of scientific knowledge. Closer links with universities are seen as a critical component to strengthening Alcan's capability to scan potentially useful technologies. "We would like to see universities reward their professors more visibly for their contribution to industries like ours, be it through promotions, or salary raises," concludes Edington.

PAPRICAN (PULP AND PAPER RESEARCH INSTITUTE OF CANADA)

Company Background

The Pulp and Paper Research Institute of Canada (PAPRICAN) is a non-profit research and educational organization. With an annual budget of $24 million, it employs 360 scientists, engineers, and supporting personnel. It maintains laboratories in Pointe Claire, Québec, and Vancouver, British Columbia. On-campus facilities are also made available at McGill University, the University of British Columbia, and Montreal's École Polytechnique.

The operating costs of its research and educational programs are borne largely by the Institute's Maintaining Member Companies, which number about fifty and represent nearly all the pulp and paper producers in Canada. The Government of Canada provides support for capital costs and buildings.

The pulp and paper industry is one of the largest manufacturing industry in Canada. In 1987, the industry produced $14 billion worth of pulp, and employed some 140,000 people.

University links

PAPRICAN's ties with universities go back to its earliest days. In 1925, the Canadian Pulp and Paper Association together with the federal government's Canadian Forestry Service agreed on joint funding of a research program on the McGill Campus. Professor Harold Hibert, an organic chemist with McGill, provided the necessary leadership. The industry also agreed to fund a university chair. Two years later, a new laboratory building was built on the campus, and was opened in 1928.

Today, PAPRICAN is a full-fledged research center, with links to three major universities. The total cost of its university program is about $3 million. Its longest links are with McGill, where six of its scientists are cross appointed to the departments of chemistry and chemical engineering, and have full academic privileges, including that of supervising Ph.D. students. Over six decades, this arrangement at McGill produced almost four hundred doctoral theses in the pulp and paper area.

In 1975, PAPRICAN began to expand its activities to the Pacific coast, where one quarter of Canada's pulp and paper is produced. It sent one of its scientists to the University of British Columbia (UBC), paying his salary, with the expectation that he would become fully integrated into the faculty. Ten years later, PAPRICAN opened a new building which now houses two of its scientists, fully cross-appointed to the departments of mechanical and electrical engineering, and ten technical support staff. In addition, eight other university professors are supervising graduate students working on industry-related problems within the centre. In the chemical engineering department, research topics include fluid mechanics, fibre suspensions, and hydrodynamics of screens; in the electrical engineering department, topics tend to be computer-related, and include adaptive controls, process control and expert systems. PAPRICAN is in the process of funding two university chairs at UBC, with support from the Natural Sciences and Engineering Research Council, a federal granting agency.

Four years ago, PAPRICAN signed an agreement with Montreal's l'École Polytechnique (Poly), Canada's largest engineering faculty. All previous links with universities to that point were arranged orally without a single written agreement. The initiative with Poly has prompted the development of similar memoranda of understanding with UBC and McGill. A draft of the administrative agreement with McGill University is included under appendix "C" of this report.

In reflecting on what it takes to develop a good relation with a university, Mr.Peter Wrist, the president of PAPRICAN says: "You have to go slowly. You are effectively negotiating a marriage licence, not a short term liaison. You have to choose carefully the people who will work in the program, and make sure -- even informally -- that they continue to be acceptable to the university community. If you don't do that, you are asking for trouble. It took us ten years to become fully established at UBC. So you need a large investment in time and people to make it work."

The scientist that is chosen to take a campus position is selected on the basis of his technical ability, his interpersonal skills, and his interest in the university environment. There is a lot of suspicion on the part of some professors on campus, who do not have any interest in industry-related problems, as well as some jealousy related to the source of funding. A PAPRICAN cross-appointed faculty member can be asked to teach graduate courses. If he wants, he also has the option to teach at the undergraduate level.

Ten years ago, the industry advisory board to PAPRICAN pointed out that their companies had a real need for high quality engineers who were familiar with the technology and could work in plant operations. The graduates they hired from universities were good engineers, but were untrained in the technology of the pulp and paper industry. Together with McGill and UBC, PAPRICAN developed a one year (twelve months) Masters of Engineering program for people who already had a good engineering undergraduate degree and in some cases, work experience. The program is a non-thesis degree, with ten months of courses, and a two month project, and is administered completely by each university, including admissions requirements. PAPRICAN's contribution involves developing the curriculum and providing lecturers. "Most of the knowledge that was required is not found in textbooks," says Peter Wrist, "and evolved through the personal experience of the staff. It's often scattered in scientific journals, and each staff member had to develop his own course material."

Each year, the curriculum is carefully reviewed by a joint University-PAPRICAN committee, and adjusted if necessary, for continued relevance to the industry. PAPRICAN also provides ten very generous scholarships ($20,000), to encourage the best students to apply for the program, rather than seek jobs in industry. Some forty students have now graduated from the program, and were "snapped up" by the industry.

In commenting on the success of the Masters program, Wrist says: "You need to know what kind of trained person you want, and then make sure the curriculum delivers it. It took us four years to develop the curriculum, and we had to get the approval of ten levels of university committees. "

PAPRICAN also participated with twenty other companies in a major granting program to l'École Polytechnique to supply it with a new electron microscopy laboratory. In terms of other links with universities, it supports ten post-doctoral fellows and hires some twenty summer students every year. Having developed strong links to three universities, PAPRICAN is considering developing some form of contracting program which would allow it to develop links with individual professors in other universities.

Regarding a successful university cooperation, Peter Wrist concluded: "You have to go slow. Don't go to a university if you want a problem solved in three months. It took us ten years to develop a successful program with UBC."

SEMEX CANADA

Company background

SEMEX CANADA was created in 1974, at the same time as its non-profit sister, the Canadian Association of Animal Breeders. It is composed of nine artificial insemination (A.I.) cooperatives, which together account for almost all Canadian exports of bovine and porcine frozen semen. Total exports in 1987 amounted to $21 million, compared to domestic sales of around $40 million.

The Canadian dairy industry has annual sales of approximately $3.5 billion, and there are 1.6 million cows in milking. Over seventy percent of all dairy cows are bred through A.I., compared to only four percent for beef cows.

Under Canadian law, SEMEX is a corporation without share capital. It is essentially the international marketing arm of the Canadian industry, a cooperative of cooperatives. SEMEX directly employs forty people, including four people with doctorates. The cooperative members of SEMEX employ a further 600 people.

University Links

Dr. Morris Freeman, the general manager of SEMEX is quite emphatic: "We support university work, because we feel we get the biggest bang for the buck. You just can't replicate the combination of a university professor supported by a team of post-doctoral fellows and graduate students. It's very hard to beat this combination. We don't fund bricks and mortar projects, we rarely pay salary or equipment costs, so we find this very economic."

SEMEX spends $400,000 a year on research, almost all of which is carried out in eight major Canadian universities, with the center of gravity located at Guelph university. The SEMEX building is on the Guelph Campus. SEMEX' sister, the Canadian Association of Animal Breeders (CAAB), also spends about $400,000 a year on research, and raises the funds through a levy on semen sold on the market by its members. The two coordinate their research efforts closely.

The industry has had strong links with R&D from its very beginnings. Issues such as the preservation and extension of semen, reduction of diseases with antibiotics, freezing and transportation were all solved through R&D. Today, research topics include molecular biology, genetics, progeny testing, improving productivity, animal biotechnology, and animal breeding strategy.

SEMEX' research program is focused around three university chairs at Guelph which it funds jointly with the federal government, through the Natural Sciences and Engineering Council (NSERC). Altogether, it supports three professors, four post-doctoral fellows and twenty-five graduate students.

The CAAB funds particular projects in several other universities. Each year, it will circulate a list of research priorities with a call for proposals. In 1987, it received 51 proposals of which it funded only 29, for a total of $400,000. The grants vary between $10 and 20,000, and serve to support adjunct professors, post-doctoral fellows and graduate students. While teaching at the graduate level is allowed, SEMEX does not allow the professors it supports to teach full courses at the undergraduate level because it detracts from their research.

The research is monitored yearly. Each recipient must file a research report, and will occasionally be asked to present a paper to annual meetings with industry representatives. Industry representatives will also sit on the grant selection committees. About six recipients were dropped over the last seven years because of poor performance.

Technology transfer activities are handled in a number of ways. SEMEX offered a course on embryo transfers and splitting for practising veterinarians. The course was given by the professors holding the appointments funded by SEMEX/NSERC. SEMEX also recently hired a veterinarian with a Ph.D. who will spend three quarters of his time at the university, and the rest on the road interacting with the industry. Dr. Freeman, who studied at Cornell university, admits that he and the three scientists who work for him have a keen interest in the results of research, even though they don't actually carry out any research themselves. Through ongoing contacts with university researchers and committees, attendance at workshops and seminars and reading, they play a critical role in interpreting the results of research to the industry. In effect, they provide the members of their industry with a technical support service.

Another important activity of SEMEX is the International Livestock Management Schools program. These are courses lasting up to sixteen weeks and dealing with various subjects, such as artificial insemination skills, embryo transfer, and livestock feeding and management skills. The courses are intended for people working with livestock outside North America, to help them apply Canadian genetic technology in their home countries.

Dr. Freeman would like to see more research money spent in this area. He is also concerned by the heavy administrative overhead of universities and the aging of faculty, two factors which reduce the productivity of university research. He would also like to further reduce the teaching load for the professors occupying the chairs funded by SEMEX. In this, he remains firmly committed to the concept of university research to support his industry.

CAE ELECTRONICS LTD.

Company Background

CAE Electronics Ltd., a subsidiary of CAE Industries, is one of Canada's largest advanced technology companies. Founded in 1947, it initially provided the military with electronics and electromechanical repair and overhaul services. By early 1950, the company produced flight, radar and weapons simulators for the Canadian armed forces and NATO.

Today, the company specializes in the application of sophisticated computer control systems to complex tasks such as aviation, power generation and transmission, air traffic control, marine systems, space exploration, and submarine detection. It is a major producer of digital computer-controlled aircraft simulators in which it holds 40% of the world market. CAE's main plant is located in Montreal. It employs 2,700 people, of which more than half are engineers, scientists or technical persons. The sales of CAE Electronics for 1987 were $250 million, and R&D expenditures were $55 million.

University Links

CAE spends about $2 million of its 55 million R&D budget on university-based R&D. Its technology requirements cover a wide spectrum, including computer systems, visual systems, magnetic position sensors, and other military equipment.

Dr. Murdoch McKinnon, CAE's director of R&D, is very sensitive to the need for strengthening university links, because he himself holds an adjunct professor position at a university. "I've been pushing stronger university links for the last ten years," he says. "In some cases, universities can contribute to product development. And we've had some important successes, like the eye tracker for our new fiber-optic helmet-mounted display for fighter pilots. That component was developed by a graduate student, as a thesis project."

Another example is an automobile simulator, which is being developed on contract by a university. The scope of the project required that the university hire technicians to work on it. Its unfortunate side effect was that CAE lost contact with graduate students. That contact, emphasizes McKinnon, is an important and valuable dimension of university relations.

CAE's links with universities take many forms. The company may provide a grant or contract to a professor for his research, supplementing it with computing equipment. It will occasionally invite professors to spend their sabbaticals at CAE laboratories. CAE is also considering the joint funding of a university chair with NSERC. It will also interact with a number of university centers, such as the Centre de Recherche en Informatique de Montréal. CAE employees will often take part-time post-graduate degrees at these institutions.

McKinnon's rationale for dealing with universities is based on the need for help on a development project, or for specific knowledge not available within CAE. For example, because of its interest in tele-robotics, CAE will interact with McGill university's robotics center, a well-established group. Since the company's reporting and accountability system is fairly strict, it is necessary to go outside, to a university, for example, if a more speculative piece of research is needed.

CAE's university research contacts have generated projects for some thirty to forty graduate students, of which about ten are doing part of their research in CAE's facilities. The company will also hire students, using the experience in the selection process for future employment.

McKinnon admits that there can be some cultural problems. CAE's in-house research projects tend to be very much objective-driven, while university projects are longer term. The university researchers that agree to work with CAE are generally pre-disposed favorably to the company's culture. "These links do not work well if you just give a project to a researcher, and hope that he will come back with the results when he's finished." says McKinnon. "You need to give him direction and manage him throughout the project."

He also observed that engineers generally are more able to meet deadlines, while some of the more theoretical computer scientists have difficulties in seeing the applied side of their work.

Intellectual property generally presents no problems, although he cites one case where a contract with a professor resulted in a piece of technology. The professor was able to set up a consulting company with control of the know-how related to the technology. This placed CAE in the uncomfortable position of having to negotiate access to that technology with the professor's company, rather than the university.

