# COMMERCIALIZING UNIVERSITY INVENTIONS

J.R.M. Gordon
N.V. Price
P.H. Helferty
P.R. Richardson

School of Business
Queen's University
Kingston, Ontario

JANUARY 1986

The views and opinions expressed are those of the authors and are not necessarily endorsed by the Department of Regional Industrial Expansion. Les points de vues et les opinions exprimés dans le rapport sont ceux de l'auteur et n'engagent pas nécessairement le Ministère de l'Expansion industrielle régionale.

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# EXECUTIVE SUMMARY

The purpose of this research is to examine the organized process of technology transfer from universities to industry in Canada. There is a growing awareness in the country of the importance of university research to industry, and reflecting this awareness, universities are creating organizations and activities to facilitate the process.

In carrying out this research, we have studied organizations that have been created at major Canadian universities with the explicit purpose of transferring university developed technology to Canadian industry. We have not examined the many transfers that go on directly between faculty and Canadian corporations. Consequently, we do not determine what proportion of innovative activities on university campuses passes through organizations described in this study. We suspect that it is a minority of such activity. Also beyond the scope of this study are the many research and technical institutes which have been set up to facilitate university-industry interaction or to carry out contract research.

Technology transfer organizations at Queen's University, the University of Toronto, and Waterloo University were the focus of this research. Descriptions of each university's organization for technology transfer and its mode of operations are described in detail. Five in-depth case studies of specific innovations were prepared in order to illustrate the working of each organization, and also to identify significant factors in the process of technology transfer between university and industry. A total of 643 faculty members at these universities were surveyed to determine their individual innovation track records, and also their perception of their university's support and encouragement for this activity.

The results suggest that organized technology transfer between universities and industry in Canada is still in its infancy, and in all likelihood is relatively ineffective. As one professor in the study commented: "it is something like a lottery" whether you are successful or not.

RECOMMENDATION:

> A NATIONAL CONFERENCE ON COMMERCIALIZING UNIVERSITY TECHNOLOGY SHOULD BE CONVENED WITH THE PURPOSE OF CREATING BETTER UNDERSTANDING OF THE PROCESS, A NETWORK OF PEOPLE INVOLVED IN THE AREA, AND POLICY RECOMMENDATIONS FOR GOVERNMENT.

## THE TRANSFER ORGANIZATIONS

No common model for a technology transfer unit exists. Varying degrees of organization for technology transfer were found at the three universities. At Queen's, the activity was coordinated through three separate committees within the existing university structure, an arrangement which appears to be relatively ineffective.

At the University of Toronto, an Innovations Foundation has been established as a separate corporation with both university and industrial involvement. This organization has had some significant short-run successes, and appears to be gaining acceptance within the university and in industry.

Two organizations have been established at the University of Waterloo. The Waterloo Centre for Process Development (WCPD) is successfully developing a contract research base, as well as facilitating the commercialization of new process technology, although it has a relatively narrow field of interest. The Canadian Industrial Innovation Centre/Waterloo (CIIC/W) has a broader scope, but also serves many other inventors besides those within the university community.

A business orientation and incorporation as a separate entity from the university appears to be an important determinant of effectiveness. The business orientation means that objectives, plans and strategies are likely to be developed for the organization. Involvement of members of the business community is also likely to be sought. The economic framework for selecting possible commercial developments to pursue is also likely to be more rigorous.

Independence allows the technology transfer organization to escape the bureaucracy of the university administrative process, allowing it to be responsive and flexible in innovation. This autonomy may also provide a liability barrier for the university.

With the exception of the WCPD, all the organizations are reactive to inventor needs. Generally, actions are only initiated when a university faculty member has a development which might be protected. In this sense, these organizations are technology driven, seeking applications for new developments. This type of innovative activity generally has a low success rate.

With the exception of the WCPD, the organizations lack the resources to implement what might be termed 'market-driven' strategies: establishing linkages with industry to determine needs which could be met through the inventive activities of university faculty. Through its contract research, the WCPD is able to undertake this type of activity.

RECOMMENDATIONS:

1. TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD BE ESTABLISHED IN ALL MAJOR CANADIAN UNIVERSITIES.

2. UNIVERSITY FACULTY, PROFESSIONAL STAFF, PRIVATE SECTOR FIRMS AND GOVERNMENT AGENCIES SHOULD ALL BE STAKEHOLDERS IN THESE ENTERPRISES.

3. UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD BE INCORPORATED AND HAVE A BUSINESS ORIENTATION AND MISSION.

4. UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD HAVE THE MANDATE TO INITIATE TECHNICAL DEVELOPMENT ACTIVITIES.

5. UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD ESTABLISH CONTINUING LINKAGES WITH PRIVATE SECTOR CORPORATIONS THAT FACILITATE THE TRANSFER OF A STREAM OF NEW TECHNOLOGIES.

## SUCCESSFUL INNOVATIONS

There is a growing body of literature in the management of technological innovation, much of which was drawn upon for this study. Of particular interest was that relating to the conditions for successful innovation which suggests that while universities might be effective at creating inventions, the lack of market awareness and the geographic and organizational barriers between them and private sector organization could inhibit successful innovation.

The findings of five case studies are summarized in Figure 1 on page x. The case studies demonstrated that these barriers did exist. In two cases, failure to clearly define a market, combined with poor involvement of private sector corporations, resulted in failure. Also in these cases, the individual faculty member championing the development was not always fully involved in the process, resulting in a considerable degree of frustration. Both these cases can be categorized as 'technology-push' types for which success rates generally are low.

The case studies also demonstrated that the conditions for success can be successfully created by universities, and that a well organized technology transfer function can facilitate the process. Key common factors in success appear to be:

1. Early identification of an initial target market for the new technology.

2. Early identification and involvement of a committed corporate sponsor and potential licensee.

3. Early demonstration of the technology by the inventor to potential licensees and customers.

4. Continuing involvement of the inventor in all phases of the activity.

5. The creation of a university-corporate team to develop a commercial product or technology.

6. Government funding to enable piloting and commercial demonstration of the technology.

The inventor, university technology transfer organization, government agencies, and private sector corporations all have key roles to play in this process, as shown in Figure 2 on page xi.

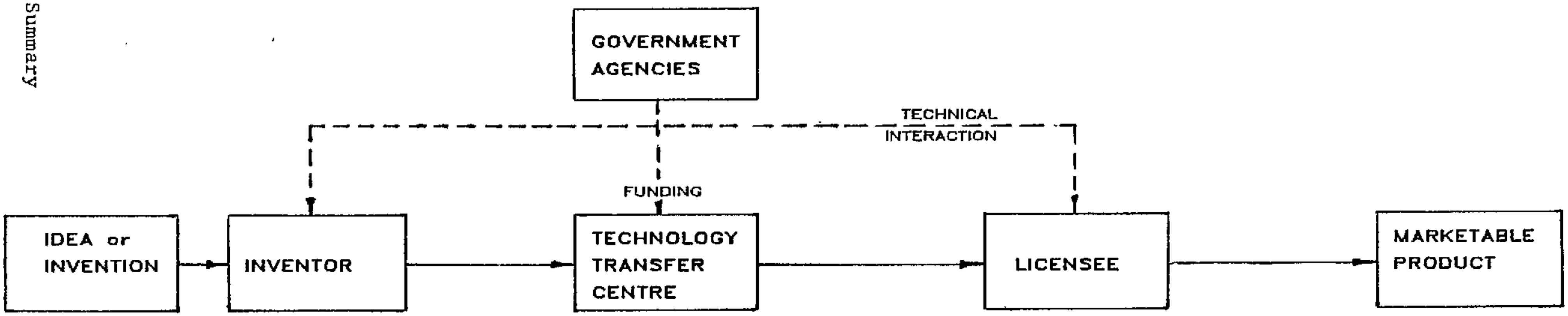
RECOMMENDATION:

UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD DEVELOP A COMMERCIALIZATION METHODOLOGY THAT INCORPORATES THESE SIX KEY ELEMENTS.

Figure 1. Summary of Case Studies

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|
| Invention | HUBNET | MFLI Microscope | Solar Panel | DRYER-MASTER | Chromo-retinoscope |
| University | Toronto | Queen's | Queen's | Waterloo | Waterloo |
| Transfer Organization | Innovation Foundation | Queen's | Queen's | WCPD | CIIC/W |
| Commercial Success | Yes | No | Yes | Yes | No |
| Market-Pull/ Tech.-Push | Mkt.-Pull | Tech.-Push | Mkt.-Pull | Mkt.-Pull | Tech.-Push |
| Inventor's Profile | Very exper. Extensive consulting | Exper. Infreq. consulting | Very exper. Regular consulting | Very exper. Extensive consulting | Exper. No consulting |
| Funding | Excellent | Good | Good | Excellent | None |
| Fund Raiser | Innovation Foundation | Queen's | Inventor | WCPD | N/A |
| Early Full-Scale Demo | Yes? | No | Yes | Yes | No |
| Inventor's Evaluation of Transfer Organization | Very effective | Not very effective | Not very effective | Very effective | Not very effective |

Figure 2. The University-Industry Technology Transfer Model




YEAR 0

CONSIDER:
- CONSULTING EXPERIENCE
- INDUSTRIAL EXPERIENCE
- EXTERNAL CONTACTS/NETWORK
- CHARACTER/PERSONALITY
- INTERPERSONAL SKILLS
- ENTREPRENEURISM
  (THESE FACTORS RELATE TO DEVELOPMENT OF MARKET–PULL OR TECHNOLOGY PUSH INVENTIONS/IDEAS)

CONSIDER:
ROLE OF CENTRE, INFRASTRUCTURE & INDIVIDUAL DIRECTING IT.

FUNCTIONS:
- EVALUATE PROJECT
- CONDUCT PRELIMINARY MARKET STUDY
- ADVISE/PROTECT INVENTION
- INITIATE CONTACT WITH INDUSTRY
- NEGOTIATE LICENSE
- RAISE FUNDS
- ATTRACT CONTRACT RESEARCH
- STIMULATE GOODWILL BETWEEN PARTIES
- PROVIDE BUFFER BETWEEN ACAMEDE & INDUSTRY–RESPONSIVE
- IDENTIFY MARKET NEEDS & COMMUNICATE THESE TO INVENTORS

REQUIRED:
- COMMITMENT OF TOP MANAGEMENT
- CHAMPION/SPONSOR
- FLEXIBILITY/PATIENCE
- DETAILED MARKET STUDY
- EARLY FULL–SCALE DEMONSTRATION
- RAPPORT WITH CENTRE/INVENTOR

TYPICAL, YEAR 5

## PROFILE OF INNOVATIVE FACULTY

Consulting and industrial work experience was found to be a key determinant of faculty members with successfully commercialized inventions. Significant differences existed between the performance of faculty with both these kinds of experience and faculty with no industrial experience. In the absence of direct work experience, consulting was found to provide faculty with an awareness of industry requirements, as well as considerable knowledge and skills in dealing with companies.

Approximately 20 percent of the faculty surveyed had protected technical developments. Of these approximately half had been able to commercialize the technology. Rates were highest among engineering faculty and lowest in the physical and life sciences.

As they are now implemented, promotion, salary and tenure policies have relatively little impact on the level of faculty interaction with industry. Very few faculty respondents felt that university policies strongly encouraged interaction with industry. Generally, faculty felt that such activities were desirable, but it is interesting to note that at the University of Waterloo, which has strong relationships with industry, 15 percent of faculty felt interaction was discouraged.

Changes to reward systems in universities may have some effect on the level of faculty participation in these innovative activities. However, in most universities, industry involvement and commercialization of inventions are not currently major components of their missions. Whether they should be is a subject for debate, and decisions have to be made on a case-by-case basis. Direct spin-offs and rewards from these activities appear to be substantial, and in general we do not recommend that promotion, salary and tenure policies should be modified to further encourage and reward them.

Faculty who had attempted to commercialize their developments were generally critical of the effectiveness of the university technology transfer organizations. Only 47 percent of the faculty with successfully commercialized innovations perceived these organizations to be effective, while 38 percent thought they were ineffective (no comment was made by others). Of those with unsuccessful commercialization attempts, only 35 percent viewed these organizations as effective, while 48 percent considered them ineffective.

RECOMMENDATIONS:

1. UNIVERSITIES WISHING TO PROMOTE INCREASED LEVELS OF TECHNICAL DEVELOPMENT ACTIVITY SHOULD FACILITATE INCREASED LEVELS OF CONSULTING AMONG THEIR JUNIOR FACULTY.

2. PROMOTION, SALARY AND TENURE POLICIES SHOULD NOT BE USED TO REWARD COMMERCIAL DEVELOPMENTS.

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# CHAPTER 1: THE INNOVATIVE CHALLENGE FACING CANADIAN UNIVERSITIES

## 1.1 UNIVERSITY-INDUSTRY INTERACTION

In the U.S. the presidents of universities and corporations have formed an organization, the Business-Higher Education Forum, to explore issues of common interest. Its second report, entitled Corporate and Campus Cooperation: An Action Agenda, details ways in which businesses and institutions of higher education can work together for their mutual benefit.[1]

In Canada, an analogous organization, the Corporate-Higher Education Forum, has been formed. Its objectives are:

1. To advance mutual understanding through an exchange of ideas and points of view at periodic meetings and by other means;

2. To develop policy statements on issues and questions of mutual interest and concern;

3. To provide a vehicle for corporate and university leadership to reflect upon issues of national significance;

4. To support and sponsor cooperative activities and programs consistent with the decisions taken by the Forum.[2]

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[1] Business-Higher Education Forum, Corporate and Campus Cooperation: An Action Agenda, Washington, D.C., 1984.

[2] Corporate-Higher Education Forum, Organization and Bylaws, Article II, 1984.

Its first report, Partnership for Growth: Corporate-University Collaboration in Canada, explored the level of cooperation between universities and industry and ways it might be increased.[3]

In January, 1985, Deans of Business, Deans of Engineering, and senior executives from industries across Canada met for a National Workshop on Management and Technology. The purpose of the Workshop was to provide a forum in which participants could identify actions which they could take together to help Canadian industry apply new technology to compete successfully in international markets.

Why, at this time, is the level of interaction between universities and industry increasing? To answer this question, a brief review of the recent history of the universities is in order.

Bok, in his book Beyond the Ivory Tower, described the traditional English and German universities as being aloof from society:

> "Both emphasized the value of learning and discovery for their own sake. Universities might influence society profoundly either by making discoveries that others could apply to practical uses or by assembling a young elite and helping them to acquire informed and inquiring minds.... But any social changes that ensued were merely the by-products of the university and not its raison d'etre."[4]

The American model differed substantially from the European, in that many American universities immersed themselves in the challenges of the

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[3] J. Maxwell and S. Currie, Partnership for Growth: Corporate-University Collaboration in Canada, Corporate-Higher Education Forum, Montreal, 1984.

[4] D. Bok, Beyond the Ivory Tower, Harvard University Press, Cambridge, 1982, p. 61-62.

emerging nation, seeing it as their responsibility to help to meet them. Most Canadian universities, especially the older ones, were developed on the British model. To a certain extent, they have retained the 'aloofness' that Bok described.

In the 1960's and early 1970's the number of universities in most of the developed countries of the western world increased rapidly. These universities were staffed by bright young professors eager to engage in research. The governments of the day were supportive of research; this was the era of Sputnik and the race to put the first man on the moon.

This expansionist era gave way to a decade of retrenchment. Most of the 'baby-boomers' had made their way through the education system. High inflation and demands for more social services led to large government deficits. At the same time, the faculties of the universities were growing older, being promoted, and becoming more and more expensive to support. Governments were unwilling to continue to fund the universities at the level they had in the past, and universities began to feel the financial squeeze. Pressed for funds, the universities have explored sources of supplementary capital, operating and research support; the most willing partners have been large corporations.

Why have corporations, especially in the U.S., been willing to help to support the universities? Perhaps the most significant factor is the lessons that have been learned from the Japanese. In the late 1960's and the 1970's, U.S. corporations focussed on the financial aspects of their operations at the expense of production and technology. Profits were to be made by altering balance sheets and income statements rather than by using technology to improve existing or start new production. Japanese firms, on the other hand, concentrated on using technology to produce high quality products at low cost. By doing so, they have come to dominate many world markets.

Western managers have realized that advanced technology is not only necessary to be an industry leader; it is required just to compete and survive. Corporations view the universities not only as a potential source of new graduates, trained to work on state-of-the-art equipment and capable of developing the technologies of tomorrow, but also as a source of new ideas and technology. Faced with a growing technical challenge, many corporations are starting to use universities to meet their basic, or fundamental, research requirements.

A comprehensive review of the literature on university-industry cooperation is beyond the scope of this research. A recently published review listed over 100 books, articles and papers on university-industry relations.[5] Baldwin and Green reported that university-industry cooperative research is heavily oriented toward technology transfer. The paper listed a number of reasons why universities and industry cooperate. Universities work with industry to:

1. replace lost federal funds
2. avoid complex federal regulations
3. develop a potential source of long term support outside government

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[5] D.R. Baldwin and J.W. Green, "University-Industry Relations: A Review of the Literature", Society of Research Administrators Journal, Spring 1984, p. 5. See also: C.E. Kruytbosch, "Annotated Bibliography on University-Industry Research Relationships", in University-Industry Research Relationships: Selected Studies, National Science Board, Washington, 1983.

4. help finance the purchase/development of sophisticated equipment

5. gain access to specialized industrial equipment

7. provide broader, more relevant education for graduate students

8. provide professional stimulation for faculty members

9. develop potential markets for university inventions with royalties returning to the university and individual faculty members.

The paper listed four reasons why industry works with universities:

1. to gain access to highly trained graduate students as potential employees

2. to gain access to competent scientists without having to develop extensive in-house capabilities

3. to improve their ability to meet environmental, health, and safety standards

4. to gain access to a source of new ideas, approaches, and products that enhance the competitive position of industry groups as well as individual companies.

The last reason in each of the above lists is particularly relevant to this study. Firms want access to the bright ideas and potential products/processes coming out of universities. Universities and professors want royalties in return for their inventions.

## 1.2 UNIVERSITY INNOVATION

In today's complex world, inventions are developed in many different milieus. While the individual inventor still exists, the high cost of R&D restricts much inventive activity to large corporations and government and university laboratories. This is especially true of complex 'high technology' inventions which are the driving force behind growth in the world economy. For inventions from university laboratories to make their way into the economy, they must be transferred to and exploited by industry; the process of <u>innovation</u> must occur.

Innovation is a process that is still not well understood. The uncertainty, complexity and extended time associated with the activity make it an extremely 'hit-or-miss-affair', even when it is well organized and managed. Geographic, market and organizational barriers all make innovation more difficult. Inventors in Canadian universities, which are typically not well organized to exploit innovation, have to surmount these hurdles if they are to exploit their inventions.

The purpose of this study is to examine how three Canadian universities (Queen's, Toronto and Waterloo) facilitate this process for their inventive faculty. Attention will be given to the different organizational units established to manage invention and commercialization, as well as the activities they engage in. The profiles of individual inventors will also be examined in a series of case studies.

Of relevance to the study is the considerable body of literature on innovation that has been developed during the last quarter century. Models of innovation, and empirical studies of this process, will be referenced throughout the study. Of immediate relevance are the conditions giving rise to an invention and the subsequent likelihood of commercialization.

## 1.3 MODELS OF INNOVATION

The first models of the innovation process were linear, beginning with the discovery or invention and ending with application. Twiss has represented this technology-push model as shown in Figure 3 on page 8.[6] The process begins with an existing body of knowledge. R&D is done and an idea for a product is developed. The next stage is the design of the product, following which materials are used to manufacture it. The output of the process is a product which is then presented to the market place. The salient feature of this model is that a specific market application for the invention is not identified early in the process. Development of the technology is the principal driving force.

In 1972, Langrish and co-workers postulated that innovations frequently do not arise via this technology-push model, and they proposed a need- or market-pull model of innovation.[7] This model is depicted in Figure 4 on page 9. Scientific knowledge is combined with an awareness of customer needs at the beginning of the process, to give rise to a technological concept. This is followed by product design and the use of the materials necessary to manufacture it. The underlying notion is that because the product is designed with customer needs in mind, it is much more likely to succeed in the market place.

Since Langrish's study, considerable research has been done to determine which of the models, technology-push or need-pull, is followed more often.

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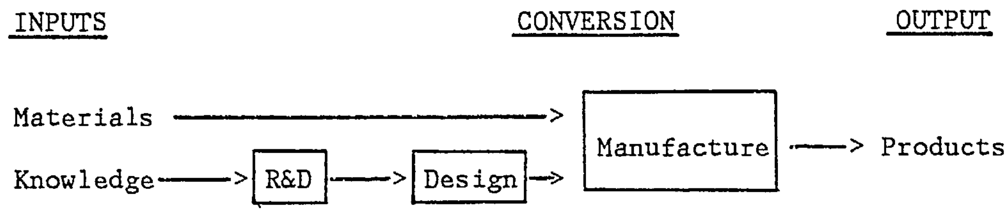
[6] B. Twiss, Managing Technological Innovation, 2nd ed., Longman Group Limited, London, 1980, p. 4.

[7] J. Langrish et al., Wealth from Knowledge, Macmillan, London, 1972.

Figure 3. Technology-push: product orientation




In a review of eight studies of innovation, Utterback found that need-pull was more common than technology-push.[8] This view is now widely accepted.

However, in a recent paper, Voss categorized 36 successful innovations not only as technology-push or need-pull, but also according to whether they were 'user-active' or 'supplier-active'.[9] Voss defined user-active innovations as those where the innovative idea is developed by the end user. Naturally, for supplier-active innovations the idea originates with the supplier. Voss found that 85 percent of the supplier-active innovations in his sample could be categorized as need-pull. However, two-thirds of the user-active innovations were consistent with the technology-push model of innovation (See Figure 5 on page 9).

[8] J.M. Utterback, "Innovation in industry and the diffusion of technology", Science, p. 183, 1974.

[9] C.A. Voss, "Technology push and need pull: A new perspective", R&D Management, vol. 14, p.147, 1984.

Figure 4. Market-pull: technology/market orientation

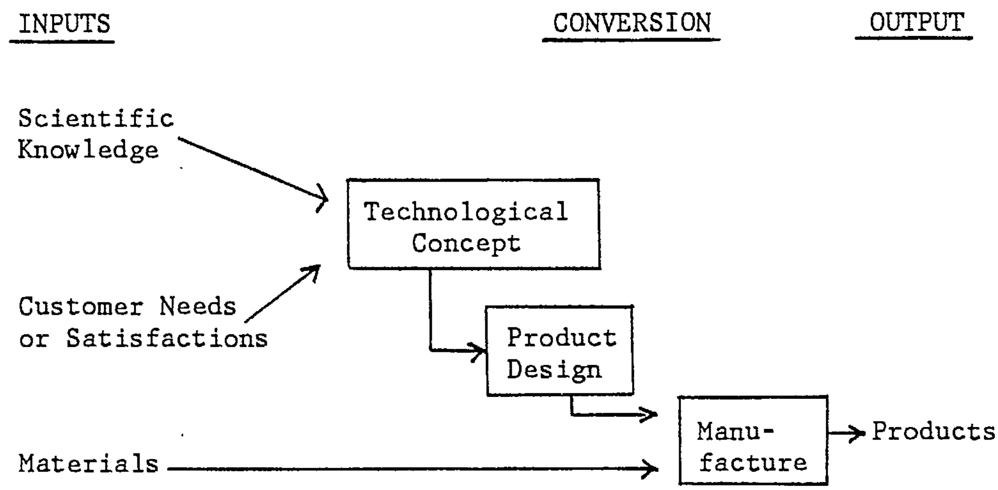



Figure 5. Sources of Innovation and Prime Mover

| | Technology Push | Market Pull | |
|---|---|---|---|
| User Active | 66% | 34% | 100% |
| Supplier Active | 15% | 85% | 100% |

This observation led Voss to suggest that the notion that market-pull dominates the innovation process is not universally applicable. For user-active innovations, the evidence is more consistent with the technology-push model. However, there is strong evidence to suggest that in supplier-active innovations, which are characteristic of most university research, a market need has to be identified early in the process for the successful innovation to occur.[10]

More recently, the linear model of innovation has been called into question. Observations of the industrial innovation process indicate that activities such as research, development and design often take place simultaneously, and that users may be involved from very early on in the process (see Figure 6 on page 11).[11] The important role users play in the innovation process has been fully elaborated by von Hippel.[12]

Innovation is also an intensely personal process. Roberts and Fusfeld outlined the importance of the champion in bringing about successful innovation.[13] They also described other roles that are important in the process, including that of the sponsor. The sponsor has the power and resources to make the proposals of the champion a commercial reality.

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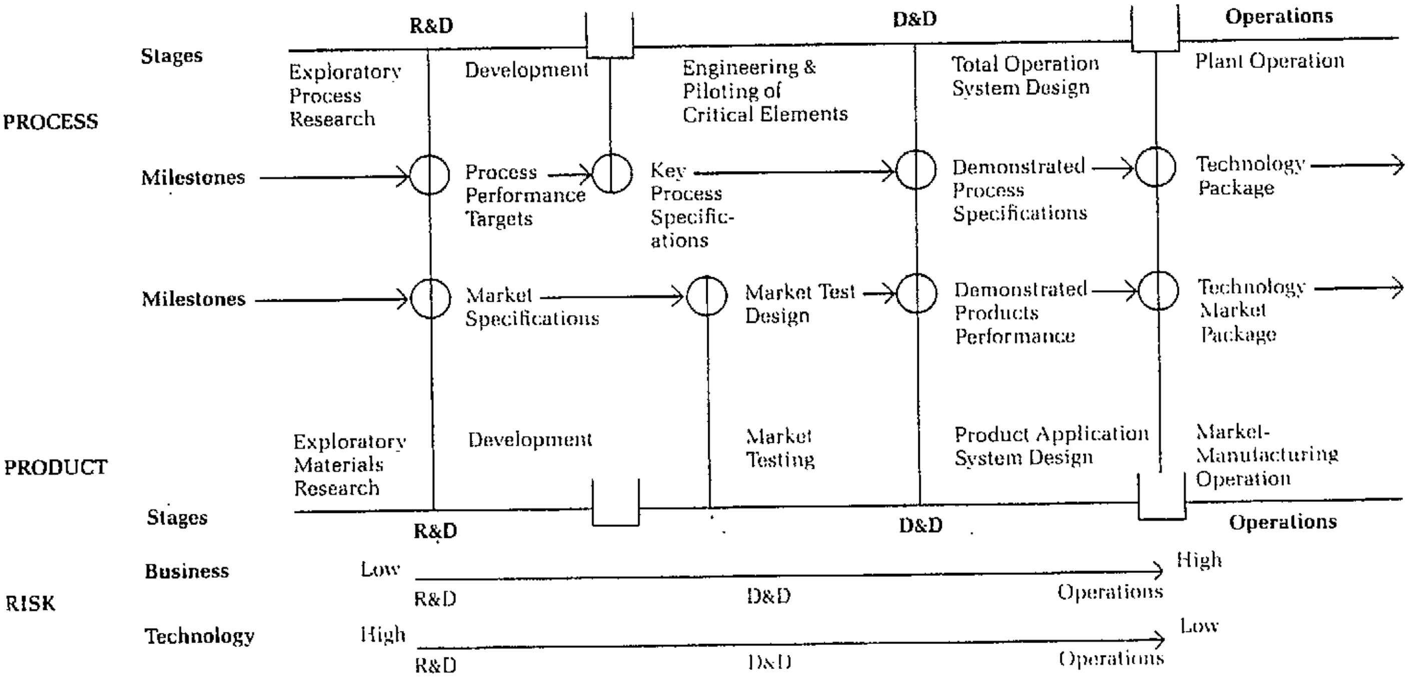
[10] Eric A. von Hippel, "Users as Innovators", Technology Review, January, 1978, p.3.

[11] G.F. Frontini and P.R. Richardson, "Design and Demonstration: Critical Factors in Industrial Innovation", Sloan Management Review, Summer, 1984

[12] von Hippel, "Users as Innovators".

[13] E.B. Roberts and A.R. Fusfeld, "Staffing the Innovative Technology-Based Organization", Management Review, Spring, 1981, pp. 19-24.

Figure 6. Process-Product-Market Concept of a Strategic Innovation




In the case of innovation in the university-industry sector, these roles are more complex because of the geographic and organizational barriers that exist. Jack Morton, a former vice-president of Bell laboratories in the United States postulated that if both organizational and geographic barriers existed between different elements of the innovative process (such as between research and development), successful innovation would be virtually impossible.[14]

This situation is shown in Figure 7 on page 13.

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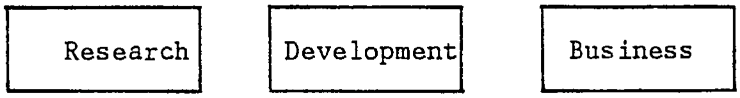
[14] J.A. Morton, Organizing for Innovation, New York: McGraw-Hill Inc., 1971.

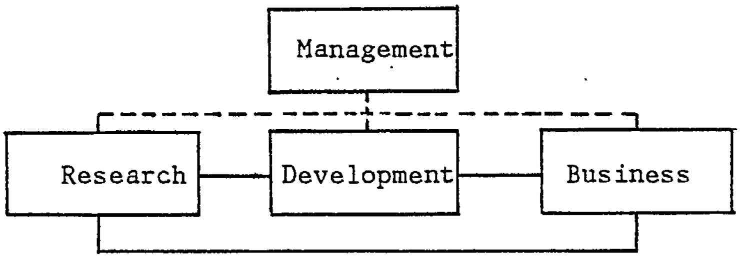
Figure 7. Organizational and Geographic Linkage for Innovation

PART A.



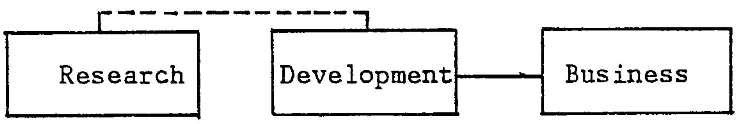

No Organizational or Geographic linkage

PART B.




—— Organizational linkage -- Geographic linkage

PART C.




—— Organizational linkage -- Geographic linkage

In part (A), geographic and organizational boundaries exist between research, development and business functions, and innovation is negligible. In part (B), all three activities share a common location and organization. In this situation, Morton argued, only short-term incremental innovation would result as the operating concerns of the business would dominate research and development. According to Morton, the most favourable conditions for innovation arise under the situation described in part (C). Here, business and development functions share the same location, but report to different managers. Research is geographically remote, but linked organizationally to development. In this case, the continuing face-to-face contact between business and development people is maintained, while research and development share common goals and objectives.

Normally, university research is both organizationally and geographically isolated from corporate technical development and business activities. However, the creation of a university technology transfer centre may be able to break down the organizational barrier and provide an effective link to business for university researchers.

These findings also suggest that successful innovations from universities need an early and continuing involvement of an industrial 'sponsor' who is capable of carrying out key commercial activities, such as design, piloting and market testing.

While university research, like industrial research, can spur industrial innovation, it is important to recognize the very significant differences between the nature of and ways research is done in universities and industry. The first difference is the purpose of doing the research.

University research is generally aimed at adding to the general body of knowledge. Industrial research is broadly intended to improve the profitability of firms, either in the short or the long term.

A second difference is in the activities of the researchers. The industrial researcher is generally a full-time researcher, whereas university professors have teaching, administrative and public service roles as well.

Related to this is the difference in the time-scale on which research is done. University research is done when time permits and is finished when the researcher is 'satisfied' and decides to work on something else. Technical and scientific success are the usual criteria by which performance is assessed. Industrial research programs usually have deadlines by which certain milestones are expected to be achieved, and are judged ultimately on their commercial success.

The final, and perhaps most significant difference for the purposes of this discussion of innovation, is that university research tends to be curiosity-oriented, while that done in industry is usually market-oriented. The major exception to this situation in universities is in sponsored or 'contract' research by an external institution on a specific problem. In this type of research the disposition of any knowledge, invention or innovation is generally agreed to as part of the contract. This difference means that the independent research done in universities tends to be done without a dominant concern for 'customer needs' or an ultimate application. Thus technology-push is the innovation model most applicable to university inventions. Need or market-pull is the more realistic model of how innovation usually occurs. While Voss found that technology-push may be more common for user-active innovations, the university is generally the supplier of the innovative idea, not the user.

It seems reasonable to suggest that a major reason that more university inventions have not been transferred to industry is because of a lack of awareness of, or concern with, 'customer needs' on the part of university researchers. Some professors, through their consulting activities, have developed an awareness of industry needs. Theory would suggest that these professors are more likely to develop inventions which are transferable to industry than those without an awareness of industry's needs. Whether this is the case is one of the questions explored in this research.

## 1.4 ORGANIZATIONS TO COMMERCIALIZE UNIVERSITY INVENTIONS

The increased interaction between universities and industry has prompted several universities to create 'boundary-spanning' organizations to assist with the evaluation and commercialization of inventions. These organizations are intended to reduce or eliminate the geographic, organizational and market barriers between industrial firms and universities. They are also responsible for formalizing procedures and activities to manage commercialization in an orderly and logical manner.

These functions used to be handled either by the university's Office of Research Administration, or by central bodies such as Canada Patents and Developments Limited. Anecdotal evidence suggests that this method was not effective, in part because commercialization of inventions was not accorded a high priority by these agencies. Moreover, the level of inventive activity at many universities is now significant enough to justify an organization devoted entirely to these activities. Government organizations, recognizing the economic benefits that could result from the commercialization of more university inventions, have been supportive of this trend.[15]

As will be seen from this study, a variety of different organization types have been created to manage this process. Many of these organizations are relatively new, and whether they will be successes or failures remains to be determined. While there have been many papers on university-industry interaction, little is known of the factors which determine if a boundary-spanning organization of this sort is effective.

The National Science Foundation (NSF) has reviewed the literature on the process of technological innovation. In a section dealing with university/non-university interactions, they identified several areas for further research:

> "... studies of the perceived incompatibilities between university and industrial goals, the relative success of different kinds of linkage mechanisms, the role of federal funding as a determinant of university-industry links, and the impact of intra-organizational structural characteristics on inter-organizational relations... the literature on university-industry interactions is more speculative and descriptive than empirical; this should be rectified."[16]

Among its objectives, this research seeks to fill some of these gaps.

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[15] Examples include the provision of funds for the establishment of university-based Innovation Centres, and IDEA Corporation's Commercial Development Officers Program (see The Innovators, vol. 1(2), 1984).

[16] National Science Foundation, The Process of Technological Innovation: Reviewing the Literature, National Science Board, Washington, 1983, p. 176.

## 1.5 DETERMINANTS OF FACULTY CAPABILITIES

The central focus of the inventive process is the creative faculty member or researcher. These individuals are the driving force behind the university-industry innovation chain, and it is their interest, involvement and activities which principally determine the ultimate outcome.

As suggested previously, many university researchers have little awareness of market opportunities for their inventions, or lack of concern with "customer needs". Many academics, lacking an appreciation of current industrial practice and technical requirements, simply do not know where to look to have an invention applied commercially. Others do not know how to approach the commercialization task. On the other hand, there are no reliable mechanisms which ensure that industry will "beat a path" to the door of the university inventor.

Promotion and tenure practices within the university may affect how researchers seek to 'exploit' their output or inventions. Generally, the first objective of young faculty and researchers is to gain tenure. Thereafter promotion and peer recognition are driving forces. These tend to arise from publication and good teaching, rather than commercial success. In fact, commercial exploitation of research or inventions may be viewed negatively in some universities if it is felt to be taking precedence over the researchers other 'responsibilities'.

Hence, the creation of organizations and policies to facilitate the commercialization of inventions and research may be seen as legitimizing this activity by faculty and researchers. This would undoubtedly be reinforced if salary, promotion and tenure policies were to support and reward interaction with industry and the application of new knowledge.

Some professors, through work experience, consulting and contract research, do develop an awareness of industry needs, sometimes of a very specific nature. Models of innovation would suggest that these individuals are more likely to develop inventions which are transferable to industry, especially if their institutional culture and policies are supportive of this type of work. Whether or not this is the case is one of the questions explored in this research.

# CHAPTER 2: FRAMEWORK, HYPOTHESES AND METHODOLOGY

## 2.1 THE FRAMEWORK

This study encompasses a mix of explanatory, descriptive and normative research. Since there is little prior work in this area in Canada, a substantial objective of this study was to describe what presently exists. Within the scope of the research, this task was accomplished by examining the activities of three major Ontario universities (Queen's, University of Toronto, Waterloo) which have adopted quite dissimilar approaches to commercializing university research.

This explanatory and descriptive part of the research was accomplished in three ways. First the strategy and structure of each university's approach was profiled. Descriptive case studies of specific innovations were then written to illustrate the commercialization process in each setting. Finally, a detailed faculty survey was carried out among scientists and engineers in each of the three universities.

To illustrate strategy and structure, a simple framework has been employed which was expected to provide broad insights into the organization of commercialization at each university. The outline is as follows:

- University Background
- Organization Structure
- Objectives
- Funding
- Processing Procedures and Policies
- Royalties

- External Contacts
- Results-to-Date (where available)

This framework presents a broad description of each university's institutional arrangement for managing innovation.

Insights into the process are provided by five comparative case studies. These illustrate in more detail how each organization works. They also provide anecdotal evidence on the profile and attitudes of 'typical' university inventors which are supportive of the findings of the accompanying large scale study of faculty/researcher involvement and attitudes.

For comparative purposes, the cases were designed around a common framework intended to expose the detailed working of the commercialization process. The major elements of this framework are:

- Source/Conception of Invention or Innovation (Market-pull or Technology Push?)
- Technical Description
- Patenting
- Commercialization Attempts
- Industrial Involvements
- Spin-offs
- Inventor Profile and Perspective
- Company Perspective
- Analysis

These elements cover the major determinants of the outcome of individual commercialization efforts.

The third major part of the study was concerned with the nature and attitude of faculty members who are the 'clients' of the university commercialization organizations. Since the responsiveness of these individuals to industrial needs and the university strategy for commercializing inventions ultimately determines the outcome of the effort, it was felt a study of this type needed a broad basis of faculty data.

Accordingly, we set out to test the influence on faculty of the following variables, which we have identified as being important in the effectiveness of the commercialization process:

- Faculty background and experience
- University policies favouring industry interaction and commercialization
- Faculty perceptions of organizations established to commercialize inventions.

Combined with the other major elements in our framework, these factors ultimately resulted in six hypotheses to be tested in the narrative part of the research, as follows:

## 2.2 HYPOTHESES

### Hypothesis 1

Professors who have industrial work experience and/or consult to industry are more likely to develop commercializable[17] inventions than those without industrial experience who do not consult.

[17] By 'commercializable', we mean that the science and technology underlying the invention is sound and that a buyer for the technology exists.

This hypothesis is derived from the market-pull view of the innovation process described in the Introduction. The notion is that professors who have industrial work experience or who consult will, through their contact with people in industry, have a greater awareness of what the market needs in terms of developments in their area of research. Having this knowledge, they are more likely to develop an invention which can be commercialized.

### Hypothesis 2

Professors interact with industry more if they perceive their university's salary, promotion, and tenure policies as encouraging interaction.

The alternative hypothesis in this case is that other factors such as industrial work experience, nature of the professor's research, or personal interests override the effect of promotion policies.

### Hypothesis 3

In order to be successful in the long-run, organizations to commercialize professors' inventions must be perceived by professors as effective.

By 'effective', we mean to have a significant number of inventions that they succeed in getting commercialized. Organizations created to commercialize inventions are expensive. In addition to patenting and other legal costs, the university must employ staff to manage the organization. If the organization does not succeed in getting a substantial number of inventions commercialized, then it is unlikely that university administrations, hard-pressed for funds, will allow it to continue to exist.

But it is not enough for the organization to be effective; faculty members must also perceive it as being effective. If they do not believe it can get their invention commercialized it is unlikely they will work with it. Rather, they will either attempt to commercialize the invention on their own, or they will not bother to do anything with it.

## Hypothesis 4

Organizations to commercialize university inventions are more effective if they are market-oriented.

By market-oriented, we mean to contrast the orientation of the organization with that of the university. The orientation of the university is towards adding to the body of knowledge, irrespective of the market value of that knowledge. The commercialization organization must be market-oriented both to know what inventions are commercializable, and therefore which ones to protect, and to know what companies to approach when attempting to commercialize inventions.

## Hypothesis 5

In order to be perceived by professors as effective, these organizations must operate in a manner consistent with the background and orientation of faculty members.

Organizations to commercialize university inventions will, in most traditional universities at least, seem almost anomalous. Many faculty members will be either uninterested in or unsympathetic with the goals of the organization; some will be hostile. If the organization is to avoid alienating the bulk of the faculty members, it cannot set up shop like a business and expect professors to arrive at the door with an invention to be patented in one hand, and an estimate of its net present value in the other. Rather, it must recognize that the majority of the professors have had little or no exposure to industry practices, and be careful not to alienate them. If it alienates them, it is unlikely to be perceived as being effective, and is unlikely to be successful in the long-run.

## 2.3 METHODOLOGY

The research was divided into three stages. The first stage began with a review of the literature on the commercialization of university inventions, and with informal discussions with science and engineering professors at Queen's, the University of Toronto and the University of Waterloo, to identify their concerns in this area. This was followed by the development of a detailed questionnaire, which was used in the interviews of the individuals in charge of the technology transfer organizations at the three universities. This questionnaire, which is reproduced in Appendix B, was sent in advance to the persons to be interviewed. The questions on it were then discussed with them in semi-structured interviews that were taped. A list of the individuals interviewed in this manner is also in Appendix B. In some instances the interviewee would choose to expand on a topic in considerable detail, or even raise issues not covered in the questionnaire. Some other questions could be dealt with rapidly.

In addition to key persons in charge of the organizations, interviews were conducted with individuals who were involved in setting up the organizations. A list of these people is provided in Appendix B. Together, these two sets of interviews served as the basis for the descriptions of the organizations in the following section.

The second of research involved the development of a series of case studies on specific inventions. In this stage of the research, employees of the innovation organizations were asked to suggest an instance of a successful, and as yet unsuccessful innovation to be studied in depth. Using the framework described earlier, a series of structured interviews were conducted with the inventor, university personnel, and company executives associated with each invention. The cases were then analyzed for their degree of fit with the more general research findings.

The third stage involved a one page multiple choice questionnaire survey, which was sent to science and engineering professors at the three universities. The questionnaire is reproduced in Appendix C together with the letters that were sent with it (a different one for each university). Questionnaires were sent via campus mail at Queen's and via I.U.T.S. to the other universities. The questionnaire was designed with the return name and address on the back so that the professor could simply complete it, fold it in half and staple it, and return it via campus mail or I.U.T.S. The questionnaires were also marked with a 'Q', 'T' or 'W' to indicate which university the response was coming from.

The names of professors to be surveyed were taken from the calendars of the graduate schools of the three institutions. All Engineering and Physical and Life Science professors at the Universities of Waterloo and

Toronto were surveyed. Similarly, all Engineering, and Physical and Life Science professors at Queen's were surveyed, except for those identified in the calendar as being on leave. (This information was not available in the other two calendars).

Within one month of sending out the questionnaire, a substantial number of responses had been obtained from all universities in all three categories (i.e., Engineering, Life and Physical Sciences) of research with the exception of the University of Toronto Engineers. Accordingly, a second copy of the questionnaire was sent to them, together with a letter asking them not to return it if they had responded to the earlier mailing. This resulted in a significant number of replies.

# CHAPTER 3: THE COMMERCIALIZATION ORGANIZATIONS

## INTRODUCTION

In the summer of 1984, a series of descriptions on the technology transfer organizations at each of the three universities was prepared. Since the approach taken at each university at that time was quite different, it has been difficult to construct the cases in a manner that facilitates direct comparison. However, the cases are summarized and compared across what we found to be the most significant dimensions at the end of the chapter.

Descriptions of four organizations are presented: one each at the University of Toronto and Queen's University, and two at the University of Waterloo. At the University of Toronto, an Innovations Foundation has been established for commercializing technology developed at the university. At Queen's, no single organization exists, but a variety of mechanisms are described which are intended to promote innovation. The University of Waterloo has a Centre for Process Development, which has a more limited scope of activity than the other organizations studied. However, university faculty can also draw on the expertise of the Canadian Innovations Centre, which is located on the campus but which also serves other clients from the local area.

## 3.1 UNIVERSITY OF TORONTO: THE INNOVATIONS FOUNDATION

### 3.1.1 BACKGROUND

The University of Toronto created the Innovations Foundation in January, 1980, to "encourage, promote and implement the commercial development and use of the results of the University's research laboratories."[18] The Foundation was incorporated as a separate company without share capital. Under the bylaws, the University has the authority to recommend and nominate members. The members, in turn, elect the Board of Directors. The majority of the thirteen Board members are from industry; three, including the vice-chairman and secretary, are from the University. The Board of Directors hires the Executive Director (who is also currently a Board member), who hires the staff.

Members of the University who were involved in setting up the Foundation feel very strongly that it was necessary for it to be a separate corporation. The main reasons given were:

1. To isolate the organization from the University's cumbersome decision-making processes,

2. To provide a liability barrier, and

3. To more readily and formally associate with the private sector.

Decisions of any significance within the University invariably involve numerous committees. It was felt that if it was part of the University, rather than a separate corporation, the Foundation would be unable to act in the rapid, businesslike manner considered necessary for success. One professor/inventor related an incident that occurred before the Foundation was created to illustrate this point. His invention was patented and a foreign company offered $10,000 as an up-front fee for the information necessary to develop a prototype. The professor signed an agreement to

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[18] Taken from an information pamphlet published by the Foundation.

this effect, collected the fee, and transferred the technology before the University began to consider the implications of the move. The company developed the prototype, but decided not to commercialize the invention. It was a year after this decision that the University's Governing Council finally approved the agreement.

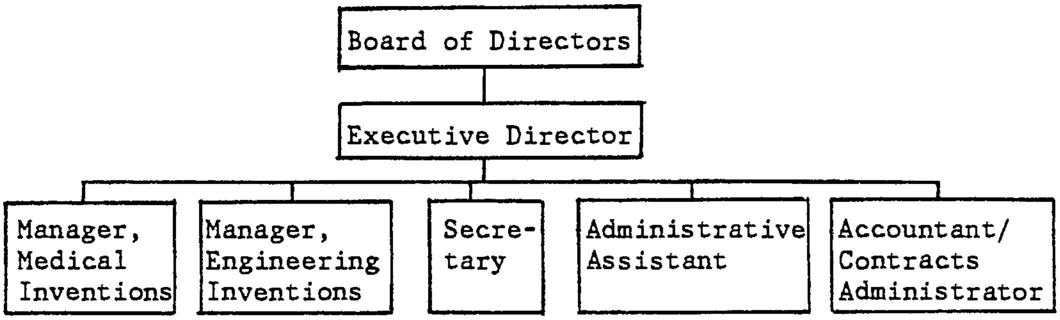
The creation of a separate foundation established a liability barrier in two ways. First, the University is not legally responsible for debts or obligations incurred by the Foundation, or damages arising from its actions. More importantly, however, it is intended to protect the University's reputation. The University recognizes that the possibility exists that the Foundation, because of the milieu in which it operates, may unwittingly take actions which could damage the University's reputation. For instance, in setting up a company the Foundation might join with individuals with whom the University would prefer not to be affiliated. By incorporating the Foundation, it was felt that a greater separation between the University and these activities could be maintained.

Incorporating the Foundation necessitated the creation of a Board of Directors. The Board is viewed as a good mechanism to enable the University to tap the expertise of the business community. It was also felt that a separate corporation operating like a business would be better able to interact with industry than an office of the University.

### 3.1.2 ORGANIZATION STRUCTURE AND OBJECTIVES

The Foundation's organization chart is presented in Figure 8 on page 31. When the Foundation was formed, it had two employees, the Executive Director and his Assistant. In September, 1982, an Accountant/Contracts

Figure 8. Innovations Foundation:

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Administrator was added, and in December, 1983, a Manager of Medical Inventions was hired. Plans are in place to hire a Manager of Engineering Inventions and a Secretary in the summer, 1984, bringing the total number of employees to six. All of the employees have industrial work experience, and none were previously employed by the University.

The long-term objective of the Foundation is the commercialization of the University's research results. In addition to this long-term goal, the Foundation developed a five-year business plan when it was first established. Included in this plan were projections for revenues and expenses for each year. The end of this five-year period is approaching, and the Foundation has prepared an eight-year plan to follow it. This plan contains not only revenue and expense projections, but also estimates of the number of inventions to be reviewed each year, the number of licences to be written, and so on. The number of employees is not expected to grow in the near future, but the expenses are expected to increase by about 10% annually over the next few years. The Foundation expects to become profitable within the time period of the second plan.

The performance of the Foundation is assessed by the Board by comparing actual to projected revenues and expenses. By this measure, the Foundation is considered to be performing satisfactorily. However, it was conceded by the former Board Chairman that the original plan was deliberately conservative in order to avoid the possibility of the Foundation being declared a failure without being given a fair chance.

### 3.1.3 FUNDING

The Foundation was provided with start-up funding by the University with the understanding that it should become self-sufficient as soon as possible. There seems to be a consensus that it started out badly under-capitalized, given the role it was intended to play. A variety of funding sources were explored, including the funds generated through the sale of Connaught Labs to the Canada Development Corporation. While the desired level of funding was not obtained, the decision was made to start under-capitalized rather than not start at all.

In the long run, the Foundation's main sources of funds are intended to be royalties from licensed inventions and dividends from companies in which it holds shares (and the sale of shares). With most inventions, the commercialization route taken is licensing to an existing or start-up company. In some cases, it transfers the technology in return for an equity position in the company and takes a smaller royalty. The Foundation will sometimes start a company to exploit an invention. In this circumstance, it will hold equity in the company.

An additional source of revenue is contract administration fees. The Foundation found that in some instances it was unable to commercialize

University inventions because they were at too early a stage of development. In this situation, the Foundation attempts to find a company interested in entering into a contract to fund further development, and perhaps apply with the University for a 'Project Research Applicable to Industry' grant from NSERC. In most cases, the invention will not have been patented at the time the contract is written, although an application may have been filed. The Foundation charges administration fees on these contracts which it arranges. While these contracts are separate from those written between an outside organization and the University directly, much of the administrative work is subcontracted to the University.

### 3.1.4 PROCESSING INVENTIONS

A professor having a potential invention is required to complete an Inventions Disclosure Form and submit it to the University's Inventions Committee. The function of the Inventions Committee is to consider who owns the invention. In the case of about one-third of the inventions, the research has been supported by a contract which gives some commercial right (e.g., first refusal to license for a specified royalty) to the supporting company. In this situation, the Inventions Committee may decide to process the invention without involving the Foundation. In other instances, the professor may claim the invention is his and not the University's. However, unless he can demonstrate that it was developed exclusively on his own time and with his own resources, the University is deemed to be the owner.

Where the University is the owner and there are no prior arrangements, the Committee refers the invention to the Foundation for further evaluation.

The Foundation is responsible for the technical and commercial appraisal of the invention, and it decides whether or not to attempt to commercialize it. In making this decision, Foundation personnel spend considerable time with the inventor, discussing his interest in seeing it commercialized, concerns about publication, and sources of funding for further development. In evaluating an invention's commercial potential, the Foundation uses whatever resources are available, including the inventor and his peers, members of the Board and the Inventions Committee, patent agents, and frequently people in industry who are potential customers. In the end, however, it is the Executive Director of the Foundation who makes the commercialization decision.

If the Foundation decides not to commercialize an invention, it is either because its commercial potential does not appear to justify it, or because protection of the technology cannot be justified. In some cases the Foundation may protect an invention with low commercial potential because it provides inroads to other important technologies.

An invention which the Foundation does not want is referred back to the Inventions Committee. In most cases the Committee will then turn it back to the inventor to do with as he wishes. However, the University does not renounce all rights to it. If the inventor successfully commercializes the invention on his own, the University expects a share (perhaps 20%) of the net revenues from it.

It should be noted that the Foundation does not turn back an invention simply because it is not patentable. For instance, software is generally not patentable, but the Foundation will often attempt to commercialize it, and will consider attaching a trade mark to it to gain some commercial right. Also, there are other non-patentable inventions which can have valuable know-how associated with them which the Foundation will attempt to license.

If the Foundation decides an invention should be patented, it pays the associated costs and it owns the patent. If the invention is returned to the inventor and he wishes to patent it, then he is the owner and he bears the costs.

In most cases, patents are applied for only in the U.S. and Canada. If the Foundation is in contact with a company that wants the invention patented in other countries, then it attempts to get the company to pay the costs. In the past, patent coverage has been obtained in as many as eleven countries, but, for most of their technologies, North America is the major market.

If someone infringes on a Foundation patent before it is licensed, the Foundation will take action to stop the infringement. In most cases, as part of a licensing agreement the licensee is given the responsibility to watch for infringement. If the licensee does not move to stop an infringement, then the Foundation has the right to take whatever action it deems necessary.

The Foundation usually negotiates non-exclusive licenses. However, it may agree not to license the invention to another company in the same territory for a certain number of years, as long as certain performance standards are met.

### 3.1.5 DIVISION OF ROYALTIES

Royalties on inventions handled by the Foundation are paid directly to it. The University and the Foundation have a contract such that the Foundation pays to the University "50% (or more, if there have been exceptional circumstances) of all licensing, royalty and other income received by the Foundation in respect of the commercial development of an Invention, less the direct legal and patenting costs associated with that specific Invention".[15] The revenue received by the University is shared equally with the Inventor. The end result is that the University and the Inventor each receive 25% of the net revenues associated with an invention. However, if the Foundation is very successful the University may eventually receive more, as any surplus funds of the Foundation's are to be returned to the University.

### 3.1.6 NUMBER OF INVENTIONS

Since being established, the Foundation has selected about 180 inventions to attempt to commercialize. Of these, approximately 10% have been licensed. The number of inventions referred to the Foundation has been increasing each year. In the last 12 months, 60-65 were brought to the Foundation's attention, and approximately 45, or 75%, were accepted for detailed evaluation.

[15] "Information Relating To The Inventions Policy," University of Toronto, December 9, 1983.

Of the inventions it selects to commercialize, relatively few are licensed within one year. However, the great majority of those which end up being licensed, are licensed within two years of the Foundation taking them on.

### 3.1.7 EXTERNAL CONTACTS

Of the organizations other than the University that the Foundation interacts with, it has frequent contact with government departments but much less contact with venture capitalists. It deals extensively with both large and small manufacturing companies. The Director estimated that more than half the companies it interacts with are foreign-owned.

The Foundation finds it easiest to work with government departments because they are least likely to demand a financial interest in an invention. Venture capitalists were considered to be most difficult to deal with. Of the projects they review, venture capitalists actually invest in very few. The Executive Director said he could not take a professor from one venture capitalist to the next to give presentations and have his invention repeatedly turned down. Many professors would be discouraged by the first rejection and would refuse to continue. After all, this is not their primary activity.

The Foundation is approached by companies seeking solutions to technical problems about ten times per year. Most often the Foundation is not able to help these people, either because the problem is "more development than research (and therefore considered inappropriate)," or because the relevant researcher is too busy to help. It is also approached by venture capitalists seeking developments for new ventures, but for the reasons stated above, it has not often dealt with them.

The decision as to whether a technology should be transferred to an existing company or be the basis for a new venture is largely determined by the nature of the development itself. In the case of a very significant invention with large commercial potential, it is more likely that transfer to an existing company will be attempted. However, in the future the Foundation will likely start more companies than previously, since this is considered to result in greater long term revenues.

One of the Foundation's responsibilities is to find venture capital to finance new venture formation. The Foundation does not restrict itself to Canadian sources of venture capital. In the past it has found that obtaining venture capital, even for developments believed to have significant commercial potential, is quite difficult.

### 3.1.8 DIRECTOR'S PERSPECTIVE

The Foundation's Executive Director said that about 90 percent of the science and engineering professors (excluding medicine) are probably aware of the Foundation's existence. For medicine, it was expected that this would be somewhat lower. He estimated that 70 percent have a reasonably clear understanding of the Foundation's functions and how they are performed. This estimated level of awareness has been achieved primarily via the grapevine rather than by more formal 'advertising'. It is unlikely that the Foundation will be promoting its services in the near future, since its case load is reportedly as much as it can handle with current staff.

The Director observed that a greater proportion of the engineering professors have industrial work experience, and that professors with such experience are more likely to bring forward inventions having commercial potential than those that don't. He said that the grasp professors have of the commercial potential of their developments varies greatly.