McKinnon would like to see more interaction with universities. He would like to see closer links, more part-time teaching for CAE scientists, and more university researchers spending time inside industry for periods of six months to a year.

ATOMIC ENERGY OF CANADA LTD.

<u>Company Background</u>

Founded in 1952, Atomic Energy of Canada Ltd. (AECL) is a Crown Corporation and is Canada's national agency for nuclear energy.

AECL is divided into three companies: CANDU operations, an engineering company responsible for designing and marketing the CANDU series of nuclear power reactors, the Radiochemical company which markets radioisotopes and irradiation equipment, and the Research company which provides underlying research and development support.

The Research Company has facilities at Chalk River in Ontario, and Pinawa, Manitoba. Its total budget, of which some 60% is covered through a parliamentary appropriation, was about $260 million for 1987, and covers four major areas:

1. reactor development (support and improvement of existing reactors, advanced reactor concepts, and small-scale reactors for local heat and electricity production, research and isotope production);

2. waste management (chemistry and diffusion of radioactive species, storage, and health and environmental protection);

3. radiation applications and isotopes (heavy water production, new radiation sources eg. accelerators, tritium technology, and uranium enrichment);

4. physics and health sciences (basic research in nuclear physics, physics of solids and liquids, health and environmental effects of low-level radiation, and nuclear fusion).

The R&D groups in these four areas have responsibility for the early stages of business development resulting from new technology, including idea generation and evaluation. Those technology opportunities that progress to a point where incubation as a business unit is required before commercial spinoff, are the responsibility of a central business development group. The Research Company employs about 3,100 scientists, engineers, technologists, and support staff.

<u>University links</u>

AECL's links with universities date back to the early days of the company, when it was still largely a research organization. In the last three years, the government's support for AECL's R&D program has been severely reduced.

Because of these recent cutbacks, Eugene Critoph, AECL's Vice President of Strategic Technology Management, emphasizes that university links will become stronger. "Our Chalk River laboratories have to be made into a national facility," says Critoph. "This means that we will be sharing ownership and broadening the base of support, in return for relinquishing part of AECL's control over these facilities. And we will have to make new arrangements for users to participate in the management of these facilities."

The laboratories at Chalk River have unique experimental equipment, particularly in the more basic research areas of physics and health sciences. Examples are the $20 million Tandem Accelerator Superconducting Cyclotron (TASCC), and the NRU research reactor. These facilities are valuable basic research tools for low energy nuclear physics, and for understanding the properties of matter. No single university could afford building or purchasing such facilities.

Funding for some equipment was obtained, in part, from government granting agencies that generally support university-based research. This outside financial support, together with the sharing of the management burden through user committees, represent a major shift in AECL's policies. Government cutbacks have brought a significant opening of AECL's research facilities to the outside world, and an increase in joint or cooperative research.

The initiative for a cooperative project is likely to come from a university researcher who might wish to use of one of AECL's unique facilities. If the user committee considers the experiment to be worthwhile, the researcher will come to Chalk River at his own expense. The AECL team will cooperate with him, and joint papers usually result from this cooperation.

AECL does not give grants but supports university interaction through research contracts, which total about $2 million a year. It also has a national program to hire up to 100 summer students as well as a co-op program involving thirty students. Together with the New Brunswick Electric Power Commission, AECL contributes to a university chair in nuclear engineering. In addition, AECL runs seminars for science teachers.

In dealing with intellectual property, AECL usually insists on retaining ownership of results arising out of an applied research contract. The question doest not arise for pure research projects.

In assessing the effectiveness of these university links, Gene Critoph says that in general, they have been successful. Pressed to identify sensitive areas in this university-industry interaction, Critoph did mention some problems with university contracts: "You need to have a clearly defined set of deliverables and milestones, otherwise you'll have a problem. We've gained more experience over the last twenty years. For instance, we generally do not use universities for key projects with short deadlines."

Other minor problems were associated with honoraria given by universities to AECL scientists holding part-time university positions. Some honoraria had grown to substantial sums which were not consistent with full-time employment and this situation was corrected.

AECL also finds that in some cases, when graduate students are attached to an AECL Laboratory, careful negotiations at the outset can avoid later misunderstandings. It is important, for instance, to clarify the role of the university-based supervisor relative to that of the AECL scientist who may also hold the position of adjunct professor, as well as being responsible for the laboratory.

There are no major cultural problems in dealing with universities, largely because of the diversity of AECL employees, who range from academically inclined scientists working in basic research, to project-driven engineers.

ONTARIO HYDRO

Ontario Hydro is a government-owned utility which generates electricity for the province of Ontario. It operates eighty hydraulic, fossil, and nuclear generating stations with a total capacity of 30 gigawatts, and an extensive power grid across the province. In 1987, it sold close to 130 billion of kilowatt-hours, for total revenues of $5.2 billion. About half of that electricity was generated from nuclear power using the Canadian heavy-water CANDU reactor. The rest was equally divided between fossil fuel and hydraulic power generation. Ontario Hydro employs about 33,000 employees including non-regular and construction workers.

The Research Division of Ontario Hydro dates back to the early days of the company when it was a small group dealing with requirements for standards and testing. Today, it provides a broad range of scientific and technical expertise to support engineering, operations, and the utilization of electricity. Projects cover a wide spectrum of engineering, physical, and environmental sciences. They include work on corrosion and tritium technology related to CANDU systems, materials and structural integrity, failure prevention studies, monitoring of large hydraulic structures, work to support the more than 100,000 km of transmission lines, evaluation of electrical-based processes for optimal utilization, and environmental protection.

The Division's budget was $56 million in 1987. Its Toronto laboratories employ 660 people, of which about half are scientists, engineers, and other technical professionals.

University Links

The Research division spends roughly $300,000 a year on university contracts, although other divisions in the corporation could be spending as much as twice that in total. Contracts are preferred to grants because they provide the potential for influencing the direction of research.

Don Mills, the Director of Research, described the Division's perception on links with universities: "It gives us first-hand access to knowledge and data through a top quality talent pool. You go to universities when you need, for example, data on fundamental properties and characteristics of materials, but not if you need it for next week."

For Mills, a successful university project involves well defined deliverables but no tight time constraints. A good example is the metallurgical problem of characterizing the behavior of hydrogen in zirconium, a metal used in pressure tubes for the CANDU nuclear reactor. This problem was given to a professor of metallurgy, who worked on it for several years and generated both valuable data and good thesis material. Generally, "real-time" problems in an operating plant are not referred to a university. "The research results would not be directly useful to an operator" says Mills.

Mikk Anyas-Weiss, head of the Science section, has mixed feelings in assessing the value of university contracts: "In the physical sciences, the research is usually carried out by graduate students or post-doctoral fellows who generally move on after a few years and do not develop the deep interest and commitment to the industrial problem at hand."

The quality of these links varies from university to university. Generally, projects with engineering faculties work better than those with the science faculties. Engineers are perceived to be more project-oriented. In the science faculties, the research is more fundamental, scientists tend to be more independent, and they are frequently attracted to new, more exciting areas.

There is no one senior manager responsible for university interaction at Hydro, nor are there explicit guidelines governing it. Most contacts are based on past personal links between the scientific staff of the Research Division, and university professors. A recent company survey on the extent of these links may well lead to a committee that could change this. One of the desirable changes would be closer monitoring of these contracts, similar to the procedures used by the Electrical Power Research Institute (EPRI) in the USA.

In describing the benefits of these contracts, Anyas-Weiss said: "You can initiate new areas of research. It's easier to start with someone from outside, rather than hire a full- time scientist." A university researcher may also have equipment which the division could not justify purchasing.

Other contacts with universities are through employees that hold faculty positions in neighboring universities as adjunct professors. There are ten adjunct professors in the research division. The Division also hires 15 co-op students a year and 30 summer students, particularly from engineering faculties.

An important link is also provided through professional development which allow employees to pursue graduate degrees. Hydro will encourage staff to further their education by giving them time off, and paying for books and fees. One difficulty is presented by some university residency requirements, which require full-time attendance. This makes it difficult for full-time employees to integrate a degree program with their work, without taking a leave of absence for a year or two. Easing such regulations would make it easier for industry people to get advanced degrees.

Since the primary function of the Research Division is to serve the needs of Ontario Hydro's power system, which includes the capability of mobilizing resources in the event of a crisis, the division is limited in the extent to which it can contract out work to universities.

In the intellectual property area, some problems have arisen because professors often perceive contracts to be research grants. With such an approach, they naturally expect any resulting intellectual property to belong to them, even if the research idea was initially conceived by Ontario Hydro. It is often not clear who is the decision-maker in the university and this makes negotiations difficult. Dealing with a university professor on a one-to-one basis is generally pleasant, but dealing with the university business office can often be difficult. In one instance involving a confidential project on the synthesis of new materials, Hydro simply chose not to go to a university because of the culture gap and the difficulty of signing a non-disclosure agreement. "University researchers operate on the principle of peer review and frequent publications. As a result, they are less concerned about the confidentiality of results than is industry," says Anyas-Weiss.

In other instances, the bureaucracy of the organization is not sufficiently sensitive to the difference in culture. "There have been cases where contracts have been prepared with clauses that prohibit publications for many years," says Craig Simpson, a principal research engineer. "Clearly, this would have been totally unacceptable to the university, and we had to replace it by a different clause, allowing publication after our approval."

Ontario Hydro is also involved in supporting a number of university research centers, including the new university-industry Centers of Excellence. "Our role in these centers, in addition to financial support, is to advise on programs, keep the focus on research of interest to industry, and to make sure that the research will yield applicable results in five years," explains Simpson. "For example, at one of the materials research center, we tried to bring practical considerations to the topic of high temperature superconducting materials. We felt that one of the critical challenges in using these new materials for electrical transmission wires hundred of kilometers long, is to be able to make these materials much larger than the current millimeter-sized single crystals. This means addressing what we call the grain boundary problem, and we convinced the researchers at the center to look at that."

Anyas-Weiss and Simpson would like to see a more coherent policy for Hydro on university interaction, and more resources dedicated to it. They would also like to see universities better funded, and therefore less hungry for money or patent ownership. These sentiments are echoed by Don Mills: "In some cases, because of financial pressure, universities will make substantial shifts in their research programs to get funding, even to the point of subverting their real purpose."

GENERAL MOTORS OF CANADA LTD

Company Background

General Motors of Canada ltd. is a wholly-owned subsidiary of the US$ 101 billion parent, GM. A large part of GM Canada's operations are concentrated in Oshawa, near Toronto. This is the location of the new $2 Billion Autoplex -- an ultra-modern car and truck assembly plant using some of the latest advanced manufacturing technology, including robotics and other forms of automation.

GM Canada employs 44,700 people, and its 1987 Canadian sales were $17 billion, a large portion of which was exported to the US parent company.

The Canadian subsidiary does very little original design work on new car models, except for adaptations required by local conditions such as the rigors of the Canadian winter. The bulk of the designing is done by the US parent.

GM Canada, however, has the most advanced manufacturing technology in all of GM. It is developing and adapting unique assembly techniques for cars and trucks. One such innovation is the application of the automatic guided vehicle, an autonomous, computer-guided moving platform on which partly assembled vehicles are physically moved from one assembly station to another. This concept replaces the traditional conveyor-type assembly line and allows for higher quality, increased flexibility, and greater job satisfaction for workers who now work in teams at a particular station.

The total R&D budget for GM Canada, $45 million, is directed at engineering products, diesels, and manufacturing engineering. There are no designated R&D facilities as such, other than a vehicle experimental facility and cold weather testing facilities in Kapuskasing. Most research on is carried in the plants.

In manufacturing engineering, the technologies would typically include robotics, automated guided vehicles, process control programs, vision systems, computer systems and area networking, and various forms of metal shaping, including pressing, forming, bending, stamping, welding, and plastics.

University links

GM Canada spends about $3 to 4 million of its total R&D budget on university contracts. Typical research topics would include improving inspection systems for transmissions, computer simulation of production systems, and computer models for metallurgy and non-destructive testing.

Asked why GM Canada would use university researchers, Carl Wintermeyer, the Manager of R&D, replied: "University-based projects are relatively easy to start, and despite the overhead of 65% that the universities usually charge, are usually cheaper than doing it in-house. There's a number of federal and provincial government programs that will contribute up to 50% of the costs of university-industry research. Then there is also the synergy that is set up between the university researcher and the GM engineer."

For GM, these university projects generally last one year. As a rule they do not deliver results as quickly as other types of contracts. Confidentiality is also an issue: "If you want to keep something secret, it's difficult to do when you deal with a university," says Wintermeyer, "because its mandate is to disseminate its research results."