The majority of inventions developed at the University are new products rather than processes or improvements to existing products. While either products or processes can be transferred to manufacturing companies, new ventures are almost always based on the former. In the Foundation's experience, commercializing products is generally easier than processes. Introduction of a new process usually requires changing an existing one, and this is likely to meet with resistance from the recipient's manufacturing manager.

The Director observed that there are more developments now than previously in the areas of bioengineering, computer software, and new chemical processes. The greatest difficulty in handling biotechnology developments is in finding companies with the expertise to take them up.

In the Director's view, the key to the Foundation improving its ability to transfer technology is more capital to assist with the initial phase of setting up new companies.

The Director observed that in attempting to transfer technology to an existing company, it is critical that the first approach be made to the right persons. For instance, he advises strongly against approaching the head of a company's R & D department with new research results. For the research director to recommend 'purchasing' such results is, in a sense, to admit failure. Similarly, he would not approach a manufacturing manager, who has probably taken pains to optimize his current processes, with a new process. Rather, he advocates approaching the President, or perhaps the New Business Development or Marketing Manager. In this way, it is less likely that the approach will be stone-walled from the beginning.

Finally, it was suggested that professors who work to have their inventions further developed and commercialized derive considerable satisfaction from this activity. The view that professors want to do only 'pure research' and are not interested in taking their work further is not consistent with the Director's experience.

## 3.2 QUEEN'S UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATION

### 3.2.1 BACKGROUND

Several organizations exist at Queen's to facilitate interaction between the University and industry. Perhaps best known is the Canada Microelectronics Corporation (CMC), whose major objective is to help Canadian universities provide research and training in integrated circuit design and application. It should be noted that, at least at present, CMC is not a 'commercialization' organization; it does not market integrated circuit designs or related technologies. Other organizations at Queen's include the Advanced Materials Technology Unit and the Centre for Guided Ground Transport.

The mechanism for evaluating and commercializing inventions at Queen's is more difficult to describe than that at the other two universities being studied, as it is less formally defined. At Queen's, there is no one person directly involved in these activities who has overall responsibility for them.

The individuals involved in the Queen's organization perceive its main function as being to facilitate the development and exploitation of professors' inventions, and in so doing, to improve the research reputation of the University. Making a profit is not a primary goal. Rather, the limited funds available to protect and promote the inventions are perceived as a constraint which will be less binding in the future if the organization is profitable.

### 3.2.2 ORGANIZATION STRUCTURE AND OBJECTIVES

An outline of the structure of the Queen's organization is provided in Figure 9 on page 42.

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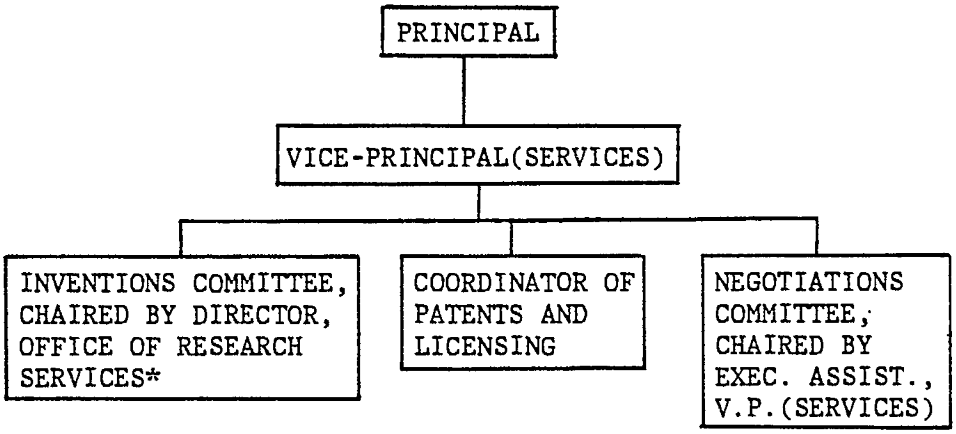
Figure 9. Queen's Technology Transfer Organization Structure:




*On matters not relating to intellectual property the Director of the Office of Research Services reports to the Principal.

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The organization consists of three distinct elements: an Inventions Committee, a Negotiations Committee, and a Coordinator of Patents and Licensing (CPL). The description of the organization below is based on interviews of the chairmen of the two committees and of the CPL.

The beginning of a significant level of activity in the area of intellectual property can be traced to the hiring on a half-time basis in 1977 of a registered patent agent as a CPL. The CPL has worked 3/4-time since 1978. The role of the CPL is more that of an advisor or support staff than decision maker. The CPL advises on patentability and assists with writing contracts. He does not write patents, although he is qualified to do so. Decision-making powers rest with the Vice-Principal (Services).

The role of the Inventions Committee is to advise the Vice-Principal (Services) on what action he should take with regard to professors' inventions. Their recommendations range from patenting immediately to having market research done to turning the invention back to the professor. The Vice-Principal (Services) is not bound by the Committee's recommendation.

The Inventions Committee is chaired by the Director of the Office of Research Services and its members include the Chairman of the Negotiating Committee, a physical science professor, and an engineering professor. The CPL is an ex-officio member of this Committee.

The role of the Negotiating Committee is to negotiate licensing agreements with corporations and individuals interested in commercializing professors' inventions. This Committee is chaired by the Executive Assistant to the Vice-Principal (Services). The individual currently in this position is a lawyer, and can therefore advise the Committee on legal issues as well. Other members of this Committee are the Chairman of the Inventions Committee, the CPL, the Secretary of the University, and the inventor or his representative.

The organization's long-term objective is to improve the research reputation of the University. It does not have formal annual objectives. Rather than set targets and strive to meet them, the organization operates in a responsive mode, processing inventions as they are brought to its attention by members of the University community. Similarly, the Negotiations Committee convenes when by one means or another it becomes aware of a party that is interested in one of the University's inventions. No coordinated marketing of inventions is done.

No formal regular evaluation of the performance of the organization is done. The organization has been allowed to evolve as its members saw fit and as it developed expertise in handling intellectual property. The Vice-Principal (Services), who is responsible for the organization, does not intervene unless he sees the need. The only instance where the organization was required to change course was when the cost of patenting was growing too high (see Number of Inventions section below).

### 3.2.3 FUNDING

The organization is treated more as a cost centre than a profit centre. The costs directly attributable to the organization are the salary of the CPL and the patenting and legal costs. These are paid by the University. Sources of revenue are licensing fees and royalties, which are paid directly to the University. These revenues currently amount to about half the 'direct costs' referred to above.

Not included in these costs is the time devoted to this activity by the Chairmen of the Committees, the Secretary of the University, and the science and engineering professors who sit on the Inventions Committee. The two chairmen each spend about one-quarter of their time on intellectual property matters. However, the revenue side of the equation is also in a sense incomplete. While it does charge overhead, the organization, unlike those at Toronto and Waterloo, does not charge administration fees on contracts it negotiates. The view is that it is more consistent with the long-term aims of the University to have as much of the contract funds as possible used in support of research.

### 3.2.4 PROCESSING INVENTIONS

A professor who has an invention which he believes may be worth protecting generally first approaches the CPL. The CPL discusses the invention with him, addressing concerns such as delays in publication associated with patenting, and outlining the steps the professor should follow if he wishes to proceed. If the professor decides that he wishes the invention to be protected, he submits to the Inventions Committee an invention disclosure form, which describes the invention in detail.

In considering whether or not an invention should be protected the Committee attempts to gain some grasp of its commercial potential. In some instances, where the nature of the invention is appropriate, the Committee will recommend to the Vice-Principal (Services) that he have the Queen's Small Business Consulting Group do market research. In most cases, however, the invention is at too early a stage of development or too complex to be handled in this way. In this situation, important criteria in the Committee's evaluation process are whether the professor intends to continue to do research related to the invention, and if having the invention protected will assist him in obtaining further research funding.

If the Vice-Principal (Services) decides to patent the invention, he refers it to the CPL who has the patent application prepared and submitted. Generally patents are obtained in the U.S. and Canada, and the cost of this is paid by the University. If a party who is interested in licensing the invention wishes to see it patented elsewhere, then that party usually pays the costs.

If the Vice-Principal (Services) decides the University should not protect the invention, the University relinquishes all rights to it. If the inventor then protects and successfully commercializes the invention, the University does not claim any right to any of the proceeds from it.

The organization has no formal mechanism for identifying potential licensees. Usually personal contacts of the the inventor(s) or of the members of the organization who might be interested in the invention are contacted. Once an interested party is identified, the Negotiating Committee meets with it to attempt to negotiate a license. Both exclusive and non-exclusive licenses have been negotiated.

If the research is at too early a stage to warrant licensing, the Committee may attempt to negotiate a research contract, in order to facilitate further development.

### 3.2.5 DIVISION OF ROYALTIES

The Negotiating Committee usually negotiates a licensing fee when it signs an agreement which is at least sufficient to cover the patenting and legal costs associated with the invention. Sixty percent of the remainder of the fee and of any royalties are kept by Queen's; the rest is turned over to the inventor(s).

In the case of software, revenues are divided evenly between the University and the inventor. The rationale for the University taking a lower proportion here is that the costs associated with software are lower (no patenting) so there is less risk taken by the University.

### 3.2.6 NUMBER OF INVENTIONS

In the early years after the CPL was hired, about 20 patent applications were filed. In the next couple of years the number rose to almost 40. At this point it was felt that the resources going towards patenting were becoming too large, and the Inventions Committee was forced to become more selective. Currently about 20 patents are filed each year. Of all the inventions that have been submitted to the Committee, about 70 percent have been protected, although this percentage is declining.

The total number of patents filed is of the order of 130. Fewer than 10 percent of these have been licensed.[20] In a number of other cases research contracts have been written which provide companies with a first right to license within a given time period.

A number of software packages (about 10) have been copyrighted and had a trade mark attached to them. More than half these have been licensed. In one case the software has been sub-licensed to a large number of companies around the world.

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[20] In late 1983, an ad hoc Advisory Committee on Patenting and Licensing at Queen's reported to the Vice Principal (Services) that only 3 percent of the inventions that had been patented were licensed. Shortly thereafter a number of license agreements were negotiated, raising the percentage to perhaps 7 percent.

### 3.2.7 EXTERNAL CONTACTS

The organization is more likely to have contact with large companies in arranging licenses, although a number of inventions have been licensed to small companies. The organization is less likely to be in contact with government departments. The only venture capitalist it has worked with is IDEA Corp., an Ontario Crown corporation.

## 3.3 UNIVERSITY OF WATERLOO TECHNOLOGY TRANSFER ORGANIZATIONS

### 3.3.1 BACKGROUND: THE UNIVERSITY

Before describing in detail the organizations the University of Waterloo has created to facilitate the transfer of technology, it is worth noting that Waterloo is, in some respects, significantly different from the other universities being studied. While both Queen's and Toronto have existed for more than a century, Waterloo is less than three decades old. A second difference is that Waterloo is built around a core engineering program, whereas the other two are dominated by large Arts and Science faculties. A third, and perhaps the most significant difference for the purpose of this paper, is the very large co-operative education program at Waterloo. While Queen's and Toronto's programs are mostly designed around the September to April academic year, Waterloo has over 8,500 students enrolled in alternating work-and-study term programs. This number includes all the engineering students, 70 percent of the mathematics students, and even 15 percent of those enrolled in the arts.

The co-op program raises the level of interaction with industry in a number of ways. First, it means that large numbers of company representatives visit the campus several times each year to interview students. While on campus, they often take the opportunity to meet with faculty who may be doing research relevant to their company. Secondly, students sometimes bring in research projects that they learn about during their work term, or they may refer their employer to a professor who could help with a particular problem. People at Waterloo believe that the co-op program in general, and the above two factors in particular, significantly lower the psychological barriers which may inhibit interaction at other universities. It has been suggested that cultural differences between the academic and industrial worlds are a barrier to the interaction of universities and industry.[21] At Waterloo, working with industry is said to be part of the culture.

Most engineering professors at Waterloo either have industrial work experience, or get it while employed by the University. Under the co-op system, most professors teach four terms out of six. Some combine two non-teaching terms and work in industry for eight months. Also, like faculty at other universities, professors from Waterloo sometimes take saabaticals in industry. Through both these mechanisms, the level of interaction with industry is raised.

According to the Dean of Research, being approached by companies with technical problems is almost a daily occurrence. In his view, they are often able to help these people. In fact, while originally problems were most often brought in by students returning from their work terms, direct approaches by companies are now more common.

Another significant difference is that the professor/inventor, not the University, owns the invention at Waterloo. In fact, professors with inventions are not even under obligation to formally inform the University of them. Although it does not claim professors' inventions, the University has participated in the creation of several organizations to assist

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[21] J. Maxwell and S. Currie, Partnership for Growth: Corporate-University Collaboration in Canada, Corporate-Higher Education Forum, Montreal, 1984.

with their commercialization. A professor who chooses to use the services offered by these organizations sacrifices some of the rights to his invention (see below for details).

The three most prominent organizations that have been created to commercialize inventions at Waterloo are Waterloo Software Products Limited (WATSOFT), the Waterloo Centre For Process Development, and the Canadian Industrial Innovation Centre/Waterloo. WATSOFT is involved in the distribution of software developed at the University. Because of the heavy emphasis on computer use, Waterloo has been the centre of considerable software development. In 1981-82, software licenses to companies and institutions around the world generated about $1,700,000 in revenue. Software licensing at Waterloo is described in considerable detail in a published article,[22] and will not be discussed further here. The activities of the Waterloo Centre for Process Development and the Canadian Industrial Innovation Centre/Waterloo are described below.

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[22] J.P. Sprung, "The Business of Software Licensing at The University of Waterloo," Journal of the Society of Research Administrators, vol. 15(2), 1983, p. 5-19.

## 3.4 WATERLOO CENTRE FOR PROCESS DEVELOPMENT

### 3.4.1 BACKGROUND

The Waterloo Centre for Process Development (WCPD) was founded in 1978 as a result of a proposal submitted by the University of Waterloo to the Department of Industry, Trade and Commerce (now the Department of Regional Industrial Expansion (DRIE)). According to the original proposal, it was intended to facilitate the development of bench scale technologies originating in any Canadian university to the point where they could be transferred to the commercial sector. Through negotiations, the mandate was reduced to a more workable one, and the Centre was given a five-year $1,000,000 grant to get it started. The Centre's primary thrust now is developing chemical and biochemical processes originating in the University of Waterloo to the point where the private sector will take an interest in them, and to effect a transfer of technology such that benefits flow both to the University and the inventor.

WCPD is part of the University, as opposed to being a separate corporation. In the legal sense it operates in the name of the University, e.g., its contracts are signed on behalf of the University and are countersigned by the Dean of Research. Its Director describes it as semi-autonomous, in that it has a Board of Directors, which meets three times each year, to which he reports. The Board has ten members: four each from the University and industry, and two from DRIE. Its main responsibility is to review the financial performance of the Centre. The Centre relies heavily on its private sector Board members to assist with technology evaluation and the identification of potential licensees. The Board members, who serve on a voluntary basis, are bound by secrecy agreements to maintain the confidential nature of the information they receive.

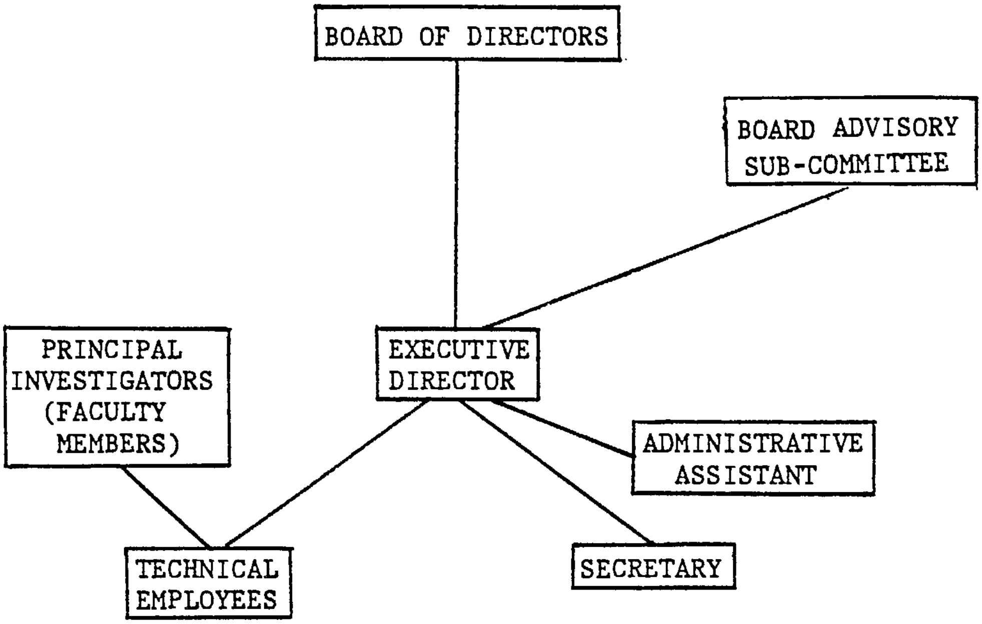
The Centre is also semi-autonomous in the sense that it is accountable as a separate cost centre. It rents the space it uses directly from the University and pays for all the other services (i.e., purchasing, personnel and financial) received from the University by returning 55 percent of all the overhead charges collected on the research contracts and 10 percent of all royalty income from licensing activities.

### 3.4.2 ORGANIZATION STRUCTURE AND OBJECTIVES

An outline of the structure of the organization is provided in Figure 10 on page 54. While not a member of the Board of Directors, the Director is a member of a Board sub-committee, which consists of one industry and two University representatives. This sub-committee, which meets two to three times per year, exists to advise him on matters such as opportunities for funding, and on the technical and commercial evaluation of projects the Centre is considering investing in. Two office employees, an Administrative Assistant and a Secretary, work with the Director.

The Centre also employs 30-45 graduate (Bachelors, Masters and Ph.D.) engineers/scientists to conduct research under the direction of faculty members. The number employed depends on the level of contract research. These employees are not students, but rather, are hired on a full-time basis. Their only commitment is to the project or contract they are assigned to. They are supervised by the Director only in an administrative sense or when their activity has an impact on the business relationship

Figure 10. WCPD Organization Chart:




with the client; on technical matters they respond to the faculty member responsible for their work.

The Centre does not have objectives for the number of patents it will apply for or licenses it will write in a given year. Its objectives are defined in financial terms in its budgets.

The current Director, who has been with the Centre for two-and-one-half years, had an objective of taking the Centre from a deficit to at least a break-even position within a certain time period, an objective he has achieved.

The performance of the Centre is assessed by the Board of Directors, which evaluates it primarily on the basis of its financial performance. While the Board is reportedly satisfied with the Centre's current performance, it was less so three years ago when the Centre was running a $400,000 deficit (this was financed by the University). In addition to the Board's evaluation, the Centre has also been evaluated by DRIE, which has continued its funding. Further, it was recently awarded the 1984 Canada Award for Excellence in Technology Transfer for its success in licensing the Single Cell Protein Bioconversion Process.

### 3.4.3 FUNDING

In accordance with the agreement at the time the Centre was established, DRIE has provided the Centre with $200,000 in each of its first five years. Originally it was thought that it could become self-sufficient on technology transfer royalties and fees alone. After a couple of years it was realized that this expectation was unrealistic, and the Centre began taking on contract research. It now does almost $2,000,000 of contract research each year. The Centre levies a 100 percent overhead charge on industrial contracts, but can charge only 30 percent on Department of Supply and Services contracts. Currently about 60 percent of the contracts are from industry and the remainder are from government departments. The overhead earned from these contracts, together with technology transfer fees and the DRIE support, is enough to make the Centre self-sufficient.

The contract research has been fruitful not only for the overhead funding it has provided; five of the seven licenses the Centre has written have been of developments either discovered or enhanced via contract research. While technology transfer fees have exceeded $400,000, the first royalty cheque only came in 1984. The flow of royalties required to replace the DRIE funding is still several years away.

In addition to the contract research, the Centre carries out a series of projects which are funded wholly or partly by the Centre. Usually projects involve the further development of processes which were supported in the early stages by NSERC grants. These projects are at a stage beyond which NSERC has traditionally funded, but are at too early a stage to be of interest to industry. If the Centre can identify a company that may have an interest in the process, it will propose that the company enter into a joint venture with it to fund the project.

Usually when the Centre decides to establish a project, it will file a patent for the invention in order to safeguard its investment. The patenting costs are paid by the Centre, and the patent is assigned by the inventor to it (as the agent of the University).

Since projects are generally at a very early stage of development, considerable funding is required to bring them to a commerciable level. For instance, the Centre has invested over $1,000,000 in its largest project, the Waterloo Single Cell Bioconversion Process. As projects are so expensive, it is clear that only a very limited number can be funded.

### 3.4.4 PROCESSING INVENTIONS

When a professor feels he has an invention that is potentially commerciable, he meets with the Centre's Director. The purpose of this meeting is for the professor to provide the Director with an accurate description of the invention, and to convince him that it is worthwhile for the Centre to patent it and to seek or provide funding for further development. In evaluating the invention, the Director uses whatever resources are available, including members of the Board, the professor's peers, and his contacts in industry. If the Director decides the invention should be patented, applications are usually filed in the U.S. and Canada, although in one instance patents are held in 15 countries. Once the invention has been 'taken on,' the Director either seeks a partner to fund the project as a joint venture, or supports it entirely with Centre funds.

Since the Centre was established, 34 patents have been issued to it, and 12-15 are pending. Currently the Centre is filing between five and ten applications per year.

Because of the nature of the technologies, the time required for developments to get into the commercial sector is quite long. While it has happened in one case, it is very unusual for processes to be in commercial use within two years of applying for a patent. Further, the Director estimated that only five percent of the technologies they develop are commercially exploited within five years of patent applications being filed.

The Director is not aware of any technology that the Centre turned away that is now in commercial use. In every case he is aware of, if WCPD did not take it up, it remained undeveloped.

### 3.4.5 DIVISION OF ROYALTIES

When a process is licensed and technology transfer fees start coming in, they are initially divided 15 percent to the inventor and 85 percent to the Centre (note that the University receives 10 percent of the Centre's portion directly). This distribution ratio continues until the Centre has recovered all its investment in the process, plus interest and expenses (e.g., legal fees). Once this occurs, the ratio becomes 45 percent to the inventor and 55 percent to the Centre. Professors who have directed or are directing research funded by the Centre receive quarterly statements advising them of the amount the Centre has invested in the project and how much royalty income has been received.

The Director believes that one of the attractive features of this arrangement is that the inventor does not have to wait until the Centre's investment is completely recovered to start benefitting financially from the invention.

### 3.4.6 EXTERNAL CONTACTS

Most of WCPD's contacts are with government departments and large corporations; of the seven licences that have been negotiated, only one was with a small company. The reason for this is that the resources and infrastructure required to scale-up and exploit the technologies being developed renders them beyond the reach of most small companies. The Centre generally directs its proposals to Canadian corporations. However, since many large companies, especially chemical companies, are foreign-owned, a significant number of the Centre's contacts are with foreign-based multinationals. The Centre has had relatively little interaction with venture capitalists, since the investment required is usually too large, and they are generally interested in products that can be the basis of start-up operations, rather than processes.

In preparing for meetings with companies, the Director first meets with the professor involved to establish objectives for the meeting. During the meeting the professor makes the technical presentation and responds to technical questions, while the Director takes the lead in any contract negotiations.

### 3.4.7 DIRECTOR'S COMMENTS

The Director reported that developments brought to him by professors having industrial work experience were generally more likely to have commercial potential. He added that most of the professors he sees actually have such experience. However, it was noted that in one of their most successful cases, the professor does not have industrial work experience. The Director suggested that the individual and his personal objectives may be more important than having industrial background.

The Director said that he is frequently approached by companies seeking solutions to technical problems. In his view, one of the Centre's key functions is providing a door for industry to knock on and to bring people together to solve such problems.

Another key role of the Centre is to identify and quantify the process-related business activities of the University. By performing this function, the Centre can help the University to maintain innovation at an appropriate level. The Centre also insures that legal and business transactions are handled properly. In the words of the Director, "a handshake arrangement between a company and a professor is fine, until there's money on the table to divide."

While trying to operate in a businesslike fashion, the Centre attempts to avoid becoming bureaucratic. The Director feels that if one attempts to organize this type of activity too much, it will most likely have a stifling effect.

In the Director's view, the main difference between the research being done now at Waterloo, versus three years ago, is that more is closer to the applied end of the spectrum.

## 3.5 CANADIAN INDUSTRIAL INNOVATION CENTRE/WATERLOO

### 3.5.1 BACKGROUND

The CIIC/W was created in 1980 with the support of the Department of Industry, Trade, and Commerce, as a corporation without share capital. Its mandate, as stated on the front page of its 1982-83 Annual Report is:

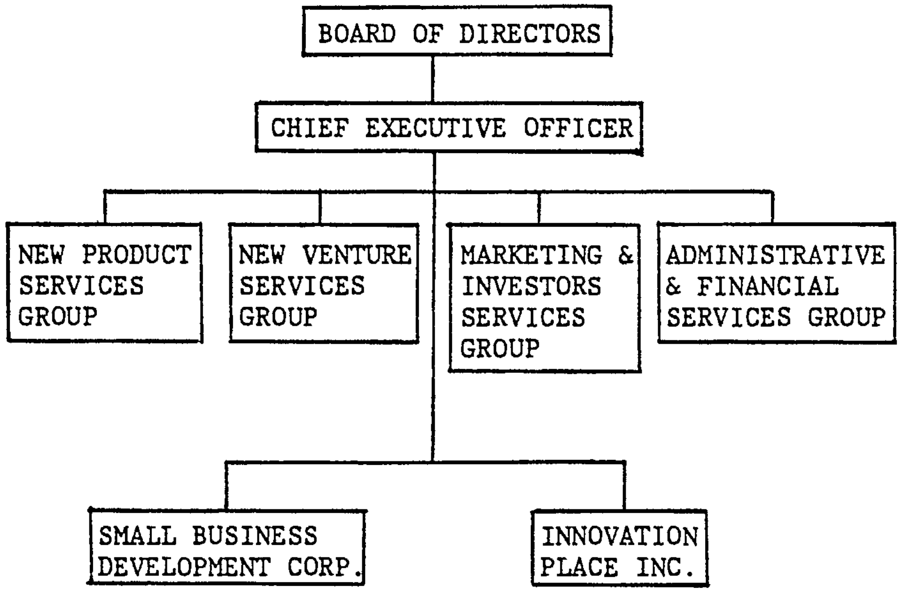
> "We help Individuals, Companies and Investors with the Early Stages of Commercializing Technology Based Innovations."

The CIIC/W differs significantly from the other organizations we have studied in that it is not part of or directly affiliated with a university. The majority of the inventors that use the Centre are from the general public. However, because of the Centre's close proximity to the University of Waterloo and the involvement of the University in establishing it, a number of professors and students do take advantage of the services it offers.

### 3.5.2 ORGANIZATION STRUCTURE AND OBJECTIVES

An outline of the organization's structure is provided in Figure 11 on page 62. The eleven-member Board of Directors includes six from the private sector, two from the University of Waterloo, one each from the federal and provincial governments, and the Chief Executive Officer of the CIIC/W. The Centre has 20 full-time employees, more than half of whom are professionals, who are divided into four groups as indicated in the figure. Most of the professional employees are engineers and some have M.B.A.'s.

Figure 11. CIIC/W Organization Chart:




In addition to the four Service Groups, CIIC/W has two subsidiary corporations: Small Business Development Corporation, and Innovation Place Inc.. Innovation Place Inc. operates an industrial mall in which these small businesses can be nurtured and grown.

The mandate of the Centre was stated in the Background section above. In addition to its annual budgets the Centre has a five-year plan. One of the goals of the plan is to become self-sufficient by 1989. One of the ways in which it hopes to do this is through developing a portfolio of early-stage technology commercialization firms, which with the help of the Centre have blossomed from the 'good idea' stage to a viable business with an appropriate management team in place.

The performance of the Centre is assessed by the Board by comparing its actual to projected revenues and expenses, and by considering the value of the portfolio the Centre has developed.

### 3.5.3 FUNDING

In accordance with its agreement with the Department of Industry, Trade and Commerce (now DRIE) when it was formed, the Centre receives $1 million each year. These funds were initially committed for the Centre's first five years, and this has been extended for another five.