University research projects generally arise when a particular problem is identified. The GM engineer will then seek out someone in Canada with specific expertise. Recruiting leads are not usually considered important, given GM's stated objective of downsizing the company by 25%. The alternative to using universities would be to ask the parent company's R&D center in the US to carry out a project, but this would involve competing against their already lengthy list of priority projects.

There have not been any visiting professors on sabbaticals staying at GM plants, but GM is participating in the funding of a university chair at Waterloo university as part of its support for a center in quality process control. There is, however, a number of training programs at the community college level. GM also hires summer and co-op students.

Like any other major corporation, GM has an active corporate contribution program. In the education area, the program focuses primarily on helping building projects at Canadian universities. Other community projects might include contributions to hospital buildings, the performing arts, scholarships, co-op programs, junior achievement awards, and engineering and business student competitions.

One noteworthy program which GM imported from its US parent is the Key Executive program, where a senior executive in the company is appointed as the official contact for a specific university. The executive is generally an alumnus of the university and the projects that he undertakes will largely depend on his interests and the willingness of the university. These projects might include funding initiatives, participation at conferences, speaking at special meetings and career days, sponsoring student competitions, or informal discussions with deans of engineering and business faculties to give them "an industry perspective" on proposed courses and curricula.

Currently, GM has Key Executives with six Canadian universities which it considers to be world class and in reasonable proximity to GM operations for recruiting purposes.

THE INSTITUTE FOR CHEMICAL SCIENCE AND TECHNOLOGY (ICST)

Institute Background

In 1985, a number of Canada's largest chemical and petro-chemical companies responded to growing global competition by creating an institute to produce pre-competitive new technology and solve common problems. The institute would also serve to improve the research linkages between universities and industry. The fact that the majority of these companies were based in Sarnia, Ontario facilitated the initial discussions leading to the creation of the Institute.

The Institute has six major industrial sponsors: CIL (a subsidiary of ICI), Dow Chemicals Canada, Imperial Oil (a subsidiary of Exxon), Polysar Ltd., Domtar Inc., and Dupont Canada. Altogether, they represent a total R&D spending force of close to three quarters of a billion dollars.

Each company contributes an annual membership fee of $85,000. There are also nine universities that are members, each of which contributes a membership fee of $10,000. Together with some government funding, this brings the research funding for 1988 close to $1 million.

In 1985, each company appointed a senior research manager to a task force, which met to identify the common technical problems facing the industry, and to discuss the merits of attacking them on a common basis.

Bill Stadelman is the Institute's Director and retired president of Canada's largest contract research organization, the Ontario Research Foundation. He says quite candidly that initial discussions were not easy: "Everyone of these companies competed in some areas against each other, and it was difficult for them to open up at the table, and discuss their corporate technical problems. The challenge was to define research projects that would be of mutual interest and high priority but still non-competitive. So you had to let them talk, and my role was that of a facilitator."

Incorporated as a national non-profit body, the Institute finally decided on six areas of common interest: industrial waste management and environmental quality, novel "on-line" sensors and measurement technology for monitoring chemical processes, new separation technologies such as membranes, surface chemistry of polymers, the relationship between molecular structures of polymers and their physical properties, and surface sciences of aqueous emulsions.

Each area of interest has its own project team, composed of representatives from each of the industrial members and university experts. These project teams define the research program, monitor approved projects, and arrange for the resulting technology to be transferred to the member companies. Because each project team member served on a part-time basis, it took two years of discussions to arrive at the current list of fifteen funded projects.

University links

In May 1986, ICST sent its first request for proposal to all Canadian universities, and in 1987, it approved its first four research proposals: chemical waste disposal through land treatment process, using enzymes to remove organic contaminants from industrial waste water, on-line monitoring of chemical reactions and processes through acoustic signals, and the study of polymer surfaces. The sizes of the grants or contracts vary from $25,000 to $210,000.

The response to the initial request for proposal was positive. There were twenty-five projects submitted for each one approved.

The technology transfer process begins at the start of each project. A liaison person from one of the companies is named. Every quarter, there is a progress report. This is reviewed by the project team which includes representatives from all the member companies. These are usually people at the sector management level, with staff of up to 50 people. The researcher will usually attend the project team meeting to discuss any problems. Every year, the project team will also hold a seminar with the chief investigator together with several representatives from each member company. Sometimes the project team will meet on the campus of the university. By the time the research project is completed, each company will be thoroughly familiar with its results and implications. "We are very project oriented," says Stadelman, "and we hope this process will make universities more aware of the time and financial controls, which are standard practice in industrial research."

Regarding intellectual property, Stadelman believes that universities still have some learning to do: "Most universities don't have too much experience in exploiting technology. They are inclined to overestimate the value of the technology they produce. Ninety-eight percent of patents never generate any real money. In my twenty years at the Ontario Research Foundation, I have only seen two patents that generated more than $1 million."

Stadelman believes that if the idea for a project originates from the university, then the rights to the intellectual property conceived prior to the research obviously belongs to them. But if a company comes to the university with a specific problem, and pays the full contract costs plus the university overhead, then the intellectual property rights should revert to the company. "If universities are really interested in playing a role in economic development, then they are making a mistake in spending too much time haggling over contracts," says Stadelman. "The industrialist is prepared to pay for what he gets, but he doesn't want to support research financially and then find out that he doesn't have access to it."

STELCO INC.

Company Background

Founded in 1910, Stelco is one of Canada's foremost steel maker, supplying a third of the country's raw steel. In 1987, it shipped 4.3 million tons of steel, and had sales of $2.5 billion.

Stelco is a vertically integrated iron and steel producer. In addition to rolled steel products, it manufactures a variety of other products such as wire, fasteners, cold drawn bars, pipe, tube, and grinding balls.

To meet the demands of a market that requires less quantity and higher quality, Stelco has gone through a major belt-tightening exercise, reducing employment from 27,000 in 1980 down to 17,000 in 1987. It also initiated a major modernization program, using the latest state-of-the-art technology in new and existing production plants. It is also moving to new kinds of steel products that will more closely meet customer requirements, such as greater ease in forming and machining, higher corrosion resistance, and increased strength.

A key component in Stelco's strategy is the creation of a new company, Stelco Enterprises, for launching new businesses with related technologies. These new businesses will not necessarily be in traditional steel fabrication and could involve new materials such as powder metal and engineering plastics. They will, however, match Stelco's traditional manufacturing and management skills.

Stelco's R&D efforts are located in its Burlington Technology center. The Technology Center employs 330 people. The R&D department employs 130 people, of which 80 are professional scientists and engineers. It expects to spend about $11 million on R&D in 1988. Currently, most of this is directed to supporting the traditional steel business, but Stelco expects that a significant part will eventually go to support new ventures.

University links

For Les McLean, Stelco's Vice President of Technology, the links with universities are of strategic importance not just to Stelco, but for the entire Canadian steel industry. "We are better at working with universities than our US competitors, and better than Japan or the UK, but on par with West Germany," says McLean in assessing the Canadian position, "and it's one of the reasons for the success of our industry to-date."

Stelco's experience with universities goes back to 1961, when it funded the first Stelco chair in metallurgy at McMaster University. It did so on its own, without any government assistance. It also funded a second chair at the University of British Columbia, and is funding two more chairs jointly with other steel companies, through the Canadian Steel Industry Research Association and NSERC. "The funding of these chairs represents a major recognition by the company of their importance," says Jock McKay, director of R&D. "These commitments require approval at the highest levels, by the CEO and the Board of Directors."

The NSERC's program of university chairs program is considered an excellent mechanism for giving industry a sense of belonging and involvement in the university effort.

Stelco spends about $450,000 a year out of its R&D budget on university links including university chairs. These links are the responsibility of Jock McKay, who spends about ten percent of his time on university matters.

Other links with universities are maintained by some of Stelco's own scientists. Four of them hold faculty appointments as adjunct professors in Canadian universities and co-supervise doctoral and masters students.

Stelco also gives out fellowships to outstanding graduate students and to their professors. The fellowships are in the form of a substantive cash award to the student, to supplement other government scholarships, and of an equipment donation to the professor.

A good example is offered by a project on modelling the flow of molten steel to study wear patterns in a vacuum degassing unit, a key step in steel manufacturing. Stelco gave a fellowship to a McGill student. The company's research lab also designed and manufactured a high-precision plexiglass model of the vacuum degassing unit for his professor, as part of the fellowship. Water, which in scaled-down models behaves almost identically to molten steel, was used to simulate the flow patterns. This equipment allowed the professor and his student to model and perform calculations predicting the flow of molten steel and the wear patterns as they would occur in the full-scale unit. The plastic model, costing several thousand dollars, would have been very difficult to build in the university machine shop.

The steel industry in Canada generally cooperates very closely with its academic colleagues. Five years ago, it sponsored five or six professors, accompanied by two industry representatives, to go on a fact-finding tour of steel facilities in Europe. This was followed by a debriefing for the industry, and a more formal report. This initiative shows the extent to which the industry considers the university community as a strategic ally. This successful experience led to another trip to Japan two years later.

The Canadian Steel Industry Research Association (CSIRA), of which McKay has been a great promoter, can be credited for catalyzing industry-wide appreciation of what universities can do for the industry. One of the CSIRA's first initiatives after its creation in 1978, was to organize visits to the thirteen Canadian universities engaged in ferrous metallurgy. These visits were an occasion not only for its industry members of CSIRA to learn about the technical capabilities of the universities, but also for the latter to find out more about industry's problems. In addition to generating useful technology, links with universities also provide complementary expertise in fundamental areas, and leads for recruiting. The

Canadian Institute of Mining and Metallurgy, a professional association, also provides a useful forum for university-industry exchange.

Stelco's R&D department used to hire summer and co-op students but discontinued the practice, because of the significant management time it required. It also had visiting professors for periods of six months to a year, but currently have no such visitors. "There is no career reward or glamour for an academic in spending time in a steel mill," says McKay. Some efforts have been made to change university attitudes through discussions with university professors and NSERC. "A professor's best career move is still to spend his sabbatical in a foreign institution, not industry."

When Stelco still had a pilot plant at the Technology Center, engineering students from the University of Toronto would visit for a week each year to carry out projects on the equipment. Stelco also offers speakers for different occasions, including career orientation.

"Never go to a university with a problem," says Jock McKay, in describing what a successful relationship with a university should be. "But go to them with a basic question such as 'What makes this process work?', requiring a long-term fundamental research effort."

This view is echoed by Les McLean, Stelco's Vice President of Technology: "There are really three kinds of research: there's the very rare occurrence of a great discovery that leads to the cry Eureka; then there's what is called invent-to-schedule, where you have a specific problem, a rigid timeframe, and a specific allocation of resources, including outside resources such as calling on university experts; and then there is the systematic probing of a domain by an expert, which sometimes leads to unexpected results. The invent-to-schedule is best done in the industrial environment. But it is the last area where university researchers are best, and if you nurture these relationships, then a professor might very well call Stelco the next time he finds something interesting. But if you bring a professor to work in the Stelco R&D lab, and have him work on invent-to-schedule type project, then it won't work. You can't tame a professor and tell him what to do."

Not all professors are suited for work with industry. The choice is usually based on personal compatibility and on genuine interest in industry's problems. There is usually a middle ground between purely theoretical work and the applied problems of industry. "You don't want clones of industry," warns Jock McKay, "you want them to keep their fundamental outlook, and to stay with a problem as long as they feel it is necessary." This means that when Stelco makes a commitment to a professor, it's for the long term, "for better or for worse. You can expect to see substantial rewards from interaction with universities only in the long run."

Stelco has close ties with about ten of Canada's leading universities. Jock McKay was able to refer to some twenty professors that he dealt with by their first names. "You have to be selective in choosing who you're going to work with," he says. "The ones we deal with are of the highest repute, and many have won international awards for scientific excellence."

ALLELIX INC.

Company Background

Created in 1983, Allelix inc. is Canada's best known biotechnology company. It is owned by Polysar Energy and Chemical Corp. (50%), and John Labatt ltd. (30%), and the Ontario Development Corporation (20%). It concentrates primarily on long-term, high potential projects.

Initial start-up funding amounted to about $90 million over five years. Allelix employs 240 people, of whom 180 are directly involved in R&D, and more than 50 have Ph.D.s. The company is located in a modern white building close to the Toronto Airport.

The company' current annual R&D budget is about $17 million. It already has ten patents, with fifty pending. Revenues from two biotechnology-derived products are approaching $1 million a year, and if research contracts are included, total revenues reach $4 to 5 million.

The company is now in the process of re-organizing itself into three divisions, which will become three independent biotechnology businesses: agriculture, biopharmaceuticals, and diagnostics.