The Centre's major source of operating revenue is fees charged for services, such as the invention evaluation service discussed below. In 1982-83 this amounted to $140,000.

In the long run the Centre expects to receive substantial revenues in the form of royalties on inventions it has patented, dividends from companies it holds shares in, and the sale of shares.

### 3.5.4 PROCESSING INVENTIONS

When an inventor has an invention that he feels may be worth patenting, he contacts the CIIC/W. Centre staff then obtain detailed information about what the invention is, who the inventors are and what they have done with it, and what the perceived market for the invention is. The Centre then begins its evaluation of the invention.

Under the Inventors Assistance Program, the Centre offers a two-stage invention evaluation service. The first stage, which takes 30 days and costs $125, is called a Critical Factor Assessment. This is conducted by Centre staff, and in it they attempt to determine if the invention has the various factors/ingredients that have proven critical for commercial success. Roughly one-third of the inventions that are submitted pass this stage of the evaluation.

The second stage, which costs $500 and takes 90 days, is offered to those inventors passing the first stage. It involves a 'custom evaluation' by two or three individuals that the Centre believes can offer an expert opinion on the potential of the invention. The Centre has a data bank of about 900 such experts, ranging from scientists to department store managers to marketers, who have agreed to provide confidential opinions on inventions for the Centre. Centre staff combine the expert opinions with their own in a 10-12 page report which recommends whether or not the inventor should proceed with the invention. If the opinion is favourable, the Centre provides the inventor with a plan of action for the next stage of commercialization. Roughly one-third of the inventions going through this stage are recommended for commercialization, for an overall success rate of about 10 percent.

In the case of most inventions coming from professors at the University of Waterloo, the first stage is not necessary and the professor receives his 'custom evaluation' report within 90 days of submitting the invention and for a fee of $500.

One week after providing a favourable 'custom evaluation' to the inventor, the Centre will indicate to him whether or not it is interested in participating in the commercialization of the invention. This participation may take the form of obtaining patents, marketing studies, packaging advice, arranging financing or even investing its own funds in further development. If the inventor agrees to work with the Centre, he assigns the technology to it in return for an agreement for a share in any profits flowing from the commercialization.

One of the vehicles the Centre uses to facilitate the commercialization of inventions is called Innovation Showcase. This quarterly bulletin is distributed to 1500 companies and individuals across Canada, and it contains brief descriptions of inventions available for license.

### 3.5.5 DIVISION OF REVENUES AND EXPENSES

There is no set formula for the way in which revenues and expenses associated with an invention are handled by the Centre and the inventor. This depends on the agreement that is negotiated at the time the inventor assigns the invention to it.

In the case of an invention by a professor from the University of Waterloo, the agreement may include a provision for providing some returns to the University if this seems appropriate.

### 3.5.6 NUMBER OF INVENTIONS

The Centre currently does about 500 first stage invention evaluations each year. Based on the pass rate data given earlier, it can be estimated that at most 50 inventions receive favourable custom evaluations.

Only a small proportion of the total number of inventions processed come from the University of Waterloo. It should be noted that the only professors' inventions that are referred to the Centre are those that are not appropriate for handling by WCPD or by the software commercialization arm.

Due to its limited resources, and also to the fact that a number of inventors choose to patent their invention by themselves rather than involve the Centre, the number of patents filed in a year is actually quite low. In the 1983 fiscal year only eight patents were filed: four each in the U.S. and Canada.

### 3.5.7 EXTERNAL CONTACTS

Most of the Centre's interaction is with inventors and entrepreneurs both from Waterloo and the surrounding area and from across the country. If it decides to participate in the commercialization of an invention, it will usually attempt to obtain financial or other support from both governments and the private sector in the first round, and usually just the private sector in the second. The CEO finds it easier to work with small companies than large because agreements can be negotiated faster and because better terms can usually be arranged.

The Centre's interaction with venture capitalists has been increasing. It also has been working with IDEA Corporation which may be willing to provide capital at the pre-venture stage, i.e., before a complete business plan has been developed.

### 3.5.8 OTHER COMMENTS

Most professors that approach the CIIC/W with inventions have industrial work experience. In the view of the CEO, science professors are more likely to come forward with major or fundamental inventions, and engineering professors' inventions are more likely to be incremental in nature.

By far the majority of the inventions seen by the Centre are new products rather than new processes. The CEO believes that this reflects the fact that the Centre's orientation is towards the individual inventor rather than, for instance, the corporate scientist. It may also reflect the fact that a substantial number of the processes developed at the University of Waterloo are handled by WCPD.

## SUMMARY

In this section, we have described four organizations at or affiliated with Queen's, Toronto, and Waterloo that have been created to facilitate the commercialization of inventions. Figure 12 on page 68 summarizes the more important aspects of each organization on a comparative basis.

Figure 12. Summary of Description of Organizations

| ORGANIZATION | QUEEN'S | TORONTO | WCPD | CIIC/W |
|---|---|---|---|---|
| NATURE | PART OF UNIVERSITY | SEPARATE CORPORATION | SEMI-AUTONOMOUS | SEPARATE CORPORATION |
| SHORT-TERM OBJECTIVES | NOT FORMALLY DEFINED | ANNUAL BUDGET | ANNUAL BUDGET | ANNUAL BUDGET |
| MED.-LONG TERM OBJ. | ENHANCE RESEARCH REPUTATION OF UNIVER. | FINANCIAL TARGETS IN BUSINESS PLAN | FINANCIAL TARGETS IN BUSINESS PLAN | FINANCIAL TARGETS IN BUSINESS PLAN |
| SOURCES OF FUNDS | UNIVERSITY LICENSING FEES AND ROYALTIES | UNIVERSITY LIC. FEES, ROYALTIES, DIVIDENDS, SHARE SALES, CONTRACT ADMIN. FEES | DRIE, LICENSING FEES, ROYALTIES, UNIVER. | DRIE., FEES FOR SERVICES, ROYALTIES, DIVIDENDS, SALE OF SHARES |
| INVENTION EVALUATION | INVENTIONS COMMITTEE | EXECUTIVE DIRECTOR | EXECUTIVE DIRECTOR | FORMAL TWO-STAGE PROCESS |
| DIVISION OF ROYALTIES (NET OF EXPENSES) | QUEEN'S 60%, INVENTOR 40% | INNOV. FDN. 50%, INVENTOR 25%, U. OF. TOR. 25% | WCPD 55%, INVENTOR 45% | CASE BY CASE BASIS |
| EXTERNAL CONTACTS (ORDER OF IMPORTANCE) | LARGE CO.<br>SMALL CO.<br>GOV. DEPTS.<br>VEN. CAP. | GOV. DEPTS.<br>LARGE CO.<br>SMALL CO.<br>VEN. CAP. | LARGE CO.<br>GOV. DEPTS.<br>SMALL CO. | GOV. DEPTS.<br>SMALL CO.<br>VEN. CAP.<br>LARGE CO. |

# CHAPTER 4: CASE STUDIES OF INNOVATIONS

## INTRODUCTION

This part of the report presents five detailed case studies of attempted technology commercialization at each university. The purpose of these case studies was two-fold:

1. To examine 'typical' innovations at each university in order to obtain a greater understanding of the functioning of the commercialization activities described in the previous chapter.

2. To examine the university-corporate technology transfer process and identify common patterns associated with success or failure.

Each case study was selected by personnel at the university involved, and no significance should be attached to the ultimate outcome of the innovation. The five studies are:

1. HUBNET (University of Toronto).

2. The Multiple Frequency Laser Interference Microscope (Queen's University).

3. The Q-Sol Solar Collector (Queen's University).

4. Dryer Master (University of Waterloo - Centre for Process Development).

5. The Chromoretinoscope (University of Waterloo - Canadian Innovation Centre).

As far as possible the structure of each case has been made similar so that comparisons can more easily be drawn between them. A summary of the major findings is presented at the end of the chapter.

## 4.1 HUBNET (THE INNOVATIONS FOUNDATION - UNIVERSITY OF TORONTO)

### 4.1.1 THE INCEPTION OF AN INVENTION

In 1979, Professor Stewart Lee, frustrated by the limitations of the existing Local Area Network (LAN) technology in the marketplace, decided he would build a better system: a system that would meet the future requirements of the communications industry. He resigned his post as chairman of the Computer Systems Research Group (CSRG) at the University of Toronto and set out to develop a network that would have inherent cost and performance advantages over its counterparts. To develop this superior system, the self-described entrepreneur teamed with the laboratory manager of CSRG, Professor Peter Boulton. Working together, they soon realized their concept, known as HUBNET®, could lead to a highly marketable product.

At about that time, Lee was a member of the Governing Council at the University of Toronto, the senior governing body in the University. The council had recently established the Innovations Foundation. The Foundation, incorporated as a separate entity without share capital, was created to "encourage, promote and implement commercial development and use of results of the University's research laboratories". Almost immediately, Lee approached Geoffrey Adamson, the newly appointed Executive Director of the Foundation, to investigate the availability of funding and to plan a course of action.

In the very early stages of their discussions, Adamson, a seasoned executive, purchased a marketing report compiled by the New York consulting firm of Frost and Sullivan. The report forecast a LAN market in excess of $1 billion within the next decade, which confirmed HUBNET'S potential and helped Adamson establish his priorities. (Later it was determined that the report was overly optimistic with respect to time.)

Adamson realized from the outset that the development of HUBNET would be extremely challenging, and that in breaking new ground in the high technology field, capital expenditure could be excessive. Moreover, he realized that to market and service a HUBNET system worldwide, the resources of a large, enterprising firm would be required. For these reasons, it was decided to initiate the involvement of industry from the project's inception. In addition, Lee's past experience had shown that a magnification effect resulted when industry contributed to university research; for every dollar contributed by industry, subsequent government funding would increase the pot substantially. Lee's hypothesis was to hold true.

As with all inventions originating at the University of Toronto, Lee and Boulton were required to submit a disclosure form to the Inventions Committee. The form was designed to answer questions on ownership, patentability, applications and potential funding. With the approval of the Committee, Adamson could proceed with patenting and licensing.

### 4.1.2 A TECHNICAL DESCRIPTION OF HUBNET

HUBNET is a Local Area Network (LAN). LAN's represent a developing technology that allow a variety of office equipment, such as computers, terminals, and work stations to share information and communicate with one another at high speeds and over limited distances. In communications terminology, HUBNET can be described as a contention-based system consisting of a set of hubs arranged in a rooted-tree topology and entirely connected by fiber optic links.

HUBNET is differentiated from other systems by its high performance and efficiency. As an example of its innovative design considerations, the network size and number of attachments can be increased by adding hubs to the tree structure. Moreover, HUBNET will have the ability to transmit large volumes of data up to 10 km, with minimal interference. Because security is a major design consideration, the HUBNET system can be "tapped" only with extreme difficulty, and in the event of a catastrophe, the complete system will not crash. Furthermore, fiber optic links are less expensive when compared to the standard coaxial cable used on less advanced systems. This, combined with its ease of installation, will make it cost competitive with existing systems.

### 4.1.3 CONTRACTING WITH CANADA WIRE AND CABLE

Within a month of their initial discussion, Adamson and Lee had prepared a proposal which was to form the basis of discussions with potential licensees. Of the three organizations approached (all large Canadian corporations), only Canada Wire and Cable (CWC) showed substantial interest in pursuing the proposal. At that time, under the leadership of its president, Bernard Ness, CWC was in an aggressive mood to diversify into the high-tech field. In particular, CWC had a business interest in fiber optics and its relationship to LAN technology. Negotiating directly with Ness, Adamson was able to ratify an agreement in a very short period of time - only four months elapsed between the initial luncheon in January

1981 and the signing of a complex agreement. (It is noteworthy that HUBNET was only a concept at this time and no prototype existed.)

The active participation of top management in the initial stages significantly expedited the negotiations, and perhaps, more importantly gave the project an unprecedented sense of moral commitment. This moral commitment was to prove essential later in its development.

### 4.1.4 COMPANY BACKGROUND

As one of the largest producers of wire and cable products in North America, Canada Wire and Cable Inc. (CWC) manufactures a comprehensive range of UL, CSA and specially engineered wire and cable products to service the North American and international electrical, electronics and communications markets. CWC, controlled by the Noranda Group, was incorporated in 1911. In 1978, CWC formed Canstar Communications to serve as its high technology fiber optics systems division. Thus, Canstar was an operating division of CWC with the General Manager of Canstar, Douglas Mitchell, reporting to the Vice-President of CWC at the Corporate Head Office.

### 4.1.5 THE CONTRACT AGREEMENT

Although the 1981 agreement was later to be renegotiated, it called for CWC to support the project through to the actual transfer stage. In dollar terms, the contract stipulated that CWC commit $350,000 to fund this development. In return for a non-exclusive licence, CWC was to pay royalties to the Foundation. These royalties, based on a percentage of sales, would in turn be shared among the Foundation, the University, and the Co-inventors as per a pre-arranged agreement.

In collaborating with the University, CWC/Canstar hoped to facilitate its research into fiber optic LAN systems with an objective of increasing sales of its fiber optic couplers (a combining or splitting device which Canstar was already manufacturing).

### 4.1.6 THE INITIAL DEVELOPMENTS

During the course of their investigation, Lee and Boulton quickly determined the limitations of the couplers in LAN applications. In fact, it became apparent that the couplers were poorly suited to application in HUBNET. With Canstar unable to implement its couplers in HUBNET, the original agreement was becoming unfocused. However, in a spirit of cooperation, a joint effort to develop HUBNET continued.

In late 1981, Canstar Communications, the high-tech fiber optics arm of CWC, became directly involved in the development of the project. Although not originally playing an active role, Harvey Ikeman, the Manager of Design and Development at Canstar, was kept abreast of the developments from HUBNET'S initial conception. Four or five months into the project, the development of a small portion of the project, the electro-optic interfaces, was not progressing as scheduled. Because Canstar had a resident expert in this area, it was agreed that they would undertake this portion of the project while the University continued with the development of the micro processor hardware and software.

## 4.1.7 BUILDING A PROTOTYPE

The first few years of research were primarily directed at establishing the hardware and software techniques necessary to meet the performance criteria of the system. This was a slow and arduous process. Although work began in 1980, it took three years to develop and test the first full scale prototype. During this period, a number of developments took place. Lee, with the assistance of Adamson, successfully secured additional government and university funding. Through BILD, a program sponsored by the Ontario Government's Ministry of Industry and Trade, Lee received $100,000. In addition, through NSERC and University of Toronto funding programs, Lee procured another $50,000.

CWC commissioned a market study in 1982. However, after only a few months, the marketing consultant claimed they could not proceed further until the product was more clearly defined. With some reluctance, that study was cancelled.

In 1983, the first generation prototype was completed and installed at the CSRG. Although this system was functional, there were serious hardware problems that needed to be addressed. The system had clearly suffered from the "second system effect" - too much added all at once. This prototype was eventually deemed unreliable and a decision was reluctantly made to scrap it. Although the model failed, the concept was still intact.

## 4.1.8 A FULL SCALE DEMONSTRATION

At about the same time as the 1983 prototype was being evaluated, Canstar was actively lobbying government for additional project development funds. The Department of Communications was formulating a field trial program for office communication systems with a mandate to encourage the development of Canadian high technology. SystemHouse Ltd., a Canadian software company providing turnkey systems to industry, was awarded a $4 million contract to supply an office automation system to the Department of National Defense (DND). An agreement stipulated that Canstar would be subcontracted to supply the HUBNET hardware to SystemHouse. In turn, SystemHouse would write the necessary software and install their system at the DND headquarters in Ottawa.

Responding to this important development, the University constructed a second generation HUBNET in the Fall of 1983. This system, simpler in design than its predecessor, was delivered to System House, which in turn completed installation at DND in the summer of 1984. In retrospect, Ikeman stated that without the System House contract, further involvement by Canstar in the development of HUBNET would have been questionable. (After the failure of the 1983 HUBNET prototype, Ikeman was instructed to minimize his time on the project.)

Although the system performed well, considerable work was still required: the product was neither cost effective nor packaged as a marketable commodity. To facilitate HUBNET'S development, Lee and Boulton, with the assistance of Adamson, applied for, and was awarded, a PRAI grant in 1983. Funded by NSERC, the PRAI is an acronym for "Projects in Research Applicable to Industry". With this grant, an amount in the neighbourhood of $0.65 million, Very Large Scale Integration (VLSI) could be developed. Using VSLI, the researchers would significantly reduce the physical size of the system.

### 4.1.9 PATENTING

An application for a U.S. patent was filed in September 1982, and almost two years later a Canadian patent application was filed. To date, only the U.S. patent has been issued. Although the patenting authorities had come across similar technology, neither Adamson nor Lee were overly concerned with obtaining patent protection. Both stated that they were licensing "know-how", and with the rapid development in high-tech, a patent offers only marginal protection.

### 4.1.10 RECENT DEVELOPMENTS

In 1984, the Foundation recommended that CWC apply to NRC under the Program for Industry/Laboratory Projects (PILP). PILP is an NRC contribution agreement designed as a technology transfer development program to assist firms bringing a product to commercialization. The award of this $754,000 agreement has assisted Canstar in HUBNET's development.

Funded by PILP, Canstar commissioned a second market study in April 1985. Although the findings of this study have not been released, according to Ikeman it was general industry knowledge that the LAN market had not grown as fast as expected; however, exponential growth was predicted late in this decade.

Speculating on the finding of the 1985 marketing report, Ikeman foresaw Canstar following one of two routes to market:

> "If you're in the board business you must team up with a large OEM, someone who buys a lot of beans (i.e. manufactures and

> sells in high volume). Because HUBNET represents a product with little value-added, you must use your network in their system".

Alternatively, to generate revenue on a value-added basis, Ikeman stated that Canstar could become a LAN systems company and supply turnkey systems to industry.

The licensing agreement was recently renegotiated. With the original 1981 agreement based on a three-phase project that collapsed after stage 1, and with much of the terminology outdated, a new agreement was necessary. The terms of this 1985 agreement still reflect the same spirit of cooperation between the two parties. However, with much of the development work behind them, the new agreement deals primarily with licensing and royalty terms.

Work is currently continuing with the objective of releasing the product into the marketplace in the first quarter of 1986. With relatively few standards in the computer industry (BUS structure varies from model to model), HUBNET must consist of a whole family of hardware. Even with product launching in 1986, work will continually be carried out to update the system.

### 4.1.11 SPIN-OFFS

The spin-offs from this invention will be far reaching. In addition to the substantial royalty forecasts, the University of Toronto has installed a prototype HUBNET system (in-house) to alleviate the chronic lack of computer power that has plagued the undergraduate programs. In the development of HUBNET, Lee's department was able to outfit its laboratories with some sophisticated equipment and was also successful in attracting two outstanding post doctorate researchers. The invention, already well known to the communications community and various government agencies, has furthered the reputation of Lee and his department. For example, the U.S. Naval Research Laboratory has taken an active interest in HUBNET's development and has recently placed an order with Canstar to supply the first production system.

For the Foundation, HUBNET has become a showcase for its very existence. It has proved beyond a doubt that the Foundation, acting as a separate entity, can be a viable mechanism for the effective transfer of technology.

For Canstar, HUBNET has the potential to establish it as a leader in the communications field while securing a significant share of the LAN market. Finally, the introduction of HUBNET could enhance Canada's reputation as an emerging leader in the communications world.

### 4.1.12 INVENTOR'S PROFILE

Professor Lee, a self-confessed entrepreneur, has had extensive interaction with industry over the last two decades. In addition to carrying out consulting assignments on a regular basis, Lee has been a director of five companies, a partner in two, and an owner in one.

Since joining the faculty at University of Toronto in 1962, Lee has attained the rank of full Professor. His field of research is in electrical engineering and computer science with specific expertise in communications between computers. Lee is well known in communication circles and has amassed a record of credibility.

### 4.1.13 INVENTOR'S PERSPECTIVE

Lee felt that the Innovation Foundation was very effective in transferring the technology. From the outset, he was confident his invention would be a success. Technically, he thought his concept was sound, and commercially, he knew that a market need existed. Because he knew Adamson and had tremendous respect for him, he was confident that the transfer process would be equally successful. As an example of Lee's trust in Adamson, the last set of negotiations between the Foundation and CWC, which will obviously have a profound effect on Lee, have been almost totally handled by the Foundation. Lee stated that it required an individual like Adamson to make a transfer centre successful. This person must possess an intimate knowledge of the business world, and have at least some insight into academia.

Lee added that without the Foundation, a contact with CWC would never have been initiated. The small stipends that would have resulted would have reduced the project to a smaller scale invention of inferior quality.

Throughout HUBNET'S development, Lee never became discouraged; he realized that it might take five or six years to develop a product from conception to market - a fact he said few can comprehend. During this time he has published papers on this invention and even gave a seminar to a competitor of CWC. He stated that a university must maintain an open intellectual environment and therefore has carried out his other endeavours as he saw fit.

### 4.1.14 CANSTAR'S PERSPECTIVE

In the opinion of Ikeman, the Foundation provided an effective buffer between his organization and the University. He felt that CWC preferred dealing with an organization such as the Foundation, which is in the business of negotiating agreements (as opposed to the University). He remarked that although fair, Adamson bargained hard and therefore obtained concessions that perhaps may not have been granted if CWC was negotiating with a less experienced negotiator.

Ikeman felt it important that CWC took a flexible stance throughout the development of HUBNET. CWC continued to fund the project long after it became clear that HUBNET'S development and the initial agreement were not in parallel with one another. When the prototype failed in 1983, CWC wisely decided to stand by the commitment and carry on in good faith.

Generalizing, Ikeman believes there is conceptual barrier between what a university thinks a product is and what industry will accept as a product. In retrospect, Ikeman reflected that the effort required for re-engineering, documentation and support is enormous, in order to take a product from a university testing bench to a marketable product.

### 4.1 15 ANALYSIS

Lee's HUBNET invention can be categorized as a classic example of a market-pull model. It was conceived and developed to satisfy the requirements of an emerging market. The fact that its development had commercial involvement from the outset ensured that the invention was designed to meet current industry requirements. In the high-tech industry this may be particularly significant as market needs could alter over an invention's development.

The mechanisms for technology transfer at the University of Toronto proved very effective. The role that the Foundation played, and particularly that of Adamson, earned the respect of both Lee and CWC. It is clear that without Adamson, a force throughout the process, the invention would never have been fully exploited. Adamson's aggressive pursuit of funding for both the University and Canstar was critical to the project's success. Also, the element of mutual trust and respect built up between Adamson and Lee greatly facilitated the transfer process. With Adamson in full control of administrative details, Lee was able to concentrate on the technical aspects of the project.

Lee's entrepreneurial and interpersonal skills were a key factor, particularly in the initial stages of the project.. Once Adamson had identified CWC as a commercial partner, Lee's ability to effectively communicate his concepts and ideas was crucial to the development of the project. It must be remembered that CWC committed itself on an unproven concept.

The flexibility shown by CWC when the project did not develop as planned was crucial to its success. The initial involvement of CWC top management, and in particular their president, in all likelihood insured their commitment.

The 1983 contract with SystemHouse provided the catalyst necessary to get the project back on track. Without the large and timely government funding provided throughout the project, neither the University nor

Canstar would have seen the project through to completion. This project highlights the enormous effort, resources and time frame required to see an invention from conception to market. Even more acutely, it demonstrates the effort necessary to take an invention from a bench-scale model to a product acceptable to the market.

## 4.2 THE MULTIPLE FREQUENCY LASER INTERFERENCE MICROSCOPE (QUEEN'S)

### 4.2.1 INTRODUCTION

As a student studying Geology in the 1960's, Tom Pearce had a nagging problem; however, the solution to this problem was beyond the capabilities of the technology available at that time. Simply stated, Pearce wanted to see a profile of the refractive index in rock samples. He believed a method of visual observation would be valuable for obtaining geological information from rock samples.

After obtaining his Ph.D. in 1967, and spending five years as a post-doctoral fellow and assistant professor in the United States, Pearce joined the Department of Geological Sciences at Queen's University. Some eight years later, in 1980, Professor Pearce initiated a research program with the objective of solving this perplexing problem.

Familiar with the Laser Interference Microscope (LIM) already on the market, Pearce believed that a multiple frequency capability would produce the results he was seeking. Thus, it was Pearce's intention to design and build a Multiple Frequency Laser Interference Microscope (MFLIM).

In 1980, Pearce, supported by a very modest Queen's research grant, began toiling quietly in his laboratory. He soon realized he would need additional funding to see his work past the initial stages. Thus, Pearce approached Dr. John Beal, Director, Office of Research Services and Chairman of the Inventions Committee at Queen's. Realizing that Pearce's work in microscopy showed substantial technological promise, Beal assisted him in obtaining additional financial resources. By 1981, supported by $25,000 in NSERC grants, Pearce had built a small working model of a Laser Interference Microscope with a single frequency.

Equipped with this first generation prototype, Pearce formally approached the Inventions Committee and gave its members a spectacular demonstration of the microscope's capabilities. Charged with determining ownership and recommending (to the Vice-Principal Services) the course of action an invention should follow, the Inventions Committee considered the prototype intriguing and speculated that a market might exist for it. However, no formal market study was carried out. In September 1981, the Vice-Principal Services, in consultation with the Committee, granted permission to patent and attempt commercialization.

### 4.2.2 PATENTING

Harvey Marshall, the Coordinator of Patents and Licensing at Queen's, prepared Pearce's invention for patenting. Through an Ottawa based patent agency, a Canadian patent was applied for in early 1982. (It was subsequently issued in March 1984.) Later, it became apparent that a larger geographic market area would be required, and after some discussion, a U.S. patent was applied for. Filed in December 1983, the patent is still pending.

### 4.2.3 THE SECOND PROTOTYPE

With continued assistance from Beal, Pearce applied for and was granted further financial support. In particular, a $74,000 NSERC equipment grant awarded in 1982 allowed Pearce to build a second generation prototype with multiple frequency lasers. (In retrospect, Pearce stated that Beal's assistance in the never-ending search for funds was invaluable.) Using strictly off-the-shelf parts assembled in a very novel way, Pearce finally found a technique to visualize the refractive index in rock samples. This model, a second generation MFLIM, became the show piece of Pearce's work. Assembled in Pearce's Laser Laboratory, the apparatus has been used primarily for research and demonstration. Attempts to commercialize it have been unsuccessful.

### 4.2.4 A TECHNICAL DESCRIPTION

The MFLIM developed by Pearce consists of a horizontal microscope and three lasers, which in combination produce multi-coloured pictures in transparent samples. The equipment can be used in two different ways. One method produces a vivid colour picture in which parts of the sample having different refractive indices appear in different colours. By tuning the microscope, the change in colour sequence brought about by the different structures within the sample can produce some rather striking and spectacular results. In the second method, the sample is crossed by a series of coloured and dark stripes called fringes. These fringes form a profile of the refractive index and composition of the samples. Observations obtained by this new method may lead to information concerning the chemical and crystallographic composition, internal structure, history and origin of the sample.

### 4.2.5 COMMERCIALIZATION ATTEMPTS

In 1982, the Negotiations Committee began meeting to discuss applications and potential licensees. The primary function of the Committee was to identify, contact and negotiate licenses with potential commercial enterprises. From the beginning, they all agreed that it was a technically outstanding invention, although they were never sure if any significant and practical applications existed. Thus, there was uncertainty as to the best route to follow in licensing.

Marshall, as Co-ordinator of Patents and Licensing and a member of the Negotiations Committee, did much of the footwork in identifying and initiating contact with potential licensees. Initially, OEM's were approached. In particular, Ernst Leitz Canada Ltd., a subsidiary of their German parent, showed some initial enthusiasm. Marshall sent photographs of the microscopes capabilities and made a follow-up visit to their Midland, Ontario plant. However, in December 1982, the microscope manufacturer wrote to say they did not wish to pursue the matter further. No specific reason was given. Pearce was to later state that he did not want contact with Leitz, as at about the same time, they were developing similar technology and he felt Leitz only expressed interest to further their own development.

Other OEM's who were formally approached by Marshall were Lumonics, Spectra Physics Inc., and Newport Research Assoc. In all cases contact was made by letter, although Marshall later made a follow-up visit to Lumonic's Kanata, Ontario plant. Again, for reasons not made clear, these organizations declined to pursue the matter further.

Marshall and Pearce also contacted the Research Division of Dupont Canada Inc. Dupont, a major producer of polyethylene and nylon polymers, was interested in adopting this technology to determine the structure of fabricated articles. At Dupont, Pearce gave a slide presentation and demonstration. Efforts to persuade Dupont were hampered by changes in personnel, although to this day, Pearce corresponds with them from time-to-time. However, attempts to stimulate serious discussion have failed.

Being unable to identify any significant commercial applications resulted in an inability to attract anything more than an initial interest by private firms. As a result, Queen's was handicapped in negotiations at this early stage.

About this time, the IDEA Corporation was formed by the Ontario Government with a mandate to support entrepreneurs and high-tech in Ontario and exploit commercially their inventions. In October 1983, a formal proposal was submitted to IDEA and a demonstration given. During their visit to the campus, the IDEA officials showed substantial interest and in the words of Pearce, "they were all set to fund". However, after some subsequent reflection, and for reasons not entirely acceptable to Queen's, funding was not to be forthcoming. IDEA officials questioned the market need for such a product. However, it was Queen's intent to partially use this funding to investigate the marketplace.

Frustrated by the lack of industry interest to commercialize, yet driven by their initial response, Pearce, upon Beal's recommendation, applied for and was granted release time to explore interdisciplinary applications. Working with a professor of urology, he investigated the use of laser fluorescence in the early detection of kidney stones. After a year of criss-crossing the country, Pearce was unable to make any significant advances. Investigating applications outside his field of expertise proved to be a difficult and unsatisfying experience for him.

Pearce had not given up. While on a trip in the United States, he contacted the editor of a technical journal. As a result, in October 1984, his invention appeared on the cover of "The Microscope", - a multidiscipline international journal dedicated to the advancement of microscopy. Despite the failed attempts at commercialization, Beal has vowed that Pearce's invention, "will be one of the first to be resurrected with the appointment of the new Marketing Officer at Queen's".

### 4.2.6 SPIN-OFFS

Although this invention has not been a commercial success to-date, the spin-offs created have been very significant. Professor Pearce's Laser Laboratory and his related research have generated over $300,000 in financial support. Moreover, operating grants have created employment for research assistants. Pearce believes these spin-offs were clearly magnified by the attempt to commercialize the invention.

From a personal perspective, Pearce has been thrust to the forefront as a researcher in his department. Spurred by this initial invention, he is currently working on two new and unrelated inventions - inventions that he considers of the market-pull variety. Furthermore, this initial invention has given him important industry contacts and a knowledge of technology transfer, factors which by his own admission are critical in the commercialization process.

### 4.2.7 INVENTOR'S PROFILE

Pearce completed his Ph.D in geology at Queen's University in 1967. After working for five years as a post-doctoral fellow and assistant professor in the United States, Pearce joined the faculty of his alma mater in 1972. Currently an Associate Professor in the Department of Geological Sciences at Queen's, his primary area of expertise is in Igneous Petrology.

Pearce estimates that he has obtained a combined total of two years industrial work experience, primarily in exploration, with both mining companies and the Federal Government. He categorizes his past consulting assignments as infrequent and on an ad hoc basis - although recently becoming more frequent.

### 4.2.8 INVENTOR'S PERSPECTIVE

Pearce has had over two years to reflect upon the transfer process and consequently has some interesting thoughts. He believes that Queen's is not fully supportive of creative work. Pearce is aware of the low percentage of university inventions that are successfully licensed to industry, a phenomenon he refers to as the "lottery effect". Because of the lottery effect, the likelihood of receiving royalties from an invention is remote, and therefore Pearce feels a reward and salary structure similar to that of industry should be instituted. Furthermore, he believes the transfer mechanisms at Queen's should be formalized and operated in a business-like manner. He felt that Queen's let IDEA "off the hook after they had already taken the bait" and is convinced that a more aggressive approach "would have landed the funding".

Throughout the transfer process, Pearce had no idea who the other members of the Queen's invention community were. Therefore, he felt it necessary for mechanisms to be set in place in order to foster interaction across departmental boundaries - specifically to discuss transfer. He envisions a forum to facilitate dialogue among fellow academics and administrators interested in technology transfer. Lastly, he states that the inventor must play a more participatory role in the transfer process. For example, outside of the IDEA Corporation, Pearce maintains that he was aware of Queen's contacting only Leitz and Dupont.

### 4.2.9 ANALYSIS

Pearce's MFLIM invention can be categorized as a classic example of a technology-push model. It was developed to satisfy a curiosity-driven technical problem in isolation of market needs. The lack of significant commercial application became evident and a source of frustration when technology transfer was attempted. This case clearly illustrates the need for proper market research prior to the commitment of significant efforts to commercialize.

The mechanisms for technology transfer at Queen's had their limitations. Marshall, by his own admission, was filling the dual role of a marketing agent, and patents and licensing officer. Carrying out his function as CPL, and when time permitted, a marketing agent, was a monumental assignment.

The importance of the inventor playing a participatory role in the transfer process cannot be overstated. Pearce had no knowledge of three of the five commercial firms contacted. Without a demonstration and a clear explanation of the technical merits of the invention, Pearce's work could never be fully communicated. Given the spectacular results that only a demonstration could convey, this was particularly distressing. At the very least, the effort that Queen's put into the transfer process perhaps could never be fully appreciated by the inventor because of his lack of participation.

With the exception of Dupont, none of the commercial firms approached was a potential end-user of the product. If interest had been stimulated in mining or metallurgical firms, for example, perhaps pressure would have been brought to bear on the OEM's. This avenue was not considered.

Pearce, described as a somewhat reserved individual, had limited contact with the industrial sector. Infrequent and ad hoc consulting restricted his network of contacts. In comparison to the other commercially successful cases, a sharp contrast exists here.

Finally, the presence of a working prototype MFLIM was important in the transfer process. Beal felt that it alleviated any technical skepticism people had and gave the invention a sense of priority.

## 4.3 THE Q-SOL SOLAR COLLECTOR (QUEEN'S UNIVERSITY)

### 4.3.1 THE INITIAL DEVELOPMENTS

In 1974, Professor Ken Rush took a sabbatical from Queen's University to further his knowledge in solar energy at the National Research Council (NRC) in Ottawa. At that time, Council scientists were just beginning their solar energy experiments and Rush was able to completely familiarize himself with the latest developments in the field. Rush was no stranger to the council; he had worked there for almost 20 years before joining the faculty of the Mechanical Engineering Department at Queen's University in 1963.

In 1975, after returning from sabbatical, Rush was routinely preparing notes for a thermodynamics lecture - a task he had repeated countless times before. During the course of his preparation, it occurred to him that a solar collector with the characteristics of a miniature steam plant could have inherent advantages over its existing counterparts. This thought was to become the start of a concentrated effort to develop a better solar collector.

### 4.3.2 BUILDING A PROTOTYPE

In the initial stages of the project's development, Rush, supported by a modest $3,000 Queen's research award, purchased solar collectors from Canadian manufacturers. Studying the limitations of these existing products, Rush set out on a program to build a better system. In doing so, he realized that additional funding would be necessary. Acting on his own initative, he applied for and received an NSERC grant, an award that guaranteed him three $9,000 annual payments, beginning in 1976.

During the next year, he duplicated the characteristics of a mini-steam plant by incorporating a thermosiphon and an internally sealed refrigerant into the collector. The advantages of this collector, later to be known as Q-Sol®, were substantial. Rush had overcome problems of corrosion and freezing which had plagued its counterparts. Moreover, he had developed a system that combined efficiency and reliability with economic attributes that were to be unparalleled by its competition.

Using this technology, Rush built a few prototypes and began monitoring an installation on the roof of a university building. However, the technology was still unproven in a full scale demonstration. This situation would soon change. In 1977, a professor in the Department of Mathematics at Queen's was building an addition on his house. This individual, who happened to be a sailing partner of Rush's, was aware of Rush's research and agreed to incorporate a solar system in the house. With the success of the full scale prototype installed in the house, Rush had removed any skepticism surrounding his invention.

### 4.3.3 THE Q-SOL SOLAR COLLECTOR

To the casual observer, the appearance of Rush's Q-Sol Solar Collector is not unlike other collectors on the market. However, the technology employed within the box-like structure (typical dimensions 4'x4'x4'') differentiates it from conventional flat plate solar collectors.

An internally sealed refrigerant inside the collector, which boils when heated by the sun, releases the solar energy, through condensation, to a small heat exchange section integral to the collector. This refrigerant eliminates the problem of scaling and corrosion associated with conventional systems. Incorporating a two-phase thermosiphon, the resultant thermal diode action (heat transfer in one direction only) eliminates the radiant loss of energy, making the system virtually freeze resistant. Moreover, the Q-Sol Collector is designed to incorporate simplified piping, reducing the installation costs and improving the aesthetics of the solar installation. In combination, these benefits afford the Q-Sol Collector greater efficiency, greater reliability and increased cost effectiveness over other systems.

### 4.3.4 PATENTING

In the mid 1970's, Queen's had an agreement with the Canadian Patents and Developments Ltd. (CPDL). Working jointly with Rush, Harvey Marshall, the Coordinator of Patents and Licensing at Queen's, submitted the invention to CPDL for patenting. However, in December 1976, CPDL rejected the invention. In their own words, they rejected it on the grounds that they would have difficulty obtaining sufficiently broad coverage, if any, for the proposal. Not discouraged by this initial rejection, Marshall later arranged a meeting with Johnson & Hicks, an Ottawa based patenting agency. Using this agency, a patent was filed in Canada in August 1977. Subsequent patents were filed in U.S.A., Japan and Australia the following summer. While the U.S., Canadian, and Australian patents were granted in December 1980, June 1981, and September 1982 respectively, the Japanese application remains outstanding.

### 4.3.5 COMMERCIALIZATION ATTEMPTS

In 1977, Rush approached the Inventions Committee at Queen's and made a very successful presentation to its members. A number of positive attributes influenced the Committee. Using a prototype to illustrate the unique properties of his panel, Rush went on to identify the advantages of his system over current technology. Moreover, at that time he had already initiated contact with commercial firms. The positive feedback shown by these firms indicated to the Committee its commercial potential. With Rush's pragmatic approach and strong personality, the committee had little doubt that the invention would be successfully licensed. Consequently, on the recommendation of the Committee, permission was granted by the Vice Principal (Services) to patent and attempt commercialization.[23]

Rush's first serious discussion with industry took place at a 1976 meeting of the local branch of the Solar Energy Society of Canada, where he met Don Sleeth, an engineer and electrical contractor. Sleeth expressed serious interest in becoming the licensee for Rush's solar collector and engaged Marshall and Rush in negotiations. Through these discussions, it became evident that Sleeth did not have the potential to exploit the invention on a broad basis. Furthermore, Sleeth's terms were totally unreasonable. Hence, his proposal was eventually deemed unsatisfactory and was rejected.

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[23] In the developmental stages of Rush's project, the mechanisms for technology transfer at Queen's, as they were later to be known, were only in their infancy. Thus, the progression of events, pertaining to the transfer was carried out on an ad hoc basis.

In November of 1977, Marshall wrote to a number of companies in the U.S. associated with the solar industry. Also in 1977, and carrying on into 1978, Rush and Marshall were engaged in serious discussions with Alcan. Alcan showed considerable interest in pursuing Rush's invention with the intention of increasing sales of aluminum by incorporating its products in the invention.

### 4.3.6 CONTRACTING WITH NORSUN

In 1978 the Department of Energy Mines and Resources initiated a "Program of Assistance to Solar Energy Manufacturers". In conjunction with this program, a former colleague of Rush's at NRC approached a newly formed Ottawa based company called Norsun Inc. (formerly Nortec Solar Industries Inc.). Jim Ramsden, the company founder, was asked by Rush's colleague to talk to Queen's about its developments in solar energy. This was the beginning of a unique professional relationship between Rush and Ramsden. With this development, all previous licensing discussions ceased.

Norsun was incorporated with very limited financial backing. Ramsden had negotiated a deal with three Ottawa based entrepreneurs, who at that time had recently acquired a vacant factory. In return for making them partners, Ramsden had the use of their factory, his overhead paid, and a guaranteed $20,000 line of credit. Initially, only Ramsden and one production man were involved in the day-to-day operation of the company. Thus, Norsun was basically a two-man operation, manufacturing a very limited product line and conducting business from a rented warehouse.

The first meeting between Ramsden and Rush was very encouraging. Ramsden was enthusiastic about Rush's work and immediately recognized the advantages of the system. (In retrospect, Ramsden was to state that the system had both advantages and disadvantages that he did not foresee.) Ramsden's motivation for taking on this new technology was two-fold: Firstly, the invention had significant advantages over existing technology, and, secondly, he knew that Norsun could receive substantial funding through the government assistance program.

The Negotiations Committee at Queen's, led by Marshall and Rush, began serious discussions with Ramsden. Beyond the government grant, Norsun had very limited financial backing and was not an established company. Although this was of concern to Queen's, Ramsden had the personal attributes of an entrepreneur. They recognized this and were impressed by his dedication and planning. Optimism overcame doubt and a deal was struck between Norsun and Queen's. A preliminary license was granted in September 1978. Norsun went on to satisfy the conditions of the agreement and an exclusive licence was granted six months later.

Not long after the exclusive license was issued, the Federal Government's Department of Supply and Services expressed a keen interest in obtaining the license. The University signed an option agreement with DSS; however, it expired when Norsun fulfilled its conditions.

As part of the agreement between Queen's and Norsun, Norsun sequestered an engineer and a technician to work in Rush's solar laboratory for six months. The terms of the contract called for Norsun to compensate Queen's in the amount of $40,000, with payments distributed over three years. Under the supervision of Rush, these people were charged with the development of the design configuration and manufacturing methodology.

This arrangement proved very effective and by 1979 the solar collector was ready for market.

Given the constraints that Ramsden was working with, the transfer process and subsequent growth of Norsun was to read like a true success story. With only Ramsden and one full-time production employee, and using wooden jigs and fixtures to manufacture the panels, Norsun began producing its first of several contracts with NRC. Rush, who was retained as their prime consultant, took a six-month leave of absence from Queen's in 1981 to help set up Norsun's research and test facilities. Building a complete line of solar systems around the Q-Sol collector, Norsun had captured over 20 percent of the Canadian market by 1985, and made major inroads into the United States, establishing it as one of the top three solar energy producers in Canada.

### 4.3.7 SPIN-OFFS

The spin-offs from Rush's invention have been very significant. In addition to the substantial royalties received by the University and the inventor, Queen's is now recognized as having one of the best equipped solar laboratories in Canada. However, this claim may be short-lived. Through Rush's efforts, Queen's is currently in the process of acquiring NRC's Solar Calorimetry Laboratory. Once transferred to Queen's, this $500,000 capital acquisition will give Queen's a world class facility. Without question, the invention has furthered the reputation of Queen's as a leader in solar energy research.

The dynamic relationship that exists between Queen's and Norsun has resulted in a disproportionate number of Queen's graduates securing permaacts as the prime consultant to Norsun. He was described by his peers as a very practical and believable man with a strong personality.

### 4.3.9 INVENTOR'S PERSPECTIVE

The mechanisms for technology transfer at Queen's were in their infancy stage. However, Rush felt that those mechanisms were not very effective, although he described Marshall as very helpful. Rush stated that an inventor must also be an entrepreneur - someone who can carry out a project from conception through to licensing and promotion. In particular, Rush believes Queen's requires a marketing representative to make contact with firms and aggressively push inventions to them.

Generalizing, Rush stated that too much research is scientifically orientated as opposed to engineering research. He differentiated scientific research as that carried out to satisfy curiosity with no commercial objective, whereas engineering research is carried out with potential applications in mind (eg., commercialization). In Rush's opinion, because the granting agencies can easily measure scientific research by the number of papers published, many researchers shun engineering research. However, he noted that publications and industrially-relevant ideas can result from scientific papers.

### 4.3.10 COMPANY BACKGROUND

Because Ramsden was the founder of Norsun and the driving force behind it, a profile of Norsun would not be complete without some background on its president. Ramsden graduated from Queen's in 1969 with a B.Sc. in chemical engineering and received an MBA from Toronto in 1975. After gaining expertise in the area of production management, Ramsden formed his own consulting firm in 1974, providing manufacturing engineering expertise to small manufacturing companies. In 1976, Ramsden became Special Assistant to the Federal Minister of Public Works and the Minister of State for Science and Technology. It was during this time that he gained specialized knowledge of the solar industry. In 1978, Ramsden founded Norsun.

In 1980, following the successful introduction of the Q-Sol Solar Collector, the partnership was dissolved and Ramsden formed Norsun Inc. By 1981, Norsun had outgrown its leased facilities and purchased its own in Manotick, Ontario. In 1982, Norsun began penetrating the U.S. market with particular emphasis on the Sunbelt States. With a sales/warehousing facility established in Florida, the U.S. has become Norsun's largest market. Today, Norsun employs 37 people and produces an average of 40 panels per day.

### 4.3.11 NORSUN'S PERSPECTIVE

Ramsden, by his own admission was "pretty green at the start". He described the negotiations with Marshall as good, but not aggressive.

When he initially became interested in Rush's invention, he felt that the product was different and that this would be the key to its success. He was looking for features that could differentiate his product line from that of his competitors - features that could form the basis of a sale pitch.

Ramsden felt the transfer of personnel between Queen's and Norsun during the pre-production stage was a major factor in the project's success. The ongoing relationship between the two organizations has contributed greatly to Norsun's continued success.

### 4.3.12 ANALYSIS

Rush's Q-Sol invention can be categorized as a classic example of a market-pull model. Rush's sabbatical at NRC, and subsequent analysis of existing solar panels on the market, equipped him with an intimate knowledge of solar technology. Only after becoming fully versed in the shortcomings of the existing technology did he set out on a program to overcome these problems. He did this at a time when solar energy was becoming a politically important issue.

It is fair to say that the mechanisms for technology transfer at Queen's did not play a significant role in the transfer process. One may speculate, however, whether an autonomous, profit-driven technology transfer unit would have pursued Norsun, given their limited backing. The "gut feeling" that Marshall and Rush had about Ramsden proved correct. It is clear that the personal attributes of both Ramsden and Rush, and the strong relationship that developed, played a significant role in the transfer. The early full-scale demonstration of the technology certainly gave impetus to the project. Also, the transfer of personnel between Queen's and Norsun, particularly in the product commercialization stage, greatly facilitated the transfer process. In fact, the employee transfer agreement should provide a model for others to follow.

Like so many other inventions originating in a university environment, without the government funding provided to the University and to Norsun, this project would never have been seen through to completion. However, unlike many inventions it was the principals, acting alone, who sought and secured this funding.

## 4.4 DRYER MASTER (WATERLOO CENTRE FOR PROCESS DEVELOPMENT)

### 4.4.1 IDENTIFYING A MARKET

With the 1970's drawing to an end, Gerald Dubrick began to recognize the potential impact of computer technology on the agricultural industry. As president and founder of Canadian Farm Tec Systems, Dubrick continually sought to advance his product line to reflect the latest in new technology. Farm Tec had already earned a reputation as an innovative firm, supplying electronic equipment to the agricultural sector. However, Dubrick believed that to maintain his firm's competitive edge and meet the future requirements of the agricultural market, Farm Tec would have to introduce new products: state-of-the-art products that could harness the proliferation of computer technology. Dubrick hoped the introduction of new and innovative products would form part of this overall mandate to identify the future direction for his company.

Allan Niziol of Farm Tec's sales and marketing department began by conducting an informal market survey. Probing his customer base and asking specific questions about their market needs, Niziol quickly discovered a significant problem - a problem that demanded a solution. Dubrick and Niziol believed the answer to this problem lay in the application of computer technology.

### 4.4.2 THE PROBLEM

The inability of commercial grain drying operations to process corn at the specified 15.5 percent moisture content had been a major problem for years. In order to process corn at or below this specification, grain dryer operators typically overdry corn to an out-put moisture in the 12 to 15 percent range. Overdrying results in excessive energy costs, unnecessary shrinkage, and quality loss.[24] Moreover, the additional throughput time associated with overdrying results in slower production runs. Processing large quantities of grain in a short drying season results in long line-ups of trucks waiting to dump. Increasing throughput by reducing drying time would allow mills to attract additional business.

At the other end of the spectrum, corn over-specification (moisture content over 15.5 percent) must be rejected. Corn stored above this point is susceptible to spoilage, and in extreme cases, spontaneous combustion.

Upon identifying the problem, Niziol surveyed the grain drying industry and found that a substantial market existed for a commercial product that could monitor and control the grain's consistency. His investigation also indicated that to be successful, a new product would require that end-users, mill owners or farmers, receive a short payback period of 1 to 2 years.

### 4.4.3 COMPANY BACKGROUND

Canadian Farm Tec Systems is a Waterloo-based manufacturer of electronic products for the agricultural industry. Since its conception twelve years ago, the company has strived for product innovation. Farm Tec's primary

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[24] In 1983, Ontario's energy consumption related to commercial corn drying was estimated at $22 million (source : Ontario Grain and Feed Dealers Association).

product line includes sensoring monitors and alarm warning devices. The firm employs fifteen people.

Dubrick, Farm Tec's president, was raised on a farm and has been associated with the agricultural business for most of his life. He enjoys a special rapport with his clients, which would prove useful later in the project's development.

### 4.4.4 CONTRACTING WITH THE WCPD

Dubrick had neither the resources nor the personnel to develop a process control device of such complexity. Thus, almost immediately he sought outside assistance. With the University of Waterloo close by, he began knocking on campus doors. Although he was aware that the University was rapidly emerging as a leader in computer research, he did not know where at the University to direct his efforts. Dubrick spent a week talking to people and being redirected before he finally came across an individual who showed substantial interest and who was prepared to take action. That person was Dr. Gerald Sullivan, an associate professor in the Department of Chemical Engineering and an expert in process control. Sullivan immediately brought the matter to the attention of the Waterloo Centre for Process Development (WCPD).[25]

Realizing the complexity of the problem, the WCPD assembled a team of scientists. Led by Dr. Edward (Ted) Rhodes, the founding director of the

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[25] The WCPD is a semi-autonomous technology transfer unit. It carries out both extensive contract research with industry and government, and project development work originating within the University.

WCPD, and Professor and Chairman of the Chemical Engineering Department at Waterloo, the team had expertise in all areas of process control. Brian Jacobson, a private consultant and adjunct professor at Waterloo, Sullivan and Rhodes were all charged with the development of the project. All three were to become co-inventors, with E.B Cross, the Executive Director of the WCPD, coordinating the activities of the project. Rhodes, with an extensive knowledge of technology transfer, was Dubrick's primary contact throughout the project.

Discussions were held with Dubrick, and site visits to grain drying operations were arranged. The visits showed that typically the rate of drying was controlled by adjusting the grain's throughput. In turn, the throughput was controlled by the manual adjustment of the metering rolls. In the absence of a process control mechanism, the operator measured the grain's moisture content at the grain inlet and outlet points and made the appropriate adjustment to the metering roll speed.

Through this activity, it was agreed that a feasibility study should be carried out to investigate the applicability of a process control system to automate and refine grain drying. In late 1981, Rhodes, acting on behalf of the WCPD, sent an unsolicited proposal to Agriculture Canada, hoping to receive funds through a Department of Supply and Services contract.

Unknown to WCPD, at about the same time Queen's University had also made a proposal to Agriculture Canada to support research in a study of grain drying. Under the suggestion of the granting agency, the two proposals were combined. Queen's received a $20,000 grant and was charged with investigating the theoretical concepts of moisture release through kernels of corn. WCPD received a $110,000 grant to study the application of these concepts with the intention of developing a microcomputer based, process control, retrofit system for conventional grain dryers.

Although the principal researchers at Queen's and Waterloo met a couple of times to coordinate activities, the research and final reports were conducted independently of one another. However, it was agreed that the results obtained at Queen's could be used to facilitate the WCPD application if they were directly useful.

### 4.4.5 THE FIRST PHASE - MONITORING A GRAIN DRYER

With the Agriculture Canada grant awarded in the spring of 1982, WCPD was able to conduct its first full-scale demonstration in the 1982 corn drying season. Using data gathering equipment and a microcomputer, a local grain dryer was instrumented and monitored during the drying operations. Unfortunately, it was an unusually wet fall and grain runs were sporadic and discontinuous. Only after the data were collected and a simulation run on the University's main-frame computer did the demonstration look promising. By the end of the first Agriculture Canada contract in the spring of 1983, the researchers had developed a sophisticated process control algorithm capable of controlling a dryer.

At this point in the development Dubrick had to make a decision. He had originally hoped they would be in a position to develop a marketable product at the end of the first contract. Although this was far from the case, Dubrick wisely decided to continue his support of the project.

### 4.4.6 THE SECOND PHASE - CONTROLLING A GRAIN DRYER

In the spring of 1983, under the guidance of Rhodes and the WCPD, Dubrick approached the Department of Regional Industrial Expansion and applied for a second grant under the Enterprise Development Program. (In 1984 this program became known as the Industrial Research Development Program). At that time EDP provided 75 percent funding, so in order to qualify for a $200,000 grant, Canadian Farm Tec invested $50,000 - a major commitment for a small company. The application was successful, allowing the development to proceed.

In the 1983 corn drying season, a prototype system was installed at a different site in Southwestern Ontario. Using off-the-shelf hardware, IBM PC's and analog-to-digital devices, they successfully monitored and controlled the dryer operation. With the success of this installation, efforts were now focused on developing a product for the marketplace.

### 4.4.7 PATENTING

In these early stages of the project, patenting discussions were held. Because the WCPD had serious reservations about its patentability, a joint decision not to proceed with patent application was reached. The Centre felt that minimal information disclosure resulting in market lead would be more appropriate. Further, with the algorithm captured in a silicone computer chip, software piracy would be unlikely.

### 4.4.8 DRYER MASTER - A TECHNICAL DESCRIPTION

The next stage in the project was concentrated on the development of a black box device, a device that became known as "Dryer Master". Dryer Master, developed as a retrofit system for conventional grain dryers, is a microcomputer based process control system designed to monitor and control the moisture content of corn. The system would be packaged in a black box device complete with keyboard functions and a LED display. Dryer Master would automatically compensate for changing dryer operations and grain drying characteristics (e.g., corn type, environmental conditions), and would process corn much closer to specification than previously possible. Dubrick's estimates that grain dryer operators would realize savings through increased energy efficiency and decreased shrinkage, of up to 20 percent using the Dryer Master system.

### 4.4.9 THE THIRD PHASE - DEVELOPING A COMMERCIAL PRODUCT

Because Farm Tec did not have the facilities to develop a prototype into a commercial product, a subcontractor was necessary. In 1984, Dubrick, working closely with the University, subcontracted with a local hardware/software company. The subcontractor was charged with the development of a computer chip that could be incorporated in the product.

By the fall of 1984, Farm Tec had sold twelve prototype Dryer Masters, installed at four sites in Southwestern Ontario. WCPD's monitoring program through the drying season indicated that their performance was satisfactory; however, there were still deficiencies that required further development.

In evaluating the 1984 prototype, it became evident that using a subcontractor to assist in the product's development had a number of shortcomings. In-house product development would give Farm Tec more control and would help expedite the process. In consultation with the WCPD, Dubrick set up a Research and Development facility and hired staff to complete the product development in-house. At this stage, WCPD's primary role was that of a consultant. Farm Tec's Research & Development team included a graduate student who had been involved with the project at Waterloo. Again, with the assistance of Rhodes and the WCPD, Farm Tec received a $30,000 National Research Council grant to facilitate this.

### 4.4.10 LICENSING

The close relationship that had developed between Farm Tec and the WCPD was reflected in the licensing negotiations and agreement. Prior to 1983, the two parties had only a hand-shake agreement. The fact that the WCPD provided a business-like organization within the traditional academic environment allowed a trusting relationship to grow during the development phase, culminating with a simple and flexible two-page agreement in 1985. Cross explained that being sensitive to the businessman's needs and conveying these to academe (and the reverse) is one of the WCPD keys to success. He added that transfer centres whose leadership involves academics only can sometimes lose this important perspective.

### 4.4.11 RECENT DEVELOPMENTS

With the new Research and Development facility in place, modifications to the 1984 model are being completed in-house. Other activities include product documentation and the development of pre-harvest operator seminars using computer simulation. Farm Tec is gearing up to manufacture and install 40 to 50 Dryer Masters in the 1985 drying season.