The agriculture division is concentrating on developing improved varieties of canola, an oilseed crop, and on exploiting microbes, primarily pseudomonads, to interact with crop plants in order to improve crop productivity. The biopharmaceuticals division is using protein structure determination and protein engineering to design pharmaceuticals. The diagnostics division has developed a number of assay kits based on monoclonal antibodies, for home use pregnancy tests, as well as tests for streptococcus infections, and sexually transmitted diseases such as gonorrhea and chlamydia.

Initial funding is coming to an end, and Allelix will likely seek another round of financing in the near future.

University links

Given growing financial pressure, Allelix has made a strategic decision to abandon its previous policy of funding all its research in-house. It will now rely more on academic and industrial collaborators. Dr. John Evans, the Chairman of Allelix, calls this new course of action "forging strategic alliances" -- linking with university researchers to produce innovations and with commercial industry to bring promising product to market.

Allelix spends between $500,000 and $750,000 a year on university research. These funds, when matched by various government programs, come to $1.5 million. There are six industrial post-doctoral fellows working at Allelix, about eight co-op students a year, and three university chairs at the universities of Guelph, Waterloo, and Toronto. The chairs represent long term commitments to a program. The company uses almost all of the available government programs designed to encourage university-industry interaction, including the National Research Council (Industrial Research Assistance Program, or IRAP), the Medical Research Council, and the Natural Sciences and Engineering Research Council.

There are also consulting agreements with half a dozen professors, and a couple of university researchers are spending their time in the company's laboratory. Six of Allelix's scientists teach at the University of Toronto.

Allelix Biopharmaceuticals has board of eminent university scientists composed of three Canadians and two Swedes, who meet quarterly to review the scientific research program. The board members are bound by a confidentiality agreement and provide a useful network of potential contacts across the world.

"We like to encourage these university links," says Graham Strachan, President of Allelix Biopharmaceuticals Division, "and to move as speedily as possible from the discovery to the product phase. If we can, we also like to access government funds to support a portion of this exceptionally high risk R&D. Otherwise, with our R&D costs of close to $17 million, and the little revenue we have up to now, we couldn't afford it." Strachan also recognizes that the technology is moving very rapidly and that there is a need for maintaining a wide network.

The university links help Allelix extend its expertise and discover new opportunities. But the relationships are not always smooth. For example, universities are more interested in science and in publications than in product development. In reviewing the last five years, Strachan says the results were mixed: "There were some disappointments as well as some successes: professors would leave on sabbaticals without letting us know, some claimed they had skills and expertise which did not exist, and then there can be personalities and big egos to get in the way."

Yet the raison d'être of these links is to transfer technology. "You have to have collaboration and a meeting of the minds to make it work," says Strachan. There have been improvements, and people have become more sensitive, particularly as some of Allelix's scientists have returned to university while maintaining links with the company. A successful collaboration involves involves both the intellectual and material levels. It includes providing supplies, chemicals, consulting fees, or sending a graduate student to a conference.

Martin Sumner-Smith, Manager of Technology Assessment, cites one of the most successful university collaborations -- the hybrid canola project where all deadlines were met and all deliverables completed. Canola, or rapeseed, produces edible oil, and has rapidly gained favor with Canadian farmers. New hybrids can offer higher crop yields, and special characteristics such as herbicide tolerance, disease resistance, or modified fatty acid profiles. These hybrids can be developed using a combination of traditional plant breeding techniques and the tools of modern biotechnology.

The research was initiated by a professor of crop science from Guelph University, Dr. Wally Beversdorf, who came to Allelix to head the agriculture division. Three years later, he is returning to Guelph while maintaining research links with Allelix. The technology for hybridization has been licensed from Guelph and appears to have significant commercial potential.

Generally, universities keep the rights to the intellectual property and sell the company an exclusive licence for a royalty fee. Compared to five years ago, universities have become much more sophisticated and more knowledgeable about intellectual property, licensing, and contractual forms. But compared to the US, they are ten years behind and have a long way to go, observes Sumner-Smith.

He is disappointed with some of the inexperience on intellectual property he still encounters from time to time: "We often find universities with no in-house patenting expertise: they will bring to the negotiating table a lawyer with no experience in licensing. On several occasions, as part of our contribution to the contract with a professor, we had to fill out all the patent application papers and file them on behalf of the university or the professor, assigning them the right of ownership." There is also little available expertise in Canada in the area of biotechnology-based patents, which is a very new area. Nonetheless, about five patents have resulted from this university collaboration.

There are many obstacles to successful collaboration. For instance, it is much easier to apply for matching funds from government agencies in areas such as micro-electronics, where it is possible to predict the development of a product within two or three years. "But try to do that with biological material!" says Sumner-Smith. "Testing alone for registration purposes can take three to ten years."

Another difficulty encountered is misrepresentation. Some academics have been found to report erroneous results which could not be reproduced in Allelix's laboratories. "In one case we sent two of our scientists to the laboratory of a professor to see how he carried out a particular purification procedure. And we discovered that we could not reproduce the results, even though there had been a press conference announcing them."

There is still some suspicion in university science and medical faculties to cooperating with industry. In one instance, a professor would not allow his graduate students to attend research seminars held on Allelix premises for fear that he would become intellectually contaminated by the private sector.

POLYSAR LTD.

Company Background

Polysar Limited is one of the world's leading manufacturers of synthetic rubber and rubber latex. Based in Sarnia, Ontario, it was originally created by the Canadian government in 1942 to produce synthetic rubbers to replace natural rubber supplies disrupted by Word War II.

With 1987 sales of $2.5 billion, the company employs about 6,500 people world-wide. It consists of two divisions, the basic petrochemical division and the polymer division. The Basic Petrochemical Division includes a large integrated refinery and petrochemical complex with a capacity of 2.8 billion pounds of primary petrochemicals a year, including a billion pounds of ethylene, a range of intermediate petrochemical products, and various fuel products. It also manufactures styrene monomer, and has interests in natural gas and natural gas liquids.

The Polymer Division is one of the world's largest producers of synthetic rubber and a major North American manufacturer of plastics. The division also manufactures latex and specialty products. It uses raw material feedstock produced by the Basic Petrochemicals division and other refiners.

Polysar has plants in six of the world's major industrial nations, 22 sales or technical service offices around the world, and distributors in more than 75 countries.

The company's recent corporate history could be described as stormy. It was owned by Canadian Development Corporation (CDC), a holding company created by the federal government. After 1984, CDC was directed by the new conservative government to divest and privatize its assets. Almost all assets were disposed of, with the exception of Polysar and an energy-based company. The holding company (CDC) became an operating company, changing its name to Polysar Energy and Chemical Corporation. Polysar limited also sold off its latex business for about $500 million to BASF AG of West Germany in 1987. In the summer of 1988, Polysar Energy and Chemicals Corporation was taken over by Nova Corporation, an Alberta petroleum and pipeline company.

The R&D organization of Polysar Limited is largely concentrated in the Sarnia area, has a budget of $73 million, and employs 550 people, of which about half are scientists and engineers.

Polysar's end products have more than 40,000 applications in a variety of industries such as automobile manufacturing, construction, communications, engineering, mining, textiles, agriculture, and packaging.

University links

Of the $73 million spent on R&D in 1987, $1.2 million was spent in universities. Half of this was spent in Canadian universities, and the rest in the U.S. and Europe.

Ted Rhodes, Vice President of Technology for Polysar, outlined his company's approach to university links: "A major source of information on polymers is in universities, so you scan the universe, and find oases or islands of expertise, and develop whatever link is necessary to get the information. When you consider that an international chemical company like Bayer spends $1.2 billion on research (ten times more than we could afford), a strategy for us is to use universities as much as possible. This makes sense, because university research is relatively low cost. It would cost us about $250,000 a year to hire a scientist, pay his salary and equip his laboratory, including a technician. But if you give a contract to a university, you will essentially have the services of a professor, a post-doctoral fellow, and a graduate student for $80,000. So there are tremendous economic incentives for developing these ties." Polysar maintains direct contacts with about 20 professors in Canada, and roughly the same number elsewhere.

Rhodes' role is to create a culture within the organization that favors these links. He does this by promoting the company policy, attending meetings, giving talks to senior managers and researchers, and commending successful links. But the action must come from the grass roots. The company scientist must see the value of these links, and must make the contact with the university researcher himself.

To make a university contract work well, Ted Rhodes, who was a professor of chemical engineering before coming to Polysar, says that the key factor is to monitor the project closely. Most failures can be tracked down to inadequate monitoring by the industry scientist on a specific project. "A good researcher must be at the university at least once every six weeks, and the university researcher should be visiting the company as often. The best collaboration happens when the two scientists work closely together."

Rhodes also feels that this collaboration should not end with the project, which generally begins as a bench-scale laboratory demonstration of a process. When the company develops the pilot plant for the process, and scales it up to do some preliminary market testing, the professor should also be involved, either working in the pilot plant, or being retained as a consultant. This close interaction can often be tremendously beneficial to both parties, says Rhodes. The worst form of collaboration is to give money with no further interest on the part of the company, other than a vague hope that something useful will happen.

Polysar's interaction with universities involves contracts, partial funding of university chairs, hiring of up to seventy summer and co-op students in its R&D labs and plant, and provision of about half a dozen adjunct professors. The company also supports some co-op Ph.D. students with Waterloo university, where a student will do course work at the university, but do his research in the company laboratory under joint supervision by a university professor and an industry scientist. The real advantage of this program for Polysar is that it gives students a first hand look at the company, which is located in a somewhat isolated industrial area of Southern Ontario. "These informal networks and contacts are the best source of new scientists," says Rhodes. "Getting an already established person to move to Sarnia can be quite difficult."

The most successful example of collaboration between Polysar and a university was the development of TORNAC, a new polymer product. It is nitrile rubber with heat and oil-resistant properties that are in increasing demand by industry, particularly in the auto sector. It originated in a contract nine years ago with Dr. Gary Rempel of Waterloo University. He was engaged to develop a catalyst to hydrogenate rubber and this was followed by subsequent contracts to scale up the process, and look for cheaper catalysts. It is now being extended to other related areas. In 1987, construction began on a new 1,600 ton commercial plant in Texas. Tornac will sell for $15 per pound, 10 to 15 times the price of conventional oil-resistant rubbers. Polysar paid for Waterloo university's patents on the process, and has an exclusive license to it. The senior researcher who managed the university contract was promoted to General Manager for his efforts.

Ted Rhodes would like to see an additional person on staff to help him out in managing university interaction. "Seeking good talent would be part of the job," says Rhodes. "There's lots of talent out there that we don't know about."

So far, Polysar has not participated in government programs to foster university-industry cooperation.

Rhodes would like to see more resources go to universities, to allow professors more time for research. As a former academic, he feels strongly about the resource squeeze faced by universities: "Today, a professor has essentially the same contact hours with students as he did twenty years ago. Yet classes are four times larger, and the budgets for teaching assistants have remained unchanged. At the end of the day, a professor has no energy left to do much industrial contract work."

Polysar also instituted a science and technology advisory committee (STAC). It consists of seven world-renowned scientists who meet periodically to discuss projects with Polysar scientists and provide advice and references to the project managers. Rhodes is very careful to point out that they do not have a formal policing or program review role: they are there to provide assistance through personal contacts and informal discussions. Should a researcher need to pursue a point with one of the members of STAC, he can do this at no charge to his budget, since the costs of any consultancy will be covered by Rhodes' office. "This committee provides us with an invaluable window on the world," comments Rhodes.

CONNAUGHT LABORATORIES

Company Background

Connaught laboratories is Canada's largest producer of biological products for health care; it is recognized as one of the world's leading biotechnological research firms. It was created in 1914 as an extension of the University of Toronto's School of Hygiene. With 1100 employees located in near Toronto, and in Pennsylvania, Connaught markets its products around the world.

Close to 80% of its sales -- $195 million in 1987 -- come from adult and children vaccines against polio, measles, diphtheria, whooping cough, tetanus, rabies, influenza, cholera, yellow fever, and bacterial meningitis. The company is the largest producer of influenza vaccines in the western world, and the only North American manufacturer of both oral and injectable polio vaccines.

In its early days, Connaught's research successes included the development of bacterial toxoids, insulin, heparine and epinephrine. Connaught became the first company to mass produce Salk polio vaccines in the 1950s.

Today, Connaught's research is more market-driven, and has resulted in products such as a conjugate vaccine against bacterial meningitis now on the market, and a recombinant DNA-derived Hepatitis B vaccine which is undergoing clinical trials. The 1987 R&D effort had a budget of about $24 million, and employed 160 scientists and technicians.