Through Farm Tec's American affiliate, the Dryer Master will penetrate the U.S. agricultural market. The reciprocal sales arrangement between the two organizations will give Dryer Master access to a market estimated at 25 times larger than Canada's. Marketing will be carried out through existing channels, on both a direct basis to mills and elevators, and to OEM's. Using the latter approach, the product will likely carry the OEM's brand.

Although not currently supported by government funding and working strictly on an voluntary basis, the WCPD remains very active in the project's development. In addition to overseeing the project's technical developments, the University is involved in other related activities. For example, under the direction of Rhodes, and using his personal research money, a student is conducting a literature survey on the rice drying industry. Using the results of this survey, Rhodes plans to develop a proposal to Agriculture Canada for additional funding to extend the application of the technology.

Further research will be carried out to study Dryer Master's adaptability to related products such as wheat and barley. Moreover, because the same principles apply, it is thought that similar technology can be applied to other industrial products where a drying process occurs (e.g., lumber and mining industries).

### 4.4.12 SPIN-OFFS

Although it is premature to estimate the revenues and royalties that Dryer Master will generate, Dubrick predicts it will "eclipse every thing that Farm Tec has previously done". As a direct spin-off from the invention, Farm Tec has acquired its own Research and Development Department. This department is actively improving Farm Tec's existing product line - a task that had previously been difficult. Dubrick believes that the invention has already enhanced the image of the company. Shortly before the last provincial election, the Minister of Agriculture introduced "The Ontario Grain Dryer Retrofit Assistance Program".

The WCPD expects to recover its overhead from the project in 1986. To the WCPD, the invention has demonstrated that the Centre can work with small organizations. Prior to this invention, the limited resources of most small businesses, combined with the long development time associated with technology transfer, were seen as barriers. The Centre is currently undertaking a second and unrelated project with another small company.

With the involvement of a local firm, the invention has generated community interest and has received generous media coverage. The Executive Director of the WCPD added that all too often a University is involved with the captains of industry, dealing with national and international interests.

### 4.4.13 INVENTOR'S PROFILE

The WCPD team of inventors was Rhodes, Sullivan and Jacobson. Each person equally contributed to the project. Rhodes, a key member of that development team, brings a wealth of knowledge to the WCPD. During his 24 years in academia, including chairman of the department for the last nine, the professor of chemical engineering has had extensive interaction with industry. Through his own consulting firm, Rhodes consults extensively.

He has been involved with four other inventions that are licensed to industry and earning royalties for him. He is the founding director of the WCPD, and a member of its technical subcommittee. Rhodes is the principal proposal writer to granting agencies for both the WCPD and his department.

Sullivan is a young professor at Waterloo who was hired under the NSERC fellowship scheme. He was attracted to Waterloo from the head office of Imperial Oil Ltd. in Toronto. Previously he obtained his Ph.D. in London, England where he was a Commonwealth Scholar. He then joined Imperial Oil and was responsible for completely modernizing the process control system at the refinery in Sydney, Nova Scotia. He is typical of the new breed of process control engineers - i.e., totally conversant with computers and new technology. As well as being involved with this project and his professional duties, Sullivan runs his own consulting company. He was responsible for Waterloo receiving the donation of IBM's Advanced Control System and necessary hardware. This was the first donation of its kind in the world.

Jacobson was Sullivan's supervisor in industry. He came to Waterloo as a free-lance businessman and has his own consulting company. As adjunct professor in chemical engineering, he teaches courses from time to time, but more importantly, he supervises undergraduates and graduates projects relevant to industry.

### 4.4.14 INVENTOR'S PERSPECTIVE

Rhodes was very enthusiastic about the project from the outset. His only initial concern about the project was a natural one: Farm Tec was a small business with limited resources. Rhodes added that Dubrick's initial market survey and identification of benefits were particularly helpful in securing the first grant.

Generalizing, Rhodes' enthusiasm for university-industry collaboration is two-fold: First, it provides a motivator, making research more relevant and exciting; and second, applied research is the single largest contributor of revenue for his department.

### 4.4.15 COMPANY'S PESPECTIVE

Dryer Master was Dubrick's first involvement with a high-tech product from conception to market. By far, Dryer Master was his company's biggest undertaking and represents its single largest commitment. At the project's conception, Dubrick admitted that he had not anticipated the extent of the long development process, the costs, and the impact it would have on his company.

Dubrick holds the WCPD in the highest regard. He stated the WCPD was very effective and helpful throughout the process. The close relationship that has developed between the two parties has greatly facilitated that process. Dubrick felt that without the weight of the University and efforts of the WCPD, Farm Tec would never have received the funding it did.

### 4.4.16 ANALYSIS

The Dryer Master invention is a classic example of a market-pull model. Through his existing customer base, Dubrick identified a market need. Teamed with the WCPD, he set out to provide a product targeted to satisfy this need. Moreover, he did this at an opportune time. Politically, the grain drying industry had been a concern to government for a number of years and had become especially important with rising energy costs; and technically, in the early 1980's, the microcomputer industry was undergoing tremendous development and growth.

The combination of WCPD and Farm Tec proved a very effective team. The relationship between these two organizations and in particular Rhodes and Dubrick greatly facilitated the process. Rhode's extensive experience in similar ventures proved an invaluable asset to the project. Given Rhodes ability to secure funding, Farm Tec's limited resource base was not a serious barrier to transfer. Dubrick's knowledge and rapport with the agricultural sector was extremely useful. Through his efforts, WCPD was able to gain the cooperation of mill operators, enabling early full scale demonstrations to be carried out.

It is interesting to contrast the involvement of Queen's University and the WCPD in the project's initial development. There is little doubt that the alignment of Farm Tec and WCPD was the major factor in the distribution of Agriculture Canada's funds between the two universities. With its infrastructure already in place, the WCPD was able to fully exploit the opportunity that presented itself, assembling a team and providing the synergy necessary to effect transfer.

## 4.5 THE CHROMORETINOSCOPE (CANADIAN INNOVATIONS CENTRE/WATERLOO)

### 4.5.1 INTRODUCTION

Retinoscopy is an optical technique used to measure objectively the refractive condition of the eye. Widely used over the last 100 years, the procedure involves shining a small light into the patient's eye and moving the light from side to side while observing the movement of the reflection coming back from the eye. The instrument used to perform this technique is called a retinoscope, a relatively simple hand-held device familiar to anyone who has undergone an eye examination. The concept and principles behind retinoscopy are well entrenched, remaining virtually unchanged in the last 100 years. Similarly, the retinoscope has undergone only minor modification over this period.

In the mid 1970's two optometrists at the University of Waterloo began research into chromoretinoscopy, a technique whereby retinoscopy is performed through coloured filters. Through this activity, Drs. Jacob Sivak and Clair Bobier were to a develop a chromoretinoscope, an instrument with a number of decided advantages over its traditional counterpart.

### 4.5.2 MEASURING THE EYE'S CHROMATIC ABERRATION

The refractive power of the human eye is not fixed, but in fact varies with wavelength. When using traditional retinoscopy techniques with a normal tungsten light source, not all wave lengths making up the white light focus on the retina. The red and blue wave lengths form the two extremes of the spectrum. Because the refractive index of all transparent media is higher for the blue wave lengths in the spectrum, the blue wave lengths focus closer to the front of eye. This phenomenon is called chromatic aberration.

Using ordinary retinoscopy techniques, an eye examination cannot objectively determine which part of the spectrum is in focus with the retina, and hence which part is being measured. Since retinoscopy findings vary with wavelength, it occurred to Sivak and Bobier that it should be possible to measure the eye's chromatic aberration by carrying out chromoretinoscopy; that is, performing retinoscopy in the usual manner except restricting the light entering the examiner's eye to a specific band of wavelengths. They were able to achieve this by carrying out retinoscopy through coloured filters, a technique known as chromoretinoscopy. In doing so, they found they could objectively measure the extent of the eye's chromatic aberration in a quick and easy manner. Moreover, they discovered this technique could increase the accuracy of all retinoscopy. Simply by cutting down the smear or spread of light entering the eye, the chromoretinoscopic procedure produced a sharper image, making measurement easier.

### 4.5.3 MEASURING THE EYE'S ACCOMMODATION

In the course of their investigation, Sivak and Bobier discovered another inherent advantage through chromoretinoscopy. When the eye focuses on a distant object, ordinary retinoscopy measurements are quite accurate and have satisfied practitioners for 100 years. However, when the eye fixates on near objects, say on reading material, the lens inside the eye must change its focal power in order to read, a process called accommodation. Conducting retinoscopy under these conditions produces an error, a fact noted some 80 years ago. Because of this error, retinoscopy has not caught on as an objective procedure to be used when the eye is fixating at near.

The biological aging process makes this phenomenon significant. Between the 40th and 45th years of life, a rapid aging of the lens inside the eye takes place and the eye begins to lose its ability to undergo accommodation. As a result, middle-aged people will invariably be required to wear corrective glasses in order to read. Prescribing glasses to patients has traditionally been a very subjective procedure and is usually done on a trial basis. For the reasons explained, retinoscopy cannot be carried out under these conditions. Therefore it would be useful to measure the amount of accommodation the eye has available to it under these conditions. Sivak and Bobier found that chromoretinoscopy was one way to achieve this.

In summary, Sivak and Bobier introduced a simple clinical procedure to measure the eye's chromatic aberration and accommodation, and to generally improve the overall accuracy of retinoscopy.

### 4.5.4 THE FIRST PROTOTYPE

Having conducted research and convinced of the advantages of chromoretinoscopy as a standard clinical procedure, in 1977 Sivak and Bobier turned their efforts to developing a commercial prototype. In the course of their investigation, they experimented with various chromoretinoscope configurations. Building a prototype involved finding a way to attach coloured filters onto a standard retinoscope, a very simple modification of existing technology. The first device that was to receive serious evaluation was a clumsy wheel device, an attachment incorporating a wheel with a series of filters built on to it. It worked by simply rotating the dial to the desired filter. By and large, in demonstrations to colleagues and practitioners, the feedback they received on the device was encouraging.

### 4.5.5 THE FIRST LICENSING ATTEMPT

In 1977 Sivak and Bobier approached the director of the Inventor's Assistance Program (IAP) at the University of Waterloo and gave a demonstration.[26] This individual, who was also the assistant director of the Waterloo Research Institute (WRI), was very encouraged by their demonstrations and explanation, and almost immediately set out to obtain patent protection.

By chance, there was an optical trade show being held in Toronto at about the same time. Sivak had a contact at one of the attending companies, Bausch & Lomb, a New York based giant and the largest optical manufacturer in the world. Sivak's colleague suggested they approach Bausch & Lomb at the show. On his advice, Sivak and Bobier attended the show and made contact with Bausch & Lomb, which immediately showed interest in the device. In fact, the response was so favorable that the IAP director set out to obtain patent protection in six countries. However, after some subsequent reflection, and a market evaluation, Bausch & Lomb's enthusiasm faded, although they were still willing to hold licensing

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[26] The IAP was founded in 1976 by the Office of Research at the University of Waterloo. The Canadian Industrial Innovation Centre/Waterloo, established in 1980, grew out of this program.

discussions. To the disappointment of the University, the agreement Bausch & Lomb proposed consisted only of a small licensing payment.

Because they were so well received initially, the University assumed they would meet with more success elsewhere. Unfortunately, this did not prove to be the case. Subsequent attempts to license were to prove even less fruitful.

### 4.5.6 PATENTING

For the reason given, broad patent protection was applied for almost immediately. However, the United States patent application quickly ran into technical problems. A patent search indicated that an ophthalmascope, a device used by physicians and optometrists to look at the structures in the back of the eye, had previously been built and patented with a wheel-o-filter. This old patent application was based on a device, although not commercially manufactured, that was claimed to be able to perform the functions of both a retinoscope and an ophthalmascope. Hence, the patenting authority could not differentiate between the two devices and subsequently rejected the University's application. Although the University appealed and then re-appealed this ruling, the decision stood.

Because the United States represented the largest optical base in the world, without a U.S. patent, they felt the other five patent applications would be of only marginal value. Therefore all patent applications were then halted. However, the British patent application was already at an advanced stage and was subsequently granted. With little gained, the University had expended considerable effort and money.

### 4.5.7 OTHER LICENSING ATTEMPTS

In total there were four serious attempts to license from 1977 to 1980. After their initial attempt with Bausch & Lomb, the University held discussions with American Optical, Keeler, and Welch Allyn, all industry leaders. In the case of Welch Allyn, Sivak and the director visited their New York operation and gave a demonstration. In turn, the company distributed prototypes to its consultant/practitioners for evaluation. As with other commercialization attempts, Sivak had no direct involvement or input in the evaluation procedure. This proved a frustrating experience for Sivak. In retrospect, he stated that without a demonstration and explanation to the end user, the prototype had little chance of gaining clinical acceptance. Sivak added that the advantages of the chromoretinoscope should have been communicated to practitioners directly, preferably in the form of demonstrations.

In parallel to these commercialization attempts, Sivak and Bobier continued their research on chromoretinoscopy. During this period they published a series of related articles. In 1978, a second prototype was developed in an attempt to make the instrument more aesthetically pleasing. Since 1979 activities relating to the invention have been sporadic. With the inception of the Canadian Industrial Innovation Centre (CIIC) in 1980, the invention was transferred to the Centre. In the interest of Sivak and Bobier, some continuity was maintained with the former assistant director of the WRI being appointed as the first director of the Centre.

In one last serious attempt at commercialization, the inventors, working with the director of the Centre, proposed building a snap-on device and marketing it through the University. Design drawings were completed and forwarded to mold manufacturers for estimates. However, with the retirement of the Centre's director in 1983, the proposal was not pursued further.

Since 1983, there have been no concentrated efforts to exploit the chromoretinoscope, although through the activities of the Centre, the invention has received some exposure. The instrument has been advertised in the 'Innovation Showcase', a licensing bulletin put out by the Centre and circulated to some 3,000 manufacturers. Also, the invention has been displayed at a few trade shows, including Tech-Ex '85 in Orlando, Florida. Through these activities, a few small companies have expressed interest, although no serious licensing discussions have resulted.

The invention now sits in the Centre's Innovation Bank awaiting a potential licensee. Here, with the Centre's large volume of inventions and limited number of staff, the invention has been assigned a low priority. Hence, the Centre acts now only to follow-up enquiries.

Bobier retired in 1982, and Sivak has long since channeled his energy into other endeavours. Sivak did state, however, that sooner or later the value of chromoretinoscopy will be recognized and commercialized.

### 4.5.8 SPIN-OFFS

Through Sivak's and Bobier's research in chromoretinoscopy a great deal has been added to the existing body of knowledge. This knowledge has been transferred to the optical profession through a series of published articles.

### 4.5.9 INVENTOR'S PROFILE

After completing his training as an optometrist at University of Montreal in 1967, Jacob Sivak went on to study comparative physiology at Cornell University. Graduating with a Ph.D. in 1972, Sivak joined the faculty at the University of Waterloo. He has since attained the rank of full professor, and for the last year has been Director of the School of Optometry. He holds a joint appointment in departments of Biology and Optometry. Sivak's primary area of interest is in the optical quality and evolution of the eye, with specific expertise in chromatic and spherical aberrations of the eye.

Although Sivak is currently involved in another unrelated development in which commercialization is being attempted in collaboration with the Canadian Industrial Innovation Centre, he certainly does not consider himself an entrepreneur. Sivak has done very little consulting to industry; however, he maintains contact with practitioners through the Continuing Education Program at Waterloo.

### 4.5.10 INVENTOR'S PERSPECTIVE

Chromoretinoscopy has gained some acceptance in the profession, and in fact has been included in a leading clinical manual. However, consistent with his beliefs, Sivak refuses to use the continuing education classes as a forum for economic gain. While students may be introduced to chromoretinoscopy, it is certainly not promoted.

Sivak has mixed feelings about the IAP and the Innovation Centre. While he felt they were hard working and sincere in their efforts, he thought they suffered from a lack of direction. Familiar with the American philosophy, Sivak believes the Centre, along with Canadians in general, must be more aggressive and risk-taking. He stated that only an acute awareness of some success stories coming through the Centre would convince him of its effectiveness.

Sivak added that with optical manufacturers based primarily in the States, consultation and demonstration with the industry is difficult. Although a firm believer in the serendipity of academic work, he stated that university-industry interaction will be of increasing importance and must therefore be facilitated.

### 4.5.11 ANALYSIS

The chromoretinoscope can be categorized as an example of a technology-push model. The instrument was developed through the course of scientific research as opposed to satisfying the requirements of a specific market need. Its lack of market potential only became evident through repeated licensing attempts. Unfortunately, considerable effort and money was expended (particularly during patenting attempts) before it became evident that the invention would meet with market resistance. Perhaps a detailed evaluation by the IAP in the initial stages would have averted this.

The ability to attract commercial interest in the instrument was hampered by the fact that the inventors had little if any input and contact with the end-users. The result was that the benefits of the device were never fully communicated to the practitioners. If the commercial sector fails to stimulate interest within the optical industry, then this task falls on the principals. However, finding the appropriate vehicle to create demand is a difficult assignment.

In all likelihood, the chromoretinoscope would be an especially difficult instrument with which to penetrate the market. Market resistance would be heightened by the long tradition the retinoscope has enjoyed and the low research and development funding that the optical industry likely associates with it. Furthermore, it may be that the additional revenue the attachment could dictate (the incremental value-added) would not off-set these factors.

## SUMMARY OF CASE STUDIES

The five innovations studied are summarized in Figure 13 on page 129. As can be seen, the successful innovations were differentiated from the unsuccessful ones along several dimensions. A market orientation was evidently a major ingredient of success, as was an early demonstration of the technology and the commitment of a corporate sponsor. Only one of the three successful inventors perceived the technology transfer organization to be not very effective.

Good funding was found to be important, but not a differentiating factor. Although only three of the innovations appear to have been commercially successful, all could be said to have been technical successes, and each has provided spin-off benefits to the faculty members, departments and universities associated with them.

Figure 13. Summary of Case Studies

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|
| Invention | HUBNET | MFLI Microscope | Solar Panel | DRYER-MASTER | Chromo-retinoscope |
| University | Toronto | Queen's | Queen's | Waterloo | Waterloo |
| Transfer Organization | Innovation Foundation | Queen's | Queen's | WCPD | CIIC/W |
| Commercial Success | Yes | No | Yes | Yes | No |
| Market-Pull/ Tech.-Push | Mkt.-Pull | Tech.-Push | Mkt.-Pull | Mkt.-Pull | Tech.-Push |
| Inventor's Profile | Very exper. Extensive consulting | Exper. Infreq. consulting | Very exper. Regular consulting | Very exper. Extensive consulting | Exper. No consulting |
| Funding | Excellent | Good | Good | Excellent | None |
| Fund Raiser | Innovation Foundation | Queen's | Inventor | WCPD | N/A |
| Early Full-Scale Demo | Yes? | No | Yes | Yes | No |
| Inventor's Evaluation of Transfer Organization | Very effective | Not very effective | Not very effective | Very effective | Not very effective |

# CHAPTER 5: DISCUSSION OF FACULTY SURVEY RESULTS

## 5.1 INTRODUCTION

The third part of this study was a survey of faculty at each of the three universities of their involvement in technical protection and commercialization activities and their attitudes towards university efforts in this area.

Faculty members from engineering, life-sciences and physical sciences were surveyed at each university. Tables and figures containing specific data from questions are provided in Appendix A. The questionnaire is shown in Appendix B. In this section of the report we summarize the major findings of the survey, and use these to test the validity of our initial hypotheses.

## 5.2 SURVEY RESPONSE

In all, 1,754 professors were sent questionnaires and 643 or 37 percent responded. Full details of the number sent in each field of research and to each school are provided in Figure 14 on page 131. That the response rate was highest at Queen's may reflect the fact that professors on leave were not surveyed. At all three institutions the highest response rate was from the Engineers and the lowest was from the Physical Scientists.

Figure 14. Survey Responses: Number of questionnaires sent and received by university and field of research.*

| SCHOOL | ENG. | PHYS. SCI. | LIFE SCI. | TOTAL |
|---|---|---|---|---|
| Waterloo | | | | |
| Sent | 137 | 226 | 50 | 413 |
| Received | 54 | 48 | 19 | 121 |
| Response(%) | 39 | 21 | 38 | 29 |
| Toronto | | | | |
| Sent | 152 | 268 | 525 | 945 |
| Received | 83 | 77 | 194 | 354 |
| Response(%) | 55 | 29 | 37 | 37 |
| Queen's | | | | |
| Sent | 81 | 125 | 190 | 396 |
| Received | 50 | 45 | 73 | 168 |
| Response(%) | 62 | 36 | 38 | 42 |
| Totals | | | | |
| Sent | 370 | 619 | 765 | 1754 |
| Received | 187 | 170 | 286 | 643 |
| Response(%) | 51 | 27 | 37 | 37 |

*One Waterloo and two Toronto respondents did not identify their field of research.

There were 643 individual responses to the survey, of which 55 percent were received from the University of Toronto (356), 26 percent were received from Queen's (168) and 19 percent from Waterloo faculty (122). Just under half the responses were from life sciences faculty, with the balance being equally distributed between engineering and physical sciences.

Two-thirds of the respondents had no full time industrial experience; of the remainder roughly 10 percent had either 1 or 2 years; 3 to 5 years, or over 5 years experience. Roughly half the respondents had consulted at least once in the past year. Professors having industrial experience were much more likely to have consulted than those with no experience. Industrial experience, and hence consulting, were much more frequent amongst engineering faculty than either of the sciences.

## 5.3 PATENTS AND COMMERCIALIZED DEVELOPMENTS

Ten percent of the respondents reported one development in the last five years. Nine percent reported two or more, including two respondents who reported more than ten developments protected. Eighty percent of the respondents had not protected any developments.

Apparently, two-thirds of the developments protected are subsequently commercialized. Eight percent of the respondents reported one development in this category, and five percent reported between two and five.

The results obtained support our first hypothesis that professors with consulting or work experience are more likely to develop commercializable inventions. The data showed that professors with industrial experience are more likely to have had an invention protected than those without such experience (See Figure 15 on page 133). Developments were most commonly to be found in the group of faculty that had work and consulting experience. As shown in Figure 15 on page 133, faculty without work experience, but who consulted, were more likely to have a development protected than faculty without either kind of experience.

Figure 15. Protection of Developments and Experience: (percent of faculty in each category with protected developments)

| | | Work Experience | |
|---|---|---|---|
| | | Yes | No |
| Consulting | Yes | 33.8% | 24.4% |
| | No | 14.3% | 8.9% |

$X^2$ Test: Results significant at 5% confidence level

As shown in Figure 16, similar results were obtained for commercialization.

Figure 16. Commercialization of Developments: (percent of faculty in each category with commercialized developments)

| | | Work Experience | |
|---|---|---|---|
| | | Yes | No |
| Consulting | Yes | 26.4% | 16.6% |
| | No | 3.6% | 5.5% |

$X^2$ Test: Results significant at 5% confidence level

As indicated earlier, about two thirds of protected developments are commercialized. Figure 15 and Figure 16 show that faculty with work experience and who consult are most likely to commercialize their inventions. Faculty with work experience, but who do not consult, exhibit a significantly lower success rate (25 percent) than the mean (66.6 percent). Interestingly, faculty with no work experience, but who consult, are more likely to be successful at developing an invention and subsequently commercializing it.

## 5.4 EFFECT OF PROMOTION, SALARY AND TENURE POLICIES

The data obtained from the survey did not support our second hypothesis that professors interact with industry more if their universities' salary, promotion and tenure policies encourage such behaviour. Promotion, salary and tenure policies, as presently implemented, were perceived to have little impact, or at best, slightly encourage interaction with industry. Very few of the faculty respondents felt that policies strongly encouraged these activities. The largest group of faculty at both Queen's and the University of Toronto felt that these policies encouraged interaction more than they discouraged it. At Waterloo over half the faculty respondents felt that interaction was encouraged while only 15 percent felt it was discouraged.

Some differences between faculties were noted. Engineers tended to consult with industry whether or not they felt it was encouraged by university policies. Life scientists, who exhibited a low level of interaction with industry generally, also seemed to view university policies as having little or no effect. Physical scientists were the only group amongst which professors were significantly more likely to consult if they felt interaction was encouraged. Generally physical scientists (43 percent of respondents) consulted more than life scientists (33 percent) but much less than engineers (84 percent).

## 5.5 PERCEPTION OF ORGANIZATIONS TO EVALUATE INVENTIONS

The first stage in the commercialization process is the evaluation and possible protection of the invention. Since most of the respondents to the survey had no protected developments, many (52 percent) were unable to provide information for this aspect of the enquiry. The number of non-respondents was much less at Waterloo than either Queen's or the University of Toronto.

Of those responding, roughly two-thirds felt that the organization at their university was either somewhat effective or very effective. At both Waterloo and Queen's, roughly three-quarters of the respondents held these views, while at the University of Toronto, the percentage was somewhat lower (58 percent). Very few of the respondents at any of the locations felt their organizations were totally ineffective.

Overall, the Waterloo professors were more willing to express an opinion, and viewed their organizations as more effective than faculty at either Queen's or the University of Toronto.

The most valuable perceptions of organizational effectiveness are obtained from those faculty who have had an invention protected. All but 10 percent of these respondents commented on their university's organizations; 58 percent (or two thirds of those responding) holding favourable views of the evaluation organization's effectiveness. Roughly the same proportions were found amongst respondents who had not had an invention protected, but over 60 percent of faculty in this category chose not to respond.

## 5.6 PERCEPTION OF COMMERCIALIZATION ORGANIZATION EFFECTIVENESS

Once the development is protected, the task of commercialization still remains. The results of the survey go some way to support our third hypothesis that to be successful, commercialization organizations must be perceived by their clients, the university professors, as being effective. Faculty respondents' perceptions of their university's commercialization organization almost exactly mirrored those of the invention evaluation organizations. Slightly more viewed the organizations as ineffective, especially at Queen's and the University of Toronto.

Among faculty that had inventions protected, there was generally a higher percentage responding who felt that the commercialization organizations was ineffective than among professors with no protected inventions. Within the former group, nearly half those with protected inventions which had not been commercialized felt the commercialization organizations were ineffective, as shown in Figure 17 on page 137.

Figure 17. Commercialization Success and Perception of the Commercialization Organization

| | View Organization As: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Effective | | Ineffective | | No Comment | | Total | |
| | No. | % | No. | % | No. | % | No. | % |
| No Experience | 124 | 24.0 | 55 | 10.7 | 337 | 65.3 | 516 | 100 |
| Unsuccessful Commercialization | 14 | 35.0 | 19 | 47.5 | 7 | 17.5 | 40 | 100 |
| Successful Commercialization | 38 | 46.9 | 31 | 38.3 | 12 | 14.8 | 81 | 100 |

Overall, the perception of the universities' commercialization organizations was less favourable than the view of the invention evaluation organization. Perceptions of faculty with actual experience of these organizations tended to be less favourable than those without, who presumably have little direct experience.

## 5.7 MARKET-ORIENTATION VS. APPARENT ORGANIZATIONAL EFFECTIVENESS

Our fourth hypothesis was that organizations to commercialize university inventions are more effective if they are market-oriented. This is a difficult hypothesis to test due to the relatively short period of time these organizations have been in existence and the limited data available.

Considering the four organizations that have been described in detail in the earlier section, it is apparent that the CIIC/W is the most market-oriented. It employs professionals who are trained in the assessment of the market potential of inventions, and in its custom evaluations, it uses individuals, sometimes potential customers, who are experts in the area of the invention.

Next in line is WCPD. WCPD has regular contact with companies who contract with it to have research done. Through these regular contacts, WCPD can keep abreast of what technologies are in demand in the market. Also, because of the relatively narrow line of technologies it works with, as compared to the Innovations Foundation or the Queen's organization, the number of markets that it has to be aware of (or oriented towards) is smaller. Hence it is better able to stay in touch with them.

Of the two remaining organizations, the Innovations Foundation would appear to be more market-oriented. It was deliberately created with a Board of Directors with majority industry representation to ensure that private sector people were available to assist the Executive Director in selecting inventions to attempt to commercialize. Further, the Executive Director, in evaluating inventions, will call his contacts in industry who might be interested in the invention and ask their opinion of it before expending his resources in protecting and attempting to commercialize it.

The least market-oriented of the organizations appears to be that at Queen's. It appears that the focus of the Queen's organization is more on the technology created than on the market for it.

In exploring the relationship between market-orientation and effectiveness, the WCPD is especially useful. When WCPD was created, it did not intend to do contract research. Rather, the intention was to fund the further development of projects coming out of the University to the point where firms would be interested in licensing them. After about two years operating without contracts, the Centre found itself in debt and without readily licensable inventions. In the three years or so since the Centre started doing contract research, seven licenses have been written; five of these have been of developments either discovered or enhanced via contract research.

Apparently, the transition to a more market-oriented organization that accompanied the initiation of contract research significantly increased the Centre's effectiveness.

The Innovations Foundation has succeeded in commercializing about 10 percent of the inventions it has taken on, whereas the percentage at Queen's is somewhat lower. This information, taken together with that presented above for CIIC/W and WCPD, appears to support the notion that more market-oriented organizations are more effective.

## 5.8 RELATIONSHIP BETWEEN PERCEPTION OF THE ORGANIZATION AND ITS OPERATION

Our fifth hypothesis was that the organization must operate in a manner consistent with the background and orientation of faculty members in order for them to perceive it as effective.

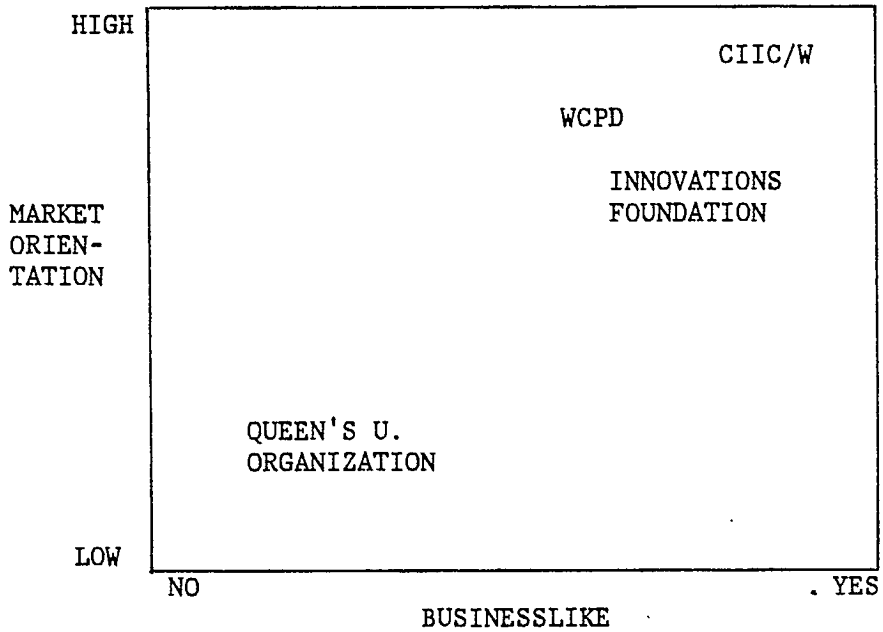
We can rank these organizations according to the extent to which they operate in a commercial manner. Based on the descriptions developed in earlier sections, it is reasonable to argue that CIIC/W has adopted the most commercial approach. It deals with the general public and charges a fee for the services it provides. It is a separate corporation from the university, having a business organization structure in which the CEO reports to a Board of Directors. Further, it has long range business plans and annual budgets, and each year it publishes an annual report and holds an annual meeting.

Using the same criteria, it seems reasonable to rank the Innovations Foundation second on our 'commercial' scale, slightly ahead of WCPD. The reason for ranking the Foundation the higher of the two is that it is a separate corporation, rather than a 'semi-autonomous organization', and also because it has established itself in offices that are physically separate from the University. WCPD's offices and labs are located in the chemical engineering building at the University of Waterloo.

The Queen's organization ranks fourth on this scale, some distance behind the other organizations. In many ways its mode of operation is more like that of a university than a business. It depends on committees made up of professors and administrators to make or recommend decisions, rather than leaving them, for instance, to the Coordinator of Patents and Licensing. Further, it is neither incorporated nor semi-autonomous, and it is somewhat fragmented.

Using our rankings of the organizations on our market-orientation and businesslike scales, we have developed the profile of the organizations shown in Figure 18 on page 141.

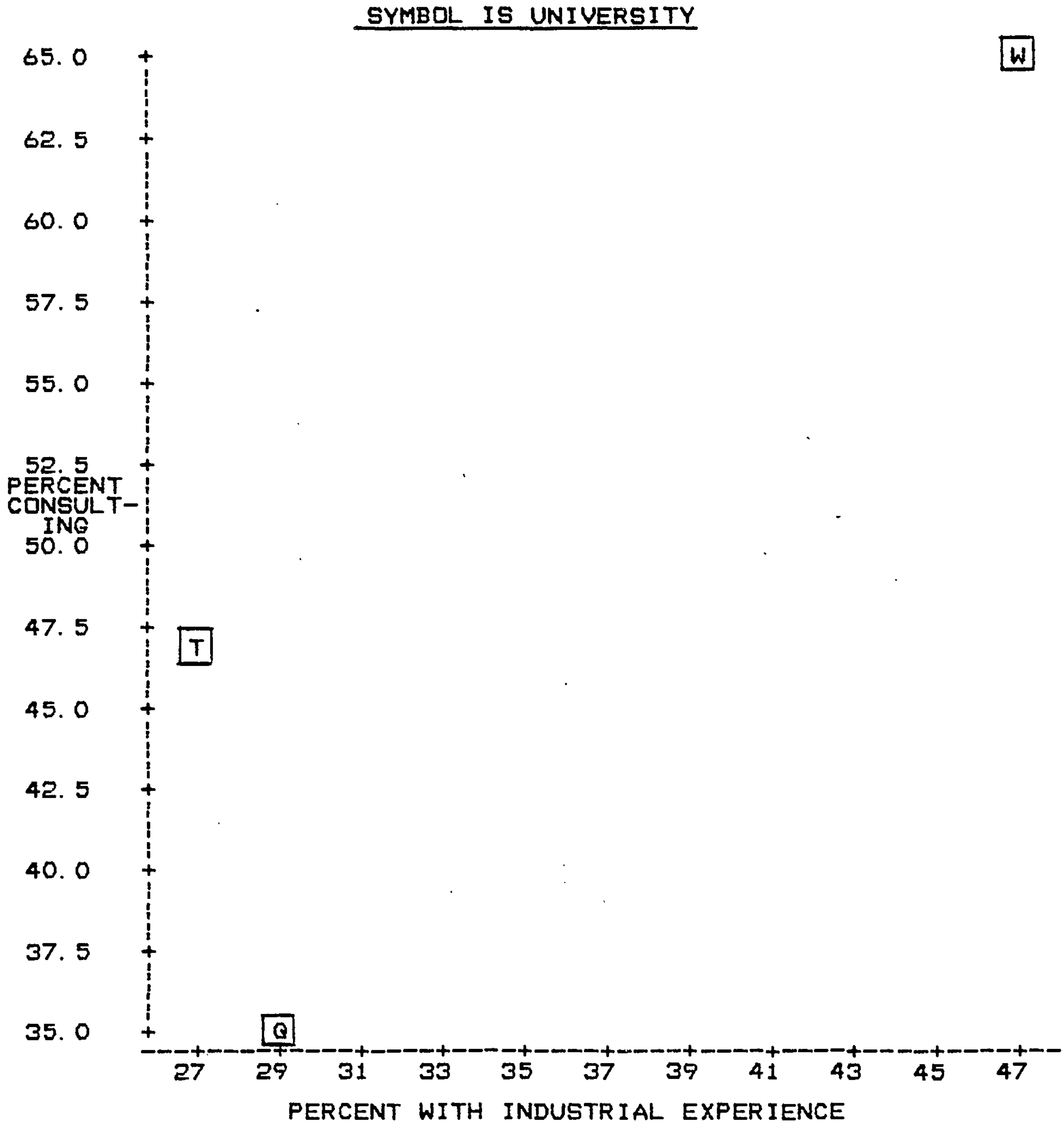
Figure 18. Profile of Commercialization Organizations:




An analogous profile of the university faculty members can be developed by comparing their responses to the consulting and industrial experience questions, respectively, to our rankings on the market-orientation and businesslike scales. Figure 19 on page 142 graphs the percentage of respondents who consulted versus the percentage with industrial work experience for each university. By comparing the last two figures, we see that the Queen's respondents, like their organization, appear in the lower left corner of the graph. Both the Waterloo respondents and the Waterloo organizations were in the upper right corner of the graph. The largest separation exists between the Toronto organization and the

Toronto respondents. This discrepancy is largest along the Businesslike/Industrial Experience axis.

Figure 19. Consulting & Industrial Experience of Respondents by University



If we now refer to the respondents' perception of the organization by university, the organization that is perceived as being least effective is that where the discrepancy is greatest, i.e., the Toronto organization.

It can be seen that the organizations form a diagonal on the chart with the Queen's organization at the lower left and the CIIC/W at the upper right.

The responses of the Waterloo and Queen's respondents were similar in that more thought the organization was effective than ineffective. The main difference between these two was that a larger number of Queen's respondents chose not to comment. This is not surprising given the lower proportion of them that are interacting with industry.

By way of contrast, the proportion of Toronto respondents that thought the organization was ineffective was roughly equal to that which thought it was effective, and a large proportion chose not to comment.

For the Toronto respondents, the Engineers, as expected, place far higher on the work experience - consulting scale than the Physical Scientists, who in turn place higher than the Life Scientists. When we examine the Toronto respondents' perception of the organization, a similar result is obtained.

Among the Engineers, more thought the organization was effective than ineffective, and a relatively small proportion chose not to comment. While more Physical Scientists thought the organization was effective than ineffective, roughly two-thirds did not comment, suggesting that they have little to do with the organization. Among the Life Scientists, however, slightly more thought it was ineffective than effective, and again, a large proportion chose not to comment. This view by the Toronto Life Scientists of the Innovations Foundation as either ineffective or, perhaps, irrelevant, is consistent with the following comments taken from two questionnaires:

> "A major problem we in the Life Sciences have at the U. of T. is understanding what the Innovations Foundation is trying to do for us."
>
> Commenting on questions 9 and 10 which asked the respondent's view of the evaluation and commercialization organization:
>
> "I know of absolutely no activity on the part of U. of T. as far as Life Scientists are concerned."

These comments are particularly surprising in view of the fact that when the survey was done, the Innovations Foundation had employed a Manager of Medical Inventions for a year.

## 5.9 OVERALL UNIVERSITY PERFORMANCE

Despite the noticeable differences in the way the three universities deal with the protection and commercialization of industry inventions, there is very little difference in the percent of faculty at each who have had developments protected, as shown in Figure 20 on page 145.

Figure 20. Percent of Faculty Respondents with Protected Developments

| | Number Protected | | | |
|---|---|---|---|---|
| | Zero | One | Two - Five | > Six |
| Queen's | 79.8% | 11.9% | 6.6% | 1.7% |
| University of Toronto | 79.5% | 10.1% | 8.5% | 0.6% |
| Waterloo | 81.2% | 7.4% | 8.2% | 0.3% |

Note: Rows do not total 100% due to no response category

There does appear to be considerable difference in the rate of commercialization at each university, as shown in Figure 21 on page 146. Queen's appears to have a somewhat lower rate of commercialization than the University of Toronto, and the faculty at the University of Waterloo has a significantly higher success rate than their counterparts at either of the others.

Figure 21. Commercialization of Protected Inventions

| | Percent of Faculty with one or more protected developments | Percent of Faculty with developments commercialized | Apparent Success Rate |
|---|---|---|---|
| Queen's | 20.3% | 11.9% | 58.6% |
| University of Toronto | 20.5% | 13.5% | 66.0% |
| Waterloo | 16.4% | 12.3% | 75.0% |

These apparent success rates are much higher than the rates reported from commercialization organizations at the University of Toronto and Queen's, which were approximately ten percent. This suggests either that faculty often circumvent the formal university organizations or that their view of commercialization success is much more limited and constrained than that taken by the university organizations themselves.

Given the similarities in the rates at which developments are protected by faculty at each university, and even allowing for possible differences in the types of inventions at each university, these differences suggest that:

a) either the screening process for protecting inventions is more effective at Waterloo,

or

b) the commercialization process at the University or Waterloo is more effective than that at Toronto, which in turn out-performs Queen's.

# CHAPTER 6: CONCLUDING COMMENT AND RECOMMENDATIONS

## 6.1 MAJOR FINDINGS

This study has examined the way in which three major Canadian universities organize to transfer technology to industry. The descriptions of the organizations at each, the case studies of specific innovations, and the survey of university faculty have provided a variety of data on these activities.

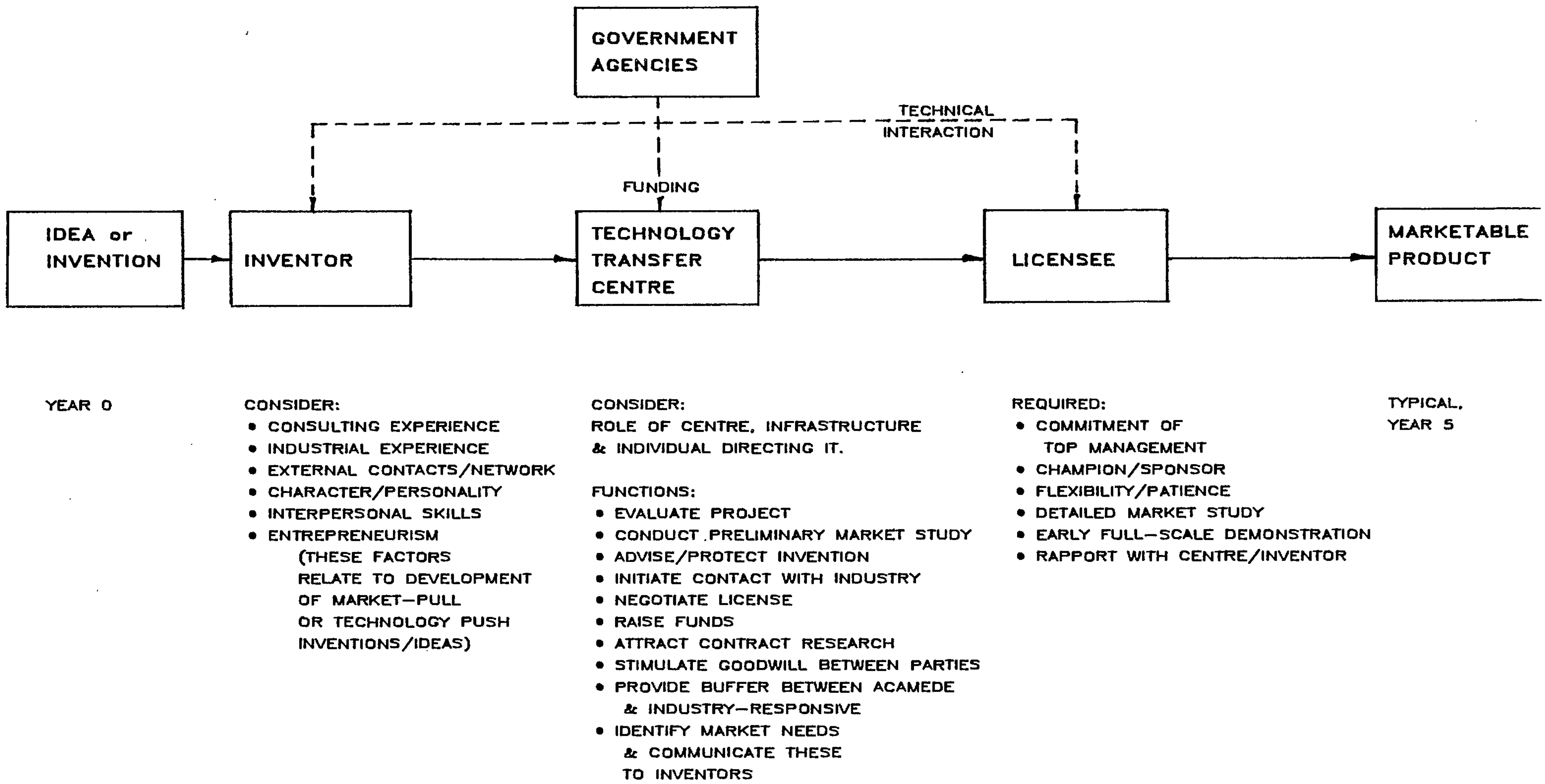
RECOMMENDATION 1: TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD BE ESTABLISHED IN ALL MAJOR CANADIAN UNIVERSITIES

It is difficult over a short period of time to establish the value of these activities, but the instances of success that we report in the case studies suggests that these transfer activities contribute significantly to the successful commercialization of new technology developed in three of Canada's premier universities. Equally importantly, even where the ultimate outcome of the development was a commercial failure, the spin-off benefits to the researchers and the university involved appears to have been significant.

RECOMMENDATION 2: UNIVERSITY FACULTY, PROFESSIONAL STAFF, PRIVATE SECTOR FIRMS AND GOVERNMENT AGENCIES SHOULD ALL BE STAKEHOLDERS IN THESE ENTERPRISES

The research permits us to put forward a framework which we believe contains the elements necessary for establishing a comprehensive university-industry technology transfer policy. The framework is summarized in Figure 22 on page 149.

Figure 22. The University-Industry Technology Transfer Model



Key roles are played by:

Inventors: who champion the innovations and may initiate the process.

Technology transfer centres: which facilitate the transfer process by providing expertise, bring together interested parties, and assist with funding requirements.

Corporations: which are often licensees of the technology, provide significant input to market and product definition, and ultimately commercialize the technology.

Government agencies: which can provide funding for research, development and demonstration activities, and also possible initial markets for new technologies.

These stakeholders all played significant roles in the three successful developments studied in the detailed case studies, but one or more were not involved in the unsuccessful developments. Success appears to come about when the different stakeholders are all involved in an innovation, each playing appropriate roles.

## 6.2 ORGANIZATIONS TO FACILITATE TECHNOLOGY TRANSFER

The organizations used by each university to facilitate technology transfer differ substantially, as shown in Figure 12 on page 68. Our data show that while there is relatively little difference in the proportion of faculty at each university with protected technical developments, there are quite large variations between universities in the rates of commercialization. Specifically, at the University of Waterloo where the percentage of faculty with protected developments is lowest, the apparent success rate for commercialization is almost twenty percentage points higher than at Queen's, whose faculty has a higher rate of protected developments.

These survey results, combined with anecdotal evidence from case studies and interviews, suggests that the form of organization adopted and its strategy have considerable impact on successful commercialization.

RECOMMENDATION 3: A NATIONAL CONFERENCE ON COMMERCIALIZING UNIVERSITY TECHNOLOGY SHOULD BE CONVENED, WITH REPRESENTATION FROM UNIVERSITIES, AS WELL AS THE PUBLIC AND PRIVATE SECTORS

The general lack of common agreement and understanding of the transfer process suggests that a national conference on the topic could play a key role in developing effective transfer organizations. The purpose of this conference would be to accomplish four principal objectives:

1. To enable participants from universities, corporations and government to better understand the challenges of the technology transfer process.

2. To educate participants about the alternative forms of technology transfer activity and organization, and which are most effective.

3. To help develop the network of professionals and academics involved in this area.

4. To identify new policy initiatives that might be taken to facilitate these activities.

RECOMMENDATION 4: TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD BE INCORPORATED AND HAVE A BUSINESS ORIENTATION

The research found that in the short-run, and we suggest in the long-run as well, the most successful technology transfer organizations are those that adopt market and business orientations. While it is difficult to establish objective measures for the effectiveness of these organizations, especially given the relatively short time for which most of them have been operating, some data are available from the study to show that this business focus is necessary, although it is likely to vary in degree given the character of each university.

The individual running the technology transfer organization has a major impact on its performance. The attitude of this individual appears to determine whether the organization is market and business oriented and how responsive university faculty perceive it to be. We believe that the selection of this person is one of the key decisions to be made during the establishment of a technology transfer unit.

The committee structure at Queen's appears to be less effective than the approach adopted at the other universities. Both the inventors associated with the specific cases examined found it not to be effective, and while Queen's faculty had the highest rate of developments protected of all three universities, the rate of commercialization was the lowest. The activity at Queen's has no profit orientation, and exists to enhance the reputation of the university, a vague notion at best. This structure involves a substantial input of time from university administrators, who might be better employed in other duties. In addition, patenting, rather than commercialization, appears to have become the prime objective.

Establishing the technology transfer activity as a separate company appears to be most effective. This action provides the organization with a clear mission which can be stated in financial and commercial terms. This structure has the following advantages:

1. It enables the university to involve executives from both industry and government as directors, and possible sponsors for specific developments.

2. It insulates the innovation process from the bureaucracy of the university.

3. It provides a liability barrier for the university.

4. It provides industry with a specific identifiable contact within the university relating to technology transfer, and possibly contract research.

In addition to the routine technology transfer activities, this corporation can be chartered to play a more proactive role by pursuing contract research that can be carried out within the university, as is done by the WCPD. This activity need not conflict with work undertaken by individual faculty or other specialized campus research institutions. The danger in this type of work is that it may become so attractive and profitable that technology transfer activities may become of secondary importance.

Creation of a single technology transfer organization also has the benefit of bringing functions connected with the protection and commercialization process together. At Queen's University, where separate patent evaluation and commercialization committees exist, there appears to be a higher attrition rate between these two phases than elsewhere. This discrepancy may be due to the criteria that are used at each stage, or because of a lack of commitment and resources to the complex commercialization activity.

RECOMMENDATION 5: UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD HAVE THE MANDATE TO INITIATE TECHNICAL DEVELOPMENT ACTIVITIES

Overall rates of protection and commercialization may be misleading indicators of the effectiveness of the different approaches, because of what one professor in the study termed the 'lottery effect'. Except for the WCPD, none of the organizations surveyed appeared to have any systematic means of seeking out new developments within their university. Rather, they simply reacted to what was brought to them by university faculty. Their work therefore tends to be unfocused and ad-hoc, precluding the development of continuing relationships and themes of work.

The research raises questions about the scope of the activities of technology transfer organizations. For those similar to Queen's and the University of Toronto's Innovations Foundation, there is essentially a serendipitous element controlling their destiny. These organizations essentially exist to react to faculty output, and have no significant role in stimulating work within the university that might lead to commercial inventions. . As such, they are necessarily predominantly technology-driven since most developments are brought to them by faculty seeking an application.

In contrast, the WCPD carries out contract research work from which new technology can be developed. To do this it must find out Canadian industry needs, and then match these with faculty skills and expertise. Given that most successful innovations are market or user-driven, this approach seems to most closely match the requirements listed above. In addition to the potential for stimulating innovation, this contract research enables the WCPD to defray organization overhead and break even financially.

The CIIC/W suggests another dimension to the scope of a university technology transfer centre's mandate: its client base. The CIIC/W serves a much broader set of clients than just the university, and is able to derive revenues from this activity.

Incorporation is likely to give the organization a greater incentive to operate in a businesslike manner. As seen in the examples of the University of Toronto Innovations Foundation and the WCPD, long-range goals, break-even targets, business plans and annual budgets can be established. The Board of Directors can be used to access the expertise of the business community and to regularly evaluate the corporation's performance. The Board can be especially useful in the early years when many policy decisions have to be made.

RECOMMENDATION 6: UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD ESTABLISHED CONTINUING LINKAGES WITH PRIVATE SECTOR CORPORATIONS THAT FACILITATE THE TRANSFER OF A STREAM OF NEW TECHNOLOGIES

The overwhelming impression gained from this study of the technology transfer process from Canadian universities to the private sector is of an ad-hoc process carried out on a case-by-case basis. Universities are not establishing through these organizations continuing linkages with corporations that build a growing two-way stream of technology transfer.

Successful innovations tend to come about when people understand each other's needs and where perceived organizational and geographic barriers are minimal. The manner in which the university technology transfer organizations work at present means that for virtually every innovation a new set of linkages and understandings have to be forged. This is particularly constraining when these organizations have extremely limited resources with which to promote innovation.

We believe that these organizations would be more effective if they targeted a limited number of venture capital companies and large firms with venturing activities seeking new technologies to market, and established working relationships with them. University developments could then be evaluated and commercialized under a joint approach. Moreover, these larger firms might then feel more confident about sub-contracting more of their fundamental applied research to Canadian universities. These relationships would not preclude relationships with small enterprises on specific technical developments.

## 6.3 THE TRANSFER PROCESS

As shown in Figure 13 on page 129, there were marked commonalities in the commercially successful developments which were correspondingly lacking in the failures. We believe that this research has shown that the six elements which comprise our next recommendation are essential aspects of any successful university commercialization of technology.

RECOMMENDATION 7: UNIVERSITY TECHNOLOGY TRANSFER ORGANIZATIONS SHOULD DEVELOP A COMMERCIALIZATION METHODOLOGY THAT INCORPORATES THE FOLLOWING SIX ELEMENTS

1. Early identification of an initial market (not just application) for the new technology.
2. Early involvement of a committed corporate sponsor and potential licensee.
3. Early demonstration of the technology to potential licensees and customers.
4. Continuing involvement of the inventor in all phases of the activity.
5. The creation of a university-corporate team to develop a commercial technology.
6. Government funding to enable piloting and commercial demonstration of the technology.

The Q-Sol solar collector case suggests that even in the absence of an effective technology transfer organization, these six activities can result in success. However, a well organized technology transfer activity is likely to be unsuccessful if these steps are not implemented.

The early identification of an initial market provides a yardstick against which ultimate commercial viability can be continually assessed. It also enables the development of a prototype or pilot meeting specific performance characteristics, rather than attempting to develop a universal technology at the outset, thus shortening the development time considerably.

Early involvement of a committed corporate sponsor provides the product market knowledge necessary to parallel the technical expertise of the inventor. The corporate sponsor provides impetus to the commercialization process, and can be in a position to assist with product definition and the rapid development of a commercial prototype.

Early demonstration of the technology builds confidence in the innovation, and can provide important feedback to the inventor. Market needs can also be more readily assessed. The value of this activity was clearly demonstrated in the Q-Sol collector case, and the result of failure to demonstrate in the Chromoretinoscope case.

Continuing involvement of the inventor appears to be important in maintaining the momentum of the development. The inventor is the champion of the innovation, and is in the best position to resolve technological uncertainty and maintain the confidence of corporations in the project.

The creation of a university-corporate team early on in the commercialization phase is important in defining markets and the actual product to be marketed. Frequently, the inventor will not have a clear idea of what is marketable or manufacturable, and the evidence in several of the case studies suggested that the combined efforts of the inventor and corporate personnel were necessary. This activity can take place either on or off campus.

Government funding played an important role in the development and commercialization of several of the developments examined in the case studies. There may be a considerable amount of work to be done before commercial viability can be determined, and especially where the corporate involvement is of a small company, government funding of the development and piloting stages can be critical to success.

## 6.4 FACULTY CHARACTERISTICS

Approximately 20 percent of the faculty responding to the survey at the three universities reported protected technical developments. University of Waterloo faculty were slightly lower in this regard than those at the University of Toronto or Queen's University.

Approximately 60 percent of these faculty reported that their developments had been commercialized, although the proportion was somewhat higher at the University of Waterloo, possibly because of a more effective commercialization activity. Queen's faculty reported the lowest success rates for commercialization, which would correspond to our finding that this activity is least effective at Queen's.

Engineering faculty exhibited the highest rates of commercialization activity, and physical and life science faculty the lowest. This corresponded to the reported rates of interaction with industry. Engineers were much more likely to have either work or consulting experience than faculty in other disciplines.

RECOMMENDATION 8: UNIVERSITIES WISHING TO PROMOTE INCREASED

LEVELS OF TECHNICAL DEVELOPMENT ACTIVITY SHOULD FACILITATE INCREASED LEVELS OF CONSULTING AMONG JUNIOR FACULTY

Consulting and work experience were the factors which principally differentiated faculty with protected and commercialized innovations from those without. Faculty with these kinds of experience were four or five times as likely to have protected or commercialized developments than faculty without such backgrounds.

Consulting was a more significant factor than past work experience associated with faculty with protected in determining successful commercialization. Only 5 percent of the faculty who did not consult had commercialized developments, compared to 20 percent who had consulted. The differences for faculty with and without work experience were significantly smaller. We surmise that the knowledge and skills obtained in consulting are directly applicable to the innovation process, which may not be the case with prior work skills.