Connaught is a subsidiary of Connaught Biosciences Inc., a Canadian Company, and has joint ventures with companies in Japan, the United States, and Denmark.

University links

Connaught's strategy for using university-based technology is based on the principle of extending the company's own internal R&D capabilities in carefully targeted areas, and of connecting to a world-wide network of experts.

About $500 to 700,000 out of the total R&D budget is spent on university research. Most of these links have been developed since 1982 and have been partially supported with federal and provincial government funds, including the National Research Council's IRAP and PILP programs, and grants from the Ontario Ministry of Agriculture and Food.

Dr. John Vose, the Director of Technology Development, is the senior manager responsible for university R&D links. He spends about 25% of his time managing these contacts. "Our links with universities are very closely targeted to our present research activities," he says, "and to those activities that we are planning to start next. These research activities are largely concentrated on vaccines -- how to design, deliver and target them better."

Dr. Keith Dorrington, the corporate Vice President for Research and Development, justifies strengthened links with universities as follows: "We don't have the resources for basic research. Our in-house efforts are more applied and product-oriented. So we need to identify basic research capabilities, or the more basic side of the R in the R&D, within universities. We use our university links primarily as a mechanism for gathering technology."

About 80% of the funds spent in universities are for contracts where a deliverable is expected. Some funds are also used to support graduate students, organize scientific meetings, or in some instances, send someone to attend a meeting. Connaught has six co-op students at any one time, and about five post-doctoral fellows. There have been visiting professors in the past. Currently there is no program to allow company scientists to spend time in universities, however, four scientists have university appointments, including Keith Dorrington who holds a position at the University of Toronto.

According to Dr. Vose, one of Connaught's important channels into the university sector is a scientific advisory board, composed of eight distinguished Canadian and US scientists and chaired by Dorrington. The board members, who meet four times a year, are selected on the basis of the match between their areas of expertise and Connaught's interests, as well as their excellence in the field. "This group has access to our deepest, darkest secrets and provides us with invaluable advice concerning the specific direction our research should take," says Vose. On an informal level, it also provides advice to senior managers on specific projects, including the evaluation of candidates for positions.

"The building of a link with a university scientist usually starts with a 'softening-up' process," says Vose, "which might include visits, seminars, and discussions. These are very useful in themselves." Sometimes, Connaught will provide seed money "to get the ball rolling." In the process, the scientist becomes more familiar with work carried out at the company. Exchange of test results may follow. If the relationship appears interesting, the company may apply for financial support to government programs for industry-university research. Usually, the scientist will be required to sign a confidentiality agreement. And in some cases, the company might even hire the scientist full-time.

Several successful projects have resulted from this university collaboration. Keith Dorrington cites a new technique of targeting antigens to the immune system. This patented technology, originally developed by Dr. Brian Barber of the University of Toronto, uses monoclonal antibodies to target antigens onto specific cells. It produces a much higher level of antibodies with a very small amount of antigens, and can dramatically increase the effectiveness of producing some vaccines. This technology could be worth several hundred million dollars.

Another major product which also originated in cooperation with the University of Toronto is a new diagnostic testing kit. Based on the use of monoclonal antibodies, the kit can determine the presence of the non-A non-B hepatitis virus, through a blood test. The potential North American market for this kit is estimated at several hundred million dollars.

"Our experience in these contacts has been very good," observes Keith Dorrington. "In almost all cases we knew the individual very well before we started collaborating. We chose university researchers who are not only interested in research, but with whom we felt comfortable. That's the key to good collaboration." John Vose is convinced that to be fruitful, university contacts have to be followed up very closely, in some cases on a weekly basis.
Academics tend to be cautious when dealing with industry, particularly if it affects their publications, involves the hiring of graduate students, or imposes secrecy on their research. "These reservations no longer hold true today in biotechnology-based research. And we tend to go with people who don't have these concerns," notes Dorrington. Vose agrees that these contacts must be based on mutual trust if they are to work well.

Dorrington believes that for a successful university link, "you need to do your homework up front." It is necessary to define the university partner's role in a project, and assess to what degree he is interested in working with the company for a common goal, rather than just for the money. Ongoing evaluation of the project, once it has been started, is also important, and projects that are not working should be stopped.

"We need to spend more time on the road looking for opportunities," says Dorrington, "rather than have people come to us, but it's a time consuming activity."

University-based collaborations do not work if three or four groups in separate institutions work on a single project. "These types of arrangements tend to be very difficult, and take up a lot of management time," Dorrington says. For John Vose, difficulties also arise when the scientific merit of a project is overstated, or where the market potential for a new product is grossly exaggerated.

Academics perceive industry to be much richer than other funding sources such as government granting agencies. They will occasionally try to negotiate higher terms for a contract. They also tend to overestimate the commercial value of their work, sometimes thinking that a little work justifies investments equivalent to major product development.

There are always problems with deliverables and deadlines because of overoptimism on the part of researchers, but these problems are equally prevalent with in-house scientists.

Dorrington notes that universities differ among themselves as to how each one of them approaches industry collaboration, including the treatment of intellectual property. Some are very sophisticated at handling questions of licensing and intellectual property, others are quite naive. The various central offices of business development and technology transfer can either be helpful, or can hinder the contacts. Their effectiveness often depends highly on the particular individual running the office.

Connaught would like to see standardized procedures regarding patenting for all universities. As far as possible, the company prefers to have full control of intellectual property. This can be done either directly through ownership of the patent, or through an exclusive licensing arrangement. In the latter case, if Connaught does not use the invention, then the university is free to go elsewhere to commercialize it.

NORANDA Inc., Technology Centre.

Noranda Inc. is an international company of over 45 subsidiaries and associated companies with more than 140 operations in 13 countries. Noranda began as a mining and mineral company. Today, it is active in four major businesses, minerals and metals, including copper, zinc, lead, silver, gold and potash (31%), forest products including pulp and paper, building materials and paperboard (28%), energy, including oil and gas exploration, production and marketing (22%), and manufacturing, including aluminum, wire and cable (19%).

Noranda's 1987 sales were $7.3 billion, and the company employed 44,000 people.

The Noranda Technology Centre (formerly known as the Research Centre) celebrated its 25th anniversary in 1988. Its efforts have concentrated on Noranda's traditional strengths, namely mining, mineral processing, metals extraction and refining, and metals applications. It will be expanding its efforts into manufacturing technology and forest industries technology, to complement the R&D efforts of the company's recent acquisitions.

The Technology Centre, located in Montreal, had an operating budget of $14.5 million in 1987, and currently employs 145 people.

University links

About 5% of the Research Centre's budget goes toward universities. These contacts have been part of the centre's culture since its beginning.

Its director, Peter Tarassoff says there are two reasons for intensifying these links: "They contribute to new technology development, and as such are an extension of our capabilities, and they help provide future employees for the research centre." Government programs such as the granting councils'matching funds have helped significantly.

Ninety percent of the funds spent by the Centre on universities is given in the form of contracts which call for a specific deliverable, and ten percent are in the form of grants. The latter involve small sums, between $5 to $10,000, to toward building a relationship.

There is no formal policy for managing relations with the academic community. University contracts are selected and managed at the project manager's level. It is the company researcher's responsibility to identify an area of needed expertise, and then to select the university.

Two of the Centre's scientists are adjunct professors, and others give periodic lectures. Noranda also sponsors seven prestigious post-graduate fellowships, worth $15,000, for students undertaking research projects in an area of direct interest to any one of the Noranda companies. Although there were post-doctoral fellows at the Centre in the past, there are none at the present time.

Noranda's Technology Centre participates with nine other mining and metals companies on the advisory body of the University of British Columbia's (UBC) Centre for Metallurgical Process Engineering. The UBC Centre was built around the expertise of a few professors, and all research is financed through specific contracts, a feature that Tarassoff finds attractive. There is no annual fee. Noranda's Technology Centre also supports a chair in hydrometallurgy at UBC.

The Technology Centre is participating in two government-university-industry projects, spearheaded by the federal government's mineral and energy laboratory, CANMET. One project involves copper refining, the other is a major environmental effort to study and manage reactive mine tailings. The Centre is also part of a university-industry consortium of European copper refiners.

The Technology Centre also participated in a consortium with several other companies to sponsor a new electron microscopy laboratory at the École Polytechnique in Montreal.

Peter Tarassoff is generally satisfied with the Centre's university contracts: "Most of our contracts have worked well. But you have to specify all the deliverables, and don't leave any loose ends. It's important to have both parties understand what is expected from the agreement."

There are some cultural differences. The industrial scientists would like the university researcher to move faster. Sometimes there are conflicts over publication of results if the university researcher wants to rush something to press without any regard for patenting opportunities.

The company's policy on intellectual property is that it generally wants to keep the first right of refusal to use a technology. It also wants to clear all publications before they go to print. Noranda usually works directly with a researcher, rarely with the university business office.

Noranda, along with ten other major Canadian companies, subscribes to the industrial liason program at the Massachusetts Institute of Technology (MIT) industrial liaison program. For the substantial fee of US$ 25,000 a year, the company is entitled to a variety of privileges, including invitations to seminars of interest, a few hours of consulting by some of MIT's faculty, reports on research in progress, and special briefings.

Tarassoff is skeptical about the effectiveness of the growing number of centres of excellence, and claims Noranda has been flooded by requests to join. "There are too many companies on these advisory boards representing too many conflicting interests, for these centres to work effectively," he says. The most successful consortium-type efforts are those where the number of participants is small and does not exceed 4 or 5.

According to Tarassoff, the most successful relationship with a university is built "when the academic seeks you out, and actively markets himself, although it must be a two-way street." Some academics will have an arrogant attitude and simply seek funding for their own projects, without any effort to show how their work might be relevant to a company. Others, whose work might very well be of interest to Noranda, will make no effort to approach the company, and expect to be supported. The need to market oneself to the client is equally applicable to the Research Centre as a whole: "Even we as a research group have to market ourselves to the operating units in this company, listen to their problems, and let them know what we can offer," concludes Tarassoff, "because they will not always come to us."

APPENDIX "B"

MODEL RESEARCH CONTRACT BETWEEN A UNIVERSITY AND A COMPANY.

This model contract covers all the essential points for a research agreement, including such points as deliverables, payment modalities and intellectual property. It can be easily adapted to any country.

Excerpted from "Spending Smarter: Update", The Corporate Higher Education Forum, 1155 Dorchester Blvd. West, suite 2501, Montreal, Québec, H3B 2K4. May 1986.

An eight-member committee consisting of research and legal administrators from both industry and universities has developed a model short form industry-university research contract. The authors of the model contract, reflecting the cooperative spirit of the members of the Corporate - Higher Education Forum, have aimed at providing insights into key issues and options for implementing both university and industry goals. The use of such a contract should enable participants in cooperative research to reduce the time spent in negotiating, thus encouraging more activity in this area.

The attached guide and model research contract are intended to assist faculty members, industrial scientists and research administrators in drafting workable agreements.

ATTACHMENT A

Guide to Industry-University Research Agreement

GENERAL COMMENTS

These guidelines developed for industry-university agreements are intended to serve as a *model* contract. In some circumstances the negotiating parties may wish to alter the model to reflect their particular situation. In the most contentious area, namely, ownership of the results, we have provided a choice of options giving either the company or the university ownership of the fruits of the labour of the project. However, regardless of the ownership, both parties share in the downstream benefits of the intellectual property developed during the course of a research contract.

Although an option is not provided for ownership by both parties, it is recognized that increasingly there may be circumstances wherein joint ownership of all or part of the project results may be desirable and more accurately reflect the input of both parties. It is expected that these agreements will be negotiated on a case by case basis.

It may first be useful to review the distinction between grants and contracts. While this distinction may not always be clear cut, there are basic differences:

A grant is financial support for an investigator, or investigators, conducting research in a particular subject area or field, without any formal detailed stipulations as to the direction of such research. The following characteristics are normally also present —

- no direct or indirect reimbursement to the principal investigator
- no stipulation as to deliverables
- no limitations on publication
- no specific transfer of results to the grantor
- payment to the university in advance of expenditures

A contract is an agreement between two corporate bodies, namely the company and the university, to provide financial support for an investigator, or investigators, to conduct research in a particular subject area or field under specific stipulations and conditions. These conditions may -

- specifically outline the scope and nature of the research
- set the time period(s) for the activity
- define the deliverables
- establish ownership, patent rights and licensing arrangements
- provide for confidentiality of information supplied and created
- establish budget approvals and payment schedules
- establish considerations for acceptance and/or termination
- limit liability of participants,

and other matters that may be appropriate to the circumstances.

It should be noted that provision of operating funds to universities are to support the academic endeavors of the university; diversion of these funds to subsidize research for a private corporation would be an inappropriate use of those funds.