A variety of vehicles are available for universities to use to facilitate increased levels of consulting. Among these are university institutes (of these the Stanford Research Institute is the best known, after which the U.B.C. Research Institute is modelled). Senior faculty can also be used to mentor their younger colleagues in these activities. Time release for consulting is also important.

RECOMMENDATION 9: PROMOTION SALARY AND TENURE POLICIES SHOULD NOT BE USED TO REWARD COMMERCIAL DEVELOPMENTS

Promotion, salary and tenure policies have relatively little impact on faculty interaction with industry and their interest in commercializing new technology. While most faculty surveyed felt that university policies generally encouraged some degree of interaction, they did not feel that they greatly affected their behaviour. Generally faculty felt that these activities were desired by their universities, but even at the University of Waterloo, which has strong linkages with industry, 15 percent of the faculty surveyed felt the university policies discouraged interaction.

Faculty who had attempted to commercialize innovations were generally critical of the effectiveness of the university technology transfer organizations. Only 47 percent of the faculty with successfully commercialized innovations perceived these organizations to be effective, while 38 percent thought that they were ineffective. The remainder were unable to comment. Among the faculty with unsuccessful attempts at commercialization, only 35 percent viewed the functions as effective, while 48 percent considered them to be ineffective.

## APPENDIX A. SURVEY QUESTIONNAIRE DATA

Note: The figures presented in this appendix are drawn from the thesis: P.H. Helferty, "The Commercialization of University Inventions." Unpublished Master's Thesis, Queen's University, Kingston, Ontario, 1985

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Figure 23. Field of Research: Responses Separated by University

| University | Field of Research | | | | |
|---|---|---|---|---|---|
| | Engineering | Life Sciences | Physical Sciences | No Response | Total |
| Queen's | 29.76 | 43.45 | 26.79 | 0.00 | 100% |
| Toronto | 23.31 | 54.49 | 21.63 | 0.56 | 100% |
| Waterloo | 44.26 | 15.57 | 39.34 | 0.82 | 100% |

Figure 24. Years as a University Faculty Member: Responses Separated by University

| University | Years as a Faculty Member 0-5 | 6-10 | 11-15 | 16-20 | >20 | No Reply | Total |
|---|---|---|---|---|---|---|---|
| Queen's | 21.43 | 14.88 | 17.86 | 24.40 | 21.43 | 0.00 | 100% |
| Toronto | 6.74 | 16.57 | 23.31 | 21.91 | 30.90 | 0.56 | 100% |
| Waterloo | 13.11 | 6.56 | 32.79 | 22.13 | 25.41 | 0.00 | 100% |

Figure 25. Rank of Respondent: Responses Separated by University

| University | Assistant Professor | Associate Professor | Professor | No Response | Total |
|---|---|---|---|---|---|
| Queen's | 19.64 | 33.93 | 46.43 | 0.00 | 100% |
| Toronto | 5.06 | 29.21 | 65.73 | 0.00 | 100% |
| Waterloo | 9.84 | 31.87 | 56.56 | 1.64 | 100% |

Figure 26. Years of Industrial Work Experience: Responses Separated by University

| University | Years Industrial Work Experience | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3-5 | >5 | No Response | Total |
| Queen's | 69.64 | 3.57 | 3.57 | 11.31 | 10.12 | 1.79 | 100% |
| Toronto | 70.51 | 4.49 | 6.74 | 6.18 | 9.83 | 2.25 | 100% |
| Waterloo | 53.28 | 9.02 | 5.74 | 15.57 | 16.39 | 0.00 | 100% |

Figure 27. Days Consulting In Last Twelve Months: Responses Separated by University

| University | Days Consulting In Last Twelve Months | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1-3 | 4-12 | 13-24 | >24 | No Response | Total |
| Queen's | 63.69 | 7.74 | 11.90 | 10.71 | 4.76 | 1.19 | 100% |
| Toronto | 51.40 | 12.92 | 18.26 | 9.27 | 6.46 | 1.69 | 100% |
| Waterloo | 35.25 | 13.11 | 23.77 | 10.66 | 17.21 | 0.00 | 100% |

Figure 28. Number of Developments Commercialized: Responses Separated by University

| University | Number of Developments Commercialized | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2-5 | >5 | No Response | Total |
| Queen's | 88.10 | 7.74 | 4.17 | 0.00 | 0.00 | 100% |
| Toronto | 85.39 | 8.71 | 4.78 | 0.00 | 1.12 | 100% |
| Waterloo | 84.43 | 7.38 | 4.92 | 0.00 | 3.28 | 100% |

Figure 29. Number of Developments Protected: Responses Separated by University

| University | Number of Developments Protected | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2-5 | 6-10 | >10 | No Response | Total |
| Queen's | 79.76 | 11.90 | 6.55 | 1.19 | 0.60 | 0.00 | 100% |
| Toronto | 79.49 | 10.11 | 8.43 | 0.23 | 0.28 | 1.40 | 100% |
| Waterloo | 81.97 | 7.38 | 8.20 | 0.32 | 0.00 | 1.64 | 100% |

Figure 30. Promotion, Salary, and Tenure Policies: Responses Separated by University

| University | Promotion, Salary, and Tenure Policies (%) | | | | | |
|---|---|---|---|---|---|---|
| | Discourage | Encourage | Strongly Encourage | No Effect | Strongly Discourage | No Response |
| Queen's | 17.86 | 26.19 | 1.19 | 34.52 | 5.36 | 14.88 |
| Toronto | 17.13 | 25.00 | 1.40 | 46.07 | 1.97 | 8.43 |
| Waterloo | 11.48 | 44.26 | 9.02 | 29.51 | 4.10 | 1.64 |

Figure 31. Perception of Invention Evaluation Organization: Responses Separated by University

| University | Perception of Evaluation Organization (%) | | | | | |
|---|---|---|---|---|---|---|
| | Not Very Effective | Somewhat Effective | Totally Ineffective | Unable To Comment | Very Effective | No Reply |
| Queen's | 9.52 | 25.60 | 2.98 | 42.26 | 10.71 | 8.93 |
| Toronto | 16.01 | 20.79 | 3.37 | 51.40 | 4.49 | 3.93 |
| Waterloo | 12.30 | 25.41 | 1.64 | 40.98 | 17.21 | 2.46 |

Figure 32. Perception of Invention Commercialization Organization: Responses Separated by University

| University | Perception of Commercialization Organization (%) | | | | | |
|---|---|---|---|---|---|---|
| | Not Very Effective | Somewhat Effective | Totally Ineffective | Unable To Comment | Very Effective | No Reply |
| Queen's | 9.52 | 20.24 | 4.76 | 47.62 | 8.33 | 9.52 |
| Toronto | 14.61 | 17.70 | 3.93 | 54.78 | 4.78 | 4.21 |
| Waterloo | 12.30 | 29.51 | 2.46 | 39.34 | 13.11 | 3.28 |

Figure 33. Relationship Between Field of Research and Consulting: Responses Separated by University

| Consulting | Field of Research | | | | |
|---|---|---|---|---|---|
| | Engineering | Life Sciences | Physical Sciences | No Response | Total |
| NO | 5.17 | 30.14 | 16.46 | 0.16 | 52.19 % |
| YES | 23.51 | 14.11 | 9.87 | 0.31 | 47.81 % |
| TOTAL | 28.68 | 44.51 | 26.33 | 0.47 | 100.00 % |

Figure 34. Relationship Between Industrial Experience and Consulting: Engineers

| | | Industrial Experience | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 7.73 | 10.50 | 18.23 % |
| | YES | 22.10 | 59.67 | 81.77 % |
| | TOTAL | 29.83 | 70.17 | 100.00 % |

Figure 35. Relationship Between Industrial Experience and Consulting: Life Scientists

| | | Industrial Experience | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 64.39 | 4.32 | 68.71 % |
| | YES | 26.62 | 4.68 | 31.29 % |
| | TOTAL | 91.01 | 8.99 | 100.00 % |

Figure 36. Relationship Between Industrial Experience and Consulting: Physical Scientists

| | | Industrial Experience | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 48.21 | 14.29 | 62.50 % |
| | YES | 25.00 | 12.50 | 37.50 % |
| | TOTAL | 72.21 | 26.79 | 100.00 % |

Figure 37. Impact of Promotion, Salary, and Tenure Policies on Consulting: Engineers Without Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | No | 0.00 | 17.31 | 7.69 | 25.00 % |
| | Yes | 5.77 | 48.08 | 21.15 | 75.00 % |
| | Total | 5.77 | 65.38 | 28.85 | 100.00 % |

Figure 38. Impact of Promotion, Salary, and Tenure Policies on Consulting: Engineers With Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | No | 3.25 | 6.50 | 5.69 | 15.45 % |
| | Yes | 16.26 | 47.97 | 20.33 | 84.55 % |
| | Total | 19.51 | 54.47 | 26.02 | 100.00 % |

Figure 39. Impact of Promotion, Salary, and Tenure Policies on Consulting: Life Scientists Without Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | No | 12.67 | 13.57 | 41.63 | 67.87 % |
| | Yes | 10.41 | 7.69 | 14.03 | 32.13 % |
| | Total | 23.08 | 21.27 | 55.66 | 100.00 % |

Figure 40. Impact of Promotion, Salary, and Tenure Policies on Consulting: Life Scientists With Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | No | 8.00 | 16.00 | 24.00 | 48.00 % |
| | Yes | 8.00 | 16.00 | 28.00 | 52.00 % |
| | Total | 16.00 | 32.00 | 52.00 | 100.00 % |

Figure 41. Impact of Promotion, Salary, and Tenure Policies on Consulting: Physical Scientists Without Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | No | 16.67 | 15.74 | 30.56 | 62.96 % |
| | Yes | 7.41 | 14.81 | 14.81 | 37.04 % |
| | Total | 24.07 | 30.56 | 45.37 | 100.00 % |

Figure 42. Impact of Promotion, Salary, and Tenure Policies on Consulting: Physical Scientists With Industrial Experience

| | | Policies | | | |
|---|---|---|---|---|---|
| | | Discourage Interaction | Encourage Interaction | No Effect | Total |
| Consulting | NO | 13.95 | 9.30 | 27.91 | 51.16 % |
| | YES | 13.95 | 13.95 | 20.93 | 48.84 % |
| | TOTAL | 27.91 | 23.26 | 48.84 | 100.00 % |

Figure 43. Developments Protected, Experience, and Consulting: Professors Without Industrial Experience

| | | Developments Protected | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 57.85 | 5.62 | 63.47 % |
| | YES | 27.63 | 8.90 | 36.53 % |
| | TOTAL | 85.48 | 14.52 | 100.00 % |

Figure 44. Developments Protected, Experience, and Consulting: Professors With Industrial Experience

| | | Developments Protected | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 24.24 | 4.04 | 28.28 % |
| | YES | 47.47 | 24.24 | 71.72 % |
| | TOTAL | 71.72 | 28.28 | 100.00 % |

Figure 45. Developments <u>Commercialized,</u> Experience, and Consulting: Professors <u>Without</u> Industrial Experience

| | | Developments Commercialized | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 59.81 | 3.50 | 63.32 % |
| | YES | 30.61 | 6.07 | 36.68 % |
| | TOTAL | 90.42 | 9.58 | 100.00 % |

Figure 46. Developments <u>Commercialized,</u> Experience, and Consulting: Professors <u>With</u> Industrial Experience

| | | Developments Commercialized | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 27.55 | 1.02 | 28.57 % |
| | YES | 52.55 | 18.88 | 71.43 % |
| | TOTAL | 80.10 | 19.90 | 100.00 % |

Figure 47. Developments Commercialized, Experience, and Consulting: Professors Without Industrial Experience but With Developments Protected

| | | Developments Commercialized | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 14.52 | 24.19 | 38.71 % |
| | YES | 24.19 | 37.10 | 61.29 % |
| | TOTAL | 38.71 | 61.29 | 100.00 % |

Figure 48. Developments Commercialized, Experience, and Consulting: Professors With Industrial Experience and With Developments Protected

| | | Developments Commercialized | | |
|---|---|---|---|---|
| | | NO | YES | TOTAL |
| Consulting | NO | 11.11 | 3.70 | 14.81 % |
| | YES | 16.67 | 68.52 | 85.19 % |
| | TOTAL | 27.78 | 72.22 | 100.00 % |

Figure 49. Perception of Evaluation Organization and Experience With It

| | | Perception of Evaluation Organization | | | |
|---|---|---|---|---|---|
| | | Effective | Ineffective | No Response | Total |
| Developments Protected | NO | 20.81 | 9.86 | 50.23 | 80.91 % |
| | YES | 10.64 | 6.57 | 1.88 | 19.09 % |
| | TOTAL | 31.46 | 16.43 | 52.11 | 100.00 % |

Figure 50. Perception of Commercialization Organization and Experience With It

| | | Perception of Commercialization Org. | | | |
|---|---|---|---|---|---|
| | | Effective | Ineffective | No Response | Total |
| Developments Made Commercial | NO | 21.79 | 11.60 | 53.61 | 86.99 % |
| | YES | 5.96 | 4.86 | 2.19 | 13.01 % |
| | TOTAL | 27.74 | 16.46 | 55.80 | 100.00 % |

Figure 51. Perception of Commercialization Organization and Experience With It: Separated by Developments Protected and Success in Getting them Commercialized.

| Commercial Successful | Perception of Commercialization Org. | | | |
|---|---|---|---|---|
| | Effective | Ineffective | No Response | Total |
| No Experience | 19.47 | 8.63 | 52.90 | 81.00 % |
| Successful | 5.97 | 4.87 | 1.88 | 12.72 % |
| Unsuccessful | 2.20 | 2.98 | 1.10 | 6.28 % |
| Total | 27.63 | 16.48 | 55.89 | 100.00 % |

# APPENDIX B. QUESTIONNAIRE FOR INTERVIEWS OF ORGANIZATION HEADS

## 1. Technology Transfer Organization

What is the mandate of your technology transfer organization? Has it been formally defined? If so, by whom?

Do you have formally stated annual objectives?

What is the structure of the technology transfer organization at your university?

How many people are involved and what are their training and roles?

What percentage of each of these persons' time does technology transfer activities consume?

How long has the organization existed?

Has it changed in the last five years? If yes, how and why?

Do you expect it to change in the next two years? If yes, how and why?

How is the organization funded?

What is the annual budget? Is this relatively constant or changing?

Do the proceeds from past transactions cover the cost of the organization? If yes, what is done with the excess funds? If no, do you expect revenues will meet expenses in the future?

Where does the technology transfer organization fit in the university organization?

Who does it report to?

How is the performance of the organization evaluated?

## 2. Interaction With Faculty

What procedure does a professor follow if he develops something he thinks has commercial potential?

How is the commercial potential of the development evaluated by the technology transfer organization?

Are persons outside the university community involved in the evaluation process?

Who pays the costs associated with patent applications?

In what countries is patent coverage applied for?

If a patent is granted, who owns it?

How is the inventor compensated?

How many patents have been applied for in each of the last five years? If this is changing, why?

Of those applied for, how many have been granted? refused? are pending?

What proportion of the products or processes patented are in commercial use within two years? Within five years?

What proportion generate revenue for the organization and/or the university?

In your view, are the proportions from the above two questions too low? acceptable? quite good? How do you decide?

If the organization does not consider the development worth patenting, can the professor proceed on his own?

If he is granted a patent and revenues are subsequently generated, does the university have a claim on these revenues?

Are you aware of products or processes that were considered not worth patenting by your organization that are now in commercial use?

In your opinion, what percentage of the science and engineering professors at your university are aware of the existence of your organization?

What percentage have a resonably clear understanding of your functions and how you perform them?

What percentage of the science and engineering professors have approached you with a development that they felt had commercial potential?

What percentage of the science and engineering professors that have developments that they believe have commercial potential, interact directly with existing companies or start a company of their own without working through your organization? If some do, why?

Have some professors having a commercially useful development resigned from the university to join an existing company or start their own? If yes, how many? Do they retain some link with the university (e.g., adjunct professorship)?

What percentage of the professors who approach you with developments have industrial work experience?

What proportion of the science and engineering professors have industrial experience?

Are developments brought to you by professors having industrial experience more likely to be considered to have commercial potential than those from professors having academic experience only?

Do the professors generally have a good grasp of the commercial potential of their developments?

At your university, are science or engineering professors more likely to be involved in developments having commercial potential?

## 3. Interaction With Government, Industry and Venture Capitalists

Who, outside the university community, do you interact with most often?

Governments?

Large companies?

Small companies?

Venture capitalists?

Which type of outside organization is easiest to work with? Why?

Which type is most difficult? Why?

Are the companies/capitalists you interact with usually government- or privately-owned?

What percentage of your contacts involve foreign-owned companies?

Are you ever approached by large or small companies seeking solutions to technical problems? If yes, how often are you able to help them?

Are you ever approached by venture capitalists seeking developments which could be the basis for a new venture? If yes, how often?

How do you decide whether a development is best suited for transfer to an existing company or formation of a new venture?

Is one of your responsibilities to find venture capital to finance the formation of new ventures? If yes, what are your most common sources?

Do you restrict yourself to Canadian sources, or do you consider or actively seek foreign capital?

In your experience, is obtaining risk capital for developments having significant commercial potential difficult?

Are there products or processes that have been developed at your university that have commercial potential but are not, and are not likely to be commercially exploited? If yes, why?

4. Technology Developed at Your University

Of the developments at your university, what percentage are

- new products?
- improvements of existing products?
- new processes?
- improvements of existing processes?

Of the above four types of developments, which are most frequently transferred to

- large companies?
- small companies?
- new ventures?

Which type(s) of development is easiest to transfer? Why?

Which type(s) is most difficult? Why?

Are the types of technology being developed at your university changing? For instance, are there now more biotechnology developments than three years ago?

Are there any problems unique to the transfer of biotechnological developments? If yes, what are they and how do you attempt to resolve them?

5. Other

Having worked within your organization for several years, do you believe it could be changed to more effectively and efficiently transfer technology? If so, how?

Are there questions not raised above that you feel should be addressed in our study?

## HEADS OF ORGANIZATIONS INTERVIEWED

### QUEEN'S UNIVERSITY

Professor John Beal, Chairman of the Inventions Committee and Director, Office of Research Services, Queen's University.

Professor Heino Lilles, Chairman of the Negotiating Committee and Executive Assistant to the Vice Principal (Services), Queen's University.

Mr. Harvey Marshall, Coordinator of Patents and Licensing, Queen's University.

### UNIVERSITY OF TORONTO

Mr. Geoffrey Adamson, Executive Director and Board Member, Innovations Foundation, University of Toronto.

### WATERLOO

Mr. Ted Cross, Executive Director, Waterloo Centre for Process Development, University of Waterloo.

Mr. Jim McPherson, Chief Executive Officer, Canadian Industrial Innovation Centre/Waterloo.

APPENDIX C. QUESTIONNAIRE AND LETTERS SENT TO PROFESSORS

SCHOOL OF BUSINESS

Queen's University
Kingston, Canada
K7L 3N6

Dear Queen's University
Science or Engineering Professor

Queen's University has a Co-ordinator of Patents and Licensing and Inventions and Negotiating Committees to assist with the evaluation and commercialization of the results of the University's research laboratories. To aid us in conducting a study of organizations with this goal, and of university-industry interaction in general, we would appreciate it if you would complete the attached multiple-choice questionnaire. After completing it, please fold and staple it so that our address is exposed, and return it to us via I.U.T.S.

Thank you for helping us with our study.

J. R. M. Gordon
Dean

P. H. Helferty
Fellow

# Questionnaire

1. What is your field of research? Engineering ____
   Physical Sciences* ____ Life Sciences ____
   *excluding engineering, including Math & Computing Science.

2. For how many years have you been a university faculty member?
   0-5 ___ 6-10 ___ 11-15 ___ 16-20 ___ > 20 ___

3. What is your rank? Assistant Professor ___
   Associate Professor ___ Professor ___

4. For how many years have you worked in industry full-time since completing your first degree?
   0 ___ 1 ___ 2 ___ 3-5 ___ > 5 ___

5. In the past twelve months, on how many days did you serve as a consultant to industry?
   0 ___ 1-3 ___ 4-12 ___ 13-24 ___ > 24 ___

6. How many developments in your university laboratory in the last five years have been patented and/or protected in some other way (e.g., trademark) by you and/or your university?
   0 ___ 1 ___ 2-5 ___ 6-10 ___ > 10 ___

7. How many of the developments referred to in the previous question are in commercial use, or will be within two years?
   0 ___ 1 ___ 2-5 ___ 6-10 ___ > 10 ___

8. In your view, how do the promotion, tenure and salary policies of your university, as they are implemented, affect the level of interaction (e.g., consulting, industrial research contracts) between professors and industry?

   ___ strongly encourage interaction   ___ encourage interaction   ___ no effect   ___ discourage interaction   ___ strongly discourage interaction

9. In your view, is the organization(s) that your university has created to assist in evaluating the technical and commercial potential of professors' inventions....

   ___ very effective   ___ somewhat effective   ___ not very effective   ___ totally ineffective   ___ unable to comment

10. In your view, is the organization(s) that your university has created to assist in commercializing (e.g., licensing) professors' inventions...

   ___ very effective   ___ somewhat effective   ___ not very effective   ___ totally ineffective   ___ unable to comment

11. Please add any comments you wish to make:

Dear University of Toronto
Science or Engineering Professor

The University of Toronto has created the Innovations Foundation to assist with the evaluation and commercialization of the results of the University's research laboratories. To aid us in conducting a study of organizations with this goal, and of university-industry interaction in general, we would appreciate it if you would complete the attached multiple-choice questionnaire. After completing it, please fold and staple it so that our address is exposed, and return it to us via I.U.T.S.

Thank you for helping us with our study.

J. R. M. Gordon
Dean

P. H. Helferty
Fellow

/lf
Encl.

Dear University of Waterloo
Science or Engineering Professor

The University of Waterloo has been involved in the creation of several organizations to assist with the evaluation and commercialization of results from the University's research laboratories (e.g., Canadian Industrial Innovation Centre/Waterloo; Waterloo Software Products, Inc.; Waterloo Centre for Process Development). To aid us in conducting a study of organizations with this goal, and of university-industry interaction in general, we would appreciate it if you would complete the attached multiple-choice questionnaire. After completing it, please fold and staple it so that our address is exposed, and return it to us via I.U.T.S.

Thank you for helping us with our study.

J. R. M. Gordon
Dean

P. H. Helferty
Fellow

/lf
Encl.

238. I wonder if a 'development section (as distinguished from a basic effort)' may not help. A mechanism that may team up the staff member who has the idea and a potential developer of it may be useful.

240. Re Q 9 & 10: Unaware of existence, unable to answer.

244. Hospital-based research institute policies take precedence over university policies. Hospital policies are much more restrictive.

250. The Innovations Foundation requires more capital support to be more effective.

256. It is my view that professors who have consulting positions are discriminated against by their colleagues who possibly lack the ability to obtain consulting positions with industry. This attitude has damaged the relationship of the University with industry and with government.

257. These questions do not address problems related to development of pharmaceuticals. The discrimination against this work by this University (overhead charges) vis a vis grants from MRC or health granting bodies is discouraging grantees and grantors.

260. O.R.A. and other administrative structures in the University of Toronto are already large, in my opinion, and attempts to improve the above could lead to an expansion of bureaucracy. Bureaucracy is not a productive part of a university.

264. Strong need to encourage interaction between university and industry.

270. Bureaucrats cannot evaluate science and engineering achievements or correctly assess priorities. Only those involved speak with technical authority. Such organizations should be brokers and assist, not obfuscate.

298. The Innovations Foundation is understaffed; otherwise it is on the right track. So is the University's policy regarding interaction with industry. It is encouraging without being stifling.

308. Re Q 9 & 10: I heard that such an organization was to be formed, but haven't heard much, if anything, since.

331. Re Q6: Developments in my lab have been of use to industry and have been applied by them, without protection.

354. There is strong peer pressure against commercial involvement, incentives are diluted at department level.

357. Re Q 9 & 10: I know of absolutely no activity on the part of U. of T. as far as life scientists are concerned.

369. Understaffing is the main reason why interaction between University and industry has not been promoted to any fruitful level.

374. Models for such organizations can be found at Waterloo University and the Universities of Wisconsin and Stanford. We have a long way to go at Toronto.

384. I was not aware of the creation of the Innovations Foundation.

403. What the hell is Q8 doing here? Whose ax are you grinding?

419. The inventor should receive a larger percentage of commercial returns than is now the case.

424. A major problem we in the Life Sciences have at the U. of T. is understanding what the Innovations Foundation is trying to do for us.

440. We tried once and got nowhere. Now three companies are selling the product (This respondent thought the organization was not very effective.).

518. Re Q 9 & 10: Main interest is in getting University's share.

540. Innovation Foundation is very effective for specific patented projects - but help is variable when approached by professors who are not clear if their research is patentable or marketable.

614. Low salary leads to more consulting.

617. U of T is not oriented to interact with industry well!

4. We require professional marketing personnel with a budget that allows for legitimate risk-taking.

5. Fees received by the University from licenses should be distributed in large part to the department in which the work originated.

6. Re Q10: Had not appreciated that we had anything as clear as an organization. Also: I doubt that an organization inside the University has any prospect for doing the commercial work required!!

12. If the University wishes to enter the commercial world, then it must set up a mechanism to promote and actively market the products.

45. Re Q8: Officially sometimes.

53. Appears to be a good system.

56. Re Q8: Strongly encourage consulting because of poor salary; strongly discourage consulting and contracts because need time for research.

69. Research on inventions is not considered sufficiently academic by administration to be given proper credit. I have patents on 19 different inventions with little or no recognition for them.

81. Patents, etc., not applicable to most fields of biological sciences.

83. Re Q8: Strongly discourage teaching. Also: I wish the University was more interested in students and less interested in enriching those who can't teach.

130. At least in the Life Sciences, I don't think the University is doing much to foster this type of Research.

131. I am involved in a spin-off company that will commercialize the invention. Information on how common a practice this is would be useful.

137. The evaluation of and the relation of commercial enterprises to promotion, tenure and salary largely remain in the domain of the Head of the Department. This will not change until a new mechanism outside the Departments is developed.

139. At one time I was a member of the Board of Directors of Canadian Patents and Developments Ltd. (This respondent thought the organizations were ineffective.)

413. In the science based disciplines, in many instances we publish rather than patent since commercialization of patents is so slow in (?). Moreover, CPDL has been the single identifiable reason for this. Since a Coordinator of Patents and Licensing was hired this has rapidly improved.

# APPENDIX F. COMMENTS FROM UNIVERSITY OF WATERLOO PROFESSORS

162. Waterloo encourages interaction with industry more than most Canadian universities. With respect to Q 9 & 10, problem is that so little of Canadian industry is interested in or can evaluate new developments.

170. For about five years of my early career I consulted for industry; with excellent results. These results were well known in my department, but had no effect on promotion. Therefore, I have concluded that in my department this type of activity is a help to some and possibly a hindrance to others.

190. I don't think I should benefit personally from any commercialization of my work if, indirectly, I am paid from the public purse.

191. My university is interested in exploiting professor's industrial contacts for purposes of prestige, but not in encouraging or supporting such contacts.

197. Respondent serves as reviewer of selected invention disclosures via locally-based organization. (probably CIIC/W)

198. Re Q8: I am at the University of Waterloo!! Official policy is that consulting, industrial research contracts are not taken into account for promotion, tenure, salary. Also: Commercialization of professors' ideas depends on the individual professor much more than on any administrative body.

205. Necessary delays in obtaining patents, which delay publication, are not conducive to a good grant record from NSERC.

206. I don't see the function of Q 9 & 10 as part of the University's mandate.

215. Re Q5: Industrial demand far exceeds 24 days per year. Re Q8: Engineering reports for industry actually have a negative effect on salary increases and promotions.

223. Our laboratory in Computer Graphics, which I am involved with, has developed some software systems which have been transferred to industry. But we give these away for considerations (equipment, student stipends). We don't licence or market.

317. Re Q 9 & 10: Innovation Centre is not very effective; WCPD is at least somewhat effective.

499. Re Q8: Our salary/tenure/promotion policies do not affect the level of interaction per se. Rather the whole University philosophy and attitude strongly encourage interaction. This is ultimately reflected in promotion/tenure/salary, but is not explicitly built in.

By the way, it is my opinion that the interaction is critical to Waterloo's rather astounding success in such a short time. Waterloo's approach should be studied as a model and variants implemented at all universities for the 21st century. I say this having graduated elsewhere and spending five years at another Canadian university.

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