DISCUSSION OF SPECIFIC ARTICLES

Formalities

It is important that a contract or agreement be signed by the persons who have the legal authority to do so, and any amendments should be signed by either the same person or other persons with the same level of authority. It is not advisable to put the expression "officer" into the paragraph before the signature, because in many cases this will not accord with the practice in either the corporation or the university. The principal investigator should sign the Acknowledgement as the person responsible for the technical aspects of the project.

Often an agreement bears several dates leading to confusion as what the "date of the contract" really is. In this Agreement, there is only one date and it is the effective date. No date is provided for the signatories because they sign "as of the effective date". This procedure takes into account that almost all agreements are signed before or after they take effect. This sometimes bothers people and leads to unnecessary delays, explanations etc. A contract must be executed by both parties but the date of signature should have no direct bearing on its effective date. A reference to "seal" is also undesirable because many companies and universities do not utilize this formality. Obviously if organizations prefer to show dates of signature or prefer to utilize a seal, then the suggested model can be altered.

A proposal should include a reference as to the period of time for which it is effective. Similarly, the covering letter submitted with an agreement should mention how long the offer is open for acceptance and the manner in which acceptance is to be indicated. For example: kindly return one signed copy by (date) along with your cheque for (first payment) as our authorization to proceed with the project.

Article 3 **Deliverables**

It is important that the deliverable(s) be clearly understood by both signators to a research agreement, particularly in light of which option in Article 15 - Ownership and Commercial Exploitation of Intellectual Property - is being followed. In most instances the deliverable will be a report but may also be software, a prototype, model or technical drawings, patterns or maps, photographs, etc. Ownership of the deliverable(s) normally is vested in the company but the rights to any invention described therein may remain with the university.

Both parties should be aware that what they are attempting to define implies a legal liability to deliver this at the completion of the project. The definition of the deliverable(s) should be as accurate as possible in order to avoid potential accusations of breach of contract at a later date.

During negotiations for a research project it is not uncommon to have a budget reduced from that originally submitted by a principal investigator. Caution should be made that such a reduction also should be reflected in the scope of work; hence, also in the deliverables.

Article 5 - **Basis of Payment**

When the Basis of Payment is to be in accordance with a budget, it is useful to provide an estimate of the level of effort of personnel and the unit rate i.e. 5 man-months at $1200/month; 100 hours at $27.50/hr. Rates which are firm should be indicated (supervision fees, use of equipment, etc.) as opposed to those which are estimates. The budget should include a statement retaining the right to shift money from item to item (with the exception of firm rates) as long as the total financial liability of Company is not exceeded.

Frequently a Plan of Work and Costs is included as an appendix. This sets out the order of tasks anticipated and the related costs, along with milestones of achievement - often marked by a deliverable.

Article 6 - **Method of Payment**

It is expected that contractual research would be self-financing to the extent that full direct and indirect costs are recovered as well as being forward financed. Universities are not profit centers and do not have resources other than their operating funds for covering any bad debts should a company default in its payment.

- An agreement for research carries an obligation by the university to produce a deliverable, most frequently in the form of a report, by a given time. It is common that 10% of the cost of the work will be held back by the company until the final report has been accepted.

A typical schedule of payments negotiated would be as follows:

- a sum due upon signing
- monthly or quarterly invoices (or payments if it is a firm fee contract)
- final payment (10% upon acceptance of the final report)

For contracts which are not based on a firm fee adjustment should be made in the final invoice for actual expenses incurred against monies received. Any funds remaining uncommitted at the end of the contract period should be returned to the sponsor.

Article 8 - Period of Agreement

One caveat for all to remember is that an agreement is not an agreement until it is signed by both parties. While this is true, it is sometimes difficult to coordinate available equipment, staff and facilities to commence on short notice for a specific date. Ideally all parties should sign the agreement sufficiently in advance to allow for an orderly start up; in practice this is difficult to orchestrate and rarely occurs. If a Plan of Work and Costs is part of the agreement, the first tasks are frequently itemized as hiring staff and ordering supplies.

Occasionally a university will be asked by the company to undertake certain tasks while negotiations relating to an agreement are still on-going. At this point the university would be well advised to remember the caveat! However, there are several options which may be utilized in order to not impede the progress of the project. If it is equipment that is to be ordered, the company may wish to purchase the equipment and arrange for delivery to the university. The agreement can address the transfer of ownership at a later date. Alternatively one may consider drawing up a letter of intent to cover the limited obligations and compensation to be undertaken prior to the effective date of the agreement.

Usually the date of termination will coincide with the scheduled date for the final deliverable. When applicable, allowance should be made for an appropriate period between the end of the Project work and the preparation of the final report.

Notice also should be taken of Article 22 - Survival of Articles.

Article 12 - Confidentiality

It is important to pay close attention to the principle of confidentiality because information which is not produced as a result of the research agreement should be safeguarded and the ownership of such confidential information should continue with the company or the university as the case may be. This applies equally to much of the information developed as a result of the agreement.

Some confidentiality provisions specify that information is *not* confidential. unless it is specifically designated as such by the disclosing party. This sounds very reasonable but does not always correspond to the real world. In many situations confidential information is transmitted orally and is mixed with non confidential material.

Depending on the type of research being done, it may be advisable to have all persons including students involved with the project at the University sign a simple confidentiality agreement - or the Acknowledgement of the Agreement.

Article 14 - Publication

It is acknowledged that universities exist to increase the total fund of knowledge in our society, and to provide for the free exchange of ideas between scholars.

At the same time commercially useful technical information in many cases loses all its value if it is made public. This applies particularly to non-patentable technical information, including software. However even in the case of patentable inventions, secrecy gives the potential patentee a lead time of at least two (2) years while the patent is being considered at the Patent Office. Some people are not aware that only a patent can be infringed, and that pending the grant of a patent, there is no protection for the inventor. It is critical that this information *not* become available to a competitor. Moreover, publication or presentation at symposia releases the information into the public domain. Patents can only be obtained for inventions within a very limited time after such disclosure.

An attempt has been made to balance the conflicting interests of industry and universities in this article. It should also be noted that if the university is allowed to participate to some extent in the commercial exploitation of an idea generated by the research agreement, there will be more incentive to keep commercially useful information secret. At the same time non-commercial information can be dealt with in a more traditional academic manner. If technical information which has to be kept secret is incorporated into a thesis, then it is published for all practical purposes. As a consequence, should the research involve the possibility of commercially useful information, the Principal Investigator should be aware that there may be restrictions on theses and other publications; thus is cautioned in considering the employment of graduate students.

Article 15 - Ownership and Commercial Exploitation of Intellectual Property

The question of who has the right to so-called "Intellectual Property" in a research endeavor is a very complex one. In the first place, the particular project may be a portion of a large body of knowledge which resides in the university or in the corporation or both. It is obviously important for both the corporation and the university to limit disclosure to the project at hand. One should also anticipate that the work may trigger ideas or open up paths of investigation for the researchers. Instead of trying to capture some of these rather ephemeral aspects of the transaction, *Option I* is structured in such a way that the "Deliverables" and other Intellectual Property, belong to the company. Sharing between the corporation and the university to some degree in the commercial profits derived from the research is provided.

Option II gives title of the Deliverables to Company but that other Intellectual Property generated by the research agreement belongs to the university which in turn grants extensive licenses to the sponsoring company. Again attention has to be paid as to what the "deliverables" are and to what extent they are included in the provisions governing intellectual property.

Reference is made to negotiating a royalty in keeping with industry norms. In these negotiations consideration should be given to the contribution of both parties, the scope of the protection afforded by patents, copyright or other intellectual property rights, exclusivity or non-exclusivity of the license, the amount and duration of the royalty, the rights to sublicense, performance obligations of the company and other relevant matters.

Since conditions of joint ownership vary so considerably, no option for such circumstances is provided in this model. However, the possibility of joint ownership is recognized and it is expected that details of such an arrangement would be identified in a manner similar to Options I & II.

Article 17 - Special Conditions

Each situation is likely to produce problems and solutions beyond any general guideline. The Article on Special Conditions could cover some of the following:

1. Accommodation of employees of Company in performing R&D on university premises or vice versa:
2. Delivery of materials, information or equipment by Company, in accordance with a schedule.
3. Special insurance or permit requirements.
4. Access to University prior know how, patents, etc. (This may be the subject of a separately negotiated agreement).
5. Company liability for Company owned equipment on University premises.

ATTACHMENT B

Model Industry-University Research Agreement

between

____

name and full address of university

hereinafter referred to as "University" and

____

name and full address of company

hereinafter referred to as "Company", herein acting and represented by

____

Company and University hereby agree as follows:

Article 1 - Objective
University shall perform the work described in Article 2 (referred to as "Project") upon the terms and conditions hereinafter set forth.

Article 2 - Scope of Work
The scope of work is as follows: (or see Appendix ______)

Article 3 - Deliverable(s)
Deliverable(s) are defined as follows:

They shall be submitted to Company by the following dates:

Unless University is notified to the contrary by Company in writing within 25 working days following receipt of the deliverable(s), the deliverable(s) will be deemed to have been accepted by Company according to the terms and conditions of this Agreement.

Article 4 - Principal Investigator
The Principal Investigator of the project shall be ________________________
of University's Department of ____________________________________.
who is responsible for the technical content of the Project.

Article 5 - Basis of Payment
In consideration of University carrying out the Project, Company shall pay University the cost of the work in accordance with the attached budget (Appendix __________), or a firm sum of __________ Canadian Dollars.

Article 6 - Method of Payment
The sum stipulated in Article 5 hereof shall be paid by Company by cheque made payable to ______________________________ within 30 days of receipt of invoice(s) according to the following schedule:

Invoice(s) shall be sent to:

Interest may be charged at the rate of_____percent per month on amounts not paid within 30 days of submission of invoice.

Article 7 - Limitation
The total financial obligation of Company is limited to ________________ which said amount shall not be exceeded without the written authorization of Company, given by one of its duly authorized representatives. University shall not be obliged to perform any work beyond the Scope of Work (see Article 2) which would cause this obligation of Company to exceed such sum, unless University receives written authorization to the contrary.

Article 8 - Period of Agreement
The present agreement shall have an effective date of__________________ and shall terminate on ______________________.

Article 9 - Amendments to Agreement
The terms herein stipulated may not be modified in any way without the mutual consent of the parties in writing.

Article 10 - Assignment
No right or obligation related to this Agreement shall be assigned by either party without the prior written permission of the other. University shall not subcontract any work to be performed except as specifically set forth in this Agreement.

Article 11 - Equipment
Any equipment or materials purchased by University as part of the Project shall remain the property of University unless otherwise specified in Article 17.

Article 12 - Confidentiality
Company and University may disclose confidential information one to the other to facilitate work under this Agreement.

Such information shall be safeguarded and not disclosed to anyone without a "need to know" within the Company or the University. Each party shall also strictly protect such information from disclosure to third parties.

Unless otherwise agreed to in writing, the terms and conditions of this Agreement are confidential.

The obligation to keep confidential shall however not apply to information which:

(a) is already known to the party to which it is disclosed;
(b) becomes part of the public domain without breach of this Agreement;
(c) is obtained from third parties which have no obligations to keep confidential to the contracting parties.

Article 13 - Publicity
Company will not use the name of University, nor of any member of University's staff, in any publicity without the prior written approval of an authorized representative of University. University will not use the name of Company, nor any employee of Company, in any publicity without the prior written approval of Company.

Article 14 - Publication
The parties agree that it is part of University's function to disseminate information and to make it available for the purpose of scholarship. They further recognize that the publication of certain technical information may destroy its commercial value.

Company shall be furnished with copies of any proposed disclosure relating to this Agreement at least ninety (90) days in advance of presentation or publication. Dissemination of such copies shall conform to Article 12. If Comapny does not object in writing to such disclosure within thirty (30) days of receipt, University shall be free to proceed. In the event written objection is made, the parties shall negotiate an acceptable version of the proposed disclosure, including the release date, within the original ninety (90) day notice period.

Disclosure includes theses, articles, seminars and other oral and written presentations.

The University shall be free to publish______ months after termination of this Agreement subject to confidentiality requirements.

Article 15 - Ownership and Commercial Exploitation of Intellectual Property
Intellectual Property may include: technical information, know-how, copyrights, models, patterns, drawings, specification, prototypes, inventions etcetera.

OPTION I - The deliverables specified in Article 3 and any other intellectual property described above shall be owned by Company, including assignment of any rights to inventions. University shall have the following rights:

(a) A royalty-free non-exclusive license for research and educational purposes only, subject to confidentiality requirements.
(b) In the event the deliverables or project results contain patentable inventions, copyrighted software or know-how which is commercially exploited, a reasonable royalty or other financial recognition shall be negotiated in keeping with industry norms.
(c) In the event Company does not exploit certain deliverables or project results within a specified time to be agreed upon, the right to commercially exploit them shall be reassigned to University, subject to a royalty-free non-exclusive license to Company.

OPTION II - Deliverables as specified in Article 3 shall be owned by Company. In the event the deliverables contain patentable inventions, copyrighted software or know-how which is commercially exploited, a reasonable royalty or other financial recognition shall be negotiated in keeping with industry norms.
Intellectual-Property other than those included in the deliverables shall be owned by University and Company shall have the following rights:
(a) University hereby grants Company a non-exclusive license to use and modify such other intellectual property with the right to sublicense to affiliated companies as agreed upon, subject to confidentiality requirements.
(b) University hereby grants Company a right of first refusal to an exclusive, royalty bearing license to use, sell and modify such other intellectual property with the right to sublicense at a royalty to be negotiated.

Notwithstanding the licenses granted hereunder, University shall retain the right to use the other intellectual property for research and educational purposes, subject to confidentiality requirements.

Article 16 - Liability and Indemnity
Unless otherwise stipulated in Article 17:

(a) Company shall indemnify University against all costs, suits, or claims resulting from the use by Company or its customers or licensees of any deliverable or intellectual property developed by University under this Agreement.
(b) University shall indemnify Company against all costs, suits or claims on account of injuries (including death) to persons participating in the Project or damage to University property during the performance of this Agreement.

Article 17 - Special Conditions

Article 18 - Termination for Default
Either party may terminate this Agreement thirty (30) days after written notice of default is given to the defaulting party and if the defaulting party does not take immediate action to correct such default within such period. Default on the part of the University shall include the death or departure of the Principal Investigator. Company shall pay for all expenses up to termination and for reasonable commitments made by the University related to the Project, prior to date of notice of default, for which the University is financially responsible.

Article 19 - Notices
Notices under this Agreement shall be sent by registered mail, return receipt requested or delivered by hand, return receipt requested to the following address of either party unless changed by written notice.

Company:	University:
Hitec Company	Knowledgefount University
Avenue	Avenue
Anytown	Anytown
Attention:	Attention:

Article 20 - Force Majeure
Neither party to this Agreement shall be liable to the other for any failure or delay in performance caused by circumstances beyond its control, including but not limited to, acts of God, fire, labor difficulties or governmental action.

Article 21 - Entire Agreement
This Agreement shall supersede all documents or agreements, whether written or verbal, in respect of the subject matter thereof.

Article 22 - Survival of Articles
Articles 12 (Confidentiality), 13 (Publicity), 14 (Publication), 15 (Ownership and Commercial Exploitation of Intellectual Property) and 16 (Liability & Indemnity), shall survive the termination of this Agreement for any reason in addition to those articles surviving by operation of Law.

Article 23 - Language
For the Province of Quebec only

This agreement is drawn up in English at the request of Company.

In witness whereof the parties hereto have signed as of the effective date shown in Article 8 above.

For University	For Company
______________________	______________________
______________________	______________________
Name & Title	Name & Title
______________________	______________________
Witness	Witness

Acknowledgment
I, the Principal Investigator, having read this Agreement, hereby agree to act in accordance with all the terms and conditions herein and further agree to ensure that all university participants are informed of their obligations under such terms and conditions.

____

Principal Investigator

Optional:

Other Participants

____
____
____
____
____

APPENDIX "C"

MODEL OF A LONG-TERM RESEARCH AGREEMENT WITH A UNIVERSITY AND AN INDUSTRY RESEARCH CENTER

Text of the administrative arrangements between the Pulp and Paper Research Institute (PAPRICAN), an industry sponsored research centre (see case study for details), and McGill University in Montreal. PAPRICAN has a laboratory on the McGill Campus, and the agreement covers the operations of the laboratory, as well as collaborative post-graduate education and research.

FINAL DRAFT
SUBMITTED TO
McGILL
MAY 20, 1987

PULP AND PAPER RESEARCH CENTRE, McGILL

ADMINISTRATIVE POLICIES

The purpose of this document is to confirm the administrative arrangements between the Pulp and Paper Research Institute (PAPRICAN) and McGill University regarding their collaborative post-graduate education and research programs and the operation of the Pulp and Paper Centre on the McGill campus. Over the past 60 years, various formal and informal arrangements have evolved. This document attempts to record the essential elements of these arrangements, thereby establishing the basic policies which will govern the operation of the Centre.

Historical Background.

1913 The Pulp and Paper Division of the Forest Products Laboratory was established by the Dominion Government of Canada in a building on the campus of McGill University.

1925 The Industry through its Canadian Pulp and Paper Association resolved to contribute to the operations of this Laboratory and to build on the research strengths already there to more efficiently investigate its scientific and technical problems. An understanding was reached on joint funding and administration between the Association and the Government.

It was recognized from the beginning that University participation was essential to the research programs being planned. McGill had in 1925 endowed a Chair of Industrial and Cellulose Chemistry with a bequest from Mrs. E.B. Eddy, and Principal Currie proposed to the Pulp and Paper Association and the Government that a pulp and paper building be constructed on the campus to house the government labs and the department established with the Chair.

1927 A historic agreement was reached between McGill and a corporation created for the purpose by the Canadian Pulp and Paper Association to construct a building at 3420 University Street to house cooperative research ventures between Industry and the University. The following year, agreement was reached between the Government and the Industry on financing of the laboratories.

1950 The 1927 Agreement effectively created the Pulp and Paper research Institute of Canada, though letters patent to authorize that title and to provide a full-time management were not promulgated until 1950. At that time the Joint Administrative Committee (Industry, University, Government) was replaced by a Board of Directors and the federal employees at the Institute became employees of the Institute.

1964 During the fifties, the Institute expanded into new facilities at Pointe Claire, Quebec, where it moved its administrative offices and many labs. By 1964, the Institute turned over the facilities in Montreal to McGill for $1.00. Educational activities, particularly graduate training, remained focussed at McGill and subject to the standards and procedures of the University. McGill agreed to operate and maintain the building and to provide the Institute with space and services for its staff involved in the post-graduate program (Reference 2).

1975 At its 50th anniversary, over 300 doctoral students had graduated from the McGill Pulp and Paper Laboratories, mainly in organic and physical chemistry, but also in Chemical and Mechanical Engineering.

1987 In response to the need for additional space and facilities for projected increased activity in the McGill program, the University proposed a major renovation of the main wing of the Pulp and Paper Building, to be phased in over the next 2-3 years.

Definitions

PAPRICAN's original educational branch in Montreal, located on the McGill campus at 3420 University Street, shall be known henceforth as the Pulp and Paper Research Centre, McGill. The Centre is a university activity intended to provide facilities for university faculty and students engaged in education and research of interest to the pulp and paper industry. With the agreement of the university, PAPRICAN provides for the administration of the Centre and members of its staff participate in the activities of the Centre as a means of promoting interest in and interaction with the pulp and paper industry. The space and facilities associated with the Centre include the main wing, engineering wing and the proposed extension (main wing renovation project, reference 3) located at 3420 University Street, as well as other space which may be designated for the Centre from time to time by McGill.

Director

The Director of the Centre shall be appointed by PAPRICAN with the advice and consent of the university. The Director is responsible for the general administration of the Centre and reports to the President of PAPRICAN through the Director of Academic Affairs and to the Principal of McGill through the Vice-Principal Research. The Director of the Centre will be a member of the Institute's educational staff participating actively in its educational and research activities and resident in the Centre. He or she will have the appropriate affiliation with a McGill academic department and have his/her principal office in the Centre.

Regarding administration of the space and facilities designated to the Centre, the Director is assisted by a Building Administrator who is appointed by the Institute with the advice and consent of McGill. He or she will respond to the regulations governing physical resources at McGill.

Staff Affiliated With the Centre

The staff affiliated with the Centre comprises selected members of the McGill University faculty and PAPRICAN educational and non-educational staff.

(a) Faculty Associates (McGill)

To be affiliated with the Centre, McGill faculty must first be appointed as Faculty Associates by PAPRICAN on the basis of project activity of interest to the pulp and paper industry. Professorships affiliated with the centre, such as the E.B. Eddy Professor of Cellulose Chemistry, the NSRRC/Xerox Polymer Professor and the Colloid Chemistry Professor, appointed by McGill in consultation with the Institute, assume automatically the title and responsibilities of Faculty Associate. These Associates may or may not assume residency in the Centre but shall have access to facilities there at the discretion of the Director, to PAPRICAN fellowships, grants and to other benefits as may be determined by PAPRICAN. (More detail regarding Faculty Associates and their responsibilities is included in Appendix 1.)

(b) PAPRICAN Educational Staff

PAPRICAN educational staff are researchers appointed and funded by PAPRICAN, who hold cross-appointments as honorary faculty in appropriate McGill Academic Departments. They are entitled to participate fully in departmental governance, to apply for and manage research grant funds through normal university channels, and to undertake the independent direction of post-graduate thesis research. They are usually required to teach post-graduate courses, but, since they have certain responsibilities to carry out with respect to PAPRICAN, are not required to teach undergraduate courses.

PAPRICAN appoints Educational Staff only with the prior approval of the relevant department at McGill following regular review processes. It is understood that each department applies acceptance criteria equivalent to those applied in hiring its own full-time staff. Following this approval, PAPRICAN educational staff are granted an appropriate academic rank within the relevant department. Since these staff are full-time residents at the University, this rank should bear a title distinct from those granted to part-time faculty.

(c) PAPRICAN Non-Educational Staff

Scientists, technicians, clerical and managerial employees who are assigned to the Centre by PAPRICAN are not subject to terms of employment governing McGill staff, but may apply to McGill departments, libraries, etc. for such status as would permit them access to McGill facilities outside the Centre.

Advisory Committee

There shall be an Advisory Committee which receives and reviews annual reports of the Centre and which may make recommendations concerning amendments to this agreement, the physical facilities of the Centre, space allocation within the Centre and appointments or reappointments of resident staff of people affiliated with the Centre from PAPRICAN and McGill. The Committee shall be responsible for ensuring that close and harmonious relationships are maintained between members of the Centre and both PAPRICAN and McGill departments and shall mediate any problems that may arise. The Committee shall meet at least yearly or when needed or requested by the Director of the Centre, PAPRICAN or McGill.

The Advisory Committee shall consist of the following or their designates: Director of the McGill Centre (ex-officio), the Director of Academic Affairs of PAPRICAN, the Vice-Principal (Research) of McGill, the Chairman of the Department of Chemistry, McGill, the Chairman of the Department of Chemical Engineering, and one staff member from PAPRICAN. The Advisory Committee reports jointly to the Director of Academic Affairs of PAPRICAN and the Vice-Principal (Research) of McGill.

Graduate Students

PAPRICAN educational staff in the Centre may direct graduate students who have been accepted and assigned by regular procedures that require recommendations of departments and the Faculty of Graduate Studies and Research. Students shall fulfill requirements specified for degrees by the department and faculty. The University has full and complete authority over academic matters affecting graduate students registered in its departments. Students may work either at the McGill Centre, elsewhere in the University, or at PAPRICAN in Pointe Claire, as needs arise when mutually agreed. The fields of potential research were originally in Chemistry and Chemical Engineering, but it is anticipated that such activities could well involve certain (other) fields of engineering and some branches of the biological sciences. Details of student relations are given in Appendix 1.

Publications, Patents and Proprietary Research

Research carried out entirely in the Centre or Institute by PAPRICAN staff is subject to research policies of PAPRICAN. Research carried out jointly by McGill students or post-doctoral fellows with PAPRICAN educational staff or Faculty Associates shall be subject to regulations and guidelines published in the Handbook for Academic Teaching Staff (chapters 5,7,8). In the event of joint invention, patent or copyright which leads to earned income by a student, Faculty Associate or PAPRICAN, McGill and PAPRICAN will negotiate a division of benefits based on standard procedures used by the University's Office of Industrial Research. Publications in refereed journals shall be reported to McGill through the annual report of the Faculty associate's department. Publications shall identify affiliations to both PAPRICAN and McGill.

Library

PAPRICAN will maintain a technical information facility at the Centre specializing in pulp and paper for the primary use of PAPRICAN staff, Faculty Associates, and graduate students. It will also be accessible to others with a legitimate interest in its services. Holdings will be made known to the PAPRICAN and McGill main library systems and to others with a need to know.

Regulations

The Director of the Centre may prepare regulations for the orderly conduct of the Centre's day-to-day operations, provided such regulations are not substantially at variance with the regulations governing the staff or students of either the University or the Institute.

References

1) PAPRICAN. The First Fifty Years.
C.A. Sankey, PAPRICAN, Pointe Claire, Quebec. 1976.

2) Letter of Agreement, signed by H. Rocke Robertson (McGill Principal) and Lincoln R. Thiesmeyer (PAPRICAN President), 1964.

3) Pulp and Paper Building Main Wing Renovation Project, prepared by the Office of Physical Resources, March 1987.

PAPRICAN FACULTY ASSOCIATES AND GRADUATE STUDENTS

The position of Faculty Associate may be offered by the Institute to full-time university faculty members who wish to be associated with the PAPRICAN post-graduate research program. The Faculty Associate supervises post-graduate students in his or her field of specialization on topics of research of interest to the pulp and paper industry. In return for this research and training of technical manpower, various types of support are provided by the Institute.

The relationship between the Associate and the Institute is based on a PAPRICAN project encompassing the Associate's activities. This may be an ongoing PAPRICAN post-graduate research project. The Associate will then join the project team and direct his or her own students in thesis topics relevant to the objectives of the project. Alternatively, the prospective Associate, in cooperation with a PAPRICAN member of staff, may submit a project proposal for acceptance by the Institute through the normal procedures for initiating new projects. If the proposal is approved, some funding and other types of support may be provided by the Institute. It is expected, however, as with all PAPRICAN educational staff, that Faculty Associates will seek funding from external sources other than the Institute or its Maintaining Members.

Students of the Associate are eligible for PAPRICAN post-graduate scholarships. The Associate and students may use resources of the Institute, such as space, library, shops, services, and supplies, within the scope of the PAPRICAN budget for the project and subject to the approval of the project's PAPRICAN supervisor.

The reporting of student research will follow the normal procedures used by the Institute. Two semi-annual progress reports are required for each thesis topic or area of research supervised by the Associate in the PAPRICAN post-graduate project. In addition, the research will be reviewed once a year by the Institute's Research Program Committee, and by McGill as normal procedures dictate. Manuscripts submitted for publication should also be issued as Post-graduate Research Laboratory Reports. Dual affiliation with PAPRICAN and the University in question is shown on all publications.

PAPRICAN post-graduate student work is considered open research. Usually, therefore, the Institute does not impose any restrictions of publication. However, in certain exceptional cases, a request may be made by PAPRICAN to the Faculty of Graduate Studies and Research at McGill for the thesis to be held confidential and duplication may be delayed at the request of the Institute with permission of the University to provide reasonable opportunity for patent protection, in accord with McGill regulations.

Faculty Associates and all Centre students are subject to the policies of the university with regard to patents. Resident PAPRICAN Research Associates and technicians in the Centre are subject to the policies of PAPRICAN. In the event of a joint invention by a PAPRICAN Research Associate or technician and a student, or by a student and a Faculty Associate working on a PAPRICAN project, the Institute and the University will, in each case, negotiate a reasonable division of benefits based on the equities of that particular case.

Faculty Associates receive no remuneration personally from PAPRICAN and they are expected to interact to a reasonable extent with the rest of the Institute and Maintaining Members on matters related to their projects. A Faculty Associate may be employed by the Institute as a consultant on PAPRICAN staff projects. In such cases, the Associate will sign a Consultant's contract with the Institute and be paid in the normal manner in conformity with McGill regulations (Chapter 6). Consulting and post-graduate research must, therefore, be regarded as separate activities, each with its own procedures and protocols.

Faculty Associates are appointed by the Director of Academic Affairs of PAPRICAN after consultation with the Advisory Committee of the Centre. The appointment is for a one-year term, renewable each year. The affiliation is normally expected to be an extended relationship lasting through a succession of post-graduate students. The main criterion for renewing the appointment is evidence of substantial ongoing research activity by the Associate in an approved PAPRICAN post-graduate student project.

APPENDIX "D"

List of senior executives interviewed for this report, including addresses and telephone numbers, listed by company.

ALCAN INTERNATIONAL LIMITED

Mr. John Wilson
Vice President, Fabricating Technology
ALCAN INTERNATIONAL Limited.
1188 Sherbrooke Street West
Montréal, Canada
H3A 3G2
Tel: (514) 848-8045
Fax: (514) 848-8115 or 8116

Dr. Jeff W. Edington
Director, Research and Development and
Vice President
ALCAN INTERNATIONAL LTD.
Tel: (514) 848-8265
Fax: (514) 848-8115

ALLELIX INC.

Dr. Martin Sumner-Smith
Manager, Technology Assessment
ALLELIX INC.
6850 Goreway Drive
Mississauga, Ontario
L4V 1P1
Tel: (416) 677-0831
Fax: (416) 677-9595

Mr. Graham Strachan
Vice President & Commercial Director
ALLELIX INC.
Tel: (416) 677-0831
Fax: (416) 671-9595

ATOMIC ENERGY OF CANADA LIMITED

Mr. E. Critoph
Vice President
Strategic Technology Management
ATOMIC ENERGY OF CANADA LTD.
Head Office
275 Slater
Ottawa, Ontario
K1A 1E5
Tel: (613) 236-6444
Fax: (613) 563-9499

Dr. A.D.B. Woods
Senior Advisor
ATOMIC ENERGY OF CANADA
Tel: (613) 236-6444
Fax: (613) 563-9499

CAE ELECTRONICS LIMITED

Dr. Murdoch McKinnon
Director, Research & Development
CAE ELECTRONICS Limited
P.O. Box 1800
St. Laurent
Montréal, H4L 4X4
Tel: (514) 341-6780
ext. 2021
Fax: (514) 341-7699

CONNAUGHT LABORATORIES LTD.

Dr. Keith Dorrington
Corporate Vice-President, R&D
Connaught Laboratories Ltd.
1755 Steels Avenue West
Willowdale, Ontario
M2R 5T4
Tel: (416) 667-2826
Fax: (416) 667-0313

Dr. John Vose
Director
Technology Department
Connaught Laboratories
Tel: (416) 667-2790
Fax: (416) 667-0313

MINING INDUSTRY OF TECHNOLOGY COUNCIL OF CANADA (MITEC)

Dr. W.G. Jeffery
Executive Director
Mining Industry Technology
Council of Canada (MITEC)
350 Sparks Street, Suite 809
Ottawa, Ontario
K1R 7S8
Tel: (613) 233-9835
Fax: (613) 233-8897

GENERAL MOTORS OF CANADA LIMITED

Ms. Barbara J. Callander
Government Relations &
Trade Policy
GENERAL MOTORS OF CANADA LTD.
Oshawa, Ontario
L1G 1K7
Tel: (416) 644-3539
Fax: (416) 644-3830

Mr. Carl H. Wintermeyer
Manager, Research & Dev.
& New Business Ventures
GENERAL MOTORS OF CANADA
Tel: (416) 644-3915
Fax: (416) 644-4018

GENERAL MOTORS OF CANADA LIMITED (CONT'D.)

Mr. Tony Costa
Administrator
Salaried Personnel Admin.
GENERAL MOTORS OF CANADA LTD.
Tel: (416) 694-7873

Mr. W.W. Peel
Director of Car & Truck
Assembly Operations
GENERAL MOTORS OF CANADA
Oshawa, Ontario
L1G 1K7
Tel: (416) 644-7478
Fax: (416) 644-4019

INSTITUTE FOR CHEMICAL SCIENCE & TECHNOLOGY (ICIST)

Dr. William R. Stadelman
Director
Institute for Chemical Science & Technology (ICIST)
31 Rykert Cresc.
Toronto, Ontario
M4G 2T1
Tel: (416) 425-4126

NORANDA

Dr. Peter Tarassoff
Director of Research and Development
NORANDA TECHNOLOGY CENTRE
240 boulevard Hymus
Pointe Claire, Québec
H9R 1G5
Tel: (514) 697-6640
Fax: (514) 697-9589

ONTARIO HYDRO

Dr. N. (Mikk) Anyas-Weiss
Section Head, Science Section
Electrical Research Dept.
Research Division
ONTARIO HYDRO
800 Kipling Avenue, KR107
Toronto, Ontario
M8Z 5S4
Tel: (416) 231-4111 ext.6170
Fax: (416) 231-9679

Dr. Craig J. Simpson
Principal Research
Engineering
Divisional Projects Dept.
Research Division
ONTARIO HYDRO
Tel: (416) 231-4111
Fax: (416) 231-9679

ONTARIO HYDRO (CONT'D.)

Dr. Don Mills
Director
Research Division
ONTARIO HYDRO
800 Kipling Avenue
Toronto, Ontario
Tel: (416) 231-4111
Fax: (416) 231-9679

PULP & PAPER RESEARCH INSTITUTE OF CANADA (PAPRICAN)

Dr. Henry I. Bolker
Director of Academic Affairs
PULP & PAPER RESEARCH INST. OF CANADA (PAPRICAN)
570 St. John's Boulevard
Pointe Claire, Québec
H9R 3J9
Tel: (514) 630-4104
Fax: (514) 630-4134

Mr. Peter E. Wrist
President & Chief Executive Officer
PULP & PAPER RESEARCH INST. OF CANADA
Tel: (514) 630-4101
Fax: (514) 630-4134

POLYSAR LIMITED

Dr. Edward Rhodes
Vice President, Technology
POLYSAR LTD.
201 N. Front Street
Sarnia, Ontario
N7T 7V1
Tel: (519) 332-1212
Fax: (519) 332-0408

SEMEX CANADA

Dr. Morris G. Freeman
General Manager
SEMEX Canada
130 Stone Road West
Guelph, Ontario
N1G 3Z2
Tel: (519) 821-5060
Fax: (519) 821-7225

STELCO INC.

Mr. John C. McKay
Director, Research and Dev.
STELTECH.
Stelco Technical Services Ltd.
Hamilton, Ontario
L8N 3T1
Tel: (416) 528-2511
Fax: (416) 332-9067

Dr. Leslie C. McLean
Vice President-Technology
STELCO INC.
Tel: (416) 528-2511 X.4340
Fax: (416) 332-9067

BELL NORTHERN RESEARCH

Mr. John F. Pinel
Director
University Interaction
BELL NORTHERN RESEARCH LTD.
P.O. Box 3511, Station C,
Ottawa, Ontario
K1Y 4H7
Tel: (613) 763-4757
Fax: (613) 763-3912

Mr. Tom M. Hennebury
Vice President
Administration and
Human Resources
BELL NORTHERN RESEARCH
Tel: (613) 763-3210
Fax: (613) 763-4583

Other persons interviewed:

Hubert Martel, Merck-Frosst
Andrew Bobkowicz, Canadian Plastics Institute
Hank Van der Pol and Keith Potter,
Canadian Mushroom Grower's Association
Leo Derikx, Natural Sciences and Engineering Council
Steve Bandak, Eli Lily
Murray Pinel, H.J. Heinz co.
Robert Goulet, Fossil Flowers Natural Bug Control Ltd.
Gordon Roeder, Stelco Inc.

APPENDIX "E"

INTERVIEW QUESTIONS.

List of questions used in the interviews with senior executives. The results of the interviews are presented in narrative form in the case studies. There were some departures from the strict list of questions, depending on the relevance of the topic.

1. <u>Tombstone data</u>

    a) annual report

    b) other documentation (list)

    c) $ Sales; $ R&D; $ University-based R&D

    d) nature of R&D, relation to product line

2. <u>History</u>

    a) How and when did links with universities get started?

    b) Why? What were the needs?

    c) technology? trained recruits? public service?

    d) expansion of company? (goals, etc...)

    e) Why does your company need universities?
    What do they offer that you don't have?

3. <u>Areas of Activity</u>

Where and how do you interact with universities?

a) grants?

b) contracts?

c) co-op students?

d) "stagiaires", post-docs, visiting profs?

e) exchanges

f) chairs (à la NSERC)

g) recruiting

h) others

i) <u>Examples</u> (chronology of events, sequence, anecdotal evidence, stories, results, conclusions)

4. **<u>Evaluation</u>**

a) How well does it (do they) work?

b) What are the benefits?

- to you
- to the university

c) What worked well? examples? results?

d) What <u>didn't</u> work well?

e) results-to-date?

f) <u>Problems</u>?

- cultural
- attitudinal (delivery, usability, practicality?)
- legal (contractual, accountability, intellectual property)

g) your criteria for a successful link

5. Strategy for Making it Work

a) Do you have a senior manager responsible for these links?

b) is it ad-hoc, decentralized?

c) What organizational/structural considerations have you put in place to make this work?

d) Do you use government programs? which ones? usefulness?

e) What would you change/modify in your present management organization and structure to make it better?